TE MANATŪ WAKA
MINISTRY OF TRANSPORT

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CBC Cost Estimate Report

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Security Classification

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This deliverable has not been informed by mana whenua and Māori engagement at this time due to TOC1a being a close-out phase at ALRL's direction; further engagement will be required before this deliverable is endorsed by mana whenua. Please refer to the Document Review Record for relevant feedback relating to this deliverable.

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1. Project Budget Estimate

Table 1.1 CBC Estimate for EPO

Project Budget Estimate (CBC)							
#	Description	Stage 1	Stage 2	Stage 3	Base Estimate	P50 Contingency	P95 Contingency
	Route Length	10,040	5,600	10,200	25,840		
1	Client Internal Cost	$379,934,737	$211,915,790	$385,989,474	$977,840,001	$-	$-
2	Client's Design				Included	$-	$-
3	Consent preparation				Included	$-	$-
4	Site Investigations	$11,656,347	$6,501,548	$11,842,105	$30,000,000	$-	$-
5	Property (Nett) *Private, Council Owned, AMA, NZTA, AT, Forestry, Kiwirail, Treaty land, Marine Work*				$1,102,225,049	Included	$-
6	Project Specific Insurances				$-	$-	$-
7	Construction	$3,923,948,508	$2,696,129,249	$1,796,495,363	$8,416,573,121	$-	$-
8	Rolling Stock				$304,200,000		
9	Project Base Estimate (1+2+3+4+5) - AACEI level 4	$4,619,739,592	$2,914,546,586	$2,194,326,942	$10,830,838,171		
10	Contingency on Physical Works and Rolling Stock (Assessed/Analysed)				(1+2+3+4+6+7+8)	$2,898,091,323	
11	Contingency on Property (Assessed / Analysed)				(5)	incl. in contingency allowance	
12	Total Project Expected Estimate (excluding escalation)				(9+10+11)	$13,728,929,494	
13	Escalation (excluding Property)				(1+2+3+4+6+7+8	$2,235,675,448	
14	Escalation (Property)				(5)	$151,343,206	
15	Total Expected Estimate incl. Escalation				(12+13+14)	$16,115,948,148	

16	Funding Risk on Physical Works and Rolling Stock (excl. property) - AACEI Level 4				(1+2+3+4+5+6+7)		$1,657,436,844
17	Funding Risk on Property - AACEI Level 4						$220,445,010
18	95th Percentile Estimate - AACEI Level 4				(15+16+17)		$17,993,830,002
19	Escalation (excluding Property)				(1+2+3+4+6+7+8)		$294,303,696
20	Escalation (Property)				(5)		$71,131,306
21	95th Percentile Estimate - AACEI Level 4 including Escalation				(18+19+20)		$18,359,265,004

2. Introduction

2.1 Project Summary

In 2021, New Zealand Transport Agency (NZTA) prepared an indicative business case for Auckland Light Rail (ALR) between Wynyard Quarter and Auckland International Airport terminus. Three options were included in that business case. Of those three options, Option 3 the Sandringham Road hybrid has been further developed through design, and a corresponding estimate prepared.

Through the design development, the original proposed twin tunnel from Wynyard to Wesley has been changed to a single mono-bore tunnel from Wynyard Quarter. There are 17 stations, one less than the original indicative business case, and the depot is now at Onehunga rather than Carr Road.

2.2 Purpose of Document

The purpose of the document is to describe how the delivery schedule and estimate have been developed, including systems, procedures, conventions and responsibilities for the required inputs, and to outline the overall methodology.

2.3 Inputs

The delivery schedule and estimate has been prepared based on the following key inputs:

- Concept designs - Auckland Light Rail Design Alliance
- Property costs - Auckland Light Rail Limited
- Client Direct Costs - Auckland Light Rail Design Alliance
- Principal's and Contractor's Design Costs - Auckland Light Rail Design Alliance
- Programme – Construction schedule – Alta
- On-site Overheads – Alta
- Utilities costs - Auckland Light Rail Design Alliance
- Tunnelling, station civils, retaining walls, viaducts, MHX and depot earthworks – Alta
- Station fit-out, public realm, rail systems and consequential costs - WTP
- Risk - Auckland Light Rail Design Alliance
- Rolling stock - Auckland Light Rail Design Alliance
- Temporary traffic management - Alta
- Alta has provided constructability advice and the delivery programme.
- WTP has collated the available information and formulated the estimate.

2.4 Current Status

This deliverable has not been informed by mana whenua and Māori engagement at this time due to TOC1a being a close-out phase at ALRL's direction; further engagement will be

required before this deliverable is endorsed by mana whenua. Please refer to the Document Review Record for relevant feedback relating to this deliverable.

3. Scope of Work

3.1 Classification of Estimate

WTP and Alta were engaged to develop and co-ordinate the estimate and programme.

The estimate draws together inputs referred to in section 2.3, with the output being a Class 4 estimate as defined in the AACEI Recommended Practice Guide 98R-18 for Road and Rail Transportation Infrastructure Industries.

The scope and nature of physical works is detailed in the Design and Constructability Report (ALRPC-ALRA-ZZZZZZZZ-ZZZ-ZZ-ZZZ-RP-RPT-000001).

3.2 Project Execution Strategy

The route has been split into three geographical packages, with a fourth package for line-wide rail systems. The packages are:

- Package 1 - Kingsland station to Onehunga
- Package 2 - Wynard to Kingsland
- Package 3 - Onehunga to AIAL.
- Package 4 - Rail Systems

3.3 Value Management

The Alliance design team has undertaken a value management (VM) exercise to explore opportunities to reduce the project capital costs. These VM items have not been endorsed for implementation at this stage, only to identify what could feasibly be considered to refine the project scope and reduce cost. The confirmation of the project requirements will occur in the future Definition Design phase. VM items have been applied to the cost estimate and upon commencement of Reference Design, the Alliance will consult with stakeholders to confirm assumptions and define project requirements. Section 7.2 details how the QRA has been applied to these VM items.

The estimate includes for these VM options. Refer to ALRPC-ALRA-000PRO__-ZZZ-PM-DEM-RP-DSM-000001 for detailed report of the Value Management Process.

3.4 General Assumptions

3.4.1 On-Site Overheads

The estimate is based on an Alliance delivery model rather than Design & Build contract.

The On-Site Overheads estimate was carried out by Alta using first principles and is based on the overall programme for the project.

The amount estimated for On-site Overheads has then been calculated as a percentage of the total amount of the direct costs and been applied to each Stage of the project.

The rolling stock is excluded from the construction Alliance scope and will be procured under a separate contract. Correspondingly there is no Alliance on-site overhead or margin applied to rolling stock in the estimates.

3.4.2 Systems Procurement and Delivery

The rail systems contractor is assumed to be integrated as a Non-Owner Participant (NOP) in the Alliance, rather than as a turnkey subcontractor, removing the duplication of On-Site Overheads, Off-Site Overheads, and margin on margin for the rail systems.

It is also assumed that the rail systems supplier can deliver as head supplier all the rail systems, excluding rolling stock and platform screen doors. The rail systems supplier can be appointed as the Systems Integrator, as is typical for other similar projects.

The following suppliers have been identified as having the capability to deliver as head contractor all the rail systems, excluding rolling stock and could also undertake the Systems Integrator role. This list is not intended to be exhaustive:

- Siemens;
- Alstom;
- Hitachi;
- Mitsubishi Heavy Industries (MHI)

Each has experience in delivering large contracts of a similar nature, including as a System Integrator. All have worked as part of an Alliance or a non-incorporated joint venture (JV) consortium.

Hitachi on the Glasgow Underground (Strathclyde Public Transport, SPT) JV'ed with Stadler for the rolling stock and Babcock for the civils and trackwork and are the integrator of the systems. The project involved the refurbishment of the tunnels, stations with new platforms and PSD, new depot, and new control centre.

MHI delivered and is delivering the rail systems for the mid-field concourse and the 3rd runway concourse in Hong Kong Airport. The mid field is a 60Million passengers per year must ride system and the 3rd runway 80Million initially and then 120Million passengers per year. Mid concourse systems have 6 stations, 2 depots and the 3rd runway as 3 stations, four tracks all interlinked to allow 100% availability.

Land Transport Authority (LTA) in Singapore, for systems contracts, also follows the one supplier approach in alliance format. They have extended the obligations to maintenance and obsolescence management, so the supplier is responsible for the service level availability and the maintenance of the product level safety case. This contractual engagement is gaining favour and MTRC for example, is also going to implement it. Network Rail (UK) has adopted a similar contractual format for the digital signalling. The East Coast Mainline ETCS L2 has been let on a similar basis with Siemens as the contractor. The above projects provide the precedence for adoption on ALR, and are outlined to support this approach as the basis for the estimate.

3.4.3 Intermediate Comparator

The Alliance has also completed a cost estimate for an Intermediate Comparator (IC). This is a viable option that is compared to the EPO through the Business Case, to test whether the project objectives could instead be met (or mostly met) with what is typically a lower cost intervention. ALR has identified Street Running Light Rail as an appropriate Intermediate Comparator.

Chapter 11 provides the full estimate details for the Intermediate Comparator incorporated within the Economic Case.

4. Project Delivery Programme

4.1 Project Schedule Basis

The project schedule has been developed based on the following construction staging approach;

Stage 1 – Onehunga Depot to Dominion Junction

- Stage 1a – Surface rail from Onehunga Depot to Wesley Station.
- Stage 1b – Tunnelled rail from Wesley to Dominion Junction (Passenger journeys terminating at Kingsland).

Stage 2 – Tunnelled rail from Dominion Junction to Victoria Park Station.

Stage 3 – Surface rail from Onehunga Depot to Airport. This stage may be further divided into:

- Stage 3a – Onehunga Depot to Mangere Town Centre
- Stage 3b – Mangere Town Centre to Airport

Figure 4.1 Proposed ALR Staging

4.2 Summary Programme

The summary programme showing the construction stages is shown below. This has been used as the basis for the estimate. Note the concurrent stages which have been determined based on resource levelling for both labour and equipment. If in the future, stages are constructed sequentially this will result in an increase to the escalation requirement, and would also increase the costs for re-mobilisation of equipment (eg TBM).

