DART+ Tunnel Route Options and Feasibility

Final Report

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National Transport Authority

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Contents

Executive Summary

Introduction

In line with the Project Ireland 2040: National Development Plan 2018 to 2027, this study has been undertaken to establish a route for the tunnel elements of the DART network expansion and allow for protection of a corridor for delivery of the scheme in the future. The study will also provide inputs to the review of the Transport Strategy for the Greater Dublin Area (GDA) being undertaken by the NTA.

The assessment of feasible routes has considered the recent and planned changes in the public transport network for the GDA since the DART Underground Railway Order was granted in 2014. The Project Objective for the study is defined as: *"To meet long-term passenger demand, as part of an integrated, accessible, and efficient public transport network in the Dublin City Centre area, including heavy rail requirements for inter-city and other rail services, by providing enhanced connectivity from the Kildare Line by connecting, either by interchange or run-through services, with north-south services operating on the Coastal Rail Line (comprising of the Northern Rail Line and the South Eastern Rail Line)."*

For this Project Objective the study considers four Operational Scenarios, which include:

1) A run through scheme from Kildare Line to the Northern Line;
2) A run through scheme from Kildare Line to the South Eastern Line;
3) A scheme that runs from the Kildare Line and connects by Interchange to the Northern Line, and;
4) A scheme that that runs from the Kildare Line and connects by Interchange to the South Eastern Line.

Assessment of Options

The identification and selection of routes followed a number of stages as shown in Figure 1 overleaf.

Options identification

21 options identified
- Based on population and employment projections;
- Location of key trip attractors;
- Environmental characteristics.

Initial sift

High level sift of 21 options identified against the Project Objective and technical feasibility – 5 options sifted out.

Stage 1 Preliminary Options Assessment

16 options assessed
- Four criteria considered:
  - Travel Demand,
  - Rail Network Operations,
  - Environmental Impacts,
  - Capital Cost.
- 5 options shortlisted for Stage 2 MCA.

Stage 2 Options Assessment

5 options assessed
- 4 run through, 1 interchange;
- MCA against all CAF criteria;
- Best performing option identified.

Figure 1: Option identification and selection process

Initially, 21 potential route options were identified. Each of these was informed by population and employment projections for the GDA up to 2050 (the forecast year), the location of key trip attractors, and environmental characteristics. Following a screening process against the Project Objective and engineering feasibility, 16 route options were brought forward to the Stage 1 Preliminary Options Assessment.

The Stage 1 assessment examined each of these remaining options in terms of four criteria: Travel Demand, Rail Network Operations, Environmental Impacts, and Capital Cost. This assessment resulted in five options being shortlisted for the Stage 2 Options Assessment, which are shown in Figure 2:

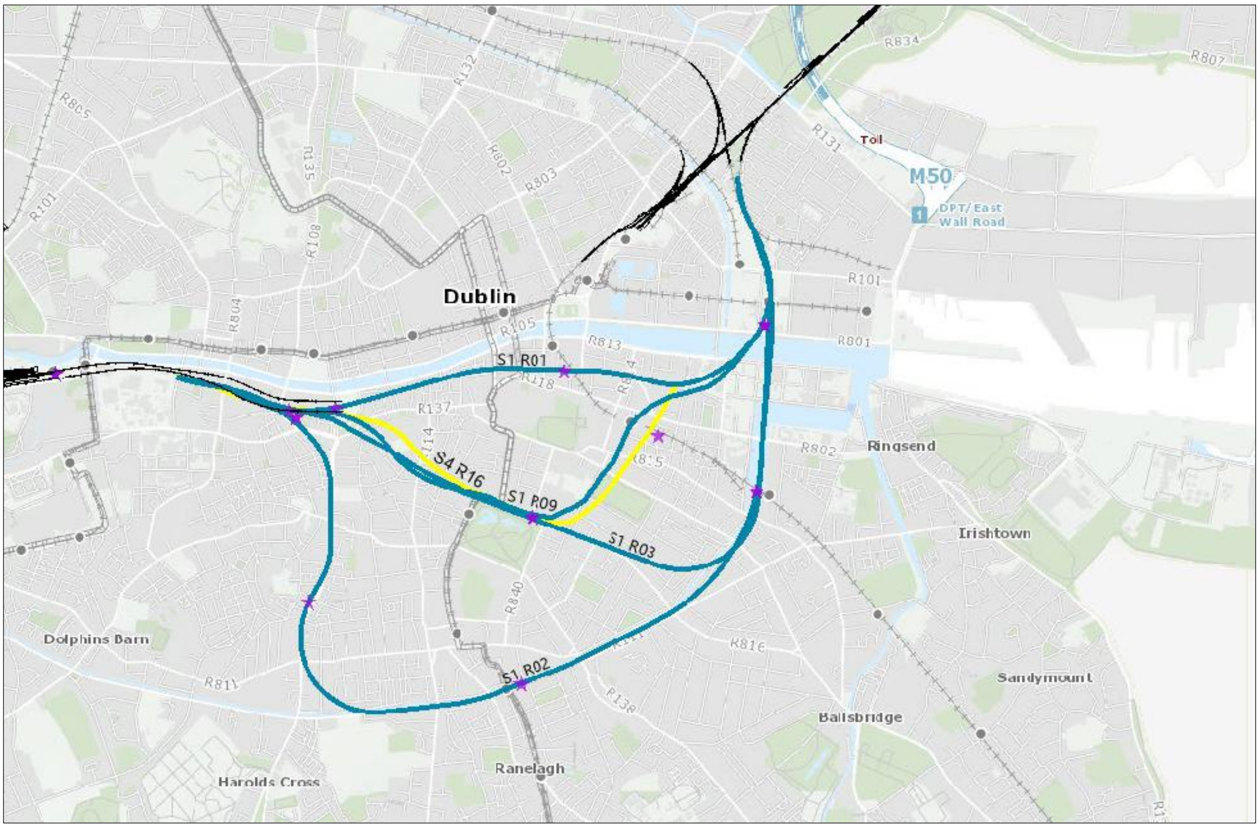


Figure 2: Shortlisted options brought forward for detailed MCA

Four of the five selected route options are from Operational Scenario 1 (R01, R02, R03 and R09), where trains run through from the Kildare line at Heuston onto the Northern Line at Docklands, and in so doing by-pass the congested network at Connolly Station. The fifth option, representing interchange Operational Scenario 4 (R16), has an underground connection and turnback facility at Pearse Station.

As part of the Stage 2 assessment, the five route options were further developed, in which additional analysis was carried out in accordance with the Common Appraisal Framework for Transport Projects and Programmes (CAF). The main criteria (and chosen sub-criteria) for the assessment are shown below:

Main criteria	Sub-criteria	
Economy	Cost	Rail Operational Efficiency
	Journey Time Saving	Assessment of Costs & Benefits
Safety	O&M Safety	Construction Safety
Integration	Land Use Policy Integration	PT Transfer Metrics
Environment	Population	Material & Cultural Aspects
	Biodiversity	Landscape & Visual
Accessibility & Social Inclusion	Accessibility to Key Trip Attractors	PT Accessibility
	Access to Areas of Deprivation	

The performance of each option in the multi-criteria analysis (MCA) is presented in Table 1. The assessment has shown that an underground heavy rail link through Dublin city centre has the potential to deliver significant economic, environmental, and social benefits for the GDA. It will result in the enhancement of the GDA's public transport network by facilitating reduced journey times, increased journey reliability, increased accessibility to employment opportunities and education, and improved interchange with other modes. The MCA identified route option S1 R09 as the best performing option for the DART+ Tunnel.

Table 1: MCA scoring for shortlisted route options

Option		Economy	Safety	Integration	Environment	Accessibility and Social Inclusion	Overall
S1	R01						
	R02						
	R03						
	R09						
S4	R16						

The assessment of the costs and transport user benefits of the options indicates a significant scale of benefits for the DART network; the tunnel section alone of the best performing option will accommodate upwards of 100,000 daily passenger movements in 2050. While this initial assessment indicates higher lifetime costs than transport user benefits, the assessment does not consider all potential benefits, including carbon savings and agglomeration. In addition, the transport user benefits assessment does not include a rationalisation of the transport network, such as integration with bus network and optimisation of the rail network.

Description of route option S1 R09

The best performing route option for DART+ Tunnel is identified as S1 R09, and it is recommended that a corridor be identified for this route to allow for its future delivery.

This 7.83km route is similar to the previously approved DART Underground route and is shown in Figure 3. The alignment starts at the western tie-in and travels in a south-eastern direction towards the northern side of St. Stephen's Green via Heuston and Christchurch. After this, the route runs along Merrion Square to Pearse Station in a north-eastern direction. The route then crosses the River Liffey prior to connecting to the Northern Line in the Docklands area.

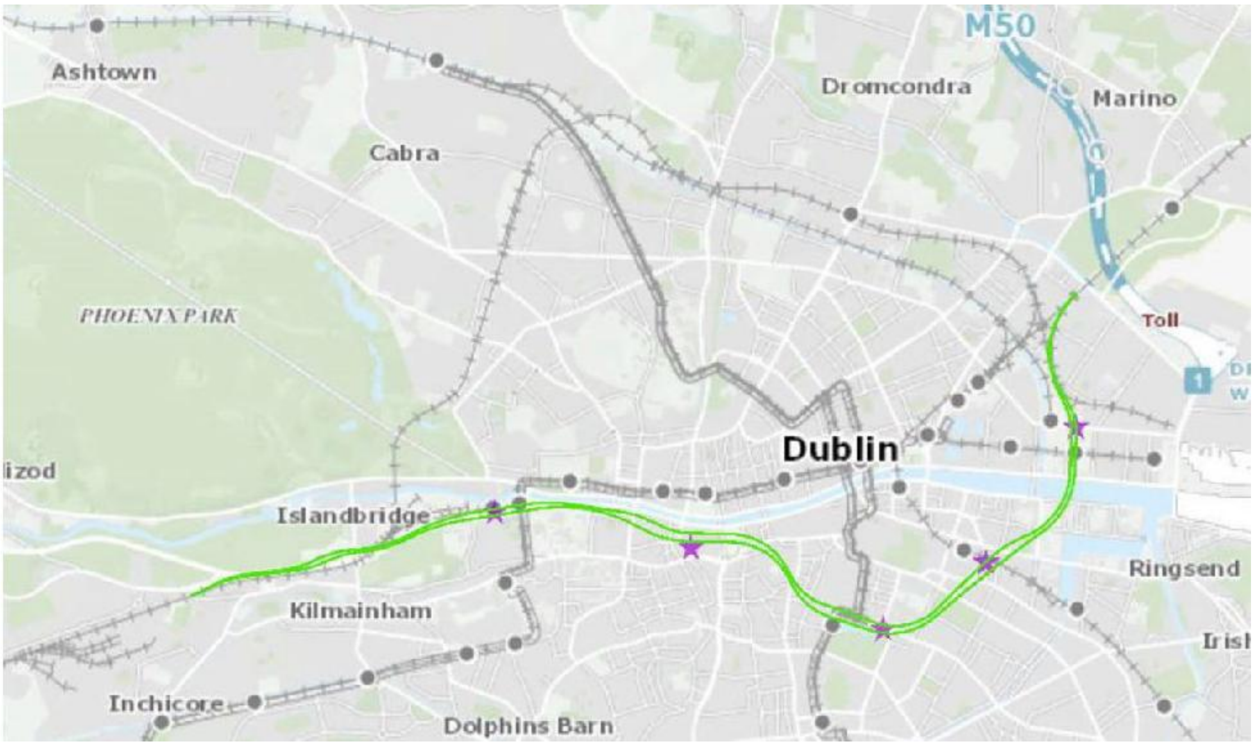


Figure 3: Route option S1 R09

Underground stations and interchanges are located at Heuston (interchange with rail, Luas and BusConnects), Christchurch (interchange with BusConnects), St. Stephen's Green (interchange with MetroLink, Luas and BusConnects), Pearse (interchange with rail and BusConnects), and Docklands (interchange with Luas and BusConnects).

Based on the high level cost estimate for construction and including for land and property acquisition costs, operation and maintenance (O&M) costs, VAT, inflation and contingency/optimism bias, it is estimated that the capital cost for the delivery of the DART+ Tunnel ranges between €5bn and €6bn.

1. Introduction

In January 2021, the National Transport Authority (NTA) commissioned Jacobs to carry out a Route Alignment Options and Feasibility Study to establish a tunnel rail link that will meet the long-term passenger demand in Dublin City Centre. The Client's Brief defined the Project objective as:

"To meet long-term passenger demand, as part of an integrated, accessible and efficient public transport network in the Dublin City Centre area, including heavy rail requirements for inter-city and other rail services, by providing enhanced connectivity from the Kildare Line by connecting, either by interchange or run-through services, with north-south services operating on the Coastal Rail Line (comprising of the Northern Rail Line and the South Eastern Rail Line)".

This report presents the route selection process undertaken by Jacobs to establish the best performing route. The route optioneering process involved the generation of feasible route alignment options in the identified Study Area, followed by preliminary assessment and a Multi-Criteria Analysis (MCA) process to select the corridor that satisfies the assessment criteria.

The study utilised the Operational Scenarios as presented in the brief to identify and assess the route option as listed here:

- Scenario 1: A scheme or schemes to connect from the Kildare Line to the Northern Line allowing run-though services;
- Scenario 2: A scheme or schemes to connect from the Kildare Line to the South Eastern Line allowing run-though services;
- Scenario 3: A scheme or schemes to allow services from the Northern Line to connect by interchange to the Kildare Line; and
- Scenario 4: A scheme or schemes to allow services from the South Eastern Line to connect by interchange to the Kildare Line.

The structure of this Route Alignment Options and Feasibility Report is set out as;

- Main Report
  - Section 1 Introduction
  - Section 2 **Methodology** introduces the study area adopted for the DART+ Tunnel scheme, sets out the methodology adopted for the identification and subsequent appraisal of route options and selection of the best performing route;
  - Section 3 **Receiving Environment** provides a description of the existing environment within the study area for DART+ Tunnel, including the data collection exercise undertaken;
  - Section 4 **Stage 1 Preliminary Assessment** describes the initial options identification process within the Study Area and presents the route alignment options;
  - Section 5 **Description of the Five Short-listed Routes** presents the engineering and environmental constraints affecting each route in terms of the project objectives.
  - Section 6 **Stage 2 Assessment** introduces the Department of Transport (DoT)'s Common Appraisal Framework (CAF) guidance for conducting an MCA assessment using the criteria of Economy, Safety, Integration, Environment, and Accessibility and Social Inclusion.
  - Section 7 **– Economy**
  - Section 8 **– Safety**

  - Section 9 – **Integration**
  - Section 10 **– Environment**
  - Section 11 – Accessibility and Social Inclusion
  - Section 12 **– Conclusion**

The supporting Appendices to the Main Report are in three sections;

- Appendix A. Transport Modelling Report
- Appendix B. Assessment Options Drawings
- Appendix C. Environmental Constraints Report

2. Methodology

2.1 Introduction

This chapter sets out the methodology used to identify the route options for the DART+ Tunnel scheme and the selection of the best performing route. The six-step process used is summarised in Figure 2-1 and this is followed by a more detailed description of the methodology for each step.

01	**Identify the Project Aim and Objectives:** Determine the project aim, rationale and the desired objectives/outcomes.
02	**Define Study Area and Collate All Available Data:** Define the study area to cover all possible options. Capture and review information on potential opportunities/constraints of the receiving environment for subsequent assessment of potential route options.
03	**Develop a Long List of Plausible Options**: Identify an initial list of potential options meeting the projects aims. While some options will be ruled out as unfeasible, it is important that the long list is made up of a wide range of potential solutions to demonstrate fully that all possible options have been considered.
04	**Option Assessment Stage 1 (Sifting Process):** The initial long list of plausible options will be sifted down to a short list of options, through a high-level preliminary assessment typically focused on environment, transport planning, and technical considerations. These short-listed options will then be brought forward to the second stage, an MCA.
05	**Option Assessment Stage 2 (Multi Criteria Analysis):** Develop short-listed options further, to sufficient level of detail, to allow a better comparative assessment using an MCA. Each option will also be modelled using the NTA's Eastern Regional Model to forecast demand and benefits for users; and a full Cost Benefit Analysis (CBA) developed for each option and fed into the MCA. Upon assessing and comparing all options using the MCA, the best-performing option will be identified as the Emerging Preferred Route (EPR).
06	**Feasibility Study and Options Assessment Report:** Once the EPR option has been determined a detailed Route Option Selection Report will be produced that outlines the approach and analyses undertaken to determine EPR.

Figure 2-1: Six-step process

2.1.1 Step 01 – Step 02: Project Objective and Study Area Definition

To assess the route options the Project Objective has been sub-divided into the following elements, with relevant questions that need to be addressed:

- Part of an Integrated Public Transport Network
  - Does the route provide for improved interchange opportunities?
  - Does the route provide potential to integrate with other modes?
  - Does the route provide opportunity for increased accessibility?
- Be Accessible
  - Would stations provide for good access from street level?
  - Is there good access between integrated services at interchange sites and is the access routing easy to understand?
  - Would the route and stations provide good access to the key trip attractors?
- Be Efficient
  - Will the route option improve the efficiency of the Public Transport network?
  - Will the route alignment enable efficient railway operations?

The study area was defined to cover all reasonable route options, and this is shown in Figure 2-2. The study area is s largely contained within the urban area of what is defined in the Greater Dublin Area (GDA) Transport Strategy 2016 – 2035 as “Corridor G” for the Dublin city area and “Corridor H” for the Docklands area. The study area takes cognisance of other radial transport corridors and proposed public transport schemes outlined in the GDA Transport Strategy. Baseline and future forecast demographic data were reviewed along with a range of planning policies, including at national, regional, and local level. As well as the GDA Transport Strategy, this included the National Development Plan, and the Dublin City Council’s Development Plan. The receiving environment, including key trip attractors, the transport network, and integration opportunities was studied in some detail.

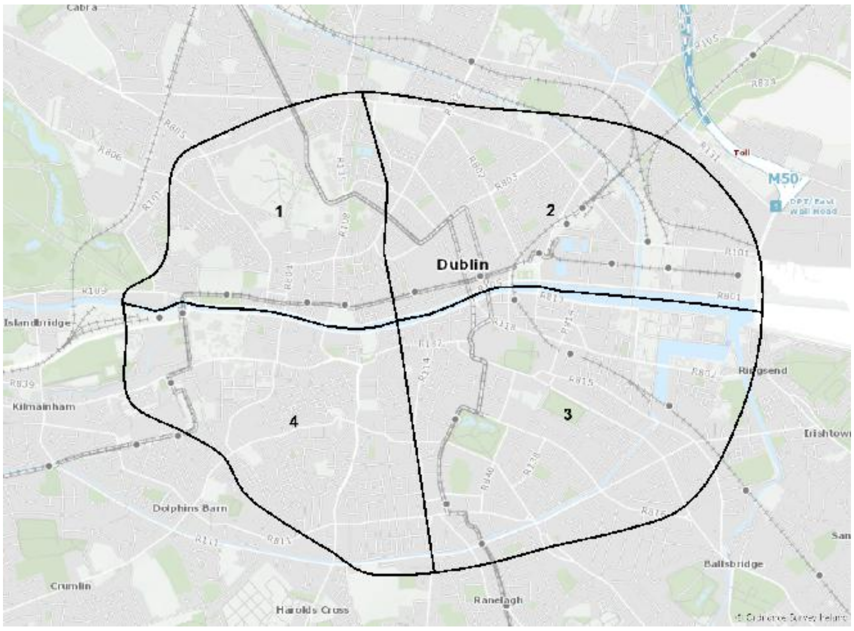


Figure 2-2: Defined Study Area

2.1.2 Step 03 – Develop a Long List of Plausible Options

This step reviewed a wide range of route options in the study area so that all reasonable options were considered. This was achieved through workshops with the NTA and with the Jacobs team of transport planners, train operations, engineers, environmental scientists, and cost consultants

A long list of 21No. plausible options were developed and assessed against the project objectives and engineering feasibility, which resulted in five of the twenty-one options being sifted out. Further detail on this process is contained in Section 4 - Preliminary Assessment of this report.

2.1.3 Step 04 – Stage 1 Preliminary Option Assessment (Sifting Process)

The first stage of assessment was to sift through the remaining 16 No. plausible route options to derive a short list of options. The Stage 1 Preliminary Assessment is a multi-criteria assessment and sifting process of the plausible route options against environment, transport planning and other technical considerations. This is a structured assessment of the long list of options to identify a shortlist that will be carried forward into the later MCA process.

The criteria considered in the Stage 1 assessment are summarised in Table 2-1 and from the sifting process a total of five route alignment options were taken into the Stage 2 Option Assessment (Multi Criteria Analysis).

Table 2-1: Stage 1 Criteria

Criteria	Sub Criteria	Stage 1 Preliminary Assessment
Travel Demand	Potential Trip Demand	This considers the likely trip demand of the route, based on the daily demand data for all modes of transport extracted from the NTA's Eastern Regional Model (ERM) for the 2050 forecast year.
	Potential Interchange	This considers the potential for each option to interchange with other DART, Luas, MetroLink and core bus corridors.
	Access to Public Transport	This considers how the route improves access to public transport for areas of the city which are less well served by the public transport network.
Railway Operation	No sub-criteria used	This considers how the route option may contribute to improvements in the efficient operation of the rail network and potential for rail services on the routes.
Environment	No sub-criteria used	Minimise impacts to Natural Heritage and Cultural Heritage (such as environmentally sensitive areas and National Monuments).
Cost	No sub-criteria used	This considers the comparative capital cost of the route option.

2.1.4 Step 05 – Stage 2 Option Assessment (Multi Criteria Analysis)

This step involves a Multi-Criteria Analysis (MCA) of the remaining five short-listed route options to identify the best performing corridor for the DART+ Tunnel scheme. The MCA assessed the selected five route options using the main criteria outlined in the 'Common Appraisal Framework for Transport Projects and Programmes' (CAF), which are Economy, Safety, Integration, Environment, Accessibility & Social Inclusion. The remaining criterion of Physical Activity was omitted because it applies to all options.

This step and the MCA of the options forms the basis of this report.

A strategic multi-modal transport modelling assessment was developed to assess the impact of the five route options on the existing transport network and locality in the year 2035 and 2050. The strategic model used for the DART+ Tunnel is the Eastern Regional Model (ERM) developed by the NTA. The ERM is a multi-modal, network-based transport model that includes all main surface modes of travel, including a:

- geographic coverage of the Eastern Region,
- detailed representation of the road network,
- detailed representation of the public transport network & services,
- detailed representation of all major transport modes including active modes, accurate mode choice modelling of residents,
- detailed representation of travel demand of four time periods (AM, Inter-Peak, PM and Off-Peak) and
- prediction of changes in trip destination in response to changing traffic conditions, transport provision and/or policy.

This ERM has a base year of 2016 and is calibrated to the 2016 Census, the 2017 National Household Travel Survey and other localised multi-modal surveys. The transport modelling work for the Stage 2 assessment is described in the DART+ Tunnel Transport Modelling Report, which is included as Appendix A of this report.

The results of the transport modelling were used to analyse the impact on the traffic volume, daily public transport trips, mode share, journey time savings, public transport accessibility and integration. These results were used to assess the route alignment options against criteria such as Economy, Integration, and Accessibility.

The sub-criteria used under each assessment criteria are presented in Table 2-2.

Table 2-2: Stage 2 Criteria

Criteria	Sub-criteria	Stage 2 Analysis
Economy	Cost	This considers the capital cost and Operation and Maintenance costs
	Journey Time	This identifies the public transport journey time saving delivered by the route option.
	Rail Operational Efficiency	This considers what potential operational efficiency to the overall rail network are provided by the different options
	Assessment of Costs and Benefits	This monetises the transport benefits provided by the route option along with the construction and operational costs of the route. It presents the transport user Present Value of Benefits and assesses an overall Benefit to Cost ratio
Safety	Operational & Maintenance Safety and Construction Safety	This assesses safety aspects of each option.
Integration	Land Use Policy Integration	This criteria considers the options ability to serve the land use and objectives in the Local Area Plans (LAPs), and Strategic Development Zones (SDZs)
	Public Transport Transfer Metrics	Daily number of transfers, and overall average transfer time are used to assess

Criteria	Sub-criteria	Stage 2 Analysis
		integration of each option with the GDA public transport network.
Environment	Material and Cultural Aspects (Archaeology, Architectural and Cultural Heritage)	This records the receiving environment for each option and assesses impacts
	Population	This records impacts on people
	Biodiversity	This records the receiving environment for each option and assesses impacts
Accessibility and Social Inclusion	Landscape and Visual	This records the receiving environment for each option and assesses impacts
	Accessibility to Key Trip Attractors	This considers how the route options improves access to key trip attractors, such as hospitals, within the study area
	Public Transport Accessibility	This sub-criterion examines how the route options improve access to public transport services for residents within the study area.
	Access to areas of deprivation	This criterion uses An Pobal's depravation deprivation index to examine how the route options improve access to the areas with low depravation deprivation index scores

2.1.5 Step 06 – Feasibility Study and Options Assessment Report

A comprehensive feasibility and options assessment report is the final part of the process and this DART+ Tunnel Route Options and Feasibility Report satisfies this requirement.

It is sufficient to note here that this report includes sufficient design inputs to identify the best performing route for the DART+ Tunnel to inform the development of a corridor for protection for the scheme's future delivery.

3. Receiving Environment

This section describes the planning context and receiving environment in which the best performing route is to be delivered. The opening year for DART+ Tunnel route alignment is taken as 2035, and the forecasting year is 2050.

The receiving environment includes the population and jobs, trips, key trip attractors, transport network and the environmental situation. These aspects have been described in the following sub-sections.

3.1 Planning Context

An overview of the relevant National, Regional and Local land-use and transport planning policy that together set the context for the DART+ Tunnel is presented below.

3.1.1 National Level

DART+ Tunnel is supported by wide ranging national land-use and transport planning policy and plans, including:

- Smarter Travel – A Sustainable Transport Future (DoT 2009), which sets out government policy to achieve a modal shift from the private car to public transport. The document forms the basis on which all land-use and transport plans throughout the country are developed;
- Building on Recovery: Infrastructure and Capital Investment 2016-2021. This plan presents the Government's framework for infrastructure in Ireland over the period 2016-2021. It recognises the former DART Underground project as a key element of integrated transport for the GDA over the longer term;
- The National Planning Framework ('Ireland 2040 Our Plan') released in September 2017 replaces the National Spatial Strategy for Ireland 2002-2020. This document is a long term, 20-year National Plan which seeks to provide a *'spatial expression of government policy'* and provide *'a decision-making framework from which other plans will follow"* – such as Regional Plans, City and County Development Plans;
- The 'Strategic Investment Framework for Land Transport' (DTTaS 2015);
- The 'Climate Action and Low Carbon Development Act 2015'; and
- The 'National Mitigation Plan' (DCCAE 2017).

3.1.2 Regional Level

At a regional planning level, DART+ Tunnel is supported by the following land-use and transport planning policies and plans:

- Eastern and Midland Regional Assembly's Regional Spatial and Economic Strategy (RSES) is "*a strategic plan and investment framework of our region to 2031 and beyond".*
- Transport Strategy Greater Dublin Area (GDA) 2016 – 2035 – The GDA Strategy aims "to contribute to the economic, social and cultural progress of the Greater Dublin Area by providing for the efficient, effective and sustainable movement of people and goods".

The RSES notes that the DART Underground will help unlock long-term transport capacity and support the development of some key landbanks.

The Transport Strategy for the GDA also cites the implementation of the DART Expansion Programme from Drogheda to Hazelhatch on the Kildare Line (including tunnel connection from the Kildare Line to link with the Northern/South-Eastern Line) through to Maynooth as one of its key schemes in the Heavy Rail Infrastructure Strategy.

3.1.3 Local level

The planning context for DART+ Tunnel is set out in several documents including the Dublin City Council Development Plan (2016–2022), the Strategic Development Zone (SDZ) plans such as North Lotts and Grand Canal Dock, and the Poolbeg and Local Area Plans (LAP) for the Liberties and George's Quay. These are discussed in the below sections.

3.1.3.1 Dublin City Council Development Plan (2016-2022)

The 'Core Strategy' of the Dublin City Development Plan is shown Figure 3-1 and it supports DART Underground through 'the policies and objectives which will promote intensification and consolidation of Dublin City. This will be achieved in a variety of ways, including infill and brownfield development; regeneration and renewal of the inner city; redevelopment of strategic regenerations areas; and the encouragement of development at higher densities, especially along public transport catchments.

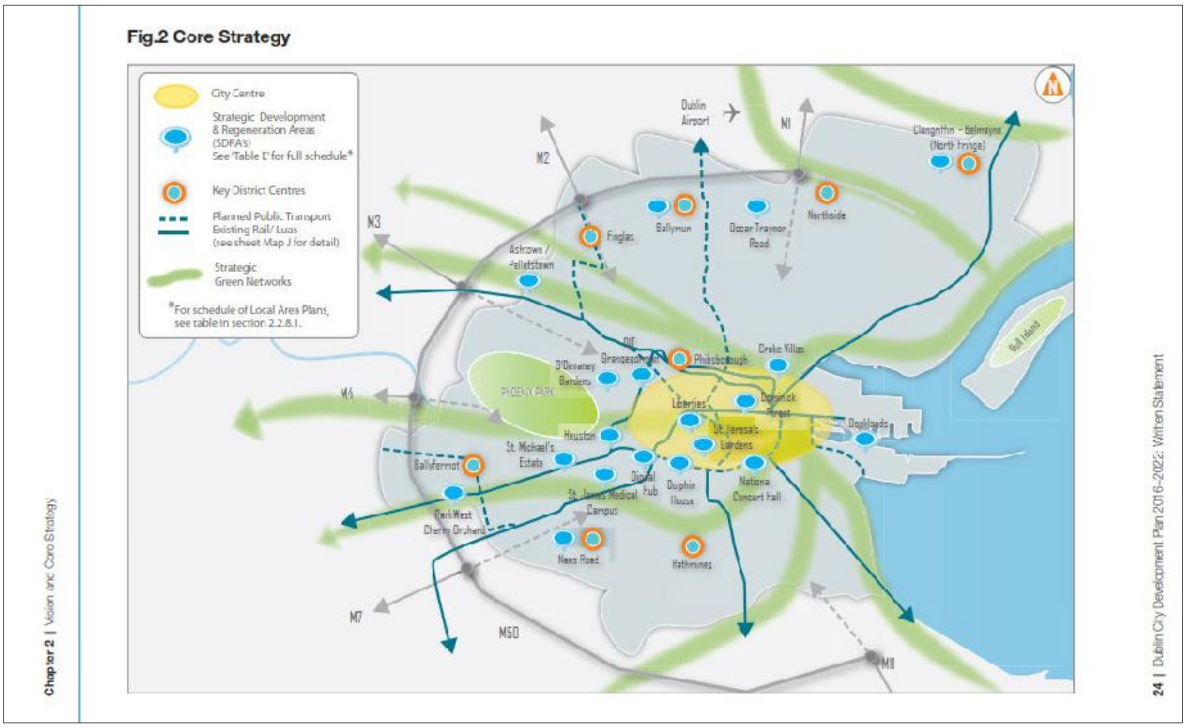


Figure 3-1 Core Strategy

DART+ Tunnel is supported by a number of land-use and transport policies and objectives within the Dublin City Development Plan, including specifically 'Policy MT4' which seeks *"to promote and facilitate the provision of all heavy elements of the DART Expansion Programme including DART Underground (rail interconnector), the electrification of existing lines, the expansion of Luas, and improvements to the bus network in order to achieve strategic transport objectives".*

DCC policy on public transport will be implemented in collaboration with the NTA's Transport Strategy for the Greater Dublin Area 2016 – 2035. The key public transport elements of this strategy includes MetroLink, and the DART+ Programme including DART Underground (now DART+ Tunnel)

It is an Objective of Dublin City Council under MTO5: (i) To facilitate and support measures proposed by transport agencies to enhance capacity on existing public transport lines and services, to provide/ improve interchange facilities and provide new infrastructure. (ii) Subject to a station layout assessment, to promote the re-instatement of station entrance at Amiens Street/Buckingham Street Junction.

3.1.3.2 Local Area Plans (LAPs)

The George's Quay Local Area Plan (LAP) (Dublin City Council 2012) was officially extended in 2017 for a further five-year period and is in accordance with the provisions of the Dublin City Council Development Plan (DCCDP) (2016 - 2022). It provides an overall strategy to support and facilitate delivery of a strong character area, consolidating the areas as a major employment hub benefiting from excellent public transport connectivity, linking the City Centre to the Docklands area with a focus on sustainable development.

The LAP is in accordance with the Government's 'Transport 21' Strategy and the National Transport Authority's draft Strategy '2030 Vision', and supports the proposal of a number of initiatives such as MetroLink North and DART Underground which will significantly improve public transport provision and accessibility in the area.

Figure 3-2: George's Quay Local Area Plan Extent

The Liberties Local Area Plan (LAP) published in 2009 was officially extended in 2015 for a further five-year period and is in accordance with the provisions of the DCCDP (2016-2022). It lays out a strategy to establish a network of routes and connections designed to improve permeability and legibility.

The LAP also cites the rail interconnector running underground along the south bank of the Liffey with an interchange at Heuston and a further station in the vicinity of Christchurch, as being a vital "backbone" of an integrated public transport system for Dublin. The LAP cites that there is potential for redevelopment of housing in three areas in the Liberties, two significant development sites for the Digital Hub that provide opportunity for high density employment and improvement of the public realm in Iveagh Market.

3.1.3.3 North Lotts and Grand Canal Dock Strategic Development Zone

Parts of the Dublin Docklands area at North Lotts and Grand Canal Dock were designated as a Strategic Development Zone (SDZ) in December 2012. The Planning Scheme for North Lotts and Grand Canal Dock was undertaken in November 2013 by DCC with the aim of sustaining a critical mass necessary to support a vibrant mixed-use urban quarter and to attract inward investment.

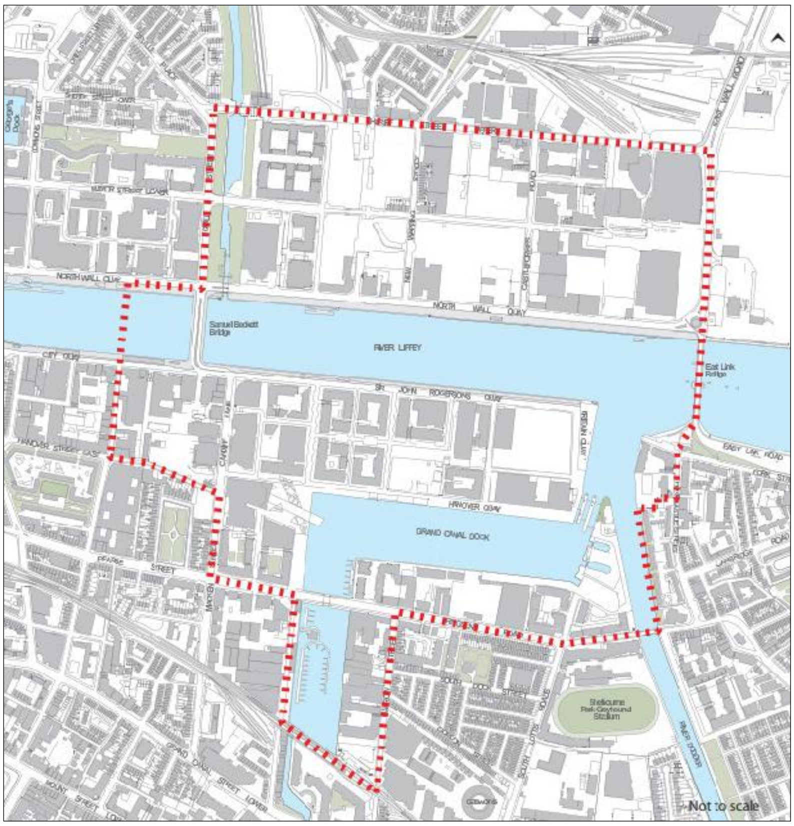


Figure 3-3: North Lotts and Grand Canal Dock SDZ extent

The North Lotts and Grand Canal Dock SDZ (Dublin City Council 2014) comprises of some 66ha of the overall 520ha Dublin Docklands area as set out in the Dublin Docklands area Masterplan 2008. The SDZ lands extend north and south of the river at a strategic location; North Lotts immediately adjoins the IFSC, and Grand Canal Dock is in close proximity to the city's central business district and south city retail core area. The Samuel Beckett Bridge provides a vital link between the two locations north and south of the Liffey. Section 1 of the Proposed Scheme (Talbot Memorial Bridge to Tom Clarke East Link Bridge) routes through the SDZ.

The SDZ cites that a DART underground station at Spencer Dock would potentially result in the lands becoming the most accessible and connected part of the city. A station at Spencer Dock will facilitate interchange with the Luas, DART, and mainline commuter services to provide access to the SDZ, which has a high focus on regeneration of the Docklands area as per the Dublin Docklands Area 2008-2013 Masterplan.

3.2 Opening and Design Years

It was agreed that the opening year of the DART+ Programme would be 2035, reflecting the Transport Strategy for the Greater Dublin Area (2016-2035). According to TII's Project Appraisal Guidelines for National Roads Unit 5.1 – Construction of Transport Models, transport models should include assessments of an opening year and a design year (i.e., Opening year + 15 years).

For these reasons, the assessment for the route alignment connecting the Kildare Line to either the Northern Line or the South Eastern Line has included the:

- Opening Year – 2035; and
- Design Year – 2050.

A review of the forecast years for 2050 and 2065 was undertaken as part of the Stage 1 Preliminary Assessment and this identified that *"whilst the total population and jobs were higher in the 2065 year the distribution of the jobs and population showed a very similar trend compared to 2050. Accordingly, for the purpose of identification of the preferred route the 2050 trip demand is considered sufficient."*

3.3 Population and Job Forecasts

Population and Job forecast data was obtained from the NTA's planning data sheet for the year 2050. The base planning data is a database of 18,641 Census Small Areas records (CSAs) with 114 different variables, showing demographic data related to place of residence and to place of work for all CSAs in Ireland for year 2016.

The foundation of the NTA's planning sheets are heavily based on published policy documents such as National Planning Framework (NPF) that set out the target population figures for each county of Ireland for 2026 and 2031. In addition, the Department of Housing provided employment figures for each county up to 2040. There are figures provided for the 'At-Work' population as well as the number of employment places per county.

The NTA have worked with the Regional Assemblies and the Local Authorities to incorporate their housing and growth priorities in the planning sheets. While the planning sheets are controlled at the regional and county level by published policy documents (NPF & RSES), the distribution of growth within counties is discussed and agreed with Local Authorities. Where agreement has not been made the NTA has based the distribution on existing patterns and zoning within the development plans.

These planning sheets are the principal land-use scenario for all plans and schemes. Interim year planning sheets for the years between 2016 and 2040, are straight line interpolation between 2016 and 2040. For the years after 2040, these planning datasheets are created by extending this straight-line interpolation onwards to the forecast year, such as 2050. The 2050 forecast distribution of the study area for population and jobs are as shown in Figure 3-4 and Figure 3-5 respectively.

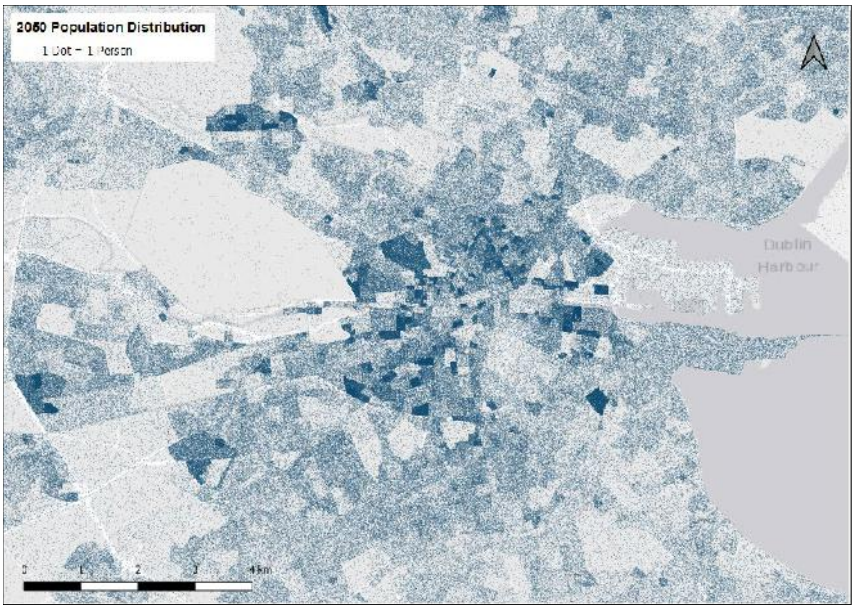


Figure 3-4: 2050 Planning Sheet Population Distribution

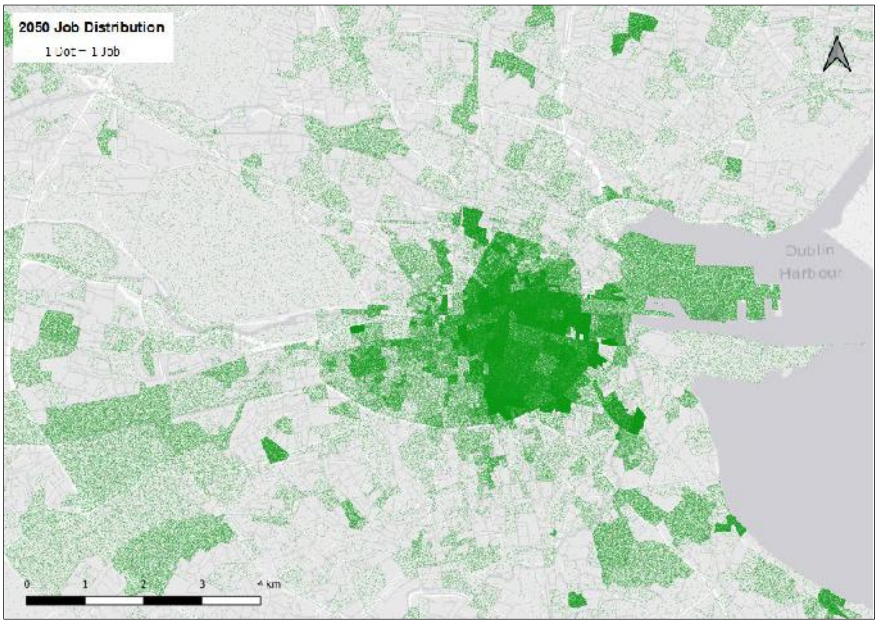


Figure 3-5: 2050 Planning Sheet Job Distribution

3.4 Receiving Transport Network

The current public transport systems that is relevant to this study consist of the Luas Green line from Broombridge to Bride's Glen, the Luas Red line from Saggart to The Point, the DART on the east coast of Dublin and railway lines from Maynooth and Kildare.

The 2045 Strategy for the GDA includes the current network with the addition of MetroLink, the Luas Lucan Line, BusConnects and the committed DART+ Programme. The receiving Public Transport network in the city centre comprises of MetroLink, DART, BusConnects and the Luas Green, Red and Lucan lines, as shown in Figure 3-6.

The receiving future year public transport network is used to assess the impact on transport interchange and access to public transport.

