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## Summary

The Auckland Central Business District (CBD) is used by more than quarter of a million people a day. The limitation on capacity of the existing public transport infrastructure, on both the rail and bus networks, is forecast to lead to constraint on the CBD's growth in the near future. Britomart, the main downtown rail and bus station, is expected to reach rail capacity by around 2020. It is clear that a major public transport infrastructure initiative is required. Construction of an underground railway from Britomart beneath the CBD to the North Auckland Rail Line (NAL) around the Mt Eden area is supported by the Auckland CBD Rail Link Study (the Study) as the preferred option which most effectively addresses this transport problem.

The Study began in August 2009, commissioned by KiwiRail (the New Zealand Railways Corporation) and the Auckland Regional Transport Authority (ARTA) and aims to identify a preferred route for the underground railway. This paper provides a holistic overview of the work done to define this land-mark project for Auckland and New Zealand. The paper primarily focuses on the challenges of the first phase of the Study, an option development and evaluation process, which was completed early 2010. The second phase of the Study is currently in progress: developing the concept design, constructability and cost of the preferred option, together with an assessment of environmental effects to support a Notice of Requirement for a Designation and development of a business case for the rail link. The final phase of the study, due to start in October 2010, includes finalisation of the engineering work, the preparation of the Notice of Requirement documentation (no decision has been made to date to start the public designation process through serving the Notice of Requirement on the Auckland Council) and completion of the business case, which will support any application to central Government for funding.

The paper provides a discussion of the first phase (option generation and evaluation) work, particularly the fourteen route options considered, along with numerous station location options, and the rationale that ultimately resulted in the selection of a preferred route and three station locations:

- 'Aotea' Station – located beneath Albert Street between Victoria Street in the north and Wellesley Street to the south

- 'K Road' (Karangahape Road) Station – located beneath Karangahape Road and Pitt Streets; and
- 'Newton' Station – located beneath upper Symonds Street between its intersection with Khyber Pass/Newton Gulley in the north and its intersection with New North Road/Mt Eden Road in the south.

The drivers that shaped the preferred alignment route from a rail network and public transport perspective are explored together with the rationale for the number of stations and their locations. Various unique urban renewal, architectural, engineering and constructability considerations and challenges are discussed in relation to the Study.

These unique considerations and challenges include the following:

- Extremely steep vertical grades which significantly influence the alignment options
- Very steep and irregular topography around some station sites that influences catchment areas
- Development context around the proposed station developments - their integration with the urban and planning fabric of the areas and what potential these stations and the rail link have in meeting the projects transport and urban growth objectives
- Commencement of a new electrified rail service
- Fire and Life Safety considerations within the tunnel system
- Heritage building protection and
- Allowing for an interface with a future potential underground North Shore rail line.

This paper will highlight the range and magnitude of these and other issues that needed to be addressed in Phase 1 of such a pivotal project. The Auckland CBD Rail Link will strongly influence the shape and nature of Auckland's future city development, economic potential and transport network efficiency. As such it is much more than a rail project and the design and planning challenges needed to be met with robust and innovative solutions.

## 1. Notation

**Cavern Station Method** – requires the main station platforms to be built in a single underground mined excavation with connections to associated shafts and structures for access, concourses and plant

**Designation** – like a ‘spot’ zoning over a site or route in a district or city plan, authorising the Requiring Authority works or project on the site or route without the need for subsequent land use resource consent from the relevant district or city Council

**District Plan** – town planning document at a city or district level which governs the use and subdivision of land

**Double Cavern Station Method** – a variant of the single cavern in which two mined bores are used for the platform tunnels connected by large cross passages

**Electric Multiple Unit (EMU)** - is a multiple unit train consisting of more than one passenger carriages, where all carriages in the train carry passengers, using electricity as the motive power

**Key Stakeholders** excluding the Clients – Auckland City Council (ACC), Auckland Regional Council (ARC), Ministry of Transport (MOT), NZ Transport Agency (NZTA), NZ Central Government Treasury (Treasury)

**Notice of Requirement** – the way a Requiring Authority gives notice to a district or city Council of its requirement for a designation

**Pedshed** – term to define the distance that the average pedestrian is willing to walk to reach a bus or train from their office, shop or home

**Requiring Authority** – a Minister of the Crown, a local authority (regional, city or district council), or a network utility operator (i.e. organisations who construct and operate railways, roads or airports, or who distribute gas, petroleum, geothermal energy, telecommunications, electricity, water, wastewater) approved under the Resource Management Act 1991

**Rolling Stock** - comprises all the vehicles that move on a railway. It usually includes both powered and unpowered vehicles, for example locomotives, railroad cars, coaches and wagons

**Station Box (Cut and Cover) Top Down method** – constructed from the surface building the walls and support structure followed by the roof after which the station box is excavated and lower structure built to complete the underground box.

