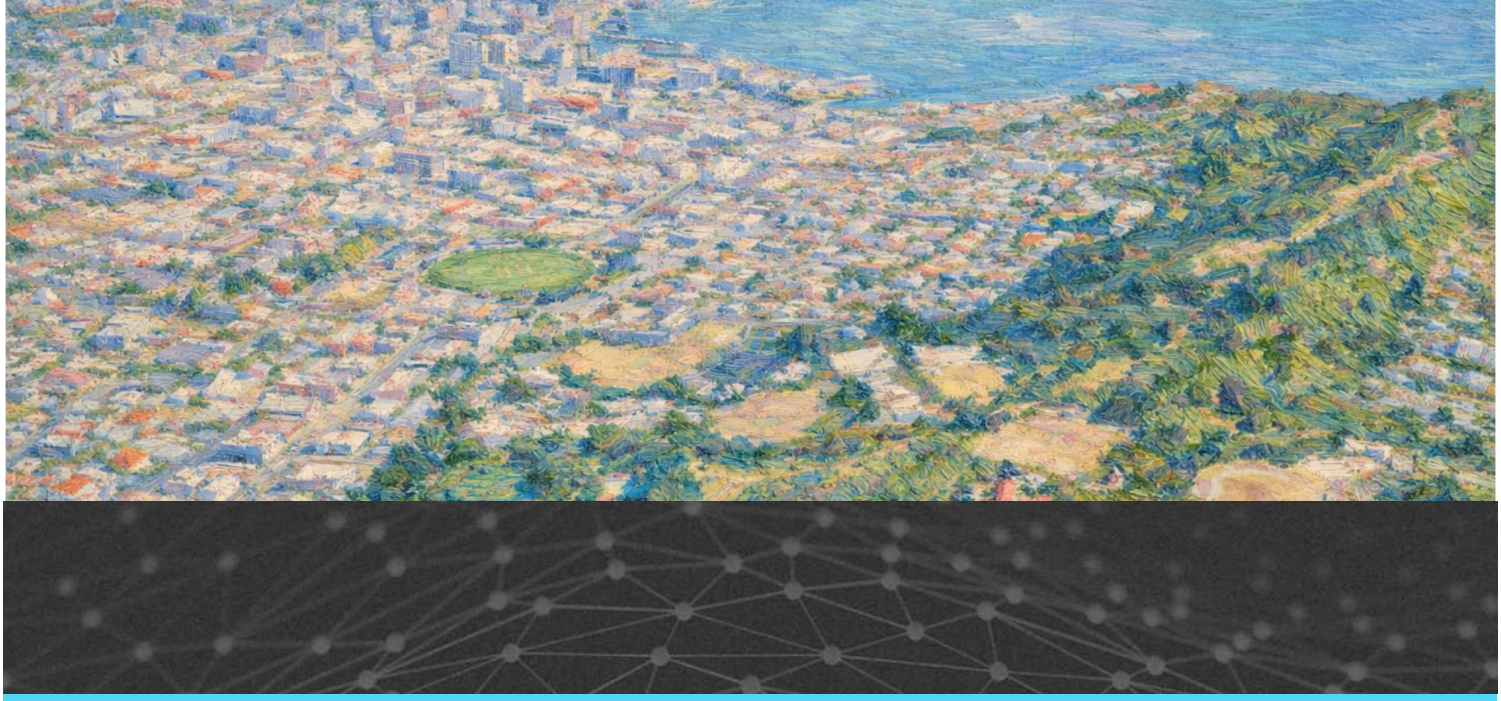

SH1 Wellington Improvements Technical Report #2:

Constructability Report - For Consenting

Client: Waka Kotahi NZ Transport Agency

Date: 4 August 2026

Consultant:

HOFFCON.PRO

Hoff Consultants Limited (Hoffcon)

Contents

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1	Morgan Harris, David Hoffman	For Consenting	4 August 2026

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Action	Name	Date
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Reviewed by	David Hoffman	4 August 2026
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1 Introduction

This document provides constructability information for the SH1 Wellington Improvements project (the Project). It is intended to support assessments required for the application for approvals under the Fast-track Approvals Act by describing potential construction activities, methods and effects. The objective of this report is to:

- Provide a basis for technical specialists and decision makers to evaluate potential / likely construction phase effects and impacts.
- Outline key construction activities, methodologies and sequencing including site establishment and main construction phases.

The construction methodologies described in this report are indicative and represent reasonable and commonly used construction approaches for infrastructure projects of this nature. The methods outlined reflect established industry practice in New Zealand and are intended to provide a realistic basis for assessing potential construction effects.

All construction details presented in this report are indicative only. The actual construction methodology will be determined by the Contractor appointed to deliver the works and may differ from what is described here. The purpose of this document is to outline potential construction approaches and provide a likely method to inform the assessment of effects, rather than to prescribe final methods.

In some cases, assumptions used in this report are intentionally conservative in order to identify potential effects and appropriately assess a range of possible methods. For example, certain scenarios assume extended closures or restricted operation of parts of the transport network. These scenarios represent a higher impact case for assessment purposes, recognising that a future contractor may implement alternative methods that modify disruption or closure durations.

The sequencing and timeframes for works presented are approximate and subject to change as design and programme are developed. If construction activities are undertaken more quickly than assumed, potential effects may occur over a shorter duration but with potentially higher intensity during that period. Conversely, if activities are undertaken over a longer period, a similar overall quantity of effects may occur but be distributed over a longer timeframe. The methodologies described therefore represent a reasonable envelope for assessing potential construction effects. Where subsequent assessments rely on specific timeframes or programme assumptions referred to in this report, allowance should be made for potential variations.

This document should be read in conjunction with supporting design information and the other Project documents.

1.1 Engagement

We have reviewed relevant comments received through NZTA's engagement with the public and councils, where feedback was provided regarding the way the Project will be constructed and potential effects during the construction phase.

While all comments have been carefully considered, many of the matters raised are more appropriately addressed within the relevant specialist reports and management plans rather than this constructability report. This version of this report does, however, address those clarifications that are specific to construction methodology and fall within its scope. In particular, WCC sought clarification regarding the recommendations for the Kilbirnie Park construction yard, which is addressed at section 3.6.5 of this report.

We are satisfied that the construction methodology described in this report is appropriate for the Project and that the matters raised through public engagement have been addressed in this report or by the relevant specialists and associated management plans.

2 Project Description

The Project is a major infrastructure project upgrade led by Waka Kotahi NZ Transport Agency, aimed at enhancing transport efficiency and access reliability through central Wellington. It focuses on improving strategic road corridors to support regional growth and reduce congestion along one of New Zealand’s most critical transport routes.

The Project runs along SH1 from north of the Terrace Tunnel to the intersection of Wellington Road and Evans Bay Parade. The Project involves interface with the Wellington City Council roading network, Basin Reserve, and the Wellington Town Belt. Parts of the Project include works adjacent to businesses and residential areas which may be affected by the construction works.

For the purposes of describing the potential construction activities, the Project has been broken up into five areas of work shown in Figure 1. These areas are:

- **Terrace Tunnel Duplication**

  Terrace Tunnel duplication including widening of SH1 north and south of the tunnel, and extension or replacement of the Ghuznee Street overbridge.

- **Te Aro Improvements**

  Reconfiguration of Vivian Street and the Arthur/Cuba/Karo intersection to increase capacity of the SH1 route.

- **Basin Reserve Improvements**

  Reconstruction of the Basin Reserve roading network to achieve grade separation between SH1 traffic and north-south local road traffic.

- **Mt Victoria Tunnel Duplication**

  Duplication of the Mt Victoria Tunnel.

- **Eastern Connections**

  Widening of Wellington Road, and Ruahine Street, east of the Mt Victoria Tunnel to Evans Bay Parade.

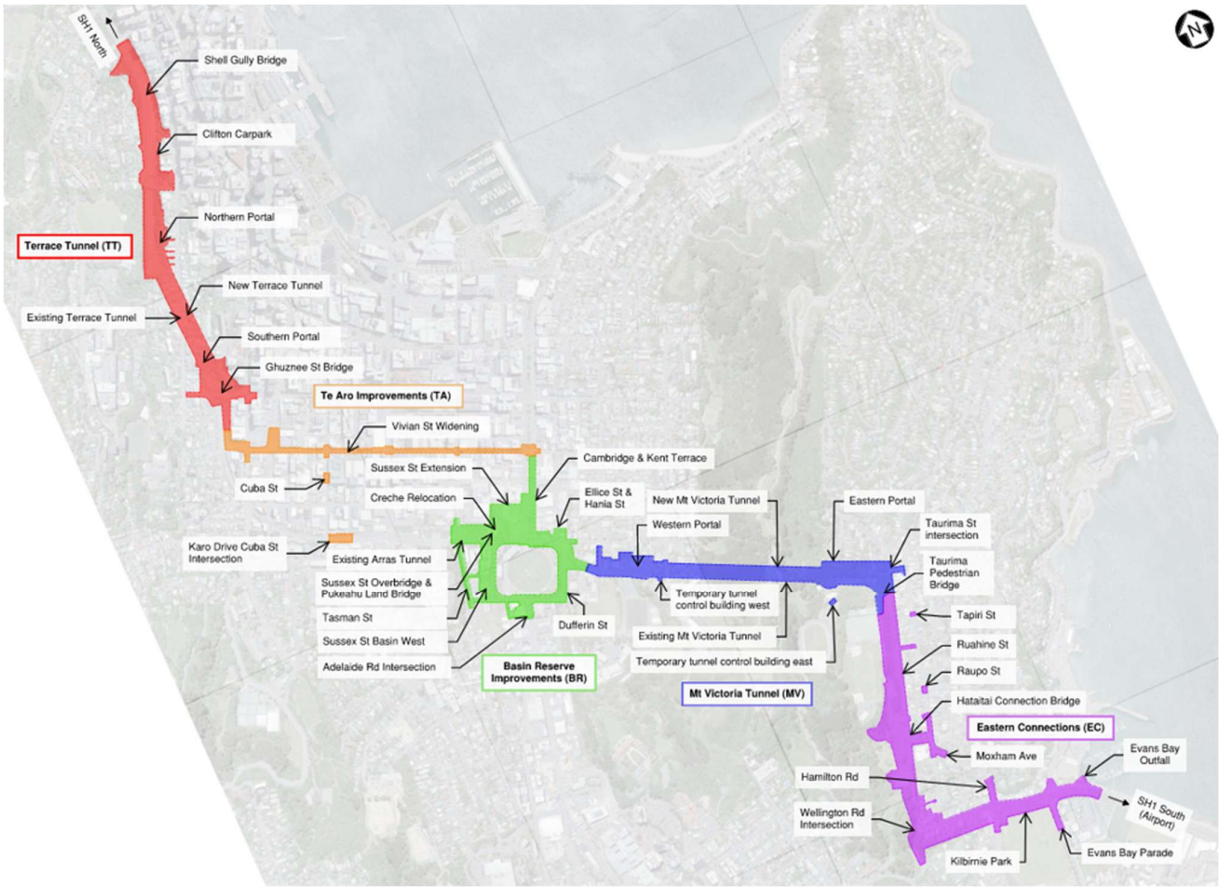


Figure 1: Areas of work. Background source WSP design documents

The order that work areas are presented in this report is not indicative of an order in which the Project will be delivered. Packaging of construction activities will be defined following approvals being granted for the Project under the FTAA to:

- Unlock staged benefits.
- Manage / reduce the cumulative impact to residents and businesses.
- Manage / reduce congestion and network disruption.
- Manage the overall Project spend and risk profile.
- Match scope to site specific risks.

3 General Construction Aspects

This section outlines aspects that are generally consistent across the Project.

3.1 Project Enabling Works

Project establishment activities can occur before the delivery of the full project. These activities enable the subsequent works to be delivered more efficiently therefore reducing the overall impact on the community. Some establishment activities may also occur prior to consenting. In all cases, these enabling works would be subject to compliance with relevant resource consent, designation conditions (which may include the requirement for certification of management plans in relation to some activities).

3.1.1 Site investigations

Further detailed site investigations to confirm ground conditions, contamination, and existing features, including:

- Geotechnical investigations.
- Groundwater level monitoring and quality sampling.
- Contaminated land assessments.
- Pre-construction condition surveys of adjacent properties and structures.
- Identification of hazardous materials within structures to be removed (asbestos survey).
- Underground service locating.
- Survey of any areas not completed or modified since design.
- Missing data collection. Potentially including any of; baseline noise, vibration, water quality, air quality, dust, sediment runoff, ecological, habitat, waste, emission, parking, travel times, traffic counts or other data required for compliance or quality verification.
- Identification and protection of existing trees.

3.1.2 Baseline monitoring

Baseline environmental investigations, including:

- Noise and vibration monitoring.
- Where sensitive buildings have been identified these may need survey controls set up including the mounting of prisms or control points to the exterior of the structures. These are to be monitored during construction and regular access to private property may be required. Consultation and cooperation with affected owners may be required to set up and monitor these.
- Air quality monitoring.
- Ecological surveys (where seasonal windows apply).

3.1.3 Vegetation and landscaping clearance for access and investigation

Clearance or trimming of vegetation to facilitate access and establish work zones, including:

- Vegetation clearance including mulching of identified trees.
- Pruning of identified trees.
- Planted island clearance.
- Grass and ground cover removal as part of earthworks activities.
- Removal of pathways and hard landscaped areas.

The main larger areas of vegetation clearance are at tunnel portals and along Ruahine St will be carried out as works progress to allow vegetated land to be retained as long as possible. However, if there are seasonal restrictions on removal of vegetation, such as requirements to avoid nesting periods, site clearance will likely be planned in advance and removal work will take place during the appropriate season in advance of works.

Consideration Activity:	Vegetation and landscaping clearance
Noise	Noise from chainsaws, mulchers, and small excavation equipment.
Vibration	Minimal
Dust	Dust from soil disturbance or during dry weather; likely mitigated through progressive stabilisation.
Erosion and Sediment	Topsoil removal and bare surfaces present erosion risk. Cleared areas to be converted to handstand with gravel or have earthworks commence shortly after being prepared.
Environmental	Vegetation removal to comply with ecological management requirements. Protected species or habitats (if present) may require specific protocols or seasonal restrictions to avoid nesting times for example.

3.1.4 Demolition and removal of structures

Demolition and removal of buildings and structures required to clear the Project footprint, including:

- Demolition of residential and commercial buildings, typically less than 3 storeys.
- Management of potentially hazardous materials including asbestos or building contents.
- Should contaminated land be present then this would also be appropriately dealt with during the demolition and removal task.
- Removal and/or decommissioning of underground services associated with removed structures and capping at termination points.
- Removal of existing street furniture including streetlights, traffic lights, signs, bus stop shelters, pedestrian shelters, cycle racks, rubbish bins, parking meters, and hard landscaping features.
- Provision of access control and site security around buildings to be demolished once ownership taken.
- Disposal, recycling and sorting for potential reuse where appropriate.

Consideration Activity:	Demolition and removal of structures
Noise	Noise from mechanical demolition, concrete slab removal, and removal of buried infrastructure.
Vibration	Vibration from demolition and service removal. Likely to be irregular rather than continuous.
Dust	Dust may be generated during structure and pavement removal. Dust control using water misting, screening, and prompt waste removal following standard construction practices will be implemented.
Erosion and Sediment	Exposed surfaces, trenches, and disturbed subgrade.
Environmental	Potential presence of asbestos, hydrocarbons, and contaminated soils.
Heritage / archaeological	There are scheduled heritage buildings that are to be removed and then returned to new sites following the Project works. Removal of these buildings will be subject to specific building requirements and management plans as provided for in the RMA conditions. In addition, there are pre-1900 buildings which are archaeological sites, which are to be demolished, and potential archaeological sites in other areas where buildings are to be demolished. These demolition works will therefore need to be carried out in compliance with relevant conditions and management plans, for example, the conditions of the archaeological authorities that have been applied for and the archaeological management plan.

3.1.5 Site establishment and access works

Establishment of temporary facilities and access necessary for construction, including:

- Construction yards and site compounds.
- Some site facilities such as those to be used for offices, hygiene facilities, lunch rooms and other inside spaces may utilise existing buildings within the site, should these be outside of the current area of works and suitable for this purpose. Alternatively, temporary or portable buildings may be used in combination with portable restroom facilities close to each work area.
- Temporary service connections for construction use, power, water, sewer.
- Temporary road sealing, gravel pavement and access track construction.
- Installation of site fencing, hoardings, gates, signage and security systems.
- Construction of temporary intersections or local road realignments where required for staging.
- Temporary laydown and storage areas, including for precast elements and spoil.

3.1.6 Utility protection and relocation

Identification, protection, and/or relocation of existing utilities and services, including:

- Application and coordination with service providers for strategic service relocations and access.
- Major infrastructure and strategic services protection and/or relocation.
- Local stormwater, wastewater, potable water, gas, telecommunications, tunnel fire systems, tunnel security systems, tunnel ventilation systems, streetlighting, and mobile phone infrastructure.
- Installation of temporary service diversions or support where required to maintain continuity during construction.
- Removal or decommission of individual service connections where the buildings they serviced have been permanently removed.

3.1.7 Environmental mitigation and control measures

Installation of initial environmental protection measures and controls, including:

- Erosion and sediment control measures (e.g. sediment fences, silt traps, settlement ponds, engineered water treatment devices etc).
- Stabilised access points and wheel wash facilities.
- Dust control measures (e.g. water carts, paved access points, fencing or hoarding).
- Spill kit stations, bunded fuel storage, and bunded chemical storage in site compounds.
- Temporary modification to stormwater containment, capture and dispersal devices to allow for staging of works and excavation while minimising impact of surface water ponding.

3.1.8 Traffic management setup

Implementation of temporary traffic management to protect public safety, including:

- Installation of temporary signage, barriers, and variable message signs (VMS).
- Temporary pedestrian route remediation works (temporary ramps, or cold seal to allow for surface level variations and accessible / cyclist routes).
- Establishment of temporary vehicle access locations to construction areas.
- Early local road modifications to enable later traffic switching.

3.2 Enabling Works Opportunities

This section contains construction activities that can be undertaken in advance of the main package delivery where they:

- Reduce programme risk;
- Deconflict high-intensity work areas;
- Shorten the duration or intensity of later impacts; or are physically or logistically independent from the main construction sequence.
- Utilise utility shutdown windows or major assets that may require extended planning.
- Allow works to avoid high demand or congestion times of year, e.g. sporting seasons, school terms, event restrictions at the Basin Reserve.

Works would only proceed where land acquisition, access arrangements, environmental approvals, and utility coordination enable commencement.

Potential activities

Utility and Services Relocation Activities

- Relocation of 33 kV electricity infrastructure around Basin and Mt Victoria.
- Installation of power and communications services required for tunnel equipment, ventilation, water control and construction plant.

Site clearance:

- Relocation / removal of buildings on Paterson St (other than heritage buildings).
- Kilbirnie Cricket Club facilities demolition and replacement.
- Demolition of other structures around the Basin Reserve and Wellington Road and Ruahine Street corridor (other than heritage buildings / structures).
- Filling or stabilisation of the Mt Victoria pilot tunnel (if confirmed).

Environmental and Mitigation Works

- Early implementation of compensation planting or landscape restoration where seasonal constraints apply.

Note that certain other activities are likely to be carried out early in the programme but are not proposed by NZTA to qualify as 'enabling works' for this Project as they are subject to specific management plan or other conditioned requirements, such as demolition or relocations of heritage buildings, construction of the Ghuznee Street bridge, and construction of the Evans Bay outfall and associated stormwater pipes.

3.3 Traffic and Parking

3.3.1 General traffic management

Across the Project, different areas present distinct traffic management challenges based on their location, road classification, and level of urban activity. Traffic management will be designed to provide safe and efficient operation of both the local road network and SH1, with special consideration given to freight, emergency access, active modes, and public transport routes.

All traffic management activities for the Project will be carried out in accordance with the New Zealand Guide to Temporary Traffic Management (NZGTTM), in conjunction with the relevant Wellington City Council and regional corridor access protocols.

Specific considerations for traffic management and anticipated traffic staging have been described in Section 6 for each area of works.

3.3.2 Permanent Parking Loss

Permanent parking loss has not been assessed in detail as part of this report. Design documents have not been developed to a level of detail that includes future parking layouts. Where comment has been made on the permanent parking loss for each location, this is based off the proposal description. However these assumptions should be used with caution and are subject to change as design develops. It is likely that some of the car parks disrupted during construction will also result in permanent parking loss. The information in this report focuses on the differences during construction from existing rather than permanent effects.

3.3.3 Temporary Parking Loss During Construction

During works, shoulders and roadside parking areas will be utilised for construction activities and to create separation zones, working areas or temporary pedestrian access where works are immediately adjacent to a roadway. The following outlines the locations where public parking may be impacted due to construction activities and provides an approximation of the number of parking spaces that may be impacted. The range in the number of parking spaces unavailable for public use is dependent on the staging of works. For example, in the Terrace Tunnel area at least 245 parks are anticipated to be unavailable for the full duration of its construction and at the most impacted time this increases to 422 parks. As works progress some parks may become available again or lose access as work progresses through an area. In other words, the lower number

is the number of parks impacted if works are sequential and the upper number is the number of parks impacted if all works in the area are carried out concurrently.

While care has been taken to estimate the extent and number of parking spaces affected, a 10% margin of error should be applied to the numbers presented in the following section. Where individual parking spaces have not been painted, a 6m length for each parallel parking bay has been assumed or 2.5m for straight and angle parks. It may be possible in many of these areas to stage works in a way that provides short duration use of loading bays or high importance parks for people of limited mobility in some areas. Alternatively, other nearby parking spaces could be reassigned for these uses, the additional space required for these uses may further reduce the number of public parking spaces in the areas. Where durations have been indicated these are a high-level estimate only and may vary significantly depending on equipment used by contractor and actual sequence of works.

- **Terrace Tunnel (TT):**
  There may be times where between approximately 245 and 422 parks are unavailable during construction. 195 car parks are expected to be closed for the full construction duration and approximately 327 parks will have intermittent availability. It is anticipated that at least 50 of the intermittently available parks will be reserved for construction works at any time with the most favourable sequencing of works to give the minimum number of disrupted parks as 245. The upper bound of 422 parks closed assumes both the Clifton car park haul route (72 to 142 parks) and MacDonald Cres (35 parks) are utilised for construction and works for the tunnel construction, Ghuznee St and SH1 Shell Gully overbridge are carried out simultaneously. The breakdown of areas includes:
  - Clifton South Car Park (~120 parks) for construction yard space assuming the full existing parking lot is used for the duration of TT construction.
  - If the Clifton north slip lane from SH1 southbound construction access is used for carting spoil, an additional area of parking within the Clifton car park will be required including Clifton upper parking lot (~72 parks minimum, ~142 maximum). Alternatively, some of this area may be used for site office or welfare facilities.
  - Below Boulcott/Everton Tce bridges (~15 parks) required for construction activities from the commencement of works to provide construction yard space and access to new north TT portal. All of these parks are removed as part of the permanent works.
  - Clifton Car Park for work on SH1 Shell Gully overbridge above (~150 parks) closed in groups of approx. 50 parks to allow for works to be carried out above the car parking areas. It is unclear if the restriction of movement throughout the car park from area closures results in additional parking space closures due to lack of access.
  - Upper Willis Street Car Park (~60 parks) removed from commencement of works to provide construction yard space and access to new south terrace tunnel portal. Some of these parks are permanently removed as the car park space is utilised for the tunnel control building and stormwater detention tanks.
  - MacDonald Cres (~35 parks). This is an alternative detour route that would potentially allow one lane of Ghuznee St to be closed for the duration of the bridge replacement. A traffic study would need to be carried out to determine if these parks or one side of parking can be maintained with increased traffic on this route.

- **Te Aro (TA):**
  With the assumed staging of works, there may be times where between 10 and 37 car parks are unavailable due to construction. All of the parks on Vivian St are proposed to be permanently removed as part of the Project to allow the existing two traffic lanes with parking to be extended to three traffic lanes. Therefore, as works progress and sections are completed, parking will be reduced until all 76 parks and 5 taxi stands on Vivian St have been made unavailable. These parks will be progressively permanently removed as each block of construction is completed, with the temporary construction impact of 10 to 37 parks referenced above being additional to the cumulative permanent losses already incurred in completed blocks. In addition, pavement works make the parking accessed from Arthur St along SH1 northbound unavailable for a time resulting in a maximum of 91 parks being closed compared to the existing arrangement.
  - Vivian St route (~75 parks and 6 taxi stands) it is anticipated that works through this area will be staged with approx. 10 to 22 parks at any one time unable to be used due to construction activities for periods between weeks to 6 months. Length of time and number of parks impacted depends on staging and other restrictions imposed. It is anticipated that all the parks within one block (10 to 22 parks) will be closed during each stage to accommodate construction working space and equipment in addition to those already permanently closed in completed blocks.

- Arthur St (~15 parks) limited access at times. It is anticipated that all 16 parks will be restricted for construction activities for a period of weeks to months on a single occasion to allow for pavement and utility works to be carried out.

- **Basin Reserve (BR):**
  It is anticipated that there may be times where at least 36 and potentially up to 82 (depending on staging) parks are unavailable during construction. 36 are expected to be closed for the full construction duration and there are approximately 94 further parks with intermittent availability. It is assumed that sequencing will result in only one side (out of 4) of the Basin Reserve being in construction at any time. Accordingly, while 130 parks in total are affected across the full construction programme (36 permanently closed and 94 with intermittent availability), the maximum number closed at any one time is 82. As stages are completed, reduction in parking capacity is expected as traffic lanes are realigned and existing roadside parking converted to traffic lanes.
  - Rugby St, Basin South (~24 parks) access restricted at times, unclear on extent or duration of impact to these parks. It is likely that access to these can be managed in stages leaving either 8 or 19 parks available for public use while the others are closed.
  - Sussex St, Basin West (~18 parks) removed from commencement of works.
  - Ellice St, Basin East (~9 parks) removed from commencement of works.
  - Hania St, Ellice St corner Basin East (~9 parks) removed from commencement of works. These parks are understood to currently be on leased land at Bogarts corner and will become part of the permanent works alignment.
  - Cambridge Tce, Basin North (~2 parks) access to these parks will be restricted at the time of pavement works for the realignment of the Terraces.
  - Kent Tce, Basin North (~32 parks) access to these parks will be restricted at the time of pavement works for the realignment of the Terraces.
  - Basin Reserve / Cricket Museum parking (~36 parks) multiple temporary restrictions with durations of weeks to months will restrict access to this parking and loading zone location.

- **Mt Victoria Tunnel (VT):**
  It is anticipated that approx. 89 parks will be out of service from commencement until completion of the realigned Paterson St. This figure comprises the Austin St, Paterson St, and Hania St/Ellice St/Brougham St parks, all of which are closed from commencement through to completion of the realigned Paterson St. The Wellington East Girls' College and Hataitai Netball Pavilion parks are excluded from this figure as the extent of impact on those locations is dependent on staging. As part of the permanent works, approximately 26 of these parks are permanently removed.
  - Austin St, (~10 parks) assumed no parking during construction to facilitate two-way traffic from commencement of works, parking may be restored once realigned Paterson St and the cut and cover tunnel is completed near completion of works.
  - Paterson St (~31 parks) removed from commencement of works.
  - Hania St / Ellice St / Brougham St access route to Mt Victoria western portal construction yard. (~48 parks total made up of ~ 29 parks on Hania St, ~10 parks on Ellice St, ~9 parks on Brougham St), assumed that parking is restricted to one side, typically parks on the western side are retained, of the streets on this route to provide additional width for vehicles to pass.
  - Wellington East Girls College within school grounds, Paterson St access may be restricted at times, likely multiple weeks on at least 2 occasions, for vehicle traffic, depending on staging of western portal works (~60 defined parks and an additional ~25 to ~40 parks on netball courts which appear to be used as overflow parking). Wellington East Girls College access is discussed specifically in Section 6.4 of this report.
  - Hataitai Netball Pavilion parking (~15 parks) this area could likely be used during construction as a site office and work area for the new pedestrian overbridge as part of the Taurima St construction yard. The extent and number of parks impacted (if any in this location) is highly dependent on the specific arrangement of the contractor's yard.

- **Eastern Connections (EC):**
  The effect on parking during construction is highly variable as works progress. Approx. 104 parks will be removed at commencement of works. To allow for staging and traffic route adjustments during works, short duration closures affecting an additional 8 to 81 parks will be periodically closed in this area. For a brief period (weeks to months), access to Hataitai Park may be restricted to allow Pavement works along the existing Goa St west of Ruahine St. This prevents access to approx. 264 parks and will likely need to be managed with users of these facilities to align the closure with a period of low use. Permanent

works in this area include the removal of carparks along SH1 (Ruahine St and Wellington Rd), and carparks along local roads (Taurima St, Goa St, Moxham Ave, Hamilton Road and Evans Bay Pde) as well as some parking within Hataitai Park.

- Taurima St approx. 4-12 parks from commencement of works, up to 27 at times to allow for modification of existing alignment.
- Ruahine St on-street parallel parking (~30 parks) to be permanently removed from commencement of works. These parks appear to be the primary parking locations for many of the adjacent houses accessed from Ruahine St.
- Hataitai Park temporary disruption during transition between work stages for new Goa St / Ruahine overpass (approx. 33 rugby club + 42 Goa St baseball diamonds + 37 Goa baseball diamond one + 15 drop off only + 39 Netball pavilion + 2 disabled parks + ambulance access parking + 95 Velodrome for a total of ~264 parks) a single closure of the only access with a duration of weeks to months is expected to impact this parking area.
- Goa St between Hataitai park baseball diamonds and Ruahine St (~42 parks in temporary case to construct soil nail slope MV-1C-RW-210)
- Badminton Centre (~ 40 parks) to be permanently removed from commencement of works. However, as the centre will be demolished and not replaced in this location, it is assumed the loss of associated parks will have minimal effect.
- Wellington Rd between Hamilton Rd and Evans Bay Pde (~16 parks) to be restricted at times during works.
- Moxham Ave (~ 30 parks) to be permanently removed from commencement of works to allow for lane modifications and restrict parking at new intersection

Across the Project, the number of additional car parks that will be unavailable during construction will depend on the staging of works and outcomes of traffic studies around detour routes (if required).

Private parking disruption such as off-street parking on Ruahine St and SH1 between the Basin and Terrace tunnel has not been assessed. It is anticipated that short duration restriction of “drive-on” access to some of these properties may occur during works immediately adjacent to these properties, timeframes for these works are anticipated to be in the order of hours to weeks, predominantly to allow paving to be carried out. Temporary access may be able to be permitted if coordinated with the site crew and ongoing management of resident / owner / customer access will be key in these areas.

3.3.4 Construction parking demand

During construction, the additional workforce will increase pressure on existing inner city car parking. While there are public transport and options for active modes of transportation, the majority of workers will likely commute in private vehicles, and some will be used throughout the day to provide transport between sites. As construction crews typically start work shifts at 7am, prior to office workers in adjacent urban areas, they will likely occupy parks that would otherwise have been used by workers. Many public parking spaces in central Wellington have time limitations and are not suitable for full day worker parking. The site compounds may at times provide parking space for some workers, but this should not be relied upon, particularly in the congested Terrace Tunnel, Basin and Mt Victoria works areas. The impact from construction worker parking will increase as works approach completion as the size of construction yards reduces (reducing onsite parking) and typically more labour-intensive tasks are undertaken (increasing workers present).

3.3.5 Potential Closures of SH1 and major routes

The majority of construction activities allow for an equivalent number of existing SH1 traffic lanes in each direction to remain open during works and this has been the base assumption for all construction methodologies presented.

There are some activities that cannot occur while the existing SH1 is operating in its current configuration. In particular, traffic switches between stages of works. Many of these activities are of short duration and can utilise night or off peak works to minimise traffic disruption. This section summarises key tasks that either require or would significantly benefit from a closure of SH1 or a major route.

Mt Victoria existing tunnel for portal strengthening and tunnel services modifications

Detailed design information is yet to be completed to assess the scope of work required to strengthen the existing Mt Victoria tunnel portals and set up rockfall protection at the eastern portal to allow the new tunnel to be built. It is assumed that the proximity of the Mt Victoria western portals will require some structural

strengthening to allow the existing buttress to be removed and cut and cover support removed. This work has to be carried out before tunnel mining commences.

It is possible that a lot of the work could be carried out with a single lane closure for a similar period or utilise off peak and night closures over a longer duration. It is difficult to see how this work could be carried out without any closure of the existing tunnel and approaches.

It is also likely that temporary service connections need to be made to the existing tunnel. This could include replacing the existing ventilation system with jet fans mounted to the ceiling of existing tunnel. The scope of this work is also unclear at this stage and may require either a short period closure with a duration of days in addition to multiple night closures.

Ruahine St for new Hataitai Connection Bridge

Multiple methods have been considered for the construction of the new Hataitai Connection Bridge, refer to 6.5.3 for full details. The main options are presented in Table 1:

Table 1: Traffic diversions for Hataitai Connection Bridge.

Scenario	Traffic diversions for Hataitai Connection Bridge
Diversion via on / off ramps with long Hataitai park closure	SH1 traffic, one lane in each direction, diverted into northbound alignment and future on and off ramps to allow new bridge to be constructed off line and SH1 traffic to continue unimpeded. Due to grade difference, access to Hataitai Park is closed for multiple months.
Bridge construction off peak over existing traffic lanes with short Hataitai Park access disruption	SH1 traffic remains in existing traffic lanes with median adjustment for majority of works. Bridge construction is carried out immediately adjacent and over traffic lanes. Short period off peak or night SH1 closures required for lifting in of bridge beams and placing of deck concrete with detour likely via Goa St / Moxham Ave / Hamilton Rd. Hataitai Park access closed for traffic switch only for a duration of hours to days.
Hybrid approach with temporary Hataitai Park access disruption	A temporary intersection between Hataitai access and SH1 is created near the Badminton club to allow traffic on the existing SH1 alignment to travel up the new off ramp in both directions into Hataitai Park. This allows SH1 traffic to either stay in existing lanes for bridge construction with short period off peak or night SH1 closures required for lifting in of bridge beams and placing of deck concrete, or be diverted to the on/off lanes. Access to Hataitai Park closed for days to weeks to allow reconstruction of access to occur on two occasions during initial diversion and during final alignment.