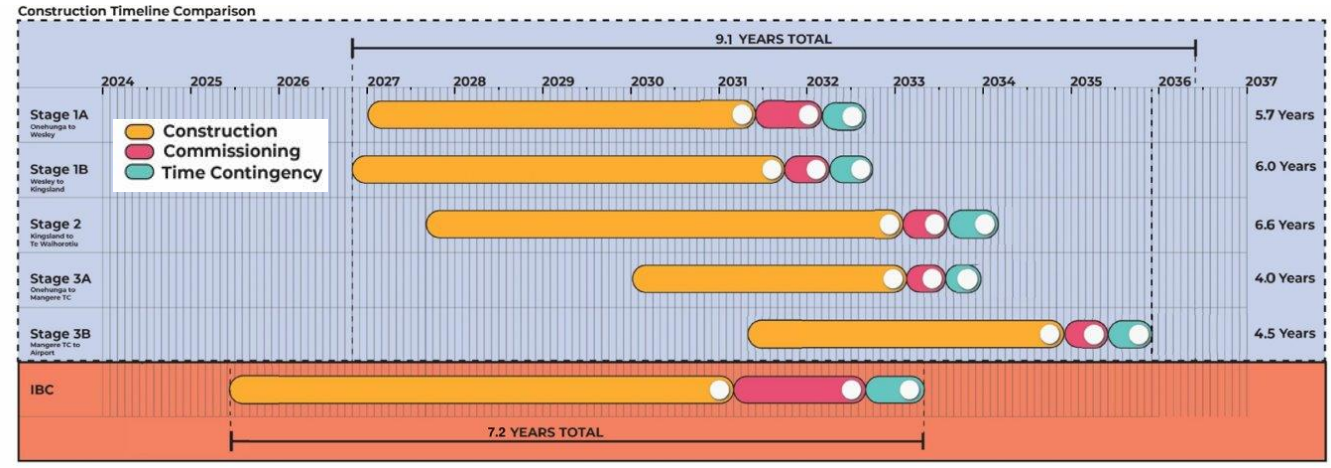

Figure 4.2 ALR Staging Summary programme

4.3 Key Project Milestone Dates

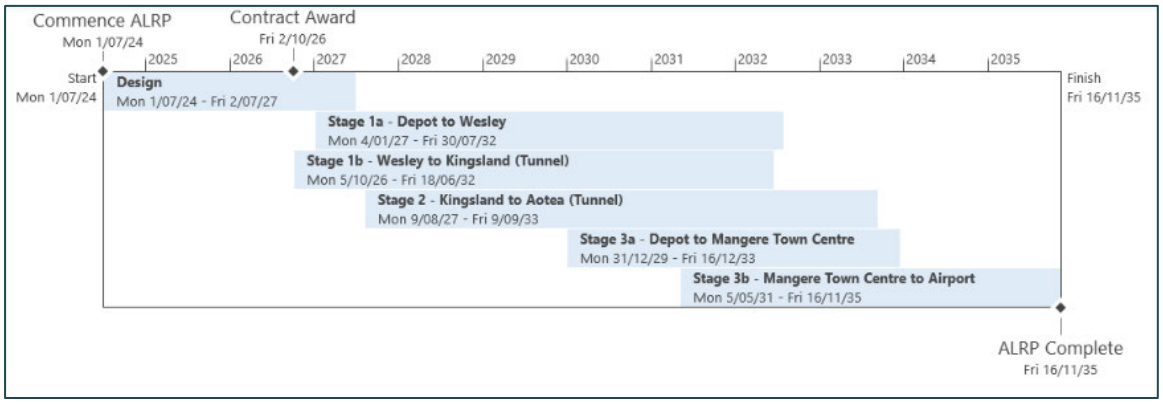

Figure 4.3 ALR Key Project Milestone Dates

ID	Unique ID	Task Name	Duration	Start	Finish	Months
1	1	**Auckland Light Rail Project**	**594 wks**	**Mon 1/07/24**	**Fri 16/11/35**	**0**
2	2	**Milestones**	**594 wks**	**Mon 1/07/24**	**Fri 16/11/35**	**0**
3	56	**Project Wide**	**594 wks**	**Mon 1/07/24**	**Fri 16/11/35**	**0**
4	31	Commence ALRP	0 days	Mon 1/07/24	Mon 1/07/24	0
5	930	Reference Design Complete	0 wks	Fri 27/06/25	Fri 27/06/25	0
6	932	Contractor Preferred Status Confirmed	0 wks	Fri 3/07/26	Fri 3/07/26	0
7	931	Contract Award	0 wks	Fri 2/10/26	Fri 2/10/26	0
8	30	ALRP Complete	0 days	Fri 16/11/35	Fri 16/11/35	0
9	986	**Construction**	**476 wks**	**Mon 5/10/26**	**Fri 16/11/35**	**0**
10	927	**Stage 1a - Depot to Wesley**	**291 wks**	**Mon 4/01/27**	**Fri 30/07/32**	**0**
11	935	Stage 1a - Commence Construction	0 wks	Mon 4/01/27	Mon 4/01/27	0
12	822	Stage 1a - Rail Systems Complete	0 days	Fri 25/04/31	Fri 25/04/31	0
13	821	Stage 1a - Stations & Structures Complete	0 days	Fri 6/12/30	Fri 6/12/30	0
14	823	Stage 1a - Commissioning Complete	0 days	Fri 23/01/32	Fri 23/01/32	0
15	925	Stage 1a - Time Contingency Complete	0 days	Fri 30/07/32	Fri 30/07/32	0
16	55	**Stage 1b - Wesley to Dominion**	**298 wks**	**Mon 5/10/26**	**Fri 18/06/32**	**0**
17	934	Stage 1b - Commence Construction	0 wks	Mon 5/10/26	Mon 5/10/26	0
18	28	Stage 1b - Running Tunnels and Gantries Complete	0 days	Fri 31/08/29	Fri 31/08/29	0
19	33	Stage 1b - Rail Systems Complete	0 days	Fri 30/11/29	Fri 30/11/29	0
20	34	Stage 1b - Stations & Structures Complete	0 days	Fri 5/09/31	Fri 5/09/31	0
21	36	Stage 1b - Commissioning Complete	0 days	Fri 5/12/31	Fri 5/12/31	0
22	924	Stage 1b - Time Contingency Complete	0 days	Fri 18/06/32	Fri 18/06/32	0
23	116	**Stage 2 - Dominion to Aotea**	**318 wks**	**Mon 9/08/27**	**Fri 9/09/33**	**0**
24	933	Stage 2 - Commence Construction	0 wks	Mon 9/08/27	Mon 9/08/27	0
25	117	Stage 2 - Running Tunnels and Gantries Complete	0 days	Fri 2/08/30	Fri 2/08/30	0
26	119	Stage 2 - Rail Systems Complete	0 days	Fri 20/12/30	Fri 20/12/30	0
27	118	Stage 2 - Stations & Structures Complete	0 days	Fri 4/02/33	Fri 4/02/33	0
28	120	Stage 2 - Commissioning Complete	0 days	Fri 4/02/33	Fri 4/02/33	0
29	923	Stage 2 - Time Contingency Complete	0 days	Fri 9/09/33	Fri 9/09/33	0
30	963	**Stage 3a - Depot to Mangere Town Centre**	**207 wks**	**Mon 31/12/29**	**Fri 16/12/33**	**0**
31	964	Stage 3a - Commence Construction	0 wks	Mon 31/12/29	Mon 31/12/29	0
32	965	Stage 3a - Rail Systems Complete	0 days	Fri 28/01/33	Fri 28/01/33	0
33	966	Stage 3a - Stations & Structures Complete	0 days	Fri 27/02/32	Fri 27/02/32	0
34	968	Stage 3a - Commissioning Complete	0 wks	Fri 29/07/33	Fri 29/07/33	0
35	969	Stage 3a - Time Contingency Complete	0 days	Fri 16/12/33	Fri 16/12/33	0
36	928	**Stage 3b - Mangere Town Centre to Airport**	**237 wks**	**Mon 5/05/31**	**Fri 16/11/35**	**0**
37	936	Stage 3b - Commence Construction	0 wks	Mon 5/05/31	Mon 5/05/31	0
38	827	Stage 3b - Rail Systems Complete	0 days	Fri 17/11/34	Fri 17/11/34	0
39	826	Stage 3b - Stations & Structures Complete	0 days	Fri 8/12/34	Fri 8/12/34	0
40	828	Stage 3b - Commissioning Complete	0 days	Fri 8/06/35	Fri 8/06/35	0
41	926	Stage 3b - Time Contingency Complete	0 days	Fri 16/11/35	Fri 16/11/35	0

Figure 4.4 ALR Key Project Milestone Dates

4.4 Project Critical Path

A critical path exists for the overall scheme, and for each discrete project stage. Critical activities include the following;

Pre-construction works

- Reference Design
- Main contractor procurement
- Detailed Design
- TBM procurement
- Utilities relocation & demolition

Stage 1

- Onehunga Depot and rolling stock commissioning
- TBM launch and tunnel/stations fit out
- Commissioning

Stage 2

- Dominion Junction station box excavation
- TBM transit through the Dominion Junction station box
- Station shafts excavation and fit out
- Commissioning

Stage 3

- Manukau Harbour Crossing
- Alignment and stations construction
- Commissioning

4.5 Schedule Elements and Assumptions

Pre-construction items:

1. Reference design – 12 months.
2. Main Contractor procurement – tendering and preferred status confirmation – 12 months.
3. Contract award - 3 months following preferred status confirmation.
4. Contractor design, consenting and enabling works (including utility relocation and demolition):
    - Generally assumed to be 24 months total.
    - These processes are accelerated at key TBM sites to streamline the tunnelling process. Key sites are the Southern Portal Drive Structure, Dominion Junction Station, and Te Waihorotiu Station.
5. TBM tunnel construction starts at 18 months after construction contract award (based on local project experience - 18 months for Waterview and 24 months for CRL)

    This includes;

    - 2 months to obtain early TBM design approval during Preferred Status phase.
    - 16 months TBM fabrication & delivery

Construction:

The overall scheme construction sequence, links and durations are assumed as:

1. Stages 1a and 1b are programmed to open simultaneously, providing day 1 passenger journeys between Onehunga and Kingsland.
2. A single TBM is programmed to undertake the two tunnelling drives. The TBM travels from south to north, and transits through the Dominion Junction station box. The TBM support site is relocated from the Southern Drive Portal to Dominion Junction to enable earlier fit out and commissioning of the Stage 1b rail tunnel.
3. Stage 2 - station shafts commence on completion of the Stage 1b station shafts ground support works to accommodate resource levelling.
4. Stage 3 – civils construction commences on completion of Stage 1a civils to accommodate resource levelling.
5. The average TBM excavation rate for the large diameter monotube is assumed to be 11 m/day (planning rate) with reference to Waterview TBM tunnel construction.
6. The TBM is tunnelling through ECBF material, the alignment avoids basalt.

7. The TBM has additional back-up gantries for construction of tunnel internal structures, which follow with a 3-month lag behind TBM excavation. The average gantry advance rates are assumed to be same as the TBM excavation rate.
8. Final adit connections from the station shafts to the TBM tunnel are made once the back-up gantries have passed the adit position.
9. The underground stations M&E and architectural fit out is assumed to be 18 months.
10. Assumed production rates are outlined in the following Table 4.1.

Table 4.1 Assumed Construction Rates

Item			Assumed average rate per crew / workfront
Initial shoring ground support	Piling	Secant Piling	2 piles / day (900mm diameter piles with 150mm overlap – effective length 600mm)
		Diaphragm Walls	1x 5.8m length panel / day
Excavation	Cut & cover shafts	Excavation of fill, silts/sands, overburden	400 m^3/day
		Excavation of ECBF	260m^3/day
		Excavation of Basalt	160m^3/day
Tunnelling	Mined cavern and tunnels	Roadheader excavation of adits	120m^3/day
	TBM tunnel	Monotube TBM tunnel construction	11m / day (24/7) (77m / week - ref Waterview)
Surface rail corridor construction	Civils	At grade corridor – flat contour	5m / day
		At grade corridor – retained to one side	2.5m / day
		Open trench corridor	1.5m / day
		Cut & cover corridor (underpasses beneath existing roads)	0.5m / day
Elevated rail corridor construction	Civils	Viaduct construction 6-10m height	1m / day
		Viaduct construction 10-15m height	0.85m / day
Rail Systems	Rail / M&E	Track & rail systems installation	100m / day per crew

Multiple crews / resources are assumed to be used in some locations.

4.6 Schedule Exclusions

The programme has been developed to the level of detail available in the EPO design. It will continue to evolve as the design is further refined and further staging considerations and decisions are developed.

4.7 Schedule Risks (Threats and Opportunities)

Risks and opportunities assessed in relation to programme impacts were identified to accommodate for impact to the scheme programme. The identified delay impact risks were grouped by project phase, and each modelled as general delay and not associated with any programme activities. Where a risk does occur, the delay is converted into a burn rate, mainly principal's costs, for that duration. It is further assumed that risks impacts do not happen in series or are not stacked, thus if a risk occurs progress on other deliverables can continue without the full impact materialising.

Full visibility of risks incurring delays and risks rolled up for delay modelling are available in Appendix C.

4.8 Activity General Details

Activities are high level only.

Activities have been created to establish a critical path.

Durations for pre-construction works have been jointly developed with the Auckland Light Rail Design team.

Construction durations have been prepared using a combination of first principles calculation and benchmarking for similar activities.

Activities have also been created to enable the estimate to be “cash flowed”.

4.9 Calendars

The following calendars have been applied to various activities;

TBM works - 7-day work week, no public holidays, 24hr/day working.

All other works - 5-day work week, 50hrs/week working, no work on public holidays or between 23rd December and 5th January.

4.10 Commissioning and System Start Up

The ALR scheme will become operational in up to 4 discrete sections. Testing and commissioning durations are assumed to be;

Rolling Stock - Initial rolling stock testing and commissioning is assumed to be 12 months, commencing upon sufficient completion of the depot, traction power, and sufficient adjacent viaduct and rail systems.

Stage 1 - Commissioning of Stages 1a and 1b is assumed to occur concurrently, with the intention of the full Stage 1 section opening simultaneously.

- Stage 1a – Onehunga to Wesley surface rail – 9 months commissioning duration.
- Stage 1b – Wesley to Dominion tunnelled rail – 9 months commissioning duration.

Stage 2 – Dominion to Te Waihorotiu tunnelled rail – 6 months commissioning duration.

This commences on completion of the M&E fit out and can occur in parallel with outstanding station architectural fit out activities.

Stage 3 – Depot to Airport – 6 months commissioning duration.

There is an opportunity to further divide Stage 3, to enable earlier opening of Stage 3a and accelerate urban uplift opportunities along this corridor. In this case, each Stage 3a and 3b are assumed to have separate 6-month commissioning activities prior to opening.

- Stage 3a – Onehunga Depot to Mangere Town Centre.
- Stage 3b – Mangere Town Centre to Airport.

4.11 Schedule Contingency and Time Allowance (Weather, etc.)

The detailed schedule item durations have been developed without contingency however as noted in section 4.4 we have applied resource levelling which means the programme had the potential for acceleration or event recovery. An overall contingency of 10% has been applied to the end of the construction & commissioning for each sub-stage. These contingencies do not compound – if one stage of works encounters a delay, it is assumed that the other stages can continue independently as the stages are not logically linked except for the overall completion of 1a and 1b. The time contingency allowed is 30 months (2.5 years) in total within each of the 5 sub-stages (1a, 1b, 2, 3a and 3b).

The programme has been based on a 5-day week whereas most contractors will work 6-days to recover slippage including from wet weather.

The majority of the works will not be delayed by wet weather as there is not a large earthworks component. Wet weather delays are allowed for in the 10% delay contingency and in the programme calendar adopted.

5. Estimate

5.1 Work Breakdown Structure (WBS)

The WBS has been developed to enable the estimate amount to be directly transferred into the business case model.

Table 5.1 Estimate WBS

Description	
Route Length	25,840m
Client Internal Cost	$977,840,001
Client's Design	Included
Consent preparation	Included
Site Investigations	$30,000,000
Property **Private, Council Owned, AMA, NZTA, AT, Forestry, Kiwirail, Treaty land, Marine Work**	$1,102,225,049
Project Specific Insurances	Included
Construction	$8,416,573,121
Rolling Stock	$304,200,000
	$10,830,838,171
Contingency on Physical Works and Rolling Stock (Assessed/Analysed)	$2,898,091,323
Contingency on Property (Assessed/Analysed)	Incl. In P50 allowance
Total Project Expected Estimate (excl. Escalation)	$13,728,929,494
Escalation (excluding Property)	$2,235,675,448
Escalation (Property)	$151,343,206
Total Expected Estimate incl. Escalation	$16,115,948,148
Funding Risk on Physical Works and Rolling Stock (excl. property) - AACEI Level 4	$1,657,436,844
Funding Risk on Property - AACEI Level 4	$220,445,010
95th Percentile Estimate - AACEI Level 4	$17,993,830,002
Escalation (excluding Property)	$294,303,696
Escalation (Property)	$71,131,306
Total	$18,359,265,006

5.2 Client Internal and Design Costs

5.2.1 Pre-Construction

Client internal and design costs are made of the following components for pre-construction and delivery phases. Costs are based on a duration of four years for pre-construction and ten years for construction as noted in the programme.

ALRL establishment and management costs

- These have been based on actual costs to date and benchmarked against City Rail Link. These costs have been provided by ALRL.

Alliance costs

- Based on actual costs and estimate to complete. Similar to City Rail Link, a Technical Advisor role to the client has been applied to the costing during the delivery phase.

Other consultants

- Provided by ALRL and based on actual costs and estimate to complete.

Pre-construction professional services costs allowed are around 2.9% compared to the WK benchmark of 2%.