## 2. Introduction

The Auckland CBD Rail Link Study (the Study) aims to identify a preferred route for an underground rail link from Britomart to the North Auckland Line (NAL) around the Mt Eden area. The Study is jointly funded by the New Zealand Railways Corporation (KiwiRail) and the Auckland Regional Transport Authority (ARTA). AECOM, Parsons Brinckerhoff, Beca Infrastructure Ltd and Hassell (working together as APB&B) were commissioned in August 2009 to undertake the Study on behalf of KiwiRail and ARTA.

The Study has been structured into three distinct phases that reflect key milestones:

- Phase 1 - Identification of preferred route and station locations
- Phase 2 - Engineering Concept Design, Business Case and Assessment of Environmental Effects for the preferred route and station locations and
- Phase 3 - Finalisation of the Study work and preparation of Notice of Requirement documentation.

The purpose of this paper is to provide a summary of the Phase One Study work, highlighting the key challenges and features of this major infrastructure project through the centre of Auckland's CBD as outlined in the opening summary. The paper is set out chronologically and covers:

- The Study drivers
- Overview of the Phase 1 process
- Option generation
- Station analysis
- Engineering challenges
- Preferred option determination and
- Development of the business case.

The option generation and evaluation process undertaken to identify a preferred route and number and location of stations is discussed, coupled with an assessment of the key constraints and challenges faced by this substantial project.

A key first task for the APB&B team was to develop and confirm with KiwiRail, ARTA and key stakeholders the project objectives, overarching principles, and the evaluation system and criteria that would be used to assess the merits of the route and stations location options under consideration as part of the Study.

As part of this process it was important to address the wider concerns of KiwiRail and ARTA, together with the key stakeholders and build these into the assessment and evaluation undertaken. In this context the rail operational and engineering requirements, along with the architectural and urban planning constraints and opportunities, were assessed. Feeding into this assessment was a review of previous other Auckland CBD Rail Link studies and the input of experience, both New Zealand and international, of the APB&B team.

In summary, the key challenges addressed in Phase 1 of the Study were:

- Identifying a number of station locations which best reflected the project objectives around passenger transport to/from and within the CBD (i.e. favoured by busy streets close to work, living and attractions, and attractive areas with future development potential) while being mindful of construction constraints and economy
- The limitation to generating feasible route options and station locations for evaluation due to the vertical height change between Britomart (some 9m below sea level adjacent the Waitemata Harbour) and the connection of the railway at the NAL, a 69m rise over 3km, meaning a required rail grade of 1 in 28 between stations
- As a subsequent effect of the above point, a necessity for deep stations, posing a challenge for both ease of patronage use, fire life and safety, and ability to construct
- The steep topography around the feasible station locations necessitated strong preferences for customer routes and hence usability of the stations
- Protection of the existing built environment and heritage
- Minimisation of potential impacts on private land through locating route options where possible beneath public roads and sites
- The right configuration of the number of stations and their locations on the route to encourage urban renewal and development
- Connectivity with other modes of public transport and a potential future North Shore rail link and
- Operational challenges of rolling stock running at the steep gradients and ensuring the electric trains currently being procured by KiwiRail's Auckland Electrification Project will be compatible with the proposed CBD Rail Link.

#### CBD Rail Link Facts

Preferred Route Length - approximately 3.6km

69m vertical climb between Britomart and the NAL (1 in 28 grade)

3 x Stations "Aotea". "K-Road" and "Newton"

Provision for 170m platform lengths at stations

Deepest Station is at "Newton" - track level at 42m below existing ground level

### 3. Study drivers

The project is much more than a major rail or public transport link – it offers a unique opportunity to stimulate and shape the future development of Auckland's economic heart. There are a myriad of project drivers as outlined below and together they demonstrate that the CBD Rail Link is a key enabler that will assist in transforming the Auckland CBD into a modern city hub.

#### 3.1 Regional Growth

Auckland is the largest city in New Zealand, with about 1.4 million people currently living in the wider Auckland Region. The Auckland region is also the economic hub of New Zealand, responsible for around 37% of GDP. Seventy five percent of New Zealand's population growth to the middle of this century is projected to occur in Auckland, with the population forecast to increase to 2.3 million by 2051. This population growth will have a significant impact on transport demand (2 million additional daily person trips – 65% more than at present).

Auckland's location centred on an isthmus between the Waitemata and Manukau harbours limits the ability for many more surface transport arteries to be built to accommodate this additional transport demand, so it is expected that public transport will need to play a significantly greater role in meeting Auckland's transport challenges than at present.

#### 3.2 Internationally comparable

To better understand the context of the opportunity afforded by a substantial rail investment in the CBD, it was important to the Study team to compare Auckland to other similarly size cities in the Australasian region, such as Perth and Brisbane, which have rail networks that contribute greatly to the daily task of shifting commuters efficiently into and out of a CBD.