Mt Victoria regular blast closures

Blasting activities for mining in the new Mt Victoria tunnel will require the existing tunnel to be fully closed and cleared prior to blast. It is likely that a regular schedule for blasting is followed. It is assumed that typically two blasts would be carried out per day to reflect works crew shifts, with one blast per shift. To accommodate blasts outside of the most disruptive hours for both noise and traffic it's likely that blasting windows will be sometime in a preassigned period likely during each of early morning 6am to 7am and either during the day 9am to 4pm or evening 6pm to 8pm each day, ideally spaced around 8-12 hours apart. Exact window of time will need to be confirmed with consent conditions. These blasting windows will need to be developed and coordinated with the contractor as the number of blasts per day, timing and use of blasting windows will depend on the contractor's methodology and rate of progress. Generally, providing more and longer blasting windows of time spread out through each day with the expectation that some may be unutilised provides more flexibility for the contractor and improves mining efficiency by limiting downtime should preparation for a blast be completed outside of a suitable detonation period.

Currently it is assumed that the closure period for each blast is between 30 minutes and 1 hour where no access to the existing tunnel is permitted. This duration allows the tunnels to be cleared of people and equipment, the warning sequence to be carried out, blasting sequence and remote firing, post blast ventilation and dust suppression, re-entry safety clearance and blast completion check for mis-fire or incomplete detonation.

With an indicated hard rock mining duration of approximately a year and the requirement for around a quarter of the tunnel to require the drill and blast method it should be assumed that multiple months of blasting may be needed.

There is a risk that damage to the existing tunnel is observed post blast that requires emergency repair prior to opening the tunnel to traffic. This could unexpectedly result in a much longer closure with no prior notice. It is anticipated that an emergency repair strategy and equipment is prepared by the contractor and possible repairs like spalling or cracking of the existing tunnel lining could be reasonably repaired to allow the tunnel to reopen within days to weeks should this type of event occur.

General traffic switches between stages of works

A traffic switch involves transferring live traffic from an existing carriageway onto a newly constructed pavement, temporary diversion, or revised lane arrangement. Generally, these fall into the following types:

Table 2 Traffic switch scenarios

Scenario	Traffic switch
Night shift closure 8-10hrs (most common)	A single night shift 8-10hrs allows for barrier alignment, paint and signage adjustments, localised pavement works at the interface may also be carried out to adjust surfacing but it is unlikely that full depth pavement reconstruction can be achieved in a single shift.
Short full closure (30 min closure)	A short closure may be used where there is a minor route variation and no transitional paving works are required at locations where longer closures or night works are not acceptable. Line marking and minor barrier re-alignment are the only activities that may be possible in such a short window. This method requires fully prepared approaches on both alignments and careful planning. Where all transitional interfaces can be completed prior to the switch a rolling block or short closure is possible.
Route modification or temporary alignment paving with multiple short closures (2x 30min closure)	For some areas of works, there are significant changes to grades for example around the Sussex St Extension Trench and the Hataitai Connection Bridge. These locations will likely require a traffic switch to temporary pavement as the grade difference requires multiple stages to adjust surrounding pavement to the design level.

Closure of SH1 for demolition of existing Ghuznee St Bridge

In the event that Ghuznee St bridge is replaced in its entirety, SH1 will need to be closed for demolition works. During the two stages of demolition, SH1 will need to be closed at times to prevent demolition material from falling onto the live carriageway. If closure of SH1 is required for the adjacent Terrace Tunnel then the same closure periods may be able to be used to carry out works at Ghuznee St Bridge provided the sequencing of works can be aligned. Potential scenarios for SH1 closures include those in Table 3. It has been assumed that a multiple month closure to allow the full bridge to be constructed is not acceptable for traffic disruption.

Ghuznee St will likely be reduced to a single traffic lane and single footpath for the duration of the Ghuznee St Bridge works with the other traffic lane diverted on adjacent routes.

Table 3: Potential SH1 closures for Ghuznee St Bridge works

Scenario	Closures of SH1 required between the Terrace and Vivian St
Scenario 1: Separate closures, staged Ghuznee demolition	2 closures (~48 hrs each) to allow for partial demolition of Ghuznee carried out in multiple stages. 10 closures (~8hrs each, night works suitable) for Ghuznee bridge beam placement over roadway, placement of concrete deck and placement of edge barriers. 2 separate temporary closures (~0.5hrs min -12hrs max each, night works suitable) to allow traffic switches to occur and open new tunnel.

Scenario 2: Separate closures, staged short period Ghuznee demolition	Approximately 8 to 20 closures (~12hrs each, night works suitable) to allow for partial demolition of Ghuznee carried out in multiple smaller stages. 10 closures (~8hrs each, night works suitable) for Ghuznee bridge beam placement over roadway, placement of concrete deck and placement of edge barriers. 2 separate temporary closures (~0.5hrs min -12hrs max each, night works suitable) to allow traffic switches to occur and open new tunnel
Scenario 3: combined coordinated closures	1 closure (4 weeks) to allow for both tunnel breakthroughs and for Ghuznee bridge first stage demolition and beam placement over roadway. 1 closure (~48 hrs) to allow for partial demolition of Ghuznee St second stage. 8 closures (~8hrs each, night works suitable) for placement of concrete deck and placement of edge barriers. 2 separate temporary closures (~0.5hrs min -12hrs max each, night works suitable) to allow traffic switches to occur and open new tunnel

Closure of SH1 cross passage breakthrough (applies to both Mt Victoria and Terrace Tunnels)

The cross passages at both tunnels connect the existing tunnel to the new tunnel. These passages are smaller tunnels constructed similarly to the main tunnels. As design information is developed, more scenarios may become available. The following scenarios presented in Table 4 are anticipated to bound construction requirements.

Table 4: Potential SH1 closures for cross passage tunnelling works

Scenario	Closures of SH1 required between tunnel portals
Scenario 1: Completing cross passages during new tunnel advance with full closure of existing tunnel.	Likely the most efficient scenario for construction as all tunnelling can be completed from the new tunnel during initial advance. This scenario requires an approx. 4 week long closure of all SH1 lanes to allow for tunnel cross passages to be completed during the initial tunnel advance. This will allow strengthening of the existing receiving tunnel, mining of the cross passages, primary and secondary lining installation, portal and fire door installation and service connections for the full cross passage in one activity. This scenario is the most efficient for construction and utilises plant that is already being used for the main tunnel advances.
Scenario 2: Completing cross passages following opening and diversion of traffic into new tunnel with closure of existing tunnel. *Note, this scenario results in a temporary arrangement with a single traffic lane in each direction reducing existing traffic capacity from the existing 1 southbound and 2 northbound lanes at the Terrace Tunnel.*	This scenario assumes the cross passages will be partially mined and lined with the new tunnel excavation but not broken through to the existing tunnel. Once the new tunnel can be opened and both directions of SH1 traffic diverted into it, the existing tunnel can be fully closed and the remaining cross passage breakthrough from the existing tunnel can occur. This method requires two stages of tunnel construction and mining equipment to remain on site longer but is potentially less disruptive for traffic and easier for additional refurbishment and systems fit out of the existing tunnel to be carried out if this is required.
Scenario 3 (Applies to Terrace Tunnel only)**:** Completing cross passages following opening and southbound diversion of traffic into new tunnel.	This scenario assumes that cross passages are partially mined and lined during the new tunnel excavation. Once the new tunnel is complete, it is open to a single southbound traffic lane in the easternmost lane. The single existing southbound lane is then closed in the existing tunnel. This allows working space for strengthening of the

	existing tunnel to be carried out at the cross passage breakthrough locations. Multiple short duration or nightworks northbound closures in the existing tunnel would then allow mining and breakthrough into the partially complete cross passages from the existing tunnel to occur. Once cross passage mining is complete, the new tunnel can be fully opened and it may be possible to keep at least 1 northbound traffic lane in the existing tunnel open during its refurbishment and fit out depending on the extent of works required.

The Mt Victoria tunnel suits scenario 2 due to the additional refurbishment works that are required within the existing tunnel, including the removal of the shared path which will be most efficiently carried out over a longer full closure while traffic operates in both directions through the new tunnel.

Potential Lane Reduction at Bogarts Corner

During the modification of SH1 to allow SH1 northbound to travel on the north side of the Basin Reserve, lane positions and alignments need to be adjusted at Bogarts Corner. The current alignment provides two southbound SH1 lanes to Mt Victoria Tunnel and two local road lanes to Adelaide Rd. The sequence of works proposed to realign this area without a diversion reduces the number of local lanes to one while keeping two SH1 southbound lanes.

Should this not be acceptable, or more space is required to facilitate the contractor's method, a diversion via local roads from Vivian St straight to Pirie St, right onto Hania St before merging back onto the existing SH1 alignment at Ellice St would be required. Car parking on these local roads may need to be temporarily removed if this diversion is to proceed.

3.4 Construction Crews

The number of workers will vary significantly as works progress and is highly dependent on methodology, staging and labour availability. A high level estimate of the maximum number of construction staff present during labour intensive periods is provided in Table 5.

Labour intensive jobs are likely to be at commencement, service relocations, construction of structures, tunnel M&E fitout, paving and finishing works where the number of workers present may approach the number of workers presented in Table 5.

Activities such as bulk earthworks and tunnel mining require heavy equipment with single operators that will naturally restrict the number of staff due to equipment number limitations. During low labour demand activities and particularly during night shifts the number of workers present during a shift is likely to be closer to 10-30 personnel per site per shift. Dual shift operations for the tunnel construction will result in increased parking demands and activity at yards at changeover times. However, 24/7 work is anticipated to predominantly occur during low total labour demand times such as during tunnel mining and not when a peak workforce of 100-150 staff is present.

The crew sizes presented are intended to reflect workers carrying out construction on site, plant operators, supervisors, site managers, on-site engineering, H&S, survey and quantity surveying staff. They exclude design staff, delivery drivers, corporate and support roles that will likely be housed elsewhere in existing offices.

Table 5: Approximate maximum number of construction workers per shift in each area of the** Project**. Assume a variation of 30% to allow for variations in the construction method and crew assignments. *The Ghuznee St bridge will add an additional ~30 staff to the Terrace Tunnel area if carried out simultaneously with peak effort during tunnel construction.

Area of work	Approximate maximum number of workers per shift
Terrace Tunnel	100*
Te Aro	30
Basin	50
Mt Victoria Tunnel	150
Eastern Connections	50

3.5 Construction Plant and Equipment

3.5.1 Light vehicles

During construction, most personnel will move within the site and between sites in utility vehicles or light trucks (<3.5T). These may be supplemented by project management, supervision, engineering, surveying, maintenance staff and small delivery vehicles which will be cars, SUVs, vans and light utility vehicles.

The total number of light vehicle traffic movements will vary depending on the staging of works. An estimate of the light vehicle movements on a busy day is provided in the table below; assume these reduce by 30% on a typical day and allow for a 30% variance once contractors' method and crews are confirmed. Management staff numbers assume each contract manager manages 30 staff, each site engineer manages 15 staff and work crews are formed with 5 staff. Where multiple shifts are proposed, such as for the tunnel construction, it is assumed that one shift (likely the overnight shift) will have less supervision and management personnel. Therefore, the highest impact day shift numbers have been provided.

Table 6: Light vehicle movements per shift from site based construction supervision staff. *The Ghuznee St bridge will add an additional ~50 staff to the Terrace Tunnel area if carried out simultaneously with tunnel construction increasing the number of light vehicle movements shown in the table by approx. 50% for the TT area.

Vehicle Type	**No. Light vehicles**					**Vehicle Movements**				
Area of works:	**TT***	**TA**	**BR**	**VT**	**EC**	**TT***	**TA**	**BR**	**VT**	**EC**
Project/Contract Managers (Utility vehicle – 3 trip/day)	3	1	2	5	2	9	3	6	15	6
Site Engineers (Utility vehicle - 6 trip/day)	7	2	3	10	3	42	12	18	60	18
Work crew (Utility vehicle - 10 trip/day)	20	6	10	30	10	200	60	100	300	100
Work crew (Light truck - 2 trip/day)	20	6	10	30	10	40	12	20	60	20
Traffic signs truck with attenuator (20 trip/day)	3	6	6	3	3	60	120	120	60	60
Small delivery / maintenance vehicle (vans, SUV's and similar 3 trips per day)	3	1	2	3	2	9	3	6	9	6
TOTAL	56	22	33	81	30	360	210	270	504	210

3.5.2 Heavy Vehicles and Plant

The anticipated heavy vehicles and plant are outlined for each of the areas in the table below. The quantity refers to the maximum number of vehicles or pieces of equipment servicing the site per day. For equipment such as excavators, loaders, watercarts, etc. the number of pieces of plant that can be accommodated on site or used simultaneously has been provided. The quantities exclude any plant on site but requiring repair as it is assumed this will be replaced promptly. Heavy truck numbers, sizes and movements for carting offsite are assessed separately in the following sections.

For all plant and equipment quantities provided assume a variation during works with plant being transported on and off site in stages at the start and end of works phases. Should time restrictions be put in place for specific activities, additional or larger equipment will likely be required.

Table 7: Construction equipment types and numbers anticipated for construction activities

Activity	**Construction equipment**	**Quantity in area**				
	Area of works:	**TT**	**TA**	**BR**	**VT**	**EC**
Demolition:	Excavator (30T-45T)	2		2	1	2
Typically, 2 to 3 storey commercial and light industry	Long reach Excavator (30T-45T)			1	1	

Activity	Construction equipment	Quantity in area				
	Area of works:	TT	TA	BR	VT	EC
with some multi-unit and stand-alone residential, verandahs on Vivian St. Ghuznee St bridge removal assumed as part of Terrace Tunnel works. Assume material for disposal carted to southern landfill.	Pulveriser mounted to excavator	2		3	3	2
	Excavator with sorting grapple	1		2	2	2
	Mobile crane	1		1	1	1
	Wheel loader	1		1	1	1
	Dump Truck (6 wheel, 25T, 6m^3)	4		2	2	2
	Waste skip bin truck		1	1	1	1
	Water cannon	1		1		
	Electrical generator	1	1	1	1	1
	Watercart	1		1	1	1
Road Works: Resealing, kerb adjustment, pavement rehabilitation etc, within tunnel paving, assumed pavement volume 150m^3 per shift from either Horokiwi or Kiwi Point Quarry.	Dump Truck (6 wheel, 25T, 6m^3)	6	6	6	6	6
	Grader	1	1	1	1	1
	Vibratory roller (5-7T)	1	1	1	1	1
	Multi-tyre roller	1	1	1	1	1
	Bitumen sprayer	1	1	1	1	1
	Pavement Milling Machine	1	1	1	1	1
	Asphalt paver	1	1	1	1	1
	Skid steer loader / bobcat	1	1	1	1	1
	Street sweeper	1	1	1	1	1
	Line marker	1	1	1	1	1
	Watercart	1	1	1	1	1
Bulk Earthworks: Bulk excavation and mass haul of cut for tunnel portals, Sussex St Extension and Ruahine St, carted with 1hr load / unload loop, 250m^3 per shift productivity.	Excavator (12T-20T)	1		1	1	2
	Excavator (30T-45T)	2		2	2	1
	Dump Truck (6 wheel, 25T, 6m3) *	6		6	6	1
	Road dump truck and trailer (45T, 12m^3) *			4	4	3
	Dozer (14T)	1		1	1	1
	Vibratory Roller (12T)	1		1	1	1
	Watercart	1		1	1	1
Road Construction: Ruahine Street, Sussex St, tunnel portals assumes preparing full depth pavement and preparing subgrade.	Dump Truck (6 wheel, 25T, 6m3)	8	8	8	8	8
	Grader	1	1	1	1	1
	Skid steer loader	1	1	1	1	1
	Wheeled loader	1		1	1	1
	Vibratory roller (5T)	1	1	1	1	1

Activity	Construction equipment	Quantity in area				
	Area of works:	TT	TA	BR	VT	EC
	Vibratory roller (12T)	1		1	1	1
	Pavement Milling Machine	1	1	1	1	1
	Excavator (5T)		1			
	Excavator (20T)	1		1	1	1
	Trench shoring		1	1		
	Pug mill / mobile stabiliser (high vibration and dust risk)	TBC	TBC	1	TBC	1
	Asphalt paver	1	1	1	1	1
	Watercart	1	1	1	1	1
Tied Retaining Walls / Anchored Slopes / Soil Nail Slopes	Rock anchor / soil nail drill rig	2		2	2	1
	Excavator Mounted Rock anchor drilling and installation rig.	1		1	1	1
	Excavator (20T)	1		1	1	1
	Concrete mixer truck	3		3	3	3
	Truck mounted concrete pump	1		1	1	1
	Shotcrete truck	1		1	1	1
	Rock anchor tensioning	1		1	1	1
	Grout mixer and pump	1		1	1	1
	Air compressor	1		1	1	1
	Telehandler	1		1	1	1
	Elevated work platforms	1		1	1	1
	Mobile crane (20T)	1		1	1	1
Secant Pile Walls	Piling Rig with Auger			1		
	Dump Truck (6 wheel, 25T, $6m^3$,			1		
	Concrete mixer truck			3		
	Truck mounted concrete pump			1		
	Excavator (20T)			2		
	50T crawler crane			1		
	Vibro casing extractor			1		
	Loader			1		
	Skip bins			1		
	Support fluid plant (bentonite or polymer slurry)			1		

Activity	Construction equipment	Quantity in area				
	Area of works:	TT	TA	BR	VT	EC
MSE Walls	Mobile crane (20T)	1		1		1
	Roller (5-7T)	1		1		1
	Padfoot roller (12T)	1		1		1
	Wheeled loader (10T)	1		1		1
	Skid Steer loader (5T)	1		1		1
	Road rock truck (6 wheel, 25T, 6m3)	2		2		2
Concrete Construction	Truck mounted concrete pump and boom arm	1		1	1	1
	Concrete mixer truck (assumed continuous two truck placement for wall and heavy concrete construction)	3	3	3	3	3
	Poker vibrator	3	2	3	3	3
	HIAB transporter truck (material delivery)	1		1	1	1
	Mobile crane (precast placement)	1		1	1	1
Street furniture, services and verandah replacement Includes roading completion works, drainage assets, utilities, signage, street furniture, overhead service modifications, traffic controls, ITS (if present).	Elevated work platform		2			
	Scaffolding and footpath pedestrian protection (100m)		1			
	High pressure water excavation	1	1	1	1	1
	Hydrovac truck	1	2	1	1	1
	Transport truck mounted HIAB	1	2	1	1	1
	Concrete saw	1	1	1	1	1
	Handheld concrete breaker	1	1	1	1	1
	Hand operated vibrator roller	1	1	1	1	1
	Mini excavator (1-5T)	1	1	1	1	1
Utility modifications (non-strategic)	Hydrovac truck	1	1	1	1	1
	Plate or light roller compactor (90-300kg)	1	2	1	1	1
	Mini excavator (3T)	1	2	1	1	1
	Light truck (5T)	2	4	2	2	2
Bridge Construction:	Crawler Crane (150T)	1		1		1
	Crane mounted auger	1		1		1
	Pile driver / vibro hammer	1		1		1

Activity	Construction equipment	Quantity in area				
	Area of works:	**TT**	**TA**	**BR**	**VT**	**EC**
Ghuznee Street / SH1 over Sussex Street / Hataitai Connection Bridge	Transporter truck	2		1		1
	Precast beam truck transporter	2		1		1
	Excavator (12-20T)	1		1		1
	Concrete boom pump truck	1		1		1
	Scaffolding and formwork	1		1		1
New Tunnel Portal Construction: Both portals of both tunnels	Excavator (30T-45T)	2			2	
	Hydraulic rock breaker	2			2	
	Rock bolting rig	1			1	
	Mobile crane or telehandler	1			1	
	Loader	1			1	
	Road rock truck (6 wheel, 25T, 6m^3, Terrace tunnel only)*	6				
	Road rock truck and trailer (45T, 12m^3, Mt Victoria only)*				4	
	Concrete pump truck and shotcrete rig	1			1	
	Water cart	1			1	
	Air compressor	1			1	
	Shotcrete truck	1			1	
	Concrete mixer truck	3			3	
Tunnel Construction: (Both Tunnels, including drill and blast as well as sequential tunnel boring with cutter head methods, assumes 24/7 operation with multiple shifts)	Road header S300	1			1	
	Drill jumbo with basket (possible multiple boom)	1			1	
	Shotcrete robotic sprayer	1			1	
	Automated rock bolting rig with carousel system	1			1	
	Excavator (30T-45T)	1			1	
	Hydraulic rock breaker	1			1	
	Grout pump	1			1	
	Telehandler	1			1	
	Elevated work platform	2			2	
	Wheel loader (15-20T)	2			2	
	Articulated off road dump trucks (15-25T, within tunnel)	2			2	

Activity	Construction equipment	Quantity in area				
	Area of works:	TT	TA	BR	VT	EC
	Road rock truck (6 wheel, 25T, 6m3, Terrace tunnel only)*	6				
	Road rock truck and trailer (45T, 12m^3, Mt Victoria only)*				4	
	ATV side by side	2			2	
	Concrete mixer trucks	6			6	
	Concrete pump	1			1	
	Tunnel ventilation units	1			1	
	Tunnel slip form liner	1			1	
	Flat bed transport trucks (20m 30T)	1			1	
	Compressor	1			1	
	Generator	1			1	
	Spoil conveyor (optional)	1			1	
	Mini rock excavator	1			1	

* Truck numbers for material cartage off site are included as average number in a typical shift. Further details provided in the following section.

Equipment for the specific tasks below have not been included and generally utilise other plant already on site for adjacent activities for a short period.

- Creche relocation – likely requires shallow excavation, hydraulic jacking, foundation construction, and minor concrete works.
- Strategic drainage assets – Stormwater at Ruahine St and Sussex St, Sewer at Basin and Ghuznee St. Assumed mix of trenched and trenchless methods including micro tunnelling. Temporary pumps, temporary fluid containment, trench excavation, trench protection.

3.5.3 Heavy Truck movements for earthworks

This section focuses on anticipated heavy truck movements for cartage of waste soil, excavated rock and tunnel spoil. This could reasonably be assumed to be similar to import rates for pavement materials.

Table 8: Vehicle and loading assumptions

	Rock truck	Rock truck and trailer
Cartage volume	5-7 m^3 (6 m^3 used)	10-14 m^3 (12 m^3 used)
Cartage weight	10-12 t	22-28 t
Gross vehicle mass	25 t	40-45 t
Number of axles	3 no	7 no
Length	8-9 m	17-20 m
Turn radius (3 point kerb to kerb)	11-12 m	16-18 m (requires spotter and working room within a controlled compound only)

Turn radius (single swing kerb to kerb)	16-18 m	25 m (NZ heavy vehicle requirement)
Loading time 12T wheel loader (2m3 bucket)	2-3 min	4-6 min
Loading time 25T wheel loader (5m3 bucket)	1-2 min	2-3 min
Loading time 30T excavator (1.5m3 bucket)	2-3 min	4-6 min
Loading time 45T excavator (2.5m3 bucket)	1.5-2.5 min	3-5 min

Table 9: Material production rate assumptions

	Bulk earthworks		Terrace Tunnel		Mt Victoria Tunnel	
	Probable	Max	Probable	Max	Probable	Max
Cross section total area	-		104 m^2		139 m^2	
Cross section top heading area	-		80 m^2		92 m^2	
Cross section bench area	-		24 m^2		47 m^2	
Overbreak assumed	-	-	2.5%	5%	2.5%	5%
Advance per shift	-	-	1.5 m	2 m	1.5 m	2 m
Volume excavated per shift probable = top heading Maximum = total cross section	250 m^3	575 m^3	125 m^3	220 m^3	140 m^3	290 m^3
Number of shifts per 48hr storage period	2	2	4	6	4	6
Volume excavated in 48hr period	500 m^3	1050 m^3	500 m^3	1310 m^3	565 m^3	1750 m^3

Bulk earthworks volume excavated assumes the maximum loading rate from a 30T excavator over an 8hr shift. Earthworks sites are assumed to be constrained with a maximum of a single machine at the cut and loading faces. For the probable rate, a 70% efficiency and 70% bucket fill factor is used with a 60 second cycle time and 1.2m^3 bucket assuming cutting soils from excavation face. For the maximum rate, a 90% efficiency and 90% bucket fill factor is used with a 35 second cycle time and 1.5m^3 bucket, assuming filling trucks from a prepared stockpile.

Overbreak assumed as 2.5-5% using road header methods, this may be exceeded for drill and blast if required at Mt Victoria Tunnel. Advance per shift assumes a full tunnelling cycle of support, mining and mucking out.

Typical spoil cartage

Assuming that excavated material is removed from site at the same rate that it is generated at, the following assumptions for truck movements can be made. Note that material from tunnels is assumed to be removed from the spoil handling facility during daytime shift(s) only. For both tunnels and bulk earthworks this results in probable rate of approximately 250m^3 of material being removed from site during a typical cartage shift.

Table 10: Typical spoil cartage

	Rock truck	**Rock truck and trailer**
Cartage volume per truck	6 m^3	12 m^3
Loading time 25T wheel loader (5m3 bucket)	1.5 min	2.5 min

Loading / unload cycle efficiency over shift	80%	80%
Number of truck trips for 250m3	42 trips	21 trips
Loading / unload cycle time*	50 min	60 min
Number of trips per shift per truck	10 trips	8 trips
Number of vehicles required	6 trucks	4 trucks
Time between arrival of trucks at spoil handling facility	10 min	15 min

* loading / unloading cycle time based on a 20min drive to disposal site. Refer to following notes for alternative location factors.

Maximum spoil cartage from spoil handling area at tunnels

Material is anticipated to all be carted off site via roadgoing trucks. In the event of 24hr tunnelling and to allow for possible disturbances or weather delays at spoil disposal sites 48hrs of storage at maximum production, approximately 1500m^3, has been allowed for at each tunnelling portal. It is expected to be able to clear this stockpile in a single shift using a large capacity wheel loader (25T, 5m^3 bucket) and continuous truck movements from an efficiently run spoil handling facility.

Table 11: Anticipated maximum spoil cartage

	Rock truck	**Rock truck and trailer**
Cartage volume	6 m^3	12 m^3
Loading time 25T wheel loader (5m3 bucket)	1.5 min	2.5 min
Efficiency over shift	80%	80%
Number of truck trips for 1500m3	250	125
Loading / unload cycle time*	50 min	60 min
Number of trips per shift per truck	10 trips	8 trips
Number of vehicles required	25 trucks	15 trucks
Time between arrival of trucks at spoil handling facility	2.5 min	4 min

* loading / unloading cycle time based on a 20min drive to disposal site. Refer to following notes for alternative location factors.

Material disposal sites

All truck movements assume a location for disposal of fill is located within a 20 minute drive (one way) during normal workday traffic allowing for 8-10 load/unload cycles per shift. Depending on the spoil disposal site chosen the number of trucks should be modified by the factors provided in Table 12. For example, if the chosen spoil site is Belmont Quarry (30 min travel time, 1.5x factor)) the number of road going rock trucks for a typical shift will increase from 6 to 6x1.5 = 9. Note that it is unlikely that any one spoil site can accommodate all fill from the Project and multiple sites may be used as works progress or at different times, some sites may also not be able to accept fill out of normal weekday working hours. The potential spoil disposal sites in Table 12 are yet to be confirmed. Based on a highest impact case of these sites and acknowledging the limited capacity of the Paekakariki sand borrow site, a conservative estimate of the maximum number of trucks operating on the Wellington region roads servicing this Project for the disposal of spoil is double that presented in the equipment and plant tables above.

Table 12: modification factors for earthworks cartage trucks based on spoil disposal location.

Potential spoil disposal sites	Approx Travel Time One Way	Factor on Truck Numbers
Southern Landfill (Base assumption)	20 min	1.0
Kiwi Point quarry (Base assumption)	20 min	1.0
Willowbank Quarry	40 min	2.0
Belmont quarry	30 min	1.5
Transmission Gully Fill Site Toomeys 1	35 min (TBC)	1.75
Transmission Gully Fill Site - Bol Fill Site 4 (199)	35 min (TBC)	1.75
Macalister Park	10 min	0.5
Paekākāriki sand borrow site	45 min	2.25
Ian Galloway Park	10 min	0.5

3.6 Construction Yards

Site compounds will be established at multiple locations across the Project area to support construction activities. These compounds will accommodate temporary facilities, materials, plant, and staff. Compound locations are subject to contractor input but are expected to be positioned adjacent to high intensity work areas like tunnel portals and within land already identified for construction use.

Specific compound locations and layouts will be refined by the contractor once specific plant requirements are identified. Some compounds may be established early as part of enabling works or relocated as construction progresses. Shared use of construction yard areas across the Project could be considered to reduce the overall footprint and maximise construction efficiency.

There are likely to be many vehicle movements in and out of each of the site compounds during working hours. Access will be restricted with signage, but it is impractical to keep gates or physical barriers closed during working hours. Where compounds are located near sensitive land uses (e.g. schools, community spaces, shops, residential areas), additional controls will be implemented to separate public from construction site areas. It is recommended that the contractor shares information with adjacent facilities so that their users understand how to safely commute around them.

Site compounds will vary in size but are generally expected to range between 500 m^2 and 2,500 m^2. They are typically on cleared land, some existing buildings may be retained if they can be reused as office and welfare spaces. Typically, hard surfaces (concrete building foundations or existing carparks) are retained and landscaped areas are covered with gravel to form a compact, mud free hardstand. It is likely that; these surfaces will be dusty, power tools will be used, and heavy machinery will be moved to be parked, refuelled and maintained in these areas at the start and end of each shift. Vibrating machinery and heavy rollers are not expected to be used in the yards with the exception of the initial compaction of the hardstands. Workers may be present in these locations before and after normal working hours to prepare for and at the completion of shifts.

All construction yards will be fenced around the perimeter, depending on adjacent access and exposure to risks these fences may vary from simple 1m high temporary flexible fences to 6ft wire fences (majority) or be solid hoarding (urban interfaces likely in Te Aro and Basin areas) where exposure of public to construction risks is high. At the tunnel construction yards an allowance is made for specific high solid fencing for the containment of noise, light, dust, to provide a visual barrier and separate construction and public spaces. These may be many metres high and will likely be installed for multiple years. In other projects, stacked shipping containers have been used a combination of timber, concrete and insulated panels.

The tunnel construction yards at the Terrace Tunnel northern portal and the Mt Victoria Tunnel western portal will operate 24/7 to support tunnel mining operations.

Typical Functions and Facilities

Site compounds will support the following activities:

- Site offices, welfare facilities (toilets, lunchrooms, showers)
- Equipment and plant storage and maintenance
- Precast component laydown
- Workshop and servicing areas
- Sediment control and groundwater treatment systems
- Refuelling areas and spill response equipment
- Security fencing, access controls, and safety signage
- Vehicle parking for staff and visitors (primarily off-site)
- Noise control measures (e.g. barriers, enclosure of generators/fans)
- Management and engineering staff facilities including offices and meeting rooms
- Stockpiling of materials (e.g. aggregate, spoil) where appropriate. The yard areas identified are compact urban sites, stockpiles are expected to be limited to 2 days of production to allow for weather windows for cartage or fill replacement particularly at tunnel portals. Long duration stockpiling is likely not suitable due to space constraints and ability to implement effective erosion, sediment and dust controls. Stockpiles should be anticipated to be present for the majority of tunnel mining and paving activities however a high rate of turnover of material is likely to mean that material is cycled in and out of stockpiles near daily. Stockpiles likely require windbreaks, continuous water misting and erosion controls.
- At the tunnel mining yards operating 24/7 the spoil handling area will be enclosed to deposit spoil extracted from the tunnel, stockpile spoil and load road trucks carting material offsite.

A potential arrangement of site compounds is provided in the following sections. Once established, these yards may be used for multiple work tasks and be prepared in advance of the area it is allocated under or its use as a construction yard may be continued beyond the completion of the allocated area.

3.6.1 Terrace Tunnel

This section explains construction yards or laydown areas that have been identified in this area of the Project. Figure 2 displays these areas which are defined below:

- **TT-SC001 – Northern Portal Yard:** This land is between the northern portal of the Terrace Tunnel, The Terrace, SH1, and the Cable Car Tracks. This area will likely house the majority of site facilities and provide space for spoil handling, stockpile materials, treat groundwater from the tunnel excavation etc. This yard area includes an enclosed spoil handling area. Activity at this site will be 24/7 during the tunnel mining operations. A high fence around the perimeter of the site will be required for safety, but may also need to have acoustic or light screening. Access may be provided via a dedicated slip lane off SH1 Terrace offramp through the Clifton car park and over a temporary cable car bridge, a new access point at the Everton Terrace / The Terrace corner and via Kumutoto Lane off Boulcott St. Long or oversized vehicles require a slip lane directly from SH1 near the portal with traffic management. All other vehicles are expected to depart site via Kumutoto Lane which is expected to be limited to an 11m truck (under traffic control to allow the vehicle to use both lanes to achieve the turn) or an 8m truck where other vehicles are potentially present. To access the work area in the Woof Woof Ruff dog park and for works above the tunnel portal or initial site clearance, there are existing single lane light vehicle tracks from between 214 and 216 The Terrace and Club K driveway off Salamanca Rd. Modification to access from The Terrace to the Woof Woof Ruff dog park may be required as the portal is excavated.
- **TT-SC002 – Clifton Carpark Access:** This is the land and exposed carpark space between The Terrace off-ramp, SH1, and the Cable Car Tracks. This is expected to require a temporary bridge over the cable car tracks to provide continuous access and create a loop to increase truck movement efficiency. Alternatively access via Kumutoto Lane and a slip lane from SH1 may be used for vehicle access. Site office facilities, parking, some storage and maintenance activities are expected on this site. Access to the northern end of this area is also via Shell Lane, Dalmuir Lane and Rosina Fell Lane.
- **TT-SC003 – Southern Portal & Ghuznee St Yard:** This is the land between the southern portal, SH1, and Willis St up to MacDonald Cres, and around to Ghuznee St. This area is anticipated to be the primary site facility for southern portal, tunnel control building and Ghuznee St bridge works. It is assumed that 24hr access to the existing tunnel control building is required to facilitate maintenance and emergency response. This limits the use of the primary access point from Willis St / Ghuznee St

corner to temporary loading and site access as storage would restrict emergency access. Some access to the western side of the Ghuznee St Bridge will be provided directly off Ghuznee St. Potentially some access may be made from MacDonald Cres and through the lane between buildings off Willis St that currently accesses the Upper Willis St Carpark.