Site investigations

- Refer to Section 5.5

Tender Stipend

- 1% for underground packages and 0.5% for surface - benchmarked against CRL and NZTA projects. Stipend is to be paid to the loser only. It is assumed 2 tenderers as per all the major NZ Alliances.

5.2.2 Delivery Phase

Costs are based on a duration of ten years for construction including defects liability. The assumed delivery model are several Alliance packages as per CRL.

- ALRL establishment and management costs been benchmarked against City Rail Link. These costs have been provided by ALRL
- Alliance costs - A technical advisor role has been assumed as per CRL and Waterview.
- Auckland Transport, KiwiRail, NZTA and ISA costs have been benchmarked against City Rail Link
- KRA's - A KRA allowance of 0.75x1.6% of Construction cost has been allowed.

Small Business Disruption Allowance

- From CRL experience, it has been acknowledged that an allowance should be made to potentially respond to small business claims and cover the disruption they will encounter during the ALR construction phase. No policy position on this matter has been confirmed at this stage. For the detailed business case the same allowance as the IBC has been used, which is a sum of 1% of the surface costs. This was calculated for the Intermediate Comparator (surface light rail) which would expect to cause significantly more disruption. The same allowance was used for the tunnelled metro scheme although there are no cut and cover tunnels proposed and all stations are located on private property rather than within the roads. The main potential

disruption will occur during the urban realm work around the stations which will be a significantly shorter duration than the main works.

5.3 Client Investigation Costs

Site investigation costs account for Geotechnical investigations (Boreholes / PSI / DSI) and Environmental investigations. Investigation costs for utilities are accounted for within the utility costs. Costs have been estimated at $30m using known costs from City Rail Link as the applied benchmark. A total of 150 boreholes has been determined as required prior to the delivery phase with 30-40 of those being drilled following requests from the tenderers. To date 31 boreholes have been drilled.

5.4 Property

These casts have been provided by the ALRL Property team.

5.4.1 Details

A Property cost has been determined for all land included within the Designation Boundary. The property cost estimate includes the following components:

- Crown Land
- Auckland Council Land
- Private Land
- PWA Costs
- Business Relocation/Buyout costs
- Temporary Occupation Costs
- The value of the residual Land was determined following completion of construction.
- The Property budget is the net value made up of all land purchases less crown land and Auckland Council land less the residual land value (in 2023 dollars).
- Further work is required to determine the risk profile of the property estimate. The current estimate includes the full purchase of several buildings that are not required for construction but have been designated subject to environmental assessments. There is also an opportunity to draw the designation back in several locations. The current basis of the estimate is that the opportunity exceeds the pricing risk. This will require further investigation in the next phase.

5.5 Utility Costs

These have been provided by the ALR design alliance.

5.5.1 Details

Utility costs have been calculated using a GIS based utility model that uses the design layer elements (alignment, bridge, bus stop, pavement, platform, precinct, road, and stations) and clipped utilities data within those footprints. All utilities data was provided by the various utility organisations in GIS format.

Unit rates are built into the GIS model to derive the utilities costs. The unit rates were based on escalated costs from the Watercare unit rates model, power costs were provided by Vector in the Indicative business case and telecommunications rates were provided by WTP.

In the GIS environment assets are categorised into lines, nodes, and polygons. For the utilities linear utilities, the model clips the measured length. Node are points within the model and therefore either fall inside or out of the model. Polygons that clash in the model are considered completely in (rather than a % measure). There are very few polygon assets in the model where most organisations use nodes to capture shape assets.

Design layer multiplication factors are used as a proxy for probability to scale the costs that are considered as outlined below:

- Alignment -100%
- Bridge - 30%
- Bus Stop - 50%
- Pavement - 30%
- Platform - 100%
- Precinct- 80%
- Road - 30%
- Station - 100%

The utilities model makes the following assumptions:

- No additions made for connection length or for diversions that are needed.
- No additions made for connections.
- Rates typically assume cost of minor nodal assets are included in the linear asset unit rates.
- Analysis does not go all the way to the airport - it is limited to the layers provided in GIS - approximately the old Landing Dr station. Currently there is no direct capex allowance for these costs but as described in 5.7.11.1 no allowances are included for public realm works or at grade works within the airport boundary as it assumed that these works will be funded by others. Otherwise, costs would be covered by P50 risk allowance, refer to QRA report in Appendix C.

Once the automated model output was provided, refinements were made by manual assessment with the main adjustments highlighted below:

- Transpower assets were ignored in the costing. Instead, an allowance of $40m has been used based on early consultation with TPRW of the ALR impacts
- Analysis is of existing assets only. There is no consideration of costs associated with servicing ALR (predominantly power and stormwater). These costs are included in rail systems.
- Vector telecommunications costs were removed where they are in parallel to major power assets as these are typically constructed in the same trench and therefore a minor cost which are considered in the margin of error of the power cable costs.
- Rates are be deemed to include the subcontractors onsite and offsite overheads, but not traffic management, main contractors onsite/offsite overheads, risk, design etc. These have been priced separately in the estimate.

5.6 Rolling Stock

The Alliance design team have prepared a reference rolling stock specification (ALRPC-ALRA-000PRO__-ZZZ-RO-RST-SP-SPG-000001). Outturn costs for rolling stock of similar specified units have been provided by Singapore Cross Island Line, Docklands Light Railway UK, Kuala Lumpur (Kelana Jaya) and Nexus Newcastle UK. During reference design, market engagement is required to validate assumptions in the spec and assess any cost impacts.

Day 1 Capex rolling stock cost is based on 30x 3 car. Increases in fleet size is detailed in the OPEX, Section 7.

5.7 Construction Costs

Table 5.2 Construction Cost Breakdown

	NZD (millions)
Stations and Stops	$1,533.41
Depot	$296.52
Public Utilities	$292.00
Bulk Earthworks	$54.66
Retaining walls	$390.53
Bridges and Viaducts	$297.72
Bored Tunnels	$1,207.61
Shafts and Portals	$151.31
Fencing	$14.39
Rail systems Power delivery	$111.57
Rail Systems Power and Distribution	$66.24
Rail Systems signalling	$44.89
Rail Systems Comms	$144.77
Rail Systems APD	$12.19
Rail Systems Fare Collection	$1.55
Rail Systems sundries	$13.60
Rail Systems Combined Service Route	$30.59
Track works	$254.93
Temporary Works	$34.91
Parallel Route	Excluded
Landscaping Public Realm	$272.23
Dominion Road/ New North Road Junction	$48.79
Consequential costs	$262.98
Road works and Paving	Included
Primary Utilities Relocations	$292.00
Demolitions	$165.19
Total Direct Costs	$5,702.59
Contractors Design	$532.16
Preliminaries	$1,305.77
Overheads and Profit	$876.05
Total Indirect	$2,713.98
Sub-total	$8,416.57

Rolling Stock	$304.20
Total (excl. Contingency and escalation)	**$8,720.77**

5.7.1 Off-Site Overheads and Profit

A 12.5% mark up on the base costs has been included for the construction Alliance off-site overheads and Profit. This has not been added to the Rolling stock base amount or the Contactor design, it is assumed that the rolling stock will be direct procured, and the amounts included for Design include for the designers' off-site overheads and profit.

5.7.2 On-Site Overheads

The amount estimated by Alta for On-site Overheads has been calculated on a first principles basis. This amount has been allocated as a percentage of the total amount of the direct costs and is applied to each construction stage for the purposes of presenting the estimate. The first principles determination of on-site overheads benchmarks the same as actual costs for the CRL Alliance.

5.7.3 Temporary Traffic Management

A first principles assessment of anticipated traffic control measures required for each construction phase/task have been undertaken. Applicable daily rates have then been applied to the task duration provided in the programme schedule. This figure was then applied as a percentage to the estimate.

5.7.4 Contractor's Design

Cost percentages between 10%-4% have been applied to the various cost centres (stations, tunnel, viaduct etc) in the estimate with values increasing with the risk proportion. The overall design fee is 6% of the total direct cost. This is deemed proportionate for the size of the project.

5.7.5 Demolition and Site Clearance

For properties listed as impacted by the alignment, the floor area of the properties has been taken from Auckland City Council's website. A generic cost per m^2 has been applied dependent on the type of property. No allowance has been included for basements or other underground structures; this is a risk to the costings.

The properties have not been visited to establish if they contain any contaminated material. For the construction cost, a nominal allowance has been included, this is a risk to the costings.

5.7.6 Tunnels

The tunnel estimate was done based on a mixture of first principles and assumptions. Quantities are based on the information provided from the various TAN documents together with the approximate alignment document. Further to these, rates used have been derived from various techniques which varies from composite unit rates of which we have utilised market rates from recent tenders or budget obtained prices from suppliers as well as actual costs from recently completed comparable projects. Tunnel design is based on that detailed in the Design and Constructability Report (ALRPC-ALRA-ZZZZZZZZ-ZZZ-ZZ-ZZZ-RP-RPT-000001)

The estimate is based on construction of the tunnels with a single Tunnel Boring Machine (TBM) and one set of back-up gantries. This setup will be used for both sections of tunnelled alignment construction.

The tunnel has been estimated with a full width mid-deck for the full tunnelled length. If this changes through design development to one of the various precast galleys types of options then there will be a corresponding change in the volume of concrete and cost. Ramps and stairs connections between the running tunnel spaces have been allowed for under internal structures.

Cut and cover at the Dominion Junction relaunch shaft is the assumed construction method and this has been allowed for as part of the Dominion Junction station excavation.

Spoil disposal is assumed to be to Woodhill, with an average turnaround time of 2 hours (45min each way plus 30min for loading and disposing) as per Value Management Technical Note Ref Tunnel Optimisation (VM-TN-000107). An allowance has been made in the contingency for disposal sites located further away.

5.7.7 Civils

The civils estimate comprises of various elements as trenching, viaducts and retaining walls, which are based on a mixture of first principles and assumptions. Quantities have been derived based on the information provided from the various TAN documents together with the estimated alignment lengths. We also made necessary assumptions where no information or designs were provided. The rates used have been derived from various techniques which varies from composite unit rates of which we have utilised market rates from recent tenders or actual costs from recently completed comparable projects.

5.7.7.1 **Viaducts**

Viaducts for the train running alignment are assumed to consist of 2 x 1,200mm diameter piles with an average depth of 20m, 1 pile cap, 1 pier, headstock, 4 x 1500mm deep precast super-tee beams, in-situ concrete deck with barriers each side. 35m average spacing between piers.

Viaduct stations are assumed to consist of 2 x 1,200mm diameter piles with an average depth of 20m, pile cap, 2 piers, headstock, 6 x 1500mm deep precast super-tee beams, in-situ concrete deck and platform slabs with barriers each side. The average spacing between piers is 35m.

Mass Stabilised Earth (MSE) walls are allowed for at each at-grade to viaduct transition.

5.7.7.2 **Retaining Walls**

Retaining walls for trenched sections where no design has been provided have been allowed for as diaphragm walls to softer upper strata, with rock bolting and shotcrete to deeper rock layers. The full trench volume is assumed as cut to waste material and an allowance is made for disposal off-site.

Where retaining wall (cut) is shown, assumed that a concrete cantilever retaining wall is required to the uphill side only.

Where retaining wall (fill) is shown, assumed for an L-shaped concrete wall with average 3m height and 1m thick foundation slab.

Retaining walls to both sides are assumed to be MSE walls with an average height of 3m.

5.7.7.3 Bridges

Manukau Harbour Crossing (MHX) pricing is based on the second MHX bridge constructed by Waka Kotahi in 2011. The cost include a single box girder bridge with new piers matching the existing adjacent SH20 bridge pier positions. Each pier is supported by two 2m diameter 20m depth piles and pile cap.

Te Ararata Creek Crossing - the same m2 rate as the MHX bridge has been applied due to level of design information currently available.

5.7.8 Shafts and Portals

5.7.8.1 Civils

Quantities have been calculated where possible or used as provided from the various TAN and VE documents. Rates are derived from various techniques including composite unit rates, market rates from recent tenders, or actual costs from recently completed comparable projects.

Basalt quantities assumed at relevant stations are:

- Balmoral Station - 40% of the excavation material
- Sandringham Station - 30% of the excavation material
- Dominion Station - 30% of the excavation material
- Kingsland Station - 10% of the excavation material

5.7.8.2 Fit Out

No allowance is included for shafts at Burton Street or Vernon Street on the basis that these shafts can be subject to value management. The contingency has made an allowance that these shafts may be required for the final scheme.

A provisional allowance only is included for the temporary shaft at Wellesley Street.

The fit-out of Mount Albert Portal and George Street shaft is based on an elemental estimate for approximate quantities and an assumed level of finish (metal roof, precast panel external walls, minor allowance for windows, main entry doors and fire egress doors, precast concrete stairs, allowance only for internal walls and internal doors as no rooms drawn, resilient floor finishes, fire rated ceilings, no plumbing required, mechanical services, electrical services, security, SCADA, BMS, fire lifts and drainage).

5.7.9 Stations/Stops

5.7.9.1 Civil Works

Quantities have been calculated where possible or used as provided from the various TAN and VE documents. Rates are derived from various techniques including composite unit rates, market rates from recent tenders, or actual costs from recently completed comparable projects.

5.7.9.2 Fit out

General

No design is currently available detailing the proposed materials and specifications for the project. The costs are therefore included based on a $/m2 based on the schedule of areas

provided by the alliance; as it develops, the design is to be monitored against these allowances. This has been benchmarked against CRL.

Wynyard Station

In addition to the guidance set out in Wynard Station Tech Note (VM-TN-000111), provisional sum allowances only are included for demolition and site clearance, public realm, station civils, station fit-out, tunnelling, tunnel MEP, utilities and systems costs.

No allowance is included for additional ventilation for tunnels under Waitemata Harbour, this is assumed to be within the scope of the Harbour Crossing works.

The additional tunnel line length from the removed Vernon Street Shaft is 320m.

No allowance is included for grade separation of pedestrian crossings.

5.7.10 Depot

5.7.10.1 Earthworks and civils

Quantities have been derived from provided cut/fill estimates and assumptions. Rates are derived from various techniques including composite unit rates, market rates from recent tenders, or actual costs from recently completed comparable projects.