The recent investment of \$1.7 billion in the Perth- Mandurah rail line (completed December 2008) has been extremely successful in this endeavour, resulting in predicted demand being reached in the first year of operation. The Perth investment added approximately 20% patronage to the Perth system. The Auckland CBD Rail Link represents a similar size investment. Comparing the Perth figures with the Auckland system (which is approximately half the size of the Perth network i.e. 40 stations versus 80 stations), the patronage capacity realised in Auckland is an additional 80% on top of the existing network. When one also considers that the Auckland project also enables much greater inner city development potential compared to the Perth project, it is clear that a CBD Rail Link has the potential to transform the shape of the city.

A second pertinent example is Brisbane, which is currently undertaking a Cross River Rail study to increase the capacity of the Brisbane network. The Brisbane rail network has almost four times the number of stations as Auckland (approximately 160). The network also carries just over a million passenger trips per

week (60 million per year) compared to Auckland's current level of approximately 8 million trips per year. While the Auckland patronage appears relatively low it has come from an extremely low base five years ago. Significant increases in patronage are being experienced as a result of the Britomart station being constructed in 2003.

### 3.3 Improving capacity on the Auckland rail network

Recent investment by KiwiRail and ARTA into the upgrading of the existing Auckland rail network and urban passenger services, after many decades of neglect, has resulted in significant growth in patronage, rising from less than 2 million journeys annually in 2003 to over 8 million in 2009. The planned introduction of electric trains from 2013, together with 10 minute interval peak period services and restructuring of bus services to connect with rail services, are expected to result in annual journeys reaching 17 million by around 2015.

While these levels of ridership are small when compared with similar cities in Australia such as Perth or Brisbane, the ability of the current Auckland rail system to handle further patronage growth beyond about 20 million journeys per year is restricted due to the capacity of the present Britomart terminus station at the northern edge of the Auckland CBD.

Britomart has five platforms located in an underground train shed, with a twin track tunnel connecting to the eastern and southern routes at Quay Park Junction. Even after the current re-signalling and train control system upgrade project being undertaken by KiwiRail for electrification is completed, the maximum throughput of the Britomart terminus is projected to be around 21-22 trains per hour. Although the rail terminus at the Britomart Transport Centre was constructed in 2003, it is expected to reach maximum capacity by around 2020 on current growth projections. By creating a through line beyond Britomart, the Auckland CBD Rail Link offers the ability to almost double the capacity of the existing rail network.

Additional increases are also anticipated due to the recently upgraded Newmarket Rail Station and the New Lynn Rail Station. Together, these important improvements to the Auckland rail network, combined with a CBD Rail Link, would greatly increase passenger journeys so that Auckland could be on a par with rail journeys in both Perth and Brisbane.

Building upon the momentum of these substantial recent rail infrastructure investments is key to transforming Auckland City and developing rail as the preferred mode of transport. The increase in patronage of passenger services on the Auckland rail network has been achieved through investment by central, regional and local government in improved services, trains, stations and infrastructure. The CBD Rail Link will unlock the potential of Auckland's rapid rail transit network, making the rail link as important to the rail network system as the Central Motorway Junction (CMJ) is to the motorways.

Furthermore, growth in patronage is projected to continue over the next decade as further investment in electrification and electric trains comes on line. In addition, the numbers of people living and working in the CBD and fringe areas is projected to more than double in the next 30 to 40 years, which will put significant strain on existing roads and public transport services. At the most basic level, the Auckland CBD Rail Link will greatly enhance the capacity of the existing Auckland rail network and, as such, it is essential that it is part of an integrated national rail network.

### 3.4 Encouraging economic stimulus

Another key driver is the projected provision of stimulus for inner city development by providing new major transport and development hubs around any new underground rail stations, along with the associated agglomeration benefits. Bringing the rail network into the heart of the city (Britomart sits on the fringe of the Auckland CBD) also has the potential to greatly reduce traffic congestion and thus stimulate economic development in the busy CBD area.

## 4. Phase 1 process

Briefly the key tasks undertaken by APB&B with KiwiRail and ARTA for the Phase 1 process of the Study were:

- Establish and confirm key stakeholders for the Study
- Develop and confirm project objectives and overarching principles
- Develop and confirm rail operational requirements for the Study
- Review previous studies, particularly route and station location options considered
- Identify any route or station location options from previous studies which had not been fully discounted and should be taken through to option evaluation as part of the Study
- Undertake an existing environment assessment – constraints mapping exercise
- Develop and confirm a set of mandatory criteria which route options needed to meet in order to be further evaluated
- Generate route options and test against mandatory criteria
- Develop and confirm a multi-criteria evaluation system
- Evaluate and recommend using the multi-criteria system the number of stations for the railway
- Using the multi-criteria system evaluate and rank the station location options and feasible route alignments to join the stations
- Undertake a 'back check' or 'weighting exercise' to ensure robustness of evaluation process

- Present the evaluation process and resulting preferred station locations and route alignment between to key stakeholders and
- Undertake further evaluation work on the top ranked station locations and feasible alignments to join them to confirm the preferred station locations and route alignment to be taken into Phase 2 of the Study.