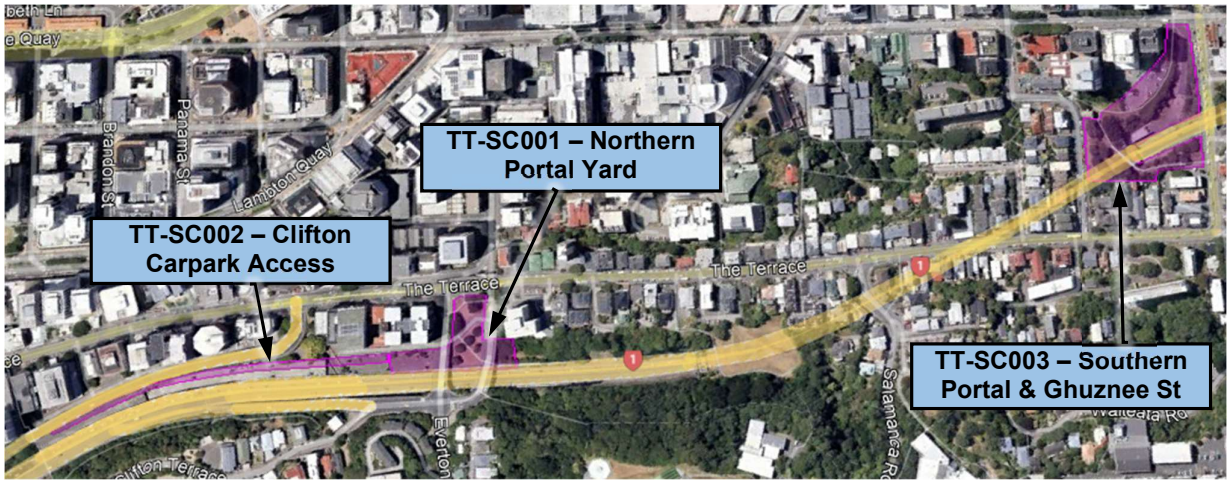


Figure 2 - Construction yards/laydown identified around the Terrace Tunnel

3.6.2 Te Aro Improvements

This section explains construction yards or laydown areas that have been identified for this area of the Project. Figure 3 displays these areas which are defined below:

- **TA-SC001 – Willis St yard:** This land is between the southern portal of the Terrace Tunnel and Willis St. It is likely that this yard houses site office and welfare facilities as well as providing a staging area for equipment. This site is shared with the Terrace Tunnel working area. Should the Terrace Tunnel works be carried out at the same time as the Te Aro works this yard and facilities are unlikely to be available to support Te Aro Improvements. Access for this site is from Willis St corner.
- **TA-SC002 – Martin Square yard:** This land is on the south side of Martin Square. This was previously used during the Arras Tunnel construction. This yard is likely to be used to store equipment and materials and act as a staging area during works. Access is via Taranaki St.

Figure 3: Construction yards/laydown in Te Aro

The areas shown are likely to be used to support the adjacent works in addition to utilising parking or lanes spaces within the footprint of works being carried out at that time. Either site can house a basic compound and some site facilities. The Willis St site would be preferred for the main site compound as it has more space for site facilities and parking although it is at the southern portal of the Terrace Tunnel and may not be available depending on sequencing of work. In general, works in the Te Aro area do not require extensive staging or material handling areas and site compounds will mostly be used to house welfare, toilet and lunchroom facilities and provide a location for parking equipment when not in use. Alternative options are available to the contractor such as using their own construction yard off site and commuting plant in each shift or utilising long term car park rental in commercial off street or city parking locations. Temporary breakrooms and mobile toilets / portaloos may also be accommodated within worksites.

3.6.3 Basin Reserve

This section explains construction yards or laydown areas that have been identified for around the Basin Reserve. Figure 4 displays these areas which are defined below:

- **BR-SC001 – Cambridge Tce Yard:** This land is currently car yards and commercial buildings between Barker St, SH1, and Cambridge Tce. The flat land accessed from Cambridge Tce will likely be utilised for plant and material storage and handling. Towards the end of works this area becomes smaller and less available as the Sussex St Extension is completed. It is likely that a secondary site office with toilets and lunchrooms will be located here, but the primary use of the area is material handling with access from the existing Sussex St, Cambridge Terrace or Barker St. Barker St will be used for light vehicles and for the majority of vehicles exiting site as it provides an existing controlled intersection onto Cambridge Terrace. Long and oversize vehicles will likely slip on and off via Sussex St.
- **BR-SC002 – Sussex St Yard:** This land is between Sussex St, SH1, Tasman St, and Rugby St. This area, likely near to the through site to Tasman St, will likely be used as the main site office and welfare facility. Regular trips for staff between this area and the works accessed from Cambridge Terrace will likely be required. Once the slip lanes to the west of Sussex St are operational, this site compound area is significantly reduced and access will be primarily via Tasman St. Material handling and storage in this area will follow progress through the site with plant and equipment parking for maintenance,

refuelling or when not in use will likely move to the future Sussex St alignment between the new slip lanes and the Basin traffic lane.

- **BR-SC003 – Ellice St Yard:** This land was previously used by the Mt Victoria upgrades. It is between Ellice St, SH1, and Brougham St. This area will allow for storage of materials and equipment. As works progress this area changes significantly as roadways are realigned; as a result only temporary facilities will be present here and it will primarily be a staging area for other areas of works around the Basin. This area is adjacent to the western Mt Victoria Tunnel Portal yard. Access to the Ellice St yard is expected to be via local roads, Hania St and Ellice St.
- **BR-SC004 – Rugby St Yard:** This small area is intended to be used to expand the intersection at Adelade Rd to Rugby St. Temporary site facilities are unlikely to be staged here.

Figure 4 - Basin Reserve area construction yards/laydown

The areas identified above should be sufficient to construct the works identified in the consent design documents. Areas will adjust as construction progresses and reduce in size as permanent works are completed. Parking for construction workers is anticipated to become an issue as construction progresses, and onsite space is permanently developed. Welfare and office facilities will likely need to be located at the Sussex St Yard or be temporary and moved multiple times as works progress.

3.6.4 Mount Victoria Tunnel

This section explains construction yards or laydown areas that have been identified around the Mount Victoria Tunnel. Figure 5 displays these areas which are defined below:

- **MV-SC001 – Western Portal Yard:** This land is between Austin St, Ellice St, SH1, and Brougham St. This is currently residential housing. This yard supports the majority of construction activities for the new and existing tunnels. This yard area includes an enclosed spoil handling area, groundwater treatment facility, new tunnel control building construction, a site office, plant and equipment maintenance, parking and storage. Activity at this site will be 24/7 during the tunnel mining operation. It is understood that some existing buildings will be removed prior to the development of the yard and

replaced at completion. A high fence around the perimeter of the site will be required for safety but may also need to have acoustic or light screening. Access will primarily be via Brougham St. Light vehicles may have access options at Austin St. Access for long or oversized vehicles may be via slip lane onto and from SH1 southbound. Should the new alignment for the north west corner of the Basin Reserve works be completed prior, a dedicated slip lane may be used to gain access to this construction yard and site from near the Ellice St corner.

- **MV-SC002 – Eastern Portal Yard:** This is the land between the eastern portal, SH1, and Taurima St that will be used to support the excavation of the eastern portal. Access into site is via slip lane off SH1 with exit via Taurima St, Moxham Ave to Goa St or Hamilton Rd.
- **MV-SC003 – Taurima St Yard:** This is the land between Taurima St, SH1, and Moxham Ave. This area will be used along with the eastern portal yard, particularly as works commence and the portal cut is being excavated when there is limited space available in the eastern portal yard. Access into site is via slip lane off SH1 with exit via Taurima St, Moxham Ave to Goa St or Hamilton Rd.

Figure 5 - Construction yards/laydown areas around Mount Victoria.

The western portal yard will be the primary site compound with the primary site office for this this area as well as handling material and spoil stockpiles during tunnel construction. Access to this area will need to be managed as it is will be the primary route for construction traffic with the majority of traffic following entering the site at Brougham St.

The areas east of the tunnel area likely to need to be coordinated with works on Ruahine St and the Eastern Connections. The eastern portal yard area only becomes available as excavation of the portal commences and prior to opening of the new tunnel as it is currently a steep vegetated embankment. Taurima St splits the Eastern Portal and Taurima St construction yard areas shown as well as a pedestrian overbridge that is currently present through the Taurima St yard. The intention is to allow the contractor to close Taurima St to the public during the portal excavation and pedestrian bridge works and potentially use the existing Taurima St alignment off SH1 as a site access point with exit via Moxham Ave before returning to SH1 via Goa St or the new Hataitai Connection Bridge.

The Eastern Portal yard and Taurima St may be joined into a single yard area on the basis that the Hataitai Connection Bridge is completed prior to commencing works at the eastern portal. The contractor's method and timing of works for the Hataitai Connection Bridge will likely determine when and the duration of Taurima St closure. This could involve either Taurima St open under temporary traffic management or a full closure of Taurima St to the public both for vehicle and pedestrian access within the proposed site footprints. Where the Hataitai Connection Bridge is complete prior to the commencement of eastern portal works, a full closure of Taurima St is likely to be the contractor's preferred approach given the construction efficiency gains it provides.

The pedestrian overbridge to Hataitai Park may be removed early in works to allow a larger and less constrained construction yard to be set up. However, it is dependent on the new Hataitai Connection Bridge replacing this access route to Hataitai Park. This pedestrian bridge may be closed for multiple years from near the start of construction when it is removed until the new pedestrian bridge is opened near the end of construction, potentially years later.

Public access will need to be managed along with works staging to allow efficient and safe construction access and spoil carting. These eastern areas will primarily be for staging of equipment and materials and handling excavated material. Welfare facilities on the eastern side will likely need to move multiple times as works progress.

3.6.5 Eastern Connections

This section explains construction yards or laydown areas that have been identified east of the Mount Victoria Tunnel. Figure 6 displays these areas which are defined below:

- **EC-SC001 – Badminton Yard:** This part of the Town Belt is the site of the Ruahine St badminton hall. This is likely the most suitable welfare and site office area. Access to the Badminton yard for vehicles may become challenging as retaining walls are constructed. However, this is likely the most suitable location for welfare, site parking and site office facilities which are accessed by light vehicles. Access is via Ruahine St and possible temporary slip lanes along the future permanent northbound alignment.
- **EC-SC002 – Wellington Rd Yard:** This is the land on the southern side of Wellington Road between Ruahine St and Kilbirnie Cres. Material handling, equipment and vehicle parking, maintenance and re-fuelling will utilise this area however it is likely larger than required at any one time. As the staging to realign Wellington Road modifies this site area as works progress it is likely not suitable to use this area for significant temporary buildings or welfare facilities. Access is via slip lane from SH1, Hamilton Rd, Kilbirnie Rd, Moxham Ave or Wellington Rd and will change regularly as work progresses and traffic switches occur.
- **EC-SC003 – Kilbirnie Yard:** This is the area where the current Eastern Suburbs cricket club is located, and a 10m strip in the Kilbirnie Park is required as construction space beside the Wellington Rd widening. This is temporary construction occupation and mainly used to access and provide a staging area off the main alignment adjacent to works. Access is via Kilbirnie Cres and Evans Bay Parade and through a temporary access route in the park. This is a temporary construction area and will be minimised in footprint and its duration of use will likely be limited to when adjacent construction tasks are being carried out.

Figure 6 - Construction yards/laydown east of the Mount Victoria Tunnel

The areas identified above are anticipated to provide sufficient yard area to allow for the construction works identified in the consent design documents. Working areas and construction yards will adjust as construction progresses. It is likely that portable welfare facilities for toilets and lunchrooms will be used here and moved throughout the site as work progresses. Space for laydown, stockpiling and material storage is plentiful with areas within the permanent alignment likely being used for this purpose during construction. Additional working space is created as excavation and widening towards Hataitai Park along Ruahine St works are completed, likely supporting an excavation method working from south to north.

3.7 Project Wide Considerations

Design alternatives proposed by contractors

Differing approaches may be preferred by different contractors to match their skills, experience and equipment. Some elements such as Ghuznee St bridge replacement vs extension, the Hataitai Connection Bridge staging and works along Vivian St have many possible methods while achieving similar outcomes.

Incomplete utility information

The Project area has many years of urban use and it is likely that there will be unmapped or abandoned services in the work areas that may not be discovered until they are exposed during earthworks. Generally, this risk can be managed by typical construction processes but high risk services such as gas, electrical and high volume water assets should be specifically investigated early to confirm locations.

Tunnel spoil and earthworks cut disposal

Across the Project there is a large volume of excavated material to dispose of. Disposal sites will need to be coordinated, as well as access to these and management of haul routes for heavy vehicles transporting material.

4 Construction Requirements

4.1 Working Hours

Construction activities will generally be undertaken during standard daytime hours with the exception of tunnelling which is anticipated to operate 24/7 and is discussed separately in section4.2. However, due to the scale and location of the Project, some activities may require extended or out-of-hours work to minimise disruption to traffic, adjacent businesses, schools, community facilities and stakeholders or to meet consent conditions.

Typical working hours required for this project in terms of construction noise are:

- Standard daytime works: Monday to Saturday, 6:00 am – 6:00 pm
- Night works (as required): Typically, 6:00 pm – 6:00 am, subject to specific traffic management and noise control measures
- Sunday and public holiday works (by exception): May be undertaken for critical activities such as traffic switches, major concrete pours, or utility outages

These working hours allow for set up and pack down activities and can be assumed to be when the access gate opens and the first person arrives, to gate closed after last person leaves site at the end of the day.

Works outside standard hours are likely to be limited to activities that cannot reasonably be completed during the day due to traffic, safety, or operational constraints. These may include:

- Traffic management controls setup or removal
- Traffic lane closures and traffic switches
- Utility diversions requiring outages
- Bridge or tunnel construction within SH1 and high-volume corridors
- Pavement resurfacing or line marking
- Night-time haulage or spoil removal to reduce peak hour impacts
- Large or oversized deliveries

Any out-of-hours works will be managed in accordance with relevant consent requirements and may require prior notification to affected residents and businesses.

4.2 Working Hours for Tunnelling

Tunnel mining typically is the critical path for progress with high value specialist equipment that is more efficient when working hours are maximised. Tunnelling activities should allow for 24/7 works. Shifts are likely to be 3x 8hr production shifts per day or 2x 10hr production shifts and a 4hr maintenance period.

The advance length is typically tailored such that a full cycle of excavation, mucking out of material and support installation can be achieved in every shift. Where blasting is used as the advance method, it is anticipated that a blast will occur near shift change over with either 2 or 3 blasts per day to match the shift cycle, although given

the various interconnected activities required for drill and blast excavation, including tunnel closures, evacuations and inspections, two blasts per day would be considered most likely.

4.3 Noise

Location	Terrace Tunnel	Te Aro	Basin Reserve	Victoria Tunnel	Eastern Connections
Occurrence	Frequent	Frequent	Frequent	Frequent	Frequent

In general, noisy activities such as the operation of heavy machinery will be carried out during normal daylight working hours where acceptable limits are typically higher. Where possible, noise and vibration emission will be managed by using typical construction controls.

The impacts of tunnelling at the Mt Victoria and Terrace locations will be specifically assessed and any mitigations required provided. With 24hr works and multiple shifts per day it is likely that these activities will have specific impacts that need consideration.

4.4 Dust Control

Location	Terrace Tunnel	Te Aro	Basin Reserve	Victoria Tunnel	Eastern Connections
Occurrence	Frequent	Occasional	Frequent	Frequent	Frequent

Dust control can become an issue particularly over the summer months or during periods of high winds that are prevalent in Wellington. As many of the sites have earthworks components and will have exposed ground, dust will likely be generated by vehicle tracking and wind. Control methods to be adopted for specific sites will be determined by the contractor in accordance with any consent condition requirements.

4.5 Erosion and Sediment Control

Location	Terrace Tunnel	Te Aro	Basin Reserve	Victoria Tunnel	Eastern Connections
Occurrence	Frequent	Occasional	Frequent	Frequent	Frequent

Effective erosion and sediment control (ESC) is a key consideration for construction given the extensive cuttings, trenching, and potential need for stockpiling near sensitive receivers and urban drainage systems.

Control and onsite treatment of stormwater runoff containing sediment will likely utilise containerised treatment systems as sediment settling ponds are unlikely to be suitable due to space and topographic constraints. Control of groundwater and treatment for tunnelling is covered in the tunnel construction section of this report.

Vehicle tracking of sediment will likely be controlled through the use of hardstands in loading zones and the use of on site only transport for the tunnels. The need for wheel wash facilities will be minimised but where required will likely be within a contained system due to space constraints.

The specific control methods to be adopted for specific sites will be determined by the contractor in accordance with any consent condition requirements.

4.6 Vibration

Location	Terrace Tunnel	Te Aro	Basin Reserve	Victoria Tunnel	Eastern Connections
Occurrence	Frequent	Frequent	Frequent	Frequent	Frequent

Generally, typical construction practices should mitigate much of the risk associated with structural damage. However, if exposed to more intensive construction vibration cosmetic damage can occur. An allowance for a

precondition survey and potential cosmetic damage should be made for high-risk activities near to vibration sensitive receivers.

The Te Aro section has a large number of potentially vibration sensitive structures close to work areas. The works in this area are not anticipated to be vibration intensive activities other than those relating to pavement surfacing. Due to the smaller scale of works in this area it might be appropriate to restrict the use of larger more disruptive equipment, but this could reduce efficiency and increase time taken.

The specific control methods to be adopted for specific sites will be determined by the contractor in accordance with any consent condition requirements.

5 Construction Activities

5.1 Hoarding and Fencing

Location	**Terrace Tunnel**	**Te Aro**	**Basin Reserve**	**Victoria Tunnel**	**Eastern Connections**
Occurrence	Frequent	Frequent	Frequent	Frequent	Frequent

Temporary hoardings and fencing will be required at the edges of construction sites where the public interfaces with the Project. Hoardings or fencing will maintain a physical barrier between the work zones and the public, with pedestrian diversions established as required.

Hoardings will require robust construction (timber framed with plywood lining typically) to remain stable in wind and other human/environmental effects. In general, the impacts associated with hoarding construction may be equivalent to standard residential timber frame house construction although experienced over a much shorter duration (days to weeks). In some instances, where they may be in place for an extended period, they may require their own foundations with minor concrete works or excavation (refer to 5.8 for activity outline).

Other forms of fencing and barriers on the Project may be either temporary or semi-permanent. The objective is to provide a physical barrier and restrict access. All fencing will be inspected to prevent loose elements becoming disruptive in wind and to identify and replace damage.

In some areas directly adjacent to sensitive receivers, noise mitigation fencing may be required and can be significant with large high concrete or insulated fences. It is possible this would be required for the tunnel construction yards adjacent to residential properties.

Consideration Activity:	**Pedestrian hoarding and fencing**
Noise	Intermittent construction noise from scaffold erection, hand tools, and fixing of hoarding structures. Hoardings can contribute to the containment of site noise, though consideration of noise generated by high wind should be considered.
Vibration	Vibration producing equipment for these tasks is generally small and hand operated.
Dust	Negligible dust generation. If works include surface preparation (e.g. sanding, drilling), dust can be managed with hand vacuum systems.
Erosion and Sediment	Negligible
Environmental	In enclosed areas with verandahs, restriction of light is possible with solid hoarding. Alternative lighting for footpath may be required if solid hoarding is used with unlit verandahs. Consideration should also be given to crime prevention through environmental design, safety at crossings or corners due to limited visibility and graffiti or vandalism considerations if hoardings are extensive.
Traffic/Access	Pedestrian detours, narrowed footpaths, or temporary crossings may be required.

	Hoardings can present a visual barrier which can impact the ability for drivers, pedestrians and other road users to manoeuvre safely if visibility is restricted.

5.2 Bulk Earthworks

Location	Terrace Tunnel	Te Aro	Basin Reserve	Victoria Tunnel	Eastern Connections
Occurrence	Frequent	Unlikely	Frequent	Frequent	Frequent

5.2.1 Excavation

Bulk earthworks excavation will be undertaken to form tunnel approaches, road alignments, and modify the landform around structures such as the Sussex St Extension Trench and adjacent to retaining walls. Works involve stripping of topsoil, excavation of subsoil or rock, benching of slopes, and hauling of material to stockpile or disposal areas. Excavation will be carried out using large excavators, loaders, bulldozers. On site dump trucks are not anticipated to be used with the exception of the tunnels as road going dump trucks are anticipated to be able to service the excavation face. Most spoil will be carted offsite to bulk fill disposal locations in the greater Wellington area. Earthworks will follow erosion and sediment control staging plans and be sequenced to minimise exposure of disturbed ground.

Consideration Activity:	**Bulk Earthworks Excavation**
Noise	Heavy equipment (excavators, dump trucks, dozers, compactors) will be used for the full activity duration.
Vibration	Heavy equipment (excavators, dump trucks, dozers, compactors) will be used for the full activity duration.
Dust	Dust potential from dry exposed surfaces, loading areas and adjacent roads. Managed through water carts, stabilisation, and traffic control.
Erosion and Sediment	Exposed ground and steep cuts present risk especially during rainfall. Staging, perimeter bunds, diversion channels, and sediment ponds required.
Environmental	Excavation may encounter ground water and may require pumped dewatering. Contaminated or unsuitable material (if encountered) to be tested and disposed of appropriately.
Traffic Impact	The removal of bulk earthworks spoil requires near continuous heavy truck movements. These will have an impact on traffic and access control to construction areas will be required.

5.2.2 Stockpiling

For stockpiling specific to tunnel construction refer to section 5.4.5 Tunnel Advance – spoil handling.

Due to the limited space available on site, stockpiling within the Project boundaries may be limited. However, there may be instances, particularly if materials are being re-used, where stockpiling may be appropriate.

Stockpiles will be sited to avoid overland flow paths and kept away from stormwater inlets, kerbs, or waterways where possible. On constrained urban sites, such as at tunnel portals or Sussex Street retaining wall works, stockpiles may need to be placed in designated hardstand areas or contained in bins made of concrete walls on two or three sides.

Stabilisation depends on the storage duration and as high turnover is likely on constrained sites its unlikely to be appropriate to stabilise stockpiles during works.

Entry and exit routes should be stabilised with compact gravel or paved hardstand, and wheel wash stations considered to avoid tracking fines onto the roading network where vehicles travel over areas of exposed earth.

If spoil is derived from different sources or potentially contaminated land, segregation may be necessary until testing confirms suitability for reuse or disposal. These materials may require additional lining or containment to prevent potential contaminant migration.

Consideration Activity:	Stockpiling
Noise	Loading, tipping, and movement of excavators, loaders, and trucks. Reversing alarms and bucket impacts during material placement.
Vibration	Heavy plant movement on hardstand or compacted subgrade.
Dust	Windborne dust from dry stockpiles and vehicle movements. Dust managed by surface covers, stabilisation, and water carts.
Erosion and Sediment	Runoff from stockpiles or accessways may carry sediment into stormwater system. Controls include silt fences, bunds, inlet protection, and stabilised access.
Environmental	Material may require segregation based on source or contamination risk. Potential leachate or fines migration controlled via lining, containment, and sampling protocols.

5.2.3 Earthworks Around Potentially Contaminated Land

Earthworks north of Sussex Street and around Kilbirnie Park may encounter ground contaminated by historical light industrial activity or former reclamation material. Activities such as trenching, piling, or excavation in these areas require specific controls to safely manage potentially contaminated soils. These controls apply whether material is being removed, stockpiled, or disposed of offsite. Spoil may include hydrocarbons, metals, asbestos fragments, or general refuse. Excavated material must be assessed, contained, and transported using procedures that avoid environmental discharge or health exposure. Ground disturbance in these areas may also require working around buried infrastructure or unstable fill.

Consideration Activity:	Earthworks Around Potentially Contaminated Land
Noise	Excavation, piling, trenching, and spoil handling using excavators, loaders, and trucks.
Vibration	Vibration from excavation and piling.
Dust	Disturbance of fill or contaminated soils may release hazardous dust.
Erosion and Sediment	Excavated material to be stockpiled on impermeable surfaces with isolated drainage. Runoff and leachate must be prevented from entering stormwater systems.
Environmental	Spoil from trenching, piling, or excavation to be removed offsite unless confirmed suitable for reuse. Material stored temporarily in sealed, bunded areas. Transport in covered trucks to licensed disposal facilities. No discharge of groundwater or washdown into the stormwater network.

5.3 Service Relocation

Location	**Terrace Tunnel**	**Te Aro**	**Basin Reserve**	**Victoria Tunnel**	**Eastern Connections**
Occurrence	Frequent	Frequent	Frequent	Frequent	Frequent

Protection, relocation, and coordination of underground and overhead services may occur ahead of or in parallel with main construction activities. This maintains network continuity and avoid conflicts with proposed structures, earthworks, and utilities. Engagement with utility providers will be ongoing throughout the Project to confirm asset locations, agree on design changes, and coordinate outages if required.

Service relocation may include the following activities:

- Confirmation of existing asset locations through survey and potholing.
- Installation of temporary support structures or bypass connections.
- Relocation or protection of:
    - Electricity (low and high voltage)
    - Water supply and wastewater networks
    - Stormwater systems and overland flow paths
    - Gas mains
    - Telecommunications (fibre, copper)
    - Traffic signals and ITS infrastructure
- Coordination with Wellington Water, Wellington Electricity, Chorus, Powerco, Vector Gas, and other asset owners.
- Development of staging plans to avoid service disruption to critical customers (e.g. hospitals, schools, businesses).
- Documentation of service relocation in accordance with utility owner standards and project records.

Service works are expected to occur progressively and may require localised traffic management, night works, or temporary road closures depending on location. Relocation of strategic utility assets is discussed in the area specific sections of this report.

Consideration Activity:	**Service Relocation**
Noise	Hand tools, saw cutting, and small excavation plant.
Vibration	Vibration from small compactors or trench excavation.
Dust	Dust from surface cutting and trenching; managed using wet-cutting and prompt reinstatement
Erosion and Sediment	Drainage inlet protection to be used, timing of works to avoid work at times of heavy rainfall.
Environmental	Temporary service outages to be coordinated and minimised.
Traffic Impact	The many of the service connections are located within the roadway, shoulders or footpaths. Lane closures, parking removal and pedestrian detours likely required during works.

5.4 Tunnel Construction

location	Terrace Tunnel	Te Aro	Basin Reserve	Victoria Tunnel	Eastern Connections
Occurrence	New Terrace Tunnel	N/A	N/A	New Mt Victoria Tunnel	N/A

Construction of the tunnels will be a complex operation with a need to remove large quantities of material from constrained sites and access points. All sites are immediately adjacent to residential properties which have a high degree of exposure to tunnelling operations for a long period of time with 24/7 works. Furthermore, both tunnels and their portals are immediately beside the existing SH1 which may present challenges in working safely and with minimal disruption. Specifics for each of the tunnel construction areas are covered in Section 6.4 Mt Victoria Tunnel and 6.1 Terrace Tunnel.

The tunnelling equipment required for the Mt Victoria Tunnel and Terrace Tunnel duplications will depend on the geology and excavation method adopted. At this stage it is understood that roadheader excavation will be the primary advance method with the potential for drill and blast in the Mt Victoria Tunnel in some areas where rock is harder.

Tunnelling operations and the subsequent fit out require a yard at the portals that services the construction. As tunnelling progresses temporary services will be run from these yards to the advance face and incrementally extended as tunnelling progresses along a service bank against a tunnel wall. This includes, lighting, water supply, water extraction, dust extraction, ventilation, power supply monitoring equipment.

The following sections detail the construction methods used for tunnelling at both sites.

5.4.1 Portals

The activities in the portal areas are largely considered by the 'Earthworks' and 'Anchored Slopes' sections of this report. It is anticipated that portals are excavated top down in stages using large excavators. As each excavation bench is stripped, the retaining rock anchors and concrete facing will be placed providing support for the next excavation layer.

The portals around each tunnel are likely to be constructed from in-situ reinforced concrete. Interfaces with the existing portals particularly at Mt Victoria where the new tunnel is close to the existing will need to be coordinated.

Consideration Activity:	Tunnel Construction – Portals
Noise	Excavation with large equipment and rock support works (e.g. rock breaking, drilling, spraying of shotcrete). Concrete pours and formwork installation.
Vibration	Excavation and rock breaking with large equipment, large plant movements, and blasting operations.
Dust	Dust from excavation, rock support works, rock drilling.
Erosion and Sediment	Excavation is staged but due to top down approach large area potentially exposed until design grade is met.
Environmental	Removal of vegetation, concrete wash water, shotcrete rebound, and drill cuttings. Storm and surface water diversion required.

5.4.2 Cut and cover at portal

The cut and cover section at the southern portal of the Terrace Tunnel and western portal of the Mt Victoria Tunnel is required to transition between excavation of soils and fractured material into hard rock mining. The length of cut and cover is anticipated to be specified to allow hard rock mining from the face. It is anticipated that the open excavation will be supported with temporary buried and abandoned solider pile walls with ground anchors or a shotcrete and ground anchor wall. Once excavation reaches formation level, a reinforced in-situ concrete tunnel arch will be constructed to span the opening. The structure will then be backfilled using low-strength concrete or controlled fill. Temporary props above the arch may also be used depending on design requirements. At the Mt Victoria western site, the Tunnel control building may be built over the cut and cover section with access to the service plenum above the shared path through the cut and cover section.

Consideration Activity:	Cut and cover at southern portal
Noise	Excavation using large plant, drilling for anchors, concrete spraying (shotcrete), and formwork activities. Concrete pumping and delivery during arch pour.
Vibration	Rock anchor drilling and excavator operation. Localised vibration during excavation and compaction of backfill.
Dust	Dust from open excavation, drilling, concrete works and backfill placement.
Erosion and Sediment	Open excavation and exposed subgrade on steep banks present
Environmental	Concrete wash water, shotcrete rebound, and drill cuttings to be contained. Backfill material to be managed to avoid runoff. Excavation to be staged over potentially long exposure duration.

5.4.3 Tunnel Advance - Roadheader

A roadheader will be appropriate for soft to moderately hard rock conditions and is likely to be used for the majority of the tunnelling for both tunnels. This system offers controlled excavation with less chance of overbreak and a comparatively lower level of noise and vibration compared to the drill and blast method. The roadheader would be mounted on a tracked crawler base similar to a large excavator. This method may be combined with the use of heavy excavators at portals where access is less restricted and ground conditions likely weaker.

Two levels of excavation are likely, a top heading followed by a bench. A top heading height of approx. 7m and bench approx. 2m allows for typical equipment sizes. Split headings where one side of the tunnel (i.e. one future traffic lane) is mined in advance of the other may be used where required by ground conditions but is likely to be less efficient for construction. There could be up to 4 mining passes in each area of the tunnel if split headings were to become a design requirement.

The geometry and use of different heading arrangements will likely need to be coordinated between the designer and constructor as machinery size dictates some excavation height limits while the staging and stability effect ground settlement.

The roadheader mining method requires:

- A high capacity electrical connection and trailing cable to power the roadheader, possibly including a small electrical area near the portal.
- Dust suppression, ventilation and dust extraction system at the advance face. Likely to be a combination of water misting and airborne dust removal.
- A conveyor is mounted to the road header to deposit spoil from in front of the machine into dumpers waiting behind.
- Tunnel dump trucks for hauling of spoil for removal to the spoil handling area at the portal outside of the tunnel. Likely 6 wheel drive off road articulated dump trucks to achieve the tight turning circle required for, with multiple dumpers supporting each road header with capacities likely between 10-30T.
- Drainage and water control for both groundwater and dust suppression to capture water at the advance face. Pumped or gravity fed into containment and treatment tanks located beyond the portal.

Consideration Activity:	Tunnel Construction – Roadheader
Noise	Tunnel excavation, rock breaking, and support installation generates noise and vibration.
Vibration	The roadheader method of construction helps to reduce vibrations from alternative methods such as blasting. Roadheader excavation generally causes near continuous vibration as the cutting head works across the advance face. If there are blasting operations required, detailed vibration modelling, monitoring, and staging is required to prevent damage to nearby structures.
Dust	The large quantity of tunnel spoil material has the potential to generate dust. Water misting and airborne dust extraction at the advance face will be used to mitigate dust impacts.
Erosion and Sediment	Ground water flows within the tunnel may contain sediment. Stockpiling of spoil to be managed as discussed in Section 5.2.
Environmental	Excavation may likely encounter ground water and may require pumped dewatering. This water may need to be treated on site before being discharged in a suitable manner.
Traffic Impact	The roadheader method has negligible traffic impact on adjacent tunnel. Other than distinct events where closure of the existing tunnel may be required to complete the cross-passage breakthrough.