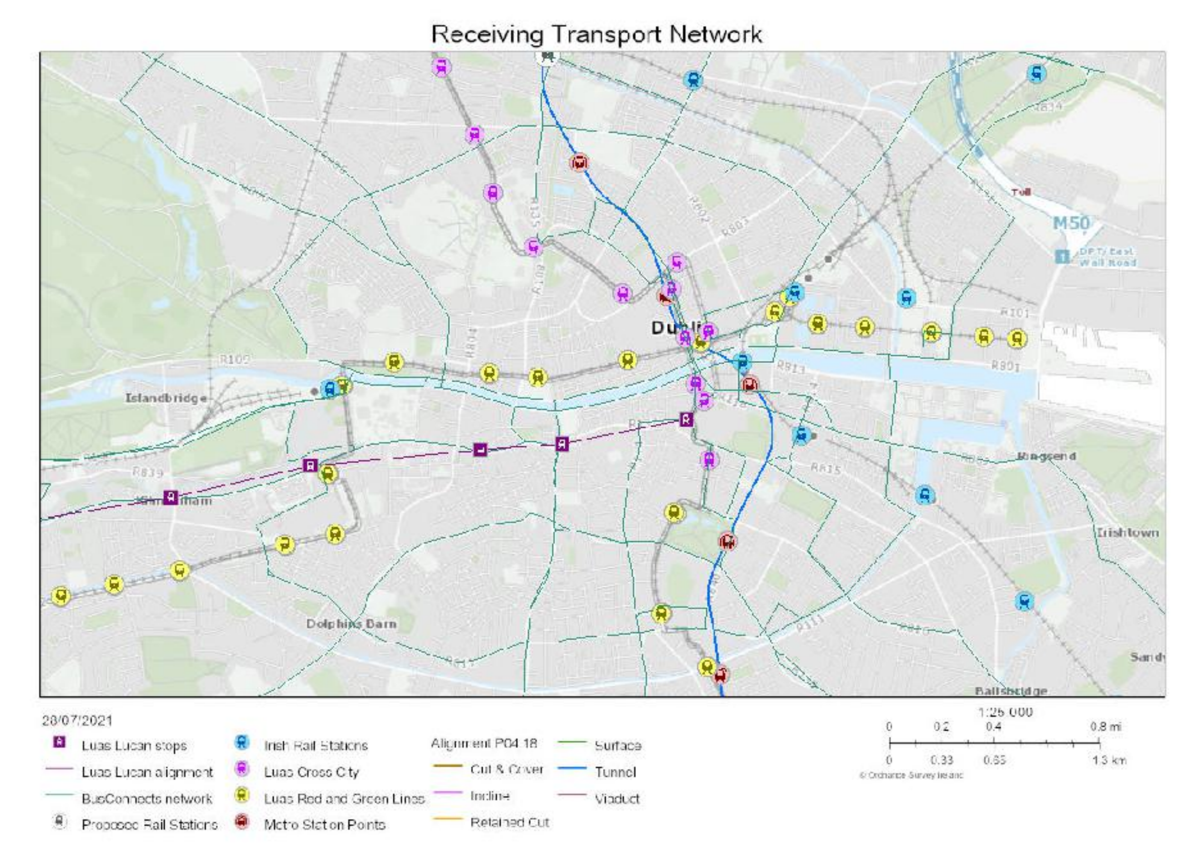


Figure 3-6: Receiving Public Transport Network

3.4.1 Production and Attraction Trips

The transport demand is assessed as daily trips. NTA's National Demand Forecasting Model (NDFM) provides the function of generating national trip demand at Census Small Area (CSA) Level.

The trip files in Table 3-1 are provided by the NTA and are based on the 2050 planning data sheet. The NDFM output files are trip ends data including all modes and all market segments. This study aggregated all these data into total production and attraction trips.

Table 3-1: NDFM Output Trip Files

File Category	File Name
Non-Retired Two-Way Productions (Origins)	NR_Two_Way_Productions_Split_2050.DBF
Non-Retired Two-Way Attractions (Destinations)	NR_Two_Way_Attractions_Split_2050.DBF
Retired 2W Productions (Origins)	One_Way_FH_Productions_Split_2050.DBF
Retired 2W Attractions (Destinations)	One_Way_FH_Attractions_Split_2050.DBF
One-Way From-Home Productions (Origins)	One_Way_TH_Productions_Split_2050.DBF

File Category	File Name
One-Way From-Home Attractions (Destinations)	One_Way_TH_Attractions_Split_2050.DBF
One-Way To-Home Productions (Origins)	RET_Two_Way_Productions_Sum_2050.DBF
One-Way To-Home Attractions (Destinations)	RET_Two_Way_Attractions_Sum_2050.DBF
NHB Productions (Origins)	NHB_Productions_Split_2050.DBF
NHB Attractions (Destinations)	NHB_Attractions_Split_2050.DBF

3.4.2 Key Trip Attractors

Key trip attractors which would generate significant demand for services were identified within each study area. For the purpose of this assessment, the following land uses have been considered as key trip attractors.

- Education (universities);
- Commercial centres (shopping centres, town centres);
- Healthcare (hospitals);
- Leisure (sport stadiums, theatres, cinemas etc);
- and Employment (business parks, large office developments etc.).

The trip attractors in the study area is shown in Figure 3-7.

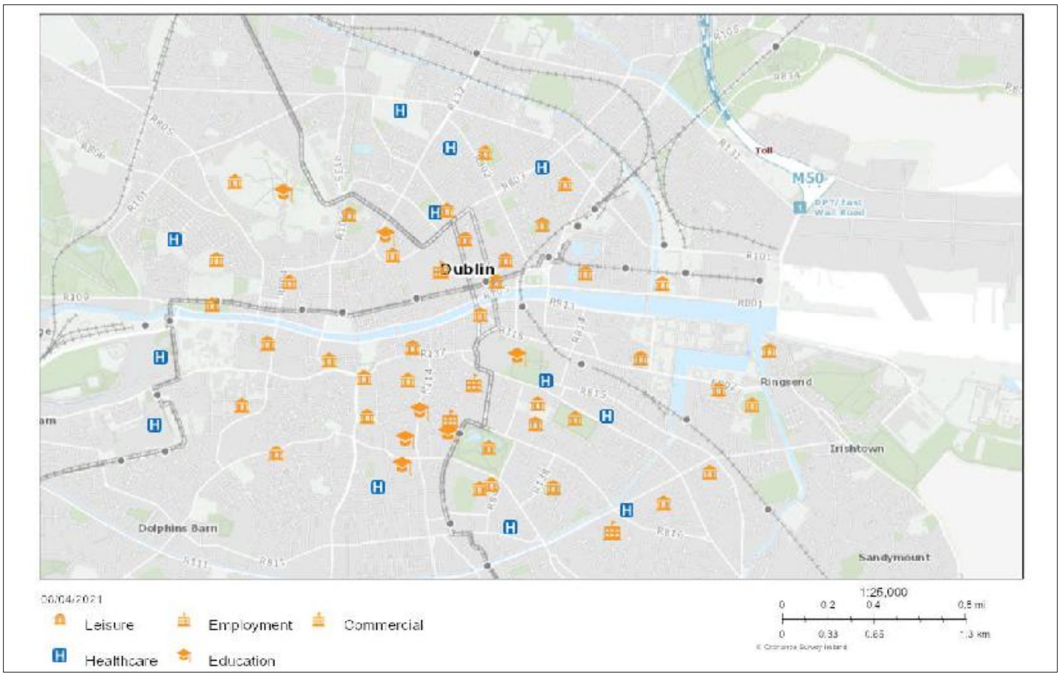


Figure 3-7: Key trip attractors in the Study Area

3.4.3 Access to Public Transport

By plotting the planning data sheet population and job data on to the Receiving Public Transport Network in a Geographical Information System (GIS), the number of accessible public transport services within 500 metres per each person or job in the city area is calculated. Figure 3-8 is a normal distribution curve for access to receiving public transport formed by the people who live in the city centre.

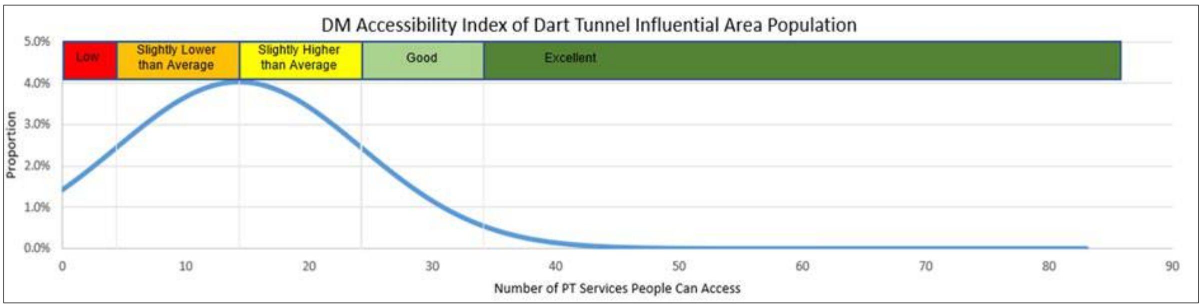


Figure 3-8: Normal Distribution over the Public Transport Accessibility of people who live within the study area

Figure 3-9 is a normal distribution line for access to receiving public transport accessibility formed by jobs located in the city centre.

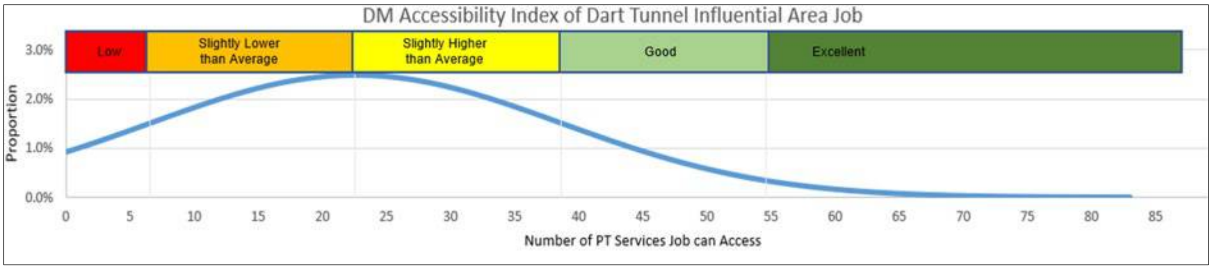


Figure 3-9: Normal Distribution, Banding and Impact over Job Accessibility

3.5 Rail Operations

The receiving train services assumes that all DART+ Programme infrastructure (excluding DART+ Tunnel) is implemented to provide a high frequency surburban train service in the Greater Dublin Area. The train services described here reflects the likely highest number of train services that could be provided on each route in the high-peak hour (when most trains are assumed to be required arriving in Dublin between 08:00 and 08:59).

Figure 3-10 shows the DART+ network in schematic form with key routes and stations.

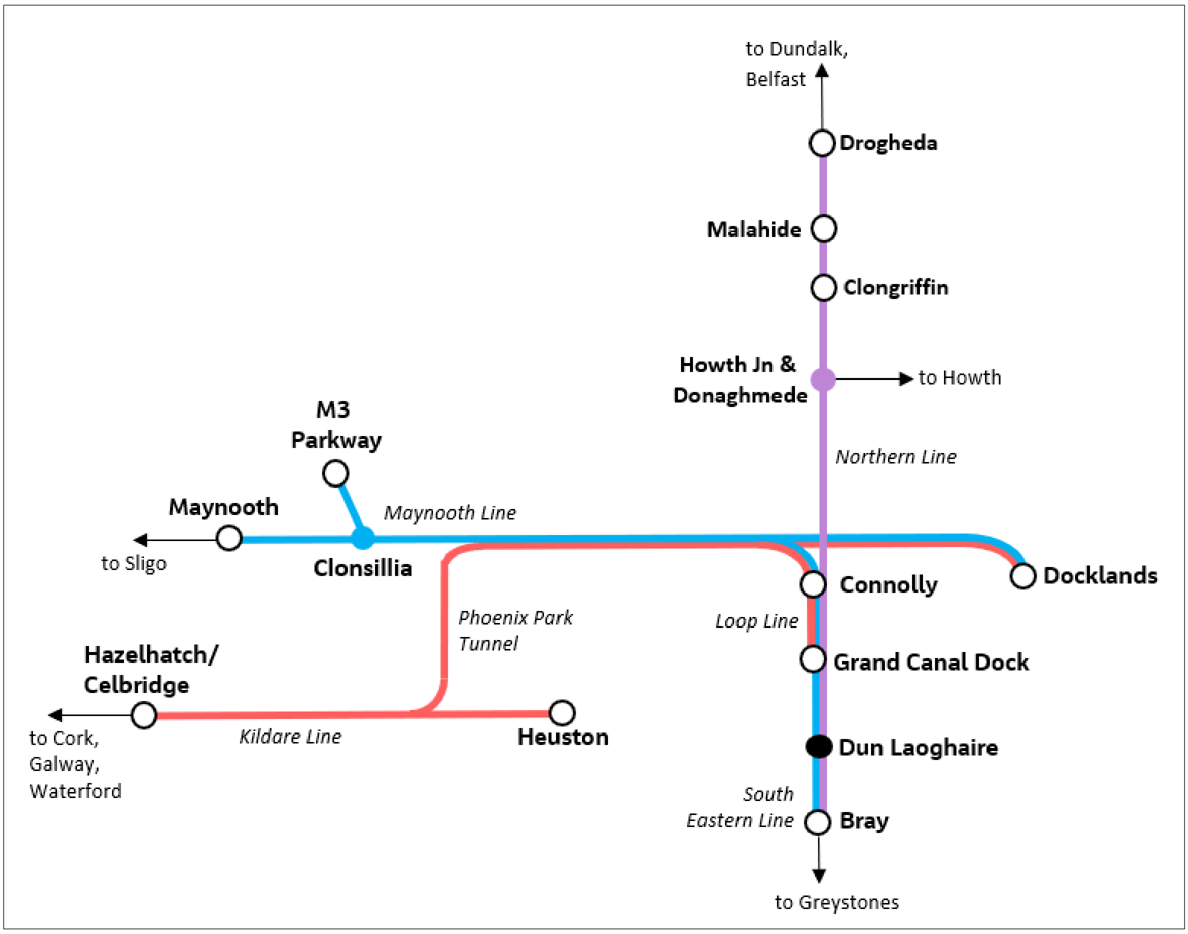


Figure 3-10: Summary of the DART+ Network (schematic, not to scale)

3.5.1 Northern Line

Train services on the Northern Line comprise a mix of DART suburban services, longer distance commuter services and inter-city services (the ‘Enterprise’ Belfast service). It is planned that the Northern Line electrification is extended from Malahide to Drogheda allowing EMU (electric multiple units) rolling stock to operate throughout.

DART services will be provided from Drogheda and Malahide to Connolly (9-10 trains per hour (tph)) and then linking with South Eastern Line services to Bray, providing through services across Dublin via the Loop Line. Longer distance services operated by non-electric rolling stock will operate between Dundalk and Connolly (2tph). Hourly inter-city (‘Enterprise’) services will operate between Belfast and Connolly.

3.5.2 Maynooth Line

Train services on the Maynooth Line comprise a mix of DART suburban services, longer distance Commuter services and InterCity services. It is planned that the Maynooth Line is electrified throughout between Maynooth/M3 Parkway, Connolly, and Docklands.

DART services will be provided from Maynooth and M3 Parkway to Connolly and Docklands. Services via Connolly extend via the Loop Line to the South Eastern Line. Two trains per hour will operate beyond Maynooth: an hourly InterCity service from Sligo to Connolly and an hourly Commuter service from Longford to Connolly. Both of these services will be operated by non-electric rolling stock.

In total, 12tph might be provided on the Maynooth Line, which would increase if conflicts are reduced, and additional paths are available at Connolly

3.5.3 Kildare Line

The Kildare Line will be electrified throughout between Hazelhatch/Celbridge and Heuston and Glasnevin Junction with all DART trains operated by EMU rolling stock.

DART+ services on the Kildare Line will operate to Heuston and via the Phoenix Park Tunnel to both Connolly and Docklands. Services via Connolly can be extended to the South Eastern Line. In total, between 10 and 15tph could be provided on the Kildare Line depending on capacity constraints through Glasnevin Junction with Maynooth Line services.

Kildare Line services will operate on the Slow Lines on the north side of the 4-track layout between Heuston and Hazelhatch/Celbridge, separate from InterCity services that will operate exclusively on the Fast Lines and terminate at Heuston.

3.5.4 Loop Line and South Eastern Line

The Loop Line between Connolly and Grand Canal Dock will have a mix of train services from the Kildare, Maynooth and Northern Lines, where it is considered that 15tph will be provided. Some trains can turnaround at Grand Canal Dock in the middle platform with all other services extended to Bray or Greystones.

In the peak hours it is assumed that services from Rosslare and Wexford operate south of Greystones only with passengers interchanging to DART services to Dublin.

3.6 Environmental Constraints

An Environmental Constraints Report is prepared as part of Stage 2 of the project on the short-listed options. In-line with TII guidelines on the approach to constraints studies[1], the information is based largely on desktop and existing data sets.

There are no national environmental guidelines for rail transit projects and so, in respect to certain environmental aspects, reference will be made to TII's guidance documents, which are largely written for national roads schemes but would assist in the design and execution in the development of a rail transit scheme. A national roads scheme and a rail transit scheme are both linear transport infrastructure and so elements of the guidance documents are applicable and relevant to this project. The methodology for environmental assessment of the DART+ Tunnel route options will be made specific to the nature of this project and will be clearly set out so that readers of this and future reports can understand the approach that has been taken.

The study area covers a large part of Dublin City, a densely populated urban area and as such, it is not always possible to represent / ascertain every constraint or environmental receptor (e.g., to show every business and each dwelling on a map). The project team has used aerial imagery and Geographical Information System (GIS) to ensure best efforts are made so that receptors are not missed, and a full account is made of all environmental considerations in the assessment of route options and subsequent determination of the best performing route option.

The following sections provide a brief overview of the environmental constraints with the study area. These sections cover Archaeology, Architecture and Cultural Heritage; Biodiversity; Landscape and

[1] TII (2019) Project Manager's Manual for Major National Road Projects PE-PMG-02042. https://www.tiipublications.ie/library/PE-PMG-02042- 01.pdf

Visual (Population is addressed in Section 3.3 of this report). While not outlined or identified here, additional environmental aspects (primarily geology and hydrogeology) have been taken into consideration and will be addressed in more detail in the next Stages of the project.

3.6.1 Archaeology, Architecture and Cultural Heritage

Archaeological sites are considered to be a non-renewable resource. The National Monuments legislation legally protects access and the visual amenity associated with National Monuments and requires consent from the Minister for invasive works within their vicinity. The primary source of information for archaeology is the Record of Monuments and Places (RMP) maintained by the Department of Culture, Heritage, and the Gaeltacht. National Monuments, monuments with a preservation order and the Record of Monuments and Places (RMP) have been considered for this study as well as areas of archaeological potential with statutory protection and archaeological constraints.

Architectural heritage is a unique and irreplaceable material asset which is given value by its design, setting quality of workmanship and use of materials. The Record of Protected Structures (RPS), the National Inventory of Architectural Heritage (NIAH), and Architectural Conservation Areas (ACAs) have been considered. We note that a number of NIAH structures are also listed as protected structures and this means that an individual structure or building may have two entries and have been considered as an NIAH and a RPS (leading to double counting). As these are two separate datasets, it was decided to present all information for consideration.

Cultural heritage sites and sites of industrial heritage are often afforded protection either as a Recorded Monument or as Protected Structure or a structure within the NIAH. The identification of sites of cultural heritage interest were considered in the context of statutory architectural and/or archaeological sites.

The Historic City of Dublin (RMP DU018-020) is a designated recorded monument and reflects the continuous intense occupation of a relatively confined area from the Mesolithic period onwards to modern times. Upstanding monuments survive in the form of the city walls, several castles, churches, graveyards, historic parks, and the quay walls.

There are 13 National Monuments within the constraints study area, and these include the walled town defences of Medieval Dublin, Dublin Castle, St Mary's Abbey, Christchurch Cathedral, St Patrick's Cathedral, St Audeon's Church and monumental structures in the form of O'Connell, Parnell and O'Brien sculptures, St Stephen's Green, and 14-17 Moore Street. The city also has deeply buried archaeological deposits which provide a rich and complex record of human activity and while not readily legible in the street scape today, have been revealed through archaeological investigation and excavation.

With reference to Figure 3-12 and Figure 3-11, the study area contains:

- 13 no. National Monuments and 3 no. monuments with preservation orders;
- 808 no. RMP sites; and
- Below ground archaeological potential in the form of stratified archaeological deposits, finds and features

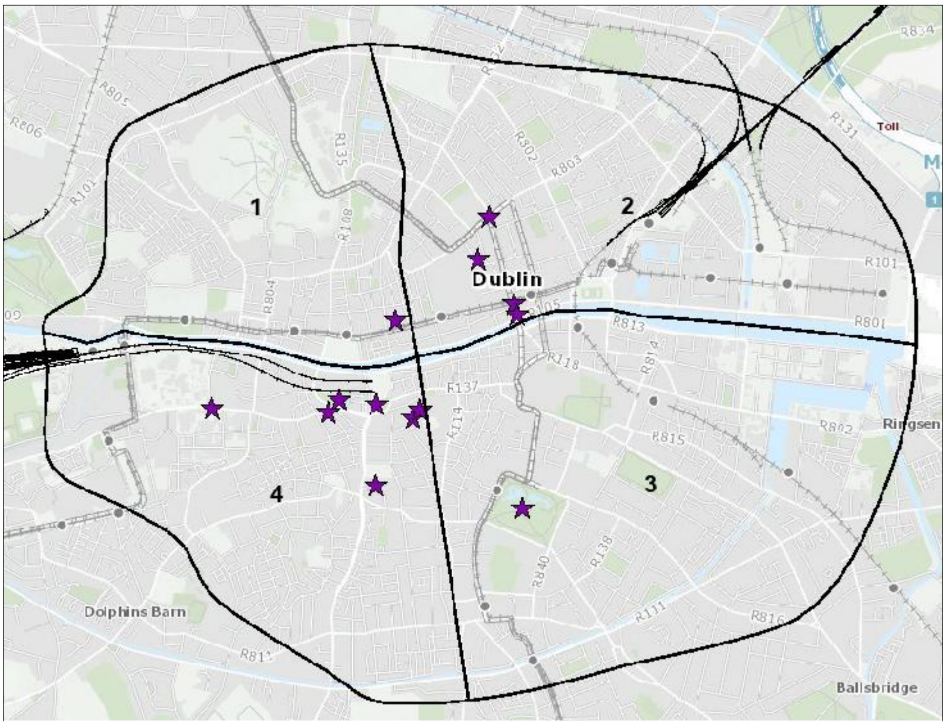


Figure 3-12 Location of Monuments

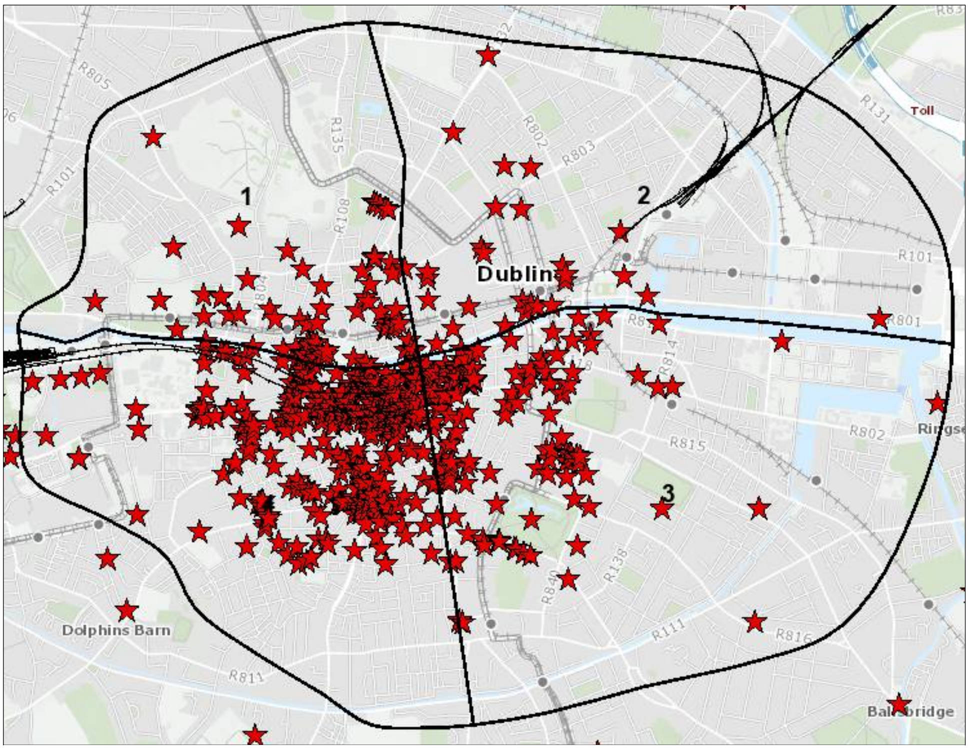


Figure 3-11 Location of RMPs

A quadrant of the study area covers a large part of Dublin City Centre which has a rich and varied cultural landscape of historic buildings and structures. These structures range from nationally important parks and designed landscapes such as St Stephen's Green to the typical Georgian and Victorian terraces that form part of the modern-day streetscape. These historic buildings remain mostly in use and support a mixture of residential and commercial uses.

Georgian Dublin in the 18th century was a period of rapid expansion and growth for the city to the extent that it became the second city of the British Empire and one of the largest and most prestigious capitals in Europe. This legacy of formal squares and gardens, newly laid out street plans as well as individual buildings, structures, bridges and street surfaces (stone sets and cobblestones etc) is recognised by the state in its nomination of the Historic City of Dublin on the tentative list as an UNESCO world heritage site. The modern street plan incorporates elements of the curving organic medieval city along with the formal classical symmetry of Georgian Dublin. Architectural features, historic street furniture and sculptures add to the cultural identity of the city. Dublin city has long enjoyed an association with writers and poets such as Swift, Goldsmith, Yeats, Joyce and Shaw, as well as institutions such as the Abbey and the Gate Theatres.

Surveys carried out by the Railway Procurement Agency for the Luas Cross City project led to the identification and recording of subterranean structures, therefore, there is the potential to reveal cellars/ basements that extend out beneath of the road surface. The form of buildings and spaces, civic, institutional, and educational buildings within set pieces of urban design, the unique Georgian squares, and streets, together with the larger areas of Victorian and Edwardian architecture north and south of the canals and the industrial buildings and smaller mews and worker's housing all contribute to the city's character, diversity, and identity.

In summary, the study area contains:

- 2,363 no. RPS sites;
- 2,150 no. NIAH structures; and
- 16 no. ACAs, including the O'Connell Street area, the Grafton Street area and the South City retail quarter.

The location of the above elements is shown in Figure 3-13.

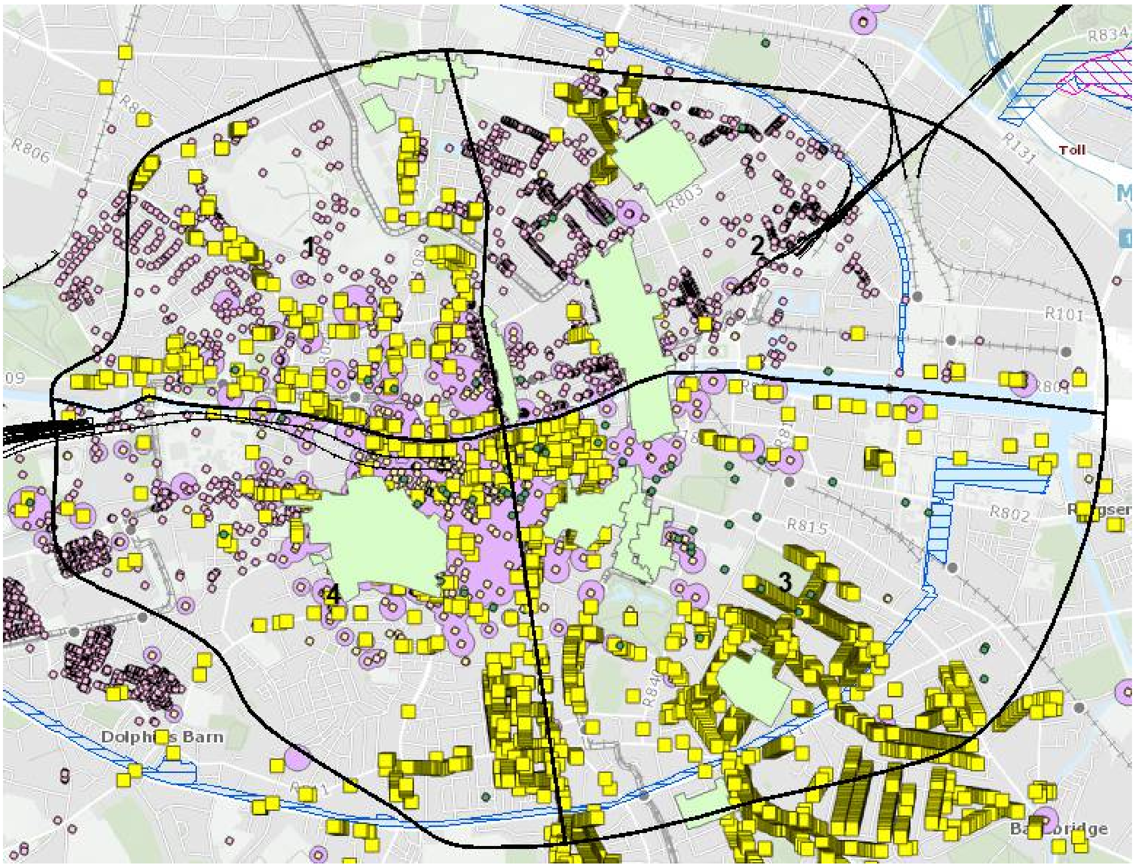


Figure 3-13: RPS, ACA and NIAH Structures

3.6.2 Biodiversity

There are no 'Natura 2000' sites within the study area, however, a number of such sites are situated beyond the study area, but are in close proximity and are hydrologically connected to the study area, namely:

- North Dublin Bay SAC;
- South Dublin and River Tolka Estuary SPA;
- North Bull Island SPA; and
- South Dublin Bay SAC.

There are two nationally designated proposed Natural Heritage Areas (pNHAs) situated within the study area, the Grand Canal pNHA and the Royal Canal pNHA. These sites have limited hydrological connectivity to Dublin Bay and the aforementioned European Designated Sites located in outer Dublin Bay. The River Liffey does not have any designated status as a conservation area but it is considered as an 'Annexed Habitat: Estuaries from Dublin Bay up to Chapelizod Weir'. The location of the Natura 2000 sites and pNHAs are shown in Figure 3-14.

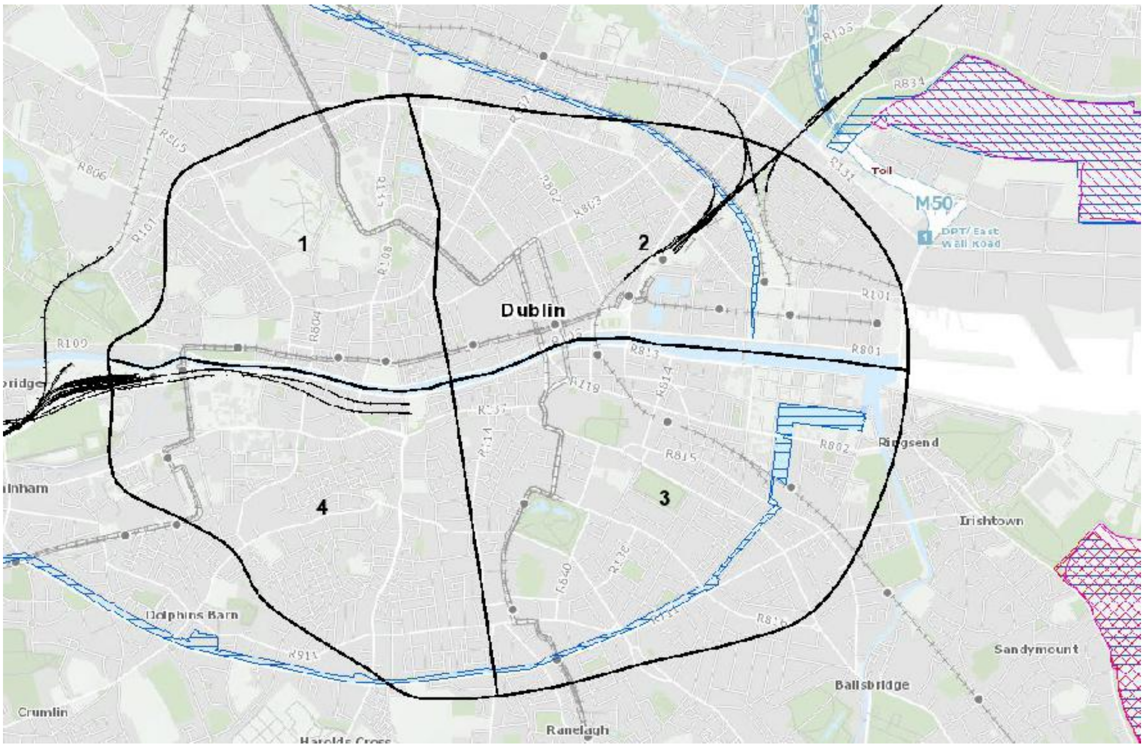


Figure 3-14: Location of Natura 2000 and pNHAs

3.6.3 Landscape & Visual

In terms of landscape, Dublin City Centre comprises some of the most significant and sensitive urban landmarks, spaces, and streetscapes in Ireland. These include the nationally and internationally recognisable urban set pieces of St. Stephen's Green and surrounding streets; examples being the Shelbourne Hotel, the Georgian streetscapes of the south city centre; Merrion Square and surroundings streets; Government Buildings (Leinster House), the National Gallery, the National Museum, the Mansion House; Grafton Street and surrounding streets; Trinity College, College Green, Bank of Ireland; Dame Street, Central Bank; Dublin Castle, St. Patrick's Cathedral, Christchurch Cathedral; Temple Bar; the Liffey Quays, Custom House, City Bridges; O'Connell Bridge, O'Connell Street, the GPO, the Spire; Parnell Square, the Rotunda; and Mountjoy Square and the Georgian streetscapes of the north city centre.

The study area also encompasses areas in Dublin north and south inner city, including the western Docklands area, Connolly, Pearse and Tara Street stations, the Grand and Royal Canals, Croke Park, Portobello, and the village areas of Phibsborough and Drumcondra. The quality of the existing urban streetscape and general residential amenity are key landscape and visual constraints in the study area.

4. Stage 1 Preliminary Options Assessment

The Stage 1 Preliminary Options Assessment report is summarised in this section. A total of 21 route options were initially developed during a multidiscipline workshop. The development of these route options was informed by existing and future population and job forecasts, location of trip attractors and environmental characteristics.

Following an assessment of these route options against the Project Objective and a review of the feasibility and the practicability of these routes, five of 21 route options were sifted out. Figure 4-1 shows the remaining 16 route options brought forward to the Stage 1 Preliminary Options Assessment. Available data was used to undertake a multi-criteria assessment based on Travel Demand, Rail Network Operations, Environmental Impacts, and Capital Cost. The objective of the Stage 1 Preliminary Options Assessment was to identify which of the 16 route alignment options were high performing route options and which route options were not. This enabled a short list of options to be brought forward into the Stage 2 MCA.

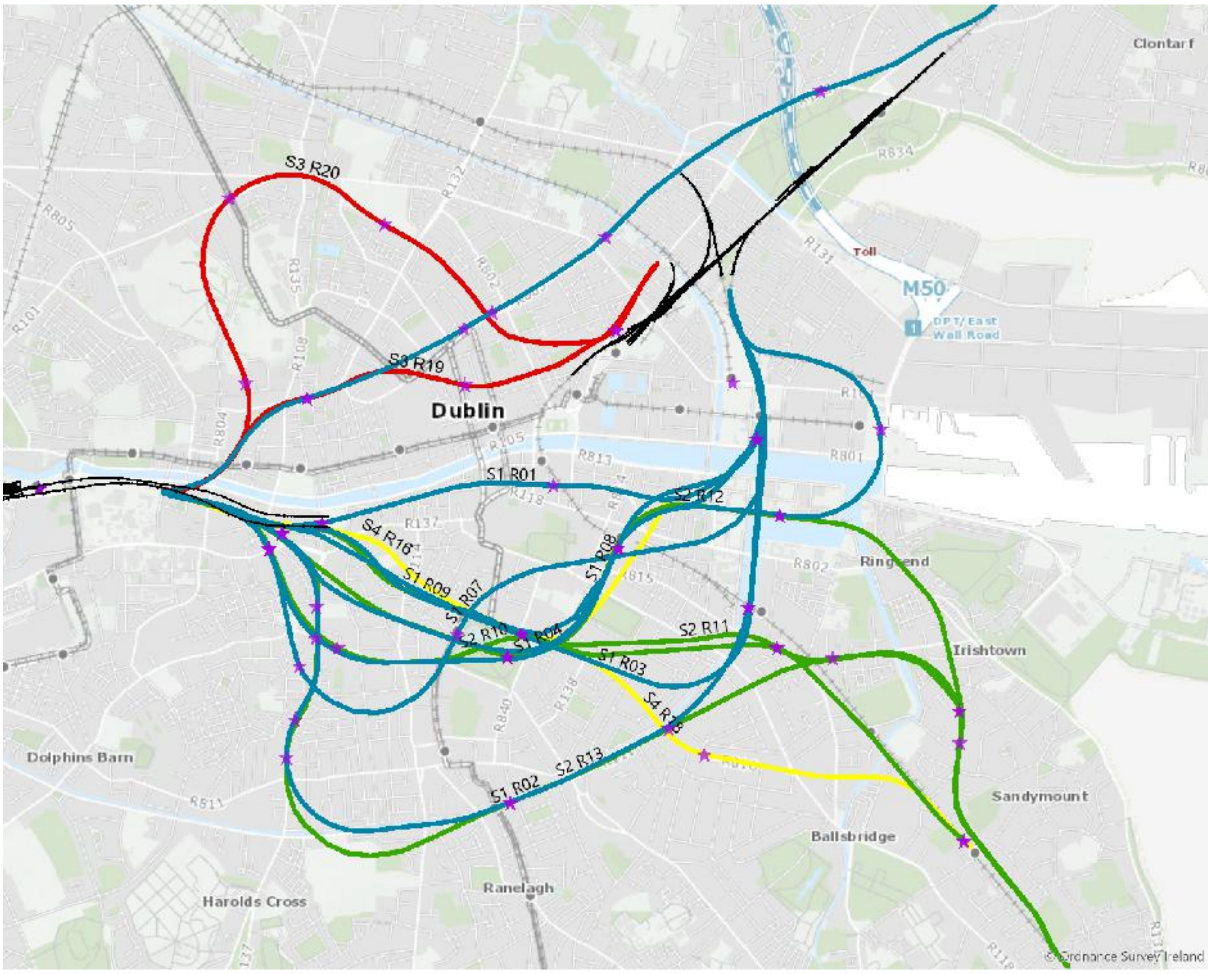


Figure 4-1: Route Alignment Options brought to Stage 1 Assessment

The results of the Stage 1 assessment are summarised in Table 4-1.

Table 4-1: Summary - Stage 1 Preliminary Options Assessment

Route		Description	Travel Demand	Rail Operations	Environment	Cost	Overall
S1	R01	Heuston – Christchurch – Tara – Docklands					
	R02	Heuston – Christchurch - St Patrick's Cathedral – Charlemont – Grand Canal Dock – Docklands					
	R03	Heuston – Christchurch – St Stephen's Green – Grand Canal Dock – Docklands					
	R04	Heuston – Christchurch – St Patrick's Cathedral – St. Stephen's Green – Pearse – Docklands					
	R07	Heuston – Christchurch – St Patrick's Cathedral – St. Stephen's Green – Pearse – Docklands					
	R08	Heuston – Christchurch – St. Stephen's Green – Pearse – Grand Canal Dock – Docklands					
	R09	Heuston – Christchurch - St. Stephen's Green – Pearse – Docklands					
	R21	Heuston – North King Street (King's Inns Park) – Parnell – Croke Park – Fairview					
S2	R10	Heuston – Christchurch – St. Stephen's Green – Grand Canal Dock – Sandymount					
	R11	Heuston – Christchurch – St. Stephen's Green – Grand Canal Dock – Irishtown					
	R12	Heuston – Christchurch – St. Stephen's Green – Pearse – Grand Canal Dock - Irishtown					
	R13	Heuston – St. Patrick's Cathedral – Portobello - Charlemont – Mespil Road – Aviva Stadium - Irishtown					
S3	R19	Heuston – Smithfield – O'Connell - Connolly					
	R20	Heuston – TUD Grangegorman – Phibsborough - Mater – Parnell - Connolly					
S4	R16	Heuston – Christchurch – St. Stephen's Green – Pearse					
	R18	Heuston – Christchurch – St. Stephen's Green – Pembroke Road - Sandymount					

Of the route alignment options under Scenario 1, the best performing route options are S1 R01, S1 R02. S1 R03 and S1 R09. The first of these, S1 R02, is the best performing route alignment in terms of travel demand, while S1 R01 is the best performing in terms of environment and cost.

In terms of rail operational efficiency, all route options under Scenario 1, except for S1 R21, are top performers. Route option S1 R21, S1 R07, S1 R04 and S1 R08 are the poorest performing under Scenario 1.

Of the route options under Scenario 2, the best performing route alignment options based on all criteria assessed is S2 R10, followed by S2 R11 and S2 R12, whilst the least well performing route alignment option is S2 R13.

Of the route option alignments under Scenario 3, the best performing route alignment option based on all criteria assessed is S3 R19, while route option S3 R20 is assessed to be the least well performing route alignment.

Of the route alignment options under Scenario 4, route option S4 R16 is the top performing alignment option.

4.1 Routes Shortlisted for Stage 2 MCA

In general, Scenario 1 (a run through scheme from Kildare Line to the Northern Line) has the best performing routes. There are four routes in Scenario 1 that have the best assessments for the selected criteria, and they will provide a sufficient range of stations for a robust Stage 2 assessment.

None of the Scenario 2 routes performed well and accordingly they are not taken into the Stage 2 assessment.

Scenario 3 and Scenario 4 include the interchange options. One interchange option, S4 R16, was considered suitable to bring forward to the Stage 2 assessment because it is one of the better performing route options in terms of cost and had the best travel demand rating of any of the interchange options.

Therefore, a total of five route options were brought forward to the Stage 2 assessment and these are S1 R01, S1 R02, S1 R03, S1 R09 and S4 R16. This means that four options from Scenario 1 (Kildare to Northern Line run through), and one from Scenario 4 (schemes to allow services from the South Eastern Line to connect by interchange to the Kildare Line are taken forward to Stage 2 assessment.

These route alignment options with underground station locations indicated by stars are presented in Figure 4-2 to Figure 4-6.