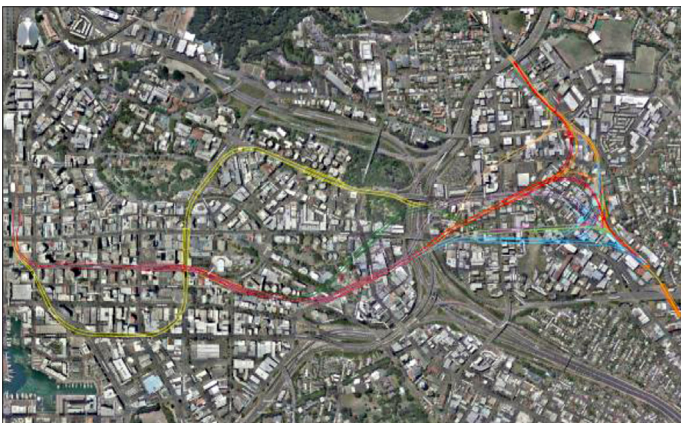
Further discussion on the key tasks which are the subject of this paper is contained within the following sections.

## 5. Option generation

A key initial step for generating route and station location options was to undertake a thorough review of existing information and previous studies on an Auckland CBD Rail Link. It is worth noting that a CBD Rail Link has been mooted, albeit in various forms, since the early twentieth century. This review helped to understand historical alignments and their historical evaluation, which was then updated to a contemporary review. All options for the Study required the completion of a rail link through the Auckland CBD and back onto the North Auckland Line (NAL). This was considered to be the most effective outcome to meet the project objectives from a transport and rail operations perspective, and also from a 'city-building' perspective. Therefore, all options considered extend from the Britomart terminus station (adjacent the Auckland CBD waterfront) and continue on various alignments through the central city area until they reconnect to the NAL in the vicinity of Mt Eden.

Figure 1 defines the Study area and shows a number of the key options considered. At the connection point with the NAL, consideration was given to options that may only connect to the west. However, limiting options to a western connection was seen as too restrictive and not maximising the flexibility of train operations into and out of the underground system.

Figure 1 - Study area and key options considered



Earlier studies, along with the initial work undertaken on this Study at the beginning of Phase 1, determined that only underground rail options presented solutions to the future CBD

public transport capacity issue. The terrain of the Auckland CBD between Britomart and the NAL also meant that most of the options developed had to climb a continuous steep gradient of between 1 in 33 to 1 in 28.. This is a challenging grade for rail, and as one of the key engineering challenges for the Study, is further discussed later in the paper.

The APB&B team with KiwiRail and ARTA, have considered various tunnel and station configurations, weighing up the pros and cons of each scenario using the developed multi-criteria system and through employing previous experience from working on international rail metro schemes. These deliberations lead to the optimum configuration for the Study being determined to be two single track rail tunnels and island platform stations. The primary reasons for arriving at this decision were that this configuration maximises the functionality at stations as well as providing a very robust outcome for Fire and Life Safety within the running tunnels.

The location of stations influenced the final route option chosen, and this is further discussed in Section 6 of the paper. Other key inputs to the option generation included:

- A constraints mapping exercise to identify whether there were any impediments which would influence the ability to locate a station and/or an alignment option between the stations. This included (but was not limited to) looking at existing and known future building structures (particularly foundation depths and construction type), existing services (particularly the location of substantial power and sewer tunnels - Vector and Orakei tunnels respectively), known heritage and archaeological buildings and sites, known sensitive noise activities, and existing plus known future community facilities
- Generation of technically feasible options for station locations and alignments were evaluated against mandatory criteria such as "Stations shall be able to accommodate 170m long platforms". Those station locations and alignments which did not meet these criteria were not progressed
- High level urban design analysis including population densities and pedestrian sheds ('pedsheds') was undertaken to highlight and identify where existing and future growth (and subsequently potential rail users) is anticipated and where opportunities exist to create and/or enhance growth and urban form
- High level land use analysis was undertaken in conjunction with the urban design analysis to identify areas for potential growth opportunities. This considered both the current District Plan provisions and the known aspirations of Auckland City Council via its Future Planning Framework document. Influences which may restrict achieving maximum potential growth, such as the volcanic view shaft protections to and from a number of Auckland volcanoes, were also identified

- Initial rail operational modelling and development of service pattern scenarios was undertaken to inform patronage and operational assumptions and
- Interaction with the parallel Auckland City Council Spatial and Transport Planning studies.