5.7.10.2 Other works

There is no design for the depot buildings; allowances only have been made. These are to be monitored once design is available.

An assumed list of equipment is included for the depot.

Allowances only are included for the external works and services to the depot.

Works associated with Day 1 tracks only are included.

5.7.11 Civil Works Associated with Rail Systems

An allowance has been included to provide a common service trench or cable trays and ducts to the entire track length.

Where the tracks are on grade or on embankments, 5m long x 600mm diameter piles have been allowed for to each side of the alignment at 35m centres for the OLE masts.

Consequential costs There are no design details provided for the scope of the consequential works, and only allowances are included at this stage.

Nominal allowances have been included for works to existing road and foot bridges where these are impacted by the alignment.

In the absence of any design, allowance nominal allowances have been included for items such as stormwater attenuation.

No allowance has been included for works to the roads within AIAL boundaries. We assumed that these works will be funded by Auckland Airport.

5.7.11.1 Public Realm

The extent of works to public realm is as detailed in the TANs provided. Only asphalt and/or concrete paving has been included except at Te Wai Horotiu where the footpath paving will match CRL. It has been assumed that any hard landscaping upgrades and inclusion of

planting, , public art, public realm enhancements beyond NoR boundary will be funded separately. Cost estimate makes $30m allowance for stormwater treatment in Package 3 and $1m at depot. Assumption is that treatment would be via existing measures in Packages 1 & 2. Insufficient design has been conducted to date to validate these assumptions. An allowance in the contingency has been included for urban realm scope creep.

There is no design for Wynyard or Mangere Town Centre; allowances only have been made. These are to be monitored once design is available.

No allowances are included for public realm works or at grade works within the airport boundary as it assumed that these works will be funded by Auckland Airport.

5.7.11.2 **Road and Footbridges**

Allowances have been included for footbridges to the at grade stations only where they cross SH20. We have not included for ramps to the bridges, a single lift and stair with optional cycle channel will be provided.

5.7.11.3 **Others**

Nominal allowances have been included for erosion and sediment controls and temporary works.

5.7.12 Rail Systems

Whilst our preferred approach was to estimate these works using a benchmarking methodology, given the very early stage of design where details have not yet been determined, the rail systems were estimated based on the Bill of Quantities provided by the design team as requested.

A further adjustment was made to the Operational Communications Systems to include GRN & PRN Metro Wide (12 x base stations at $3m each) and to omit O&M radio (mainline and SMF) as instructed by the design team.

An internal review of the estimated rates was undertaken by the WTP Sydney team against benchmarked cost data.

5.7.13 Exclusions

The construction cost estimate excludes the following items:

- Queenstown Road Station – as not in CBC
- Favona Station – as not in CBC
- Airport Commercial Station – as not in CBC
- No allowance for a Hospital Station – as not in CBC
- Park and Ride Facilities – as not in CBC
- Upgrade to Mt Albert Road
- Modifications/realignment of Sandringham Road outside of NoR Boundary
- Alteration of other Public Transport facilities
- No allowance for KiwiRail corridor costs along SH20.
- Commercial developments on residual land or within / above stations
- Ultimate station plan for Kingsland (existing train station platforms widened / new SW bridge & concourse built / existing bridge demolished)

- Relocation of existing houses
- Heritage requirements of existing buildings
- Relocation of the fuel line at the airport
- Works to roads at the airport
- The base date for the estimate is July 2023, escalation is provided separately and in addition to the estimated costs
- All costs for post Day 1 Works (these are included along with the Opex costing as a cashflow for the Business Case team to allow NPV calculation). It is assumed the platforms are extended after 15-20 years as required by the predicted patronage growth.
- Greenstar or other similar sustainability measures
- GST
- Any other matters specifically noted in the estimate.

Exclusions and assumptions are addressed in the QRA report (Appendix C) which describes how funding is covered for cost and design uncertainty and event risks.

6. Escalation

The Budget Estimates use a base date of July 2023 and escalation is calculated in NZ dollars and applied over the duration of the project.

A programme–based cashflow for the various construction stages has been developed and cost escalation has been applied monthly to each element of the cost.

To determine the escalation forecast from July 2023 to the planned project completion in June 2036 a set of project specific indices has been developed for application to the cash flow. These indices are built up using existing data from Stats NZ and are:

- Professional Services,
- Civil Work,
- Building Work,
- Tunnelling Work and Rail Systems.
- Each of the indices is a combination of subordinate indices in various proportions representing the mix of plant, material and labour costs and type.
- The various indices have been benchmarked against historical trends which indicated an annual growth of between 2.5% to 3%.
- This approach provides a high level of confidence in the indices applicability over time and removes short term changes which may be caused by large scale economic issues.
- A rate of between 2.5% and 3.0% has been used as the base rate for forecast cost escalation from July 2023 to the estimated construction completion in June 2036.

7. QRA Approach

The active management of the project risk register provided a platform to conduct this QRA. For the development of the EPO QRA a two-stage approach was taken.

7.1 Initial Top-Down Contingency Estimate

Estimation of risk for the cost estimate began with a high level, top-down risk estimation process as part of the initial value engineering processes during August and September 2023. This provided a first indication of quantified project risk contingency on the EPO.

Top-down estimates were based on a least, most and highest likely ranges and based on the cost elements as per the provided cost estimate. Percentages ranges were used to vary the cost estimate values in the cost estimate. Each range estimate incorporated the following elements into a single estimation range:

- Cost uncertainty
- Event risk:
    - Likelihood
    - Consequence / Impact
- Design uncertainty.

Assumptions to constrain the top-down estimate were:

- Scheme scope was set as defined. Any scope changes were noted as variations to the scheme.
- Cost of scope removed / reduced as part of VE activities were not transferred to risk contingency.

The initial top-down estimate was used as a path finder and replaced by the detailed value engineering estimate.

7.2 Value Engineering Contingency Estimate

As the EPO's Value Engineering process progressed, further detail was added to the risks contributing to the cost estimate's contingency. The top-down estimate has been further refined with input from the risk register, workshops pertaining to cost, design, and scope resulting in unique identified risks to be included in the detailed QRA. These risk where further categorised into 4 distinct elements for the cost estimate, namely:

- **Cost Estimation Uncertainty:** Estimate ranges applied to each top-level cost estimate line item to account for any inaccuracies in rates estimations, quantities, or productivity rates. Rates used can be found in Appendix C.
- **Design Uncertainty:** Elements in the definition design which includes risk and / or opportunity where costs can increase or decrease. Design risk and opportunities can be found in Appendix C.
- **Scope Uncertainty:** Scope at risk of being removed or added that has the probability to impact the scheme. Scope risks can be found in Appendix C.

- **Risk and Opportunities:** Identified risk and opportunities that have been identified through the Project Risk register and subsequent risks identified during QRA development. Risk identified and included in the QRA can be found in Appendix C.

Detailed outputs can be viewed in section 7.4.

7.3 Limitations, Constraints and Assumptions

The following limitations, constraints, and assumptions apply:

- All costs are in New Zealand Dollars (NZD).
- The QRA scope is limited to risks defined on the risk register and specific design, scope and cost uncertainties inputs received from project stakeholders.
- The expected project cost estimate as provided by WT Partners and ALTA Cost estimate.
- Impact ranges were determined via analysis and consultation with subject matter experts for each category and or risks.
- Property risk estimated by the property team and assumed to be a P50 expected value.
- Risks with an impact of project abandonment or cancelation, that are not within the project's control, were not modelled. (Including significant delays due to unforeseen events, fundamental changes, or force majeure events)
- We have not modelled a delay to the start of construction due to delays in the investment decision.
- Costs with an impact on programme only are included in the QRA as an aggregated risk. The impact of these risks is reflected as a cost reflective of the overall delay incurred on the project. Costs are aligned to the highest probable delay in a project phase. This is done to allow for risks occurring in parallel, and limit stack of risk consequences.
- Costing assumptions for each risk and modelling parameters are outlined in Appendix C.
- Not all risks on the register were modelled in the QRA. Risks were grouped if they shared a common consequence with another modelled risk or not modelled if the risk did not have a cost impact.
- Subject matter expertise (SME) input was used to determine the consequential ranges and likelihoods in conjunction with costs provided by the project's cost estimators and where not enough detail are available a provision has been made for its probable cost.
- All risks modelled in the QRA are based upon the current project scope. Risks have been modelled to account for possible external scope change influences.
- Modelling outputs are run to at least the minimum number of iterations to achieve a convergence in the mean between iteration runs of 3% with 95% confidence.

7.4 QRA Results

7.4.1 Summary

The contingency estimation including property. For use in the Emerging Preferred Option (EPO) cost estimate has been established as 2,898 million NZD or 26.76% of base estimate at P50 for the project expected contingency. Funding Risk Contingency (Calculated as P95 – P50) has been estimated at 1,878 million NZD or 17.34% above the Expected Contingency, see Table 5. This provides a total contingency of 4,776 million NZD, or 44.10% of base estimate. Detailed breakdown of results is available in section 3 of the report.

Table 7.1 Contingency Summary, Contingency, EPO

Contingency	Million NZD (Excl. Property)	% of Base (Excl. Property)	Million NZD (Incl. Property)	% of Base (Incl. Property)
Project Expected Contingency (P50)	2,898	29.79%	2,898	26.76%
Funding Risk Contingency (P95 – P50)	1,657	17.04%	1,878	17.34%
Total Project Contingency (P95)	**4,555**	**46.83%**	**4,776**	**44.10%**

7.4.2 QRA Results

This section contains the output risk distribution and statistical results summary for all 4 uncertainties considered. The 4 uncertainties are also classified as Inherent risk (Cost and Design) and Event based (Scope, Risk and Opportunities) uncertainties. These classifications ensure comparability to the Interim Business Case phase.

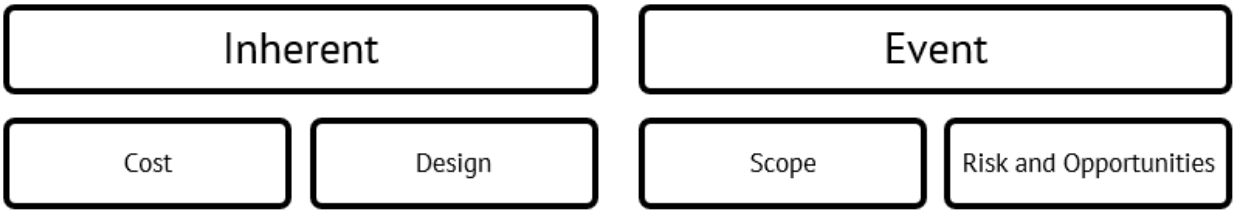

Figure 7.1 Uncertainty Classification

Contingency estimation for use in the cost estimate has been established as 26.76% of base estimate at P50 for Project Expected Estimate, and 44.10% at P95 for Funding Risk Contingency. A further 20% is added to the P95 estimate to account for risks impacting property as the property estimate has been provided at a P50 value. Table 7.2Statistical Results Summary, EPO below summarised the output per contributing uncertainty with the inclusion of the property estimate.

Table 7.2 Statistical Results Summary, EPO

Metric / Uncertainty (M NZD)	Base Est.	P10	P50	Mean	Std Dev.	Mean + 1 Std Dev.	P95	50% Perc #	95% Perc #
Base + Cost	9,729	199	10,361	10,423	118	10,541	11,190	6.90%	15.45%
Design		199	703	742	434	1,176	1,529	7.25%	15.78%
Scope		353	635	652	249	901	1,089	6.55%	11.23%
Risk and Opportunities		388	744	850	545	1,396	2,185	7.68%	22.54%
Total	**9,729**	**11,711**	**12,627**	**12,667**	**838**	**13,505**	**14,284**	**29.79%**	**46.83%**
Property	1,102		1,102				1,323	0.00%	20.00%
Total, Incl Property	**10,831**	**11,711**	**13,729**	**12,667**	**838**	**13,505**	**15,607**	**26.76%**	**44.10%**

 # Due to Interdependencies in QRA model and the summing of distributions, % of Base Costs does not sum to the same as the total.

Figure 7.2 below provides the distribution for the total risk adjusted cost, excluding property as modelled by the QRA model.

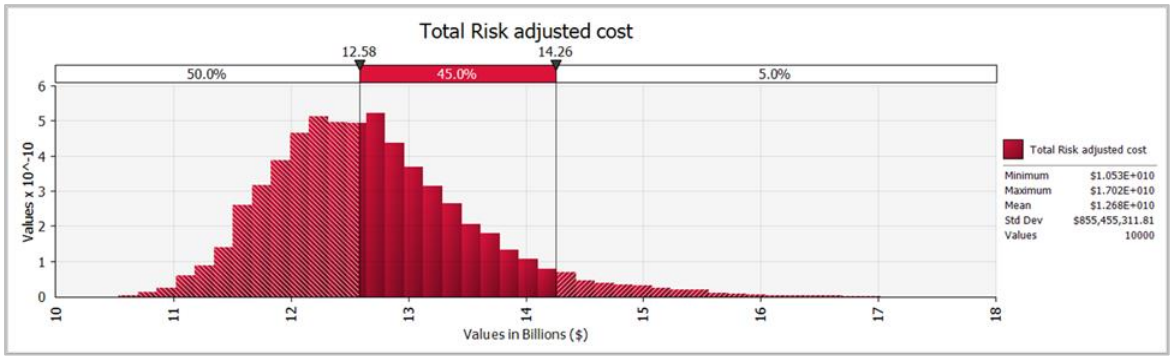

Figure 7.2 Total Cost Including Risk

Table 7.3 shows the categorisation of risk by Inherent (Cost and Design) and Event (Scope, Risk and Opportunity) uncertainty with respective distribution shown in Figure 7.3Inherent Cost Risk Distribution and Figure 7.4Inherent Event Risk Distribution for each.