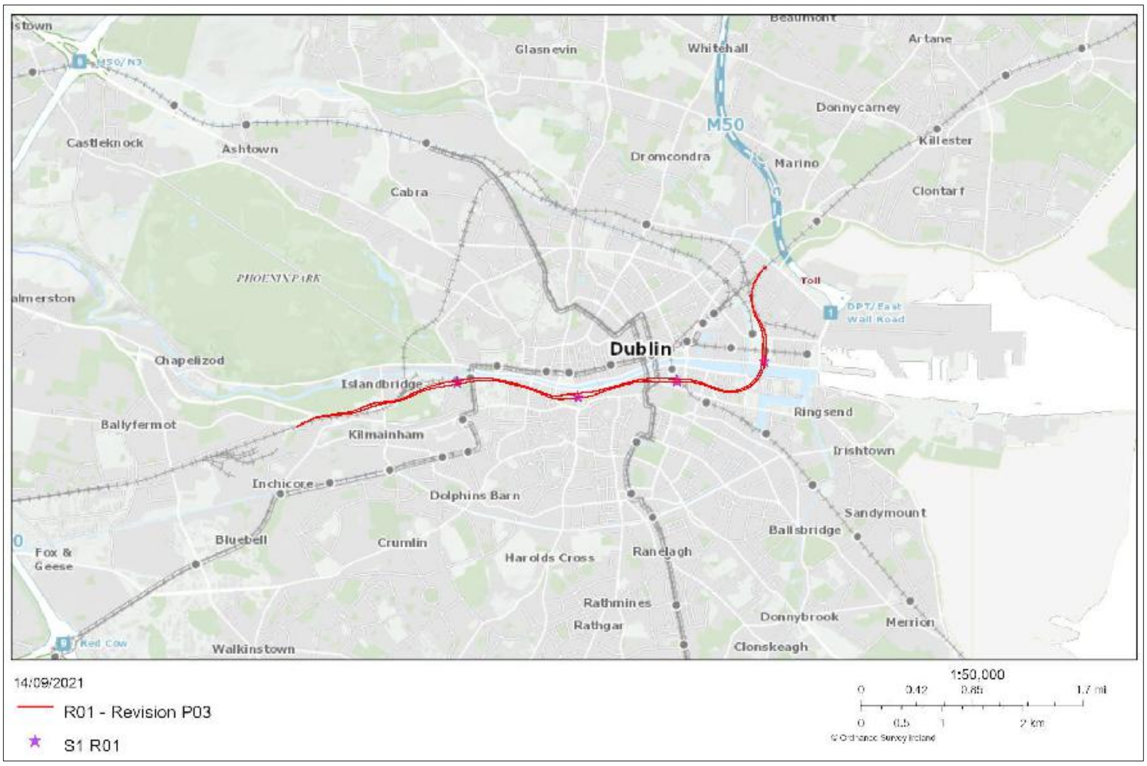


Figure 4-2 Short Listed Route Alignment Option R01

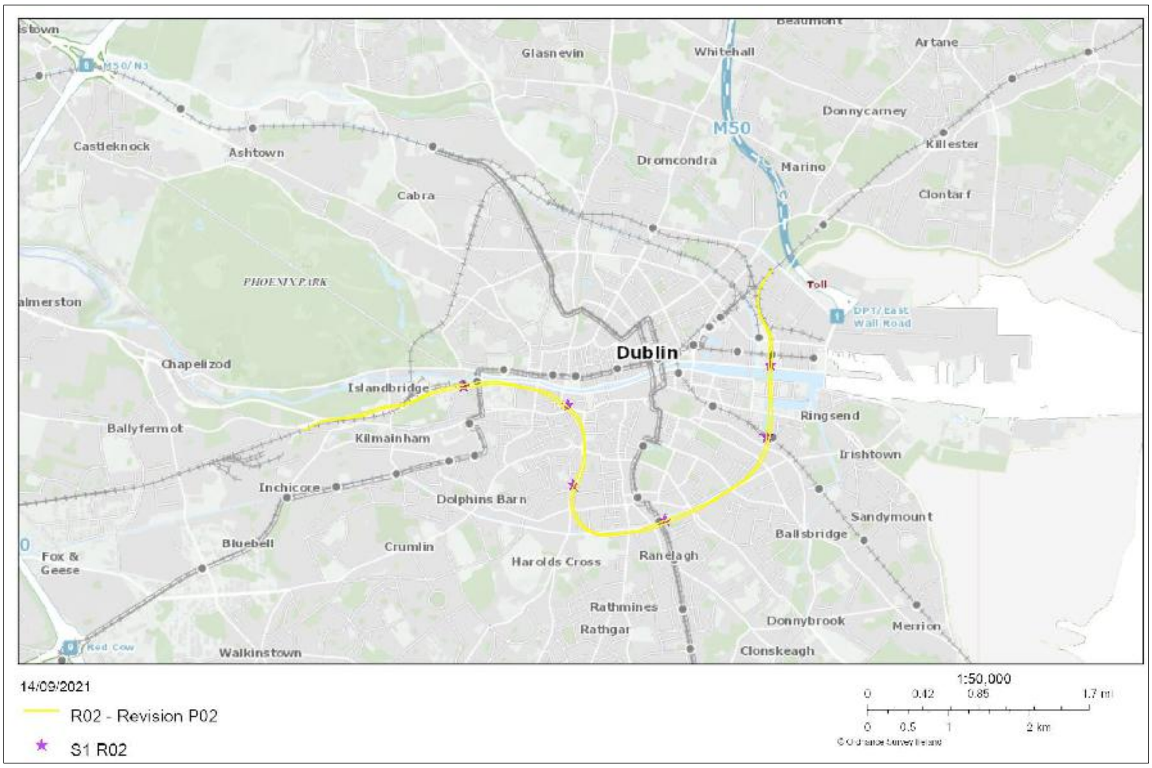


Figure 4-3: Short Listed Route Alignment Option R02

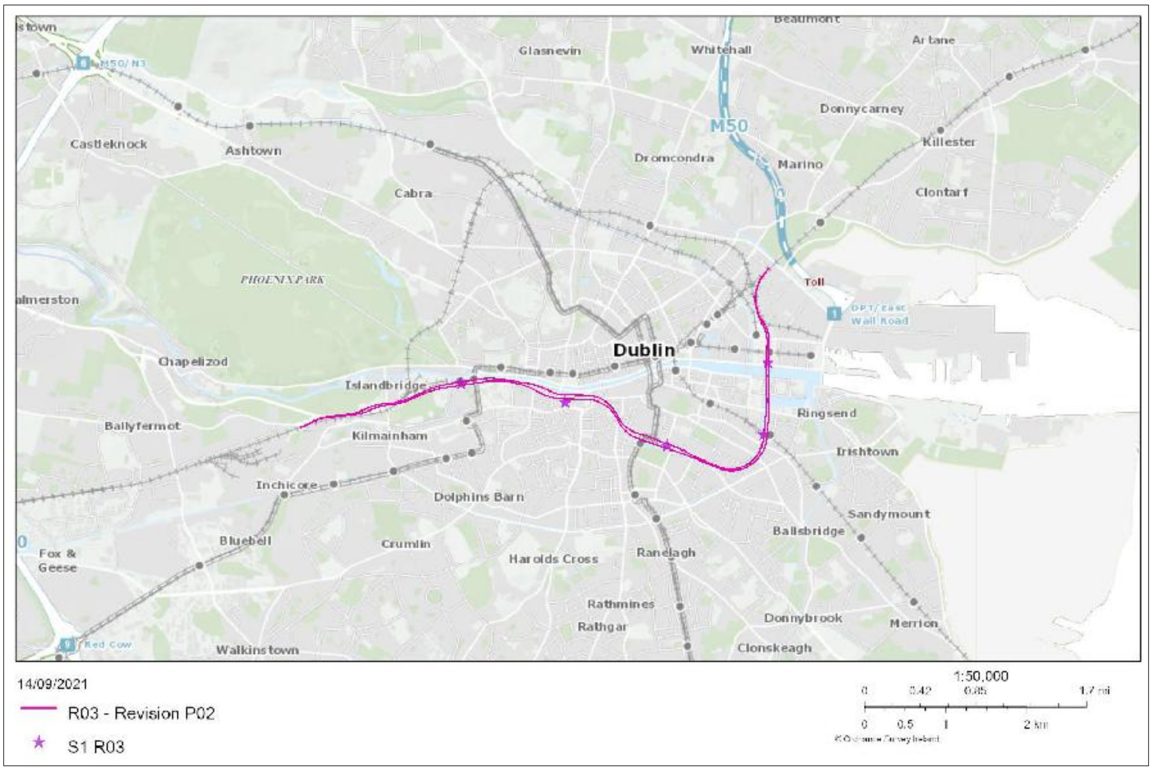


Figure 4-4: Short Listed Route Alignment Option R03

Figure 4-5: Shortlisted Route Alignment Option R09

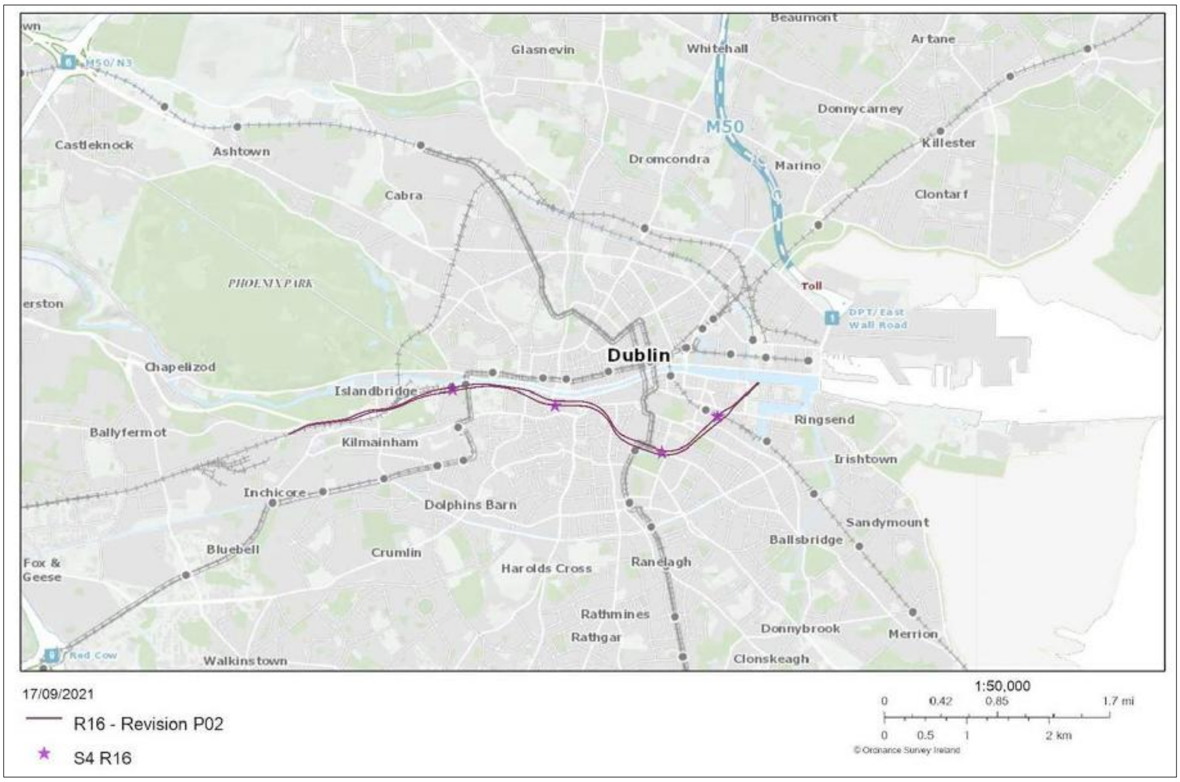


Figure 4-6: Short Listed Route Alignment Option R16

5. Description of the Five Short-listed Routes

The Stage 1 Preliminary Options Assessment led to five route alignment options being brought forward to the Stage 2 assessment. Four route alignment options are under Scenario 1 and one route alignment option is under Scenario 4. These five route alignment options are described in the following sections. Common to all potential route options are the tie-ins to the existing railway infrastructure at the western end of the route (as well as the eastern tie-in for Scenario 1 routes only) and these are described below.

Permanent way drawings are provided in Appendix B.

5.1.1 Western Tie-in

The western tie-in location for all five alignments is west of Heuston Station. For the four run-through options under Scenario 1 it is likely that the western tie-in will be a TBM reception site, and the launch site will be at the eastern tie-in location at Docklands. For route option S4 R16, with its turnback cavern at Pearse Station, the TBM will more likely be launched at the western tie-in site and this means that additional temporary land might be required from the grounds of the adjacent GAA Club.

For all options land is required outside of the railway boundary to form the connection of DART+ Tunnel and the future Kildare slow lines, and temporary land use for construction will also be necessary. A plan of the potential portal site is shown in Figure 5-1 with the estimated area for the TBM launching site indicated.

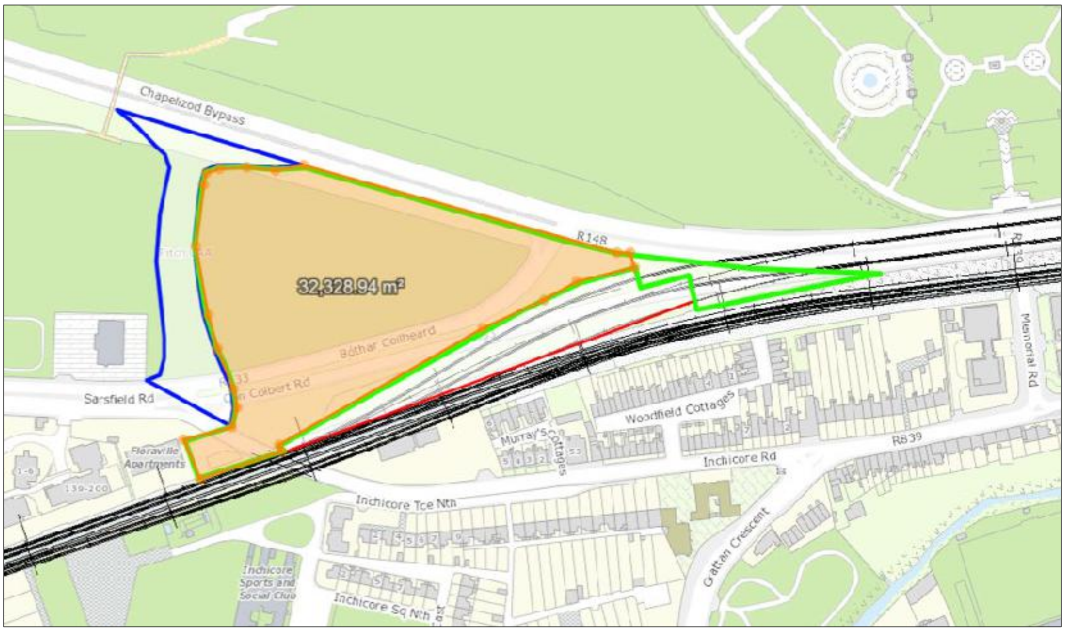


Figure 5-1 Western Tie-in and Portal

It was found necessary for the track connection point to be moved further east when compared to Western Tie-in study by Arup for the NTA (2017), so that the switches are moved off the Sarsfield Road underbridge. This change increased the design challenges on track gradients where because of the twin constraints of the existing underbridge at Sarsfield Road and the Chapelizod Bypass the ground cover to the tunnel is limited, even with a steep ramp gradient. Ground improvement measures will be required to manage the risk of settlement of the bypass road.

5.1.2 Eastern Tie-in at Docklands

The Docklands area provides a good location for a portal and TBM launch site for the four Scenario 1 route options. (The interchange option under Scenario 4 has its own turnback challenges at Pearse).

The Docklands location is in railway land and there could be potential to use the rail network for material supply and spoil removal. A plan of the potential portal and launch site is shown in Figure 5-2. The intention for this tie-in is to replicate the reference design developed by IÉ for the successful Railway Order on the basis that the complex trackwork in the area is likely to be the only effective way of connecting the several lines in the area.

The added complexity of the proposed DART+ West shallow station at Spencer Dock has not been considered on the understanding that it would need to be temporarily relocated during the construction of the DART+ Tunnel and, afterwards, be reinstated and integrated with the new underground heavy rail station.

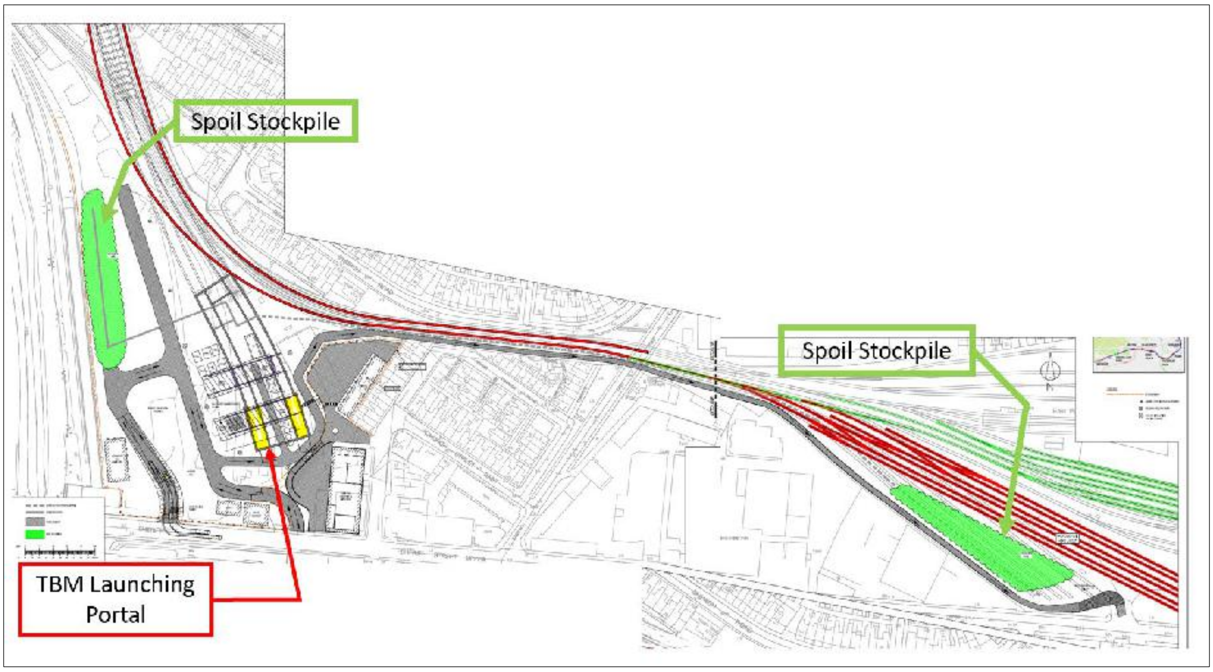


Figure 5-2 Eastern Tie-in and Portal with possible Construction Areas

5.1.3 Basis of Design for Track Alignment

The track alignment design for each of the five short-listed routes for DART+ Tunnel assumes that:

- It will be constructed using a Tunnel Boring Machine (TBM);
- The track is designed to accommodate 8-car DART EMUs;
- Underground station platforms are to be minimum of 174m long and have a maximum track gradient at platform of 0.2%;
- Nominal track gauge is 1600mm;
- Minimum horizontal radius for new track is 400m;
- Maximum cant is 100mm;
- Maximum vertical gradient is 3.5% for a maximum length of 1.66km and 3% over longer distances;
- Alignments are designed for 75kph; and
- Junctions are designed for 50kph.

The horizontal alignment is designed for the five shortlisted routes and the track/tunnel interval between stations has been minimised. The vertical alignments takes cognisance of rockhead levels as well as existing and planned rail track alignments and stations (IÉ lines, Luas, and MetroLink) and interfaces with other underground utilities.

5.2 Scenario 1 Route Descriptions

5.2.1 Stations and Geology

Scenario 1 consists of schemes to connect from the Kildare Line to the Northern Line allowing run-though services and four of the five route alignment options brought forward to Stage 2 Assessment are from Scenario 1, including R01, R02, R03 and R09.

A number of stations are common under Scenario 1 as shown in Table 5-1.

Table 5-1 Common Stations for Scenario 1

Scenario 01 Route and Stations	Heuston	Christchurch	Tara Street	St. Stephen's Green	St Patricks Cathedral	Pearse	Charlemont	Grand Canal Dock	Docklands
R01	Y	Y	Y						Y
R02	Y	Y			Y		Y	Y	Y
R03	Y	Y		Y				Y	Y
R09	Y			Y		Y			Y

The geology and geotechnical situation can also be taken as common to the four route options under Scenario 1.

The general geological and stratigraphical sequence within Dublin City consists of soils and bedrock formed and altered by erosion and various glacial events. The geology of Dublin is dominated by its recent geological history which sculpted the bedrock beneath the city and then covered/obscured it with the deposits it produced forming the current topography. During the last Ice Age there were between five and seven glacial events, each one had variations in the depth of ice, ice movements, and periods of melting, which destroyed or re-worked the effects of its predecessor. A general description of the stratigraphy is presented in Table 5-2.

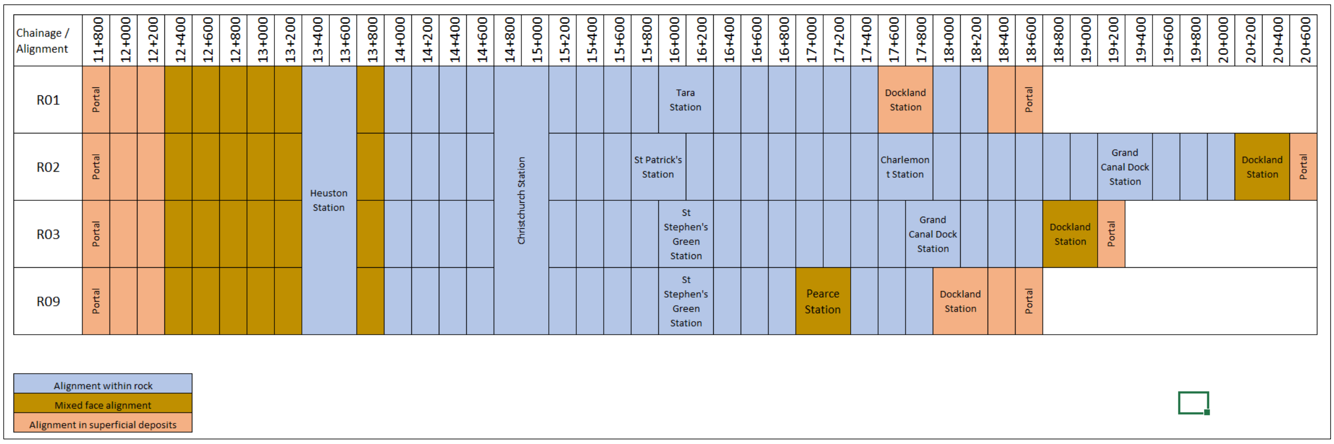
Table 5-2 Geological Stratigraphy of Tunnel Alignments under Scenario 1

Geology	Stratigraphic Divisions		Lithostratigraphy and Sedimentary Classification	Simplified Description
SUPERFICIAL (Soils)	QUATERNARY	Recent	Made Ground / Fill and Reclaimed Land	Man-made and natural earth material (anthropogenic)
			Alluvial/Estuarine Clays and Silts	Generally soft silts and clays, may be locally stiff to very stiff (where consolidated) and may contain organic material
			Alluvial/Estuarine Gravels and Sands	Dense to very dense sub- angular to sub-rounded sandy gravels and gravelly sands

Geology	Stratigraphic Divisions		Lithostratigraphy and Sedimentary Classification			Simplified Description
		Glacial	Drift (Glacial Till)	Glacio-marine Sediments		Very stiff (to hard) sandy, clayey silts and medium dense to dense silty sands, locally interstratified with thin laminae of clay
				Brown Boulder Clay	UBrBC	Firm to stiff brown sandy gravelly clay (with cobbles and boulders in places) overlying very stiff dark grey to black sandy gravelly clay (with cobbles and boulders in places). May have thin sand and gravel lenses present in places
					UBkBC	
				Black Boulder Clay	LBrBC	
					LBkBC	
				Glacial Gravels and Sands		Dense, angular to sub-angular sandy, slightly silty gravels or very gravelly, slightly silty sands
SOLID (Bedrock)	LOWER CARBONIFEROUS		Predominantly Limestones			Calp Limestone - argillaceous limestone and calcareous shales in several different formations

The Calp Limestone is suitable for tunnel construction by Tunnel Boring Machine (TBM), and this strata will minimise ground movements at the surface if a rock cover thickness is at least one tunnel diameter above the tunnel profile. However, this might not always be possible so mixed face conditions and full-face superficial deposit conditions could be encountered at some point along the drive. Table 5-3 provides a brief description of the extents of the alignment in rock (using 1 x 6.8m outside diameter of cover) in a mixed-face or in a full-face of superficial deposits.

Table 5-3 Extents of the alignment in rock (with 1 diameter of cover),



This following section provides more engineering detail on each of the four Scenario 1 routes in the following order:

- Track Alignment
- Tunnelling and Geotechnical Situation,
- Civil Engineering and Stations,
- Rail Operations

- Transport Planning,
- Environment, and;

5.2.2 Route S1 R01

The length of the S1 R01 alignment is 7.4km length and begins at the western tie-in and extends towards the east after passing underneath the northern edge of Saint James's Gate, as shown in Figure 5-3.

The route runs parallel and to the south of the River Liffey for most of its length before crossing under the river towards the Docklands area and the connection with the Northern Line. It has four new underground stations at Heuston, Christchurch, Tara Street, and Docklands. The proposed station at Tara Street is an interchange station with DART and MetroLink services.

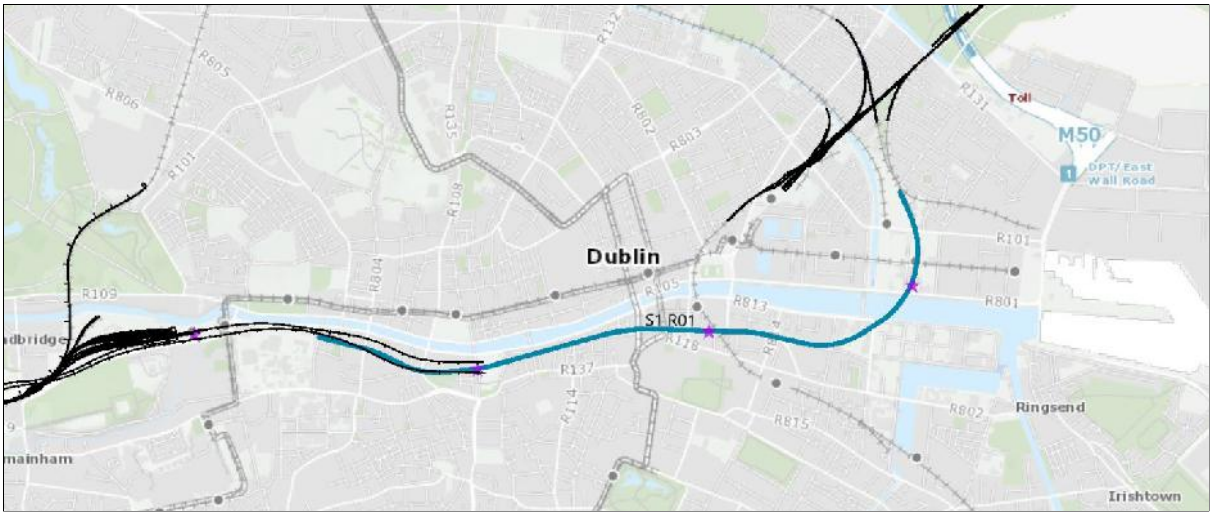


Figure 5-3: Short Listed Route Option – S1 R01

5.2.2.1 Track Alignment

The track alignment design for this route option considered:

- Where there is commonality between this route and the works undertaken as part of the previous 2014 Railway Order (RO) for the DART Underground, the alignment has been based on these prior works with some appropriate refinement;
- The eastern and western tie-ins are as outlined in the previous section;
- The vertical alignment takes cognisance of the estimated rockhead levels to assist with tunnel boring and stability;
- The track levels at the new underground Tara Street heavy rail station allows for the planned MetroLink single bore tunnel and station as well as the presence of a large trunk sewer in Townsend Street;
- The track alignment complies with Irish Rail standards.

The following maximum / minimum values are achieved by the track alignment design for this and other route options are shown in Table 5-4.

Table 5-4 S1 R01 Route-Wide Track Alignment Values

S1 R01 Route-Wide Track Alignment Values	
Maximum Gradient	3.5%

Minimum Horizontal Radius	400m
Maximum Cant	90mm
Minimum Vertical Curve radius	1643m
Maximum Vertical Curve radius	35000m

At each of the station locations on this route, the following values Table 5-5 have been achieved.

Table 5-5 S1 R01 Station Specific Track Alignment Values

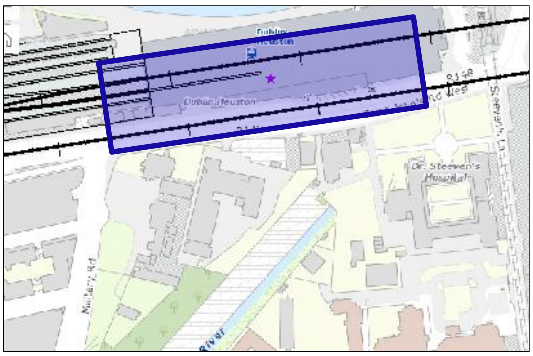
S1 R01 Station Specific Track Alignment Values	
Heuston Station	
Track interval	39.112m
Horizontal alignment	Straight
Vertical alignment	0.2% grade
Christchurch	
Track interval	51.664m
Horizontal alignment	Straight
Vertical alignment	0.2% grade
Tara Street	
Track interval	39.392m
Horizontal alignment	Straight
Vertical alignment	0.2% grade
Docklands	
Track interval	28.393m
Horizontal alignment	Down Main Underground: 10000m radius*
Vertical alignment	0.2% grade

For more design detail reference can be made to drawings DT1-JA-RTA-ROUT_XX-DR-Y-2001 to 2009 in Appendix B.

5.2.2.2 Tunnelling and Geotechnical Situation

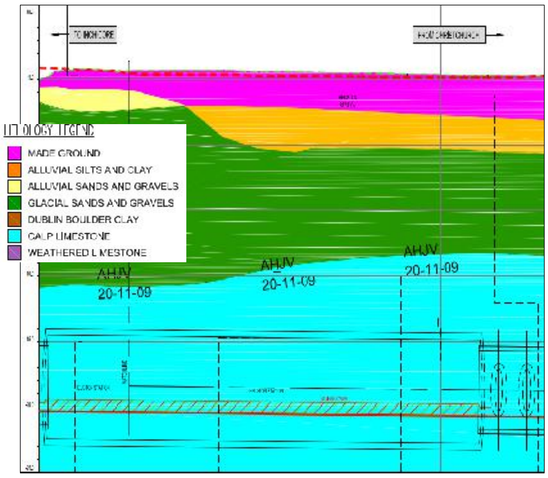
5.2.2.2.1 Heuston Station

Location: The proposed station at Heuston is located beneath the existing Heuston surface level station. It is common to all route alignments and all operating Scenarios. The ground conditions in the area for the proposed Heuston Station are dominated by the influence of the adjacent River Liffey. Existing ground levels are circa +5mOD



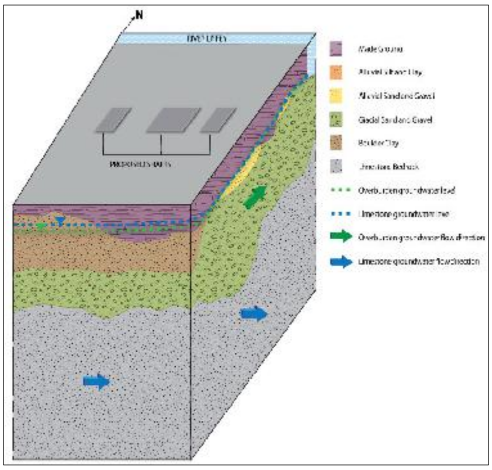
Geology: Ground conditions have been extracted from published data and the boreholes identified in this area show strata of:

- Made Ground: approx. 1m to 5m depth of sandy gravely clay with cobbles, pieces of brick and concrete,
- Alluvial Silts/Clays (closest to the existing river): sandy gravelly clay or a laminated organic silt from about +3mOD to +0mOD,
- Glacial Gravels/Sands: dense slightly clayey sandy gravel with cobbles from about +3mOD to -11mOD,
- Calp Limestone: bedrock from about -8.5mOD to -10.5mOD to depth.



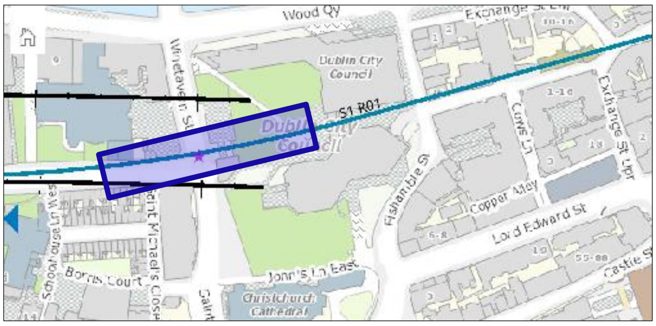
Groundwater: From published data, recorded and monitored ground water levels indicate that:

- the overburden and limestone are in hydraulic continuity in this area as the groundwater levels recorded in both geological units show similar levels and ranges,
- the groundwater in the limestone to move upwards and rest within the gravels,
- the groundwater regime in the area is also likely to be influenced by the River Liffey. Quay walls are present along its banks in this area, however there is likely to be a hydraulic connection between the river water and the shallow groundwater.



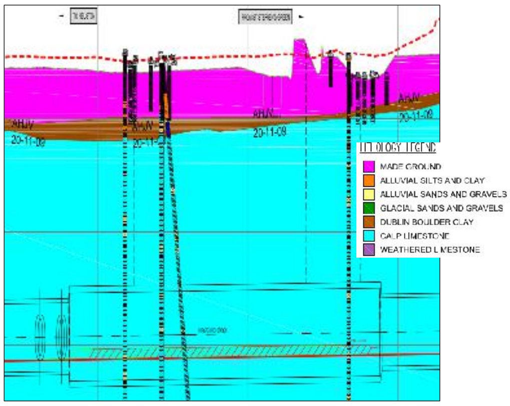
5.2.2.2.2 Christchurch Station

Location: The proposed Christchurch station is located beneath the grounds of the Dublin City Council (DCC) offices. The overburden ground conditions are dominated by the historic development of Dublin city into the River Liffey channel and the recent alluvial deposits of the river itself. Existing ground levels range from circa +3.5mOD to +5mOD.

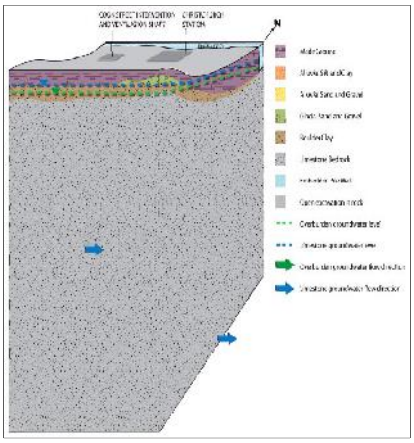


Geology: Ground conditions have been extracted from published data and boreholes identified in this area show strata of:

- Made Ground: approx. 1.5m to 5m depth of sandy gravely clay with brick, concrete, shell, wood, and animal bones),
- Alluvial Silts/Clays (locally): 1m to 2m of organic clay with shells, pieces of wood and peat,
- Glacial Till (DBC): sandy gravely clay layer ranging from about +3mOD to -2mOD,
- Calp Limestone: bedrock from about +2mOD to -2mOD to depth.

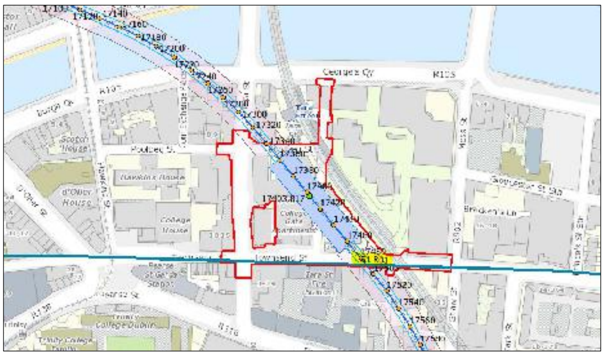


Groundwater: From published data, recorded and monitored ground water levels indicate that:



- the groundwater levels recorded in the overburden show the groundwater levels to be falling, while those recorded in the limestone are steady; this indicates that two different groundwater regimes are being monitored at this location,
- the limestone groundwater levels are generally consistent indicating that the level of groundwater in the overburden is being influenced by outside forces such as a leaking drain or surface water body,
- it is likely that the River Liffey is in hydraulic continuity with the Made Ground deposits in places. The extent of this will depend on the variability of the Made Ground deposits and the competence of the quay walls,
- the River Liffey may be hydraulically connected with the groundwater in the bedrock as the base of the River Liffey lies in bedrock at this location. The extent of this connection will depend on the connectivity of the fractures and the siltation at the base of the river.

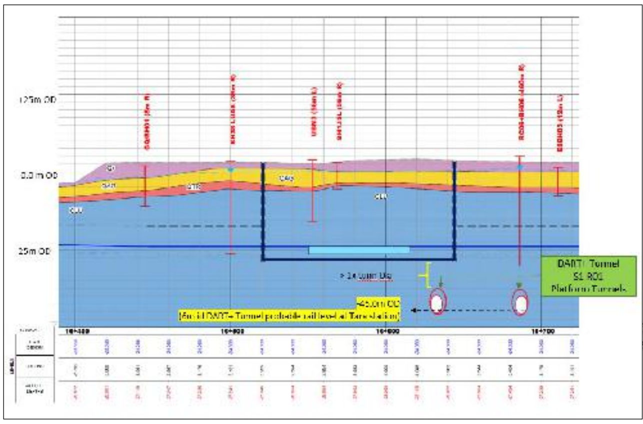
5.2.2.2.3 Tara Street Station



Location: This proposed station is unique to route alignment S1 R01. The proposed MetroLink Tara Street station is adjacent and west of the existing elevated DART Tara Street Station. The underground S1 R01 station would be immediately south of the MetroLink station and beneath Townsend Street. Existing ground levels in this area are circa +4m OD.

Geology: Ground conditions have been extracted from the MetroLink geological profile and indicate:

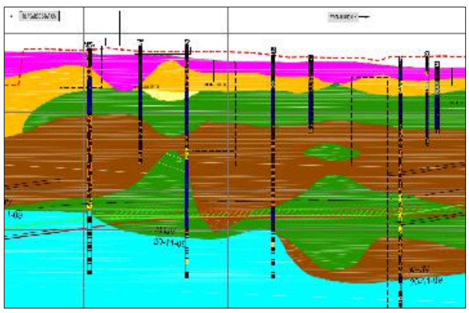
- Made Ground: approx. 2.5m to 4m depth,
- Alluvial Sand and Gravels 0mOD to – 5m OD (thickness varies),
- A circa 2.5m transition zone between the gravels and the Limestone
- Calp Limestone: bedrock from about -22.5mOD to depth.



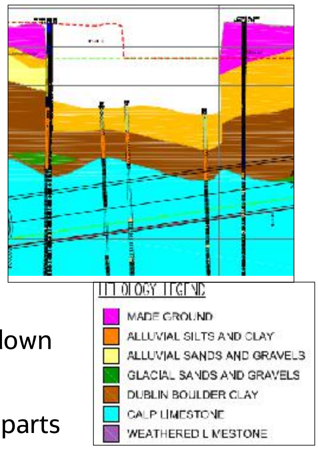
Groundwater: Groundwater strikes were recorded in two of the six boreholes in the vicinity on the MetroLink profile and would appear to suggest groundwater within the Brown Boulder Clay approximately 3mbgl.

5.2.2.2.4 Docklands Station

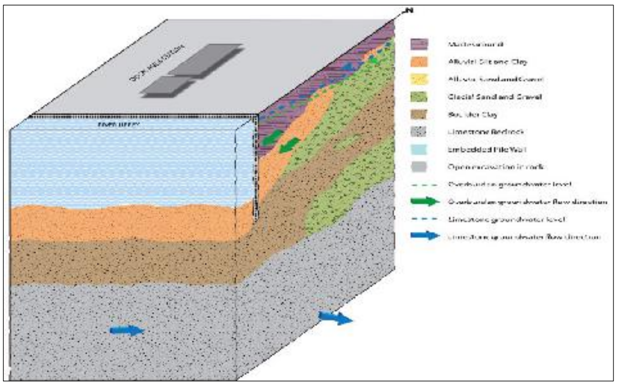
Location: The proposed Docklands station is located immediately north of the River Liffey and south of the proposed Spencer Dock station as part of the DART+ West project and is common to route alignment S1 R01, R02 and R09. The existing ground conditions at the proposed Spencer Dock station are dominated by the history of the River Liffey/Dublin Bay and the more recent reclamation which has gone in to raise ground levels above the prevailing sea/tide level. Existing ground levels in this area are circa +3mOD to +1mOD.



Geology: Exploratory holes identified in the vicinity of the proposed DART+ West Spencer Dock Station show strata layers of:



- Made Ground: approx. 1m to 2.5m depth (locally up to 5m - 6m) of sandy gravely clay with cobbles, brick, ash, timber and shell fragments,
- Alluvial Silts & Clays: soft/loose silt and silty gravel/silty sand with peat from about +2mOD to -2mOD (typically +0mD), down to approx. -9mOD close to the River Liffey
- Glacial Sands & Gravels: dense clayey sandy gravel from about to -2mOD to -8mOD (thickness varies),
- Glacial Till/Dublin Boulder Clay (DBC): stiff sandy gravely clay down to levels of approx.-10mOD to -17mOD,
- Glacial Sands/Gravels of variable thickness further underlain in parts by Glacial Till: sands and gravely clay
- Calp Limestone: bedrock from about -20mOD to -26 mOD.



Groundwater: From published data, recorded and monitored ground water levels indicate that:

- the groundwater regime is expected to be tidal in this area; data loggers show that the range of tidal influence is up to 2 m with the shallow deposits closest to the river being the most susceptible to tidal influence (this is likely to be due to the influence of the sea on the bedrock groundwater and not just the Liffey),
- the groundwater levels recorded indicate that the groundwater in each geological unit is likely to be hydraulically connected. However due to the presence of lenses of boulder clay and the heterogeneity of the deposits, perched water tables are also likely to be present,
- the area is reclaimed and relatively flat, there is very little groundwater gradient, with shallow flows towards the river and basal flow in the rock more likely towards the coast.

5.2.2.3 Civil Engineering for Stations

In this option, 4 no. new stations are proposed along the route – starting from the west and travelling east – and include Heuston, Christchurch, Tara Street and Docklands. Engineering details on each of the stations are noted below.

5.2.2.3.1 Heuston Station

The underground heavy rail station at Heuston is proposed to be constructed under the existing Heuston ground level station. The proposal requires the temporary closure of the existing platform 1 and the temporary relocation of platforms 2 and 3. The existing electrical sub-station and switch room, offices, and station concourse facilities would need to be relocated to the north-west corner of the existing station. Refer to Figure 5-4 below.

Figure 5-4 Heuston Station Layout

The construction approach is from the surface using three cut and cover shafts. The shafts will house passenger access and ventilation facilities. From these shafts the deep structures would be formed by mined construction while dealing with the River Camac culvert as it crosses south to north under the existing station.

This construction method is focused on the shafts and this would maintain the construction programme should the TBM arrival at Heuston from Docklands be delayed. The movement of materials and spoil from this site would be either by truck or by locomotive hauled wagon trains.

The Camac culvert, the arched vaults and the basements to the original station building are likely to be significant structures, which will need to be strengthened to manage any risk to the Heuston area.

A configuration of a Deep Mined Typical Station is shown in Figure 5-5. This arrangement, with its three vertical accesses (one at each end and in centre), is taken as a typical example for all underground stations in this study. The central access shaft will enable the construction of stairs and escalators and from these shaft, short tunnels will be mined to connect concourses and adits with the platform tunnels.

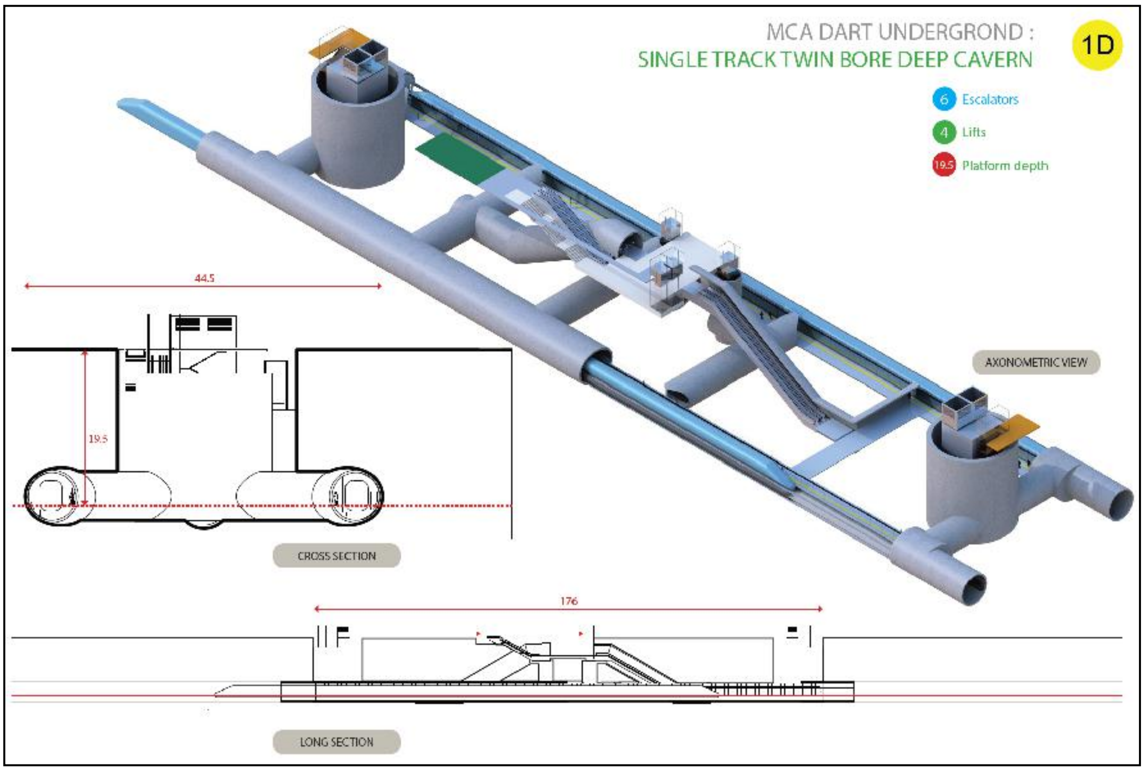


Figure 5-5 Deep Mined Typical Station Configuration (Tunnel Configuration Report by Arup for NTA)

5.2.2.3.2 Christchurch Station

The underground Christchurch station is under Cook Street and the grounds of the DCC offices, as shown in Refer to Figure 5-6.