In summary the option generation process was undertaken in a series of steps, as follows:

1. Review of tunnel geometry and selection of single or twin bore configuration
2. Review of existing alignment options and determination of those which should be carried forward into the main option generation exercise (using previous study material)
3. Development of technically feasible vertical and horizontal alignments within the Study area (options assessed against mandatory criteria)
4. Developed generic station forms using international experience and examples in a context of the general station location, space requirements, ground conditions and access
5. Investigated technically feasible general station locations for 3, 2 and 1 station options along the route based upon patronage catchments and rail operational considerations
6. Investigated station and tunnel ventilation and building services demands to determine space requirements underground or in adjacent buildings
7. Tailored the generic station forms for proposed station locations, e.g. location of event buildings, access and platform and plant layout
8. Refined route alignment options to workable vertical and horizontal alignments within the constraints of operational rail requirements for the Study, minimising route options being located under private land, existing buildings and structures (EBS) and ground conditions (using existing environment material)
9. Introduced additional alignment refinements for grade separated junctions and alternative radii to improve the option performance against the operational rail requirements for the Study and
10. Checked for 'fatal flaws' in all route alignment options and station options.

Having completed this ten step process of generating the options, a total of fourteen route options were developed for the main option evaluation against the multi-criteria system.

Figure 1 demonstrates that the majority of the fourteen route options followed a path from Britomart, up Albert Street, under Karangahape Road and the Central Motorway Junction (CMJ) to Newton and ultimately the NAL. However, there was one route that differed markedly, traversing to the west from Britomart

before swinging back east to follow Wellesley Street to Symonds Street. This route option was brought forward from previous Studies as the APB&B team along with KiwiRail and ARTA did not feel that it had been robustly closed out as an option. Its main function as a route option allowed more direct capture of Auckland University patronage.

## 6. Station analysis

A key driver for the Study is that railway stations within the Auckland CBD will generate the opportunity to provide enhanced access to commercial and community facilities and other areas within the Study vicinity. The overarching station design objective for the Study is to achieve a pleasant and safe transport experience. The station environment must be attractive, functional, safe and inviting, and accessible to all Aucklanders. The desire from the Study is that stations located on the Auckland CBD Rail Link will be integrated into the existing environment, creating and enhancing quality built environments.

The first step in the station analysis was to determine and recommend the number of stations for the railway. This analysis considered one, two or three stations. More than three stations on the route are not feasible due to the gradient constraints (maximum rail grade for the route was set as part of the operational requirements at 3.5%, 1 in 28, uncompensated or 4% compensated). Further, more than three stations were considered inconsistent with the catchment and patronage requirements and with international benchmarking. It is important to point out that a fourth station was considered but ruled out due to failing to achieve the constraint of level or near level (max grade of 1 in 200) platforms, along with catchment areas overlapping between stations.

As part of this process feasible location catchments were identified through consideration of previous studies and patronage catchment information. A multi-criteria evaluation was used for this analysis. At the conclusion of the process it was recommended that the Study proceed with three stations as there was no compelling reason at this early stage to 'drop' the number of stations from three.

Following determination of the number of stations for the route, an essential defining requirement for the Study was the number of feasible station options available for a particular station catchment area. Generating these station options included looking at the purpose of the stations (i.e. catchment served), the functionality of the station in terms of pure passenger function (being influenced by depth of the station and the steepness of the surrounding terrain), the level of existing activity surrounding the station, and the potential for increased activity and development activation as a result of the station development.

Consequently, a key first step was to derive the principles for the stations, which meet the requirements of the project objectives, and are in keeping with the current international standards for underground passenger rail systems. The design principles adopted in the conceptual development of stations include:

- High quality design and operational performance
- A comfortable and convenient passenger experience
- Optimal passenger and staff safety, amenity and accessibility
- Station environments will be attractive and inviting
- Station entries will be instantly recognisable and clearly signed urban landmarks
- Station precincts will be easy to navigate and customer focused
- Integrate with the local urban environment in which it operates
- Celebrate and protect significant buildings, spaces and connections
- Facilitate future transit oriented urban development and
- Encourage travel behaviour change toward public transportation.

Subsequently, a number of key criteria were developed to guide the generation of generic station forms. For example, the technically feasible station form is determined by a number of factors, including but not limited to the following:

- Depth of station
- Space required for construction at ground surface
- Clearances to adjoining buildings
- Rolling stock
- Concourse access configuration interaction with station form
- Relocation of utilities
- Clearance to existing utilities
- Pedestrian and passenger studies
- Vertical transportation
- Civil and structural engineering
- Building services including station and tunnel ventilation and
- Fire and Life Safety strategies.

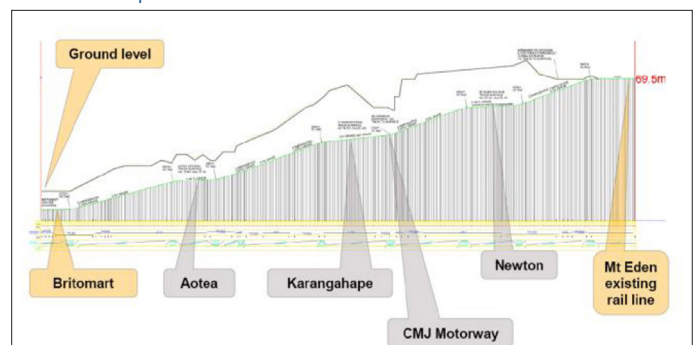
It is important to note that determining alignments and station locations is an iterative process – the feasible alignments have identified likely station locations and potential station locations have influenced possible alignments. Moreover, three generic station forms (cavern, station box and double cavern (also referred to as a 'binocular' cavern) were developed to accommodate the range of depths and construction environments encountered along the potential rail link. These generic station forms were customised to each confirmed station location in Phase 2, with associated services and means of access.