Table 7.3Inherent and Event Uncertainties

Metric / Uncertainty (NZD)	Base Est.	P10	P50	Mean	Std Dev.	Mean + 1 Std Dev.	P95	50% Perc #	95% Perc #
Base + Cost	9,729	10,448	11,116	11,165	588	11,754	12,201	14.68%	25.88%
Design		924	1,395	1,502	602	2,104	2,825	14.39%	29.14%
Total	9,729	11,711	12,627	12,667	838	13,505	14,284	29.79%	46.83%
Property	1,102	0	1,102	0	0	0	1,323	0.00%	20.00%
Total, Incl Property	10,831	11,711	13,729	12,667	838	13,505	15,607	26.76%	44.10%

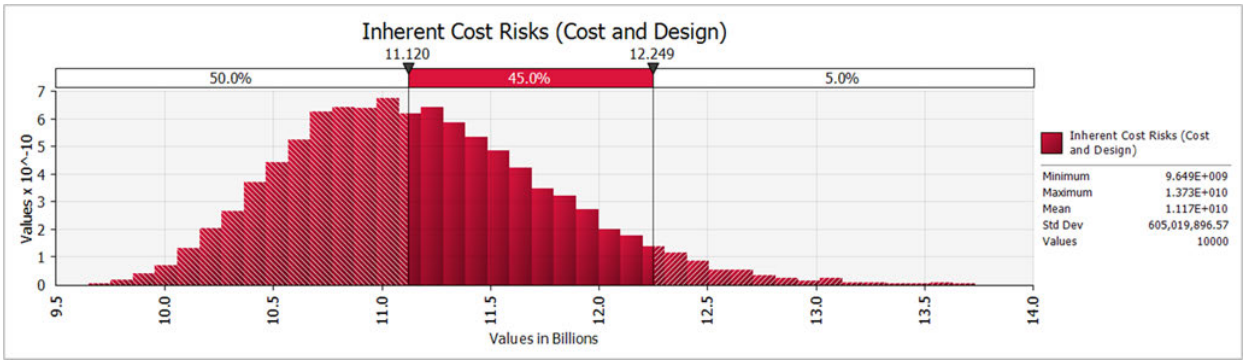

Figure 7.3 Inherent Cost Risk Distribution

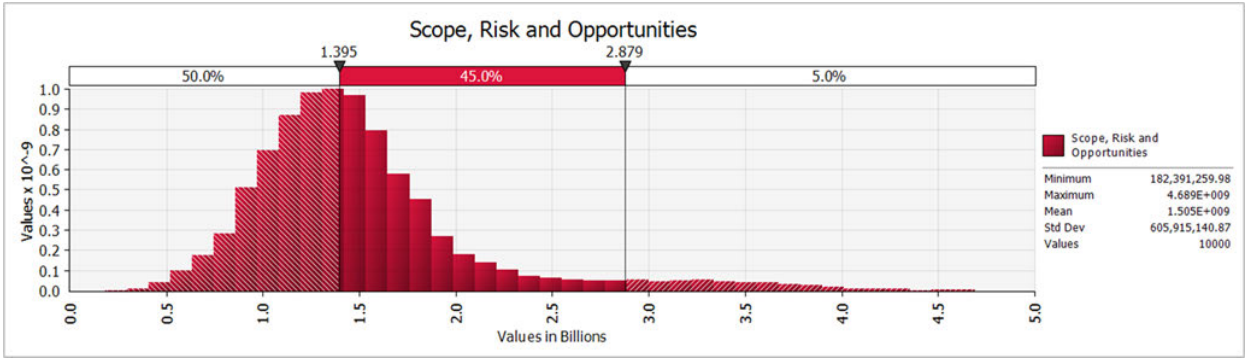

Figure 7.4 Inherent Event Risk Distribution

Contingency estimation for use in the cost estimate has been established as 29.79% at P50 for project contingency and 46.83% at P95 for Funding Risk Contingency excluding property risk Table 7.4Contingency Summary, Incl Property Contingency includes Property Risk and summarises Total Contingency provision for the Emerging Preferred Option (EPO).

Table 7.4 Contingency Summary, Incl Property Contingency

Contingency Incl. Property	Million NZD	% of Base
Project Expected Contingency	2,898	26.76%
Funding Risk Contingency	1,878	17.34%

Detailed breakdown of risk contingency provision can be found in the QRA report in Appendix C.

7.4.3 Benchmarking

The Engineers Australia, Contingency Guidelines, 2nd Edition, 2019 includes the following table as a guide to suitable contingency allowances based on the stage of the project for Transport projects in Australia.

Project Phase	Type of estimate	P50 Range	P90 Range
Initiation and Strategic Assessment	Preliminary Business Case	20% to 40%	30% to 70%
Concept	Full Business Case	10% to 15%	25% to 40%
Delivery Readiness	Pre-Tender	5% to 10%	10% to 20%
Delivery	Construction	Up to 5%	Up to 10%

Table 7.5 Common benchmarking of P50 and P90 contingency allowance for Transport Projects (Source: Engineers Australia, Contingency Guidelines, 2nd Edition, 2019)

This estimate is supporting the Full Business Case and the project is considered to be at Concept Phase.

The total P50 contingency of 27% is greater than then benchmarked range at the Concept Phase of development. The assessed P95 total contingency of 44% is also greater than the benchmarked P90 range.

8. Opex

8.1 Summary

The OPEX estimate provides an estimate of the Operating and Maintenance (O&M) cost of the Delivery Entity over the operations phase of the asset over the first 30 and 60 years of its life.

The estimate includes for the maintenance of the asset as delivered on Day 1, the increase in rolling stock and the required increase in lengths of platforms are included as an extra over cost. The costs are September 2023 costs.

The O&M estimate is split into two parts:

- the day-to-day operational costs including planned reactive maintenance of the asset
- renewals of the assets

A summary of these costs is detailed in the summary below (full details are provided in Appendix E)

Table 8.1 Opex Summary

Description	Pre-Commencement	Years 1-30	Years 31-60	First 60 Years
DAY 1 asset				
Operational Costs	$ 154,066,840	$3,781,881,015	$ 3,781,881,015	$ 7,563,762,030
Renewals	$ -	$ 936,302,770	$ 1,243,753,822	$ 2,228,665,862
Contingency	$ -	$ 471,818,379	$ 502,563,484	$ 979,242,789
	$ 154,066,840	$ 5,190,002,164	$ 5,528,198,321	$ 10,771,670,681
Additional service Level				
Additional Rolling stock and platforms lengths	$ -	$ 141, 372,000	$ 169,646,400	$ 311,018,400
O&M	$ -	$ 8,646,000	$ 8,646,000	$ 17,372,000
Contingency	$ -	$ 15,001,800	$ 17,829,240	$ 32,831,040
	$ -	$ 5,355,021,964	$ 5,274,319,961	$ 11,132,812,121

The following chart shows the expenditure over time (September 23 costs)

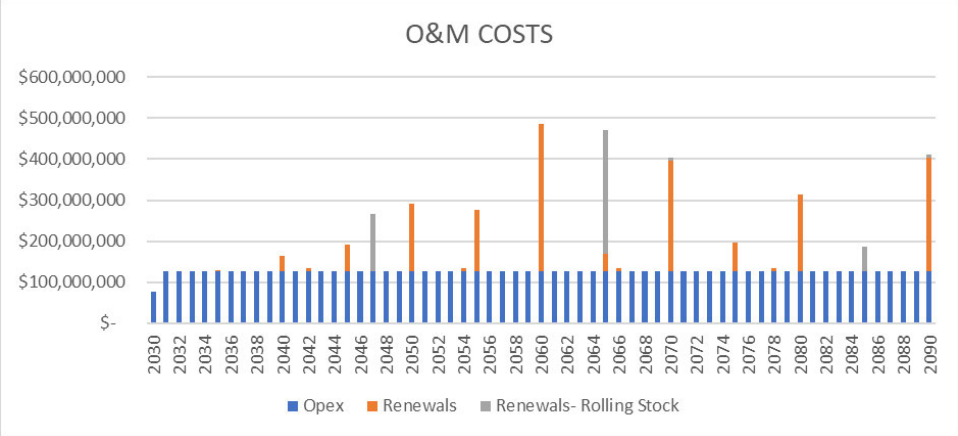

Figure 8.1 Opex Time Expenditure

The peaks are due to the expenditure pattens on the renewals of the various assets.

8.2 Basis of Estimate

The following are excluded from the estimate:

- Revenue from fare box
- Revenue from concessions at stations/ stops
- Providing additional services for events
- Maintenance and renewals of public realm
- Structure
- Assets with Life Cycles greater than 60 years
- Remedial/refurbishment work (unless outlined in the methodology below)
- Inspections
- Furniture

All costs are September 2023 costs.

8.3 Operational Costs

A summary of the O&M costs is detailed in the Table 8.2 below.

Table 8.2 Operational Costs

Description	Pre-Commencement	Years 1-30	Years 31-60	First 60 Years
	$ -	$ -	$ -	$ -
Operational Costs				
Spares	$ 100,000,000			
Customer Service Advisor on Units				
Manpower	$ 33,258,556	$2,287,893,375	$ 2,287,893,375	$ 4,575,786,750
Staff Sundries	$ 8,125,884	$ 187,910,334	$ 187,910,334	$ 375,820,669
Insurance		$ 150,000,000	$ 150,000,000	$ 300,000,000
Fees etc		$ 37,500,000	$ 37,500,000	$ 75,000,000
Stations Power/rates		$ 239,162,674	$ 239,162,674	$ 478,325,347
OPEX - Stations (Materials etc)		$ 46,638,856	$ 46,638,856	$ 93,277,712
OPEX - Depot Building		$ 841,634	$ 841,634	$ 1,683,267
OPEX -Rail Systems		$ 307,362,537	$ 307,362,537	$ 614,725,074
OPEX Tunnel MEP		$ 17,275,625	$ 17,275,625	$ 34,551,251
Power	$ 12,682,400	$ 507,295,980	$ 507,295,980	$ 1,014,591,960
Sub Total Opex	**$ 154,066,840**	**$3,781,881,015**	**$ 3,781,881,015**	**$ 7,563,762,030**

8.4 Pre-Commencement Costs

Details have not been confirmed on how the system will be tested before operational commencement except for the commissioning period included in the programme. However it is expected a trial running period of at least 3 months will be implemented which will require full operational staff.

A provision of $100m has been included for the initial purchase of spare parts for all the assets including the rolling stock. This is the same sum as included in the 2021 Firecone report. The spares allowance is for spares provided at contract completion. The additional parts required for replacement during the maintenance of the infrastructure are include in the material allowances in Table 8.2 above.

The O&M team provided a list of personnel required to operate and maintain the asset which has been priced. For the pre-operational costs, assumptions have been made as to when these personnel will be recruited and employed by the delivery entity; most are assumed to be brought on 6 months prior to the system becoming operational.

Staff sundry or overheads have been included the majority of this is for recruitment ($6.3m).

9 months of rolling stock power costs have been included.

8.5 O & M Costs

8.5.1 Manpower

As noted above, the O&M team provided a list of personnel required; this has been used as the basis of the estimate.

Staff sundries including items such as training, recruitment because of personnel churn, drug testing, and uniforms, have been priced.

8.5.2 Insurance

It has been assumed that the asset owner would self-insure and as such a sinking fund of $5m per year has been included.

8.5.3 Fees

An allowance of $1.25m pa has been included for legal fees, account audits and safety audits.

8.5.4 Power and Rates

Station and depot power consumption has been assumed at 500GW pa for the depot, 365GW pa for the below ground stations and 25GW pa for the above ground stations.

The council rates for the below ground stations are based on the current rates for Britomart Station and for above ground stations are based on Puhinui Station.

8.5.5 Opex

Operational costs, excluding manpower, have been based on the design, and provisions have been made to account for the allocation of resources such as materials, utilities, or consumables.

We have utilised our Facilities Management Cost Library (FM Cost Library) to estimate the Operational Expenditure (OPEX) costs for a select group of outsourced suppliers, materials, utilities (water rates), and consumables, tailored to the specific typology.

Our FM Cost Library is primarily assessed based on the cost per square meter of gross floor area or building envelope. In cases where it is more suitable, we can also calculate the cost on a per-asset basis. In addition to this, where the typology/s are different to our FM Cost Library, a discount has been applied to reflect the nature of the building's scale and complexity.

The scope of the OPEX costs includes the following:

Station Buildings and Depot Buildings

- Outsourced Supplier:
- External Building Washes

- Waste Removal
- Fire Protection & Detection
- Pest Control
- Material, Utilities, and Consumable Allocations
- Mechanical
- Electrical
- Plumbing
- Vertical Transport
- Security Assets Only
- Cleaning
- Water Rates

Station Platforms:

- Outsourced Supplier
- Waste Removal
- Fire Protection & Detection
- Pest Control
- Material, Utilities, and Consumable Allocations
- Electrical
- Security Assets Only
- Water Rates

8.5.6 Traction Power

Traction power consumption has been included as advised in the Power Simulation report. A rate of 18c KWh has been used which covers both the power and line costs.

8.6 Renewals

Table 8.3 details the renewal costs.

Table 8.3 Renewals Summary

Description	Years 1-30	Years 31-60	First 60 Years
RENEWALS			
Overhaul of the Rail Systems	**$ 370,211,770**	**$ 391,897,553**	**$ 762,109,323**
Rolling Stock	**$ 141,372,000**	**$ 378,528,000**	**$ 519,900,000**
Facilities			
Depot Buildings	$ 33,943,897	$ 38,640,939	$ 77,281,878
Stations	$ 366,006,927	$ 383,838,478	$ 767,676,956
Tunnel MEP	$ 24,768,176	$ 50,848,852	$ 101,697,704
Subtotal	**$ 424,719,000**	**$ 473,328,269**	**$ 946,656,538**

8.6.1 Methodology

With the current stations design maturity, the renewal estimate was largely based on building and space type/use. The renewal estimate required different methodologies for each building/system type (Depot Buildings, Stations, Tunnels, Railway Track and Systems, and Rolling Stock) based on the varying levels of available design information.

The different methodologies and approaches to the renewal estimate for each building/system type are outlined below.