As for Heuston underground station the construction approach is developed from surface shafts but instead of three only two will be used, one located within the existing DCC office grounds and the second in the adjacent lands of the Church of the Immaculate Conception – Adam and Eve's.

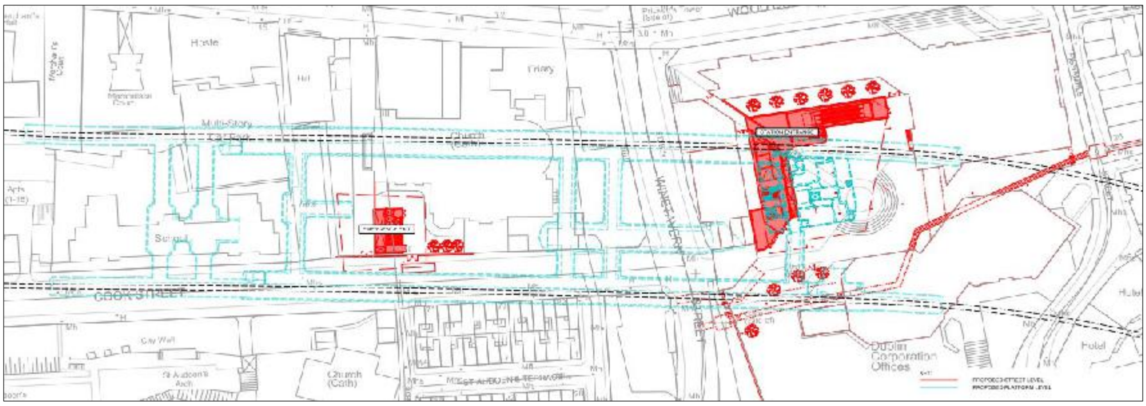


Figure 5-6 Christchurch Station Layout

5.2.2.3.3 Tara Street Station

The underground Tara Street station is proposed to be constructed parallel to Townsend Street, and almost perpendicular to the existing Irish Rail DART station and proposed MetroLink station. As for Heuston underground station the construction approach is developed from surface shafts but instead of three shafts, only two will be used and both will be constructed on Townsend Street. The shafts will be designed to house passenger access and ventilation facilities for the completed station. From these shafts, mined construction would create the lower-level structures. Refer to Figure 5-7.

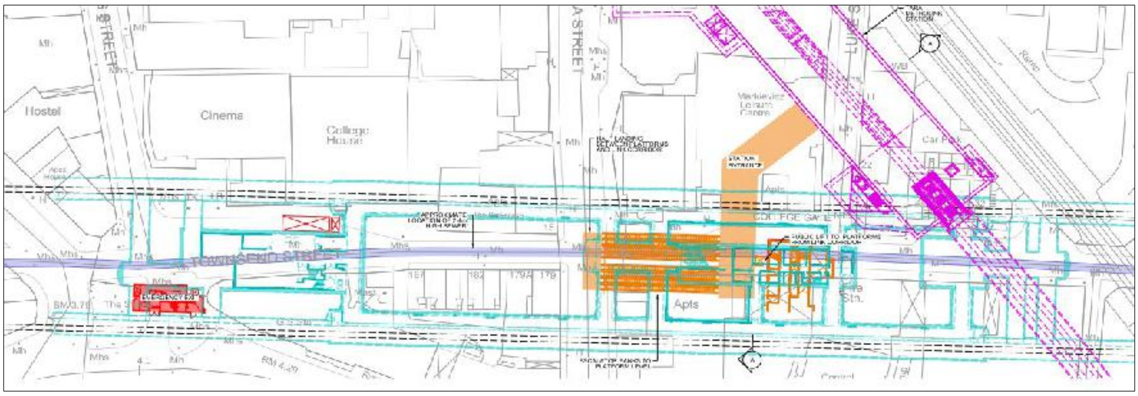


Figure 5-7 Station Layout

The construction of the underground station platforms will be achieved by horizontal fronts of excavation from within the shafts using a mined rock excavation approach to meet the TBM tunnels.

Tara Street station will have the added complexity of being an interchange station with the MetroLink station and the existing Irish Rail Tara Street station. An underground connection between the proposed Tara Street station for the S1 R01 route and the MetroLink station box would be formed at each of the concourse levels. Another major constraint for this station is the existing 8ft (approx. 2.4m) diameter Victorian-built trunk sewer that currently serve a large proportion of Dublin (more than 270,000 people). It runs along Townsend Street and it would need to be diverted in order to build the station.

For the proposed MetroLink works, Irish Water wrote in relation to any diversion proposal that, " *It should be noted that a suitable solution may not be achievable taking into account all constraints*".

The sewer location relative to the proposed works is shown in Figure 5-8.

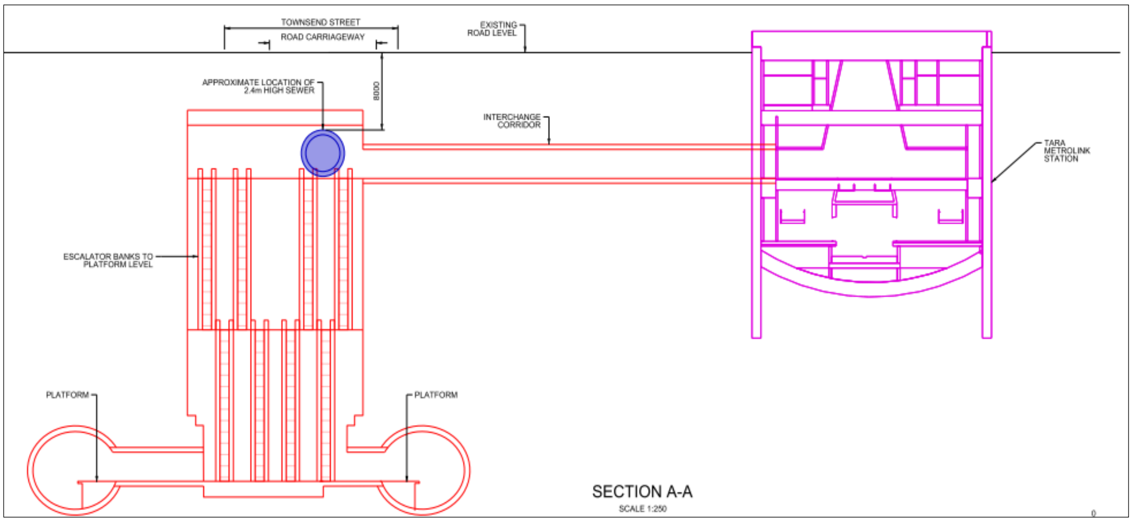


Figure 5-8 Tara Street Station Cross Section showing 8-foot Sewer

5.2.2.3.4 Docklands Station

The station at Docklands as shown in Figure 5-9 is proposed to be constructed under disused railway land largely between Sherriff Street Upper and North Wall Quay and immediately east of existing residential apartment blocks.

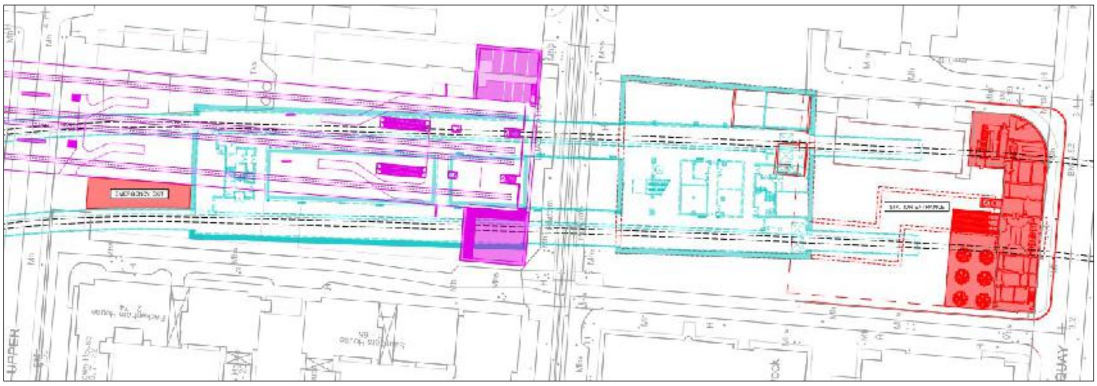


Figure 5-9 Docklands Station Layout

The longitudinal section in the south to north direction is shown in Figure 5-10. The vertical constraints of the River Liffey, the Luas on Mayor Street, and Sherriff Street Upper are evident before the tunnel can rise up to make the connection to the Northern Line. An intervention shaft was indicated on the previous design for the 2014 Railway Order at the north end of the underground station platforms to the north of Sherriff Street. The requirement for this shaft should be re-examined on the basis that the distance between the proposed Docklands and the portal is less than 2km.

New buildings will be required in the area including the Operational Control Centre for the tunnel and a maintenance facility, all as proposed for the 2014 RO for DART Underground.

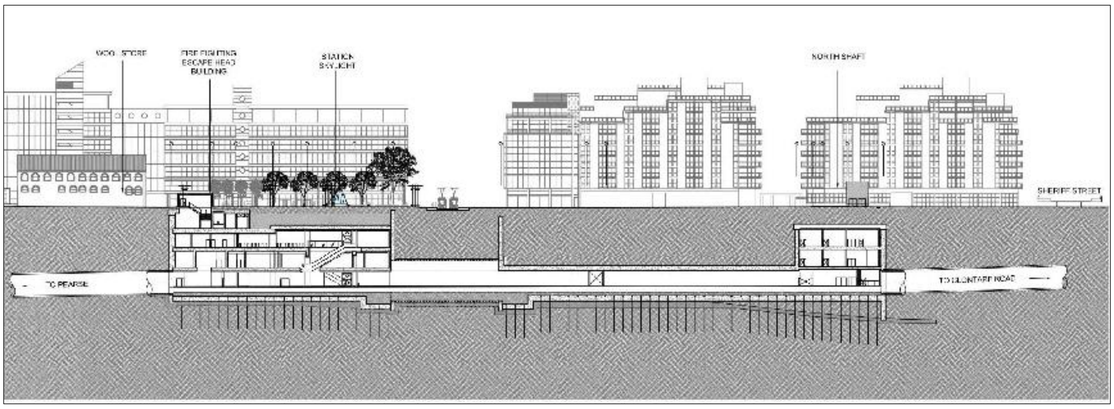


Figure 5-10 Docklands Station Longitudinal Section as for DART Underground RO Proposal

There are poor ground conditions in the area, and it is proposed that the station is constructed as a cut and cover station with local tunnelled/mined sections under the existing Luas Line, which will need some form of ground stabilisation.

The added complexity of this station is that there is currently a new shallow level station proposed for the DART+ West project that will be located over the Scenario 1 underground Docklands station. This station is likely to be constructed before the any DART+ Tunnel station and, as previously stated, would need to be temporarily relocated during the construction of the DART+ Tunnel and, afterwards, be reinstated and integrated with the new underground heavy rail station.

5.2.2.4 Rail Operations

With all or most Northern Line services diverted to Spencer Dock and no longer serving Connolly, interactions with trains from the Maynooth Line are removed and so significantly reduce the number of conflicts on the approaches to Connolly. This removes the bottleneck and operational performance constraints and thereby increases overall capacity.

The consequence of removing Northern Line services at Connolly means the number of services via the Loop Line and South Eastern Line is reduced. These could be replaced with services from the Maynooth Line that would extend to the South Eastern Line to replace the displaced Northern Line services. The majority of current Northern Line services on the Loop Line would divert via the DART+ Tunnel. Similarly, Kildare Line services to Spencer Dock could operate via DART+ Tunnel and not via the current route of Phoenix Park Tunnel and Glasnevin.

With Maynooth and Northern Line services separated this means that the number of trains operating on the Northern Line can increase by two trains per hour and a total of 11 DART services could operate These services would link with the Kildare Line via the DART+ Tunnel and the remaining services on the Northern Line (hourly inter-city Enterprise services from Belfast and Commuter services from Dundalk) would operate to and terminate at Connolly.

The removal of conflicts at Connolly and at Glasnevin means that additional Maynooth Line services could operate. These would have to be directed to Connolly and the Loop Line (replacing diverted Northern Line services) to provide through services to the South Eastern Line, maintaining a frequent service between Connolly, Grand Canal Dock and Bray. This then allows for a cross-city pattern: Northern Line linked with the Kildare Line and the Maynooth Line linked with the South Eastern Line.

Kildare Line services via Phoenix Park Tunnel would be limited to those services operating to Connolly and the Loop Line, as all other Kildare Line services will operate via DART+ Tunnel to Spencer Dock. If 11tph operate via DART+ Tunnel, 2 or 3tph could operate via Phoenix Park Tunnel.

5.2.2.5 Transport Planning

Trips by mode and mode share

The number of daily public transport trips undertaken in the S1 R01 scenario and in the Do Minimum scenario in 2035 and 2050 are shown in Figure 5-11. The R01 route alignment option would increase the number of daily public transport trips by 10,250 (+0.99%) in 2035 and 13,680 (+1.12%) in 2050 compared to the Do Minimum scenario.

The Do Minimum scenario assumes the full implementation of the GDA Transport Strategy with the DART services adopted from the National Development Plan 2018 – 2027 but excluding the DART+ Tunnel scheme. Light rail schemes included in the Do Minimum are LR1: MetroLink to Charlemont; LR2a: Luas Cross City incorporating Luas Green Line Capacity Enhancement – Phase 1; LR3: Luas Green Line Capacity Enhancement - Phase 2; LR4: Luas Extension to Finglas; LR5: Extension of Luas Green Line to Bray; and LR6: Lucan Luas. Bus schemes included in the Do Minimum include BC1: Radial Core Bus Corridors (CBCs); BC2: BusConnects Fares / Ticketing; BC3: BusConnects Routes and Services; and BC4: BusConnects Orbital Bus Corridors.

A full specification of the Do Minimum scenario is provided in the Transport Modelling Report (Appendix A).

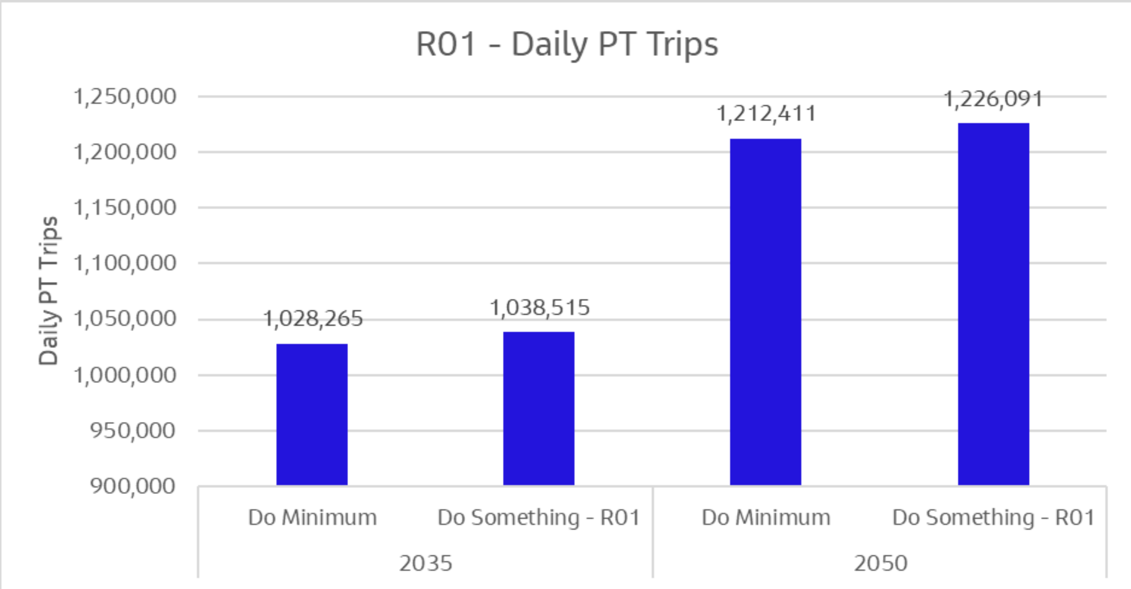


Figure 5-11: Daily Public Transport trips of R01 and Do Minimum in 2035 and 2050

In 2035 the R01 route alignment has a 0.13 percentage point increase in public transport mode share in comparison to the Do Minimum scenario. Of this, a 0.07 percentage point is from Cycle, a 0.04 percentage point comes from Car, and a 0.01 percentage point is from the Walk mode share. In 2050, the R01 route alignment has a 0.15 percentage point increase in public transport mode share in comparison to the Do Minimum scenario, and of this, a 0.08 percentage point is from Cycle, a 0.05 percentage point comes from Car and a 0.02 percentage point is from the Walk mode.

These mode share changes are presented in Figure 5-12.

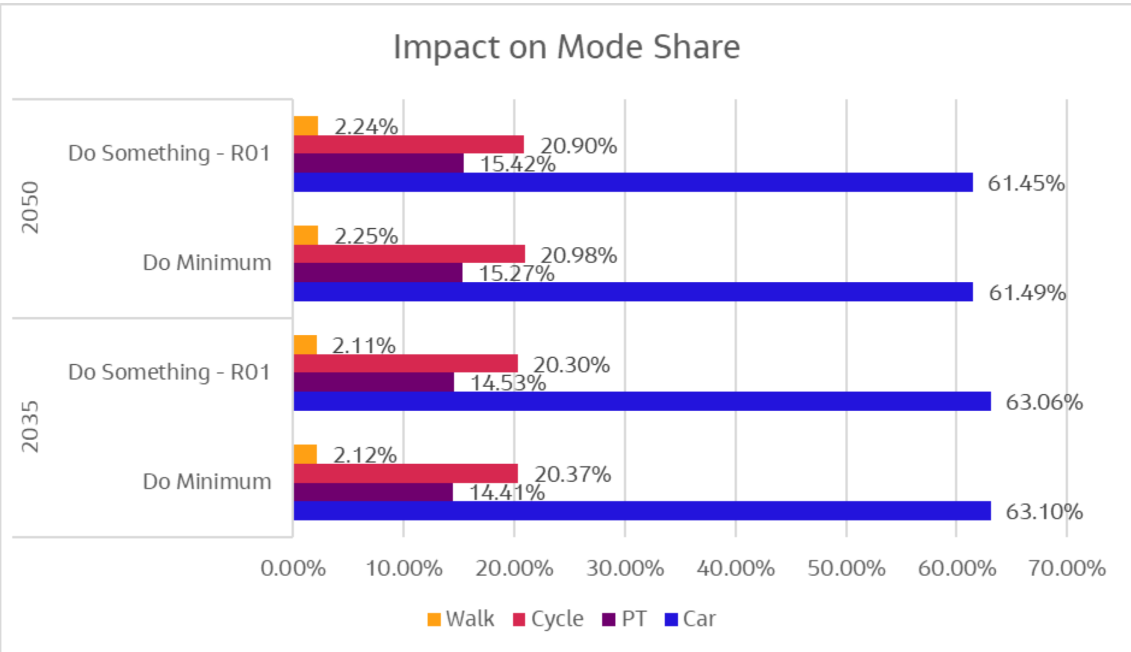


Figure 5-12: Mode Share of R01 and Do Minimum in 2035 and 2050

Rail passenger volumes

Figure 5-13 shows the percentage change in daily public transport passenger volume when comparing route alignment R01 to the Do Minimum Scenario in 2035. Positive changes are shown in green and negative changes are shown in red. The absolute volumes on the DART+ Tunnel R01 alignment are shown in black. Rail services are grouped and displayed according to the following service groups:

- Luas
- Metro
- 'Rail' which includes Irish Rail services and DART services

This classification is used throughout this report but in Figure 5-13 an additional classification is made to distinguish passenger volumes on the DART+ Tunnel section of the railway line from the Rail services on existing sections of the railway. As can be seen in the figure there is an estimated daily passenger volume flow of up to 57,000 in 2035 along this route alignment (both directions combined).

For the R01 route the daily passenger volume along the Phoenix Park Tunnel and all Luas lines are much lower as compared to the Do Minimum. The number of daily passengers using the Phoenix Park Tunnel is estimated to decrease by over 90% in 2035. The Luas line experiences a reduction in passenger volume of up to 13% in 2035 as compared to the Do Minimum. On the Northern Line there is a 40% reduction in passenger volume in the city centre section of the line south of Clontarf Road, but this is associated with services moving to the DART+ Tunnel. The actual impact on passenger volumes using the Northern Line is minor, with reductions in passenger volume of no more than 4%.

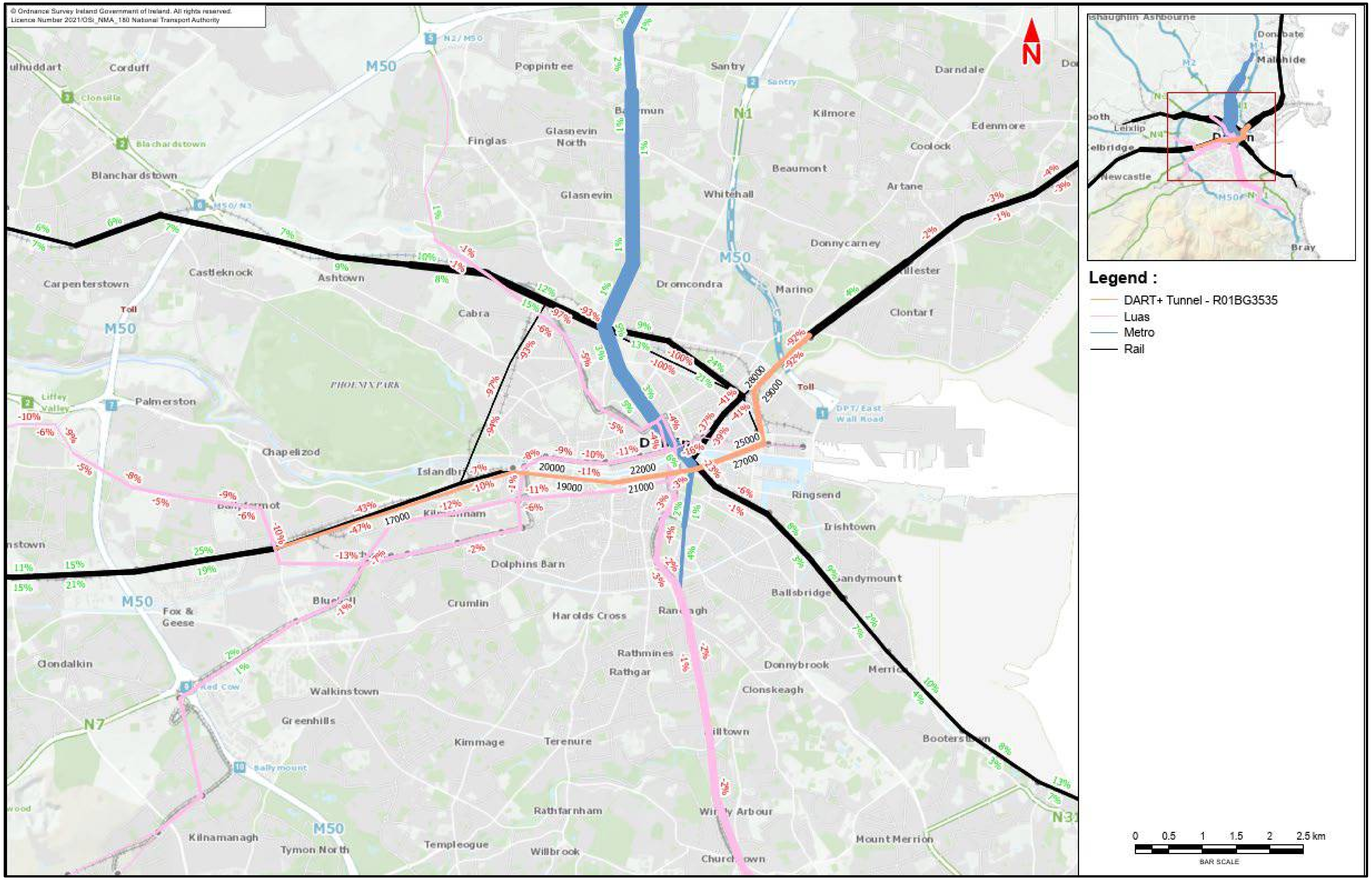


Figure 5-13: Difference in Daily Rail Passenger Volume between R01 and the Do Minimum in 2035

Boarding and Alighting

This section summarizes the AM peak boarding and alighting movements that arise from the catchment area of each station. Figure 5-14 shows the number of AM peak hour boarding and alighting movements by station for the R01 route alignment scenario. The station with the highest alighting movements is at Tara Street underground station which also is noted to be a highly used station due to the presence of the Tara Street elevated DART station and Tara Street MetroLink station.

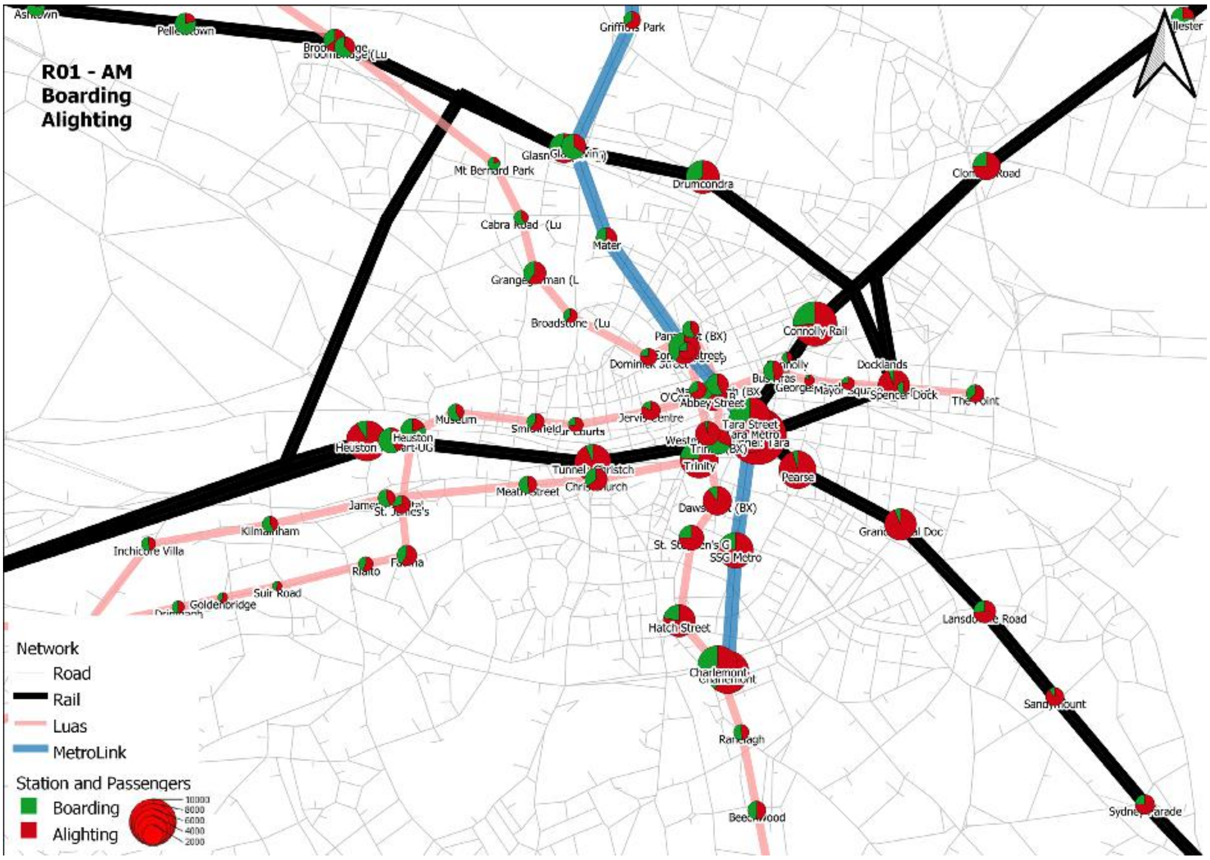


Figure 5-14: R01 AM Peak Boarding and Alighting movements by station the study area

Table 5-6 shows the comparison of AM peak hour boarding and alighting movements at key stations in 2035.

The boarding figures during the AM peak period at Heuston railway station is 61% less than in the Do Minimum. There are also reductions at Connolly, Pearse, and Grand Canal Dock stations along the coastal DART line as compared to the Do Minimum. In contrast, Hazelhatch railway station and the Luas stop at Heuston Station experience an increase in the number of boarding and alighting movements due to the former having a direct connection to the city centre and the Luas stop at Heuston station becoming an important interchange station with services using the DART+ Tunnel. No significant impacts are seen in the number of boarding and alighting movements at the other Luas stops and MetroLink stations.

Table 5-6: Comparison of AM Peak boarding and alighting movements at key stations - R01 vs Do Minimum

Station Name	**Percent change in the number of Boarding and Alighting movements as compared to Do Minimum Scenario**	
	Boarding	Alighting
Heuston Luas	+20%	-4%
Hazelhatch	+47%	+13%
Charlemont MetroLink	0	+7%
Tara Street MetroLink	+6%	+3%
Glasnevin Rail and MetroLink	-4%	+4%
Heuston Rail	-61%	-16%
Pearse	-5%	-43%
Connolly Rail	-15%	-38%
Grand Canal Dock	-23%	-26%

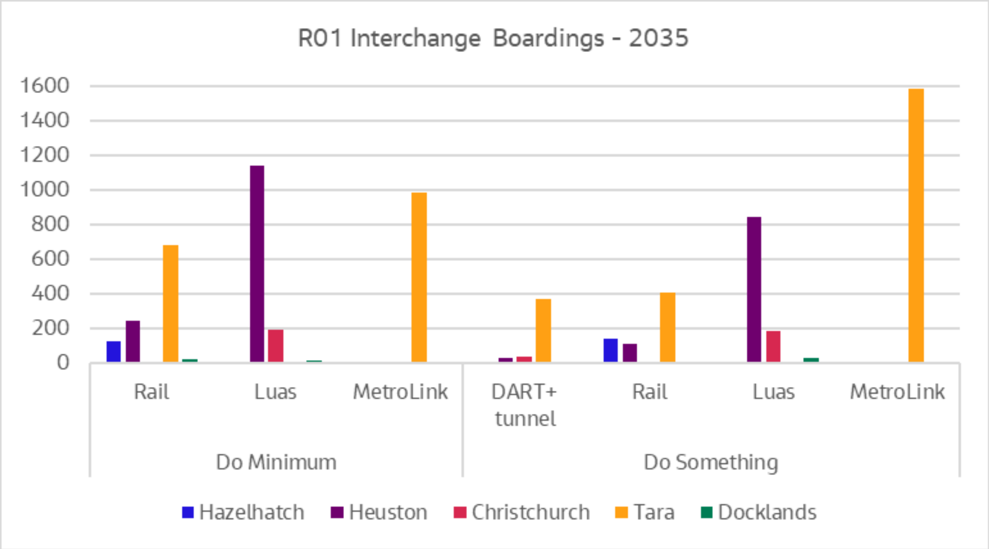
Interchange movements

This section summarises the AM peak boarding and alighting movements by station that arise from or to other transport modes, that is between Rail, Luas and MetroLink.

As previously noted, 'Rail' includes Irish Rail services and DART services, and in addition interchanges at new underground stations on the DART+ Tunnel section of the railway line are distinguished from interchanges at existing stations.

The number of AM peak hour interchange movements (by boarding and alighting) by station in 2035 in the Do Minimum and R01 are shown in Figure 5-15. In R01, Tara Street underground station is the most used station for interchange. There is an increase in interchange boarding and alighting at the Tara Street MetroLink station of approximately 60% and 16% respectively. With a direct connection from the Kildare Line to the Northern Line, a significant proportion of people is estimated to alight at Tara Street underground station and board onto the Tara Street MetroLink station for interchange.

A significant decrease in interchange boarding and alighting is observed at Heuston railway station as compared to the Do Minimum. The Heuston railway station experiences 35% less interchange alighting as compared to the Do Minimum. The Luas stop at Heuston Station experiences 40% less interchange alighting as compared to the Do Minimum. The decrease in alighting figures of Heuston railway station implies that a lot more people travelling on the Kildare Line now have a direct connection to the city centre as opposed to alighting at Heuston railway station or going through Phoenix Park Tunnel as in the Do Minimum scenario.



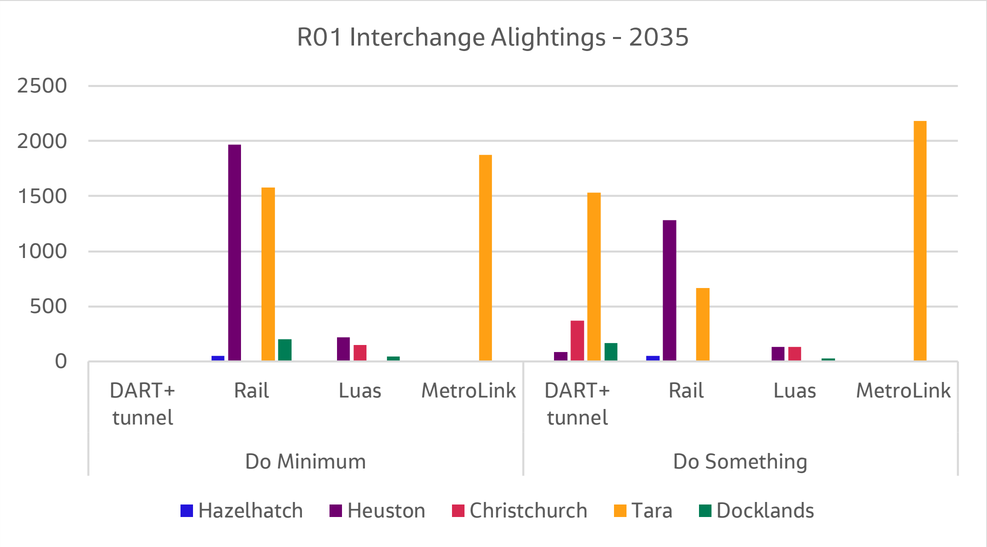


Figure 5-15: R01 AM Peak Hour Interchange Boarding and Alighting movements in 2035

Figure 5-16 shows the number of AM peak hour interchange boarding and alighting movements by station in 2050 for the Do Minimum and RO1. The impact of R01 as compared to the Do Minimum is similar in 2050 to 2035. Interchange boarding at Tara Street MetroLink station is 60% greater than in the Do Minimum in 2050, and there is less boarding and alighting at the Heuston railway station and the Luas stop.

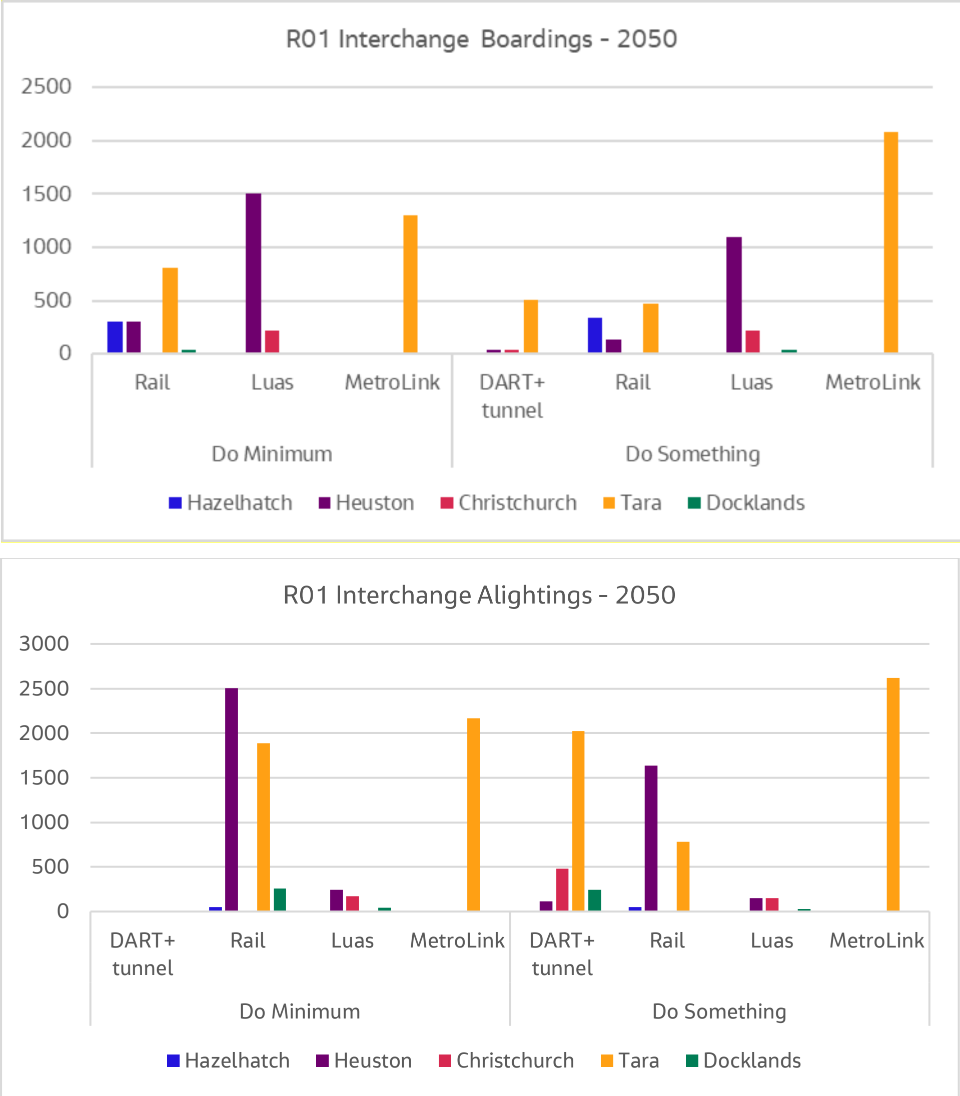


Figure 5-16: R01 AM Peak Hour Interchange Boarding and Alighting movements in 2050

Passenger loadings by line – Luas Services

Figure 5-17 presents the number of daily passengers travelling on each of the Luas lines (Red, Green and Lucan) by stop (on departure from each respective stop) for the 2050 Do Minimum scenario and the 2050 R01 scenario. The stops are arranged from city limits stations to city centre stops from left to right.

As shown in the figure, R01 generally results in less patronage on each Luas line. On the Luas Red line R01 has approximately 5,000 less passengers (-10%) than the Do Minimum on the section of line from Heuston stop to Abbey Street stop. The Lucan line has approximately 10% less passengers in the R01 scenario as compared to the Do Minimum across the majority of stops in the Lucan line. The Green line, between Charlemont stop and Cabra Luas stop, has on average 1,700 less passengers (-5%) in the R01 scenario as compared to the Do Minimum. There is typically less than 2% difference between the scenarios at the other stops on the Green Line.

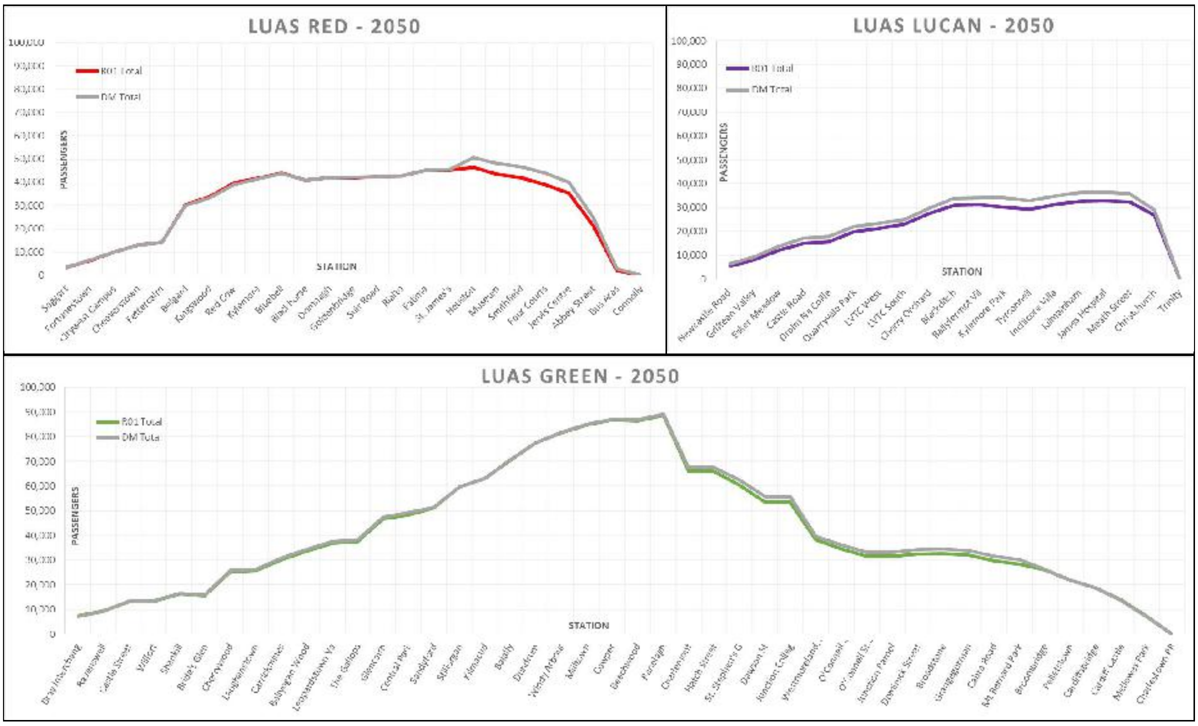


Figure 5-17: 2050 Luas Daily Passenger Flow R01 vs Do Minimum

Passenger loadings by line – MetroLink

Figure 5-18 presents the number of daily passengers travelling on the MetroLink by station (on departure from each respective station) for the 2050 Do Minimum scenario and the 2050 R01 scenario. The stations are arranged from city limits stations to city centre stations from left to right. As shown in the figure, R01 results in approximately 6,000 additional passengers than the Do Minimum on the section of line from Glasnevin Station to O'Connell Station.

This additional patronage in R01 is likely to be the result of the operation changes applied to the Northern Line in the R01 scenario while the Phoenix Park Tunnel services are significantly reduced which has discouraged people to transfer between MetroLink and DART at Glasnevin.