## 7. Engineering challenges

From the outset of the Study, it was clear that the engineering challenges were both considerable and varied and would necessitate utilising the experience of all facets of the APB&B team. The primary engineering challenges are summarised as follows:

- Extremely steep vertical grades which significantly influenced alignment options on the 69m vertical climb from Britomart to the NAL (Figure 2)

Figure 2 - Steep gradients from Britomart to NAL with indicative locations of potential future stations.



- Very steep and irregular topography around station location options, influencing catchment areas
- Retrieving an adequate amount of geotechnical information from previous studies, pre-existing sources and subsequent new investigations so that informed engineering decisions could be made
- Understanding constraints of existing building infrastructure within the Study area – this meant that a comprehensive information retrieval process was undertaken, predominantly with Auckland City Council, so that the team could understand the location of Heritage buildings and protection requirements, deep foundations, basement levels and potential future developments (Figure 3)

Figure 3 - Understanding constraints such as basements and heritage foundations of CBD buildings during option evaluation phase



- Existing and future utility services – a workshop was held early in the Study with the main utility service providers to explain the objectives of the Study and the key areas affected within the Study area.
  - Following this, retrieval of the existing services information (which was mapped into a Geographical Information System) was undertaken. All but two of the main utility service providers have assets in the area. The two major utilities within the Study area are the Watercare 'Orakei' Sewer in Victoria Street and the Vector power tunnel as it enters the CBD from the Central Motorway Junction.
  - Traffic/transport – the existing transport environment (i.e. roading location, layout, hierarchy, existing available traffic movements and counts, and existing public transportation routes) was reviewed. This information was then fed into the option evaluation process, particularly in terms of looking at both the impacts during the construction phase and permanent impacts as a result of the placement of stations and/or route alignments. Consideration of the need to re-route public transport routes and whether high volume roads would require temporary or permanent diversions (and whether these could likely be accommodated) was included. The challenge of constructing major underground station boxes within central city streets whilst still maintaining an adequate level of service to pedestrians, and vehicles was a major determiner of construction method and forms of structure selected.
  - Minimising station volumes whilst respecting the key passenger volume and design principle requirements as referred to earlier. This is a key cost driver and requires consideration of the design principles in close conjunction with the Fire and Life Safety system and the construction methodology. The development of the station design has led to innovation in the ventilation system and emergency egress which has led to substantial reductions in underground volumes.
  - Fire and Life Safety strategy and systems within the tunnel and stations. As referred to above, the tunnel and station ventilation in emergency mode are combined and routed from station ends under the platform to the main entry shaft. Similarly the fire egress stairs from station ends are routed back to the main shaft which all leads to volume and cost savings.
  - Construction challenges to build the rail dive structures in the NAL corridor while maintaining the NAL dual direction service, and tunnelling under the Central Post Office building adjacent to Britomart while keeping the building operational and station accessible
  - Interaction with the commencement of a new electrified rail service and ensuring the new rolling stock currently being purchased are compatible with the CBD Link and vice versa
  - Allowing for an interface with a future potential underground North Shore rail line and
  - Rail Operational Modelling - the steep gradients on the route options and uncertainty over the type and configuration of future Electric Multiple Unit (EMU) trains (being purchased for Auckland under the current electrification project), meant that it was prudent to undertake some preliminary rail operational modelling during Phase 1. This was achieved by simulating the performance of a 3 car EMU configuration over a representative CBD Rail Link alignment option, using a specialised rail simulation software tool, OPENTRACK, to calculate the journey times (including station stops) for each train configuration.
- The primary outcomes of this preliminary operational modelling were:
- Uphill journey times between Britomart and Kingsland, including stops at stations 'Aotea', 'K Rd' and 'Newton', were between 9 minutes and 13 seconds and 13 minutes and 13 seconds
  - The 3-car EMUs to be used for CBD Rail Link services should have a minimum of 50% powered axles in order to provide optimum journey times and to have sufficient power to be able to rescue a failed train by pushing it to the next station uphill
  - If a simple rail signalling system is installed, with only departure signals at each station, the capacity of the CBD Rail Link would be around 12 to 15 trains per hour in each direction and
  - If a more sophisticated signalling system is installed, with both arrival and departure signals at each station, the capacity of the CBD Rail Link would potentially rise to around 20 to 24 trains per hour in each direction.