5.4.4 Tunnel Advance - Drill-and-Blast

There are some areas of rock in the Mt Victoria Tunnel route that may require the drill and blast method to be used. The assessment of rock quality at the Terrace Tunnel suggests that drill and blast will not be required. These are anticipated to be near the middle half of the tunnel where harder rock is more likely to be encountered that may reduce the advance rate of roadheader mining to a point where drill and blast is required. On the basis that hard rock mining has an estimated time frame of around 1 year and around a quarter of the length may require drill and blast it can be assumed that drill and blast effects will have a duration of multiple months.

This method involves sequential cycles of drilling, controlled blasting, ventilation, spoil removal (“mucking out”), and primary lining ground support (e.g. shotcrete, rock bolts, mesh). Works will be accessed from the portals and carried out progressively along the tunnel alignment. Controls such as pre-wetting and misting as well as

closing the adjacent tunnel and using a warning siren may be implemented to manage safety, air quality, dust generation and distraction to drivers during blasts. Tunnel blasting may occur on a regular cycle, typically once per shift, with exclusion zones and short-term traffic or pedestrian holds where required. Blasting operations produce significant noise and vibration but over a very short impulsive duration. This method requires:

- Hydraulic drill jumbos (1–3 boom depending on tunnel cross-section and availability of equipment).
- Explosives delivery and charging equipment.
- Ventilation system for post-blast fume extraction.
- Misting and water suppression for dust control.

The procedure for blasting is likely to follow:

- Survey control and validation of blasting pattern
- Drill holes for explosive using a jumbo
- Charging of holes with explosive likely using ANFO (Ammonium Nitrate Fuel Oil) or emulsion
- Set up water misting and protect ventilation for blast
- Clear mined tunnel and the adjacent tunnel of people and equipment near to blast zone

  --- Existing Mt Victoria Tunnel closed to all users ---

- Full walk / drive through of existing Mt Victoria Tunnel to confirm clear of people (5 min)
- Sound blasting warning siren
- Fire blast
- Ventilate mined tunnel to clear dust and fumes until gas detector readings are within safe range (15 min)
- Enter mined tunnel to confirm blasting completion and check for potential misfire (10 min)
- Once blast confirmed to be complete, a full inspection of the existing tunnel is required to check for damage or disturbance (10 min)

  --- Existing Mt Victoria Tunnel reopened to all users ---

- Scaling of the blast face to remove loose material
- Excavation muck out and hauling of spoil to portal
- Primary support installation
- Extend ventilation, ducting, power, drainage to new face

Full closure of the existing Mt Victoria tunnel during blasting operations and for inspection following is anticipated to be between 30 min and 1 hour per blast. There is a residual risk that damage is identified that results in immediate unexpected closure of the Mt Victoria Tunnel. While collapse of the existing tunnel is highly unlikely, cracking or spalling of lining poses a risk to traffic using the tunnel as it could fall on or near traffic. The contractor will have a plan to address this risk and pre-approved repair method and equipment on site.

Consideration Activity:	**Tunnel Construction – Drill and Blast**
Noise	Tunnel excavation, rock breaking, and support installation may generate noise and vibration, especially near sensitive receivers. Noise from the tunnel may tend to be amplified and directed out of the tunnel along its axis. Impulsive noise emission from blasting will occur.
Vibration	Transient vibration may be generated during blasting. Detailed vibration modelling, monitoring, and staging is required to prevent damage to nearby structures.
Dust	The large quantity of tunnel spoil material exposed during blasting will generate dust. Misting after blasting, both near the face and portal is likely required to reduce dust carried by blast impulse and to contain dust within the tunnel until it can be suppressed.
Erosion and Sediment	Ground water flows within the tunnel may contain sediment. Stockpiling of spoil to be managed as discussed in Section 5.2.
Environmental	Excavation may likely encounter ground water and may require pumped dewatering. This water may need to be treated on site before being

	discharged in a suitable manner. Blasting fumes and fine particulates managed through active ventilation and dust suppression.
Traffic Impact	The drill-and-blast approach may require closure of the adjacent tunnel for blasting and post-blast inspections (30mins to 1hr).

5.4.5 Tunnel Advance – spoil handling

Spoil is anticipated to be deposited into heavy construction dump trucks at the advance face before being driven to and dumped in the spoil handling area outside of the portal. The spoil handling area at the Mt Victoria west portal and Terrace North portal is anticipated to be enclosed. This allows works to progress 24/7 with less noise, dust and light emission while mitigating effects of weather on production rates. From here it is stockpiled until it is carted offsite by road going trucks. Road going trucks can then be loaded on hardstand and are less likely to require wheel wash and can be loaded in all weather conditions.

Within the tunnel, offroad 4 or 6 wheel articulated dump trucks are likely to be used to cart spoil. These provide high capacity and can tolerate rougher surfaces while achieving tight turn radius.

The onsite spoil handling area is anticipated to contain up to 2 days of advance (4-6 shifts), which equates to approximately 1,000m^3 to 1,500m^3 of material for each tunnel when considering 24/7 work at peak production. The construction yard area defined at the Mt Victoria western portal allows for multiple layout variations that can accommodate a suitable enclosed spoil handling area. The Terrace Tunnel Northern Portal construction yard is more restricted and is laid out as a long narrow site with the option of extending some construction yard facilities into the Clifton Carpark. It will be complex to allow for an enclosed spoil handling facility that can store 1,500m^3 of material at peak production for this yard. However, there are multiple options for the storage of around 500m^3 of material which may be a more typical production rate for about 2 days of production or 4 shifts. The contractor will determine an acceptable balance between providing a large spoil handling area that reduces risks around production rates and the use of available construction yard space for other activities.

Generation of material is anticipated to be relatively consistent with a period of mucking out every shift. However, disposal offsite may be limited at times of poor weather or other factors at disposal sites therefore multiple options for disposal should be considered to minimise the risk of delaying the advance. It is possible that if a stockpile becomes full or near full, additional road trucks could be used to remove most of its volume in a single shift which would increase the number of trucks servicing the site for that period. While a stockpile of material will likely be present for nearly the full project duration the turnover is anticipated to be very high with regular filling and emptying.

Consideration Activity:	**Tunnel Construction – Spoil handling**
Noise	Dump truck movement, tipping, and loading activities. Concrete surfaces, articulated truck reversing, and material impacts. Enclosure reduces emissions.
Vibration	Vehicle movements on hardstand and internal ramps. Dumping and loading of spoil.
Dust	Spoil tipping, movement of vehicles, and wind exposure on stockpiles. Dust suppression required within and outside enclosures.
Erosion and Sediment	Stockpile runoff, vehicle tracking, and sediment-laden water from spoil handling areas. Enclosed facilities, hardstand and drainage required.
Environmental	Spoil to be tested as required before disposal or reuse. Temporary storage, handling, and transport to comply with environmental and waste management plans.

5.4.6 Cross Passages

Cross passages between the new and existing tunnels will be constructed after the tunnel has advanced past each of the three passage locations in the Mt Victoria Tunnel and at two locations in the Terrace Tunnel, spaced

at approx. 150 m intervals. Each passage will connect the new tunnel to the existing tunnel, provides emergency egress, and supports tunnel systems during operation.

Prior to breakthrough of cross passages, works within the existing tunnel require closures to modify and strengthen the receiving tunnel. For this reason, it is proposed to complete the cross passages to approximately two thirds of the length between the tunnels during the initial tunnelling phase from the new tunnels. This length will need to be confirmed following assessment of the existing tunnel lining and rock pillar between tunnels. This reduces the risk of impacting or damaging the existing tunnels and allows them to remain operational in their existing state for a longer duration. It is anticipated that the initial construction phase for the cross passages includes mined tunnelling, primary lining and temporary support of the exposed face to be broken through at a later time from the existing tunnels. This will follow with the secondary lining, preparing the cross passage portal and installing the fire doors at the new tunnel end. Service connections, conduits, ducts and stairs (where required) will also be partially prepared to allow the new tunnel to function. To prevent damage to the partially completed cross passage during breakthrough, a steel mesh or similar containment will likely be installed at the advance face to catch loose rock.

Once the new tunnel is completed, traffic will be diverted into the new tunnel allowing the cross passage connections to be completed from within the existing tunnel. In the Mt Victoria tunnel, demolition of sections of the shared path at cross passage locations will be required to expose the tunnel lining at the cross passage locations. The competition of cross passages from the existing tunnel will likely progress by strengthening the existing tunnel lining around the passage location and installing advance support. Then the lining can be broken back and the remaining rock pillar broken out. Once rock is removed primary and secondary linings can be completed at this location. The passage will be completed with the installation of the cross passage portal, fire door and service connections on the existing tunnel side.

Alternative cross passage construction sequences are provided in the traffic scenarios in section 3.3.5.

To minimise the risk of damage to the existing tunnels, drill and blast will not be used for the cross passages and breakthroughs. This improves control and reduces risk of overbreak or damage to the existing tunnels.

Consideration Activity:	**Tunnel Construction – Cross tunnels**
Noise	Similar to main tunnel advance. Intermittent noise during demolition of the existing shared path (Mt Victoria only) and breakthrough works (e.g. saw cutting, coring). Mechanical excavation, ventilation fans, and concrete placement create ongoing noise.
Vibration	Similar to main tunnel advance.
Dust	Dust generated from concrete cutting, excavation, and spoil handling. Managed using misting, tunnel ventilation, and dust screens within the existing tunnel.
Erosion and Sediment	Similar to main tunnel advance.
Environmental	Similar to main tunnel advance. Some spoil will be removed through the existing tunnel in addition to demolition of concrete. Localised containment and water control required.

5.4.7 Tunnel advance support

Where areas of fractured or low quality rock is encountered advance support may be required to support the tunnel crown. As both tunnels cross through areas with faults it is possible that less stable or fractured rock may be encountered which will require support to reduce the risk of destabilisation at the crown. The main advance support types proposed are outlined below and generally involve drilling into and reinforcing the rock beyond the excavated profile.

- Canopy tubes / Spiles
    - These are near horizontal tubes or bars that are drilled into the rock above the tunnel face before tunnel face excavation then grouted with cement or resin. These are installed during tunnelling ahead of advance for broken rock or fault zones.
- Steel sets / ribs

- These are steel sections fabricated to match tunnel profile installed at regular centres at low cover zones where rock bolts cannot be installed and are most likely to be present near portals and cross passages. These are bolted in position.

- Steel mesh
  - Steel mesh may also be used in unstable zones to prevent rock fragments falling prior to primary lining installation. The mesh is secure with rock bolts and may also be sprayed with shotcrete for added retention.

Consideration Activity:	Tunnel Construction – Advance support
Noise	Drilling for spiles or canopy tubes, installation of rock bolts, handling of steel ribs, and fixing of mesh. Compressors and drilling rigs operating at tunnel advance face.
Vibration	Drilling into rock mass for bolts and tubes. Vibration from impact, handling and positioning of steel sets and mesh.
Dust	Drilling activities and material handling at the excavation face. Dust management required for worker safety through ventilation, airborne extraction and misting.
Erosion and Sediment	Any slurry or grout from canopy tube installation to be contained and managed within the tunnel.
Environmental	Grout and drilling residues to be managed to avoid uncontrolled discharge.

5.4.8 Tunnel Primary Lining - Shotcrete & Rock Bolts

Following each tunnel excavation advance, primary ground support will be installed to stabilise exposed surfaces and maintain tunnel geometry. This includes installation of rock bolts into the tunnel crown and walls to secure the rock by stabilising rock wedges and blocks on to competent intact rock behind. After drilling each hole, a steel bolt is installed and is grouted in place with cement or resin. Depending on design these bolts may then be tensioned and a steel plate is used to secure the exposed end into the primary shotcrete lining.

Shotcrete (sprayed concrete) lining can also be applied on exposed rock faces to secure any loose rock. Shotcrete will be applied in layers, often with fibre reinforcement and may include lattice girders of reinforcement or mesh in larger span or less stable areas. Typically, this primary shotcrete layer is 200-300mm thick. Rock bolts or anchors will be drilled and grouted in place using mechanised equipment and are typically between 3m and 6m long. Smaller drilling equipment for the installation of rock bolts may be required in the smaller dimension cross passages. These works are carried out progressively and are part of the advance excavation cycle with spacing of the rock anchor groups likely to match the tunnelling advance length, typically around 1.5 to 2m.

Consideration Activity:	Tunnel systems and control building
Noise	Activities occur underground, including drilling equipment, shotcrete pumps, and ventilation fans.
Vibration	Minimal
Dust	High dust potential from drilling. Managed using water misting and ventilation.
Erosion and Sediment	Activity within tunnel, with minimal impact.
Environmental	Traffic generated by regular concrete truck movements. Excess grout, and wash water to be collected and disposed of in accordance with environmental management procedures. Drilling fluids, if used, to be managed on-site.

5.4.9 Tunnel Secondary Lining – Structural Concrete

After completion of primary support, the tunnel will receive a secondary concrete lining. This could occur behind the advance face or if programme allows and space is insufficient for parallel works then the full tunnel length

could have the secondary lining placed following breakthrough to allow construction traffic to pass through the tunnel and reduced restrictions on vehicle size and turning.

It is currently anticipated that the tunnels will be drained rather than tanked, which reflects the construction of the existing parallel tunnels. A continuous waterproof membrane has been specified around the arch of the tunnels with drainage against each wall at invert level to capture groundwater. The installation of the membrane can be complex but is highly dependent on the lining system specified in design and a method for this will be developed at a future stage once detailed design has progressed. At this stage, it is anticipated that a flexible plastic continuous sheet membrane will be used, requiring thermal plastic welding and the use of chemical adhesives. Alternatives could be liquid applied coatings, spray applied liquid membranes, special concrete mixes and rigid sheet barriers. All are likely to have similar impacts with the primary controls required being containment of any hazardous materials used and prevention of contamination of groundwater and runoff while systems are being installed.

Cast in-situ concrete will likely be placed in lengths of 5-20m at a time with concrete being delivered via pump into the mobile arch shaped formwork. The formwork will be moved progressively along the tunnel alignment. This method allows for consistent geometry and efficient installation over long tunnel sections.

An alternative lining method would be the use of a permanent shotcrete lining, which has been adopted on other tunnel projects in Australasia. A permanent shotcrete lining would be placed over the primary shotcrete lining as a separate operation and may require some modification to the assumed method of waterproof membrane installation. A permanent shotcrete option may be investigated at a future detailed design stage.

Consideration Activity:	**Tunnel secondary lining - structural concrete**
Noise	Noise from concrete pumps, vibrating equipment, and operation of equipment within the tunnel.
Vibration	Minimal impact, localised vibration of concrete within formwork.
Dust	Minimal. Activity involves wet concrete placement. Dust risk limited to movement of dry materials or equipment.
Erosion and Sediment	Concrete washout and slurry from equipment must be managed at portal areas or support zones to prevent discharge.
Environmental	Concrete supply and pumping operations to be controlled to avoid spills. Wash water, excess concrete, and admixtures must be contained and disposed of appropriately.

5.4.10 Tunnel systems and control building

New tunnel control buildings and associated systems will be constructed to manage operation at both tunnel sites. This includes installation of ventilation fans and ducting, fire suppression systems (e.g. deluge, hydrants), stormwater and washdown water detention and treatment, lighting, electrical reticulation, communication systems, and instrumentation. The control building will house monitoring, control, and backup systems and may include generator and backup power systems. Services will be installed progressively following the completion of linings and likely following civil pavement works. Services will be tested and commissioned prior to tunnel opening.

Deluge water for fire supply and stormwater detention tanks will be provided at both tunnel sites. In terms of construction, these may be partially or fully buried below ground requiring deep excavation, either open or with temporary shoring, depending on space constraints. Light craneage and complex concrete works will be required.

The Tunnel Control building construction at the portals is anticipated to use conventional construction methods with concrete, concrete block wall and steel being the primary materials. All four buildings will likely be similar single or two storey and likely rectangular in footprint. Special heavy machinery is not expected to be required for construction, however there will likely be a mobile crane present, regular deliveries from trucks and worker movement. The structures are expected to be simple beam, column and walls similar to other infrastructure buildings. Access to the permanent tunnel control building site and timing of other works within the construction yard area where these buildings will be will likely dictate when these are built. There is an opportunity to remove the need for temporary systems should the permanent building be built and commissioned before existing control buildings are removed. However, due to space constraints and arrangement of current services temporary service connections and control facilities have been allowed for at both tunnel sites.

Consideration Activity:	Tunnel systems and control building
Noise	Construction noise from installation of ducting, cable trays, mechanical plant, and electrical equipment. Surface-level works may involve concrete pours, foundation construction and crane lifts. Plant movement, small cranes, drilling and installation of mechanical and electrical equipment. Deliveries by HIAB or flatbed truck. Tank excavation and placement require excavators, concrete works, and possible sheet piling.
Vibration	Minimal impact for control buildings. Excavation for tanks, especially with shoring or sheet piling. Minor vibration from compactors and equipment used for backfill and service installation.
Dust	Minimal impact from building construction. Some dust generated from excavation, backfill, and service trenching.
Erosion and Sediment	Minimal impact once foundations complete.
Environmental	Systems installation includes management of hazardous substances (e.g. fire suppression agents, battery storage).

5.4.11 Tunnel Dewatering, Groundwater Control and stormwater Treatment

It is anticipated that groundwater can be treated on site and disposed of into existing drainage systems, either sewer or stormwater depending on contamination level. At the northern Terrace Tunnel portal there are existing 1200mm stormwater and 900mm sewer services near Kumutoto Lane. The capacity of these to accommodate additional flows is unknown. However, with some on site storage for high rainfall events it is expected that these services will be sufficient. For the Mt Victoria tunnel, nearby existing services include 150mm sewer and 300mm stormwater pipes, with larger connections on Cambridge and Kent Terrace. A new stormwater connection is expected to be built to service the new tunnel and deluge system, this may need to be in place at an early stage of construction to accommodate the temporary dewatering discharge.

During excavation of the tunnels, groundwater present in the rock or from seepage through the rock will likely be encountered. Interception of groundwater and active dewatering to maintain safe and dry working conditions is anticipated. Dewatering systems will include submersible pumps, sump pits, and collection pipelines to manage inflows during excavation and lining. Collected water will be temporarily stored and treated on-site to remove sediment, and if necessary, hydrocarbons or dissolved contaminants, before discharge. Discharge locations and quality requirements will be confirmed based on receiving environment and consent conditions. Pumps will likely be located near the tunnel portals with pipelines to the advance face and treatment area within an adjacent site compound.

It is anticipated that on site treatment for water extracted from the tunnels during construction is required. Contaminants are expected to include pH adjustment, blasting containments particularly nitrates, ammonium and hydrocarbons if ANFO (Ammonium Nitrate Fuel Oil) is used as the explosive material, hydrocarbons, diesel, hydraulic oils, lubricates, concrete and cement fluids. Fire suppression systems may also contain chemical compounds requiring special treatment should these be activated. Drilling lubrication is anticipated to be compressed air, water or water based polymer. Water cutting slurry will be captured and treated.

Specific controls such as diversion bunds and temporary exposed earth protection at the tunnel portals will be required, in particular where the advance face proceeds downhill at the northern Terrace Tunnel portal and eastern Mt Victoria Tunnel portal. These are intended to stop surface water flowing into the worksite and prevent cross contamination of surface water from different sources.

Consideration Activity:	Tunnel dewatering, groundwater control and treatment
Noise	Noise will be generated from the operation of pumps, generators, and water treatment equipment. Continuous operation will likely be required but can be enclosed or acoustically shielded.
Vibration	Minimal impact from pump operation.
Dust	None.
Erosion and Sediment	Discharge will be to city drainage assets via stormwater or sewer depending on level of contamination. Overflow locations and potential failure points such as pumps will require localised protection.

Environmental	Groundwater may require treatment prior to discharge to sewer, stormwater or receiving environment. Monitoring of flow rates, turbidity, and potential contaminants (e.g. hydrocarbons) may be required depending on consent conditions and contaminants present.

5.5 Roading, Pavements, and Surfacing Construction

Location	**Terrace Tunnel**	**Te Aro**	**Basin Reserve**	**Victoria Tunnel**	**Eastern Connections**
Occurrence	Frequent	Frequent	Frequent	Frequent	Frequent

Roading, pavements, and surfacing construction will be undertaken across the Project. In many instances the road construction work will be staged to allow continued operation of the road under temporary traffic management. In these locations it may be less disruptive to traffic and surrounding residents to undertake works at night.

Generally, these works will see milling back of the existing surfacing before any new pavement, kerbs, services etc. are installed before the surfacing and line marking is re-applied.

Line marking for existing roads is often carried out at night to minimise traffic influence and to avoid parked vehicles but is generally a low disruption activity with idling trucks the primary disturbance.

When working in 'green-field' areas such the Sussex St Extension and Eastern Connections work, construction of the pavement layers may be more involved and be accompanied by the installation of stormwater and other roading services as required. This can include induction loops for traffic sensors, cats eyes, tactile pavement and other auxiliary pavement items.

Roading works also include the associated signage, traffic lights, streetlights and pedestrian furniture. These are all generally low disturbance activities to construction with minimal heavy equipment, generally complete within short durations, can be carried out with partial or single lane or footpath closures and mainly require hand tools.

Consideration Activity:	**Roading, Pavement and Surfacing Construction**
Noise	Pavement milling, asphalt paving (rollers, pavers), saw cutting, use of plate compactors and loaders can contribute intermittent noise.
Vibration	Compaction with vibrating rollers, existing pavement milling and excavation during basecourse preparation can produce vibration.
Dust	Demolition of existing surfaces, aggregate placement, and traffic on unsealed areas can cause localised air quality nuisance, visibility reduction, and sediment transport into drainage systems.
Erosion and Sediment	Runoff from exposed subgrade or transitions between new and existing pavement surfaces.
Environmental	Use of hydrocarbons for bitumen. Minimal risks associated with this activity with industry standard controls.

5.6 Kerb, Channel, Trenching and Stormwater Assets

Location	**Terrace Tunnel**	**Te Aro**	**Basin Reserve**	**Victoria Tunnel**	**Eastern Connections**
Occurrence	Frequent	Frequent	Frequent	Frequent	Frequent

New kerb and channel, along with associated surface stormwater assets (e.g. sumps, inlets), may be formed and cast in situ along the corridor edges. This activity involves excavation of the existing pavement or verge, placement of formwork, reinforcement steel fixing (if required), concrete pouring, and finishing. Sumps and inlets may be installed concurrently or integrated into the kerb pour.

Trenching for shallow pipes and other shallow below ground services includes the use of small excavators (5T or less) and hydro excavation vacuum trucks to expose ground. Trench protection or shoring may be used for deeper trenches or where benching can't be accommodated.

These works are linear and progressive, generally occupying a narrow work zone along the carriageway edge or within parking or lanes shoulders. Works may require temporary traffic management and may restrict kerbside access during concrete placement and curing.

Consideration Activity:	Kerb, channel and stormwater assets
Noise	Construction noise from concrete saws, excavators, compactors, and concrete trucks/pumps. Noise emission is short-duration and shift progressively along the corridor.
Vibration	Vibration from small rollers or plate compactors during trench backfilling.
Dust	Negligible.
Erosion and Sediment	Excavation near drainage inlets and exposed subgrade can lead to localised sediment runoff during rainfall. Use of inlet protection (e.g. filter socks), bunding, and daily stabilisation is required.
Environmental	Concrete works and slurry to be contained and prevented from entering stormwater.

5.7 Signage and ITS

Location	Terrace Tunnel	Te Aro	Basin Reserve	Victoria Tunnel	Eastern Connections
Occurrence	Frequent	Frequent	Frequent	Frequent	Frequent

Signage and Intelligent Transport Systems (ITS) may be constructed as part of the Project in all areas to provide guidance to road users and pedestrians. These works are anticipated to require the construction of minor structures to support signage and trenching/concrete cutting to allow for ducts to be run along the alignment and at intersection.

Consideration Activity:	Signage and ITS Construction
Noise	For brief periods of time, concrete cutting/breaking equipment may need to operate to allow the construction of sign foundations. Other than this, noise levels are anticipated to be similar to general construction plant noise.
Vibration	Minimal vibration anticipated other than compaction when backfilling service trenches and repairing pavement edges.
Dust	Dust associated with concrete cutting and earthworks may need to be suppressed as required.
Erosion and Sediment	Excavations may need to be treated like other earthworks on the Project with erosion control measures and prevention of sediment entering stormwater assets.
Environmental	No specific impacts.

5.8 Piling and Foundation Construction

Location	Terrace Tunnel	Te Aro	Basin Reserve	Victoria Tunnel	Eastern Connections
Occurrence	Frequent	N / A	Frequent	Frequent	Frequent

The following foundations are anticipated to be constructed on the Project. These may be revised as the design is developed and as the site conditions and construction become understood.

- **Retaining wall foundations:** Likely to use bored, secant or continuous flight auger (CFA) piles for large reinforced concrete walls (e.g. Sussex Street Extension).
- **Portal structures:** Deep pile foundations for lateral and vertical support at tunnel portals.
- **Small Structure Foundations:** In some instances, for signs and smaller structures, the appropriate foundation type may be reinforced concrete pad footings or single small diameter bored piles.
- **Temporary works:** Sheet piles or soldier piles with lagging for excavation support during temporary support conditions in construction. These may be incorporated into permanent works, abandoned in place or removed following activity completion.

The method of construction and required machinery anticipated for construction of piles and other foundations are:

- **Driven piles:** Can be cost and time effective solution for lightly loaded foundations. Installed using a drop hammer attached to a specialised rig or crane. Vibro-hammers may also be used where ground conditions are appropriate.
- **Bored piles:** Preferred for permanent foundations due to low vibration and controlled installation. May require slurry (bentonite/polymer) or casing to support borehole walls. Installed via a piling rig or crane. Casings may be permanent or sacrificial.
- **Secant piles:** Useful where top-down construction methods are utilised for retaining and bridge foundations.
- **Sheet piles (temporary works):** May be used for trench excavation support; Generally, these will be installed with a drop-hammer or vibrated into the ground. Pre-auguring or silent pressing techniques may be required to mitigate vibration in highly sensitive areas.
- **Mini-piles or micropiles:** May be needed in constrained access zones or to support existing structures during cut works.
- **Shallow Pad footings:** may be utilised where there are good ground conditions and adequate space. Construction requires excavators and potentially compaction equipment.

Consideration Activity:	Piling and Foundation Construction
Noise	Driven piles cause a short, high-volume impact as the hammer connects with the head of the pile. This can be controlled through the use of cushioning devices and acoustic screens but not eliminated. Vibro-hammers and augers require heavy equipment.
Vibration	Driven and vibration driven piles may transfer vibration into nearby properties. Bored piles and other drilled piles present a reduced vibration effects, though can still result in vibrations being noticeable to nearby properties.
Dust	Dust is not typically generated during piling. However, exposed earthworks and pile hole spoil from augured holes may allow wind-blown dust to be generated in dry conditions.
Erosion and Sediment	Excavations will need to consider requirements. Groundwater is often encountered and can be treated on site where it's required to be removed.
Environmental	Where drilling fluid is required to stabilise holes, this will need to be managed by specialist equipment and treated prior to disposal. Concrete overflow and tremie (placing concrete via a submerged pumped pipe while submerged in fluid) methods of placement require specific methods and controls. Collection and treatment of displaced water when pouring concrete in holes filled by rain or groundwater will also be required.

5.9 Secant or Contiguous Pile Wall Construction

The secant method involves drilling overlapping concrete piles to form a continuous wall. Unreinforced piles are installed first using low strength concrete, followed by reinforced piles cut partially into the adjacent piles. Drilling may be supported with casing or drilling fluids, depending on ground conditions. Alternatively, a continuous flight auger may reduce the need for pile hole support. Secant walls can function as temporary or permanent structures and are suited to constrained urban environments where space is limited.

Contiguous pile walls are similar however the piles do not overlap and are instead closely spaced. Depending on the retained material the gaps between can be infilled with concrete during excavation.

Consideration Activity:	Secant and Contiguous Pile Wall Construction
Noise	Noise from rotary drilling rigs, concrete pumps, and spoil handling. Continuous operation during piling phases.
Vibration	Pile walls are drilled, not driven, so vibration is minimal.
Dust	Dust from spoil handling and dry material movement; managed by wet drilling and water suppression.
Erosion and Sediment	Wet spoil and drilling fluids may require containment and dewatering. ESC controls (e.g. bunded work areas, sediment tanks) are necessary at pile sites.
Environmental	Use of drilling fluids (e.g. bentonite or polymer) requires proper handling, reuse or treatment. Concrete waste and washout must be managed to prevent discharge.

5.10 Bridge Superstructure Construction

Location	**Terrace Tunnel**	**Te Aro**	**Basin Reserve**	**Victoria Tunnel**	**Eastern Connections**
Occurrence	Ghuznee St Bridge	N / A	SH1 overpass and Pukeahu Land Bridges	Taurima Footbridge	Hataitai Connection Bridge

The bridges for the Project are assumed to be of the following types on either MSE or piled foundations.

- Road bridges - precast prestressed concrete girder with insitu concrete deck
- Pedestrian bridge – prefabricated steel or precast prestressed concrete girder
- Land / green bridge at Pukeahu and adjacent pedestrian bridge – Steel plate girder with precast planks and insitu topping or precast prestressed girders with insitu deck.

All of these superstructure types follow a similar construction process. Following completion of piling and build-up of fill at abutments reinforced concrete abutments and pier caps are cast insitu. Girders are then delivered on long oversize trucks and lifted into position using large cranes likely greater than 150T and likely to be crawler cranes. Once girders are positioned, precast deck planks or formwork is installed to allow reinforcement to be placed and an insitu concrete deck to be cast. Barriers, drainage and approach works follow prior to pavement and completion.

Consideration Activity:	Bridge construction
Noise	Heavy cranes operation, concrete pumping and placement.
Vibration	Heavy cranes operation and deliveries on heavy trucks.
Dust	No specific impacts.
Erosion and Sediment	Superstructure works have minimal impact as they are above ground however multiple regular deliveries and movement of heavy equipment and crawler cranes require robust hardstands around the construction area.
Environmental	Traffic impacts from heavy cranes and oversized trucks used during girder installation. Night works may be preferred for this activity to limit traffic disruption and allow SH1 to be closed at Ghuznee St and Hataitai Connection Bridge during beam installation and concrete deck placement. Control of concrete slurry and washdown water used during concrete works.

5.11 Anchored Slope/Wall Construction

Location	Terrace Tunnel	Te Aro	Basin Reserve	Victoria Tunnel	Eastern Connections
Occurrence	Frequent	N / A	Frequent	Frequent	Frequent

Anchored slopes and walls are required in several locations on the Project. These introduce some environmental considerations through the drilling process and general operation of heavy plant. The level of impact will vary depending on the materials that anchors are being installed in. Construction of the anchored slopes generally will see partial excavation of the slope undertaken (2-3m lift) before ground anchors and concrete are placed on the exposed face. Subsequently, the excavation is continued and the process repeated as required working down from the top of the slope.

Consideration Activity:	Rock anchor / Soil nail installation
Noise	Noise will be generated during drilling and any excavation that requires hydraulic hammers.
Vibration	Material falling from the face onto hard surfaces during excavation may produce impact vibration.
Dust	Some dust is produced by drilling in dry materials, though generally suppressed by drilling fluids.
Erosion and Sediment	Drilling is generally undertaken with water to flush-out holes, the quantity of water is generally low. However, if ground water is intercepted this may need to be captured, treated and disposed of. Most anchored slopes are anticipated to be cut into rock with minimal erosion potential. Surrounding interfaces with natural ground and the tops of walls will need control measures to prevent erosion.
Environmental	Drilling fluid and over-flow grout will require capture and disposal/treatment on site.

Following ground anchor or soil nail installation, wall facings will be constructed to provide a structural cover and long-term durability. Facing installation may require temporary access unless it can be constructed top down where the excavation bench can be used for access. Facing options may include:

- Shotcrete – applied in layers over mesh and anchors to follow ground contours.
- Cast in situ concrete – using formwork to produce a smooth structural face, often in high-visibility or accessible areas.
- Precast concrete panels – lifted into place and fixed to anchor heads for modular installation. Often used as a secondary facing on the exposed face in addition to a primary lining against the retained material.

Consideration Activity:	Wall facing construction/installation
Noise	Noise from concrete pumps, vibrators, formwork handling, and crane use (for precast). Shotcrete involves continuous spraying with compressors and pumps.
Vibration	Minor vibration from formwork fitting or shotcrete rebound. No piling or ground disturbance.
Dust	Dust from surface preparation (e.g. scaling or drilling), particularly for shotcrete. Managed by misting and vacuum extraction if needed.
Erosion and Sediment	Minimal erosion effects.
Environmental	Water used for curing to be captured and treated on site. Insitu concrete and shotcrete to only be placed against damp and dry surfaces and in suitable weather where water pooling is unlikely. Wash water, form release agents, and concrete residues to be contained and managed. Work zones to be isolated from stormwater inlets or waterways.

Refer to earthworks and erosion and sediment control sections for associated activity considerations.

5.12 MSE Wall Construction

Location	Terrace Tunnel	Te Aro	Basin Reserve	Victoria Tunnel	Eastern Connections
Occurrence	Frequent	N / A	Frequent	Frequent	Frequent

Construction of Mechanically Stabilised Earth (MSE) walls such as at the Sussex Street Extension transitions, or portal approaches, is relatively unintrusive. MSE walls typically require the subgrade to be cut back to form a firm platform before layers of fill material are placed and compacted with layers of either geogrids or steel straps are placed between lifts. The facing of the wall is typically installed with the lifts and supported temporarily until the lift is completed. It is assumed that precast concrete facing panels will be used.