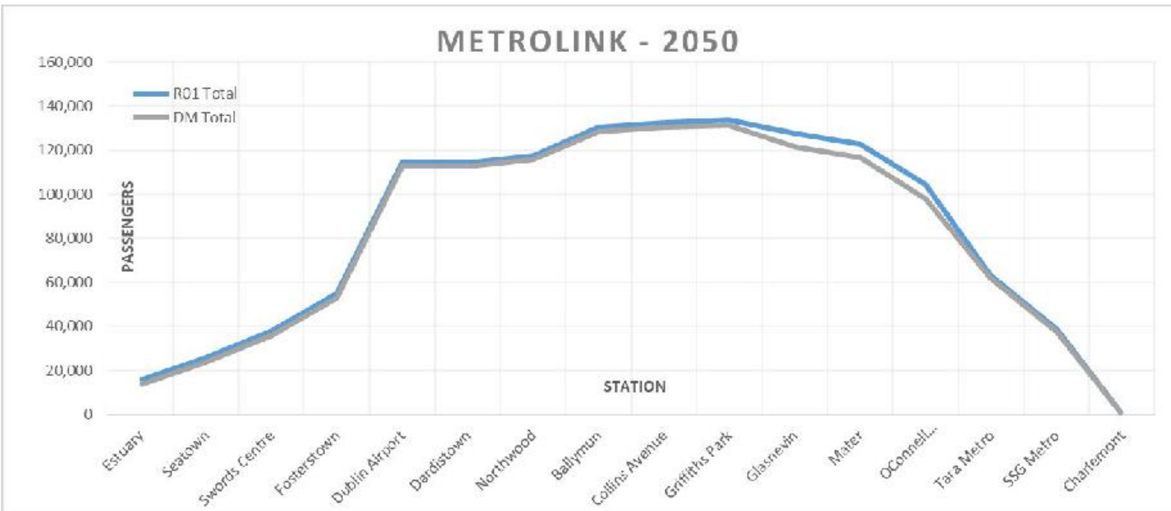


Figure 5-18: 2050 MetroLink Daily Passenger Flow R01 vs Do Minimum

Passenger loadings by line – Rail

The number of daily passengers travelling on the Rail lines; Maynooth Line, Northern Line, Kildare Line and South Eastern Line are presented in Figure 5-19. The figures are presented by station (on departure from each respective station) for the 2050 Do Minimum scenario and the 2050 R01 scenario. The stations are arranged from city limits stations to city centre stations from left to right.

As shown in the figure, R01 generally results in more patronage on the Maynooth Line, Kildare Line, and the South Eastern Line, but a reduction in patronage on the Northern Line.

The Maynooth Line attracts more passengers in the R01 scenario than in the Do Minimum scenario. The biggest difference is on the section between Broombridge station and Glasnevin station, where the difference in passenger volume is approximately 8,700. Glasnevin station has higher demand in the Do Minimum than in the R01 scenario as the Phoenix Park Tunnel services which run through this station are significantly reduced when the DART+ Tunnel scheme is in place.

Passenger volume on the Northern Line is less in R01 than in the Do Minimum except sections after Clontarf Road Station travelling towards the city centre. The biggest difference along the line is at Howth Junction Station where R01 has 5,000 less passengers (-9%) as compared to the Do Minimum. The reduction after the Clontarf Road station would be the result of the reduction in services heading south of the Royal Canal in comparison to the Do Minimum.

The Kildare Line corridor is the line that is most affected by the scheme. The demand along the Kildare Line is much greater in the R01 scenarios as compared to the Do Minimum. At the City Centre patronage is approximately 17,850 more passengers (+30%) in R01 than in the Do Minimum. Passengers using the Phoenix Park Tunnel in the Do Minimum are diverted to the DART+ Tunnel in R01 and only approximately 1,100 passengers remain on services through the Phoenix Park Tunnel.

The South Eastern Line attracts more passengers across the majority of stations in R01 comparing to the Do Minimum. There are approximately 2,500 more passengers on the sections between Bray to Lansdowne Road Station in R01 than in the Do Minimum. At Grand Canal Dock station, and to the city centre, the South Eastern Line has approximately 2,700 less passengers (-5%) in the R01 scenario as compared to the Do Minimum.

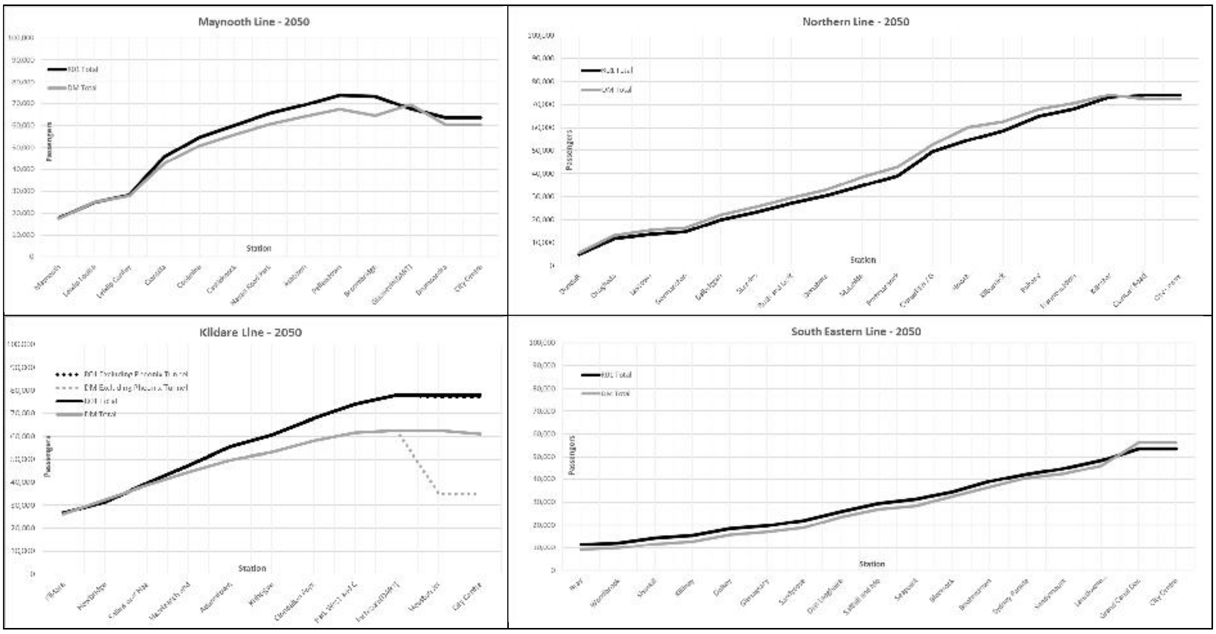


Figure 5-19: 2050 Rail Daily Passenger Flow R01 vs Do Minimum

5.2.2.6 Environment

Three of the four proposed stations (Heuston, Christchurch, and Tara Street) are located within the Historic Centre of Dublin City Designated Site and Christchurch station is also situated in the Zone of Archaeological Potential of multiple RMPs. No direct ecological constraints were identified. All proposed station locations are situated in built up areas of an urban landscape environment, impacts to visual amenity are envisaged to be limited. All proposed station locations are situated close to high density residential and commercial properties, allowing for the potential of disruption to communities and businesses.

5.2.2.6.1 Heuston Station

This station is all five options – S1 R01, S1 R02, S1 R03, S1 R09 and S4 R16.

Population: The station location is situated in central Dublin City and is largely confined to the area within and around Heuston Station including Saint John's Road West. There is little residential or commercial properties in this location however it is seen as a hub for connectivity with important transport links such as Luas and Irish Rail.

Archaeology, Architectural and Cultural Heritage: The station is situated within the Dublin City Zone of Archaeological Potential. There are no Record of Monuments and Places (RMP) or Sites and Monuments Record (SMR) or any other sites of Archaeological significance in its vicinity. There are a number of sites of Cultural Heritage significance however, namely: a post box, utilities box and lamp posts along Saint John's Road West as well as the Railway Terminus (Heuston Station) building. There are no Architectural Conservation Areas (ACAs) or Protected Structures in the vicinity of the station however there are a number of National Inventory of Architectural Heritage (NIAH) designations, all associated with the existing Heuston Station building itself. Considerable alterations are anticipated to the building housing Heuston Station to facilitate the works.

Landscape and Visual: The station location is situated in a high-density urban city centre environment with transportation connectivity being the main land use in this locality. There is little to no green space of any visual amenity value in this location, aside from the small open green space with some few mature trees outside the adjacent Dr. Steevens' Hospital/ HSE Headquarters.

Biodiversity: There are no ecological designated sites in the vicinity of the station, however it is approximately 25m south of the River Liffey which feeds into multiple ecological designations downstream of it, namely: South Dublin Bay and River Tolka Estuary Special Protection Area (SPA); South Dublin Bay Special Areas of Conservation (SAC); North Bull Island SPA; North Dublin Bay SAC; North Dublin Bay Proposed Natural Heritage Areas (pNHA); and South Dublin Bay pNHA.

5.2.2.6.2 Christchurch Station

This station is in all five options – S1 R01, S1 R03, S1 R09 and S4 R16.

Population: Impacts to the Church of the Immaculate Conception (also known as Adam and Eve's) will be significant to the parish and church users. Surface construction works will be significant and will need to be coordinated to avoid times when the church is in use. Disruption to Dublin City Council (DCC) will also be significant to the local community and office workers. The underground car park is used by DCC workers and impacts will require mitigation.

Archaeology, Architectural and Cultural Heritage: The area of the proposed station is within Dublin City Zone of Archaeology Potential and there are a large number of RMP/SMR sites in the immediate vicinity. There will be a significant effect on the archaeology of the area at this location and there will be high potential for undiscovered archaeology. The station will have surface interactions in the open space adjacent to DCC offices and across from Winetavern Street (Area of Historic Street Furniture) and the Church of the Immaculate Conception (RMP/SMR site). There will also be works at the south side of the church on an area which is currently a garden with a religious statue. Works here will impact the setting of the church.

Landscape and Visual: The impacted surface areas are green open spaces. The church garden on Cook Street is generally not accessible to the public but has high value in a densely developed area of the site. It is a grassed area with some planting and semi-mature trees. The area adjacent to DCC offices has been landscaped after the construction of the offices and underground car park. It is also not generally accessible to the public and is gated. The area is open grass, with landscape area and some mature trees.

Biodiversity: There are no ecological designated sites in the vicinity of the station location, however it is approximately 45m south of the River Liffey which feeds into multiple ecological designations downstream of it, namely: South Dublin Bay and River Tolka Estuary SPA; South Dublin Bay SAC; North Bull Island SPA; North Dublin Bay SAC; North Dublin Bay pNHA; and South Dublin Bay pNHA.

5.2.2.6.3 Tara Street Station

This station is in only one of the options – S1 R01.

Population: The station location is situated in central Dublin city and in close proximity to a number of public services buildings (Pearse Street Garda Station, Dublin Fire Brigade HQ, and Oisin House, landmarks (Trinity College Dublin and The Westin Hotel), and public transport services (Luas Green Line, Tara Street DART station and various Dublin Bus routes / stops). Considerable land acquisition (of residential, commercial, and public properties / spaces) is necessary for the development of the proposed station in this location and significant disruption is anticipated. The presence of the 8-foot 8ft (approx. 2.4m) Victorian trunk sewer, which serves over 270,000 people is a major constraint and Irish Water have highlighted its concerns about any potential work in this area that could impact the sewer. This is because of potential disruption to the sewer, which serves much of Dublin, and the risk of very significant environment damage. They have also highlighted that a potential diversion or replacement may not be achievable. This issue is a significant environment and population risk.

Archaeology, Architectural and Cultural Heritage: The station location is situated within the Dublin City Zone of Archaeological Potential. It does not directly impact any RMP / SMR Sites however it is located within the Zone of Archaeological Potential for 4 RMP Sites, namely: Standing Stone Site (DU018-020129); Chapel Site (DU018-020161); Site of Historic Religious Foundation (DU018-020061); and Church and associated Graveyard Site (DU018-020648). These sites are also registered with the National Monument Service. There are no other sites of Archaeological or Cultural Heritage significance to note in its vicinity. The eastern extent of the station location is situated within the O'Connell Street Architectural Conservation Area (ACA), signifying the rich architectural heritage and special character of the area. However, there are no Protected Structures or NIAH designated buildings in the immediate vicinity of the Proposed Station Location.

Landscape and Visual: The station location is situated in a high-density urban city centre environment with redevelopment ongoing currently in its immediate vicinity (i.e., the old College House / Hawkins House site redevelopment) There is no available green space in the immediate vicinity.

Biodiversity: There are no ecological designated sites in the vicinity of the Station location, however it is approximately 150m south of the River Liffey which feeds into multiple ecological designations downstream of it, namely: South Dublin Bay and River Tolka Estuary SPA; South Dublin Bay SAC; North Bull Island SPA; North Dublin Bay SAC; North Dublin Bay pNHA; and South Dublin Bay pNHA.

5.2.2.6.4 Docklands Station

This station is in four of the options – S1R01, S1R02, S1R03, and S1R09.

Population: The area above the proposed station is used as a car hire office, associated car park and a park area (Central Square). This is a popular area with office workers and the public in a dense urban area. The surface works will impact the use and enjoyment of this area. The Spencer Dock Luas stop and Spencer Dock Lunchtime Market (held in Central Square/Spencer Dock Park during pre-Covid times) are also located in this area. The surrounding area is comprised of offices and residential apartments.

Archaeology, Architectural and Cultural Heritage: The area of the proposed station is under the former British Rail Hotel (Protected Structure) and adjacent to the North Wall Quay (Zone of Archaeological Potential).

Landscape and Visual: The Central Square park is of value in this dense urban area. The surrounding area is a mixture of modern constructions and older buildings associated with the industrial history of the area.

Biodiversity: There are no ecological designated sites in the vicinity of the station location, however it is approximately 30m south of the River Liffey which feeds into multiple ecological designations downstream of it, namely: South Dublin Bay and River Tolka Estuary SPA; South Dublin Bay SAC; North Bull Island SPA; North Dublin Bay SAC; North Dublin Bay pNHA; and South Dublin Bay pNHA.

5.2.3 Route S1 R02

This S1 R02 route alignment of 10km between tie-in points begins at the western tie-in and extends towards the east before travelling south from St. Audoen's Park through Clanbrassil Street Lower, as shown in Figure 5-20. The alignment then turns east approaching Portobello and before the Grand Canal and continues along the Grand Canal until it connects to the Northern Line after it crosses the River Liffey.

R02 is proposed to have underground stations at Heuston, Christchurch, St Patrick's Cathedral, Charlemont (interchange with MetroLink), Grand Canal Dock (interchange with the South Eastern Line) and Docklands.

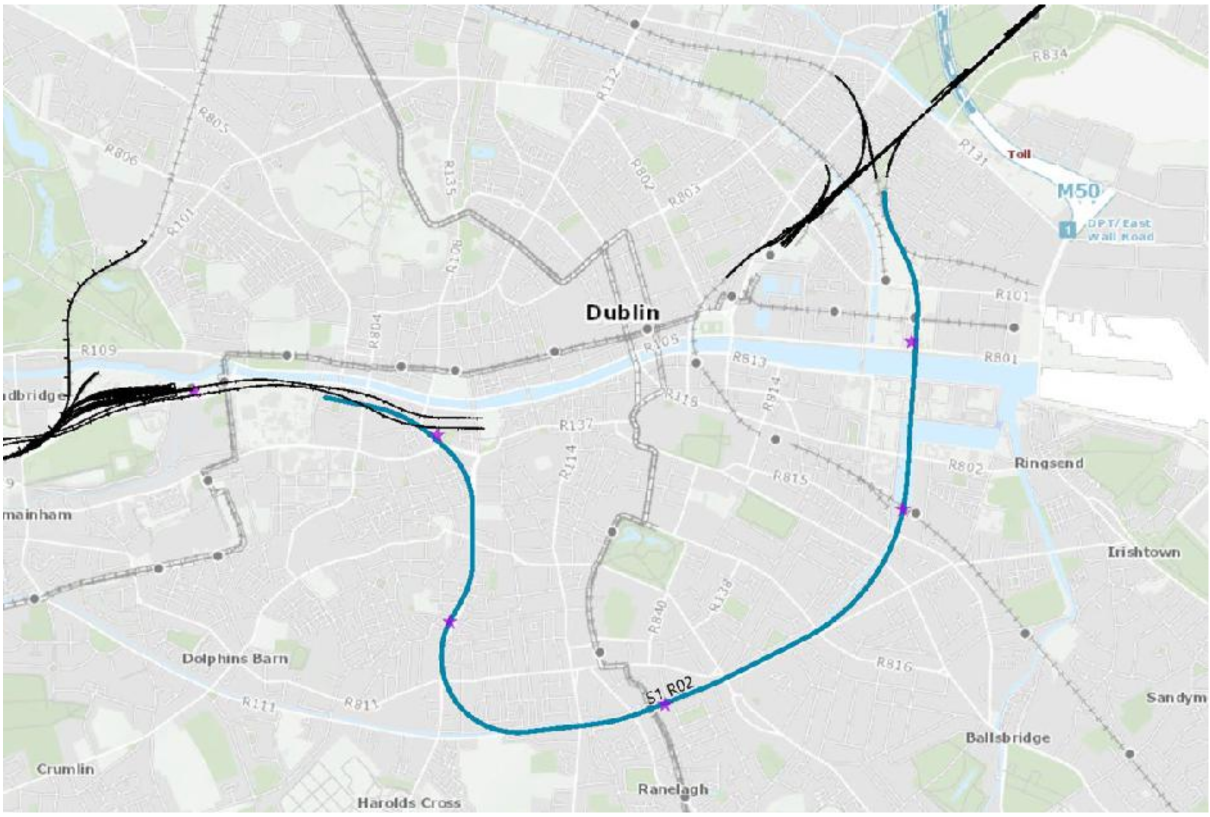


Figure 5-20: Short Listed Route Option – S1 R02

5.2.3.1 Track Alignment

The following key features have shaped the track alignment design for this route option:

- Where there is commonality between this route and the works undertaken as part of the previous 2014 Railway Order (RO) for the DART Underground, the alignment has been based on these prior works with refinement where appropriate
- The eastern and western tie-ins are proposed as previously outlined.
- The proposed station locations are as determined through the Stage 1 Preliminary Options Assessment.
- The vertical alignment takes cognisance of the rockhead levels
- The levels at Charlemont Station have been proposed taking into account the proposed MetroLink line.

The maximum / minimum values achieved by the track alignment design for this route option are shown in Table 5-7 for each of the station locations on this route and the alignment design complies with IÉ standards.

Table 5-7 S1 R02 Station Specific Track Alignment Values

S1 R02 Station Specific Track Alignment Values	
Heuston	
Track interval	39.112m
Horizontal alignment	Straight
Vertical alignment	0.2% grade
Christchurch	
Track interval	39.392m
Horizontal alignment	Straight
Vertical alignment	0.2% grade
St. Patrick's Cathedral	
Track interval	39.392m
Horizontal alignment	Straight
Vertical alignment	0.2% grade
Charlemont	
Track interval	39.392m
Horizontal alignment	Straight
Vertical alignment	0.2% grade
Grand Canal Dock	
Track interval	39.392m
Horizontal alignment	Straight
Vertical alignment	0.2% grade
Docklands	
Track interval	28.393m
Horizontal alignment	Down Main Underground: 10000m radius*
Vertical alignment	0.2% grade

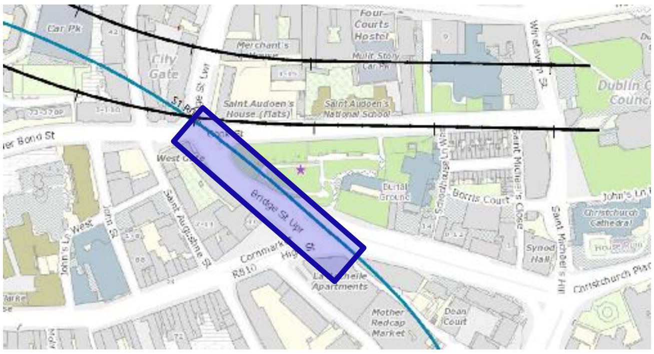
*it is recommended that these values are reviewed at a subsequent design stage to determine whether these stations can be provided on straight horizontal alignments. Refer to drawings DT1-JA-RTA-ROUT_XX-DR-Y-3001 to 3013 in Appendix B for further details.

5.2.3.2 Tunnelling and Geotechnical

5.2.3.2.1 Heuston Station – refer to S1 R01 description in 5.2.2.2.1

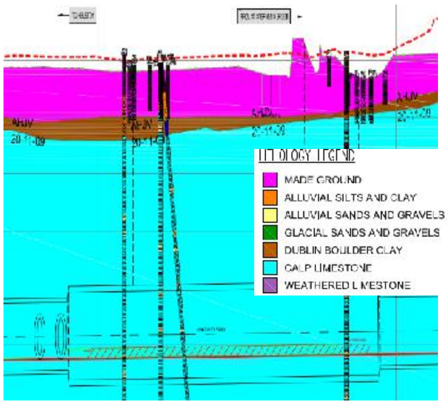
5.2.3.2.2 Christchurch Station

Location: Christchurch station is located on the south side of Bridge Street Upper, opposite St Audoen's Church, 200m south of the Liffey. This is different to the location for Route S1 R01, which was sited partially beneath the DCC offices and the Church of the Immaculate Conception, as outlined in section 5.2.2.2.2. The overburden ground conditions in the area of the proposed station are dominated by the historic development of Dublin city into the River Liffey channel and the recent alluvial deposits of the river itself. Existing ground levels range from circa +3.5mOD to +5mOD.

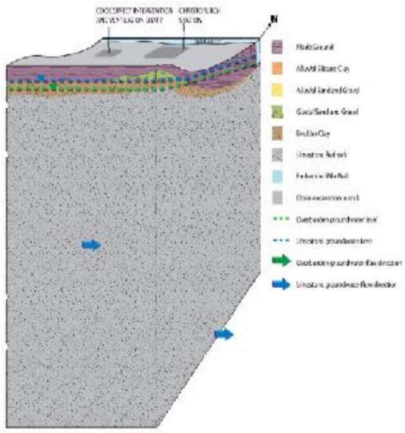


Geology: From published data, boreholes identified in this area show strata layers of:

- Made Ground: approx. 1.5m to 5m depth of sandy gravely clay with brick, concrete, shell, wood, and animal bones),
- Alluvial Silts/Clays (locally): 1m to 2m of organic clay with shells, pieces of wood and peat,
- Glacial Till (DBC): sandy gravely clay layer ranging from about +3mOD to -2mOD,
- Calp Limestone: bedrock from about +2mOD to -2mOD to depth.



Groundwater: From published data, recorded and monitored ground water levels indicate that:

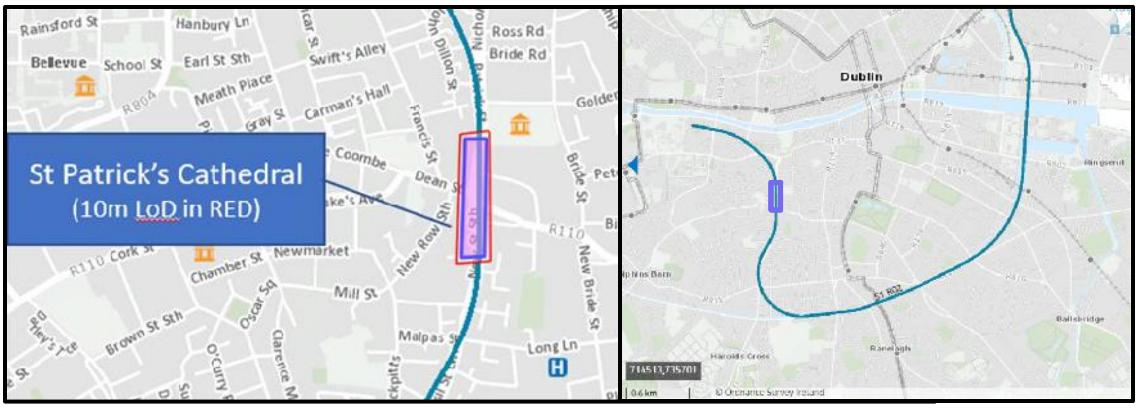


- the groundwater levels recorded in the overburden show the groundwater levels to be falling, while those recorded in the limestone are steady; this indicates that two different groundwater regimes are being monitored at this location,
- the limestone groundwater levels are generally consistent between rounds indicating that the level of groundwater in the overburden is being influenced by outside forces such as a leaking drain or surface water body,
- the River Liffey is likely to dominate the groundwater levels in the overburden at this location,

- it is likely that the River Liffey is in hydraulic continuity with the Made Ground deposits in places. The extent of this will depend on the variability of the Made Ground deposits and the competence of the quay walls,
- the Liffey may be hydraulically connected with the groundwater in the bedrock as the base of the Liffey lies in bedrock at this location. The extent of this connection will depend on the connectivity of the fractures and the siltation at the base of the river.

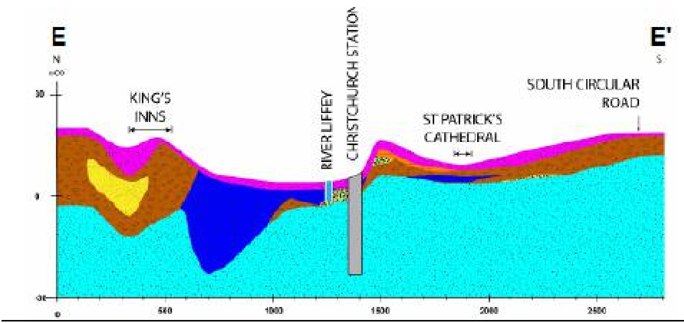
5.2.3.2.3 St. Patrick's Cathedral Station

Location: St. Patrick's Cathedral Station is located beneath New Street South opposite St. Patrick's Cathedral. A station serving this location is only on route alignment S1 R02. Existing ground levels within and immediately surrounding the footprint of the station are circa +10 to +15mOD.



Geology: From published data 21 no. historical exploratory holes have been identified within and immediately vicinity of the proposed footprint. Logs have been extracted from the relevant reports held on the GSI website and a review indicates the following stratigraphy:

- Made Ground: up to 3mbgl of variable composition including medium dense gravelly clays, cobbles, boulders, red brick, rubble,
- Glacial Silts/Clays (locally): brown sandy gravelly clay, with cobbles and boulders, may contain organic material,



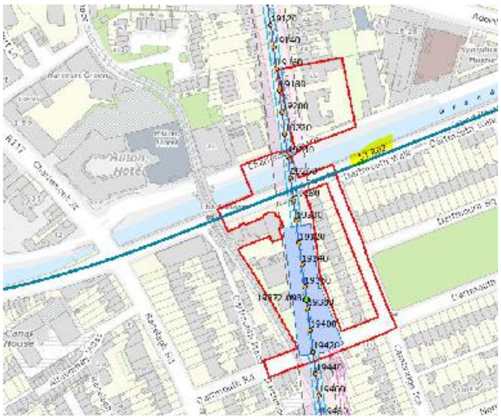
- Glacial Sands and Gravels: extremely dense fine to coarse sand and gravel, with cobbles and boulders,
- Glacial Till or Dublin Boulder Clay (DBC): v hard black silty sandy stony clay at circa 4 to 7mbgl, up to 2.5m thick,
- Calp Limestone: bedrock at circa 5 to 7mbgl.

Groundwater: Groundwater strikes were recorded in eight of the holes in the Glacial Sands and Gravels from 3-6.10mbgl rising to 2.00-3.70mbgl. One hole encountered groundwater at the base of the Made Ground perched above a layer of "organic remains" (0.55m thick). No groundwater was recorded in the Calp Limestone, possibly masked by drilling fluids.

The proposed station footprint is also in proximity to the River Poddle. The River Poddle flows northwards through Dublin and most of its course is diverted underground. This watercourse has been heavily modified through the city via channelisation and culverts, and the final stages of the river's flow were complex, with related waters separating and joining. The river is important owing to the channelisation and is classed as an audited geological heritage site.

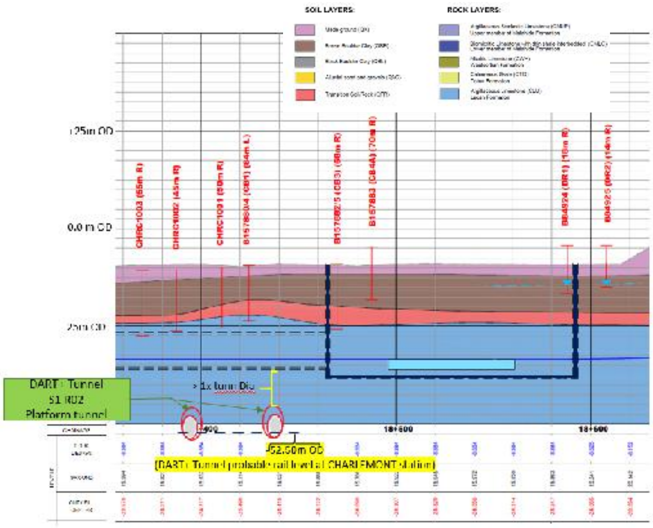
5.2.3.2.4 Charlemont Station

Location: An underground Charlemont station for heavy rail service will be immediately north of the existing MetroLink Charlemont station beneath the banks of the Grand Canal. A station serving this location is only found onto route alignment S1 R02. Existing ground levels in this area are circa -9m OD..



Geology: Ground conditions have been extracted from the MetroLink geological profile and indicate:

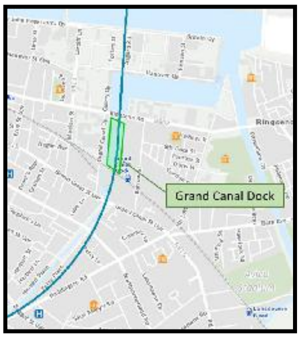
- Made Ground: approx. 1m to 2.5m depth,
- Brown Boulder Clay from -12.5mOD to – 17.5m OD (thickness varies),
- A circa 4m transition zone between the clays and the Limestone
- Calp Limestone: bedrock from about -22.5mOD to depth.



Groundwater: Groundwater strikes were recorded in two of the eight boreholes in the vicinity on the MetroLink profile and would appear to suggest groundwater within the Brown Boulder Clay approximately 6mbgl.

5.2.3.2.5 Grand Canal Dock Station

Location: Grand Canal Dock Station is located beneath the Grand Canal basin south of Ringsend Road on route alignment S1 R02. Existing ground levels within and immediately surrounding the footprint of the station are circa +6 to +12mOD. Water and bed level of the dock are unknown.



History: The Grand Canal is an important historic landscape feature and is part of the cultural heritage of Dublin. Canals are artificial channels where the water level is maintained at perched level. They are largely isolated from the natural hydrological environment. The Grand Canal enters the Liffey River at the locks at Grand Canal Dock at Ringsend on the south bank of the river. The locks are located directly adjacent to the confluence of the River Dodder with the River Liffey. The locks prevent tidal influence of Grand Canal Dock. The dock therefore remains as freshwater.

The Grand Canal Docks first opened in 1796. Subject to the normal industrial revolution contamination of black coal, along with chemical factories, tar pits, bottle factories and iron foundries, by the 1960s, the Grand Canal Docks were almost completely derelict. Regeneration began in 1998 of the former gasworks site located in the area between Sir John Rogerson's Quay and Hanover Quay. The process involved constructing an underground wall eight metres deep around the affected area, and the contaminated soil being dug out and removed.

Geology: From published data 17no. historical exploratory holes have been identified within the vicinity of the proposed Grand Canal Dock Station. Logs have been extracted from the relevant reports held on the GSI website and a review indicates the following stratigraphy:

- Made Ground: up to 4mbgl of variable composition including medium dense gravelly clays, cobbles, boulders, red brick, rubble.
- Possible Mage Ground or organic alluvium comprising 1.70m of “grey peaty Silt” encountered to the west of the dock
- Alluvium (Dock Silt) – soft grey/black organic silt with some fine sand up to 2.7m thick.
- Glacial Silts/Clays (locally): brown sandy gravelly clay, with cobbles and boulders, may contain organic material,
- Glacial Sands and Gravels: dense fine to coarse sand and gravel, with cobbles and boulders,
- Glacial Till or Dublin Boulder Clay (DBC): v hard black silty sandy stony clay from circa 6mbgl, up to 2m thick,
- Calp Limestone: bedrock at circa -0 to -7mOD
- Cavities were recorded on one of the exploratory hole logs .

Groundwater: Groundwater strikes were recorded in four of the holes immediately below the Made Ground at the top of the Glacial Sands and Gravels from 2.1-3.9mbgl rising to 2-3mbgl. No groundwater was recorded in the Calp Limestone, possibly masked by drilling fluids. The station footprint is also in proximity to a groundwater borehole well in Barrow Street.

5.2.3.2.6 Docklands Station

Refer to S1 R01 description in 5.2.2.2.4

5.2.3.3 Civils and Stations

In this option, 6 no. new stations are proposed along the route – starting from the west – at Heuston, Christchurch, St. Patrick's Cathedral, Charlemont, Grand Canal Dock and Docklands. Engineering details on each of the stations are noted below.

5.2.3.3.1 Heuston Station

Refer to S1 R01 description in 5.2.2.3.1

5.2.3.3.2 Christchurch Station

Due to the track alignment of this option the proposed station at Christchurch differs to that of route alignment options S1 R01 (and also S1 R03, S1 R09 and S4 R16) hence the underground station at Christchurch station is proposed to be constructed under Bridge Street Upper. Similar to Heuston the construction approach is developed from surface shafts but instead of three only two will be used. Due to space constraints, there is no available 'free' land to provide these shafts hence in order to construct this station this will require apartment blocks and houses to be acquired. The shafts will be designed to house passenger access and ventilation facilities for the completed station. From these shafts, mined construction would create the lower-level structures. Refer to Figure 5-21.

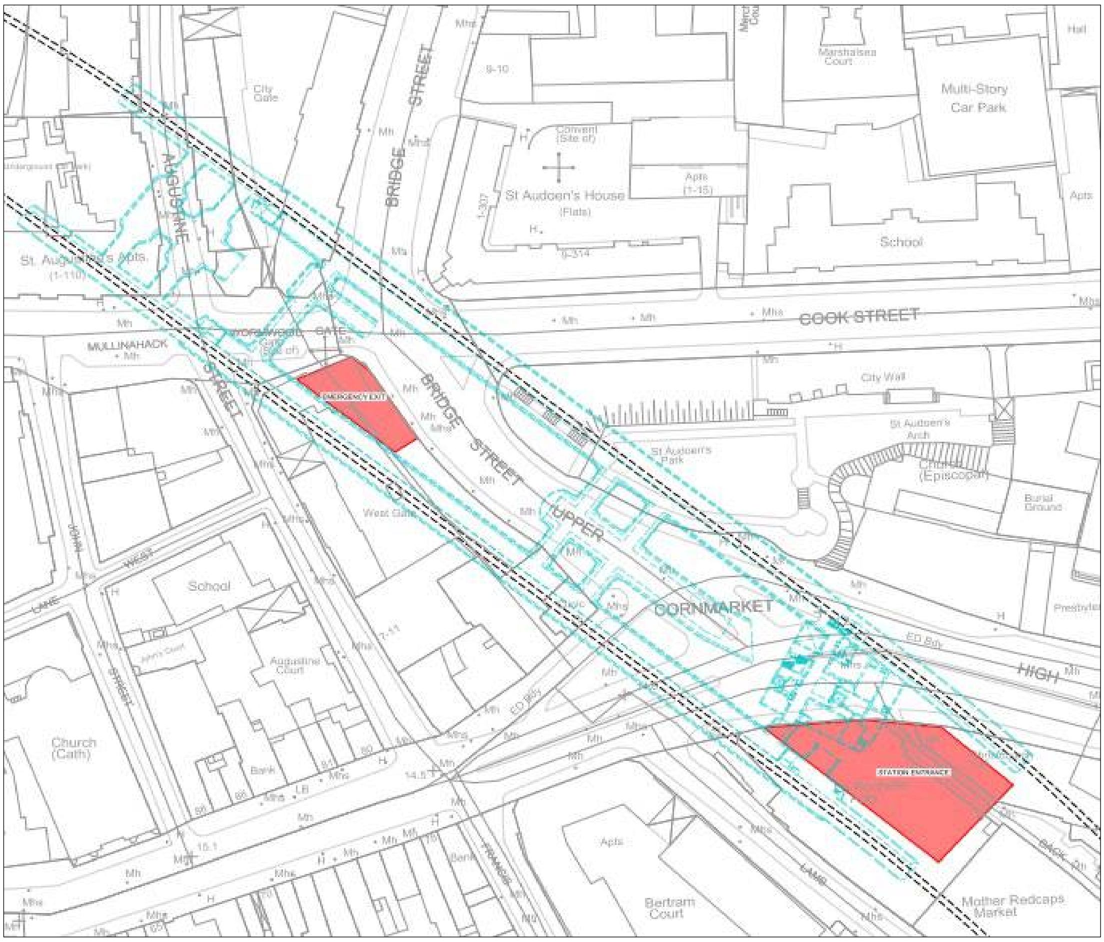


Figure 5-21 Christchurch Station Layout

The construction of the underground station platforms will be achieved by horizontal fronts of excavation from within the shafts using a mined rock excavation approach to meet the bored tunnels.

5.2.3.3.3 St. Patrick's Cathedral Station:

The underground station for St. Patrick's Cathedral is proposed to be constructed under Clanbrassil Street Upper. Similar to Heuston underground station the construction approach is developed from surface shafts but instead of three only two will be used. Due to space constraints, there is no available 'free' land to provide these shafts hence in order to install this underground station the demolition of apartment blocks and houses will be required.

Additionally, because the route alignment runs parallel and directly under Clanbrassil Street Upper the layout of the station shafts cannot follow that of Heuston underground station. The proposed solutions would be to rise vertically out of the central shaft to a level above the eastbound line, to cross over the westbound line to the proposed ground level shafts below the existing apartments and houses. Temporary closure of Clanbrassil Street Upper will be required in order to provide the horizontal boxes from the centre of the platforms to the ground level shafts. Refer to Figure 5-22 and Figure 5-23.

Figure 5-22 St Patrick's Cathedral Station Layout

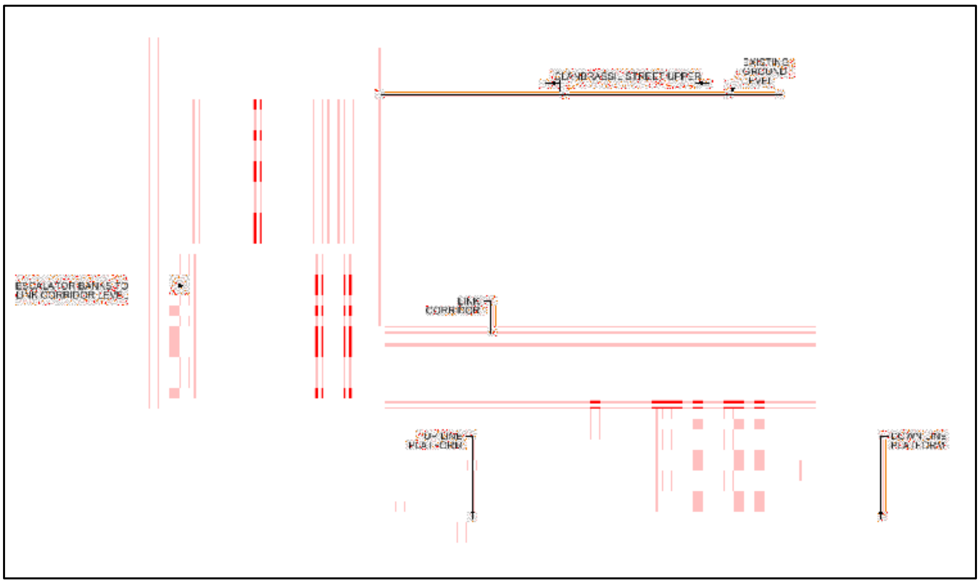


Figure 5-23 St Patrick's Cathedral Station Section

The construction of the underground station platforms will be achieved by horizontal fronts of excavation from within the shafts in Clanbrassil Street Upper using a mined rock excavation approach to meet the bored tunnels.

5.2.3.3.4 Charlemont Station:

The underground station at Charlemont is proposed to be constructed under parallel to Grand Parade, and roughly perpendicular the proposed MetroLink station.

Similar to Heuston underground station the construction approach is developed from surface shafts but instead of three only two will be used, and both will be constructed on Grand Parade. The shafts will be designed to house passenger access and ventilation facilities for the completed station. From these shafts, mined construction would create the lower-level structures. Refer to Figure 5-24.

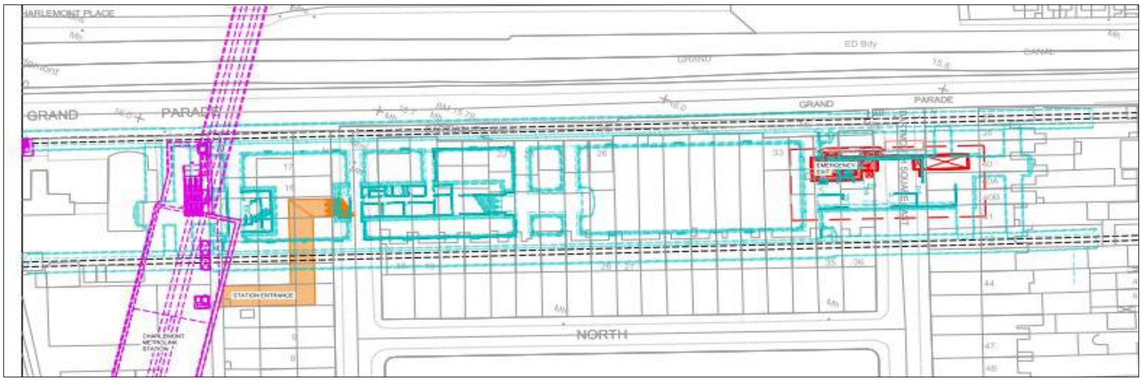


Figure 5-24 Charlemont Station Layout

The construction of the underground station platforms will be achieved by horizontal fronts of excavation from within the shafts using a mined rock excavation approach to meet the bored tunnels.

Charlemont will have the added complexity of being an interchange station with MetroLink. It is proposed to connect the heavy rail underground station with the MetroLink station at the concourse level to provide an effective interchange. This would be formed of a cut and cover link between the external diaphragm walls of the MetroLink station to the proposed heavy rail station.

5.2.3.3.5 Grand Canal Dock Station:

The proposed underground station at Grand Canal Dock would be constructed under the existing Grand Canal Dock Irish Rail station. Similar to Heuston underground station the construction approach is developed from surface shafts but instead of three only two will be used and both will be constructed within the canal basin with one located adjacent to the existing Grand Canal Dock Irish Rail station, while the other will connect to the footbridge behind Bolands Mill. We note that the new Bolands Mills development is intended to be high rise to 50m height. The shafts will be designed to house passenger access and ventilation facilities for the completed station. From these shafts, mined construction would create the lower-level structures. Refer to Figure 5-25.

Figure 5-25 Grand Canal Dock (GCD) Station Layout

To construct the shafts within the existing canal basin, cofferdams will be required down to platform level. Additionally, the diagram walls will need to project above ground level up to the existing Grand Canal Dock station level and the footbridge to the rear of Bolands Mill. A new plaza type arrangement would be formed to create an interchange between the existing ground level station and the proposed underground station.

The construction of the underground station platforms will be achieved by horizontal fronts of excavation from within the shafts using a mined rock excavation approach to meet the bored tunnels

5.2.3.3.6 Docklands Station

Refer to S1 R01 description in 5.2.2.3.4

5.2.3.4 Rail Operational Efficiency

Refer to S1 RO1 description in 5.2.2.4

5.2.3.5 Transport Planning

Trips by mode and mode share

The number of daily public transport trips undertaken in the R02 scenario and in the Do Minimum scenario in 2035 and 2050 is shown in Figure 5-26. The R02 route alignment option would increase the number of daily public transport trips by 11,760 (+1.13%) in 2035 and 14,250 (+1.16%) in 2050 as compared to the Do Minimum scenario.