8.6.2 Renewal Formula

The WTP renewal Formula requires the asset name, rate (replacement/refurbishment cost in $NZD) and typical design life cycle (years). The formula currently does not escalate any of the values. The formula determines the year at which each asset needs to be replaced and inserts the rate to replace the asset providing. The formula is applied over a 60-year life cycle to provide the renewal cost over 60 years.

8.6.3 Depot Buildings

A square metre (sqm) rate was developed for the construction of the depot buildings. To calculate the renewal, this rate was separated out into its elements providing different sqm rates per building element category. The resultant sqm rates per building element category were then able to be filtered to represent only the building element categories that fall within a renewal estimate (i.e., excluding structure, external works etc.). WTP added a 20% uplift to the renewal sqm rates to account for preliminaries, design and consultancy fees, and contingency.

The above calculation provided the cost of replacing the various building element categories based on the sqm of the building. The next part of the calculation involved assigning lifecycles to the building elements within the categories (as assets within a building element category have different life cycles). WTP used their database of previous projects to estimate the different weightings of each life cycle per building element category.

This created sqm rates for each life cycle within each building element category. The depot building areas were then multiplied by each of the rates and plugged into WTP's renewal formula to calculate the renewal for the Depot Buildings.

8.6.4 Stations

Using WT's database of previous renewal estimates, a sqm renewal rate per space type was calculated. This rate was then further broken down to develop a rate for each building element category within each space type (thereby acknowledging that different space types have different constructions and weightings of building element categories). WTP added a 20% uplift to the renewal sqm rates to account for preliminaries, design and consultancy fees, and contingency.

The above calculation provided the cost of replacing the various building element categories based on the sqm of the space types. The next part of the calculation involved assigning lifecycles to the building elements within the categories (as assets within a building element category have different life cycles). WTP used their database of previous projects to estimate the different weightings of each life cycle per building element category.

This created sqm rates for each life cycle within each building element category for the different space types. The space type areas for each station were then multiplied by each of the rates and plugged into WTP's renewal formula to calculate the renewal for the Stations.

8.6.5 Tunnels

Calculating the renewal for the Tunnels started with obtaining a register of all assets within the scope of a renewal estimate (this register was created from the WTP estimate). Life cycles and rates were then applied to each asset and linked to the renewal formula to calculate the renewal for the Tunnels.

A separate line item was included in the Tunnel renewal estimate for the fire detection system. This was calculated using a sqm rate based on the Station renewal rate for fire egress.

8.6.6 Railway track and systems

Calculating the renewal for the Railway Track and Systems started with obtaining a register of all assets within the scope of a renewal estimate (this register was created from the WTP estimate). Life cycles and rates were then applied to each asset and linked to the CAPEX formula to calculate the renewal for the Railway Track and Systems.

There was no detailed asset register for the signalling systems, therefore, a life cycle was applied to the sum allowed in the WTP estimate for each station for the signalling systems and linked to the renewal formula.

8.6.7 Rolling stock

The Rolling Stock assets included the units and simulator. The maintenance allows for a refurbishment of the units at year 20 and replacement at year 30 (estimated unit life cycle).

The renewal was calculated by assigning rates and life cycles to the assets and linking the values to the renewal formula.

8.6.8 Risk

A 10% contingency has been included for risks.

Increase in costs due to additional rolling stock.

We have included as an extra over the costs for extending the platform to accommodate addition length of the units plus the additional costs of the units as an extra over.

9. Comparison to IBC

A summary of the construction costs included in the IBC and the estimated costs for the EPO is provided as follows:

Table 9.1 IBC Comparison

	IBC Estimate		Escalated to Q2 2023		Current
Stations and Stops	$359.10		$432.86		$1,533.41
ParkNRide - Active Mode	$26.70		$32.18		Excluded
Bus Interchange	$8.50		$10.25		Excluded
Depot	$82.80		$99.81		$296.52
Public Utilities	$68.50		$82.57		Included in Utility relocations
Bulk Earthworks	$68.30		$82.33		$54.66
Retaining walls	$450.20		$542.67		$390.53
Services	$27.20		$32.79		Included in Tunnel MEP and Rail Systems
Bridges and Viaducts	$181.50		$218.78		$297.72
Bored Tunnels	$1,562.60		$1,883.56		$1,207.61
Shafts and Portals					$151.31
Fencing	$10.30		$12.42		$14.39
Rail systems Power delivery	$125.40		$151.16		$111.57
Rail Systems Power and Distribution	$99.90		$120.42		$66.24
Rail Systems signalling	$103.40		$124.64		$44.89
Rail Systems Comms	$4.80		$5.79		$144.77
Rail Systems APD					$12.19
Rail Systems – Fare Collection					$1.55
Rail Systems sundries					$13.60
Rail Systems Combined Service Route	$44.60		$53.76		$30.59
Track works	$99.60		$120.06		$254.93
Temporary Works	$34.90		$42.07		$34.91
Parallel Route	$12.50		$15.07		Excluded
Landscaping Public Realm	$127.60		$153.81		$272.23

Dominion Road/ New North Road Junction					$48.79
Consequential costs					$262.98
Road works and Paving	$38.50		$46.41		Included
Primary Utilities Relocations	$95.00		$114.51		$292.00
Demolitions	Included in Property				$165.19
Total Direct Costs	$3,631.90		$4,377.89		$5,702.59
Contractor's Design	$544.80	15.00%	$656.70	9.30%	$532.16
Preliminaries	$1,427.30	39.30%	$1,720.47	22.90%	$1,305.77
Overheads and Profit	$672.50	12.00%	$810.63	11.60%	$876.05
Total Indirect	$2,644.60		$3,187.80		$2,713.98
	$6,276.50		$7,565.69		$8,416.57
Rolling Stock	$485.74		$585.51		$304.20
					$8,720.77

9.1 Comparison Overview

9.1.1 Stations and Stops

The GFA of the below ground stations has increase by approximately 35% and the depth of the stations has been increased. The above ground structures for the EPO have increased in area.

The IBC design is based on lightrail stops at grade whereas the EPO design have metro stations that include enclosed stairs, public WC buildings and track escape routes.

Wesley Station was below ground in the IBC design; it is on a viaduct in the EPO design.

9.1.2 Shafts

No separate shafts were included in the IBC design.

9.1.3 Tunnel

The tunnel has been revised from a twin tunnel to monobore tunnel and has been reduced in length in the EPO design.

9.1.4 Depot

The IBC depot was proposed to be located in Carr Road, Mount Roskill. The EPO depot is proposed to be located in Onehunga. The site-specific factors are the key reason for the difference in cost (earthworks, requirement for viaduct access to site) along with the increased building area included in the estimate. The property costs for the new Depot location are significantly less.

9.1.5 Permanent Way

The difference is primarily in the track work which is due to rates. There is a minor difference only for the rail systems.

9.1.6 Utilities

Public utilities and relocation of utilities has mainly been impacted by the Transpower assets at Onehunga which was not identified during the IBC. Increased utility model review (as per Section 5.5) at this stage compared to IBC has identified greater number of utilities affected and risks.

9.1.7 Bridges and Viaducts

The length of the bridges and viaducts has been increased in the EPO, which is offset by rate changes.

9.1.8 Retaining Walls and Bulk Earthworks

The length of the trenches has been increased in the EPO, which is offset by rate changes. There are no detailed models for bulk earthworks required at grade for the EPO, and allowances only have been included.

9.1.9 Public Realm

Additional scope associated with the shafts and over motorway bridges with associated egress to at grade stations are not included in the IBC design. Wesley station is an above ground station in the EPO design and Wynyard Station is now located in Victoria Park, which has resulted in additional public realm works. The extent of the works has also been revised across the rest of the alignment.

9.1.10 Consequential Costs

These costs were included as roading costs only in the IBC estimate. The EPO estimate includes for works required to bridges along the SH20 alignment which require modifications or relocation.

9.1.11 Demolitions

These costs were previously included in property costs.

10. Peer Review (E3)

10.1 Summary

E3 Advisory has reviewed the reasonableness, completeness, and appropriateness of the ALR CAPEX and OPEX Cost Estimates. Full reporting from E3 is available in their peer review report, separate to this. The Peer Reviewer has independently determined the costs for the project. A discussion on the significant differences was held and several changes were made to the cost estimate, however due to the independent methodology a detailed reconciliation with the peer reviewer was not undertaken.

A comparison table of the CAPEX cost is listed in Table 10.1.

Table 10.1 Capex Peer Review

	Final Alliance CBC (September 2023)	Interim Alliance Peer Review (July – August 2023)	E3 Peer Review (July – August 2023)		% difference	% difference
	($m)	($m)	Min ($m)	Max ($m)	Min	Max
Contractor Direct Costs	5,703	5,790	6,025		4%	
Contractor Indirect Costs	2,714	2,730	3,422		25%	
Total Core Construction Costs	8,417	8,520	9,447		11%	
Rolling Stock	304	304	304		0%	
Owners Costs	1,008	975	975	975	Not Reviewed	
Total Core CAPEX Excl Property	9,728	9,799	10,726	10,726	9%	
Nett Property Costs	1,102	963	963	963	Not Reviewed	0%
Total Core CAPEX Excl Risk	10,831	10,762	11,689	11,689	9%	9%
Contingency P50	2,898	2,744	2,438	3,413	11%	21%
Base Cost (P50)	13,729	13,506	14,420	15,573	6%	14%
Contingency P95	4,776	4,900	5,363	6,338	9%	25%
Escalation	2,387	2,400	2,231	2,409	7%	1%
Total CAPEX Project Cost (P50)	16,116	15,906	16,784	18,050	6%	13%
Total CAPEX Project Cost (P95)	18,359	18,450	20,002	21,267	8%	15%

The Peer review was completed based on the Interim Alliance PR cost estimate (shown in 2nd column). A number of changes to the final CBC estimate (shown in the 1st column) were made including taking on Feedback from the Peer Reviewer. These changes are as follows:

1. Additional value engineering which reduced the direct costs by $87M (1.5%)
2. Change in nett property costs (not reviewed by Peer reviewer)
3. Increase in the rail systems costs
4. Increase in the Owners costs
5. Increase in P50 risk percentage to 29.76% of base costs excluding property
6. Increase in the P95 risk percentage to 47% of base costs excluding property

The outcome of the Peer review is that Direct costs were very close (4%) and overall construction costs were within 11%. The main difference is the higher P&G adopted by the Peer Reviewer based on Australian benchmark projects whereas the first principles estimate undertaken benchmarks well against CRL.

The P50 risk allowance built bottom up (30%) is midway between the Peer reviewers' allowance of 25-35%. This means the CBC P50 base cost is within a range of 6-14% of the Peer reviewer which is considered acceptable.

The P50 risk allowance as noted in section 7.4.3 is greater than the benchmarked range included in *The Engineers Australia, Contingency Guidelines, 2nd Edition, 2019* which would be 10-15% for the Final Business Case stage of a project.

10.2 Class of Estimate

The peer review assessed the class of estimate against the AACE 98R-18 "Cost Estimate Classification System-As Applied in Engineering, Procurement, and Construction For The Road And Rail Transportation Infrastructure Industries". Table 10.2Table 10.2: ALR Assessment of Project Maturity of the Tranche 4 ALR Estimate Table 10.2 demonstrates that the estimate is a mix of classes but overall can be classified as Class 4 as per the statement in Section 3.1.

Table 10.2: ALR Assessment of Project Maturity of the Tranche 4 ALR Estimate

AACE Estimate Classification	Maturity level of project definition deliverables	% Cost Estimate
Class 3	10% to 40%	34%
Class 4	1% to 15%	57%
Class 5	0% to 2%	9%

10.3 Cost Centre Comparison

10.3.1 Contractor Direct Costs

Table 10.1 highlights the peer review found the percentage difference between the direct cost estimates to be 4%. At a Class 4 estimate where AACE 98R-18 defines the expected accuracy to be between -15% and +50%, this can be viewed as a confidence level in the upper end of the guidance.

Table 10.3: Contractor Direct Cost Comparison ($m)

	ALR	Peer Review	VAR	VAR (%)
Stage 1	2,283	2,328	45	2%
Stage 2	1,807	1,700	107	6%
Stage 3	980	996	16	2%
Stage 4	720	1,001	281	39%
Total	5,790	6,025	235	4%

The Contractors Direct costs comprise of elements such as demolition, utilities, tunnel, viaduct, trench, civil works, and traffic management. Table 10.3 shows the variances across each stage. Physical works for Stages 1-3 are between 2-6% which again can be viewed as a confidence level in the upper end of the guidance. There are variances across each element between 1-23% but this is to be expected due to maturity of design elements being between a Class 3 and 5.

Rail Systems (Stage 4) have the highest variance of each of the stages.

The main difference in approach is that the Peer Reviewer has priced the rail systems supplier as a subcontractor rather than Alliance participant. (Refer to section 3.4.2). This means the Peer Review rates include P&G and margin, whereas we have assumed that the Rail systems integrator will be an Alliance Participant which means there is no double-up of P&G or margin on margin. Therefore the comparison above is comparing direct costs with full rail systems cost including P&G, Design and Margin. If you add the Rail Systems indirect cost allowances to the Alliance costs you get $1040M which is greater than the Peer Review Estimate.

At a granular level, Peer Review costs are greater for signalling and testing and commissioning(T&C) with commentary made that greater design is required to assess the scope. The Alliance design uses Communications-based train control (CBTC) for railway signalling which has a significant lower cost compared with more traditional rail signalling systems. The view of the Alliance is that the peer reviewer has used an incorrect benchmark associated with this. WTP benched marked the CBTC costs against the Sydney Metro project.

The other significant difference relates to testing a commissioning. The majority of T&C cost sits with engineering staff and would be included in the P&G. It is noted that our full P&G cost has been applied to the total of 39 months of commissioning period included in the overall programme.

Overall, the direct cost estimate was assessed as being reasonable against the material variances of the rail systems for signalling and testing and commissioning.