Consideration Activity:	MSE Wall Construction
Noise	Excavators, compactors, and delivery of facing units and fill via truck. Panel installation and compaction are intermittent and localised.
Vibration	Compaction equipment including vibratory rollers will be used.
Dust	Placement and compaction of granular backfill can release fine particles, particularly during dry and windy conditions.
Erosion and Sediment	Exposed subgrade and backfill layers are vulnerable to erosion, especially on or immediately adjacent to steep batters and during rainfall. Erosion controls are difficult to maintain as works progress daily.
Environmental	Minimal environmental effect in construction. Fill material shall be screen for contamination before being incorporated into the MSE wall.

5.13 Precast Concrete Panels

Location	Terrace Tunnel	Te Aro	Basin Reserve	Victoria Tunnel	Eastern Connections
Occurrence	Frequent	N / A	Frequent	Frequent	Frequent

Precast concrete panels used for retaining walls, or architectural facing will be cast off-site and delivered to the corridor for installation. Installation will involve lifting panels into position using truck-mounted or crawler cranes and securing them via bolting, welding, or grout fixing. These activities are generally short in duration per panel but may require traffic or pedestrian management during lifting operations to maintain public safety and working clearance. Panels will typically be installed from within existing work zones or behind temporary hoardings.

Consideration Activity:	Precast concrete panels
Noise	Construction noise from cranes, delivery trucks, and hand tools during positioning and fixing. Impact noise (e.g. alignment tapping, pin driving) may occur intermittently.
Vibration	Vibration due to mechanical fixing, concrete compaction and grouting.
Dust	Dust possible from on-site adjustments or surface cleaning, managed with hand tools or water suppression if required.
Erosion and Sediment	Not applicable, no ground disturbance or material processing.
Environmental	Delivery and lifting managed to prevent spills, grouting or adhesives (if used) must be handled per environmental management procedures.

5.14 Ground Improvement

Ground improvement may be required in many areas where soft or liquefaction prone soils are present near surface. Ground improvement may be required for bridge abutments, around areas of soft ground at the Sussex St Trench and for improving the ground where settlement or movement may be an issue. Options for ground improvement are presented in this section, the selection of which depends on the existing conditions, access, soil types and other design requirements. Due to the expense and complexity of ground improvement the contractor may suggest design refinements or excavating out material and replacing it with competent, compact, granular material instead of completing ground improvements.

5.14.1 Cutter Soil Mixing liquefaction mitigation ground improvement

Cutter Soil Mixing (CSM) ground improvement in areas with poor or variable ground conditions to increase strength, reduce settlement, and control liquefaction. The CSM process involves mixing in-situ soils with cementitious slurry using a rotating cutter head to form interlocking columns or panels of stabilised ground. forming a grid or lattice of stabilised soil columns. These columns interlock to form a subsurface improvement matrix beneath future structures (e.g. tunnel portals, embankments, retaining walls). The CSM process is suited for constrained urban sites and avoids spoil generation typical of bored piles.

CSM works are completed from the surface prior to foundation or abutment construction and require batching plant, grout pumps, cement slurry handling systems, and access for mixing rigs. The layout and movement of the mixing head will need to be carefully planned and controlled to avoid and work around buried services. Some excess spoil is generated as the cutter head is inserted and withdrawn and excess grout or cement slurry can return to the surface in saturated soils.

Consideration Activity:	CSM ground improvement
Noise	Operation of mixing rigs, grout pumps, and spoil extraction systems. Cement delivery and truck movements at batching areas.
Vibration	Minimal vibration from the CSM process itself. Some vibration from tracked plant or spoil handling may occur during site setup and following works.
Dust	Dust from handling of dry cement and exposed earthworks. Mitigated by enclosed systems, misting, and sealed storage or transfer areas.
Erosion and Sediment	Spoil and slurry to be contained within bunded work zones. Surface water diversion required to prevent contamination of nearby drains or watercourses.
Environmental	Grout mix and return slurry must be contained, sampled, and disposed of appropriately. Mixing in close proximity to bridge foundations and services must be coordinated to prevent damage or interference. Cement products to be isolated from stormwater systems.

5.14.2 Ground Improvement Jet Grouting

Jet grouting may be adopted in localised areas along the alignment to improve poor or variable ground conditions particularly near structures, services, or where groundwater control is required. It involves the injection of high-pressure grout through small diameter boreholes that enhance strength, stiffness, and permeability control. Jet grouting is typically used for underpinning, seepage cut-offs, or to create support for the Sussex St Extension Trench.

Operations generally include borehole drilling, high-pressure grout injection using rotating nozzles, spoil management, and formation verification. Works are expected to occur within established work zones or shaft areas. Grouting activities will typically use silos and batching plant, grout pumps, and drilling rigs.

Consideration Activity:	Ground Improvement Jet Grouting
Noise	Drilling rigs, grout pumps, and spoil handling equipment operating continuously during grouting. Intermittent noise from delivery trucks, mixers, and plant movement.
Vibration	Limited vibration from small diameter drilling operations into soil.
Dust	Dust from cement handling, mixing, and spoil management.

Erosion and Sediment	Spoil generated during drilling must be captured and handled to prevent discharge. ESC measures around spoil bins, bunded work zones, and diversion of clean water flow required.
Environmental	Grout return (spoil slurry) must be contained and treated or disposed of appropriately. Spill kits and bunding required at grout batching areas. Potential for ground heave or settlement if not carefully managed.

6 Main Works Description By Area

6.1 Terrace Tunnel Duplication

This section focuses on the **Terrace Tunnel duplication** and adjacent works. This section explains the construction philosophy and the key construction sequences anticipated for specific elements to provide guidance on specific construction activities in this area.

6.1.1 Scope of works

The **'Terrace Tunnel Duplication'** area and is associated with the prefix **'TT'**. This area extends from the northern extent of the project on SH1 in Shell Gully to south of Ghuznee St Overbridge and is shown in Figure 7.

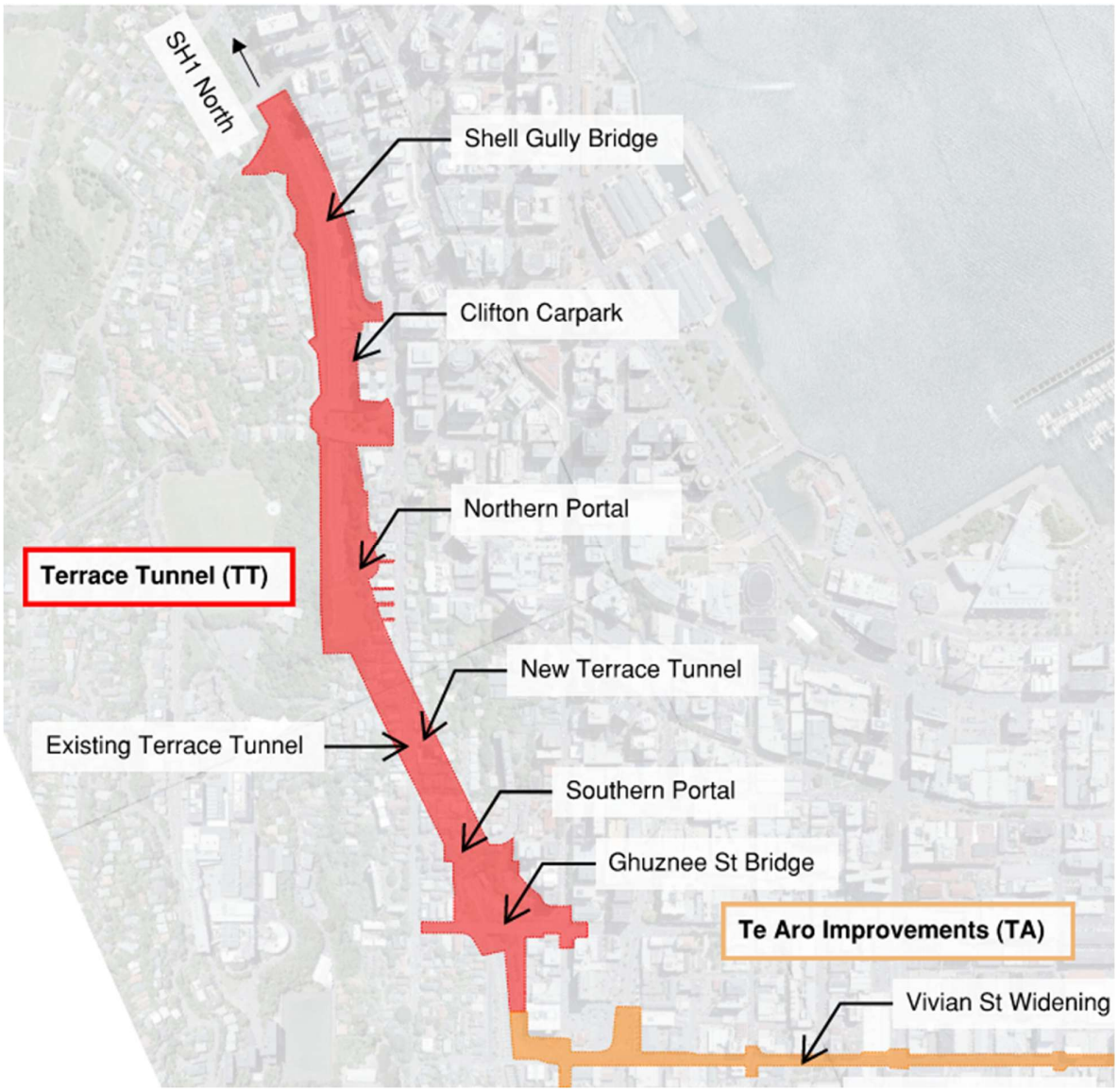


Figure 7: Terrace Tunnel (TT) area of works.

The **Shell Gully** area includes work to the Shell Gully Bridge and its approaches to add an additional lane for southbound traffic.

Northern Portal includes the excavation and construction of the Northern Portal for the new Terrace Tunnel and associated works to create the portal.

The **New Terrace Tunnel** includes work undertaken between the northern and southern portal to construct a new duplicate tunnel adjacent to the existing Terrace Tunnel as well as cross passages between the new and existing Terrace Tunnels.

The **Existing Terrace Tunnel** work is within the current Terrace Tunnel. The consent design includes the re-configuration of lane layouts to two northbound lanes with additional shoulder width and side barriers.

Southern Portal includes work undertaken between southern portal of the new Terrace Tunnel and the tie into to Vivian Street.

The **Ghuznee St bridge** is the modification or replacement of the Ghuznee Street Bridge.

6.1.2 Sequence of Work

The new tunnel control buildings, deluge water supply and stormwater tanks are required to be built after the majority of tunnel works are complete due to space constraints and are required to be commissioned prior to opening the new tunnel. The existing tunnel control building at the southern portal needs to be open and accessible for maintenance prior to refurbishment of the existing tunnel. Due to conflict between this and the permanent new southbound alignment a temporary in corridor detour is required prior to the existing building's removal.

The anticipated construction methodology and traffic staging in this area is provided in Figure 8 and generally allows for the construction of the new tunnel advancing from the northern portal southwards. Once tunnelling is complete traffic is switched to the new tunnel and modifications are made to the existing tunnel.

Figure 8: Potential Construction staging for Terrace Tunnel and Ghuznee St bridge works.

Tunnel mining

Currently it is assumed that the northern portal will be used for the majority of the new tunneling works as it has superior access and staging areas in comparison to the southern side. Therefore, the northern portal will be constructed first and the southern portal commenced at some stage following prior to the main tunnel advance reaching the southern portal.

It may be possible to carry out tunneling from south to north. A south to north advance would assist in stormwater and groundwater infiltration as the tunnel would be graded such that water runs away from the advance face but may further limit access and the site area at the southern portal is potentially more congested during works to construct tunnel control facilities and the Ghuznee St Bridge works. Removal of spoil from the southern portal would need to be considered in greater detail should this portal be used for mass excavation or large load deliveries.

A hybrid approach where the tunnel is advanced from both ends is likely the fastest method but is dependent on having enough equipment and personnel to support these concurrent tasks and will cause the highest disruption at access points. There may also be additional cost from doubling up on facilities and equipment. The relatively short tunnel length means that a single road header mining from the northern end to south is most likely.

Tunnel control buildings

The southern tunnel control building, service modifications and new detention tanks will likely not be constructed until the southern portal is finished, possibly during secondary lining or fit out of the tunnel as these tasks occupy the same construction space. As the existing tunnel control building is required to service the existing tunnel a temporary traffic arrangement with a slight eastward diversion for traffic lanes could be used to allow the existing building to remain in service while the new tunnel is in operation.

The northern control building pump station and fire supply tanks occupy the construction access to the new tunnel and therefore will likely be carried out after the bulk of works in the new tunnel are complete so as not to block access.

The sequence for providing continuous services supply to the operating tunnel(s) would likely follow the following process:

Traffic is kept in its existing arrangement in the existing tunnel

- Construct new tunnel portals
- Mine new tunnel header and bench
- Complete secondary lining and new tunnel half of the cross passages
- Construct new tunnel services buildings
- Construct new deluge supply and detention tanks
- Complete pavement and temporary alignment at southern portal to avoid existing tunnel control building
- Commission new tunnel services for new tunnel

Open new tunnel to two way traffic, close existing tunnel for refurbishment

- Remove existing tunnel control building
- Complete cross passages
- Retrofit and refurbish existing tunnel
- Connect new tunnel control building and services to existing tunnel
- Complete permanent alignment paving at southern approach

Traffic configuration is adjusted to the completed configuration, possibly over two traffic switches at southern portal of new tunnel to allow for realignment of carriageway and to allow signage and minor modifications for traffic in a single direction.

Existing tunnel works and completion

There are multiple methods available to complete works once the second tunnel is largely complete. The base case assumes that all traffic is diverted into the new tunnel with one lane operating in each direction while existing tunnel is closed and works within the existing tunnel are completed. This creates a temporary reduction in capacity from the existing two northbound lanes and single southbound lane to a single lane in each direction.

An alternative sequence of works involves diverting just the southbound traffic lane into the new tunnel prior to completing the cross tunnel passages with a single direction of traffic in each tunnel. The closed lanes of space in each tunnel then provides better access to the cross passages. Access to the construction areas will need to be managed as it is effectively split by traffic lanes and requires construction crews to merge in and out of SH1 traffic at each end of the work area.

6.1.3 Traffic Diversions and Staging

Work in this area is adjacent to the existing SH1 north and south of the existing Terrace Tunnel and the Ghuznee Street bridge. As with Mt Victoria, this is a high-volume strategic corridor with limited alternative routing. Key traffic management considerations include:

- Maintaining SH1 functionality with minimal closures.
- At peak times and during weekdays the existing capacity of two northbound lanes and one southbound lane will be maintained as long as possible with at least one lane in each direction otherwise.
- Staging tie-ins and bridge works to avoid long-term lane reductions.
- Integrating works with adjacent activities. Access points are constrained and will require coordination and likely rely more on off-peak and night work windows for works at Ghuznee St Bridge.

Shell Gully Overbridge

The sequencing to allow the 3 existing traffic lanes to remain in service during the barrier modification works are shown in Figure 9.

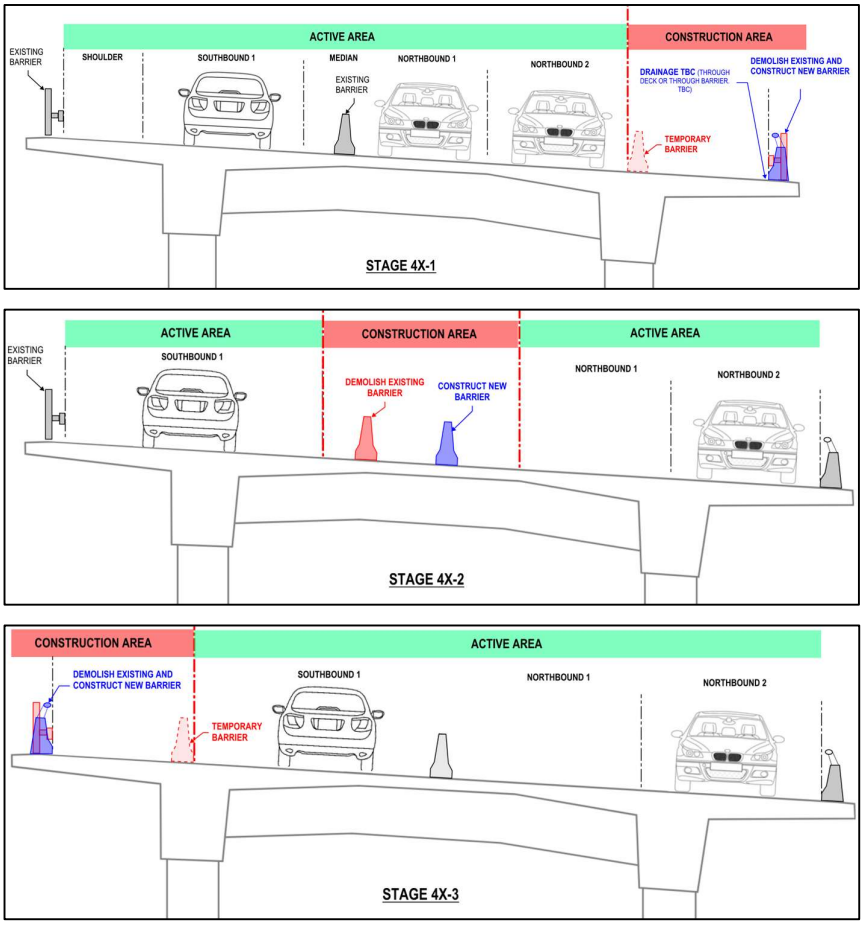


Figure 9: SH1 Shell Gully potential barrier modification sequencing.

Ghuznee St Bridge

Currently the design assumes that the bridge will be replaced in two halves, starting with extending foundations at both abutments before removing part of the northern lane and footpath making the bridge one lane. Then a new extension of the existing structure is built parallel slightly north. Traffic is switched to the new section before the remaining existing bridge is demolished. Finally, the new southern foundations and bridge deck is completed and the new bridge opened in its final configuration. This approach allows either one or two lanes of the route to remain open.

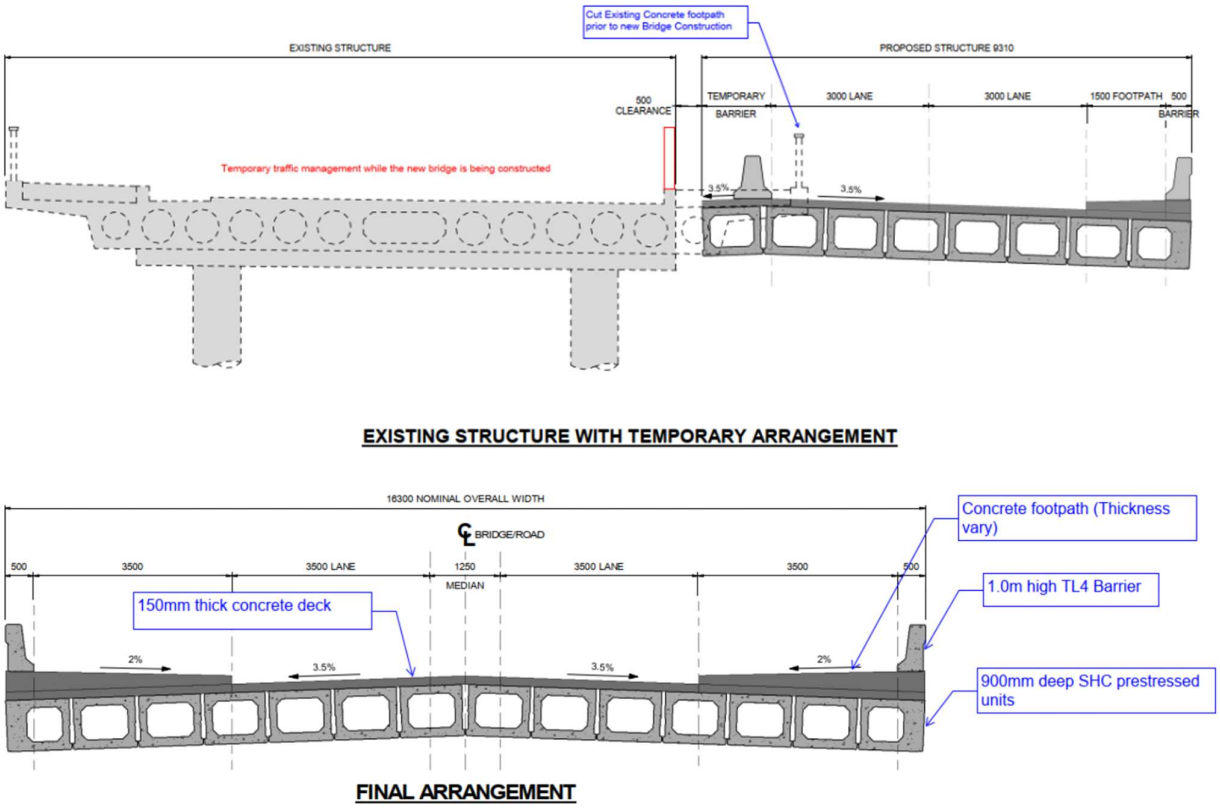


Figure 10: Ghuznee St Bridge potential construction methodology. Upper figure shows intermediate stage and the lower figure the completed arrangement. Source: 03 TT Design Assumptions, Details and Construction Considerations produced by Waka Kotahi April 2025.

Design options for the Ghuznee St Bridge also include extending the existing bridge structure. This will likely minimise the need for SH1 closures with work focusing on the eastern abutment area. Coordination and risk management of utilities including the strategic sewer and stormwater assets will be important to enable construction of an extension option. Traffic disruption on Ghuznee St will likely be similar for either option with at least one traffic lane and one footpath maintained during construction and one traffic lane and one footpath closed to public for a period of around a year.

6.1.4 Methods

Shell Gully

The Shell Gully section upgrades SH1 between the Aurora Terrace and Everton Terrace bridges to accommodate an additional southbound lane by narrowing shoulders and relocating the median barrier. Existing post and rail edge barriers will be replaced with new edge protection traffic barriers. Works are self-contained and can be completed independently of other Project areas.

Construction will occur under staged lane and shoulder closures, maintaining two northbound and one southbound lanes within the total 4 lane existing bridge footprint. For works on the deck edge, areas of the Clifton Car Park below will need to be closed to mitigate the risk of falling objects and materials, and provide space to lift out existing barriers and lift in new barriers from below. Median barriers will be replaced using pre fabricated units lifted into place after removing the existing barrier and preparing the pavement. Edge barrier replacement involves isolating the work area with temporary barriers, removing existing posts and rails, installing new pre fabricated barrier units, pouring stitch joints and attaching steel rails. Additional works include trimming vegetation, adjusting streetlights within rollover zones, and completing localised pavement remediation, surfacing, line marking, and ITS installations. Possible drainage modifications may also be carried out.

Northern Terrace Tunnel Portal

The Northern Portal section involves excavation and slope stabilisation works to form the entry point for the new Terrace Tunnel and its tie-in with SH1. The main entry for light vehicles to this site and primary exit for all

vehicles, except long and oversized, is via Kumutoto Lane. Kumutoto lane is shared use with residents in adjacent buildings on the Terrace and traffic control is required. A new access route through the Clifton South Carpark area may be used, which could be used throughout construction to provide access to the new tunnel portal as well as for staging materials and equipment should a load assessment justify this use.

The sequence of works for preparing the tunnel portal includes staged excavation cuttings supported by ground anchors and facing panels, with the portal face treated with temporary rock bolts and shotcrete. Excavated material will be carted offsite, and the access road upgraded to support tunnel construction traffic.

Key activities include establishment of a haul route for removing excess spoil and portal material, construction of cut slopes in layers, ground anchor installation, erosion control, and staged portal excavation. Following tunnel completion, the SH1 tie-in will be constructed including kerb, drainage, surfacing, ITS, signage, and barrier installations. Temporary works and compound areas will then be removed, and landscaping, footpaths, and road assets reinstated. Construction access will be constrained by low bridge clearances and narrow turning paths at Kumutoto Lane, with potential for temporary access modifications. Construction noise, heavy truck movements and the closure of car parking spaces are likely to need consideration in this area of works.

Northern Tunnel Services and Control Building

In the same work zone as the northern portal and construction access to Kumutoto Lane is the new tunnel control services building, deluge storage water tanks, deluge and fire supply pumps as well as stormwater treatment devices, new maintenance accessways and other service connections. The existing tunnel control building above the existing northern portal will be retained during construction and may be upgraded or retrofitted.

The other service connections and stormwater assets are likely to be trenched with excavation and concrete placement tasks on site. These are typically completed as part of finishing works once large equipment is off site.

Providing access and working space for construction of these facilities while maintaining a route into the new tunnel will be a challenge in this long narrow site. While in construction tunnel lay down and work areas will likely be within the new tunnel and a dedicated lay down area for the services, control building and tanks will be provided around the tunnel portal or areas previously used for spoil handling.

Southern Terrace Tunnel Portal

The southern portal of the new Terrace Tunnel involves staged excavation and slope stabilisation from the existing disused Terrace Tunnel offramp and the carpark behind 184 Willis Street. The works enable construction of the southern tunnel portal, tunnel services building, and connection to SH1. Site establishment includes setup of compounds, fencing, erosion controls, drainage modifications, and haul routes. Excavation is carried out in layers with slope stabilisation using ground anchors, rock bolts, and shotcrete. A temporary service road is established for tunnel fitout and plant access. Depending on the extent of excavation some access may be made from MacDonald Cres particularly for vegetation clearance.

Final works include construction of the new southbound carriageway, drainage, surfacing, barriers, and integration into the SH1 network and Vivian Street tie-in. Upon completion, site facilities are removed and affected areas reinstated with landscaping and permanent access improvements.

New Terrace Tunnel

The new Terrace Tunnel involves construction of a southbound tunnel parallel to the existing northbound tunnel, beginning at the northern portal and progressing downhill to the southern portal (though the opposite orientation is also viable). Excavation will likely occur in two stages, top heading and bench, with tunnel spoil and groundwater managed and exported via the northern portal to the Kumutoto Lane access. Two cross passages will connect to the existing tunnel, and the completed tunnel will include safety systems. Groundwater will be treated before discharge, and surface water will be diverted around the construction zone.

Further information on tunnel construction can be found in section 5.4.

Existing Terrace Tunnel

The reconfiguration of the existing Terrace Tunnel involves converting the current three-lane arrangement into two northbound lanes. Works include removing the existing southbound lane, installing new barriers, modifying drainage if required, and constructing two cross passage portals to the new tunnel. Safety system upgrades and pavement resurfacing are also included.

Construction activities and refurbishment of the existing tunnel will commence only after the new tunnel is operational. Most activities in the existing tunnel can be carried out while traffic is switched into the new tunnel or during night-time closures and staged lane closures. Cross passage construction will involve removal of the existing tunnel lining and localised groundwater control. Final works include pavement reshaping, drainage installation, surfacing, new road markings, barriers, and integration with the realigned SH1 and Shell Gully section.

Southern Terrace Tunnel Services

As part of the tunnel works, new services and modifications to the existing tunnel are required. These may include:

- Fire detection, suppression and safety systems
- Lighting, signage, ITS systems, emergency egress paths and direction
- Hydrants and water supply
- Deluge water supply tank at northern portal adjacent between existing and new tunnels
- Drainage and detention tanks between tunnels at southern portal
- Drainage and stormwater treatment
- Ventilation systems
- Two electrical substations

A new control building above the southern portals will be constructed to replace the existing tunnel control building that conflicts with the new southbound lanes and becomes inaccessible once the new alignment opens to traffic.

The construction of these systems requires new utility connections to be made. Works are staged, often with two systems operating in parallel or by using a temporary system to provide continuous safe operation of the existing tunnel. As the new tunnel approaches completion, the new systems will be installed and tested before it is opened to traffic. Connecting and upgrading systems in the existing tunnel requires this tunnel to be closed. To limit disruption this will be done following the opening of the new tunnel.

The control buildings are simple structures with complex internal electrical and mechanical components. Construction of these utilises equipment typical to commercial buildings, light cranage, multiple daily deliveries by HIAB or flatbed trucks. The majority of assembly is with hand tools and does not require specific consideration.

The new deluge water storage and runoff detention tanks are significant structures. The deluge storage tanks are to be located adjacent to the SH1 corridor alignment (at road level) in the vicinity of the Boulcott St bridge with access during construction from Kumutoto Lane. The detention tanks are buried at the southern portal and will require deep shored excavation or a smaller buried pump station with pressure mains to large detention tanks outside of the main alignment closer to Willis St.

Ghuznee St Overbridge

The Ghuznee Street Bridge will be extended to span the widened SH1 corridor, accommodating four traffic lanes and a median. Design options for achieving this include removing and replacing the full bridge and extending the structure east.

The new bridge option will likely be a multi-span, prestressed hollowcore structure with MSE wall abutments and piers within the SH1 median. Construction will be staged to maintain traffic flow across and beneath the bridge, using night-time closures of the existing SH1 alignment for demolition or beam placement. Initial works involve site preparation and staged construction of the eastern MSE wall. The bridge is then built in halves, beginning with demolition of the northern footpath and shoulder, followed by foundation piling, superstructure erection, and deck construction for the northern half of the new bridge. Traffic and services are transferred to the new structure, enabling demolition of the remainder of the existing bridge. The southern section is then constructed using similar methods. Final works include surfacing, drainage, lighting, and SH1 signage reinstatement. Bridge beam installation over live lanes is expected to be completed during night closures. This methodology assumes that the existing bridge can be reduced to a single traffic controlled lane for the duration of works or that the northern half of the new bridge supports two full traffic lanes.

The extension of existing bridge option again allows for a single existing traffic lane to remain operational during construction. This work likely includes excavation and piling at the new eastern abutment under one existing traffic lane, shoulder and footpath. The existing abutment would likely be jacked and underpinned. Then the deck can be extended to the new abutment. Traffic is switched to this lane before the same process of works is carried out for the remaining traffic lane. Once both sides of the bridge extension are complete the underpinned

abutment can be removed and excavation to the new abutment face carried out opening up the area below the bridge to accommodate SH1 traffic on the new alignment.

6.1.5 Specific Construction activities and potential impacts

Works in this area include many of the construction activities outlined in the general construction aspects of this report. In addition to the general construction aspects, specific construction activities that are not present in other area include the following tasks:

6.1.5.1 Temporary bridge over Cable Car Tracks in Clifton carpark.

This temporary bridge is only required should the Clifton carpark be used as part of the construction yard or if access through the Clifton carpark to the tunnel portal from the Terrace offramp is required.

This temporary bridge allows construction traffic to access the site directly from a SH1 terrace offramp slip lane, reducing construction traffic on local roads. Access over the Wellington Cable car tracks will need to be negotiated and mitigation of impact measures may be required. It is likely that any impact on the cable car will be limited to short duration closures of the cable car route during install and removal of the temporary bridge, likely for a duration of days to a week. Any proposed closure could be aligned with an existing cable car maintenance period to minimise impact. The temporary bridge will be removed once tunnel excavation is complete. The temporary bridge may require independent foundations and is likely to be a Bailey or Acrow prefabricated panel bridge assembled on site. The geometry of the temporary bridge will be outside of the cable car operating envelope and allow the cable to operate normally while the temporary bridge is in service.

Consideration Activity:	Temporary Bridge Over Cable Car Construction
Noise	During assembly crane and steel erection equipment will likely be used including impact wrenches. During operation there may be some noise as vehicles transverse the metal bridge.
Vibration	Not anticipated with the exception of piling for foundations if required.
Dust	Not anticipated, surfaces are sealed.
Erosion and Sediment	Not anticipated, surfaces are sealed.
Environmental	The temporary bridge will cover the Wellington Cable Car tracks, changing appearance and restricting natural light. Approach routes through the Clifton carpark result in temporary parking loss

6.1.6 Considerations

Clifton Public Parking below Shell Gully Overbridge work area

It is anticipated that some areas of the public parking and lower levels of the public parking area at the Clifton St parking building can remain in use by the public during construction. There may be the need to close areas of this parking for works above to reduce the consequence of potentially falling items, materials or concrete. As discussed in the parking and traffic section of this report it is anticipated that sections of approximately 50 car parks will need to be closed. The position of these changes as works progress, once works are complete in an area there does not appear to be a construction reason to keep these parks closed.

Rock quality and strength exceeds plant limits

The anticipated rock quality ranges from highly weathered to fresh, resulting in variable rock strengths throughout the length of the tunnel. It is noted in the Waka Kotahi design document 03 TT Design Assumptions, Details and Construction Considerations that UCS (unconfined compression strength) of rock ranges between 21MPa and 125MPa at the sampling locations and the upper limit for a S300 road header is around 130MPa. There is a risk that rock quality varies and this exceeds the capacity of equipment or results in very slow progress. This could necessitate a change to the tunnelling method during works potentially changing the mining method to drill and blast.

Groundwater ingress during construction

There is a threat that groundwater ingress during construction is more than anticipated and causes issues during construction. Backup strategies or plans may be required to account for this. These could result in an increased construction yard footprint around the Clifton car parks should further treatment or storage of water be required.

At times of high rainfall or surfacing flooding, additional controls may be required to prevent surface water from entering work zones.

6.2 Te Aro Improvements

This section focuses o**n Te Aro Improvements** and explains the construction philosophy and the key construction sequences anticipated for specific elements to provide guidance on area specific construction activities.