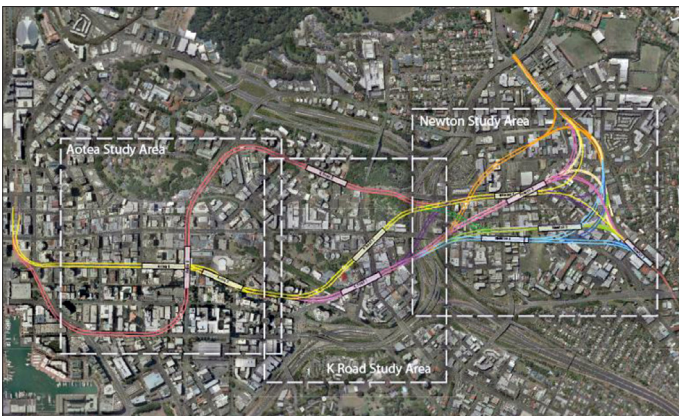
## 8. Preferred option determination

Having agreed on the multi-criteria evaluation system and generated the station and route options, the next important step in the Phase 1 process was to undertake a high-level screening of the fourteen options generated to discount those that didn't meet the mandatory criteria for the project. The mandatory criteria included:

- The alignment shall link Britomart to the NAL (in the vicinity of Mt Eden)
- That both eastern and western connections from the CBD Rail Link to the NAL at Mt Eden be provided
- That the route provides a double track alignment
- That the alignment facilitates a future passenger interchange with a potential future North Shore rail line
- That stations shall accommodate 170m long platforms and
- That the absolute maximum gradient shall be 3.5%, 1 in 28, uncompensated (4% compensated).

As a result of this screening of the route options against the mandatory criteria, three options were discounted due to their inability to provide for feasible western and eastern connections to the NAL. The remaining eleven options were then evaluated against station criteria pertaining to station location, alignment criteria, operational impacts, and construction impacts. In terms of station locations, three options (Figure 4) were considered in the mid-town area of the Auckland CBD, three options examined around the Auckland University/Karangahape Road area, and four options considered in the Newton area.

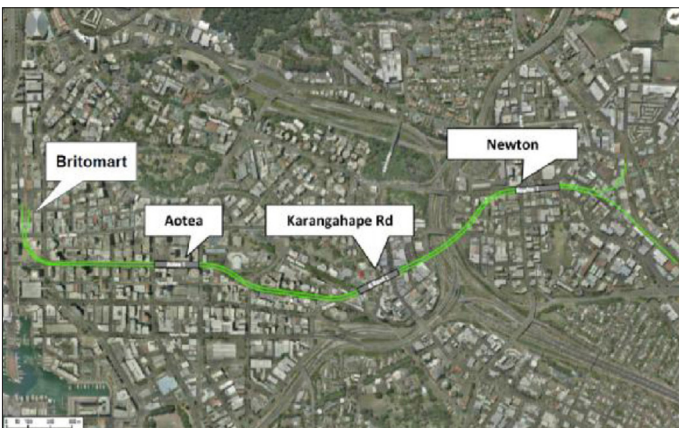
Figure 4 - Station and alignment options and study areas



The evaluation process resulted in the identification of top ranked station locations and a ranked alignment (Figure 5) to join them, being:

- 'Aotea Station' - Station box under Albert Street between Victoria and Wellesley Streets
- 'K Road Station' - cavern form station at junction of Pitt Street and K Road and
- 'Newton Station' - cavern form station junction of Mount Eden Road/Symonds Street.

Figure 5 - Proposed route and station locations



The rationale for selecting these station locations is provided below:

**'Aotea Station'**

The Aotea location (Figure 6) provided the opportunity for a station entrance on the corner of Mayoral Drive and Wellesley Street as a focal point. It was also considered beneficial due to a potential interchange with bus services on Albert Street and a future North Shore underground rail link, which may run east – west under Wellesley Street. The track level at the 'Aotea' station location is approximately 15m below the surface.

Figure 6 – Proposed Aotea Station Location



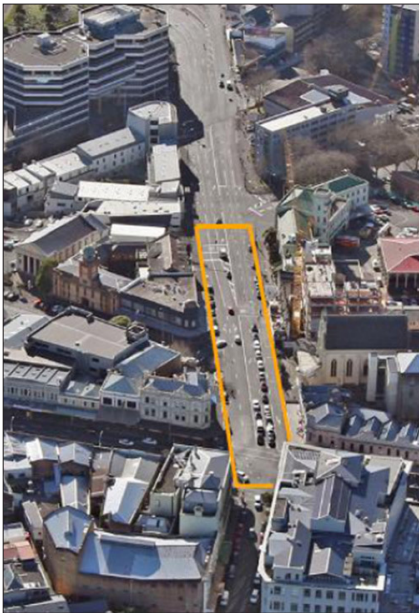
Other key advantages included:

- Good pedestrian connections to Queen Street, Albert Street, Sky City, Aotea Square, the Universities and the Victoria Quarter
- Opportunities for access from adjacent buildings (e.g. Sky City complex and the proposed Dai Ju Development on the current Bungy Jump site) and
- No heritage buildings affected.