10.3.2 Contractor Indirect Costs

Table 10.4 Contractor Direct Indirect Cost Comparison ($m)

	ALR	Peer Review	VAR	VAR (%)
Preliminaries and General	1,306	1,807	501	32%
Design	541	565	24	4%
Offsite Overheads and Profit	883	1,050	167	17%
Indirect Total	2,730	3,422	692	25%
Total Construction Costs	8,520	9,447	927	11%

Table 10.4 breaks down the Contractor Indirect Costs. Design costs are the clearest example where the peer review aligns with the Alliance estimate. As explained Section 5.7.4 cost percentages between 10%-4% have been applied to the various cost centres (stations, tunnel, viaduct etc) in the estimate with values increasing with the risk proportion. Overall, this equates to 7.1% direct costs which the peer review has found compatible with benchmarking.

Preliminaries and General (P&G) has the greatest variance percentage with peer reviewer. The Alliance has used a first principles estimate that benchmarks very closely with the CRL Alliance actuals, whereas the peer review has used Australian benchmarking of 30-40%. They have settled on the lower end of 30%. The Alliance evaluated with WTP and Alta on how to keep P&G manageable and concluded on basing the estimate on an Alliance delivery model rather than Design & Build contract. The rail systems contractor is assumed to be integrated as a Non-Owner Participant (NOP) in the Alliance, rather than as a turnkey subcontractor, removing the duplication of on-site overheads, off-site overheads, and profit between the parties. Should ALR not follow this model then higher P&G may be applicable.

The Peer Review has deemed that the 12.5% mark up for offsite overheads and profit (as per section 5.7.1 is reasonable. The variance is due to peer reviewer applying the percentage to all direct costs, on-site overheads, and design costs. The Alliance disagreed with this as the model is for direct procurement of the rolling stock, and contractor mark up does not apply to Designer's Limb 2 in Alliances.

The Indirect Total variance of 25% is at the higher end of a Class 4 estimate, due to the variances listed for P&G and Off-Site Overheads and Profit. However, when the costs are combined with Direct Costs, this reduced to 11%. This value is normal for a project of ALRs size before Reference Design has taken place, and estimators are working with greater assumptions. Direct and Indirect costs can be viewed with good confidence at this stage.

10.3.3 Rolling Stock

As shown in Table 10.1 the peer review found the rolling stock costs to be the same as the Alliance. Estimate is based on an initial purchase of 30No. 3 car sets, a LRV simulator and fire fighting trolleys.

10.3.4 Contingency (P50)

Table 10.5 Contingency P50 Comparison

	Final Alliance CBC (September 2023)	Interim Alliance Peer Review (July – August 2023)	E3 Peer Review (July – August 2023)		% difference	% difference
Contingency P50	2,898	2,744	2,438	3,413	11%	21%
Base Cost (P50)	13,729	13,506	14,420	15,573	6%	14%

The Peer Review agreed with the PERT method (3-point estimate approach) adopted by the Alliance to evaluate project contingency at the level 3 WBS (Work Breakdown Structure) level. Both parties agree this is appropriate for a project at this phase of the Business Case. The risk review has been undertaken for each stage and key elements; again the peer review found this to be a prudent approach. Rails Systems and Utilities have the highest ranging due to the low level of scope definition and complexity of work.

The Alliance adopted a P50 percentage of 29.8% against base costs excluding Property. The peer review has advised that the Australian Risk Engineering Society Contingency Guidelines on risk contingency should be between 25-35% at this stage of an infrastructure project, which ALR therefore sits within. Table 10.5 reflects this with the values of $2,438m to $3,413m against the Alliance's $2,744m. It is worth noting that Contingency

To determine the 29.8% for use, a process was followed to actively identify and manage risk throughout the development of the business case whereby a wide range of stakeholders provided input into the risk process. The process ensured that known and unknown risks are considered and quantified for inclusion into the contingency calculations. This process is deemed as suitable due diligence review of project risk. For the final CBC, the P50 risk allowance built bottom up (30%) is midway between the Peer reviewers' allowance of 25-35% which is considered acceptable.

It worth noting that the referenced contingency Guideline actually benchmarks a P50 contingency of 10-15% for Concept Design supporting a full Business Case – refer to section 7.4.3.

10.3.5 Escalation

Table 10.1 shows that the escalation estimated by the Alliance is within 1% of the peer review for the upper bound. The peer review acknowledges the method used by the Alliance to be correct and well implemented to appraise the project. Escalation values are based on values from Stats NZ for a variety of infrastructure disciplines, due to external factors such as post COVID-19 market flux, political influences and global supply constraints, there are still inherent uncertainties for ALR with escalation predictability.

10.4 OPEX

In undertaking the Value Management exercise (Section 3.3), the Alliance produced an Operating & Maintenance cost assessment to support the CAPEX assumptions. This cost estimate was submitted to both WTP and E3 to undertake a parallel review. The OPEX costs listed in Section 8 and those implemented into the Corridor Business Case are those produced by WTP in review and have been adopted by the Alliance.

E3 reviewed the costs associated with the first 30 years of operation on ALR. The view of the peer reviewer was that the "*60-year column did not appear complete and was not included in the scope of our review*", this was due to the Value Management exercise still being undertaken once the peer review had commenced. A comparison table of the OPEX costs for the first 30 years is listed in

Table 10.6, costs associated with 60 years are within Table 8.1.

Table 10.6 Opex Peer Review – 30 years

	E3 ($m)	WTP/Alliance ($m)	% difference
Pre-Commencement	-	$ 268	
Staff	$ 2,647	$ 2,287	15%
Utilities	$ 612	$ 507	19%
Maintenance	$ 692	$ 796	14%
Overhead	$ 613	$ 375	48%
Overhaul	$ 206	$ 370	57%
Rolling Stock	$ 727	$ 306	82%
Traction	$ 108	$ 239	76%

Risk	$ 560	$ 471	17%
Total OPEX Cost	$ 6,165	$ 5,619	9%

Table 10.6 highlights the peer review found the percentage difference between the estimates to be 9%. At a Class 4 estimate where AACE 98R-18 defines the expected accuracy to be between -15% and +50%, this can be considered acceptable.

10.4.1 Pre-Commencement, Staff and Overhead

The Alliance and peer reviewer had differing views on how many staff would be required to operate ALR. Alliance have benched marked against example light metro operations such as Copenhagen, Docklands Light Rail, and Singapore Circle Line where Customer Service Advisors would operate dual safety critical duties and paid accordingly. The peer reviewer adopted a greater number of staff paid at a lower rate. This resulted in a 15% difference which is suitable position to be at whilst the Concept of Operation for the project has yet to be finalised.

The peer review report makes no mention of Pre-Commencement costs. Assuming these are accounted for in the Staff costs; Alliance costs would be $2,555 compared to $2,647, a difference of 4%.

Both estimates have made allowances for the same Overhead assumptions (insurance, training, recruitment, PPE, IT, HR, legal fees etc). The difference in costs is due to the difference in staff numbers and the allowance the estimate should make for each staff member.

10.4.2 Utilities and Maintenance

Both estimates are based on $680k/route track km/year. The variance in estimates is due to each party using different rates for benchmarking. The peer reviewer has noted "*Given the nature of early stage estimates and the small scale of ALR the costs are expected to be at the higher end of the range and are considered not unreasonable*."

10.4.3 Overhaul

The overhaul cost produced by the Alliance are greater than the peer reviewer. More allowance for overhaul of station fixtures, furnishing and equipment has been made which the peer reviewer did not include.

10.4.4 Rolling Stock

Rolling Stock maintenance costs are where the two parties are the furthest apart, this is due to different views on benchmarking. The peer reviewer has used a mid-point pricing of $5.25/km for a 3 car consist. The Alliance understands that this is based on light rail systems similar to those used in Melbourne. The view of the Alliance is that these have higher maintenance costs than light metro vehicles. The Alliance has benched marked against the projects listed in 10.4.1 to determine a value of $2.20/km. For comparison the Australian Transport Assessment and Planning Guidelines provide guidance of $1.3/km (December 2018 data).

10.4.5 Traction

Both parties are generally in agreement on the rates applied in the estimates. The difference in cost estimate is due to the total power consumption used. WTP have taken an annual flat

rate from the traction power simulation report, whereas the peer reviewer has used the headway consumption from the Alliance's initial estimate calculations.

10.4.6 Risk

The peer review did not provide a contingency allowance, as such 10% has been added to E3 reviewed the costs associated with the first 30 years of operation on ALR. The view of the peer reviewer was that the "*60-year column did not appear complete and was not included in the scope of our review*", this was due to the Value Management exercise still being undertaken once the peer review had commenced. A comparison table of the OPEX costs for the first 30 years is listed in

Table 10.6, costs associated with 60 years are within Table 8.1.

Table 10.6 for full comparison with the Alliance values.

11. Intermediate Comparator Estimate

11.1 Scope

The CBC requires an Intermediate Comparator – refer to the Economic Case for details. and Figure 11.1 outlines the scope of the Intermediate Comparator, highlighting where the solution is similar and where it deviates from the EPO solution. A cost comparison of both schemes is provided in Section 11.2. The IC estimate was not peer reviewed.

Figure 11.1 Intermediate Comparator Route

Table 11.1 Intermediate Comparator Scope

	Solution Source			
Element	**IBC**	**EPO**	**IC**	**Definition/Rationale**
1. Southern terminus	✓	✓		**Specification:** Airport. **Rationale:** An airport terminus was defined within the IBC's strategic case and matches the EPO alignment. This decision reflects major employment sites and opportunities around the airport business precinct.
2. Northern terminus	✓	✓		**Specification:** Wynyard. **Rationale:** This approach aligns to the overall project limits and the scope defined within the IBC and EPO.
3. Fleet			✓	**Specification:** 66m LRT vehicle comprised of two coupled 33m units. For capacity and operational assessment, the assumed specification is equivalent to the Citadis X05 class (currently operating in Sydney) with a maximum capacity of 48 seated and 185 standing (@ 4ppm^2) totalling 466 pax per 66m vehicle. 750 VDC traction power with full route overhead electrification (excluding any consideration at this stage of the airport designation and any AIAL requirements). **Rationale:** The IBC considered trade-offs of meeting urban outcomes with transport capacity needs. A 66m vehicle is considered to balance impacts on property, operations, and traffic. 750 VDC overhead electrification can facilitate on-street operation and is a proven technology with lower costs than proprietary or battery powered catenary-free solutions.
4. Operations	✓			**Specification:** Key operational assumptions: - 15 trains per hour as a maximum feasible frequency with full signal priority at all intersections. - Maximum speed in operation of 63km/h (based on alignment limitations). - Stop dwell time of 20/30/40 seconds (related to forecast patronage). **Rationale:** Previous modelling demonstrated issues in managing the overall road network at service frequency above 15 trains per hour due to required changes to standard cycle times and disruption to cross-street traffic. An increase in frequency to 20 trains per hour without signal priority is not compatible with cycle times, given it introduces variability, increasing journey times and potential bunching.
5. Horizontal Alignment	✓	✓	✓	See items 5a-5d below for summary.
5a. Wynyard to Puketāpapa	✓			**Specification:** As per IBC, on street running. **Rationale:** The IBC alignment represents a direct route between stop locations that can be achieved largely within existing highway land minimising property impact.

	Solution Source			
Element	**IBC**	**EPO**	**IC**	**Definition/Rationale**
5b Puketāpapa to Te Ararata		✓	✓	**Specification:** As per EPO alignment, with the exception of: - A short linking section from Puketāpapa to EPO alignment parallel to SH20 - The approach to Onehunga via lagoon reserve connecting to Princes Street where the IC route runs on-street to Onehunga station in an alternative location before linking back to EPO alignment on approach to depot. - variation in vertical alignment on section detailed above to reduce length/heights/depths of viaduct and trench and facilitate on-street running. **Rationale:** The EPO alignment connects destinations between Puketāpapa and Onehunga and has been the subject of development both in terms of identifying preferred station locations and the design of a preferred alignment between them. Therefore, the EPO horizontal alignment has been adopted, however opportunity for vertical alignment variation using gradient ability of LRVs has been considered (see section 16). This response considers consultation feedback and wider factors including property impact, interaction with other transport modes and major utilities routes.
5c Te Ararata to Māngere Town Centre		✓	✓	**Specification:** As per EPO adjacent to SH-20, with the exception of: - a diversion from the EPO alignment at SH-20/20A interchange to serve a stop at Māngere Town Centre located on Orly Avenue and returning to SH-20A via residential area. - variation in vertical alignment on SH-20/20A interchange section to minimise impact on public realm, transport routes, commercial access, and property. **Rationale:** The proposed alignment blends aspects of the IBC and EPO with connecting sections specific to the IC. The resulting alignment offers improved accessibility to Mangere Town Centre in comparison to the EPO (but with impact on overall journey time).
5d Māngere Town Centre to Airport		✓		**Specification:** From tie-in point to EPO (parallel to SH-20A) the IC vertical and horizontal alignment follow the EPO to Airport. **Rationale:** This section varies in comparison to the EPO due to access to Mangere Town Centre but is otherwise the same using refined alignment from design development of the EPO.
6. Stop locations		✓	✓	**Specification:** 21 stops locations based on whether the alignment section is IBC, EPO or IC specific (see Figure 4.1). Additional stop count (above the EPO) are in the Wynyard to Puketāpapa section. **Rationale:** From Wynyard to Puketāpapa stop locations are consistent with the IBC option. Review considered proximity of stops in Wynyard/Victoria Park/Viaduct Harbour/Britomart section and also Milton Road/Lambeth Road section in terms of