6.2.1 Scope of works

This area referred to as **'Te Aro Improvements'** and is associated with the prefix **'TA'**. It extends from Vivian St south of the Ghuznee St overbridge to Cambridge and Kent Terrace as well as some intersection and pavement works along Karo Drive / Arthur Street (SH1) east of Cuba Street

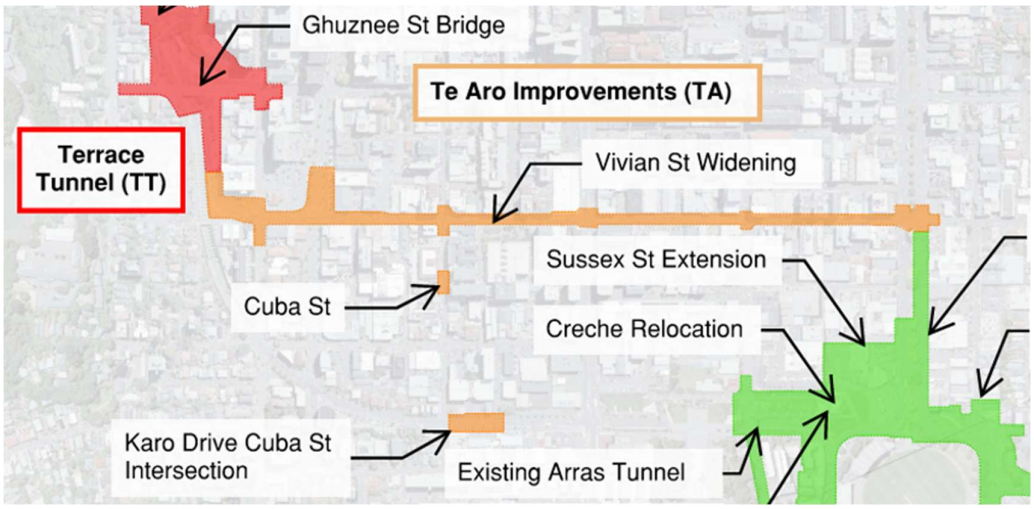


Figure 11: Te Aro area of works (source NZTA background documents)

Vivian St Widening includes the work undertaken between the tie-in to the existing SH1 south bound carriageway at the western end of Vivian St, through to the intersection with Cambridge Tce and Kent Tce at the eastern end of Vivian St.

Karo Dr and Cuba St Intersection includes the work undertaken on SH1 Northbound on the approach to the Cuba St Intersection.

6.2.2 Sequence of Work

There are no strict interdependencies between areas of work in this area. However, it would make sense to progress from one end of Vivian St to the other to minimise and localise disruption.

6.2.3 Traffic Diversions and Access Staging

This area involves the reconfiguration of Vivian St and the Karo Drive/Arthur Street intersection with Cuba Street both of which are key commuter routes through the Wellington CBD. Traffic volumes are high, intersections are signalised and complex, and the corridor is flanked by dense development with minimal room for temporary works. Traffic management in this area is assumed to require:

- Careful staging and lane reconfiguration to maintain flow.
- Responsiveness to complaints or unplanned impacts due to the high public visibility.
- 24/7 pedestrian access management, especially around commercial frontages.
- Coordinated communications with businesses and residents. This area is expected to require the most intensive traffic management effort of the Project, with a strong case for collaborative contracting and flexible delivery to manage disruption adaptively.
- Two traffic lanes to remain in operation during construction along Vivian St and Karo Dr.

Work sequences on Vivian St are anticipated to be similar with construction commencing in one lane on one side then switching to the other side before completing the central pavement reconstruction. This allows the existing two traffic lanes plus parking or shoulder area to be used to provide two traffic lanes and a working zone. A typical staging arrangement for the Vivian St upgrades is shown in Figure 12.

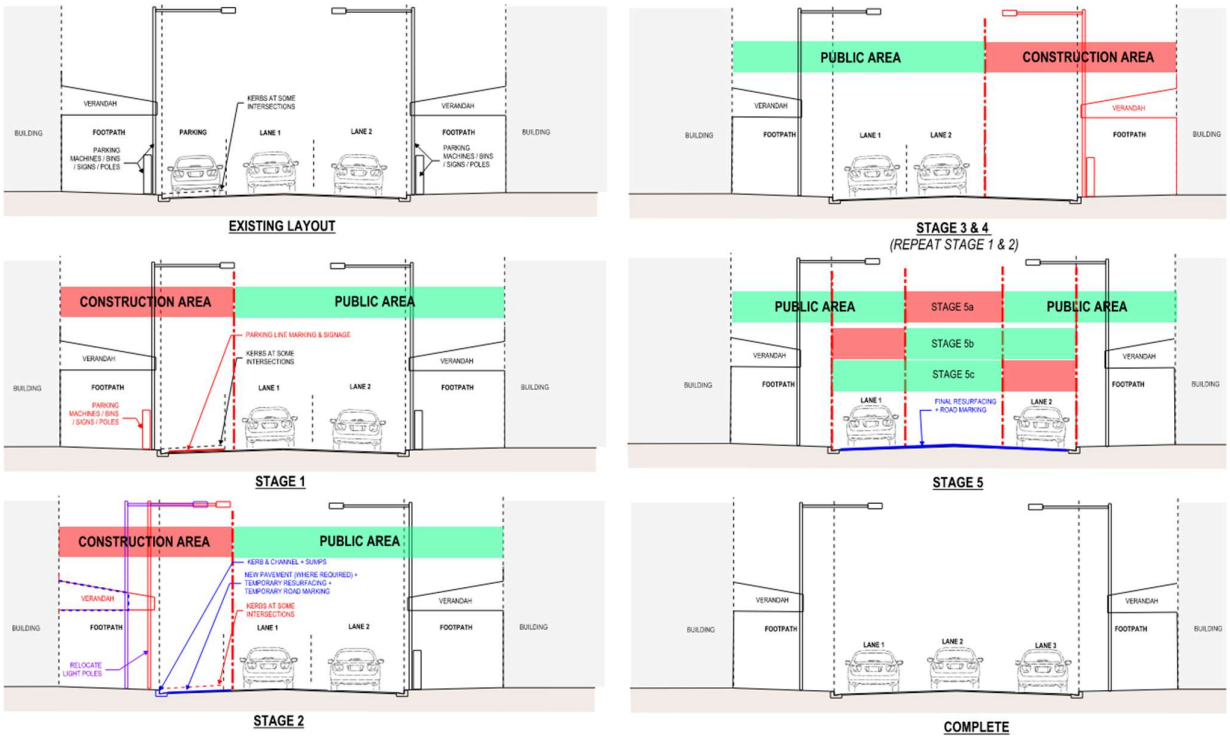


Figure 12: Potential Te Aro construction staging. The approach shown is typical for many areas of works along Vivian St.

Access to Buildings and Accessways on Vivian St

Vivian St has a mixture of residential and commercial spaces alongside the street's footpaths. The work on Vivian St may reduce, and in some cases block, access to driveways and shop front entrances. Traffic management plans will require care around side driveway access for businesses and residential buildings. The management plans will also need to consider access to the shops with Vivian Street frontage entrances to ensure customers can still access these locations.

Traffic management may also affect fire exits for some buildings that exit onto the footpath from the first floor. By extension this may also affect fire evacuation mustering areas.

Consideration will need to be made for the potential need for providing offset parking when access to private parking is blocked by the works and working with the owners and operators of these premises to develop strategies to manage these effects. A potential mitigation strategy is to carry out works in a very localised manner between access points and covering exposed works with steel plates when not actively being worked on to allow access through the worksites.

6.2.4 Methods

Vivian St widening works

The Vivian St widening works involve staged reconstruction of the SH1 corridor through Te Aro to accommodate two southbound lanes, including localised kerb realignments, footpath upgrades, and resurfacing. Construction is divided into "Blocks" and "Intersections", each with a consistent methodology and limited space requiring staged use of available carriageway and footpath zones. It is anticipated that an initial package of works will see the removal of signage and parking control assets located in the footpaths, along with the modifications to building verandahs.

Block works proceed in two halves: first clearing carparks and constructing the northern side (including kerb and channel, footpath, drainage, and pavement), then shifting traffic and repeating on the southern side. Intersections are constructed sequentially around each corner, then resurfaced across the full intersection width

in multiple passes. Final stages include full-width pavement milling and overlay, new line marking, ITS, lighting adjustments, and reinstatement of signage. Temporary closures of side roads and footpaths will be required, managed via staged line marking and signal adjustments.

Cuba St intersection

The Karo Dr/Arthur St and Cuba St Intersection works are limited in scope and primarily involve resurfacing, kerb alignment changes, footpath widening and signal modifications. Pavement works require staged milling and resurfacing of the existing three-lane carriageway with line marking reinstated after each lane is completed. No pavement widening or reconfiguration is proposed. At the intersection, signal upgrades and signage changes will remove right-turn movements. Signal reprogramming and installation of 'No Turn' signage will be completed with minimal disruption to existing traffic flows.

6.2.5 Specific Construction activities and potential impacts

Works in this area include many of the construction activities outlined in the general construction aspects of this report. In addition to the general construction aspects, specific construction activities that are not present in other area include the following tasks:

6.2.5.1 Specific construction activity - Reconstruction of verandahs.

Verandahs extending from commercial buildings over footpaths will require partial or full removal and reconstruction where modifications are needed to suit the new corridor alignment. These works may involve disconnection of existing fixings, structural demolition (cutting, unbolting), and installation of replacement cladding. Works will be undertaken from scaffold or hoarded zones established within the footpath and may require temporary closure or diversion of pedestrian access. Coordination with building owners and tenants will be required to maintain access to commercial premises during construction.

Specific risks likely being assessed as part of the design but extending into the construction phase include:

- **Suitability for re-use:** existing structural support may no longer meet building code requirements and modification requires the system to be upgraded to meet the current building code.
- **Discovery of damage or deterioration:** existing verandahs may not be weathertight or could have suffered from deterioration overtime. It may mean that once exposed during construction additional works are required to repair discovered deficiencies or damage.
- **Impact on fire escape egress:** some verandahs are utilised as a fire escape route, during temporary works this may not be possible and if permanently modified they may not remain compliant.
- **Structural modification:** Modification of verandah support may require modification to other areas of cladding or building envelope. Where support is required to extend into the primary building structure this would need to be done in coordination with the owners.
- **Heritage values:** Some verandahs are associated with scheduled heritage buildings, meaning that any modifications to the verandahs should be limited and in keeping with the building's architectural style – these matters will be provided for through specific conditions and plans as described in the heritage report.

Consideration Activity:	Reconstruction of verandahs
Noise	Intermittent construction noise from scaffold erection, hand tools, and fixing of hoarding structures.
Vibration	Vibration producing equipment for these tasks is generally small and hand operated, including bolting or verandah construction.
Dust	Works include surface preparation (e.g. sanding, drilling), dust will be minor and can be managed with hand tools and vacuum systems.
Erosion and Sediment	Not applicable
Environmental	There is the potential that verandahs contain hazardous materials (asbestos, lead flashings etc.) which may require specialist disposal.
Traffic/Access	Pedestrian diversions, narrowed footpaths, or temporary crossings may be required.

6.3 Basin Improvements

This section focuses on works around the Basin Reserve and explains the construction philosophy and the key construction sequences anticipated for specific elements to provide guidance on specific construction activities.

6.3.1 Scope of works

This area of works is referred to as **'Basin Reserve improvements'** and is associated with the prefix **'BR'**. Key work areas are shown in Figure 13 and this area extends between the edge of works being carried out in the Te Aro Improvement area at Vivian St and the Arras Tunnel on the western side and the Mt Victoria Western Portal at the east extent.

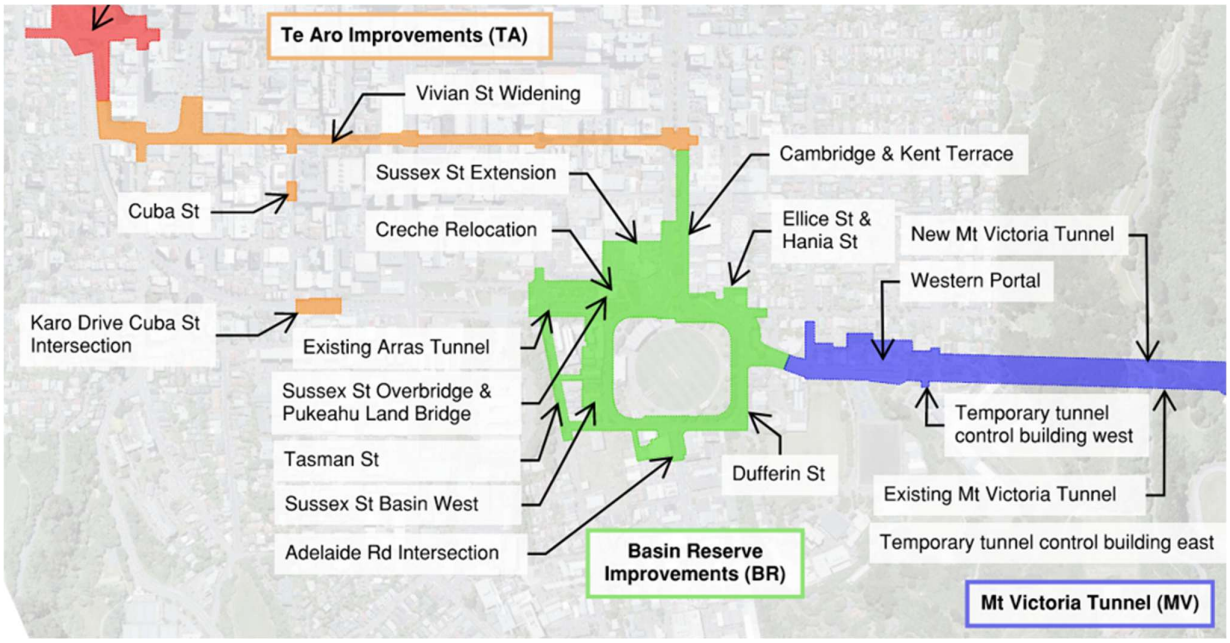


Figure 13 – Basin Reserve area of works

Cambridge-Kent Tce includes the rearrangement of lanes on Cambridge Tce and Kent Tce including construction of new road sections connecting to the Sussex St Extension.

The **Creche Relocation** is the relocation of the historic creche building to make way for subsequent works in the area.

Sussex St Extension includes the construction of a new road extending the new Sussex St underpass to Cambridge Tce. The **Sussex St Overbridge and land bridge** includes the construction of a new SH1 bridge over Sussex St Extension and an adjacent land bridge connection between Pukeahu National War Memorial Park to Cambridge Tce.

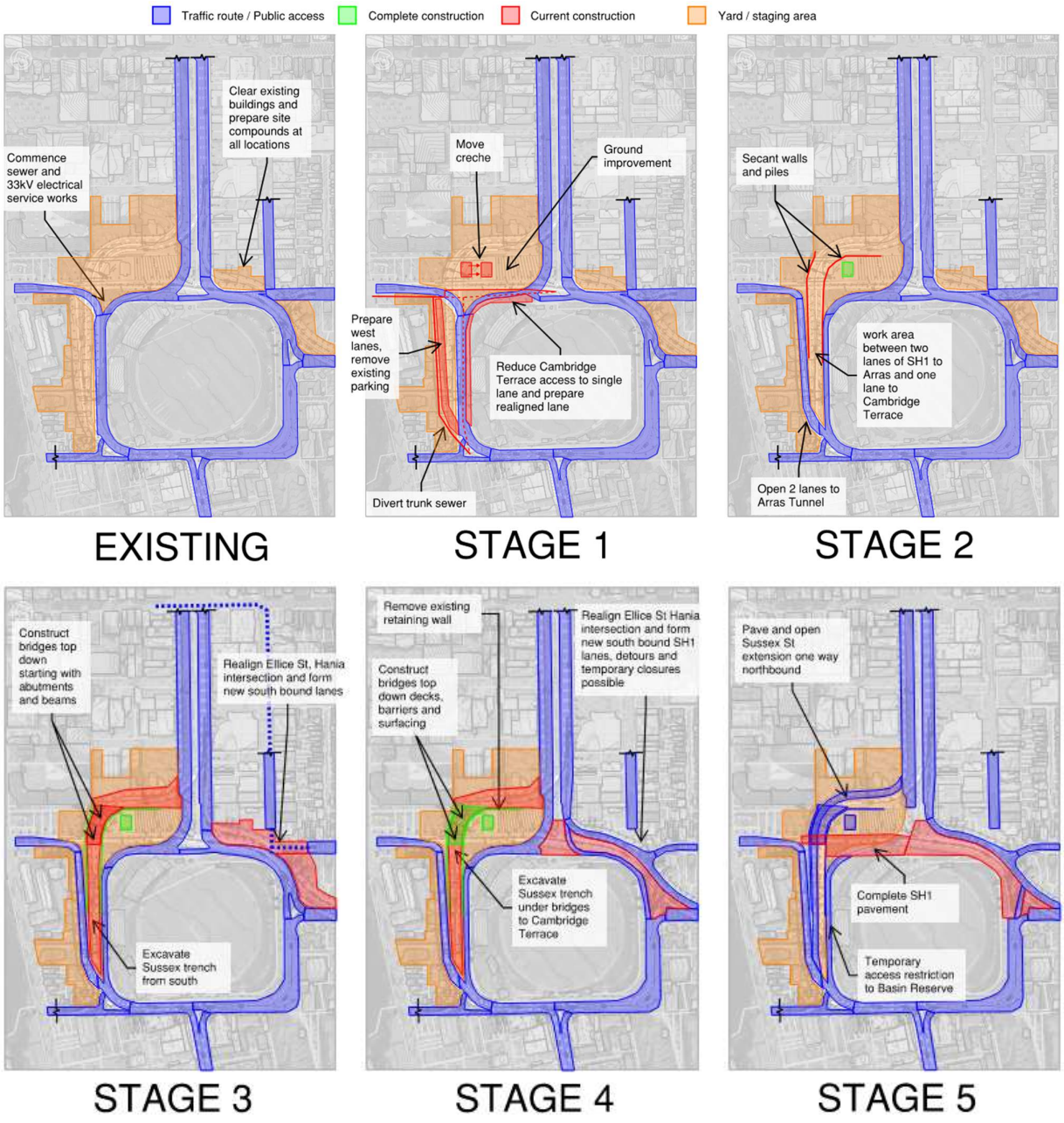
Sussex St, Basin West includes the rearrangement of Sussex St between Rugby St and the Sussex St Overbridge. This includes the construction of the new Sussex St trench, slip lanes to SH1 northbound, and an access road to Cambridge Tce behind the West Stand of the Basin Reserve.

East Basin includes the construction of a new northbound SH1 and realignment of the southbound SH1 to the Mt Victoria Tunnel Western portal area.

The **South Basin** works include the rearrangement of Adelaide Rd from SH1 (at the Mt Victoria Tunnel western portal area) to Sussex St with the intersection at Rugby St and modifications to school access areas east of the Basin on Dufferin St.

6.3.2 Sequence of Work

The sequence of works will be critical to maintaining access for construction and for the public through the site. Many activities require others to be completed prior to them being able to be undertaken without resulting in significant disruption. A potential sequence of works is shown in Figure 14.


Traffic route / Public access
Complete construction
Current construction
Yard / staging area
Commence sewer and 33kV electrical service works
Clear existing buildings and prepare site compounds at all locations
EXISTING
Move creche
Ground improvement
Prepare west lanes, remove existing parking
Reduce Cambridge Terrace access to single lane and prepare realigned lane
Divert trunk sewer
STAGE 1
Secant walls and piles
work area between two lanes of SH1 to Arras and one lane to Cambridge Terrace
Open 2 lanes to Arras Tunnel
STAGE 2
Construct bridges top down starting with abutments and beams
Realign Ellice St, Hania intersection and form new south bound lanes
Excavate Sussex trench from south
STAGE 3
Remove existing retaining wall
Realign Ellice St Hania intersection and form new south bound SH1 lanes, detours and temporary closures possible
Construct bridges top down decks, barriers and surfacing
Excavate Sussex trench under bridges to Cambridge Terrace
STAGE 4
Pave and open Sussex St extension one way northbound
Complete SH1 pavement
Temporary access restriction to Basin Reserve
STAGE 5

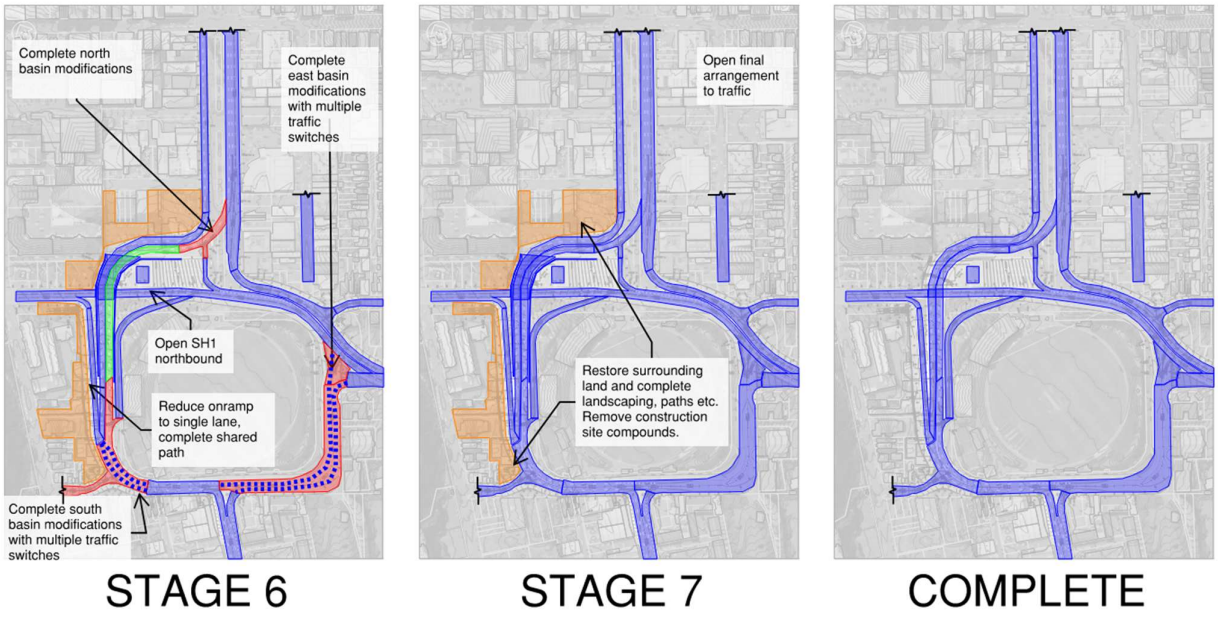


Figure 14: Potential staging for Basin Improvements works.

The key sequence constraints include:

Completing the new Cambridge Terrace alignment and opening Sussex St northbound under the new SH1 overbridge to public traffic. This allows the work zone for the new SH1 alignment north of the Basin Reserve to be used for construction activities.

Following this there are a series of minor lane adjustments within the designation that allow Cambridge Terrace to be set up for two way traffic and road works completed for the SH1 northern route to be complete.

The next major switch is opening the new SH1 alignment north of the Basin Reserve. This reduces traffic flow on Sussex St allowing it to operate in two directions. Southbound traffic on Sussex St allows Dufferin St to be made one way.

A further series of minor traffic switches complete works around the southern and eastern sides of the Basin Reserve during which time traffic volumes through this area of site should be significantly reduced due to the northern routing of SH1 northbound traffic.

6.3.3 Traffic Diversions and Access Staging

While still urban, this area presents more opportunity for controlled staging, especially along Kent Tce and Cambridge Tce. Grade separation works will require:

- Monitoring of detour routes, turn priorities and signal optimisation
- Specific planning around public transport corridors and cycling routes.
- Phased implementation to maintain through-movement around the Basin. This area will require phasing and early engagement with public transport operators, schools, and sports/event organisers due to frequent use of the Basin area.

Construction sequences consider construction disruption and will meet the following criteria:

- Provide two north bound and two south bound SH1 lanes between the Mt Victoria Tunnel and Vivian St / Arras tunnel.
- Provide one local traffic lane in each direction between Adelaide Rd and Kent / Cambridge Tce (shared with SH1 lanes in some sections).
- Minor local road intersection closures or turn restrictions permitted as required
- Pedestrian and cycle access restrictions through Pukeahu National War Memorial Park and around the Basin Reserve while providing a minimum of one north/south and one east/west route around the basin for pedestrians and cyclists.

Access to St Mark's School and Preschool

St Mark's School and Preschool have two vehicle access points onto the Dufferin St eastern service lane. These access points will be kept open for most of the construction period. Access to the service lane may be controlled via stop-go or other types of traffic control when Dufferin St is undergoing road reconstruction for a period of months. Should trenching or drainage works be required, there may be periods of days to weeks where vehicle access to St Mark's is temporarily disrupted. These works may be coordinated with holiday periods, weekends, or other times of lower use. Access can also likely be restored at the end of each shift with temporary cover plates and utilise off peak work to minimise disruption. As works in this area are completed there will be a traffic switch phase that requires access to be blocked for a short period of hours to days while final tie ins, signage and line marking are completed.

Pedestrian access to St Mark's is currently via two access points. Construction works can be managed during Dufferin St road re-construction to allow continuous access to at least one of these access points. Communication with St Mark's and the public directing users along safe routes will be managed as works progress.

Bus services can use the Dufferin St service lane bus stop (Metlink number 6010) during the majority of construction. This bus stop will be relocated during Dufferin St road re-construction. Alternative bus stop locations will be created in the parking spaces on the south side of Rugby St during construction phases that restrict access to the Dufferin St bus stops.

Commonwealth Walkway and Cycle Trail and Old Buckle St Pathway

The Commonwealth Walkway and Cycle Trail currently provides pedestrian, wheelchair and cycle access between Pukeahu National War Memorial Park at Tory St to Cambridge Tce and forms a key part of the east west route north of the Basin Reserve. This area and pathway will be closed for the full duration of construction of the Sussex St Extension Trench and overbridges as well as during the creche move. It is unlikely to open again until Sussex St is open to traffic and SH1 is on its new alignment.

The Old Buckle St pathway, south of the Arras Tunnel trench, is the alternative route for pedestrians travelling east west between the Basin Reserve and areas towards Adelaide Rd. This pathway will be closed as one of the first construction or early works tasks to allow the strategic services to be relocated. It won't open until after SH1 traffic is on the new alignment and the slip lane from Sussex St has been reduced to a single lane. The clear alternative route for users is to continue down Tasman St to Rugby St before continuing their journey.

The primary diversion route for east west pedestrians through this area is from Pukeahu National War Memorial Park around the south side of the Basin along Tasman St and Rugby St. For north-south movement routes to the east of the Basin are anticipated to remain accessible during construction with localised detours around active construction sites.

Access for events should prioritise Basin Reserve access from the north and south access points and control of pedestrians travelling east west should be considered as crossing points aren't controlled.

6.3.4 Methods

Home of Compassion Creche

The Home of Compassion Creche is a masonry Category 1 heritage building. Moving this structure out of the construction work area requires it to be fully closed, potentially strengthened, then slid over the top of heavy structural beams using jacks to its new position. This is similar to the move carried out during the previous Arras Tunnel works and a similar method is proposed. Clearing the site around the new SH1 alignment and Sussex St overbridge requires the removal of vegetation and landscaped areas. Its movement may also result in the loss of the turning bay at the end of Martin Square. It is expected that at least one section of Commonwealth Walkway and cycle trail can remain open for the majority of the works to move the creche except for a short duration (days to weeks) closure to allow the repositioning movement to occur. Depending on permanent works staging, the Commonwealth Walkway may reopen before being closed for bridge construction or be closed from the creche movement until completion of construction. The construction of the sliding beams likely has the most impact with minor excavation and reinforced concrete works, the movement is slow and powered by jacks with minimal vibration or noise. Permanent access and parking has not been considered but will likely result in a paved surface accessing the creche and landscaping around the final position.

Strategic service realignment

There are many services that run along the Arras Tunnel corridor. Some of these have been relocated in 2014 to sit in trenches immediately behind the tunnel walls. They are generally electrical/telecoms/gas and small diameter water, stormwater and sewer pipes. These have the potential to introduce complexity around the new

construction, with the potential to require re-routing or bespoke details to accommodate them. Near surface services would need to be exposed and rerouted prior to secant walls or other piling works commence. This added complexity would be anticipated to be accompanied by cost and time impacts. The existing drainage services are shown in Figure 15.

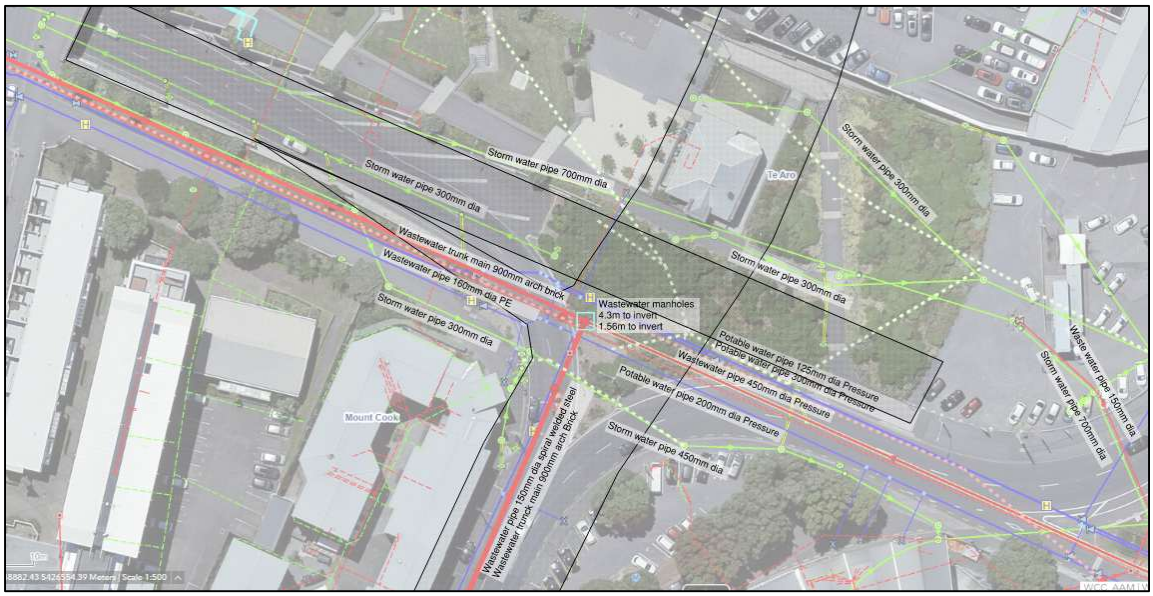


Figure 15: Overlay of drainage and water services at the eastern end of the Arras Tunnel trench.

The consent design for the bridges and Sussex St Extension Trench requires existing strategic services to be moved. This includes the following significant and complex assets:

- 33kV electrical cables, likely oil filled and nearing end of life, currently positioned near the southern side of SH1 alignment. These cables can only be spliced at specific locations and may require a much longer length of cable to be replaced than that directly affected by the works footprint. No detailed design information has been provided on their relocation and it has been assumed that the cables can be spliced near to the Arras Tunnel and to the east of the Basin. The detour route is assumed to be south of the Basin Reserve adjacent to the road corridor likely underground beneath footpaths accessed via open trenching. This cable is assumed to be the same cable being replaced in the Mt Victoria Tunnel, therefore it may be sensible to consider replacement of the full length at one time if works can be coordinated. A coordinated replacement would also limit service disruption.
- 900mm brick arch sewer main currently positioned near the southern side of SH1 alignment coming from the south side of the Arras Tunnel before turning south down the existing Sussex St. This is to be realigned east adjacent to the new SH1 onramps and in the footprint of cleared buildings on Sussex St before meeting the existing connection near Rugby St. Brick sewers are highly sensitive to disturbance and vibration. The sewer invert near the new Sussex overbridge is approx. 4.5m below existing grade. Brick sewers may also have archaeological value and therefore subject to specific requirements and conditions in the archaeological authorities for the Project.
- 450mm pressure sewer main currently positioned near the southern side of SH1 alignment transporting fluid from the Kent Tce pump station. This will be replaced with a new parallel pipe connected to the SH1 overbridge. Pressure sewers are typically less complex to move as they do not require a set fall, provided the existing pump station has sufficient head and capacity for the increased flow length and elevation. However, the long length of sewer to the nearest valve chamber at Kent Tce and the repositioning of the outlet makes this service connection complex as a parallel pipe will need to be laid and temporarily supported above ground near to the proposed over bridge before the existing main is disconnected.
- 700mm stormwater main servicing the Arras Tunnel is required for the operation of the Arras Tunnel and is assumed to allow for deluge extraction as well as general stormwater. It is buried in the National War Memorial Park near the current creche position approximately 6m below the surface at the bridge abutment. The diversion route for this service is to pick up the line underground near the new bridge abutment and deviate north through Pukeahu park on the retained side of the proposed secant pile wall.

It then breaks through the existing concrete retaining wall on the north side of the park and follows the new Sussex St alignment to Cambridge Tce where it discharges into larger stormwater assets.

For all these strategic services, it is assumed that continuous operation must be maintained with negligible disruption to service. To allow for this, parallel services in their permanent position need to be installed prior to the service switch. As there are a limited number of access chambers in the vicinity of works, new manholes are required. Careful design consideration of the location of these manholes is important to allow access during construction and maintenance without needing to close traffic lanes in the current or future alignments while allowing space for tasks to be carried out.

33kV connection

The new 33kV electrical cables can likely be installed by directionally drilling between access shafts at the nearest connection points. This work can be carried out at any time prior to the trench excavation and could be identified as an early works opportunity.

900 brick sewer

For the sewer pipes, the first stage of works involves clearing the existing properties on Sussex St. This will allow a new large diameter (likely 1200mm) sewer interceptor pipe connection to be made between the end of the Arras Tunnel retaining wall and the existing Rugby St manhole. This will likely be a combination of open trenching and micro tunnelling where depths make open excavation impractical. The path of this pipe will need to consider any existing deep foundations or piles from the existing buildings on Sussex St. Connection to the existing manhole at Rugby St will require open excavation and is anticipated to be straight forward and carried out by breaking into the existing manhole. Connection at the Arras Tunnel end will be significantly more challenging. The only existing nearby manhole is directly in line with the proposed Sussex St Extension Trench, therefore a new manhole is proposed west of the works footprint behind the Arras Tunnel retaining wall. This requires deeper excavation to expose the brick arch barrel but allows these works to be carried out without significant traffic disruption.