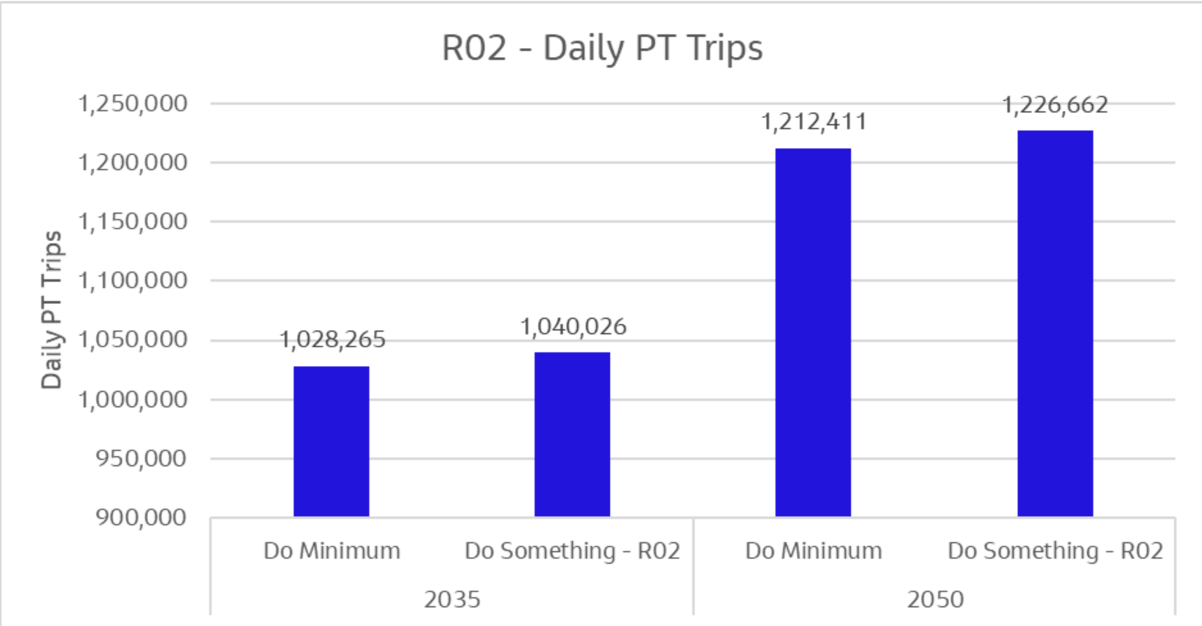


Figure 5-26: Daily Public Transport trips of R02 and Do Minimum in 2035 and 2050

In 2035 the R02 route alignment has a 0.15 percentage point increase in public transport mode share in comparison to the Do Minimum scenario, of this, 0.09 percentage points is from Cycle, 0.04 percentage points comes from Car and 0.02 percentage points from the Walk mode share. In 2050, the R02 route alignment has a 0.16 percentage point increase in public transport mode share in comparison to the Do Minimum scenario of this, 0.09 percentage points is from Cycle, 0.06 percentage points comes from Car and 0.02 percentage points from the Walk mode share. These mode share changes are presented in Figure 5-27.

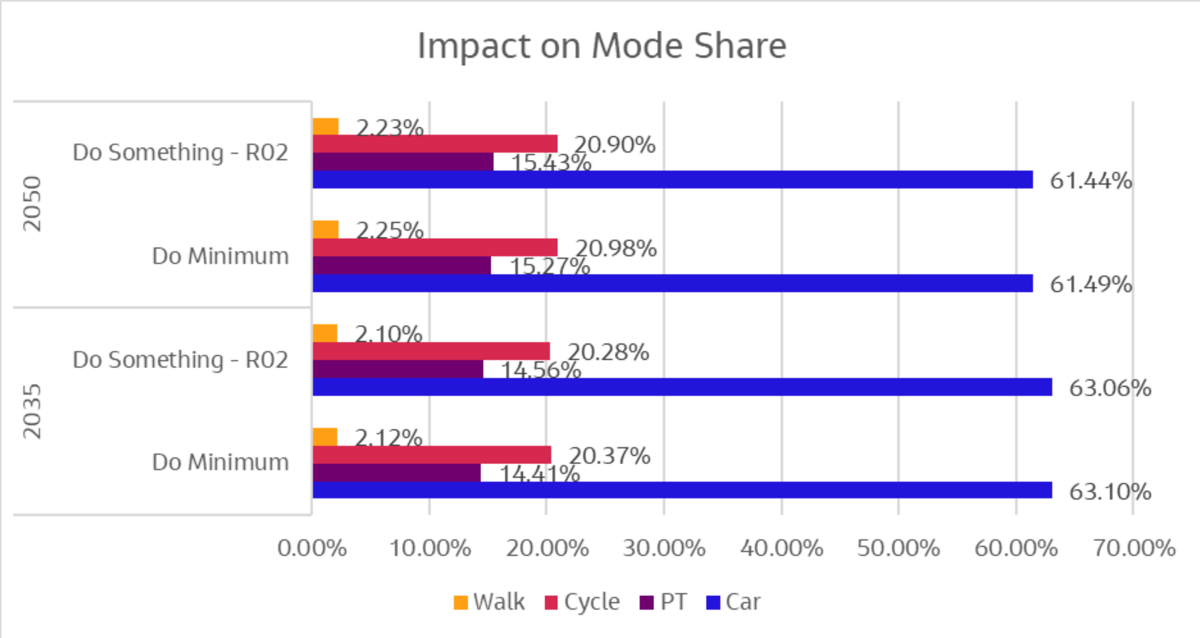


Figure 5-27: Mode Share of R02 and Do Minimum in 2035 and 2050

Rail passenger volumes

Figure 5-28 shows the percentage change in daily rail passenger volume when comparing route alignment R02 to the Do Minimum Scenario in 2035. As can be seen in the figure there is an estimated daily passenger volume flow of up to 58,000 in 2035 along this route alignment (both directions combined).

In the R02 scenario, the daily passenger volume along the Phoenix Park Tunnel and all Luas lines are much lower as compared to the Do Minimum. The number of passengers using the Phoenix Park Tunnel is estimated to decrease by as much as 95% in 2035. The Luas line experiences a reduction in passenger volume of up to 11% in 2035 as compared to the Do Minimum. On the Northern Line there is a 40% reduction in passenger volume in the city centre section of the line south of Clontarf Road station, but this is associated with services moving to the DART+ Tunnel. The actual impact on passenger volumes using the Northern Line is minor, with reductions in passenger volume of no more than 4%. There is a 20% increase in passenger volume on the Maynooth Line in the city centre.

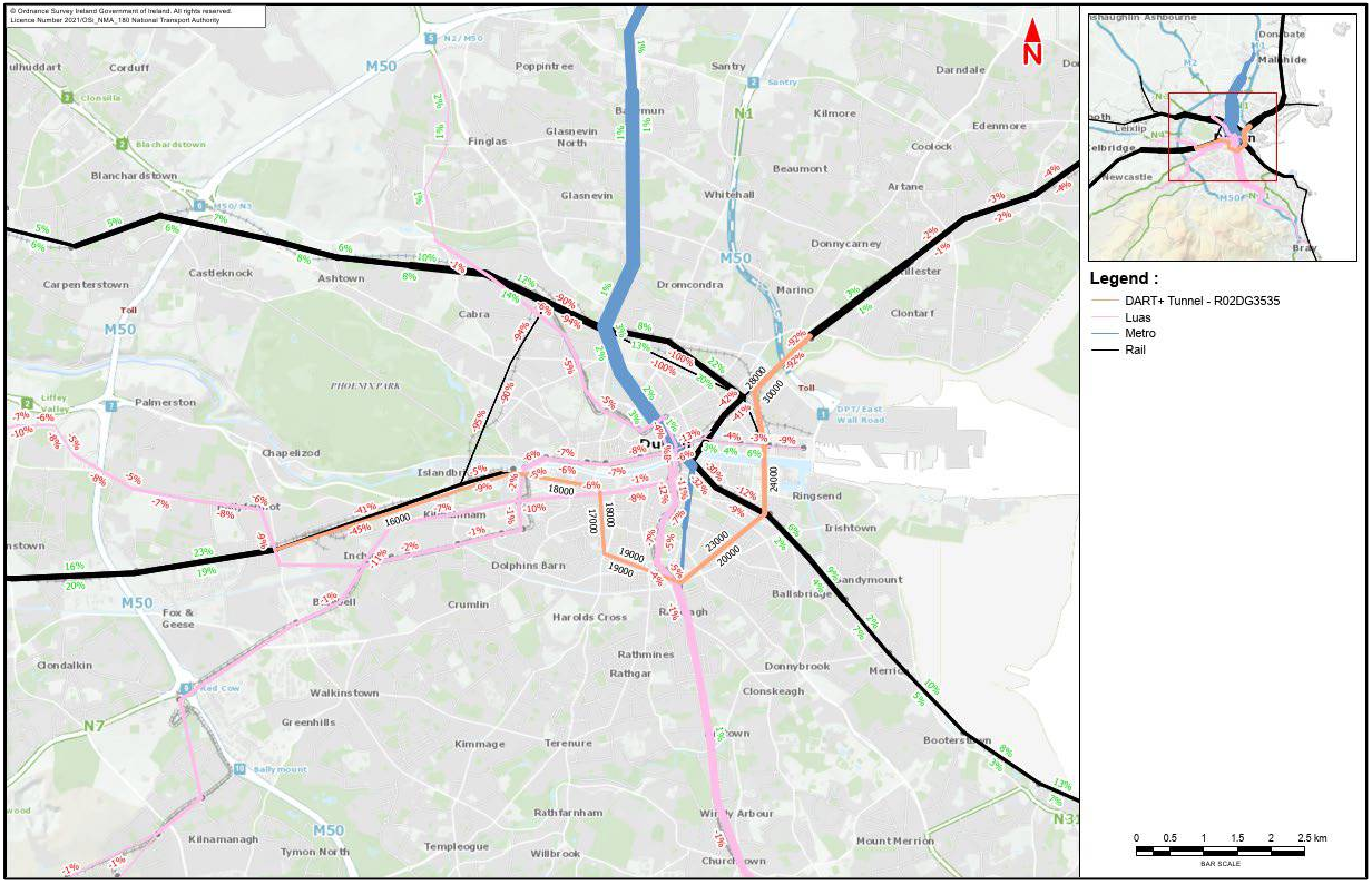


Figure 5-28: Difference in Daily Rail Passenger Volume between R02 and the Do Minimum in 2035

Boarding and Alighting

This section summarizes the AM peak boarding and alighting movements that arise from the catchment area of each station. Figure 5-29 shows the number of AM peak hour boarding and alighting movements by station for the R02 route alignment scenario. The station with the highest alighting movements is Grand Canal Dock underground station, with Charlemont underground station noted as being highly used due to the presence of Charlemont Luas stop and the Charlemont MetroLink stations..

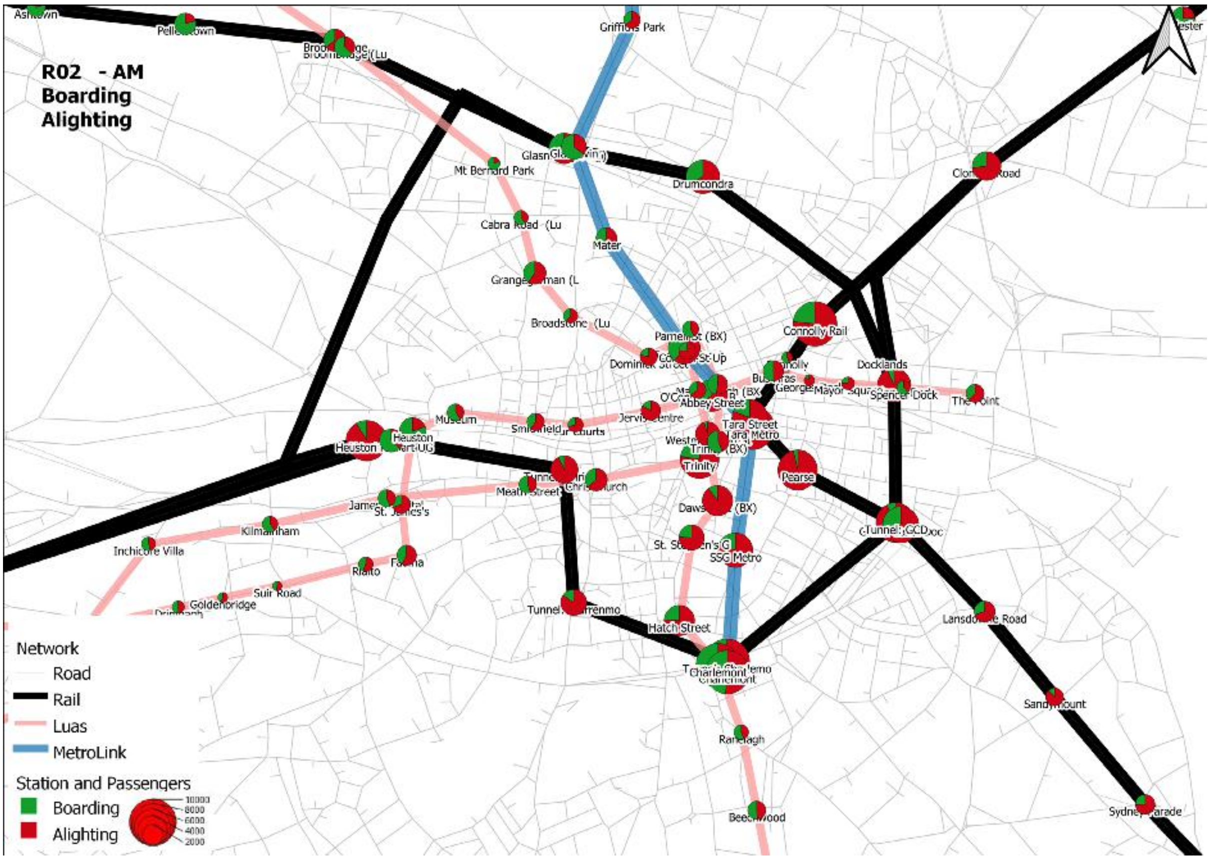


Figure 5-29: R02 AM Peak Boarding and Alighting movements by station the study area

Table 5-8 shows the comparison of AM peak hour boarding and alighting movements at key stations in 2035. The greatest difference in boarding movements during the AM peak period was at Heuston railway station with 64% fewer boarding movements. The greatest difference in alighting movements was at Tara Street railway station with 42% fewer alighting movements than in the Do Minimum. There are also significant reductions at Connolly, Pearse, and Grand Canal Dock railway stations along the coastal DART line as compared to the Do Minimum. In contrast, Hazelhatch railway station and the Connolly Luas stop have a notable increase in the number of boarding and alighting movements due to Hazelhatch railway station having a direct connection to the city centre. No significant impacts are seen in the number of boarding and alighting movements at the other Luas stops and MetroLink stations.

Table 5-8: Comparison of AM Peak boarding and alighting movements at key stations – R02 vs Do Minimum

Station Name	**Percent change in the number of Boarding and Alighting movements as compared to Do Minimum Scenario**	
	Boarding	**Alighting**
Hazelhatch	+40%	+9%
Connolly Luas	+9%	+10%
Tara Street MetroLink	+4%	+9%
Heuston Rail	-64%	-17%
Tara Street Rail	-24%	-42%
Grand Canal Dock	-24%	-38%
Connolly Rail	-14%	-35%
Pearse	-7%	-32%

Interchange movements

This section summarises the number of AM peak hour interchange movements (by boarding and alighting movements) by station that occur from or to other transport modes (i.e., Rail, Luas and MetroLink). Figure 5-30 presents the 2035 AM peak hour interchange movements in the Do Minimum and in the RO2 scenario.

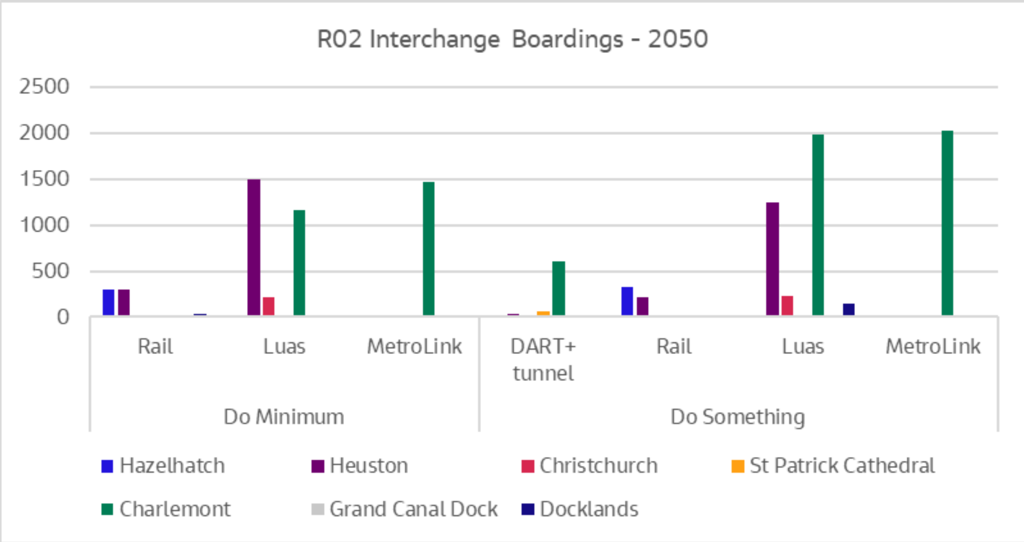
In the R02 scenario Charlemont underground station is the most used station for interchange. There is an increase in interchange boarding at the Charlemont MetroLink station and Luas stop of approximately 28% and 69%, with the Luas stop experiencing the highest increase. With a direct connection from the Kildare Line to the Northern Line, a significant portion of people is estimated to alight at the underground Charlemont heavy rail station and board onto the MetroLink and Luas at Charlemont for interchange.

A slight decrease in interchange boarding and alighting is observed at Heuston railway station. Heuston railway station experiences a 24% decline in interchange alighting. The Luas stop at Heuston station notes a decrease in interchange alighting by 19%. The decrease in alighting figures of Heuston railway station implies that a lot more people travelling on the Kildare Line now have a direct connection to the city centre as opposed to alighting at Heuston railway station or going through Phoenix Park Tunnel as in the Do Minimum scenario.

Due to a heavy rail station location at St. Patrick's Cathedral, usage of this station for boarding and alighting has been observed. Usage of Christchurch and Docklands underground stations for interchange has also been noted, as seen in Figure 5-15.

Figure 5-30: R02 AM Peak Hour Interchange Boarding and Alighting figures in 2035

Figure 5-39 shows the number of AM peak hour interchange boarding and alighting movements by station in 2050 for the Do Minimum and R02. A similar trend is apparent for the boarding and alighting figures in 2050, where interchange boarding at Charlemont MetroLink station is 38% greater than in the Do Minimum. At Heuston, there is less boarding and alighting for the railway station and the Luas stop.



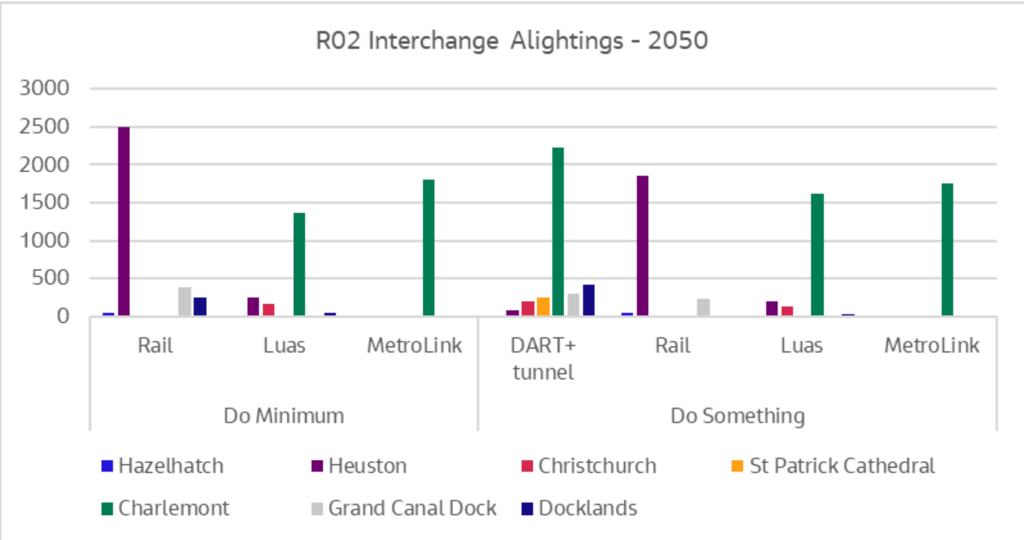


Figure 5-31: R02 AM Peak Hour Interchange Boarding and Alighting figure in 2050

Passenger loadings by line - Luas Services

Figure 5-32 presents the number of daily passengers travelling on each of the Luas lines (Red, Green, and Lucan) by stop (on departure from each respective stop) for the 2050 Do Minimum scenario and the 2050 R02 scenario. The stations are arranged from city limits stops to city centre stops from left to right.

As shown in the figure, R02 generally results in less patronage on each Luas line. On the Luas Red line R02 has approximately 2,500 less passengers (-6%) than the Do Minimum on the section of line from Heuston stop to Abbey Street stop. The Luas Lucan line has approximately 3,000 less passengers (-10%) in the R02 scenario as compared to the Do Minimum across the majority of stops in the Lucan Line. The Luas Green line, between Charlemont stop and Cabra Luas stop, has on average 3,000 less passengers (-5%) in the R02 scenario as compared to the Do Minimum. At the other stops on the Green Line there is typically less than 2% difference between the scenarios.

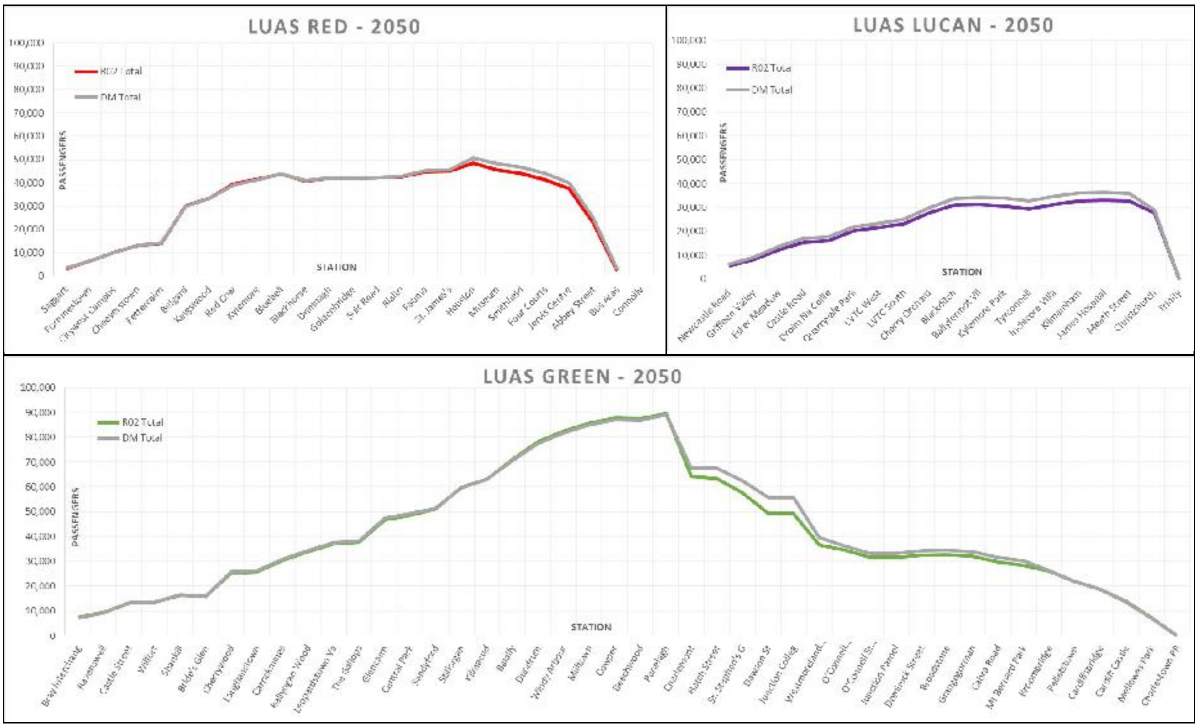


Figure 5-32: 2050 Luas Daily Passenger Flow R02 vs Do Minimum

Passenger loadings by line - MetroLink

Figure 5-33 presents the number of daily passengers travelling on the MetroLink by station (on departure from each respective station) for the 2050 Do Minimum scenario and the 2050 R02 scenario. The stations are arranged from city limits stations to city centre stations from left to right.

As shown in the figure, R02 results in approximately 4,000 additional passengers (+4%) than the Do Minimum on the section of line from Glasnevin Station to O'Connell Street stop, and an additional 1,700 passengers at other stations. This additional patronage in R02 is likely to be the result of the operation changes applied to the Northern Line in the R02 scenario while the Phoenix Park Tunnel services are significantly reduced which has discouraged people to transfer between MetroLink and DART at Glasnevin.

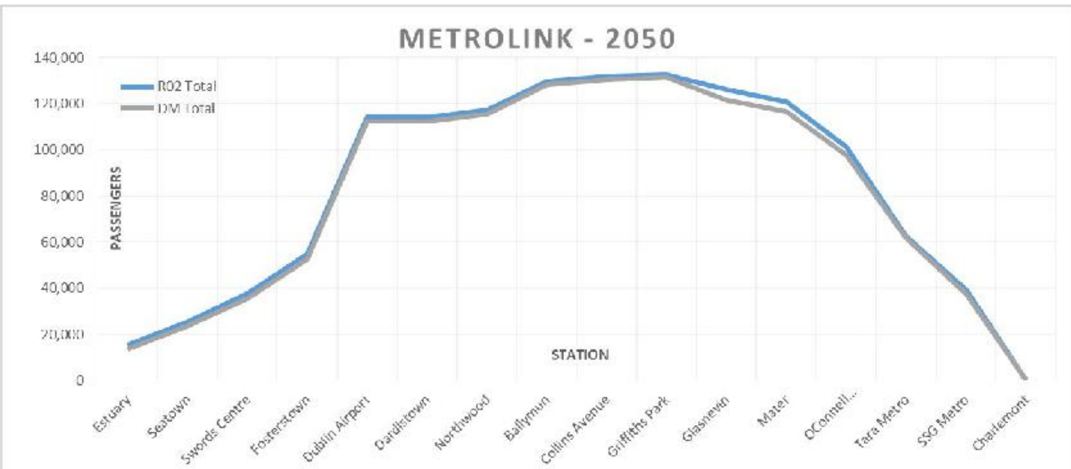


Figure 5-33: 2050 MetroLink Daily Passenger Flow R02 vs Do Minimum

Passenger loadings by line - Railway

Figure 5-34 presents the number of daily passengers travelling on the Railway lines; Maynooth Line, Northern Line, Kildare Line and South Eastern Line. The figures are presented by station (on departure from each respective station) for the 2050 Do Minimum scenario and the 2050 R02 scenario. The stations are arranged from city limits stations to city centre stations from left to right.

As shown in the figure, R02 generally results in more or slightly more patronage on the Maynooth Line, Kildare Line, and the South Eastern Line, but a slight reduction in patronage on the Northern Line.

The Maynooth Line attracts more passengers in the R02 scenario than in the Do Minimum scenario. The biggest difference is on the section between Broombridge Station and Glasnevin Station, where the difference in passenger volume is approximately 8,700. Glasnevin Station has 4% higher demand in the Do Minimum than in the R02 scenario as the Phoenix Park Tunnel services which run through this station are significantly reduced when the DART+ Tunnel scheme is in place.

Passenger volume on the Northern Line is less in R02 than in the Do Minimum except sections after Clontarf Road Station towards the city centre. The biggest difference along the line is at Howth Junction Station where R02 has 4,000 less passengers (-7%) as compared to the Do Minimum. The reduction after the Clontarf Road station would be the result of the reduction in services heading south of the Royal Canal in comparison to the Do Minimum.

The Kildare Line is the line that is most affected by the scheme. The demand along the Kildare Line is much greater in the R02 scenarios as compared to the Do Minimum. At the City Centre patronage is approximately 13,000 more passengers (+21%) in R02 than in the Do Minimum. Passengers using the Phoenix Park Tunnel in the Do Minimum are diverted to the DART+ Tunnel in R02 and only approximately 1,300 passengers remain on services through the Phoenix Park Tunnel.

The South Eastern Line attracts more passengers across the majority of stations in R02 compared to the Do Minimum. There are approximately 2,500 more passengers on the sections between Bray and Lansdowne Road station in R02 than in the Do Minimum. At Grand Canal Dock station and to the City Centre the South Eastern Line has approximately 6,700 less passengers (-12%) in the R02 scenario as compared to the Do Minimum.

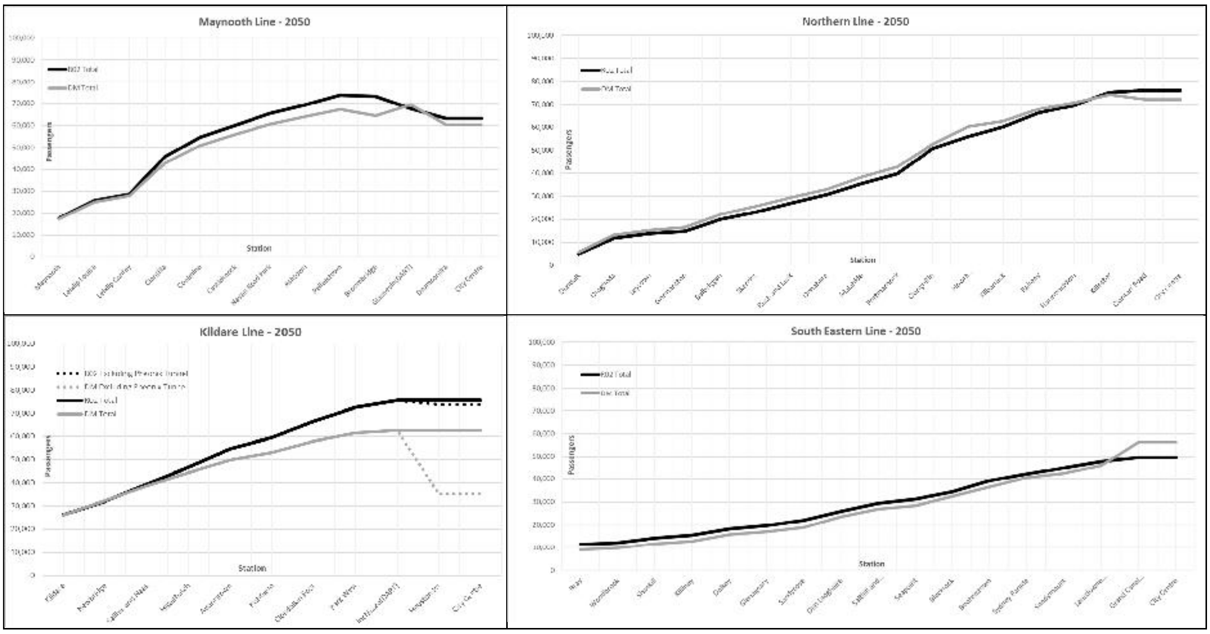


Figure 5-34: 2050 Rail Daily Passenger Flow R02 vs Do Minimum

5.2.3.6 Environment

Three proposed stations (Heuston, Christchurch, and St. Patrick's Cathedral) are located within the Historic Centre of Dublin City Designated Site however the third mentioned station location is immediately adjacent to an area known for containing historic street furniture (undesignated linear archaeological heritage site). No constraints are present at the other proposed station locations. Direct ecological constraints are identified with the station at Grand Canal Dock situated within the canal basin, which is also a designated pNHA. All proposed station locations are situated in built up areas of an urban landscape environment, however two of them are in the locality of the Grand Canal which will likely impact the visual amenity of the area significantly. All proposed station locations are situated close to high density residential and commercial properties, allowing for the potential of disruption to communities and businesses.

5.2.3.6.1 Heuston Station

Refer to S1 R01 description in 5.2.2.6.1

This station is in all five options – S1 R01, S1 R02, S1 R03, S1 R09 and S4 R16.

5.2.3.6.2 Christchurch Station

This location is in all five options – S1 R01, S1 R02, S1 R03, S1 R09 and S4 R16. However, the station design is different for S1 R02 – see Section 11.2.2.3.2 of this report for further details.

Population: Due to space constraints, there is no available 'free' land to provide these shafts, hence in order to construct this station apartment blocks and houses will have to be acquired as well as commercial businesses, which are local amenities for the area. St. Audoen's Park will be avoided however there will be impacts on the visual amenity of the area during construction.

Archaeology, Architectural and Cultural Heritage: The area of the proposed station is within Dublin City Zone of Archaeology Potential and there are a large number of RMP/SMR sites in the immediate vicinity. The area affected is designated as an area containing historic street furniture and an area of Archaeological Potential (Hiberno-Norse, Medieval and Post-medieval Activity). There will be high potential for undiscovered archaeology. The station will have surface interactions that will need residential and commercial buildings (not protected structures) to be acquired. Part of Old Dublin City Wall (DU018-020001) is directly adjacent to the La Rochelle Apartment which will be removed as part of the works.

Landscape and Visual: The 'townscape' of this area will significantly change with the removal of buildings, but the area and the buildings do not have designations.

Biodiversity: There are no ecological designated sites in the vicinity of the station location, however it is approximately 150m south of the River Liffey which feeds into multiple ecological designations downstream of it, namely: South Dublin Bay and River Tolka Estuary SPA; South Dublin Bay SAC; North Bull Island SPA; North Dublin Bay SAC; North Dublin Bay pNHA; and South Dublin Bay pNHA.

5.2.3.6.3 St Patrick's Cathedral

This station is in one of the options –S1 R02.

Population: The station location is situated on the fringes of the city centre in an area of high residential properties. A number of bus routes also use Clanbrassil Street Lower as a means for direct connection to the city centre. A considerable number of residential properties (> 20 no.in total) are likely to be acquired to facilitate the station in this location. Significant disruption is likely.

Archaeology, Architectural and Cultural Heritage: The station location is situated within the Dublin City Zone of Archaeological Potential. It does not directly impact any RMP / SMR Sites however it is located within the Zone of Archaeological Potential for one RMP Site, namely: Historic 18th / 19th Century Dwelling (DU018-020360-). This site is also registered with the National Monument Service. St Kevin's Hall Weaving Mill (a site of Archaeological significance) is situated in the centre of the

Station location along Clanbrassil Street Lower, however there are no visible remains of this feature. There are also two sites of Cultural Heritage significance within the extents of the Station Location, namely: Post Box at the junction of Clanbrassil Street Lower and Daniel Street and a Sculpture at the bus stop following the junction of Clanbrassil Street Lower and Malpas Street. Clanbrassil Street Lower is also considered an area of undesignated archaeological potential. There are no Architectural Conservation Areas (ACAs) or NIAH designated buildings in the vicinity of the Station location, however there are a number of Protected Structures just north of the Station location along Fumbally Lane and New Street South. Considerable disruption to the archaeological features in this area is expected.

Landscape and Visual: The station location is situated on the fringes of the city centre, within a high-density urban environment comprising predominantly of residential properties. There is little to no green spaces within the vicinity of the Station Location.

Biodiversity: There are no ecological designated sites in the vicinity of the Station Location.

5.2.3.6.4 Charlemont Station

This station is in one of the options – S1 R02.

Population: Access to the station at this location will be through the proposed MetroLink station. This will limit the surface effects that will have the more significant effects on population. It is assumed that there will be no significant construction effects (noise, vibration, dust, etc) due to the mined nature of the proposed station. The local area has many amenities with the presence of the canal and walkways, cycle tracks along Grand Parade Road, and the Charlemont Luas stop and track. The area is largely residential.

Archaeology, Architectural and Cultural Heritage: The station at this location will be mined and above ground impacts will be limited. However, there will be surface interactions such as ventilation and fire lifts. These should be located to avoid impacts as far as possible. The works are outside of the Dartmouth Square Architectural Conservation Area (ACA) and while none of the adjacent properties are protected structures (RPS/NIAH), impacts on the setting of the area are anticipated. Charlemont is outside of the Dublin City Zone of Archaeological Potential; however, there will be potential for discoveries during surface works.

Landscape and Visual: There will be surface interactions such as ventilation and fire lifts. These elements will have effects on this largely residential area adjacent to the canal.

Biodiversity: The Grand Canal is designated as a pNHA at the proposed station. It is assumed there will be no impacts to the canal and its bankside vegetation (e.g., mature trees) at this location due to the nature of construction

5.2.3.6.5 Grand Canal Dock Station

This station is in two of the options – S1 R02 and S1 R03.

Population: Grand Canal Dock has many functions, from being the location of the Waterways Ireland Visitor Centre, as a marina for small ships but also as a place of residence for those who reside in houseboats. It is noted that the MacMahon Bridge prevents access for tall ships to the marina adjacent the proposed station. Public access to the area outlined for the station location is limited as there are buildings and road immediately adjacent to it. Part of the western quay side is a designated public area. The top-down construction method for part of the station would affect the use of the marina and disrupt the setting overall. Grand Canal Dock is the terminus of the Grand Canal which is a navigable channel from the Liffey to the Shannon thereby impacting the navigability of the canal. There are likely to be significant impacts on residential, commercial and community receptors in this area.

Archaeology, Architectural and Cultural Heritage: The Grand Canal Dock itself is an important industrial heritage feature but it is not designated as a cultural heritage feature, nor are there any other features of archaeological or cultural heritage significance in its vicinity.

Landscape and Visual: The area is a mix of industrial heritage and modern development. The Grand Canal Dock offers scenic views in a densely urban area.

Biodiversity: The dock is part of the Grand Canal pNHA. The Canal is connected to the River Liffey and onwards to Dublin Bay (and associated designated sites - South Dublin Bay and River Tolka Estuary SPA; South Dublin Bay SAC; North Bull Island SPA; North Dublin Bay SAC; North Dublin Bay pNHA; and South Dublin Bay pNHA).

5.2.3.6.6 Docklands Station

Refer to S1 R01 description in 5.2.2.6.4

This station is in four of the options – S1 R01, S1 R02, S1 R03 and S1 R09.

5.2.4 Route S1 R03

This route alignment of 8.55 km between tie-in points begins at the western tie-in and runs in a south-eastern direction towards the northern side of St. Stephen's Green, after which the route goes to Grand Canal Dock before crossing the River Liffey prior to connecting to the Northern Line in the Docklands.

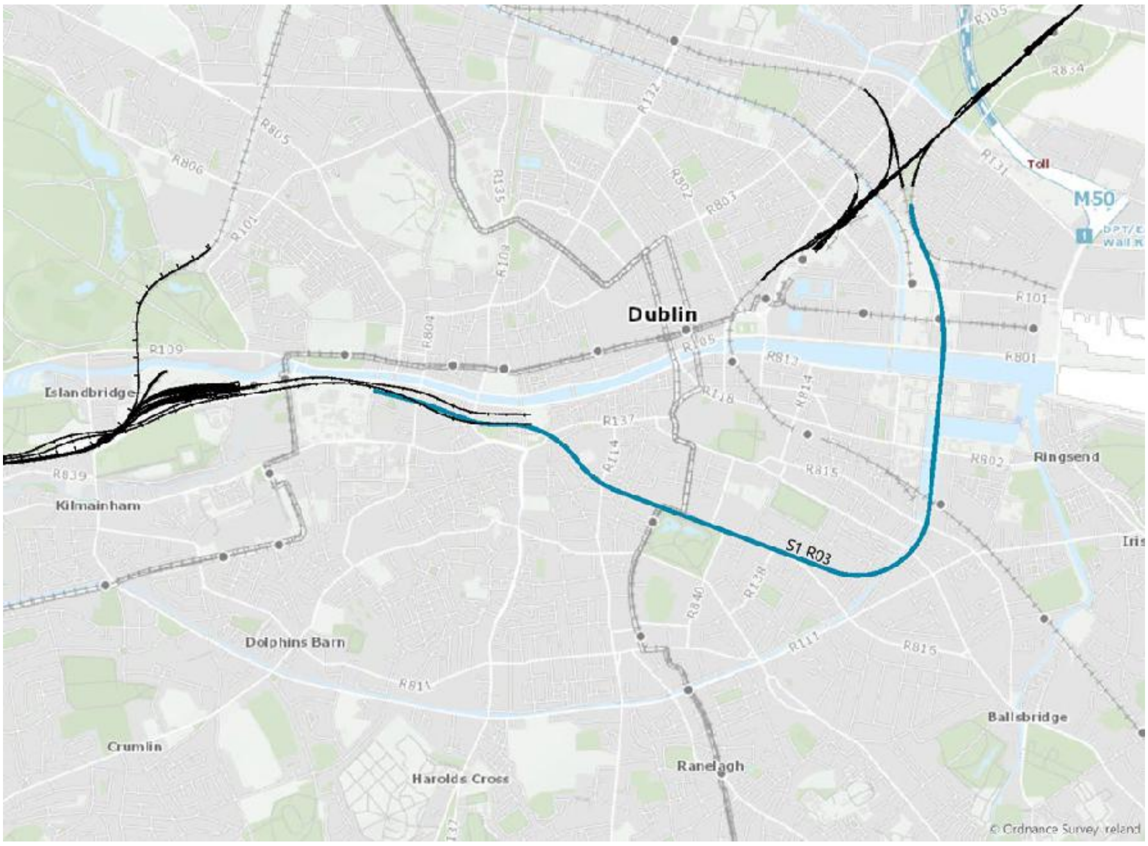


Figure 5-35 Alignment for S1 R03

5.2.4.1 Track Alignment

The maximum / minimum values design values for track alignment design for this route option are shown in Table 5-9 and reference can be made to the drawings DT1-JA-RTA-ROUT_XX-DR-Y-4001 to 4011 in Appendix B for further details.

The track design complies with IÉ standards, based on 2014 RO for DART Underground with refinement where applicable

Table 5-9 S1 R03 Station Specific Track Alignment Values

S1 R03 Station Specific Track Alignment Values	
Heuston	
Track interval	39.112m
Horizontal alignment	Straight
Vertical alignment	0.2% grade
Christchurch	
Track interval	51.646m
Horizontal alignment	Straight

S1 R03 Station Specific Track Alignment Values	
Vertical alignment	0.2% grade
St. Stephen's Green	
Track interval	Start: 63.446m
Horizontal alignment	Straight
Vertical alignment	0.2% grade
Docklands	
Track interval	28.393m
Horizontal alignment	Down Main Underground: 10000m radius*
Vertical alignment	0.2% grade

*it is recommended that these values are reviewed at a subsequent design stage to determine whether these stations can be provided on straight horizontal alignments.

5.2.4.2 Tunnelling and Geotechnical Situation

5.2.4.2.1 Heuston Station

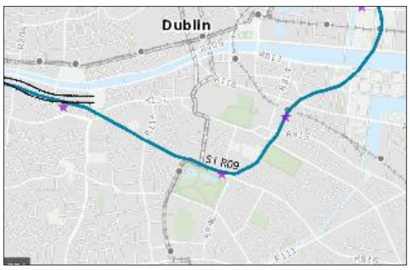
Refer to S1 R01 description in 5.2.2.2.1

5.2.4.2.2 Christchurch Station

Refer to S1 R01 description in 5.2.2.2.2

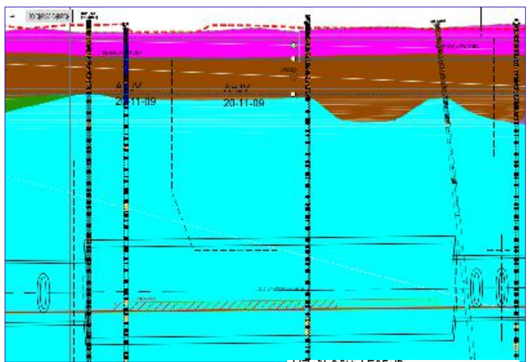
5.2.4.2.3 St Stephen's Green Station

Location: The underground station at St Stephen's Green is located beneath the north side of the historic St. Stephen's Green park. It is proposed for route alignment S1 R03, S1 R09 and S4 R16. Existing ground levels in this area are circa +11mOD.



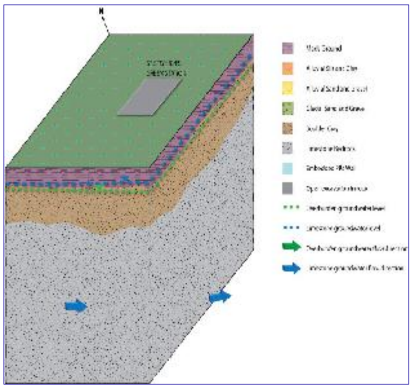
Geology: From published data boreholes identified in the area of the proposed underground heavy rail station at St. Stephen's Green show strata layers of:

- Made Ground: up to approx. 3m depth of gravely clay with pieces of brick and cinders,
- Glacial Till (DBC): sandy gravely clay from about +8mOD to +1mOD,
- Calp Limestone: bedrock from about +5mOD to +1mOD to depth.