	Solution Source			
Element	**IBC**	**EPO**	**IC**	**Definition/Rationale**
				journey time impact but as a result of improved accessibility, low operating speeds and no impact on alignment all stations were retained. From Hayr Road to the Airport stop locations are as for the EPO option with the exceptions of Onehunga and Māngere Town Centre which are in IBC locations.
7. Stop design/size			✓	**Specification:** 70m platforms are assumed to serve 66m low-floor vehicle. On-street stops to be accessed from street including at grade-track crossings. Access to stops on sections of separated running to match EPO access arrangements with grade-separated track crossings. Assumption of no Platform Screen Doors (PSD's). **Rationale:** For on-street stops where vehicle speeds are typically low, at-grade access provides ease of access/egress and can be more readily accommodated in the streetscape. For separated sections where vehicle speeds are higher, grade-separated access arrangements will provide improved safety and access/egress from either side of the SH20/SH20A motorways for both passengers and other active mode trips.
8. Depot		✓		**Specification:** Onehunga as per EPO. **Rationale:** The selection of the Onehunga depot location was based on extensive MCA assessment for the EPO. The primary reasons for selection were not rail mode specific and so for comparison, the same location will be assumed for the IC, requirement for facilities have been reviewed.
9. Land-use assumptions			✓	**Specification:** LUTI modelling as per EPO. **Rationale:** The different alignment, station locations and overall slower journey time will affect the accessibility impacts of ALR and subsequent land use response, which is central to future patronage demand. For these reasons land use modelling has been undertaken for the IC.
10. Network Demand Modelling			✓	**Specification:** Demand modelling has been repeated for IC specification, calculated with alignment, stops (20/30/40s dwell times based on forecast patronage), journey time and vehicle specification inputs. **Rationale:** The IC uses station locations and alignment that differ from previously modelled ALR schemes. As a result, the journey time and demand response will differ.
11. Staging			✓	**Specification:** Single stage construction/opening. **Rationale:** Review considered that while feasible, there is little driver to deliberate staging from either an industry capacity or affordability/cashflow perspective. Opening of a complete scheme will result in significantly higher accessibility and benefits particularly for southern areas of the route without major delay in comparison to a staged opening.
12. Cross section – LRT	✓	✓		**Specification:** IBC cross section for on-street, EPO cross section for separated sections. Assume that for

Element	Solution Source			Definition/Rationale
	IBC	EPO	IC	
				on-street sections LRT would operate on raised, dedicated area of roadway with kerbs to improve traffic separation. **Rationale:** The space required for LRT operation is mainly determined by the kinetic envelope of vehicles. To ensure priority and reliability it is intended that this space would be dedicated except for intersections or stations where access to shared sections would be controlled with traffic signals. Where the IC operates on separated sections, the route corridor width used for the EPO has been assumed, as these sections are typically adopted from the EPO alignment (see element 5). The cross section for both on-street and separated sections will enable overhead electrification masts to be provided within it.
13. Cross section – Non-LRT	✓			**Specification:** Two cross sections for on-street running have been considered 1. Desirable minimum width of 25.0m. This width will require intermittent land/property take - Assume all known utilities renewed. - Cycle lanes included. - Footpath widths of 2.5m assumed. - Traffic lanes retained. 2. Absolute minimum width of 20.0m Where desirable minimum of 25.0m is considered to have net negative impact overall a reduced absolute minimum width of 20.0m has been applied. - Assume all known utilities renewed. - Cycle lanes, street trees, furniture zone, buffer excluded. - Wider footpath widths of 3.5m assumed. - Traffic lanes retained. **Rationale:** Where the IC alignment operates on-street it will be within existing public road corridors, bounded to either side by private ownership (often buildings). Design work undertaken at the IBC stage considered the trade-off between the AT Transport Design Manual standards and the space available along the IC alignment and proposed a range of cross sections with differing widths to understand the trade-offs between space and the facilities which could be accommodated. The property impact has been investigated for both (1) a consistent 25m corridor and (2) a 25m corridor which pinches to 20m where there would otherwise be extensive sections of significant impact on existing buildings – specifically in town centre locations along the corridor.
14. Shared operation with North Shore Rapid Transit Network			✓	**Specification:** Passive provision at Wynyard. **Rationale:** The route and northern terminus at Wynyard provides potential for extension of the CC2M route. It is assumed any North Shore route would operate as the new northern terminus, i.e., there would be no increase in the assumed operational limit of 15 trains per hour (element 4).

	Solution Source			
Element	**IBC**	**EPO**	**IC**	**Definition/Rationale**
15. Shared operation with North West Rapid Transit Network			✓	**Specification:** No provision for northwest RTN. **Rationale:** A connection to the northwest corridor would require a mid-route connection to the ALR CC2M route with shared running for the portion of the route. Due to assumed operational limit of 15 trains per hour (element 4) it would not be possible to provide sufficient capacity for two RTN corridors to share infrastructure. It is noted that as of November 2023 the emerging preferred option for the northwestern corridor is a bus-based provision.
16. Vertical alignment	✓	✓	✓	**Specification:** As detailed under 5a-d the vertical alignment for the section of the route Wynyard to Puketāpapa has adopted design from IBC Option 1B. For the section of the route from Puketāpapa to Onehunga vertical alignment will be reconsidered to take advantage of the greater gradient capability of Light Rail Vehicles using a desirable maximum gradient of 7% and an absolute maximum gradient of 10% (for short sections). For the section of the route from Onehunga to Airport vertical alignment has been reconsidered only for IC specific sections of design, notably around Mangere Town Centre. **Rationale:** The increased gradient capability of Light Rail Vehicles enables different design solutions to be considered for sections of the route where there are significant natural topographical features or the need to cross other infrastructure. IBC Option 1B previously considered vertical alignment for LRV operation on the section of route from Wynyard to Puketāpapa but LRV operation has not been considered for the section of the route adopted from the EPO from Puketāpapa to Airport.
17. Microsimulation modelling	✓			**Specification:** No Microsimulation modelling for the IC. **Rationale:** Operation of on-street sections is consistent with IBC microsimulation modelling, namely service frequency and approximate vehicle specification, therefore findings will be assumed to be consistent with that work.

11.2 Cost Comparison Summary

A comparison of the EPO and Intermediate Comparator (IC) is summarised as follows:

Table 11.2 Intermediate Comparator Capex Summary

Description	EPO	IC
Route Length	25,840m	
Client Internal Cost	$977,840,001	$642,436,534
Client's Design	Included	Included
Consent preparation	Included	Included
Site Investigations	$30,000,000	Included
Property **Private, Council Owned, AMA, NZTA, AT, Forestry, KiwiRail, Treaty land, Marine Work**	$1,102,225,049	858,147,455
Project Specific Insurances	Included	Included
Construction	$8,416,573,121	$4,855,274,993
Rolling Stock	$304,200,000	$588,500,000
Base Estimate	$10,830,838,171	$6,944,358,980
Contingency on Physical Works and Rolling Stock (Assessed/Analysed)	$2,898,091,323	$2,131,999,897
Contingency on Property (Assessed/Analysed)	Incl. In P50 allowance	Incl. In P50 allowance
Total Project Expected Estimate (excl. Escalation)	$13,728,929,494	$9,076,358,877
Escalation (excluding Property)	$2,235,675,448	$1,556,400,761
Escalation (Property)	$196,594,826	$72,470,553
Total Expected Estimate (P50) including Escalation	$16,161,199,768	$10,705,230,191
Funding Risk on Physical Works and Rolling Stock (excl. property) - AACEI Level 4	$1,657,436,844	$7,027,748,448
Funding Risk on Property - AACEI Level 4	$220,445,010	$171,629,491
95th Percentile Estimate - AACEI Level 4 (excl. Escalation)	$18,039,081,622	$17,904,608,130
Escalation (excluding Property)	Excluded	Excluded
Escalation (Property)	Excluded	Excluded
Total	$18,359,265,006	$17,904,608,130

Table 11.3 Intermediate Comparator Opex Summary

Description OPEX	Pre-Commencement $-	Years 1-30 $-	Years 31-60 $-	First 60 Years $-
Spares	$100,000,000			
Insurance	$5,000,000	$150,000,000	$150,000,000	$300,000,000
Manpower	$5,779,128	$2,369,442,375	$2,369,442,375	$4,738,884,750
Staff Sundries	$8,223,534	$195,808,059	$195,808,059	$391,616,119
Fees etc	$2,282,459	$37,500,000	$37,500,000	$75,000,000
StationsPower/rates	$-	$136,947,525	$136,947,525	$273,895,050
OPEX - Stations (Materials ect)	$-	$6,274,313	$6,274,313	$12,548,625
OPEX - Depot Building	$-	$841,634	$841,634	$1,683,267
OPEX -Rail Systems	$-	$329,593,275	$329,593,275	$659,186,551
Power	$2,460,902	$147,654,144	$147,654,144	$295,308,288
Rolling Stock (Parts)		$90,000,000	$90,000,000	$180,000,000
Sub Total Opex	$123,746,023	$3,464,061,325	$3,464,061,325	$6,928,122,650
RENEWALS				
Overhaul of the System Rail		$410,081,904	$645,301,095	$1,290,602,190
		$410,081,904	$645,301,095	$1,055,382,999
Rolling Stock		$126,500,000	$729,000,000	$855,500,000
		$126,500,000	$729,000,000	$855,500,000
Facilities				
Depot Buildings		$33,943,897	$38,640,939	$77,281,878

Stations		$135,169,599	$173,239,062	$346,478,123
		$169,113,496	$211,880,001	$423,760,001
Contingency		$416,975,672	$505,024,242	$926,276,565
	$-	$416,975,672	$505,024,242	$926,276,565
	$123,746,023	$4,586,732,397	$5,555,266,663	$10,189,042,216

11.3 Intermediate Comparator QRA

11.3.1 Background

For the intermediate comparator risk modelling, we used the risk profile established within the IBC phase for Option 2B as a starting point. This IBC risk profile, or equivalent risk distribution, has been modified to reflect the reduced risk achieved by sharing portions of the corridor with the Emerging Preferred Option corridor and additional design development achieved.

11.3.2 Contingency

Contingency provided for the Intermediate Comparator (IC) is based on an adjusted Intermediate Business Case (IBC) phase risk profile and resulted in a P50 project expected contingency of 30.07% and a funding risk contingency of 103.67%, see Table 11.4Contingency Summary, Contingency, IC. This provides a total contingency 134.37% of base estimate. A Detail description of the risk profile determination is available in section 11.3.3.

Table 11.4 Contingency Summary, Contingency, IC

Contingency	Million NZD (Excl. Property)	% of Base (Excl. Property)	Million NZD (Incl. Property)	% of Base (Incl. Property)
Project Expected Contingency (P50)	2,132	35.00%	2,132	30.07%
Funding Risk Contingency (P95 - P50)	7,027	115.47%	7,199	103.67%
Total Project Contingency (P95)	**9,159**	**150.47%**	**9,331**	**134.37%**

11.3.3 IBC Phase Risk Profile

An evaluation of the IBC Phase's risk profile on Option 2B evaluated provided the below Weibull distribution, see Figure 11.2IBC Option 2B Risk Distribution.

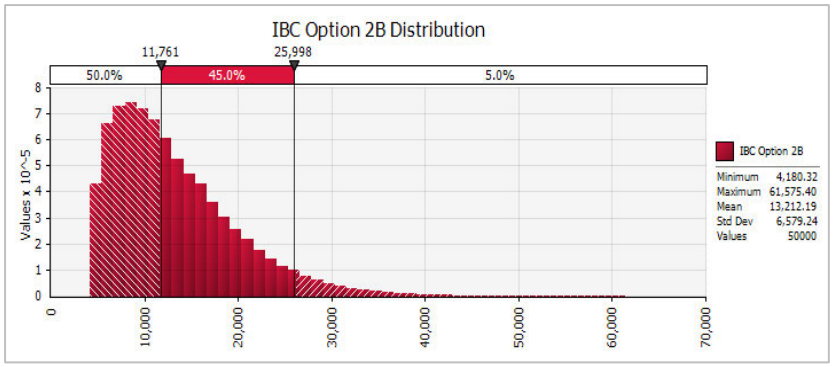

Figure 11.2 IBC Option 2B Risk Distribution

11.3.4 Application of Risk Profile

To accommodate for the increased certainty as provided by the Emerging Preferred Option (EPO) investigations and designs, the Weibull distribution was shifted to align the risk distribution profile to an expected P50 of 30.07% of base costs excluding property. The section of IC alignment from the City Centre to the end of Dominion Road was prepared to Reference Design level by Auckland Transport and the remainder of the alignment has been prepared to Consent Design Level by the Alliance. Therefore, the IC is considered to be to the same design maturity as the EPO and a P50 risk allowance of 30.07% is considered appropriate. An adjustment was made to the IBC's P95 representation of risk by reducing the top end of the distribution by 20% was also made.

11.3.5 QRA Result, IC

This resulted in a Project Expected Contingency (P50) of 30.07% of the Intermediate Comparator's base cost estimate and a Funding Contingency of 103.67% of the Intermediate Comparator's base cost estimate, excluding property. This is considered reasonable given the maturity of the design.

It is expected the P95 would reduce with further development of the scheme.

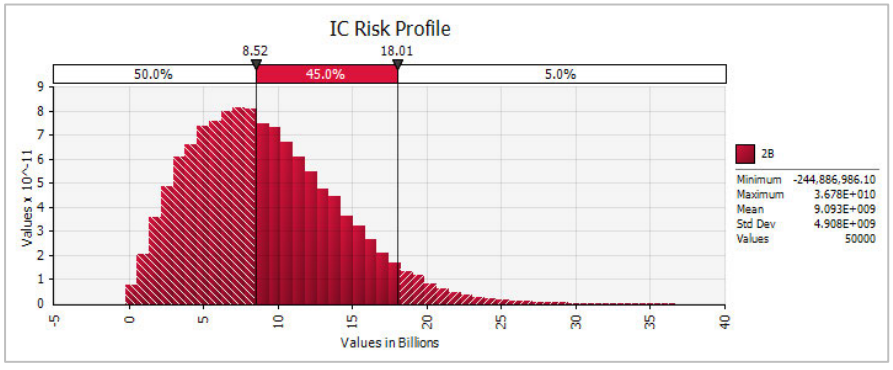

Figure 11.3 Intermediate Comparator Risk Distribution

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Appendix A Construction Capex (Estimate Output)

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Appendix B Programme

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Appendix C Risk

Quantitative Risk Assessment Report

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Appendix D Property

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Appendix E OPEX Cost Estimate

Refer ALRPC-ALRA-000PRO__-ZZZ-LP-PPS-DS-DAT-000002

Appendix F Peer Review

Appendix G Intermediate Comparator Estimate