Excavation of the existing brick sewer will be careful and slow, likely utilizing hydro vacuum trucks. Trench protection is necessary due to the depth and position adjacent to operational traffic lanes that prevents a full open cut. Sheet piling or other temporary methods are unlikely to be suitable due to the fragility of the brick sewer. Once exposed, a containment basin, manhole and connection to the new interceptor pipe need to be constructed. This and the pipeline to Rugby St will need to be complete prior to breaking into the existing pipe. Once break in is achieved, the short length crossing over the existing SH1 as well as the full length from the manhole east of SH1 to Rugby St can be sealed and fluid removed via suction truck for this section to complete the decommissioning of the existing asset.

Sewer rising main

A further connection at the new access chamber south of the Arras tunnel should be made for the sewer rising main from Kent Tce. Directional drilling or micro tunnelling techniques could be used to drive this to a new manhole at the western side of the new Sussex overbridge location beneath the Sussex St to Arras Tunnel section of SH1 while it remains in operation. This may be deep below ground and needs to consider interfaces with existing retaining walls around the eastern approach to Arras Tunnel. Considering the topography this section may be able to be gravity fed with the manhole being the termination for the rising main.

A new pressure sewer rising main can then be installed likely between the valve chamber at Kent Tce and the new manhole at the eastern abutment. A portion of which may be temporarily exposed and supported above ground at the bridge to allow diversion over the new Sussex St overbridge. This pipe would then be connected to the bridge once the bridge is built.

It could be that the simplest and lowest construction risk option is to replace the full run of pipe from the valve chamber at Kent Tce to the Rugby St manhole. This option is a longer but much simpler route as it removes all interfaces with proposed retaining walls, trenches and prevents the need for supporting the pipe from the bridge or the construction of new manholes.

Once all sewer connections are made then the rising main pressure sewer can be transferred to the new pipeline.

700mm stormwater main from Arras Tunnel

There are multiple options to allow the 700mm stormwater main from Arras Tunnel to Cambridge Tce to be relocated. The details of which will be developed during detailed design phases. In all cases diversion of this stormwater pipe is required before secant piling for the new Sussex St Extension Trench can be carried out.

An option is to carry out deep excavation in a shored or temporary trench from a new connection point and new manhole near to the arras tunnel retaining wall to the retaining wall between the Te Papa Tongarewa Museum of New Zealand collection storage facility and new Sussex St Extension trench. This includes removing sections of existing retaining walls, potentially strengthening retaining walls that remain but are penetrated by the pipe and excavation of a deep shored trench.

One alternative option is to construct a new pump station in Pukeahu National War Memorial Park to intercept this stormwater pipe to lift the pipe over the new bridge before continuing as a gravity pipe to Cambridge Terrace. This pump station option may be temporary during construction until a new pipe can be connected after the secant walls, piles and bridge are constructed or it may become a permanent solution to pump stormwater over the bridge. Installing the pump station and potential detention tank requires a deep shored and propped excavation pit within Pukeahu National War Memorial Park or potentially providing an intake near to the existing manhole and lateral on the eastern side of Arras Tunnel. The pump servicing this equipment is expected to be operational during periods of wet weather, during cleaning or when the deluge fire suppression system operates. The pump may also operate intermittently to control groundwater ingress. Should the pump station be temporary it will likely be at surface and will generate noise.

It may also be possible to reroute this pipe elsewhere from the existing manhole on the eastern side of Arras Tunnel. Connections within the tunnel require shallow simple excavation but will be carried out within a single lane closure to keep traffic capacity at a minimum of two northbound lanes. As this location is directly adjacent to where the current alignment extends from two to three lanes, extending the position of the lane increase for a temporary period while this work is carried out is not anticipated to be a traffic control constraint. Options will be developed during detailed design.

Sussex Street Extension

The Sussex Street Extension involves constructing a new local road north of the Basin Reserve in a trench below the new SH1 northbound alignment. The first stage includes demolition of existing commercial and light industrial buildings on Cambridge Tce and removal of landscaping features through the Pukeahu National War Memorial Park. This will block pedestrian and cyclist access through this area of the park including the commonwealth walkway and cycle route.

As the Sussex St Extension is in a trench, it splits the new SH1 onramp and Basin reserve access road. To allow for continuous access and two lane SH1 traffic, a new two lane onramp will be constructed parallel to the existing alignment. Traffic will be diverted to this to allow the secant or contiguous pile walls lining each side of the trench and supporting the overpass to be built. Once the bridge is complete (see following section) the trench is excavated using these secant walls as side retaining support. The exposed secant walls are often covered with a precast concrete facing. Pavement works then complete the extension. The base of the trench is likely to be up to a 9m deep excavation with buried permanent props and a groundwater drainage system. Near ground level props at the top of the wall may also be required during construction for the deeper excavation areas.

Noise and vibration effects from demolition, retaining wall works, and compaction activities could affect adjacent buildings, in particular the Te Papa Tongarewa Museum of New Zealand collection storage facility which is understood to have highly sensitive exhibits. Vibration monitoring and property condition surveys are recommended to manage risks to nearby sensitive structures or contents.

SH1 Sussex St Overbridge, Land Bridge and Active Modes Bridge

The Sussex St Overbridge, adjacent land overbridge and active modes bridges involve construction of new single-span bridges. For SH1 over the future Sussex St Extension Trench, immediately east of the Arras Tunnel. The bridge deck will likely consist of precast concrete beam units supported on bored pile abutments that are likely installed as part of the secant wall works. The land bridge allows the National War Memorial Park to continue over Sussex St and will likely be either prestressed concrete or streel girders with a concrete deck.

The bridges will be constructed top down to make use of the access from Sussex St and reduce working at heights construction risks. All three bridges are conventional in construction with heavy equipment required for pile installation, cranage for superstructure beam positioning, concrete works for the abutments, decks and barriers.

Basin Reserve, Kent Tce and Cambridge Tce

Construction along Cambridge Tce, Kent Tce, and around the Basin Reserve involves staged pavement reconstruction, kerb realignment, service relocations, and installation of stormwater and traffic management infrastructure. Early works will include removal of parking and footpath assets, with resurfacing, landscaping, and utility upgrades sequenced to maintain traffic flow through Kent and Cambridge Terraces and accommodate reverse traffic flow scenarios. These works will be staged to limit disruption and effects but require traffic management, footpath closures, and temporary changes to pedestrian and cycle access.

To the east, west and south of the Basin Reserve, the realignment of SH1 and the Adelaide Rd intersection works require multiple traffic shifts and adjustments to pedestrian facilities. To the west of Sussex St and at the corner of Adelaide Rd, buildings will be demolished, and pavement reconstructed while maintaining Sussex St as a live corridor. On the east side, staged modifications to the Adelaide Rd intersection and Dufferin St will enable bus, school and government house access while introducing a new SH1 slip lane from Paterson St. Temporary access points and bus loading zones may be needed during construction.

The eastern side of the Basin Reserve on Dufferin St requires careful consideration and timing of works. While pavement reconstruction and minor realignment are common construction tasks, this area is critical to traffic flow and providing access to schools. It is also likely that the eastern side of the Basin will serve as the primary pedestrian and cyclist diversion route while the more complex works around Sussex St overbridge and the Sussex St Extension Trench are being carried out. Impacts on traffic disruption, access changes to schools, access for Basin Reserve events, local businesses, and the cumulative impact of staged construction on pedestrian and cyclist movements are all considerations in this area. Due to traffic and access constraints, it is likely that night works will be utilised in this area to allow more restrictive traffic controls to be implemented. Vegetation clearance, and utility relocations will also require management of construction noise and community interface.

6.3.5 Specific Construction activities and potential impacts

Works in this area include many of the construction activities outlined in the general construction aspects of this report. In addition to the general construction aspects, specific construction activities that are not present in other area include the following tasks:

Construction Activity – Groundwater Reinjection

Groundwater reinjection may be required where deep excavation dewatering for the Sussex St Extension Trench alters the natural groundwater regime and affects nearby assets or environmental receptors (e.g. settlement-sensitive buildings). The process involves capturing pumped groundwater, treating it as needed, and reinjecting it into the ground via wells located outside the immediate construction zone. Reinjection systems may include pre-treatment units (e.g. filters, tanks), distribution pipework, and pressure-controlled injection points. The system design depends on local hydrogeology, available reinjection zones, and required flow rates.

Consideration Activity:	Groundwater Reinjection
Noise	Pumps, valves, and water treatment units in continuous operation. Noise sources include electric pumps and backflushing systems.
Vibration	Reinjection involves low-pressure flows and does not generate ground vibration.
Dust	Negligible
Erosion and Sediment	Overflows or line leaks may cause localised erosion near reinjection points. Reinjection areas must be stabilised and bunded.
Environmental	Reinjected water must meet quality standards to prevent aquifer contamination. Reinjection system must be monitored for flow, pressure, and water quality. Coordination with consent conditions for both discharge and reinjection required.

6.3.6 Considerations

Access for events

The area around the Basin Reserve and Pukeahu National War Memorial Park are pedestrian throughfares for public events. Construction activities may need to be aligned such that pedestrian access can remain delineated from construction activities. At present the construction site for the new Sussex St Extension Trench and SH1 bisects a main pedestrian route and temporary access through site may be required for events.

Demolition material management

Common risk mitigation strategies for building demolition including asbestos management and dealing with potentially contaminated waste materials will need to be implemented. An assessment of existing buildings in this zone to identify potentially hazardous materials should be undertaken prior to starting demolition. There is also potential for contaminated land to be present from the areas past use as automotive repair and light industry.

Destabilisation of adjacent structures from permanent works

Destabilisation, settlement or increased loading of Te Papa Tongarewa Museum of New Zealand collection storage facility southern wall and Basin Reverse cricket museum is a risk to be managed. A monitoring program with sensors and alarm levels is recommended as well as a precondition survey. Heavy vehicle access and the use of large compaction equipment within the influence areas of these structures should be avoided. This monitoring should remain in place until the Sussex St Extension overbridge and trench is completed and adjacent retaining walls to identify if movement or settlement is occurring and potentially for years following should settlement issues be identified.

Additional geotechnical risks from the movement of material and lowering of groundwater table should also be assessed. These geotechnical risks are largely related to the permanent works but will have an effect during construction as ground pressures change and earthworks are completed. Settlement risks also apply to in ground services particularly gravity fed drainage pipes with low slopes that may risk new localised low points from settlement.

Vibration to adjacent structures

Immediately adjacent to 75 Cambridge Tce is the Te Papa Tongarewa Museum of New Zealand collection storage facility. It is possible that some items held in its collection are sensitive to vibration. Demolition works, drilling for ground anchors, construction of secant and other retaining walls as well as compaction of fill are all construction activities that produce vibration. Vibration limits need to be identified early and monitored during works. It may be that particularly sensitive items need to be relocated to minimise risk for the duration of adjacent construction works.

Access to Educational Facilities East of Basin Reserve

The zone contains preschool, primary and secondary school facilities. Access to these will need to be maintained during the works. Pedestrian and vehicular traffic (including school bus) peaks at drop off and pick up times will need to be managed during construction.

Access to Government House

Government House's main access is located east of the Basin Reserve. Consideration should be given to access during construction, noting that alternate access is available from Hospital Road.

Strategic service interaction

There is a risk that strategic services become damaged or go out of service during relocation works. This would impact a large portion of the city and cause widespread disruption with limited ability to repair promptly. The assets are generally old, fragile and approaching end of life, further increasing this risk. These strategic services have been identified in design documents and specific measures will be taken by the contractor to protect these during works. It is likely that the service owner will require detailed methodologies, protection details and contingency plans to be approved before allowing the contractor to procced with works in the vicinity of strategic services.

Temporary stability and basal heave at Sussex St Extension Trench

During construction dewatering will be required and likely compensatory pumping to allow construction in the dry. Should a pump failure occur during construction elevated groundwater pressures could permanently destabilise the ground below the base slab and destabilise temporary works. Due to the large excavation extent and potentially high groundwater pressures control of basal heave and groundwater pressure at multiple points along the excavation extent will be critical.

Contaminated land at Sussex St Extension Trench northern extent.

There is a possibility of contaminated land being encountered at the northern end of the Sussex St Extension Trench. While this can likely be managed with typical construction practises from a surface earthworks perspective, groundwater movement including both dewatering and compensation pumping combined with

inevitable fluctuations in groundwater level may result in contaminants being spread through adjacent soils and water bodies.

6.4 Mt Victoria Tunnel Duplication

This section focuses on the **Mt Victoria Tunnel Duplication** and explains the construction philosophy and key construction sequences anticipated for works in this area.

6.4.1 Scope of works

This area is referred to as **'Mt Victoria Tunnel Duplication'** and is associated with the prefix **'MV'**. The area shown in Figure 16 and extends between the Basin Reserve and Ruahine St at the interface to the Eastern Connections area.

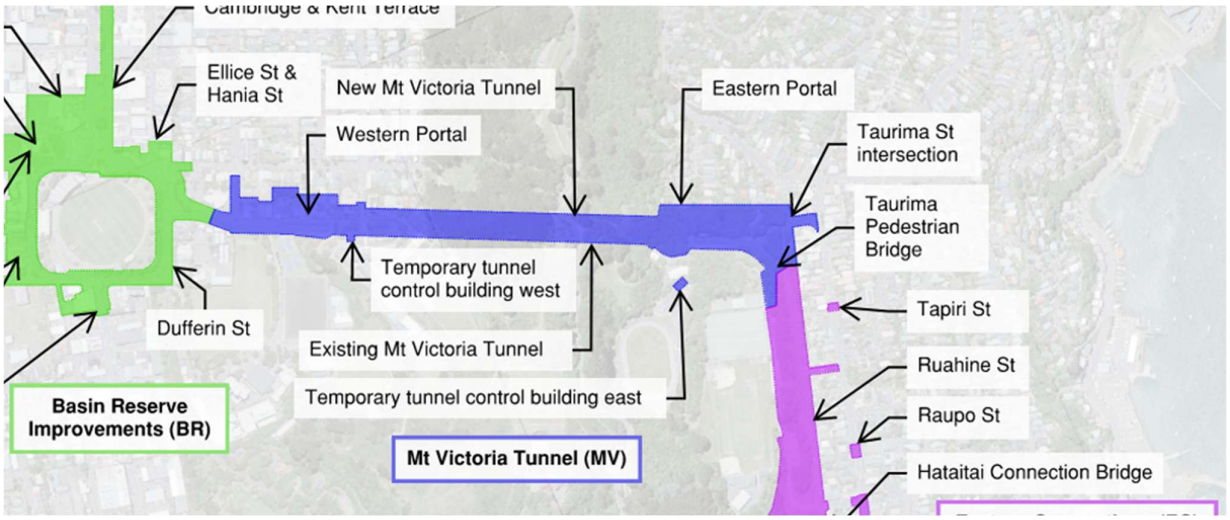


Figure 16: Mt Victoria Tunnel Duplication (MV) work area

The **Western Portal** area of works includes the tie-in to the Basin Reserve Improvements area, through to the Western Portal of the Mt Victoria Tunnels. This is predominantly bulk earthworks to excavate the area around the existing Paterson St and the cut required for the new Mt Victoria Tunnel western portal. It includes temporary relocation and replacement of historic houses, construction of a new tunnel control building and stormwater detention tanks, decommissioning of the existing tunnel control buildings and creation of a construction yard to facilitate tunnel mining.

The **New Mt Victoria Tunnel** includes work undertaken between the western and eastern portal to construct a new duplicate mined tunnel adjacent to the existing Mt Victoria Tunnel. There is an area of cut and cover at the western end. This also includes cross passages between the new and existing Mt Victoria Tunnels.

The **Existing Mt Victoria Tunnel** work includes the removal of an elevated shared path, new tunnel services and decommissioning of ventilation shafts.

The **Eastern Portal** area is a large cut excavation to form the new tunnel portal north of the existing tunnel. A second tunnel controls building and fire deluge water supply tanks with a pump station are also proposed. The removal of the existing and construction of a new Taurima St pedestrian overbridge is also in this area. As are a replacement block of public toilets should the existing block conflict with works and require removal.

6.4.2 Sequence of Work

The sequence of works for the Mt Victoria Tunnel duplication assumes that the new tunnel will advance from the western portal uphill towards the east. For traffic to be able to use the new tunnel, pavement works, adjacent road realignments and changes to grade need to be completed. On the western side this likely extends to the Paterson St to Dufferin St Intersection. On the eastern side this extends to the approximate position of the existing pedestrian bridge over Ruahine St. Some of these works are included in the adjacent Basin Improvements and Eastern Connections areas of works. A potential construction sequence is presented in Figure 17 and Figure 18.

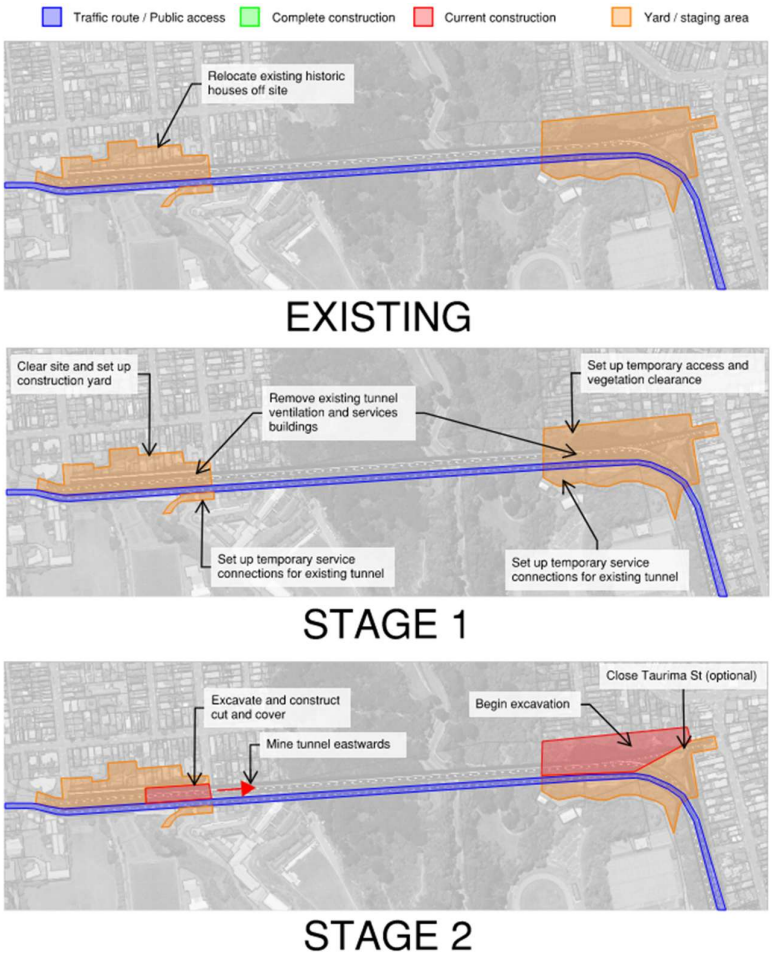


Figure 17: Mt Victoria Tunnel potential construction sequence from commencement to stages 1 and 2.

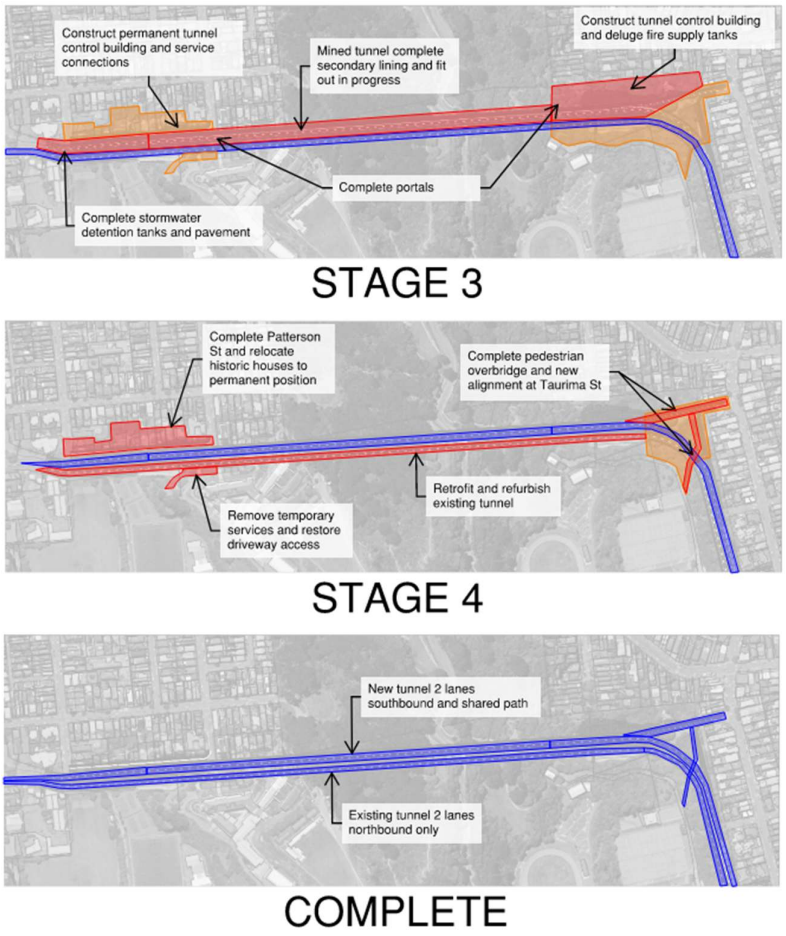


Figure 18: Mt Victoria Tunnel potential construction sequence from stage 3 to completion.

The sequence of work allows for the new tunnel to be constructed first then once works at both approaches is complete two way traffic is switched to the new tunnel. The existing tunnel is then upgraded before the final traffic arrangement is achieved with one way, two lane traffic in each tunnel.

To allow for continuous service supply to operating tunnels, temporary facilities are required. The existing tunnel control and services are on the northern side of the existing tunnel between it and the new tunnel. All of the existing facilities must be removed early in construction to free up work areas and portal excavation. It is anticipated that one of the early work tasks is to construct temporary service connections and control buildings in the Wellington East Girls' College car park at the western portal (subject to approval by the Ministry of Education) and near the substation in Hataitai Park on the eastern side. This may also extend to replacing the existing tunnel ventilation system with jet fans hung from the ceiling of the existing tunnel that will need to be installed during brief closure periods over weekends or night works. This would remove the need to keep external fans and ventilation operational simplifying staging and reducing conflicts.

Once temporary services are connected to the existing tunnel the existing facilities can be removed and portal excavation can commence. The western portal and set up of the construction yard will be prioritised to allow tunnelling mining to begin as early as possible. Once the Paterson St area is cleared and historic buildings relocated the yard and spoil handling areas will be set up. The cut and cover excavation with shotcrete walls and soil nails will be cut. The contractor then has the option to continue with mined excavation and proceed into the main drive with the road header or complete the forming of the concrete arch at the cut and cover early. Once the cut and cover arch is formed it can be backfilled with low strength concrete.

Mined tunnelling can continue eastwards while the eastern portal is excavated with rock anchor and shotcrete supported slopes. Once the initial header cut breaks through the eastern portal should be excavated and complete once the bench cut returns. After mining, the secondary lining is installed and fit out commenced. During this stage construction yards are rearranged to allow tunnel control buildings services and deluge fire supply and stormwater detention tanks to be built. The large water supply and detention tanks will likely be

buried below the road alignment and are significant structures in deep shored trenches. The construction of these will disrupt access to the tunnel for larger vehicles and one at each end will likely be built at a time once break through is made to allow continued access.

6.4.3 Traffic Diversions and Staging

This section includes the construction of a second Mt Victoria Tunnel and modifications to the existing tunnel. Construction staging will need to:

- Manage access to adjacent schools.
- Have a methodology developed that allows the existing tunnel to operate while the new tunnel is being constructed.
- Remove pedestrian and cycle access through Mt Victoria Tunnel during tunnel construction
- Retain existing road capacity (during the day) through Mt Victoria Tunnel

The key stages for construction of the duplicate Mt Victoria tunnel include:

1. Close Paterson St for duration of works and clear site around western portal.
2. Construct new tunnel services building and temporary facilities as required, relocate services from the existing tunnel to these to maintain operation.
3. Excavate and construct western portal
4. Advance tunnel from west to east
5. Excavate and construct eastern portal
6. Complete cross passages and pavement on approaches
7. Switch traffic to new tunnel in a bidirectional flow mode with one lane in each direction
8. Open new tunnel shared path to users
9. Refurbish existing tunnel
10. Open permanent traffic arrangement with single direction traffic in each tunnel.

Closure of existing Mt Victoria Tunnel shared path

The closure of the shared path on the north side of the existing Mt Victoria tunnel during construction is required to:

- Facilitate access to work areas between the two tunnels, at the existing services buildings and for excavation at the portals.
- Allow demolition of existing tunnel service facilities on the northern side at both portals.
- Allow for modifications of the ventilation system that currently utilises vertical shafts and an air plenum below the shared path.
- Allow for cross passage breakthrough activities at each of three locations that penetrates the shared path.
- Minimise closure time for blasting operations (if required) in the new tunnel as the existing tunnel and path will need to be vacant during each blast.
- Allow 33kV cables to be accessed for relocation that are currently buried beneath the shared path approaches at both ends of the tunnel.
- Provide space along the length of the tunnel for new or relocated services prior to the existing tunnel refurbishment. Is it anticipated that services disrupted by cross passage construction or temporary services such as ventilation will be diverted onto the shared path walkway or utilise the air space immediately above the path.

The assumption is that the shared path would be closed at the commencement of works until the new tunnel is complete and its shared path can be opened. This increases construction efficiency, reduces multiple stages of temporary works and improves safety as the works area is fully separated from live traffic and pedestrian routes.

Closure of the shared path through the existing tunnel may also be dictated by excavation of the eastern portal cut slope, whereby path closure may be required to address the risk of excavated material falling onto the path as it emerges at the tunnel's eastern portal.

Design options that could minimise the closure period would need to include temporary access at both portals (likely stair towers and temporary bridges over the existing portals) and consider how ventilation and other service disruptions could be managed. Regardless, there will be a period of time, with a duration of years, once cross passage works commence until the new southbound tunnel shared path is opened where pedestrian access through the Mt Victoria Tunnel is not possible.

Access to Wellington East Girls' College

Wellington East Girls' College currently has two vehicle access points. With the primary two way vehicle access point to the main driveway from Paterson St, and a secondary Austin St entrance that appears to be primarily pedestrian access with gates restricting vehicle access to a single car. During the Mt Victoria Tunnel construction, the Paterson St driveway entrance will be closed from commencement of works until the new tunnel cut and cover section is completed allowing a new access to be formed. This is expected to have a construction duration of years. Traffic using the existing Paterson St driveway exit will be re-routed to the Austin St entrance and internally within the school.

The access steps from Paterson St steps to the main school building may remain open. However, pedestrian access will be blocked on Paterson St where the section of road is closed and a detour will be put in place via Austin St, and Ellice St. Alternatively, pedestrians can use the Austin St access for low mobility access.

The existing pedestrian access via the pathway along the southern side of SH1 will be unaffected for students catching buses from the area in front of St Mark's School and Preschool. The primary bus services for the school are still expected to use the Austin St bus stop (Metlink number 6008) during construction.

It is anticipated that during initial retaining works around the new tunnel western portal and for final pavement works to reinstate the Paterson St driveway, access to the school from the end of Austin St may be temporarily closed for duration of weeks, for each task at the start and end of tunnelling works, to allow working space above the tunnel portal. This would restrict all vehicle access to the school. The requirement for this restriction of access is highly dependent on the temporary retaining required to form the end of the cut and cover tunnel section and specific permanent works design details. If this type of access restriction is required, this will need to be carefully discussed with the school and timed during a period of low use of the school, so as to minimise impacts.

Should a larger construction area be required or greater extent to allow for the cut and cover portion of tunnel to transition to hard rock tunnel there is an option to use a temporary bridge structure to span over the tunnel portal and provide continuity of access to Wellington East Girls' College. This temporary bridge could remain in place during all construction works in this area and provide a reliable access point for pedestrians, cyclists and vehicles. A temporary bridge could also mitigate any disruption by replacing access to the Paterson St driveway.

Paterson St will be closed during construction. This will require consultation with the school to manage current pedestrian, bus, and private vehicle access to the college to mitigate complaints or access issues during construction.

6.4.4 Methods

Western tunnel portal

The western portal works involve demolition of residential buildings on Paterson St and staged construction of a new Mt Victoria Tunnel portal, associated retaining walls, and a replacement tunnel services building. A cut-and-cover section is included to visually align the new tunnel with the existing one and provide support to the existing portal. Multiple retaining structures including soldier pile, MSE, soil nail, and cast in situ retaining walls will support deep excavations and enable access to the tunnel portal. Early works include service relocations, including stormwater, potable water, sewer, and high-voltage power, along with site clearance and establishment of site access routes.

Construction will be sequenced to maintain vehicle access to the existing Mt Victoria Tunnel and Wellington East Girls' College, while supporting spoil handling during tunnel excavation. Initial activities include closing Paterson St, relocating services, removing buildings, and establishing construction access. The new tunnel services building will be commissioned early in the construction staging to allow decommissioning of the existing facilities. Temporary services may be required to keep the existing tunnel in operation during transfer between service facilities. Retaining walls will be installed progressively using top-down construction methods, with some sections supporting later tunnelling works. Temporary closures of SH1 are expected utilising night works to manage traffic impacts to complete works directly adjacent to the existing traffic lanes including the removal of the shared path and services buildings.

Later stages include construction of the cut-and-cover tunnel, formation of the new portal, backfilling, and pavement reconstruction along Paterson Street. Final works include pavement tie-ins, structural finishes, tunnel systems integration, and installation of lighting, drainage, barriers, and signage. Some works on the existing tunnel and existing portal may be completed after the new tunnel opens to reduce disruption. Key impacts include temporary changes to road access, traffic staging, shared path closures, and construction noise and vibration near schools and residential areas.

Alternative construction options

The area at the end of Paterson St and Austin St provides access to Wellington East Girls' College but is directly impacted by the proposed works. Alternative options include fully removing this access point and providing primary access to the school via the Mt Victoria Quarry pathway or a temporary bridge over the tunnel portal site. These alternatives are unlikely to be suitable for vehicle traffic without modification and are not usable for buses. Access for disabled users should also be considered. It is possible the construction team could look to utilise school holiday periods where there are significantly fewer users to set up or remove access provisions in this area.

Eastern tunnel portal

The eastern portal works involve demolition of buildings on Taurima St, removal of the existing tunnel services building, significant excavation, construction of a new portal, pedestrian bridge, and associated retaining structures.

The pedestrian bridge providing access to Hataitai Park will be replaced as part of works It is assumed the new pedestrian bridge will be a prefabricated steel or concrete superstructure on concrete piers and bored or driven piles.

Staged excavation of the portal face will be carried out top-down with rock anchoring and shotcrete to stabilise slopes. Rockfall protection and traffic separation will be required throughout. Once the portal face is complete, a cast in situ headwall will be constructed, followed by tunnel breakthrough and final pavement and service works. Precast facing panels or architectural cladding may be applied.

New tunnel construction

The new Mt Victoria Tunnel involves constructing a parallel tunnel to the existing one to accommodate two southbound traffic lanes and a separated shared path. The tunnel will be constructed from the western portal to eastern portal using a mechanical mined tunnelling method utilising a road header and tunnel excavator, with the potential need for some drill and blast. All tunnelling activities, including spoil handling, plant access, and groundwater treatment, will occur via the western portal, with laydown areas established on Paterson St.

Construction of the new shared path, safety and fire systems, lighting, and pavement will follow tunnel excavation and secondary lining. Night works should be anticipated for all tunnelling works. Key impacts include intermittent existing tunnel closures, noise and vibration from excavation, transport of spoil and construction materials through central Wellington.

More details on tunnel construction are provided in Section 5.4 of this report.

Tunnel Services and Control Buildings

As part of the tunnel works, new services and modifications to the existing tunnel are required. These may include:

- Fire detection, suppression and safety systems
- Lighting, signage, ITS systems, emergency egress paths and direction
- Hydrants and water supply
- Deluge water supply tank
- Drainage and detention tanks
- Drainage and stormwater treatment
- Ventilation systems
- Two electrical substations

New control buildings above the western portal and near Taurima St on the eastern side will be constructed to replace the existing tunnel control facilities.

The construction of these systems requires new utility connections to be made. Works are staged, often with two systems operating in parallel or by using a temporary system to provide continuous safe operation of the existing tunnel. As the new tunnel approaches completion, the new systems will be installed and tested before it is opened to traffic. Connecting and upgrading systems in the existing tunnel requires this tunnel to be closed. To limit disruption this will be done following the opening of the new tunnel.

The control buildings are simple structures with complex internal electrical and mechanical components. Construction of these utilises equipment typical to commercial buildings, light cranage, multiple daily deliveries by HIAB or flatbed trucks.

The new deluge water storage and runoff detention tanks are significant structures. Likely to be buried multiple meters deep requiring temporary shoring or large open excavation. The detention tanks are buried at the southern portal and will require deep shored excavation or a smaller buried pump station with pressure mains to large detention tanks outside of the main alignment closer to Willis St.

Existing tunnel modifications

Works within the existing Mt Victoria Tunnel focus on removing the north-side shared path to enable construction of cross passages and provide additional lane width. The existing shared path also contains ventilation and high-voltage electrical services, which will be rerouted to allow for demolition and integration with the new tunnel services building at the western portal. While core systems such as lighting, fire suppression, and monitoring (installed in the 2010s) are not expected to be altered, the tunnel ventilation system is likely to be upgraded as the shared path platform will no longer be useable for ventilation once the cross passages are complete. The shared path will be permanently closed and not reinstated, with pedestrian and cyclist access redirected through the new tunnel once complete.