**'K Road Station'**

The selected central location on the Karangahape Road ridge (Figure 7) promoted both access to the immediate area servicing residential, retail, commercial and leisure/visitor land use activities, as well as connectivity to good 'level' and largely covered walking routes in both directions towards the Hospital and towards Ponsonby Road. The track level at this station location is approximately 31m below the surface.

Figure 7 – Proposed Karangahape Station Location



Some of the other key reasons for selecting this location were:

- Opportunities for development on K Road and Mercury Lane
- Fewer dependencies on the requirement to gain private landowner agreement and land acquisition (as this station is generally located within the road reserve) and
- To provide increased penetration of public transport services into this area (currently it is only served by the Link Bus and bus services from West Auckland).

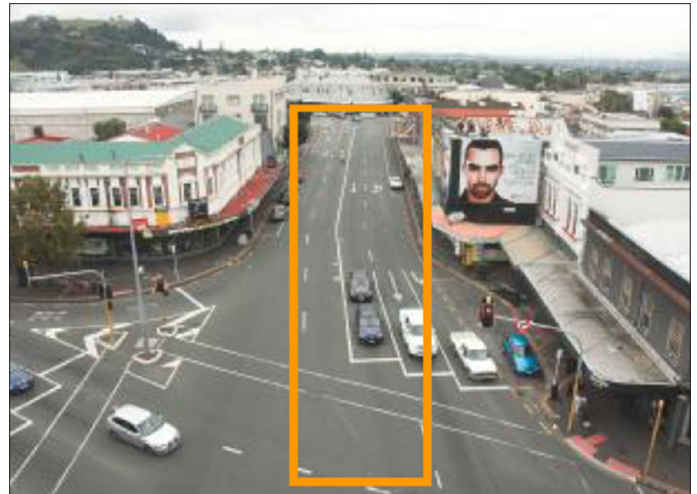
**‘Newton Station’**

The proposed location was chosen for a variety of reasons including that it is in the centre of the Newton area (Figure 8), which is a future node/hub noted by Auckland City Council’s future framework; along with its good potential for mixed use development within the 500m catchment of the station. The station itself has a track level 42m below the surface.

Other advantages include:

- The integration with other public transport modes to the CBD, Newmarket (and routes from there) is very good
- Connection of key arterial roads into this location, i.e. Dominion and New North Roads to the west and Mount Eden to the south
- Opportunity to enhance existing active street frontages and amenity, and improve the area as a focal point
- Flexibility in design, with a number of options available to provide access buildings and portals and
- Fewer dependencies on the requirement to gain private landowner agreement and land acquisition (as this location is generally located within the road reserve).

Figure 8 – Proposed Newton Station location



**9. Development of the business case**

In parallel with the preparation of the concept design and assessment of environmental effects, a business case to support designation of the route and stations locations is currently being developed.

The business case comprises the following elements:

- Project Definition and Strategic Alignment
- Assessment of Alternative Options
- Estimation of Project Costs and Benefits and
- Development of Funding Strategy.

International experience indicates that major urban transport infrastructure projects, such as the Auckland CBD Rail Link, can shape the development of cities as well as address transport issues. Therefore the approach taken to the business case is a combination of conventional transport project economic benefit/cost analysis following New Zealand Transport Agency guidelines, and a broader assessment of the wider economic impacts that may be expected. This includes an assessment of the productivity (‘Agglomeration’) benefits that are expected to result from improved accessibility to customers and labour markets, together with an assessment of the potential for intensification of land use (Transit Oriented Development) in the vicinity of both the proposed CBD Rail Link stations and other stations on the current Auckland rail network.

In addition to the assessment of costs and benefits, a key element for the business case is the development of a funding strategy for the project, given the likely magnitude of the capital and operating costs. This includes the identification of possible revenue sources, in addition to farebox income, that may assist with financing of the project, such as real estate value increase capture mechanisms, as used in North America to finance rapid transit projects. The Business Case is planned to be completed in the last quarter of 2010.

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## 10. Conclusions

The Phase 1 work of the CBD Rail Link Study concludes that there is a major opportunity to transform Auckland into a city founded on a world-class urban metro system. The opportunity is being proven through the potential of stations, from an opportunity at Aotea to bring the workforce to the centre of the city to generating an urban transformation in the Newton area. This challenging project has taken a critical first step towards becoming a reality as the challenges are being identified and resolved with innovative solutions, through a team with international rail experience. Further, the momentum of recent rail infrastructure spending has generated a resolve and a catalyst to take a major step in completing Auckland's CBD Rail Link so that Auckland can be mentioned in the same breath as proven successful urban passenger rail systems in Perth and Brisbane.

## References

Auckland CBD Rail Link Study – Options Evaluation Report, APB&B, February 2010