Groundwater: From published data, recorded and monitored ground water levels

- groundwater levels are relatively steady, with the piezometric head lying within the boulder clay deposits,
- groundwater levels recorded in other local boreholes show a wider range of groundwater levels (varying by up to 2.6m) and the piezometric head lies within the Boulder Clay when the groundwater levels are at their highest and within the limestone when they are at their lowest,
- the low permeability nature of the Boulder Clay indicates that the groundwater within the bedrock will be confined by the overburden,



- perched water tables may be present in the Boulder Clay and Made Ground.

5.2.4.2.4 Grand Canal Dock Station

Refer to S1 R02 description in 5.2.3.2.5

5.2.4.2.5 Docklands Station

Refer to S1 R01 description in 5.2.2.2.4

5.2.4.3 Civil Engineering for Stations

In this option, 5 no. new stations are proposed along the route – starting from the west and travelling east – and include Heuston, Christchurch, St. Stephen's Green, Grand Canal Dock and Docklands. Engineering details on each of the stations are noted below.

5.2.4.3.1 Heuston Station

Refer to S1 R01 description in 5.2.2.3.1

5.2.4.3.2 Christchurch Station

Refer to S1 R01 description in 5.2.2.3.2

5.2.4.3.3 St Stephens Green Station:

The underground heavy rail station at St. Stephen's Green is proposed parallel to the road along the northern perimeter of the park and roughly perpendicular to the proposed MetroLink station, which is located on the east side of the park.

The St. Stephen's Green option is on the same alignment as the previously successful 2014 Railway Order (RO) for the DART Underground that was obtained by IÉ. For the purposes of this exercise the layout of the station remains as the RO design, but it will be mirrored so that the main entrance is located next to the proposed MetroLink station inconsideration of future interchange movements.

Similar to Heuston underground station the construction approach is developed from surface shafts and these will be constructed in and under the road to the north of St. Stephen's Green and also under part of St Stephens Green park. With reference to Figure 5-36 the shafts will be designed to house passenger access and ventilation facilities for the completed station. Mined construction would create the lower-level structures from the shafts

Figure 5-36 St. Stephen's Green Station Layout

St. Stephen's Green station will have the added complexity of being an interchange station with the MetroLink station. It is proposed to connect the underground heavy rail station to the MetroLink box at the concourse level to provide a connection/interchange. This would likely be formed of a cut and cover link between the external diaphragm walls of the MetroLink station to the proposed heavy rail station.

5.2.4.3.4 Grand Canal Dock Station

Refer to S1 R02 description in 5.2.3.3.5

5.2.4.3.5 Docklands Station

Refer to S1 R01 description in 5.2.2.3.4

5.2.4.4 Rail Operational Efficiency

Refer to S1 R01 description in 5.2.2.4

5.2.4.5 Transport Planning

Trips by mode and mode share

The number of daily public transport trips undertaken in the R03 scenario and in the Do Minimum scenario in 2035 and 2050 is shown in Figure 5-37. The R03 route alignment option would increase the number of daily public transport trips by 11,325 (+1.09%) in 2035 and 13,439 (+1.10%) in 2050 as compared to the Do Minimum.

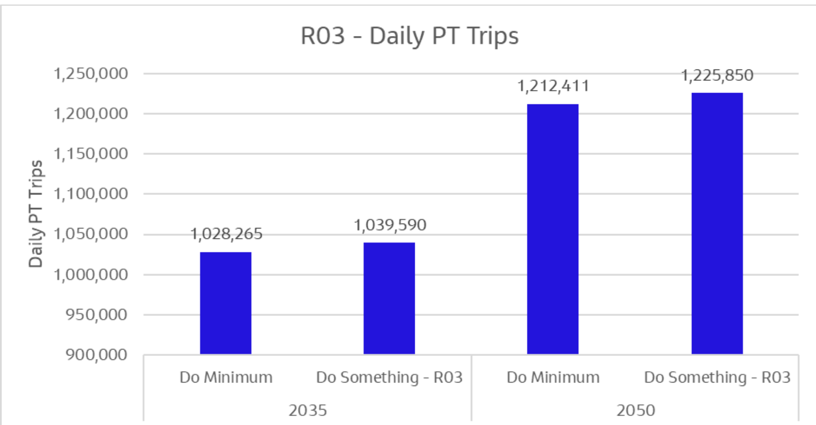


Figure 5-37: Daily Public Transport trips of R03 and Do Minimum in 2035 and 2050

In 2035 the R03 route alignment has a 0.14 percentage point increase in public transport mode share in comparison to the Do Minimum scenario. Of this, a 0.08 percentage point is from Cycle, a 0.04

percentage point comes from Car, and a 0.02 percentage point is from the Walk mode share. In 2050, the R03 route alignment has a 0.15 percentage point increase in public transport mode share in comparison to the Do Minimum scenario. Of this, a 0.09 percentage point is from Cycle, a 0.04 percentage point comes from Car, and a 0.02 percentage point is from the Walk mode share. These mode share changes are presented in Figure 5-38.

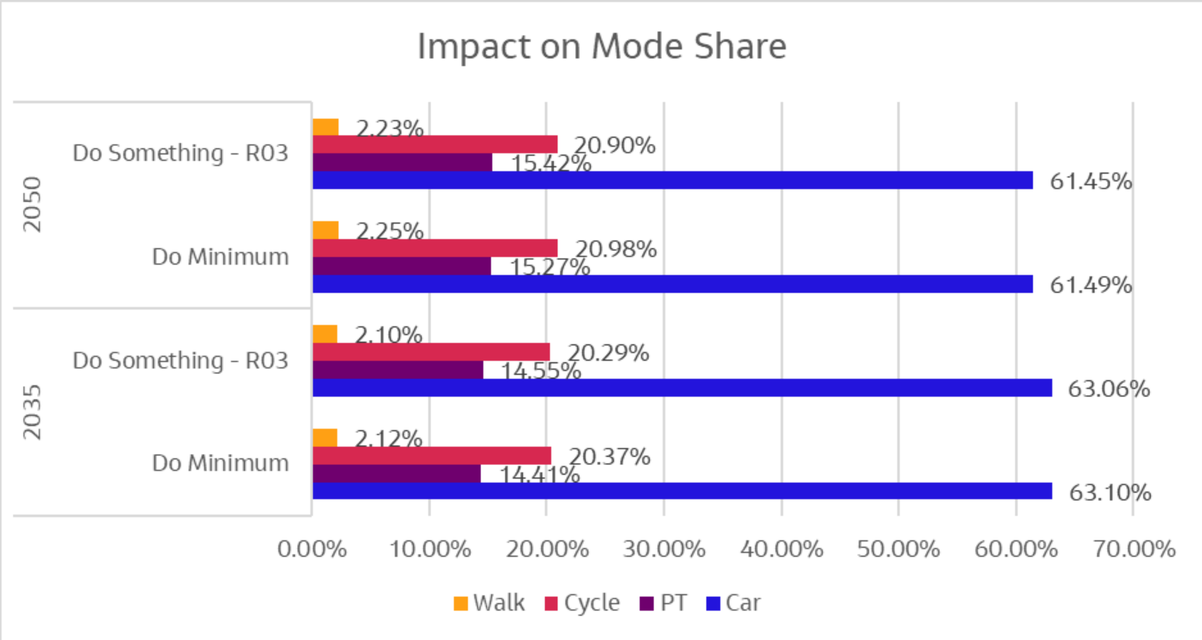


Figure 5-38: Mode Share of R03 and Do Minimum in 2035 and 2050

Rail passenger volumes

Figure 5-39 shows the percentage change in daily rail passenger volume when comparing route alignment R03 to the Do Minimum Scenario in 2035. As can be seen in the figure there is an estimated daily passenger volume flow of up to 56,000 in 2035 along this route alignment (both directions combined).

In the R03 scenario, the daily passenger volume along the Phoenix Park Tunnel and all Luas lines are much lower as compared to the Do Minimum. The number of daily passengers using the Phoenix Park Tunnel is estimated to decrease by as much as 95% in 2035. The Luas line experiences a reduction in passenger volume of up to 14% in 2035 as compared to the Do Minimum. On the Northern Line there is a 40% reduction in passenger volume in the city centre section of line south of Clontarf Road, but this is associated with services moving to the DART+ Tunnel.

The actual impact on passenger volumes using the Northern Line is minor, with reductions in passenger volume of no more than 4%. There is a 20% increase in passenger volume on the Maynooth Line in the city centre.

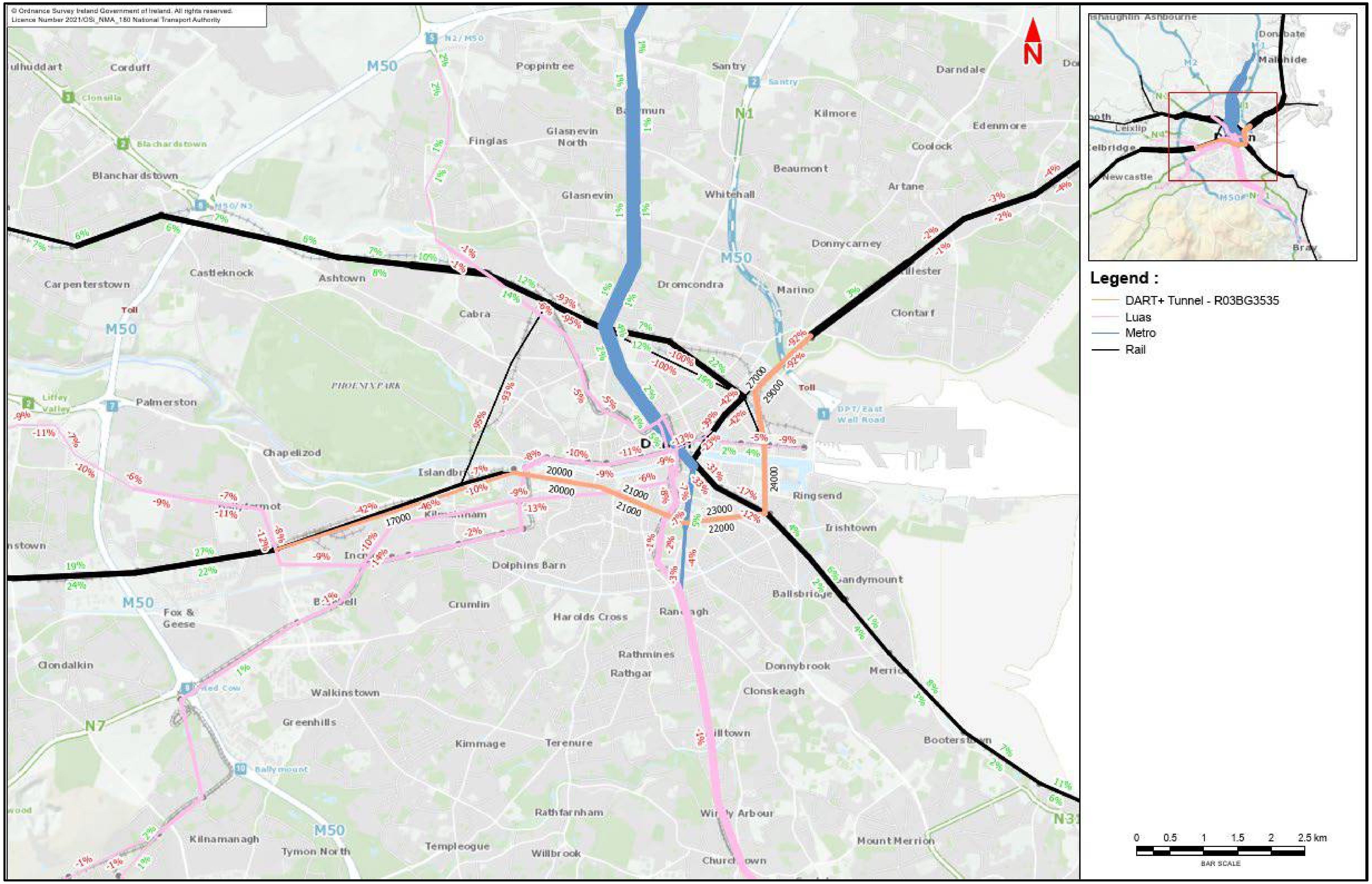


Figure 5-39: Difference in Daily Rail Passenger Volume between R03 and the Do Minimum in 2035

Boarding and Alighting

This section summarizes the AM peak boarding and alighting movements that arise from the catchment area of each station. Figure 5-40 shows the number of AM peak hour boarding and alighting movements by station for the R03 route alignment scenario. The station with the highest number of alighting movements is St. Stephen's Green underground station, noted to be a highly used station due to the presence of both the Luas stop and MetroLink station at the same location for interchange.

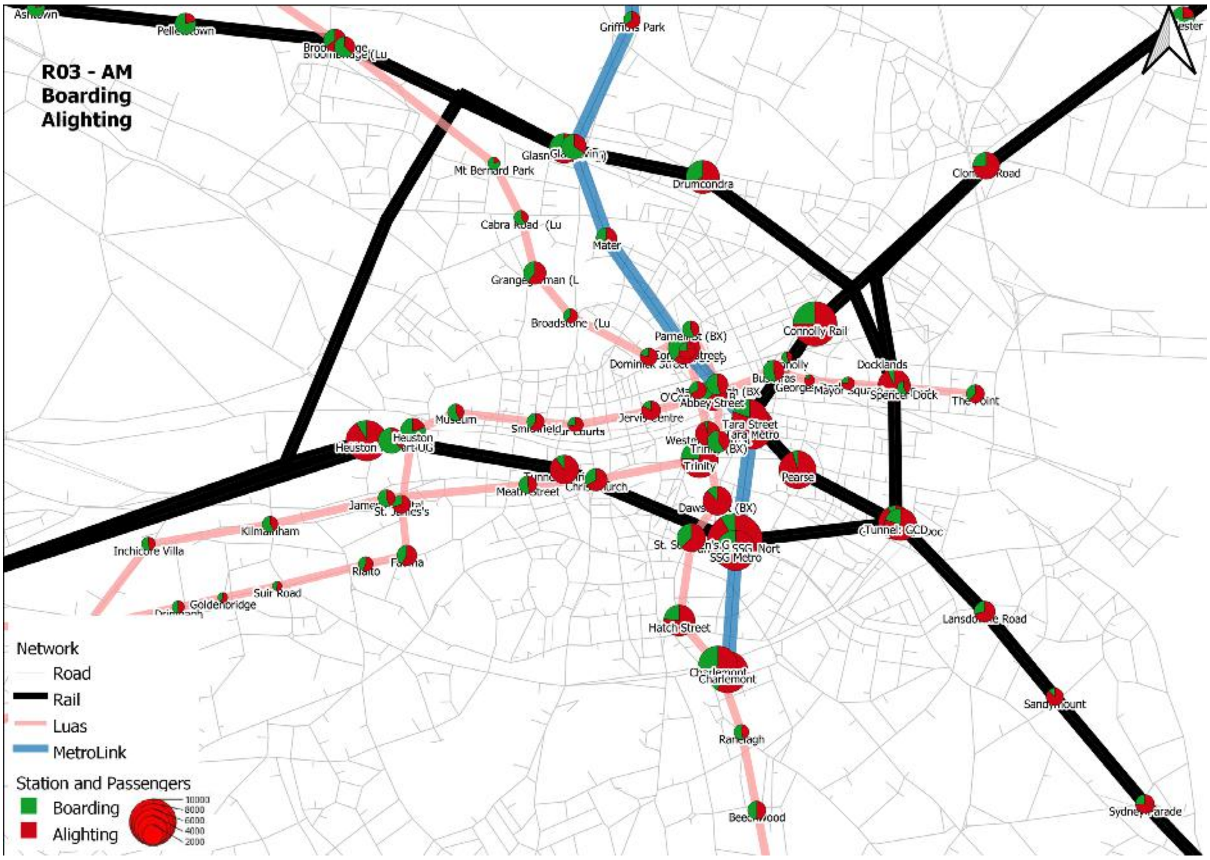


Figure 5-40: R03 AM Peak Boarding and Alighting movements by station in the study area

Table 5-10 shows the comparison of boarding and alighting movements in the AM peak hour at key stations in 2035. The greatest change in boarding movements is at Heuston railway station where there is 61% less movements, and the greatest change in alighting movements is at Tara Street Railway station where there is 44% less than in the Do Minimum. There are also reductions at Connolly, Pearse, and Grand Canal Dock stations along the coastal DART line as compared to the Do Minimum.

In contrast, Hazelhatch railway station and the Luas Stop at Heuston have a notable increase in the number of boarding and alighting movements due to them having a direct connection to the city centre. No significant impacts are seen in the number of boarding and alighting movements at the other Luas stops and MetroLink stations.

Table 5-10: Comparison of AM Peak boarding and alighting movements at key stations - R03 vs Do Minimum

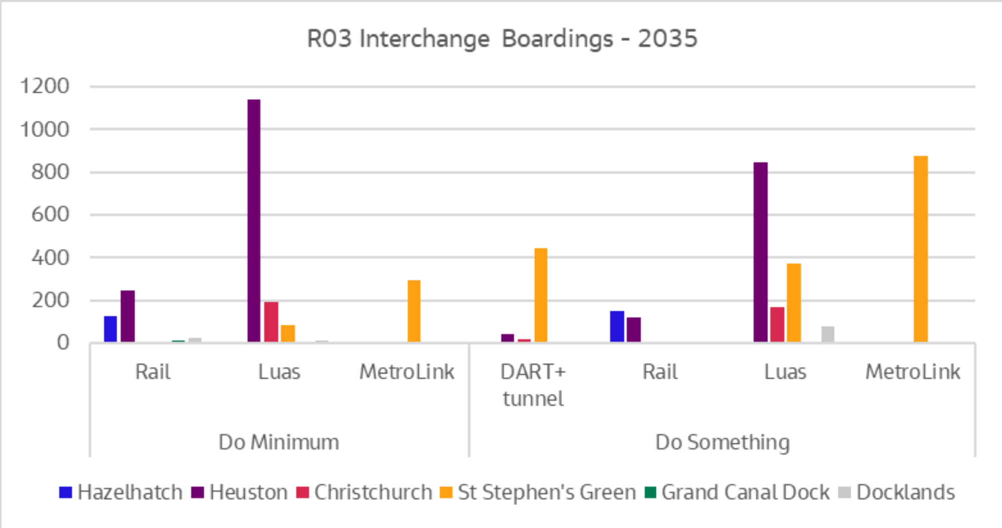
Station Name	**Percentage of Increase and Decrease in Boarding and Alighting figures compared to Do Minimum Scenario**	
	Boarding	Alighting
Hazelhatch	+56%	+12%
Heuston Luas	+13%	-2%
Connolly Luas	+3%	+7%
Tara Street MetroLink	+5%	+7%
Heuston Rail	-61%	-17%
Tara Street Rail	-22%	-44%
Pearse	-5%	-42%
Grand Canal Dock	-26%	-39%
Connolly Rail	-15%	-37%

Interchange movements

This section summarises the AM peak boarding and alighting movements by station that arise from or to other transport modes (i.e., Rail, Luas and MetroLink). The number of 2035 AM peak hour interchange movements (by boarding and alighting) by station in the Do Minimum and R03 is shown in Figure 5-41.

In the R03 scenario the underground heavy rail station at St. Stephen’s Green is the most used station for interchange. There is a significant increase (+198%) in interchange boarding at the MetroLink station at St. Stephen's Green as compared to the Do Minimum. With a direct connection from the Kildare Line to the Northern line, a significant proportion of people is estimated to alight at St. Stephen’s Green underground heavy rail station and board onto MetroLink station and Luas for interchange.

A slight decrease in interchange boarding and alighting is apparent at the surface Heuston railway station and Luas stop. Heuston railway station experiences a 37% decline in interchange alighting, while the Luas stop at Heuston has a decrease in interchange alighting by 36%. The decrease in alighting figures of Heuston railway station implies that a lot more people travelling on the Kildare line now have a direct connection to the city centre as opposed to alighting at Heuston railway station or going through Phoenix Park Tunnel as compared to the Do Minimum scenario.



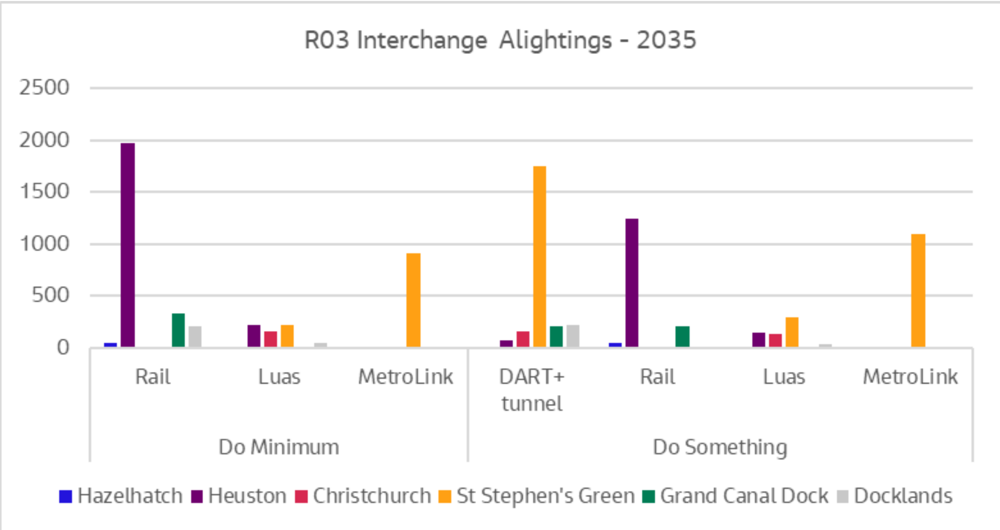
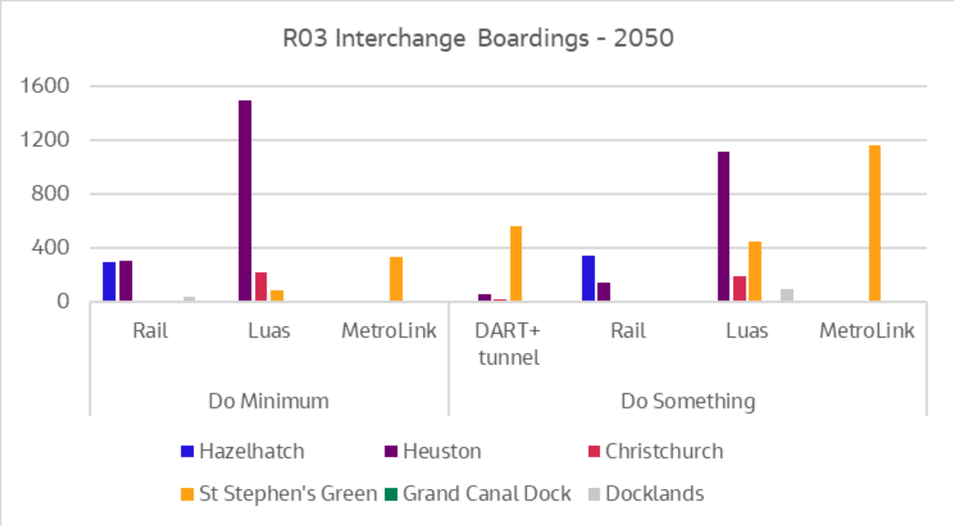


Figure 5-41: R03 AM peak hour Interchange Boarding and Alighting movements in 2035

Figure 5-42 shows the number of AM peak hour interchange boarding and alighting movements by station in 2050 for the Do Minimum and R03. A similar trend was observed for the boarding and alighting figures in 2050, where interchange boarding at the MetroLink station at St. Stephen's Green was increased by three times when compared to the Do Minimum in 2050. At Heuston, there is less boarding and alighting for both the railway station and the Luas stop.



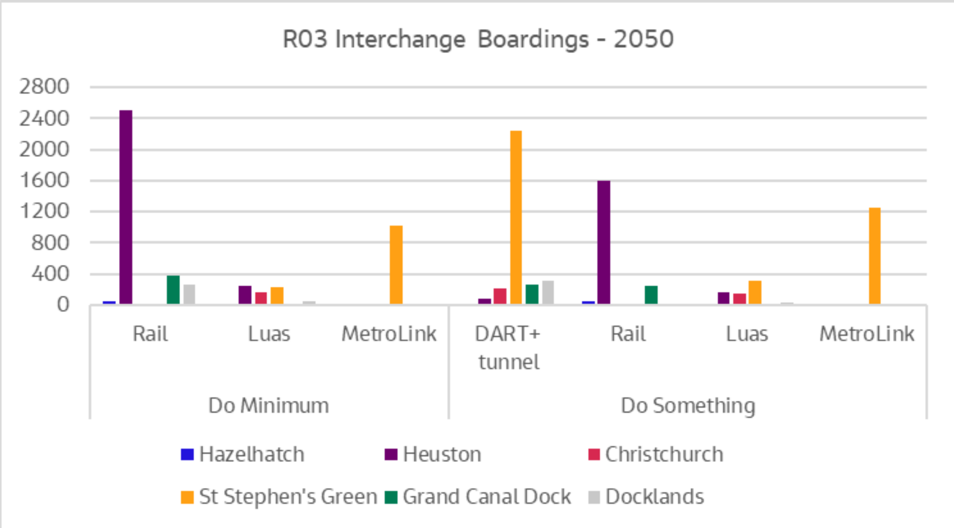


Figure 5-42: R03 AM Peak Hour Interchange Boarding and Alighting movements in 2050

Passenger loadings by line - Luas Services

Figure 5-43 presents the number of daily passengers travelling on each of the Luas lines (Red, Green, and Lucan) by stop (on departure from each respective stop) for the 2050 Do Minimum scenario and the 2050 R03 scenario. The stops are arranged from city limits stops to city centre stops from left to right.

As shown in the figure, R03 generally results in less patronage on each Luas line. On the Red line, R03 has approximately 4,000 less passengers (-8%) than the Do Minimum on the section of line from the Heuston Luas stop to Abbey Street Luas stop. The Lucan line has approximately 10% less passengers in the R03 scenario as compared to the Do Minimum across the majority of stops in the Lucan Line. The Green line, between Harcourt Luas stop and Cabra Luas stop, has on average 2,300 less passengers (-6%) in the R03 scenario as compared to the Do Minimum. There is typically less than 2% difference between the scenarios at the other stops on the Green Line.

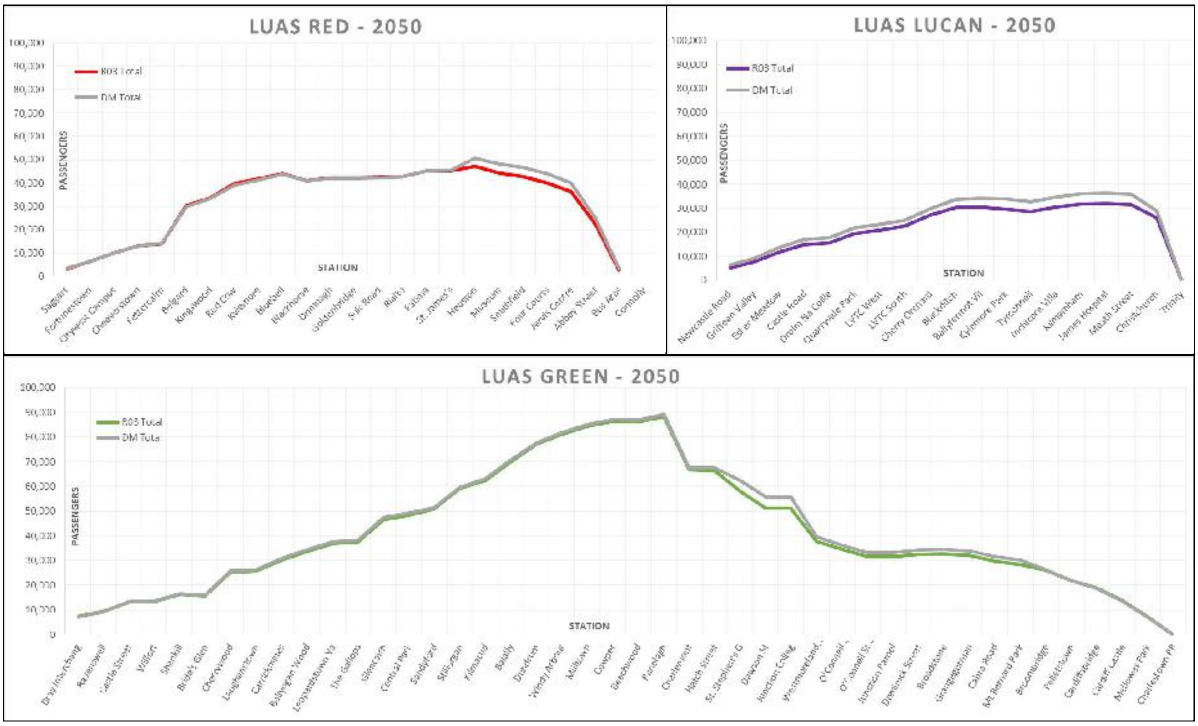


Figure 5-43: 2050 Luas Daily Passenger Flow R03 vs Do Minimum

Passenger loadings by line - MetroLink Services

Figure 5-44 presents the number of daily passengers travelling on the MetroLink by station (on departure from each respective station) for the 2050 Do Minimum scenario and the 2050 R03 scenario. The stations are arranged from city limits stations to city centre stations from left to right.

As shown in the figure, R03 results in approximately 5,000 additional passengers (+5%) than the Do Minimum on the section of line from Glasnevin station to O'Connell Street stop. This additional patronage in R03 is likely to be the result of the operation changes applied to the Northern Line in the R03 scenario while the Phoenix Park Tunnel services are significantly reduced, which has discouraged people to transfer between MetroLink and DART at Glasnevin. At the other stations on the MetroLink Line there is typically less than a 1,500 difference in passenger volume between the scenarios. .

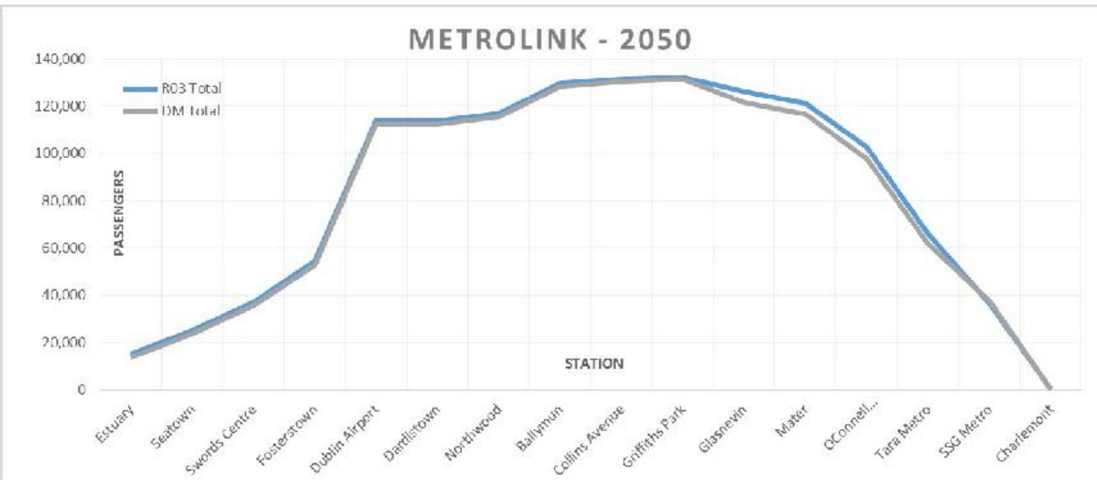


Figure 5-44: 2050 MetroLink Daily Passenger Flow R03 vs Do Minimum

Passenger loadings by line - Rail

Figure 5-45 presents the number of daily passengers travelling on the Railway lines; Maynooth Line, Northern Line, Kildare Line and South Eastern Line. The figures are presented by station (on departure from each respective station) for the 2050 Do Minimum scenario and the 2050 R03 scenario. The stations are arranged from city limits stations to city centre stations from left to right.

As shown in the figure, R03 generally results in more patronage on the Maynooth Line, Kildare Line, and the South Eastern Line, but a reduction in patronage on the Northern Line.

The Maynooth Line attracts more passengers in the R03 scenario than in the Do Minimum scenario. The biggest difference is on the section between Broombridge station and Glasnevin station, where the difference in passenger volume is approximately 8,000. Glasnevin station has higher demand in the Do Minimum than in the R03 scenario as the Phoenix Park Tunnel services which run through this station are significantly reduced when the DART+ Tunnel scheme is in place.

Passenger volume on the Northern Line is less in R03 than in the Do Minimum except sections after Clontarf Road Station towards the city centre. The biggest difference along the line is at Howth Junction station where R03 has 5,500 less passengers (-9%) as compared to the Do Minimum. The reduction after the Clontarf Road station would be the result of the reduction in services heading south of the Royal Canal in comparison to the Do Minimum.

The Kildare Line is the line that is most affected by the scheme. The demand along the Kildare Line is much greater in the R03 scenarios as compared to the Do Minimum. At the City Centre patronage is approximately 16,800 more passengers (+27%) in R03 than in the Do Minimum. Passengers using the Phoenix Park Tunnel in the Do Minimum are diverted via the underground rail link R03 and only approximately 1,450 passengers remain on services through the Phoenix Park Tunnel.

The South Eastern Line attracts more passengers across the majority of stations in R03 comparing to the Do Minimum. There are approximately 2,500 more passengers on the sections between Bray to Lansdowne Road Station in R03 than in the Do Minimum. At Grand Canal Dock station and to the City Centre the South Eastern Line has approximately 8,500 less passengers (-15%) in the R03 scenario as compared to the Do Minimum.

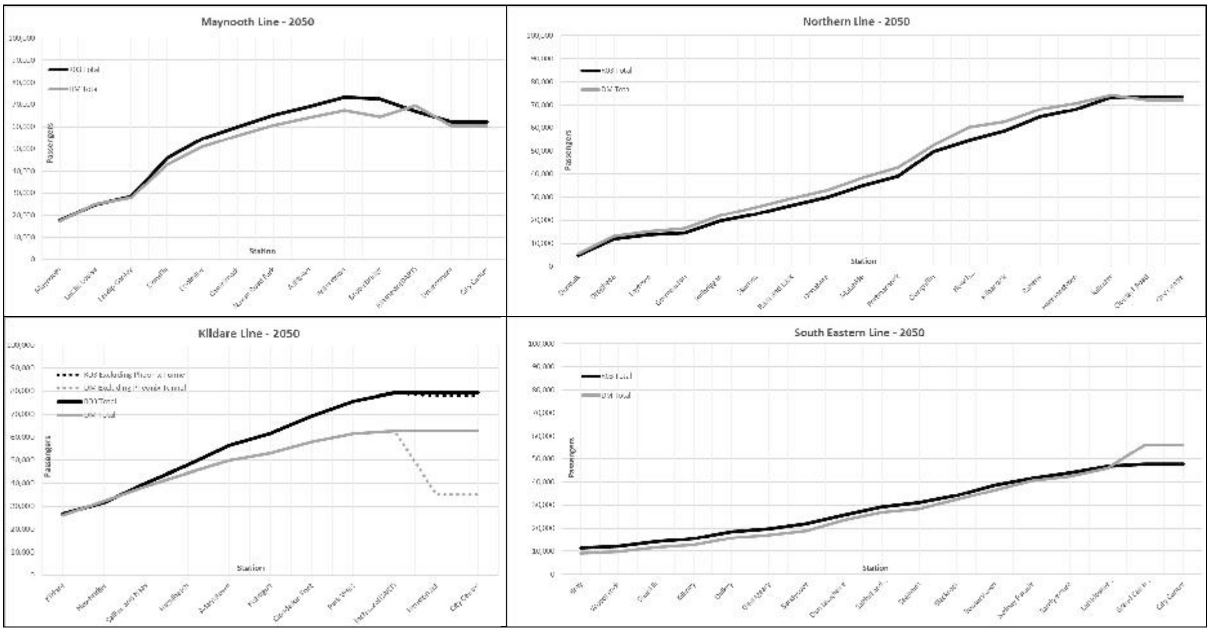


Figure 5-45: 2050 Rail Daily Passenger Flow R03 vs Do Minimum

5.2.4.6 Environment

The proposed underground rail stations of Christchurch, St. Stephen's Green, and Grand Canal Dock are located within the Historic Centre of Dublin City Designated Site, while Christchurch and St. Stephen's Green stations are situated within the zone of archaeological potential for multiple RMP sites. No environmental constraints are identified at other proposed station locations. Direct ecological constraints are identified for the station location at Grand Canal Dock, which is to be situated within the canal basin, is also a designated pNHA. All proposed station locations are situated in built-up areas of an urban landscape environment. One of the stations is located immediately adjacent to St Stephen's Green, which may impact the visual amenity of the area. All proposed station locations are situated close to high density residential and commercial properties, allowing for the potential of disruption to communities and businesses.

5.2.4.6.1 Heuston Station

Refer to S1 R01 description in 5.2.2.6.1

This station is all five options – S1 R01, S1 R02, S1 R03, S1 R09 and S4 R16.

5.2.4.6.2 Christchurch Station

Refer to S1 R01 description in 5.2.2.6.2

This station is in all five options – S1 R01, S1 R02, S1 R03, S1 R09 and S4 R16 (although S1 R02 is in a different location).

5.2.4.6.3 St Stephen's Green Station

This station is in three of the options – S1 R03, S1 R09 and S4 R16.

Population: The station location is situated in central Dublin city and is a very popular for locals and visitors alike for various reasons. St Stephen's Green represents the only sizeable amenity area in the city, and as such is considered to have high amenity value. Considerable land take is likely to be required from the park to facilitate the Station location in this locality. It is also an area important for connectivity with a number of important transport links such as Luas, Irish Rail and Dublin Bus.

Archaeology, Architectural and Cultural Heritage: The station is situated within the Dublin City Zone of Archaeological Potential and it is located within St Stephen's Green, which is a RMP / SMR Site (DU018-020334). It is also in the Zone of Archaeological Potential for another, namely a Graveyard Site (DU018-020166) along York Street and St Stephen's Green west. These sites are also registered with the National Monument Service. St Stephen's Green is also a recorded National Monument. There are no other sites of Archaeological or Cultural Heritage significance of note in its vicinity. The northern extents of the station are situated within the Grafton Street Architectural Conservation Area (ACA) signifying the rich architectural heritage and special character of the area. However, there are no Protected Structures or NIAH designated buildings in the immediate vicinity of the Station Location, aside from St Stephen's Green itself.

Landscape and Visual: The impacted surface areas are green open spaces, in an area that could be considered the most valued visual amenity space in Dublin city centre. St. Stephen's Green possesses open green space, mature trees, shrubbery, and manicured gardens that are widely accessible to the public.

Biodiversity: St. Stephen's Green holds considerable ecological value in this urban environment.

5.2.4.6.4 Grand Canal Dock Station

Refer to S1 R02 description in 5.2.3.6.5

This station is in two of the options – S1 R02 and S1 R03.

5.2.4.6.5 Docklands Station

Refer to S1 R01 description in 5.2.2.6.4

This station is in four of the options – S1 R01, S1 R02, S1 R03, and S1 R09.

5.2.5 Route S1 R09

As shown in Figure 5-46 this route alignment of 7.83km starts at the western tie-in and travels along a south-eastern direction towards the northern side of St. Stephen's Green, after which the route runs along Merrion Square and to Dublin Pearse in a north-eastern direction. The route alignment then crosses River Liffey prior to connecting to the Northern Line in the Docklands."

This route alignment is closely based upon the works undertaken as part of the previous 2014 RO for the DART Underground project, with refinement where appropriate

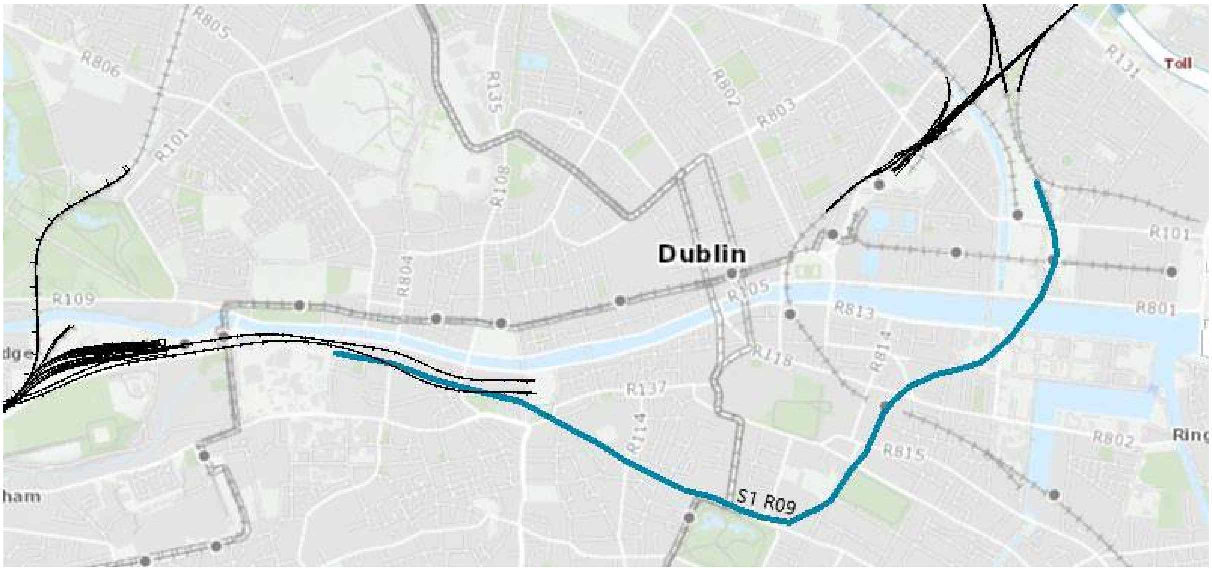


Figure 5-46: Short Listed Route Option – S1 R09

5.2.5.1 Track Alignment

The track alignment complies with Irish Rail standards and is based on the 2014 Railway Order for DART Underground with refinement where applicable. At each of the station locations on this route, the following values shown in Table 5-11 have been achieved:

Table 5-11 S1 R09 Station Specific Track Alignment Values

S1 R09 Station Specific Track Alignment Values	
Heuston	
Track interval	39.112m
Horizontal alignment	Straight
Vertical alignment	0.2% grade
Christchurch	
Track interval	51.646m
Horizontal alignment	Down Main Underground: 10000m radius*
Vertical alignment	0.2% grade
St. Stephen's Green	
Track interval	Start: 63.446m
Horizontal alignment	Straight
Vertical alignment	0.2% grade
Pearse	
Track interval	Start: 51.239m
Horizontal alignment	Down Main Underground: 10066m radius*

S1 R09 Station Specific Track Alignment Values	
Vertical alignment	0.2% grade
Docklands	
Track interval	28.393m
Horizontal alignment	Down Main Underground: 10000m radius*
Vertical alignment	0.2% grade

*it is recommended that these values are reviewed at a subsequent design stage to determine whether these stations can be provided on straight horizontal alignments.

Refer to drawings DT1-JA-RTA-ROUT_XX-DR-Y-1001 to 1010 in Appendix B for further details.

5.2.5.2 Tunnelling and Geotechnical Situation

5.2.5.2.1 Heuston Station

Refer to S1 R01 description in 5.2.2.2.1

5.2.5.2.2 Christchurch Station

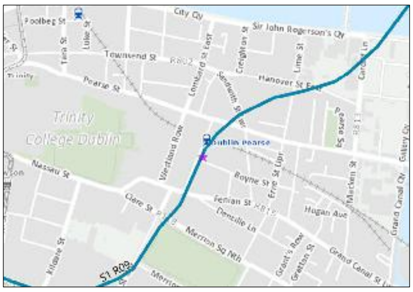
Refer to S1 R01 description in 5.2.2.2.2

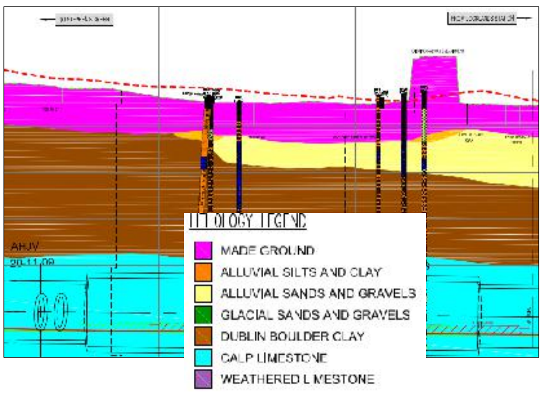
5.2.5.2.3 St Stephen's Green Station

Refer to S1 R03 description in 5.2.4.2.3

5.2.5.2.4 Pearse Station

Location: The underground station is located beneath Cumberland Street South adjacent to the elevated DART Pearse Station. It is also in the S4 R16 option, albeit that is an interchange/terminus with a turnback facility. Existing ground levels in this area are circa +3mOD.