Once the new tunnel is operational with bidirectional traffic flow, full refurbishment of the existing tunnel will proceed under closure, including pavement and drainage adjustments, barrier installation, and upgrades to signage, lighting, and traffic systems to support unidirectional traffic. Key impacts include tunnel closures, service disruptions and altered pedestrian and cyclist access during construction.

The existing vertical ventilation shafts will be decommissioned as part of the new ventilation system. These will require access through the Town Belt for construction vehicles. There are existing tracks for maintenance though these may require localised improvements to provide suitable access for construction vehicles. Activities required consist of; demolition of the existing ventilation shaft buildings, localised excavation, and construction of a capping slab to seal off the opening before being backfilled.

6.4.5 Specific Construction activities and potential impacts

Works in this area include many of the construction activities outlined in the general construction aspects of this report. In addition to the general construction aspects, specific construction activities that are not present in other area include the following tasks:

6.4.5.1 Specific construction activity – Modification of existing portals

The existing Mt Victoria Tunnel, constructed in the 1930s, may require modifications to allow the new tunnel to be constructed. These works are currently undefined but may include:

- **Structural modifications** such as installation of rock bolts and local concrete strengthening to walls or roof areas.
- **Service modifications**, including relocation, removal, or temporary reconfiguration of lighting, ventilation, power, or communication systems to enable continuous operation during transition phases.
- **Modifications to pedestrian access**, including localised removal of the existing elevated shared path and modification of access to allow use during more construction phases.

These works may need to be carried out under staged closures or night works to limit disruption. Once the new tunnel is operational, full refurbishment of the existing tunnel is expected, allowing access for intrusive works without public traffic.

Consideration Activity:	Modification of existing portals
Noise	Concrete cutting, drilling for rock bolts, service relocation, and demolition.
Vibration	Rock bolt drilling and minor demolition works. Vibration management required near ageing concrete and surrounding infrastructure
Dust	Dust from cutting, drilling, demolition, and service trenching.
Erosion and Sediment	Above-ground demolition and limited excavation activities.
Environmental	Debris and waste from demolition to be contained and removed offsite. Service modifications to be isolated from live systems during works. Pedestrian access changes to maintain minimum egress standards during staged construction.

6.4.5.2 Specific construction activity – Backfill of existing pilot tunnel with flowable fill

A pilot tunnel constructed in the 1970's and approximately 2.5m in diameter, in a position that is parallel to the proposed new tunnel will be backfilled prior to mining of the new tunnel. The backfilling will use a low-strength, flowable concrete fill to fully occupy the void and prevent future settlement, groundwater movement, or void migration. Access to the pilot tunnel will be via existing portal openings, and placement will be staged to allow controlled flow and curing. The fill will likely be placed using gravity or low-pressure pumping systems depending on alignment and access.

Consideration Activity:	Pilot tunnel backfill
Noise	Concrete batching or delivery trucks, low-pressure pumping, and handling of formwork or access covers. Localised and short-duration activities.
Vibration	Minimal. No heavy equipment or ground-disturbing works expected during fill placement.
Dust	Minimal. Dry mix handling (if done on-site) and minor dust during access preparation.
Erosion and Sediment	Potential overflow or washdown water to be contained and isolated from stormwater systems.
Environmental	Concrete wash water and excess flowable fill must be contained. Access to pilot tunnel to be safely managed during pumping. Fill to be designed to avoid leaching or groundwater interaction.

6.4.5.3 Specific construction activity – Strengthening of existing tunnel

The requirement for and design of strengthening is yet to be determined in detail and is dependent on tunnel spacing, seismic design requirements and design of the cut and cover section. Should strengthening of the existing tunnel be required the main options include:

- Steel mesh and bolts
- Shotcrete and bolts
- Shotcrete, mesh and bolts
- Cast in situ lining (or lining replacement)

All of these options are installed from within the existing tunnel and will require it to be closed during works. Works could be carried out prior to other work over multiple closures or during the refurbishment period while traffic is running in the new tunnel.

Consideration Activity:	Strengthening of existing tunnel
Noise	Drilling for rock bolts, mesh fixing, shotcrete application, concrete batching or pumping for lining works. Contained within existing tunnel.
Vibration	Rock bolt drilling and equipment operation inside tunnel.
Dust	Dust generated from drilling, surface preparation, and shotcrete rebound.
Erosion and Sediment	Internal works only; dust and rebound to be collected and removed. No stormwater exposure but cleaning water must be contained.
Environmental	Washdown water, rebound concrete, and excess grout must be captured and disposed of. Lighting, air quality, and access conditions to be controlled during confined-space operations.

6.4.5.4 Specific construction activity – Decommissioning of existing Mt Victoria ventilation shafts

Existing tunnel ventilation shafts, vertical concrete-lined structures extending from the existing tunnel to the surface, will be decommissioned and permanently sealed. There are two of these, one within the school grounds between the Mt Victoria quarry and Wellington East Girls' College and the other east of Alexandra Rd within the Town Belt. These shafts have a small ventilation building where they surface. Works include decommissioning of electrical systems, removal of the above-ground fan units and small control buildings, shallow excavation around the shaft head (approx. 2 m depth), and construction of a reinforced concrete cap to close off the shaft. All activities will be undertaken within the Town Belt, with temporary fencing and safe access controls in place.

Consideration Activity:	Decommissioning of existing ventilation

Noise	Noise from building demolition, fan removal. Noise from saw cutting, small excavation plant, formwork, and concrete pouring. Intermittent but confined to defined work areas.
Vibration	Vibration from concrete breaking or excavation near shaft heads. Vibration from plate compactors and equipment used for backfilling and form preparation.
Dust	Relatively small areas of excavation will be required dust generation is not anticipated and exposed for a relatively brief period. Dust from concrete cutting and excavation; managed using wet-cutting and water suppression.
Erosion and Sediment	Soil disturbance during shaft excavation; bunding or silt socks to be used to prevent runoff into surrounding park or stormwater system.
Environmental	Given the age of the structures there may be hazardous materials present that require specialist disposal (asbestos etc). Electrical decommissioning to comply with isolation procedures. Waste materials, including mechanical plant and concrete debris, to be removed to appropriate facilities. Shaft voids to be made permanently safe, access to be highly restricted prior to capping while temporarily exposed during decommissioning.

6.4.5.5 Specific construction activity – Rockfall protection

Rockfall protection measures will be installed to mitigate slope instability and protect road users from dislodged material. These may include high-tensile steel mesh draped or anchored over cut slopes, catch fences at slope toes, or shotcrete facing in targeted zones. Installation involves drilling for anchor placement, mesh deployment, fixing, and in some cases, concrete spraying. Works are typically carried out using rope-access or elevated work platforms, and may occur adjacent to live traffic lanes, requiring protective barriers or temporary closures.

Consideration Activity:	**Rockfall protection**
Noise	Noise from drilling anchors, installing mesh, and (if applicable) shotcrete operations. Localised and variable depending on slope height.
Vibration	Vibration from anchor drilling, generally not perceptible beyond slope face.
Dust	Dust from drilling or surface preparation, especially in dry weather; managed with localised water suppression.
Erosion and Sediment	Potential during slope disturbance or anchor drilling. Use of sediment barriers or temporary diversion channels recommended at slope toe, along with hydroseeding and other surface control systems.
Environmental	Anchoring and mesh installation may generate spoil or dust. Controls needed to avoid material entering stormwater systems or sensitive vegetation.

6.4.6 Considerations

Storage of materials and staging area

There is limited space within the work zones to store and stage materials around the Mt Victoria Tunnel site, particularly at the eastern portal and at the commencement of works. If works in this area are carried out after the Basin and Eastern Connection works, construction crews may be able to utilise other nearby construction compounds. This staging of site compound use and positioning will need to be carefully considered in consultation with many stakeholders.

The current area adjacent to the western portal cut is sloped (or terraced) and will make spoil handling more complex or assembly of large temporary works items such as the secondary lining form difficult. An option is for the contractor to cut down the site west of the portal, within the Project designation, to a constant level creating a near flat construction yard. This requires an additional earthworks phase as the ground likely needs to be reformed after works but has efficiency benefits. Additionally, this option lowers the construction yard relative to adjacent receivers potentially reducing noise, light and dust emissions from the site.

The area around the eastern portal is also highly constrained and there is limited space within the construction corridor to accommodate a site compound staging area, materials handling zone and environmental controls that may be required such as water treatment, wheel wash and erosion control. It is understood the area around the badminton hall could be utilised should it not be in use at the time for the Ruahine St works. This would be beneficial for worker facilities, bathrooms, offices and meeting spaces. However, a closer location and one that removes the need to cross over SH1 would be preferable to allow faster construction and reduce construction traffic on the existing SH1.

6.5 Eastern Connections

This section focuses on works along Ruahine St and wellington road referred to as **Eastern Connections.** It explains construction philosophies and the key construction sequences anticipated for specific elements.

6.5.1 Scope of works

The works in this area are shown in Figure 19 named as **'Eastern Connections'** and is associated with the prefix **'EC'**.

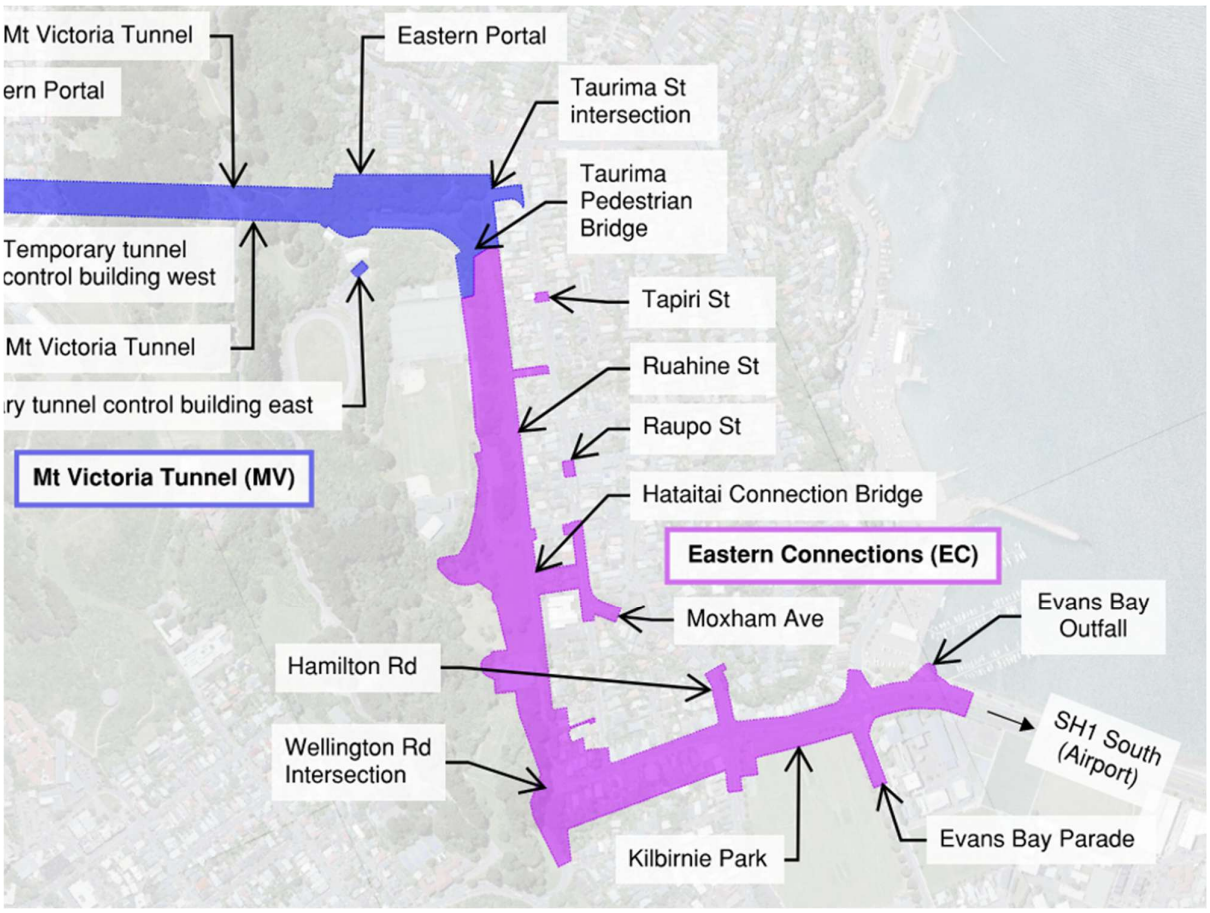


Figure 19: Eastern Connections (EC) area of works

The **Eastern Connections** along Ruahine St and Wellington Rd includes works undertaken between the Eastern Portal of the Mt Victoria tunnel to Cobham Dr. The works include widening of Ruahine St, Hataitai Connection Bridge, a grade separated interchange providing access to Hataitai Park, modification of Wellington Road intersection, widening of Wellington Rd, and local road intersection upgrades in Hataitai and Kilbirnie.

In addition, there is a new stormwater main (1200mm to 1500mm) proposed from Ruahine St near Goa St to an upgraded outfall at Evans Bay.

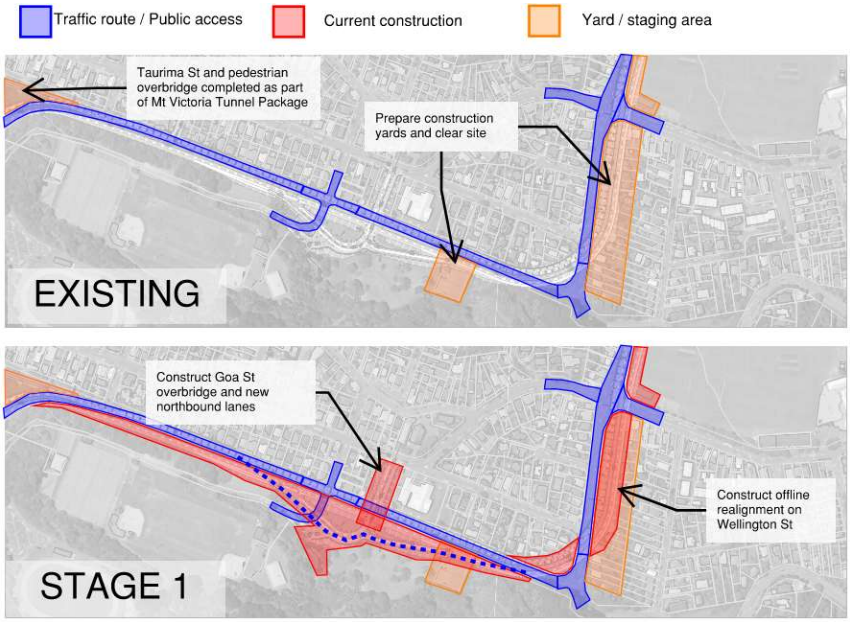
6.5.2 Sequence of Work

The construction of the new stormwater main (1200mm to 1500mm) from Ruahine Rd near Goa St to Evans Bay will need to be carried out early in the construction process to limit disruption and allow for continuous operation of stormwater assets. Currently there are multiple options for the route and multiple install methods for this pipe. In general, these options utilise trenchless techniques with launch pits off the alignment near Hataitai Park, Kilbirnie Park and Evans Bay where the pipes are deep below surface ~5-30m for the majority of the ~600m pipe length. Where the new pipe is shallower, with an invert less than approx. 3m, and at the new outfall location at Evans Bay open trenching would likely be preferred. Some options also include disruption to Moxham Ave and Hamilton Rd where launching pits are proposed within the existing road corridor. Should the options that include disruption to local roads be carried forward then the construction of this new stormwater main will need to be carried out prior to the main eastern connections construction works. This would prevent disruption to multiple parallel routes.

The Hataitai Connection Bridge and interchange could be completed prior to removing the Taurima St and existing Goa St access points to maintain traffic flows and turn options. The Hataitai Connection Bridge could be constructed and opened prior to removing the Hataitai Park pedestrian bridge at Taurima St to maintain continuous grade separated access for pedestrians.

The works along Wellington Road generally are able to progress within the permanent road alignment with multiple traffic switches to maintain access to properties and intersections. The modifications at Kilbirnie Park and reconstruction of the cricket club building can be completed at any time.

A potential construction sequence is presented in Figure 20.



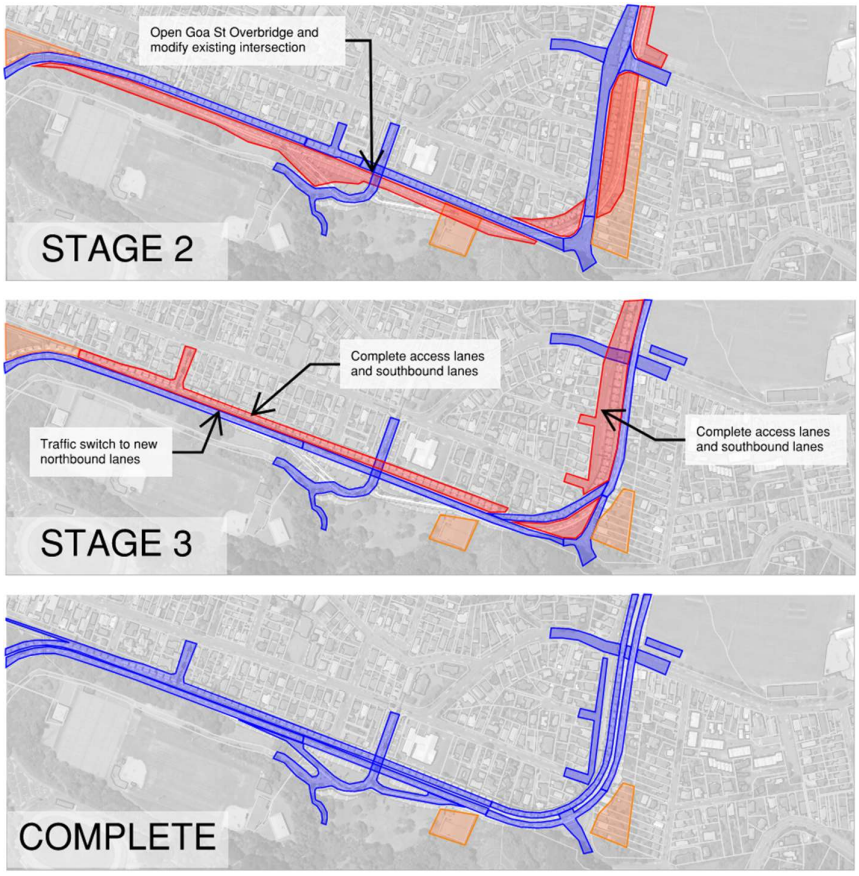


Figure 20: Potential construction sequence for eastern connections.

Alternative construction sequences are also possible, including working on separate sections, i.e separating the Wellington Rd works from those along Ruahine St and this may reduce disruption on sporting facilities at Hataitai and Kilbirnie parks. In the unlikely event that Taurima St does not need to be closed for the Mt Victoria Eastern portal works it may be possible to delay the Hataitai Connection Bridge works and complete this later in the works programme, allowing more flexibility for traffic diversions.

6.5.3 Traffic Diversions and Access Staging

This section includes widening of Wellington Road and Ruahine Street. These routes form a key freight and commuter link to the airport. Construction staging will need to:

- Manage access to and public transport through Hataitai village.
- Manage configuration changes to intersections, especially to Hataitai village.
- Coordinate closely with emergency services.
- Haul routes and spoil removal will need to be managed to mitigate sensitive times and routes and may require night works with appropriate mitigation for adjacent residential areas.
- Retain one lane in each direction during workdays and at peak times along Ruahine Street.

Works in this area require existing on street parking to be removed near the beginning of construction. The existing traffic arrangement at the Mt Victoria Tunnel and Kilbirnie Park end of the site could be maintained until the new Hataitai Connection Bridge is constructed. Once the new Hataitai Connection Bridge is complete, the Taurima St intersection modifications could be made to allow traffic to flow in its permanent arrangement.

Re-alignment works on Wellington Rd requires multiple traffic switches but generally do not restrict access or traffic movements with the exception of access to properties that will be resolved as part of the permanent works. Work in this area is assumed to be staged to allow the new alignment northbound lanes to be constructed off line, traffic in both directions to be diverted onto this, then resident access can continue from the existing road while the local access lane is constructed in sections. Temporary drive on access restrictions to some

properties should be anticipated for a short period (days to weeks) while paving is completed in the transition zone in front of each property.

Pedestrian access across SH1 to Hataitai Park should also be considered in the staging of works as once the existing pedestrian bridge near Taurima St is removed to allow the new SH1 northbound lanes to be constructed there is no other safe crossing point or controlled intersections until the Hataitai Connection Bridge is completed.

The primary staging options for completing the Hataitai Connection Bridge and interchange include:

The first option, as designed, allows the new northbound and interchange alignments to the west of existing to be completed offline. SH1 traffic can then be diverted from the existing alignment onto the new on-ramps and off-ramps at the interchange and northbound traffic lanes to allow the bridge construction and access lane works to complete. There will be a period of time (likely several months) with this arrangement that access to Hataitai Park will be closed while the ramps are completed through the existing Goa St alignment. Access to private properties that are currently accessed from Ruahine St will be disrupted while the new accessway and SH1 southbound lanes are re-graded and pavement re-constructed. No temporary access to Goa St can be maintained during this phase due to a height difference at the intersection, resulting in a detour for local traffic to Taurima St or Hamilton Rd. Once the overbridge, access lanes and southbound SH1 lanes are complete, traffic can be re-routed to the new alignment in both directions. This option is particularly efficient for bridge construction as the site can be dedicated to construction activities with traffic diverted around.

An alternative option reduces traffic disruption and reliance on local detours. This allows the construction of the new Hataitai Connection Bridge and interchange with traffic on the existing SH1 traffic lanes with a localised reduction in central median width at the bridge site (a full traffic lane in each direction and all turns are maintained). A series of overnight or off-peak closures of Ruahine St will be required to place beams, concrete the deck and complete barriers for the overpass. However, a short parallel diversion route via the existing Goa St to Hamilton Rd is available for these periods. The overbridge for the new Hataitai Connection Bridge alignment between Moxham Ave and Hataitai Park can then be opened to traffic prior to the closure of the existing Goa St at grade intersection and prior to the removal of the Taurima St pedestrian bridge. An overnight or off-peak closure of the access to Hataitai Park is required to complete tie in works. Following this, the existing Goa St at grade intersection can be removed and the northbound SH1 lanes completed. This allows SH1 to be diverted to the new northbound traffic lanes while works in the existing southbound lanes are completed. This option minimises traffic and access disruption but results in a restricted zone for the construction the new bridge pier.

A further hybrid option would follow a process similar to the design sequence but also include additional temporary paving and further preparation works to reduce the period of time access to Hataitai Park is closed to days to weeks. This would include preparing the southern offramp first and paving a temporary access that ties into the existing rugby club and park access near the first Hataitai Park parking area. A temporary intersection to the existing SH1 near the badminton hall would be required. This would allow two-way access from SH1 near the badminton hall to Hataitai Park via what would become the permanent northbound offramp. This access would then allow Goa St to be closed and the grade difference between new and existing at the base of the Hataitai Park access resolved. Once the existing Goa St is closed, either of the two methods presented above can be used to complete the works. Either diverting all traffic through the on and off ramps and building the bridge offline or keeping SH1 traffic in the existing traffic lanes and building the bridge over live traffic. This option is more complex, requires more staging and a temporary alignment with intersection but reduces Hataitai Park Access disruption and potentially improves access for bridge construction.

Works required to complete the construction of the new stormwater pipe between Ruahine Rd near Goa St and Evans Bay are expected to have minimal impact to traffic if carried out prior to or during the main works and a pipe alignment avoiding local roads is selected. Launch pits within the road corridor are required, these could be up to 10m x 10m in plan and between 5m and 10m deep. They are likely to be adjacent to the roadway at discrete locations and have traffic controls in place for many months while pipe installation is completed.

6.5.4 Methods

Ruahine St to Cobham Drive

The section from Ruahine St to Cobham Dr involves widening the existing SH1 corridor from one to two lanes in each direction, along with median separation and intersection upgrades. Works extend from the eastern Mt Victoria Tunnel portal to Evans Bay Parade and include earthworks, realignment, retaining structures, and property clearance. Construction will be staged to maintain live traffic lanes but will require multiple traffic shifts to allow either side of the corridor to be worked on. Traffic management will need to be clear to users as the live lane positions may change many times to accommodate staging. Pedestrian and cyclist access, as well as

restricting users from unintentionally entering the construction area, will need to be considered as the Mt Victoria Park is a community space with sportsgrounds and many public points of access.

Earthworks in this area generate an excess of fill which is intended be carted offsite due to limited storage or locations to reuse this material within the corridor. Retaining walls along Hataitai Park and toward Wellington Road are constructed using soil nails with shotcrete or mesh facing, enabling the widened carriageway to be cut into adjacent slopes. The intersection at Goa St will be reconfigured with access changes and formation of a cul-de-sac. The Wellington Rd to Ruahine St intersection will be fully reconstructed to provide signalised turning lanes, requiring property demolition on both sides and staged traffic shifts. Kilbirnie Park works include removal of the tiered seating and realignment of the corridor southward through the area currently occupied by the Eastern Suburbs Cricket Club. Access from Moxham Ave and Walmar St to SH1 will be removed and replaced with new cul-de-sacs. Across the corridor, construction activities include pavement formation, drainage, footpaths, lighting, traffic signals, signage, and staged traffic management. Impacts include property loss, traffic disruption, altered access to local roads and parks, and temporary effects on stormwater infrastructure and vegetation. Existing low-lying areas around Kilbirnie Cres and Hamilton Rd that are prone to flooding will need specific stormwater controls to reduce the risk of construction activities increasing flooding risk.

6.5.5 Specific Construction activities and potential impacts

Works in this area include many of the construction activities outlined in the general construction aspects of this report. In addition to the general construction aspects, specific construction activities that are not present in other area include the following tasks:

6.5.5.1 Specific construction activity – Trenchless construction for 1200-1500 stormwater main

A new stormwater main (1200–1500 mm diameter) will be installed between Ruahine Rd near Goa St and Evans Bay over a distance of approximately 600m beneath a residential area and below road alignments. To avoid surface disruption, trenchless installation will be used for most of the pipe alignment, with reinforced concrete pipes jacked through the ground from a series of launch and reception pits. The location of these pits is highly dependent on the pipe route and ground conditions and are generally located at every change in pipe direction or connection to other pipes. Launch pits will typically be approximately 10 m × 10 m squares or 8m in diameter and 5m to 10m deep, spaced along the alignment based on drive length, ground conditions, and alignment geometry. The design of launch pits needs to consider the proximity to traffic lanes and structures that impose unequal soil pressures. Ground movement around deep pits and following replacement of material may cause localised settlement and therefore should be sufficiently distant from sensitive structures. Pits will be constructed using sheet piles or other temporary retention systems and will include dewatering, jacking frames, and service access. Surface reinstatement will follow completion of each pit. Effects are concentrated around the launch pit locations. The pipe can then be installed horizontally below ground using pipe jacking or micro tunnelling methods. There are typically very few noticeable effects from micro tunnelling activities other than at the launch pits.

Areas where the pipes are shallow may be installed using open trenching. Typically, open or benched cuts are preferred for safety of workers and ease of access but where geometry is restricted by boundaries, traffic lanes or other services shored trenching is used. Shoring of trenches includes temporary steel frames within the trench. Due to the hazard that deep open holes cause, pits and trenches are often surrounded by high fences and covered by steel plates when not being directly worked on. Where other services or utilities are likely to be present hydro excavation using a vacuum truck will likely be using in conjunction with small excavators (typically 5T or less for service installation).

The construction of a new or modified outfall at Evans Bay needs to consider the interface with the coast including controlling water ingress into the construction area which will likely be below high tide level and subject to wave action. Works are likely to be carried out in stages and be scheduled around weather conditions and tides. Erosion protection works around the outlet tip including rip rap and excavation may require temporary cofferdams or similar controls of disturbed marine sediment.

Consideration Activity:	Trenchless pipe installation
Noise	Pit excavation (excavators, compactors, sheet piling) and pipe assembly and jacking (hydraulic jacks, ventilation fans) as well as dewatering pumps.
Vibration	Pipe jacking and micro tunnelling induces minimal vibration; However, localised vibration may occur during pit excavation and during installation and removal of sheet piling at each launch pit.

Dust	Dust from pit excavation, spoil handling, and site access.
Erosion and Sediment	ESC controls required at each pit location, including silt fences, bunding, and inlet protection. Spoil to be stored and removed in accordance with erosion control plan.
Environmental	Groundwater inflows at pit locations may require dewatering and treatment. All jacking operations and spoil management to prevent ground settlement or groundwater drawdown affecting adjacent residential properties. Launch pits will be present for many months with lane closures and high fencing required to restrict public access for safety.

6.5.5.2 Specific construction activity – Kilbirnie Park sports field construction and reinstatement

The existing Kilbirnie Park sports field that is temporarily used for construction laydown and modified in shape by the road realignment will be reinstated to support community recreational use. This includes re-establishment of a grass playing surface and reconstruction of a cricket pitch. Works will involve removal of temporary surfacing or fill, ground contouring, placement of topsoil, turfing or hydroseeding, and construction of a cricket wicket. Final reinstatement will follow council specifications for sports field performance and durability.

Consideration Activity:	**Sports field reinstatement**
Noise	Minimal
Vibration	Vibration from plate compactors and equipment used for backfilling.
Dust	Dust from soil handling or during dry weather; managed by progressive covering, watering, or turfing. Risk is eliminated once turf established.
Erosion and Sediment	Exposed topsoil may be prone to erosion prior to grass establishment. ESC measures (e.g. bunding, silt fence) required during and post-works.
Environmental	No specific risks

6.5.5.3 Specific construction activity – Kilbirnie Park Eastern Suburbs Cricket Club building demolition:

An existing single-storey clubhouse building within the park will be fully demolished. Demolition will involve disconnection of services, soft strip-out, structural deconstruction, and removal of foundations. Works will be undertaken within a defined compound with perimeter fencing and construction access via adjacent roads.

Consideration Activity:	**Cricket club building demolition**
Noise	Noise from demolition (e.g. saws, hammers, trucks) and general construction plant. Confined to day-time hours.
Vibration	Minimal
Dust	Dust from demolition and earthworks controlled through water suppression and site management.
Erosion and Sediment	Minimal during works, risk eliminated once grass reestablished
Environmental	Demolition waste to be sorted for reuse/recycling.

6.5.5.4 Specific construction activity – Evans Bay stormwater outfall:

The existing stormwater outfall discharging into Evans Bay will be replaced or enlarged to accommodate upgraded flows. Works are likely to include:

- Removal or partial demolition of the existing outfall structure
- Installation of a new outfall pipe and connection to the upgraded stormwater network
- Construction of new inlets, chambers, or pipework to tie into upstream drainage infrastructure
- Installation of erosion protection at the outfall interface, such as rock armouring, energy dissipation structures, or geotextile matting

These works are likely to occur in the coastal margin and may require tidal or stormwater flow control during construction.

Consideration Activity:	Evans Bay Stormwater Outfall
Noise	Excavation, pipe cutting and joining, demolition of existing structure, and placement of erosion protection. Use of excavators, pumps, and compactors.
Vibration	Minor vibration from excavator operation and compaction around new pipe bedding and outlet apron.
Dust	Dust from cutting, backfill placement, and equipment movement.
Erosion and Sediment	Coastal and stormwater interface requires bunding or flow diversion during construction. Erosion protection to be installed prior to reconnecting live flows.
Environmental	Works within the coastal marine area may disturb sediments or affect water quality. Measures required to prevent concrete or sediment discharge into Evans Bay. Material storage and mixing to be isolated from the receiving environment. Fish passage and habitat disturbance considered in the marine ecology assessment.

6.5.6 Considerations

Access to properties between Wellington Road and Kilbirnie Crescent

During construction, the alignment of the existing SH1 is likely required to be changed multiple times to allow for traffic to flow through the site while works are completed for widening and at the intersections of Wellington Rd and Kilbirnie Cres. Currently 23 properties are either accessed directly from SH1 or Walmer St in this zone. Vehicle access to these properties may be restricted at times and will require coordination with on site works as cars will need to pass through the construction site. Temporary steel cover plates can be used to bridge over small trenches if required.

Residential area and nightworks

There are a number of tasks that are best carried out while the roadway is closed, these works include setting up construction areas, relocating services, works directly adjacent to traffic lanes and completing the transitions between stages of work. Nightworks offer the constructor the opportunity to carry out works during times of less traffic and lower demand on services. Some of the tasks can be noisy or disruptive to local services. The construction team will need to be mindful that this is a residential area where the majority of adjacent residents will likely be home during periods of low traffic. Potential mitigations for this risk include using smaller equipment that produces less noise and vibration following a ‘less disruption for longer’ approach. Alternatively, a high disruption option where residents may be offered alternative accommodation or other compensation in return for allowing more disruptive construction activities for a shorter duration.

Access to construction site

One side of the site is adjacent to Hataitai Park. This park has multiple access points and pedestrians may have the intention to cross through the construction site. As the site is very long it may not be clear where designated crossing points are. Site fencing and providing direction towards designated crossing points may mitigate this risk trench guards and unprotected edges need to be carefully considered where it is possible the public could unknowingly enter the construction site. Similarly in residential areas the construction site may be directly in front of property and residents will need access through the site to get to and from their properties, parking or to activities. Clear direction and communication will need to be provided throughout the construction period.

Flood risk and potential for stormwater pumping

Wellington GIS maps identify areas of flood hazard, with flood zones along much of Ruahine St and at the Hamilton Rd to Wellington Rd intersection. Sequencing of works and implementing construction controls will be required to contain excess stormwater and control potential ponding while not increasing the existing flood risk. Should stormwater services need to be significantly modified, over-pumping may be required which may create additional noise adjacent to residential areas when pumps are in operation at any time of day or night.