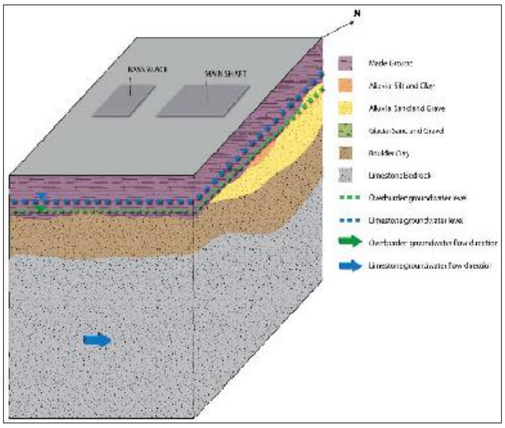




Geology: From published data existing boreholes identified in the area of the proposed Pearse Station show strata layers of:

- Made Ground: approx. 2m to 5m depth of sandy gravely clay and silt with cobbles and pieces of brick, peat, and shell fragments,
- Alluvial Silts/Clays (locally): 0.5m to 2.0m thick, may contain organic material,
- Alluvial Sands/Gravels: dense sandy gravel below the Made Ground from about +0mOD to -6mOD,
- Glacial Till or Dublin Boulder Clay (DBC): sandy gravely clay from about -1mOD to -15mOD,
- Calp Limestone: bedrock from about -14mOD to -15mOD to depth.

Groundwater: From published data, recorded and monitored ground water levels indicate that:



- the groundwater levels observed in boreholes are steady and showed little variation over 21 rounds of monitoring,
- groundwater levels recorded in the limestone have their piezometric head lying in the overburden,
- the Dublin Boulder Clay will likely confine the groundwater in the limestone,
- the presence of Alluvial Sands and Gravels above the Boulder Clay indicates that perched water tables are likely to be present in the area,
- work in the wider area showed that these Alluvial Sands and Gravels can have relatively high permeability values,

The higher permeability sand material which lies above the Boulder Clay may be hydraulically connected to the surface water in the River Liffey. However, the clay present beneath these deposits will prevent the groundwater in the sand from being connected with the groundwater in the limestone.

5.2.5.2.5 Docklands Station

Refer to S1 R01 description in 5.2.2.2.4

5.2.5.3 Civil Engineering of Stations

In this option, 5 no. new stations are proposed along the route – starting from the west and travelling east – and include Heuston, Christchurch, St. Stephen's Green, Pearse and Docklands. Engineering details on each of the stations are noted below.

5.2.5.3.1 Heuston Station

Refer to S1 R01 description in 5.2.2.3.1

5.2.5.3.2 Christchurch Station

Refer to S1 R01 description in 5.2.2.3.2

5.2.5.3.3 St Stephens Station

Refer to S1 R03 description in 5.2.4.3.3

5.2.5.3.4 Pearse Station:

The underground station at Pearse is shown in Figure 5 47 and it is assumed that it will be the same design as the 2014 Railway Order (RO) for the DART Underground.

Figure 5-47 Station Layout for Pearse

The construction approach is similar to the underground station at Heuston using two cut and cover shafts and horizontal fronts of excavation from within the shafts using a mined rock excavation approach.

5.2.5.3.5 Docklands Station

Refer to S1 R01 description in 5.2.2.3.4

5.2.5.4 Rail Operational Efficiency

Refer to S1 R01 description in 5.2.2.4

5.2.5.5 Transport Planning

Trips by mode and mode share

The number of public transport trips undertaken in the R09 scenario and in the Do Minimum scenario in 2035 and 2050 is shown in Figure 5-48.

The R09 route alignment option would increase the number of daily public transport trips by 11,221 (1.08%) in 2035 and 12,443 (1.02%) in 2050.

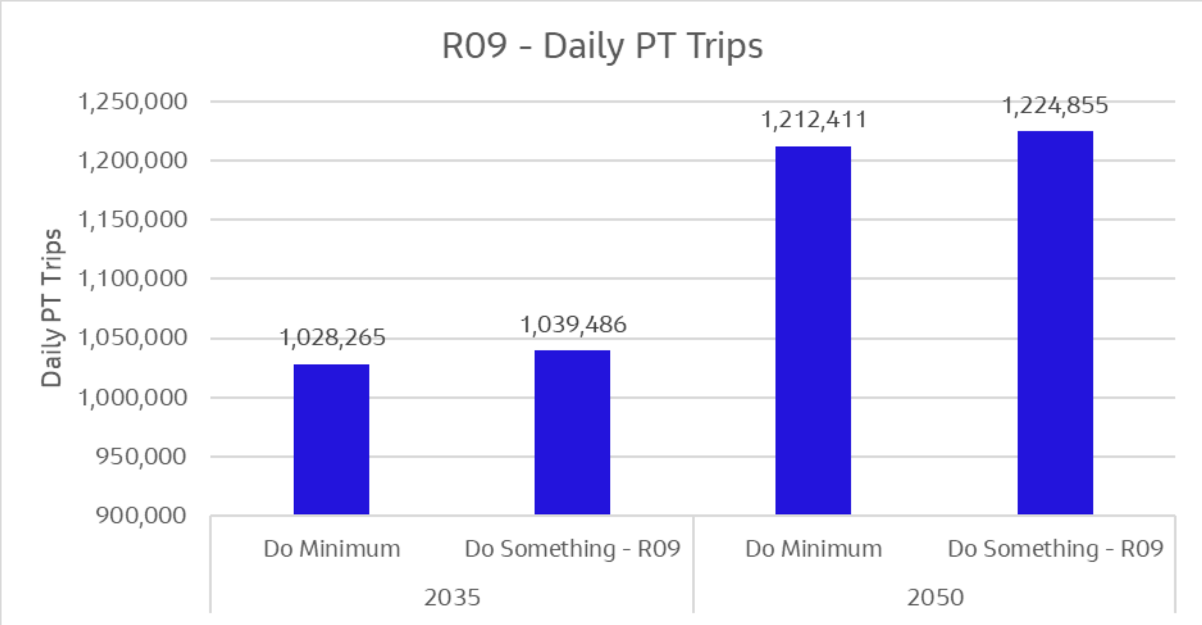


Figure 5-48: Daily Public Transport trips of R09 and Do Minimum in 2035 and 2050

In 2035 the R09 route alignment has a 0.14 percentage point increase in public transport mode share in comparison to the Do Minimum scenario. Of this, a 0.08 percentage point is from Cycle, a 0.04 percentage point comes from Car, and a 0.02 percentage point is from the Walk mode share. In 2050, the R09 route alignment has a 0.14 percentage point increase in public transport mode share in comparison to the Do Minimum scenario. Of this, a 0.08 percentage point is from Cycle, a 0.04 percentage point comes from Car, and a 0.02 percentage point is from the Walk mode share.

These mode share changes are presented in Figure 5-49.

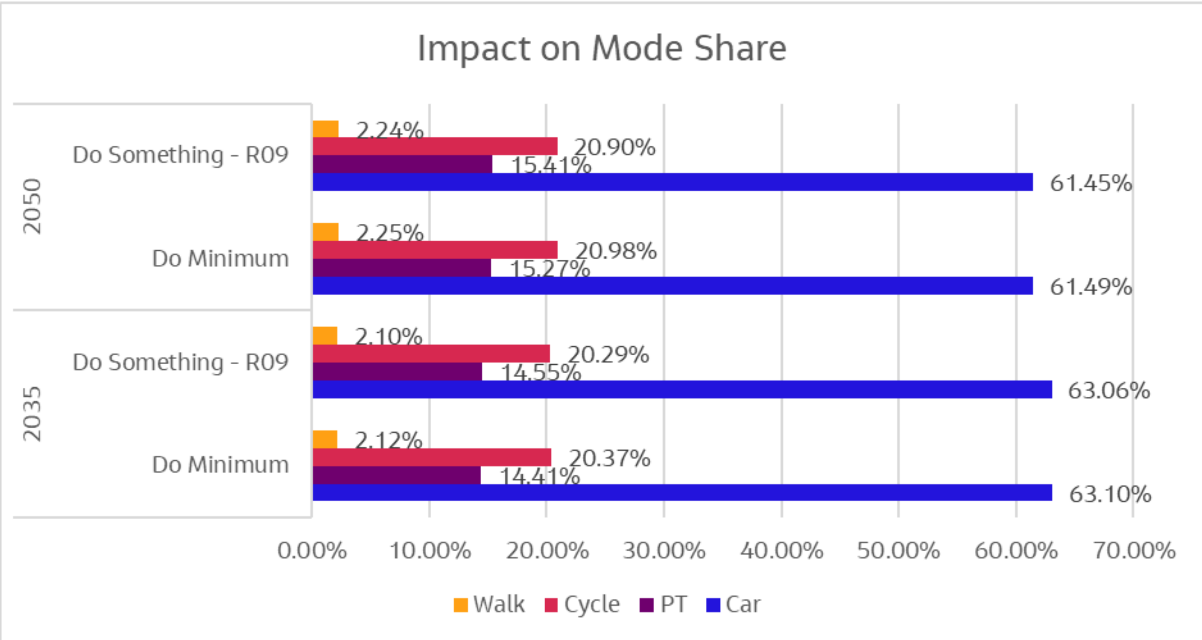


Figure 5-49: Mode Share of R09 and Do Minimum in 2035 and 2050

Rail passenger volumes

Figure 5-50 shows the percentage change in daily rail passenger volume when comparing route alignment R09 to the Do Minimum Scenario in 2035. As can be seen in the figure there is an estimated daily passenger volume flow of up to 58,000 in 2035 along this route alignment (both directions combined).

In the R09 scenario, the daily passenger volume along the Phoenix Park Tunnel and all Luas lines are much lower as compared to the Do Minimum.

The number of daily passengers using the Phoenix Park Tunnel is estimated to decrease by as much as 96% in 2035. The Luas line experiences a reduction in passenger volume of up to 12% in 2035 as compared to the Do Minimum. On the Northern Line there is a 40% reduction in passenger volume in the city centre section of the line south of Clontarf Road, but this is associated with services moving to the DART+ Tunnel. The actual impact on passenger volumes using the Northern Line is minor, with some increases in passenger volume of up to 5% and reductions of no more than 2%. There is a 20% increase in passenger volume on the Maynooth Line in the city centre.

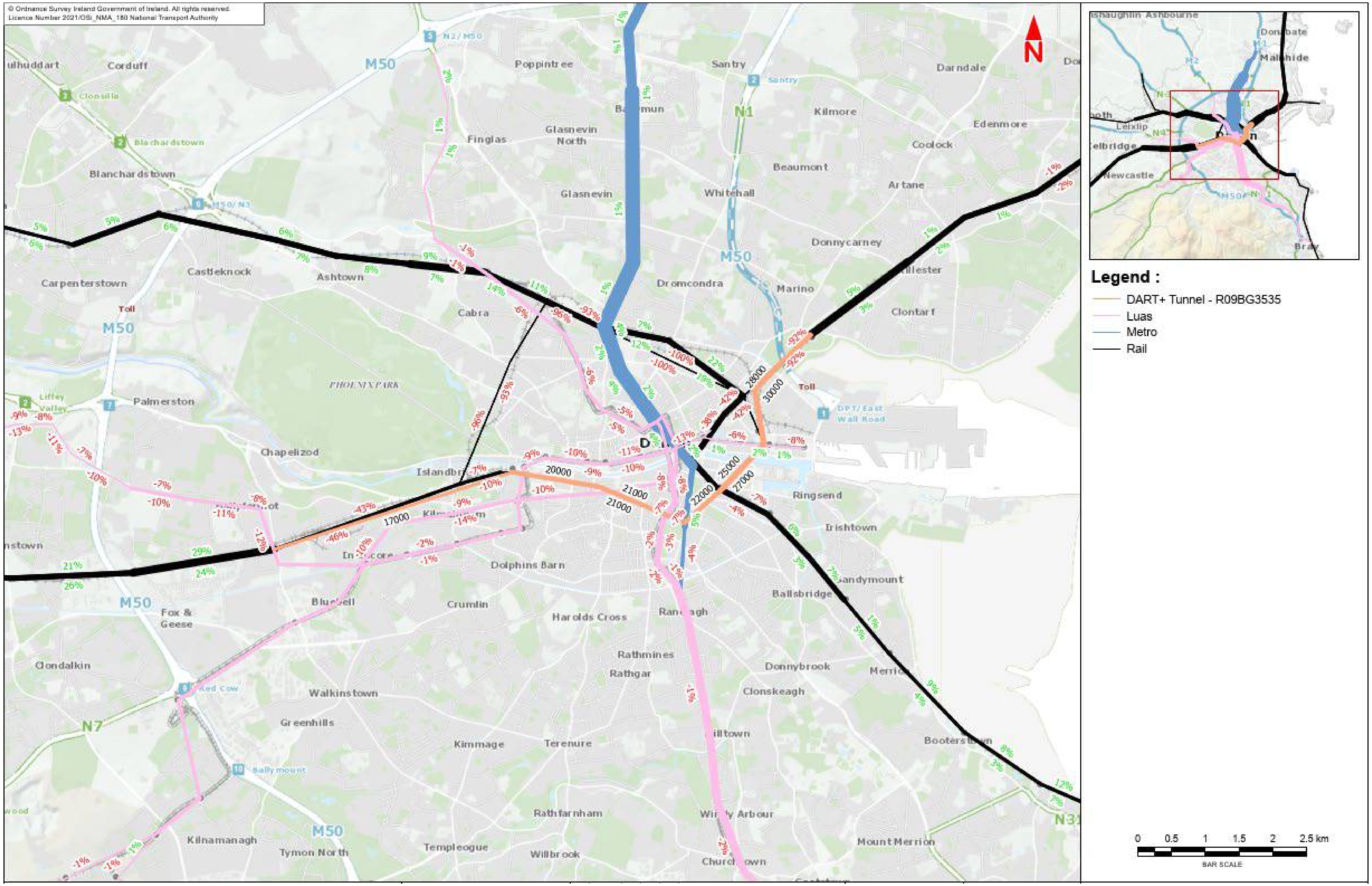


Figure 5-50: Difference in Daily Rail Passenger Volume between R09 and Do Minimum in 2035

Boarding and Alighting

This section summarises the AM peak boarding and alighting movements that arise from the catchment area of each station. Figure 5-51 shows the number of AM peak hour boarding and alighting movements by station for the R09 route alignment scenario. The station with the highest alighting movements is at the underground heavy rail station at St. Stephen's Green, noted to be a highly used station due to the presence of both the Luas stop and MetroLink station at the same location for interchange.

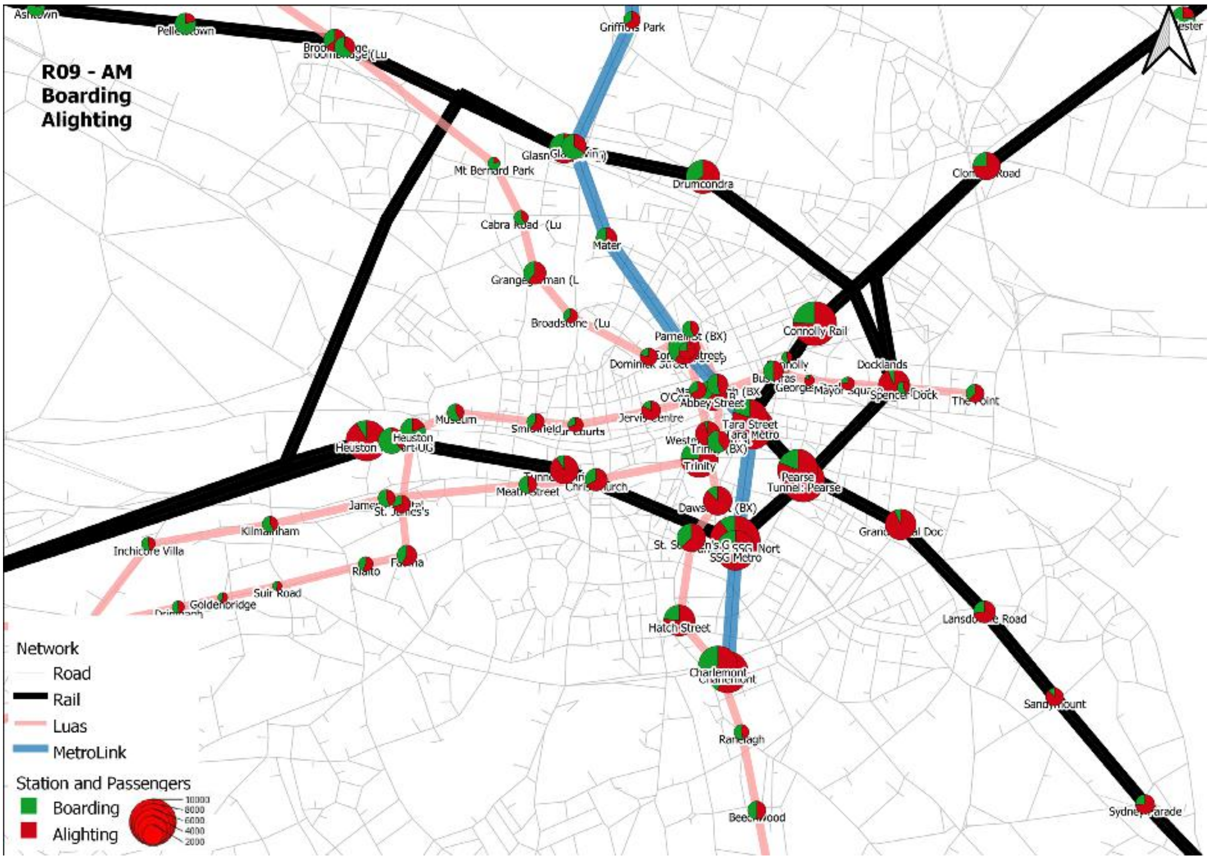


Figure 5-51: R09 AM peak Boarding and Alighting movements by station in the study area

Table 5-12 shows the comparison of boarding and alighting movements in the AM peak hour at key stations in 2035. The greatest change in boarding movements is at Heuston railway station where there is 62% less movements, and the greatest change in alighting movements is at Pearse where there is 44% less than in the Do Minimum. There are also significant reductions at Connolly, Glasnevin, and Grand Canal Dock stations along the coastal DART line as compared to the Do Minimum.

In contrast, Hazelhatch, Heuston and Connolly Luas have a notable increase in the number of boarding and alighting movements due to them having a direct connection to the city centre. No significant impacts are seen in the number of boarding and alighting movements at the other Luas and MetroLink stations.

Table 5-12: Comparison of AM Peak boarding and alighting movements at key stations - R09 vs Do Minimum

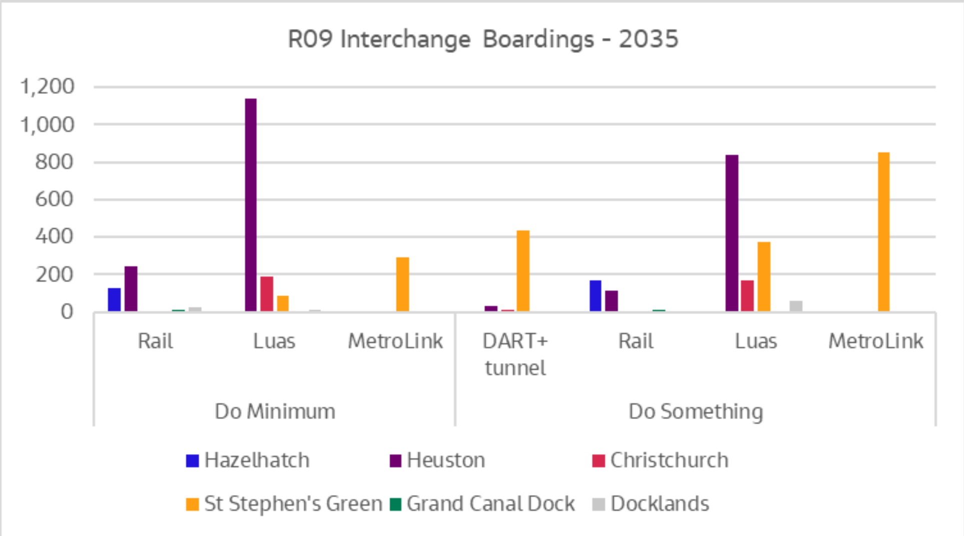
Station Name	Percentage of Increase and Decrease in Boarding and Alighting figures compared to Do Minimum Scenario	
	Boarding	Alighting
Hazelhatch	+52%	+11%
Connolly Luas	+12%	+8%
Heuston Luas	+10%	-3%
Heuston Rail	-62%	-17%
Pearse	-5%	-45%
Tara Street Rail	-18%	-44%
Connolly Rail	-14%	-37%
Glasnevin Rail	+3%	-35%
Grand Canal Dock	-23%	-31%

Interchange movements

This section summarises the number of AM peak hour interchange movements (by boarding and alighting movements) by station that occur from or to other transport modes, that is, Rail, Luas, MetroLink. Figure 5-52 presents the 2035 AM peak hour interchange movements in the Do Minimum and in the RO9 scenario.

In the R09 scenario St Stephen's Green station is the most used station for interchange. There is a 100% increase in interchange boarding at St. Stephen's Green station on the MetroLink and 20.5% increase in alighting. With a direct connection from the Kildare Line to the Northern Line, a significant portion of people is forecast to alight at St. Stephen's Green from DART+ Tunnel and board onto MetroLink.

A significant decrease in interchange boarding and alighting is apparent at Heuston Station. Rail at Heuston Station experiences a 54% decline in interchange boarding and a 38% decline in interchange alighting. Luas at Heuston Station has 27% less interchange boarding and 37% less interchange alighting compared to the Do Minimum. The decrease in boarding and alighting movements to/from Rail at Heuston Station implies that a lot more passengers travelling on the Kildare Line now have a direct connection to the city centre as opposed to alighting at Heuston Station or going through Phoenix Park Tunnel as in the Do Minimum scenario.



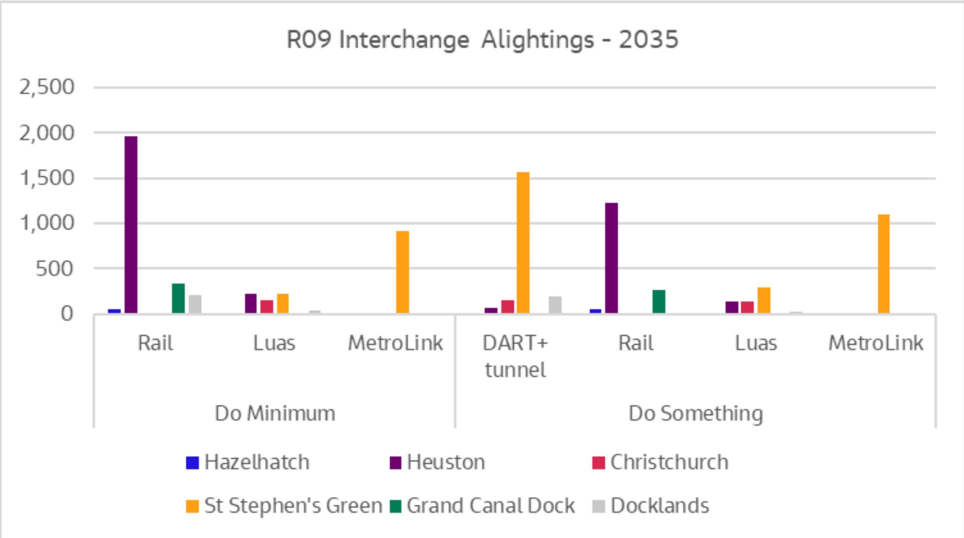
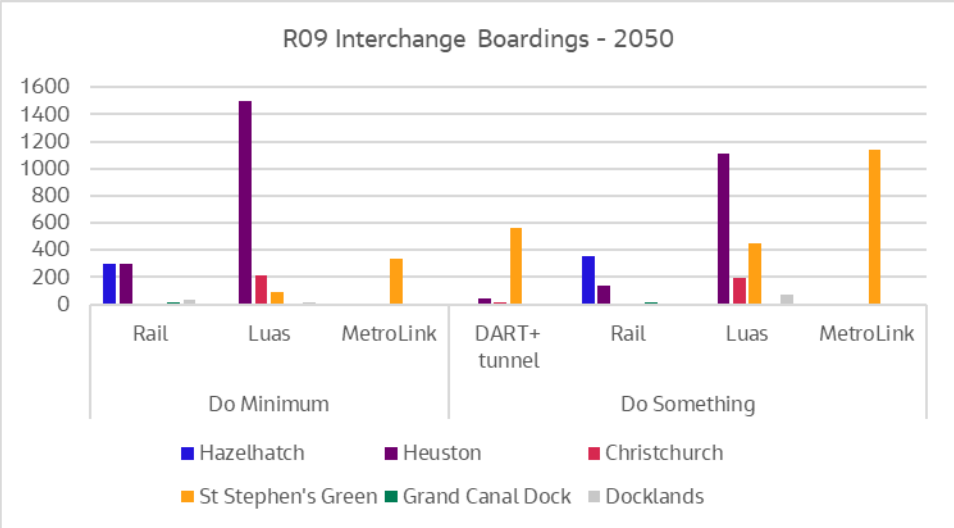


Figure 5-52: R09 AM Peak Hour Interchange Boarding and Alighting figures in 2035

Figure 5-53 shows the 2050 interchange boarding and alighting movements by station in the Do Minimum and R09. A similar trend was observed for the boarding and alighting movements in 2050, where interchange boarding by MetroLink passengers at St. Stephen's Green station is twice as much as compared to the Do Minimum in 2050. A decline of in the use of Heuston station for boarding and alighting passengers was observed for both rail passenger and Luas passengers.



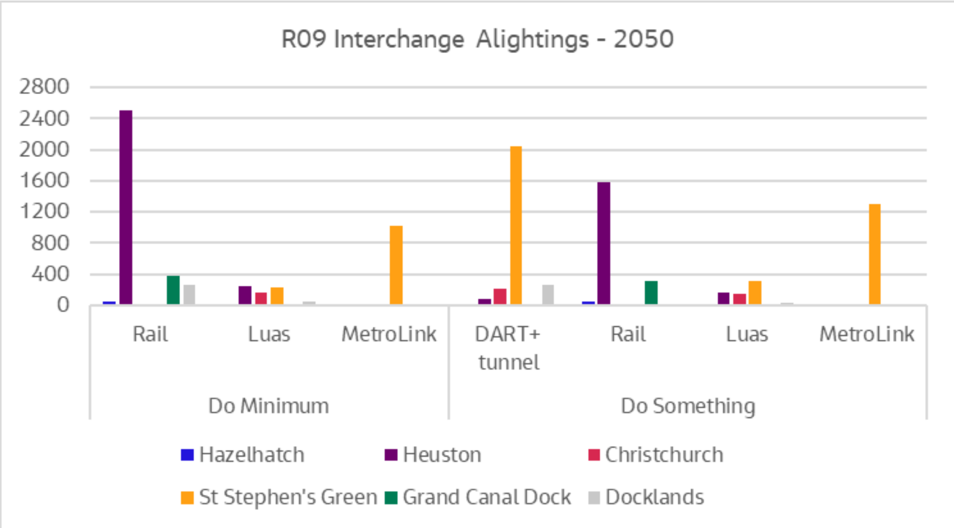


Figure 5-53: R09 AM Peak hour Interchange Boarding and Alighting figures in 2050

Passenger loadings by line - Luas Services

Figure 5-54 presents the number of daily passengers travelling on each of the Luas lines (Red, Lucan and Green) by station (on departure from each respective station) for the 2050 Do Minimum scenario and the 2050 R09 scenario. The stations are arranged from city limits stations to city centre stations from left to right.

As shown in the figure, R09 generally results in less patronage on each Luas line. On the Red line R09 has approximately 4,000 less passengers (-9%) than the Do Minimum on the section of line from Heuston Station to Abbey Street Luas Stop. The Lucan line has approximately 12% less passengers in the R09 scenario as compared to the Do Minimum across the majority of stations in the Lucan Line. The Green line, between Charlemont Station and Cabra Luas stop, has on average 2,400 less passengers (-6%) in the R09 scenario as compared to the Do Minimum. There is typically less than 3% difference between the scenarios at the other stations on the Green Line.

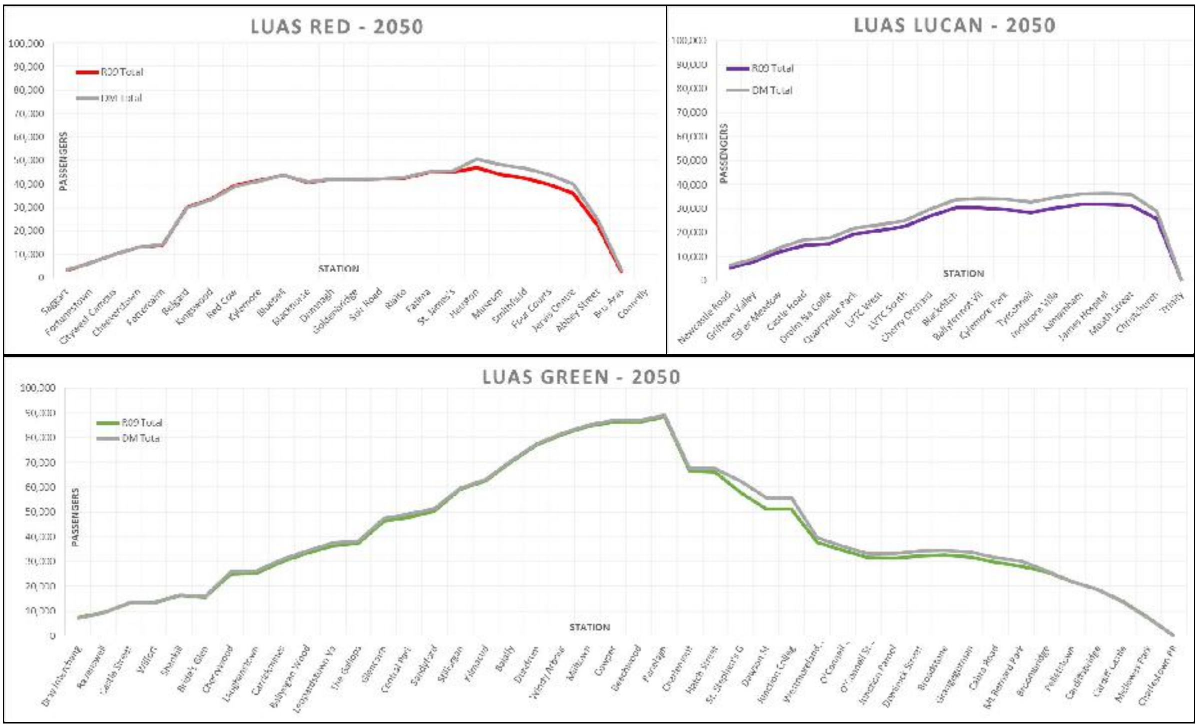


Figure 5-54: 2050 Luas Daily Passenger Flow R09 vs Do Minimum

Passenger loadings by line - MetroLink

Figure 5-55 presents the number of daily passengers travelling on the MetroLink by station (on departure from each respective station) for the 2050 Do Minimum scenario and the 2050 R09 scenario. The stations are arranged from city limits stations to city centre stations from left to right.

As shown in the figure, R09 results in approximately 4,000 additional passengers than the Do Minimum on the section of line from Glasnevin station to O'Connell Street station. This additional patronage in R09 is likely to be the result of the operation changes applied to the Northern Line in the R09 scenario while the Phoenix Park Tunnel services are significantly reduced which has discouraged people to transfer between MetroLink and DART at Glasnevin. At the other stations on the MetroLink Line there is typically less than a 500 difference in passenger volume between the scenarios.

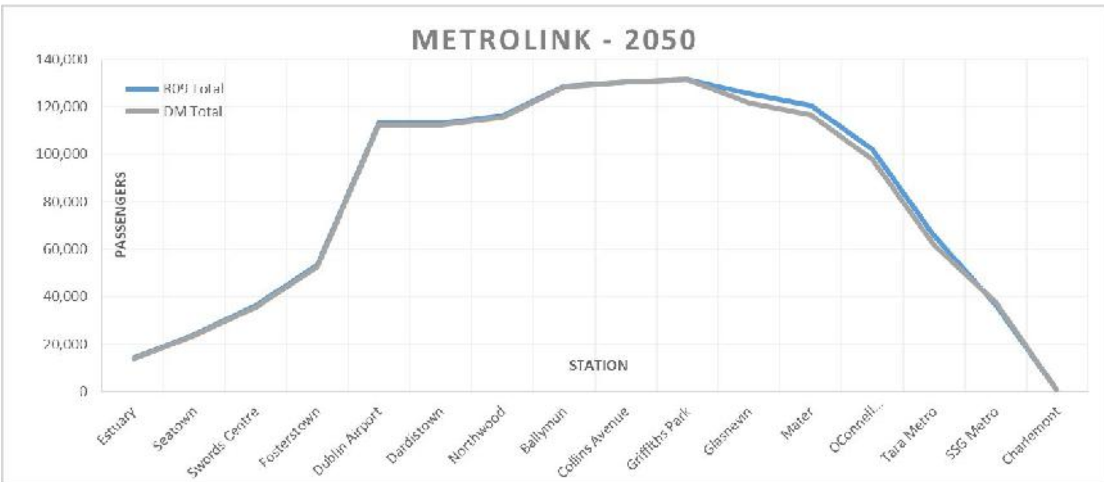


Figure 5-55: 2050 MetroLink Daily Passenger Flow R09 vs Do Minimum

Passenger loadings by line - Rail

Figure 5-56 presents the number of daily passengers travelling on the railway lines; Maynooth Line, Northern Line, Kildare Line and South Eastern Line. The figures are presented by station (on departure from each respective station) for the 2050 Do Minimum scenario and the 2050 R09 scenario. The stations are arranged from city limits stations to city centre stations from left to right.

As shown in the figure, R09 generally results in more patronage on the Maynooth Line, Kildare Line, and the South Eastern Line, but a reduction in patronage on the Northern Line.

The Maynooth Line attracts more passengers in the R09 scenario than in the Do Minimum scenario. The biggest difference is on the section between Broombridge station and Glasnevin station, where the difference in passenger volume is approximately 8,100. Glasnevin station has higher demand in the Do Minimum than in the R09 scenario as the Phoenix Park Tunnel services which run through this station are significantly reduced when the DART+ Tunnel scheme is in place.

Passenger volume on the Northern Line is generally less in R09 than in the Do Minimum except sections after Raheny Station towards the city centre. At Clontarf Road station there is approximately 4,500 more passengers (+6%) in R09 than in the Do Minimum. It seems the reduction of service heading south of the Royal Canal has the impact over the demand using Northern line.

The Kildare Line is the line that is most affected by the scheme. The demand along the Kildare Line is much greater in the R09 scenarios as compared to the Do Minimum. At the City Centre patronage is approximately 16,750 more passengers (+27%) in R09 than in the Do Minimum. Passengers using the Phoenix Park Tunnel in the Do Minimum are diverted to the DART+ Tunnel in R09 and only approximately 1,400 passengers remain on services through the Phoenix Park Tunnel.

The South Eastern Line attracts more passengers across the majority of stations in R09 comparing to the Do Minimum. There are approximately 2,500 more passengers on the sections between Bray to Lansdowne Road Station in R09 than in the Do Minimum. At Grand Canal Dock station and to the City Centre the South Eastern line has approximately 4,000 less passengers (-7%) in the R09 scenario as compared to the Do Minimum. The passengers on the section to the north of Grand Canal Dock are diverted to the DART+ Tunnel in R09.

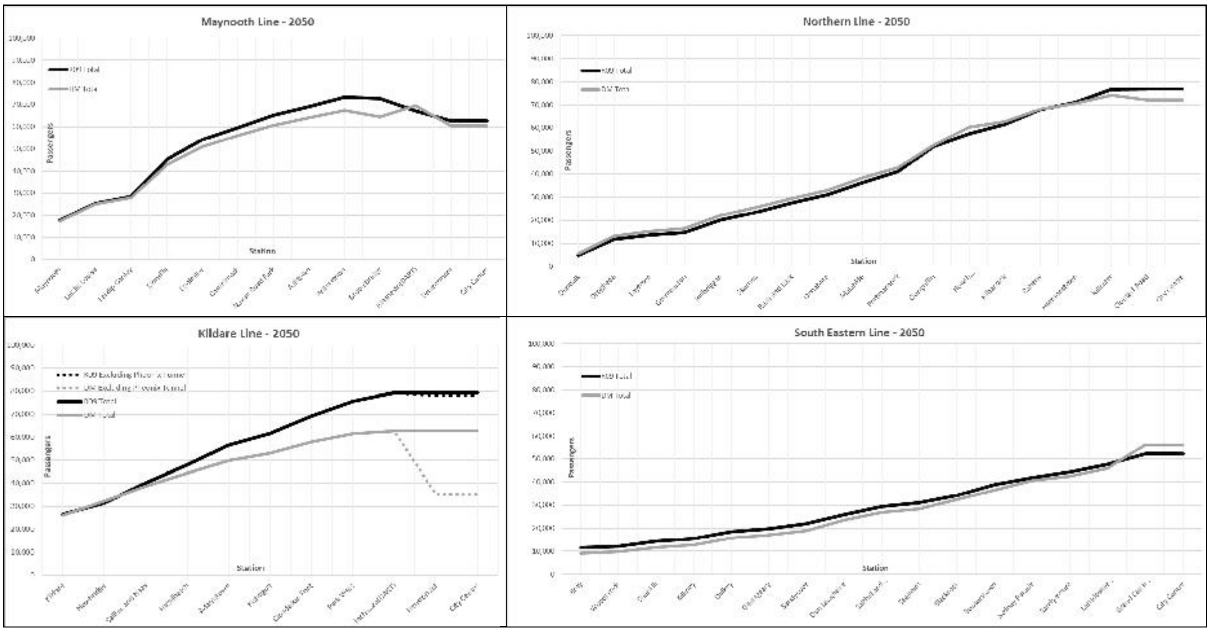


Figure 5-56: 2050 Rail Daily Passenger Flow R09 vs Do Minimum

5.2.5.6 Environment

Three proposed station locations (Christchurch, St. Stephen's Green and Pearse) are located within the Historic Centre of Dublin City Designated Site as well as ZAPs for multiple RMPs. There are no constraints in respect to cultural heritage at the other proposed station locations. No direct ecological constraints were identified. All proposed station locations are situated in built up areas of an urban landscape environment, however one of them is located immediately adjacent to St Stephen's Green, which may impact the visual amenity of the area. The station location at Pearse Station could also encroach into Merrion Square which is of notable architectural heritage value. All proposed station locations are situated close to high density residential and commercial properties, allowing for the potential of disruption to communities and businesses, while the location of the proposed station adjacent to St Stephen's Green.

This route option has some disadvantages over other options because of a station located at St. Stephen's Green, which is likely to lead to significant ecological, landscape, and population impacts.

5.2.5.6.1 Heuston Station

Refer to S1 R01 description in 5.2.2.6.1

This station is in all five options – S1 R01, S1 R02, S1 R03, S1 R09, and S4 R16.

5.2.5.6.2 Christchurch Station

Refer to S1 R01 description in 5.2.2.6.2

This station is in all five options – S1 R01, S1 R02, S1 R03, S1 R09, and S4 R16.

5.2.5.6.3 St Stephen's Green Station

Refer to S1 R03 description in 5.2.4.6.3

This station is three of the options – S1 R03, S1 R09, and S4 R16.

5.2.5.6.4 Pearse Station

Population: The station is situated on the fringes of the city centre in an area of medium residential and commercial properties. The existing elevated Pearse station is located to its immediate north, however there are no other transport connections in this location. Residential properties (at least 7 no. in total) are likely to be acquired to facilitate the underground station in this locality.

Archaeology, Architectural and Cultural Heritage: The station is not situated within but is adjacent to the Dublin City Zone of Archaeological Potential. There are no RMP / SMR Sites or any other sites of Archaeological or Cultural Heritage significance in its vicinity. There are no Architectural Conservation Areas (ACAs), Protected Structures or NIAH designated buildings in the vicinity of the station.

Landscape and Visual: The station location is situated on a brownfield site on the fringes of the city centre, within a medium density urban environment comprising predominantly of residential and commercial properties. The existing DART Pearse station is immediately to the north of the site.

Biodiversity: There are no ecological designated sites in the vicinity of the station, however it is approximately 425m west of Grand Canal Dock which forms part of the Grand Canal pNHA and subsequently feeds into multiple ecological designations downstream of it (via the River Liffey), namely: South Dublin Bay and River Tolka Estuary SPA; South Dublin Bay SAC; North Bull Island SPA; North Dublin Bay SAC; North Dublin Bay pNHA; and South Dublin Bay pNHA.

5.2.5.6.5 Docklands Station

Refer to S1 R01 description in 5.2.2.6.4

This station is in four of the options – S1 R01, S1 R02, S1 R03, and S1 R09.

5.3 Scenario 4

Scenario 4 consists of a scheme to allow services from the South Eastern Line to connect by interchange to the Kildare Line. Route alignment S4 R16 was brought forward to the Stage 2 assessment.

5.3.1 Route S4 R16

This route alignment of 6.35km starts at the location of the western tie-in, travels south until St. Stephen's Green, then runs north along Merrion Square before terminating at Pearse Station. S4 R16 is proposed to have underground stations and key interchanges at Heuston, Christchurch and St. Stephen's Green, before terminating at Pearse, as shown in Figure 5-57.

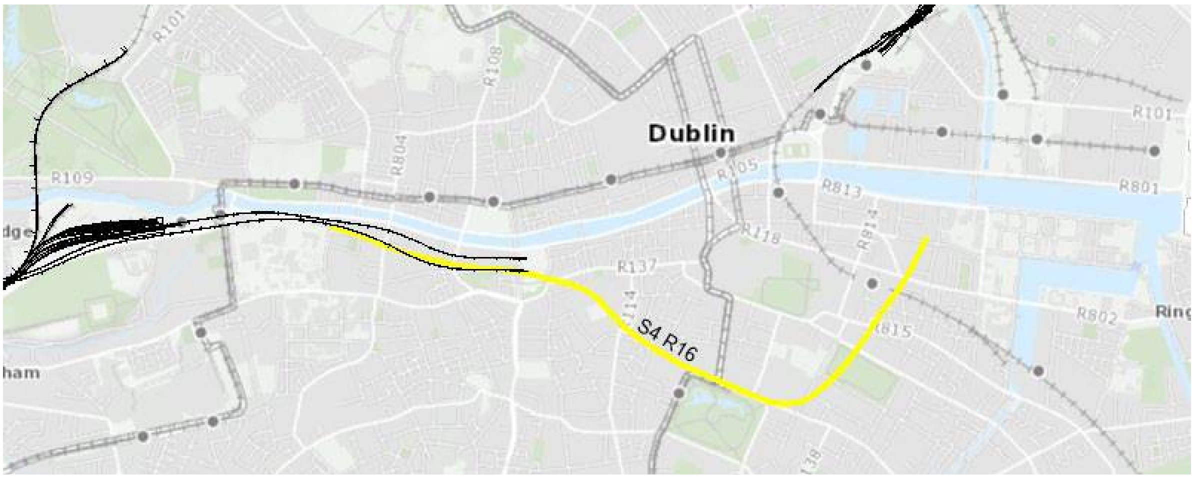


Figure 5-57: Short Listed Route Option – S4 R16

5.3.1.1 Track Alignment

The track alignment complies with Irish Rail standards and its alignment is similar to S1 R09 except it terminates at Pearse with an underground turnback facility. It is therefore closely based upon the work undertaken as part of the previous 2014 RO for the DART Underground project, with refinement where appropriate. Refer to drawings DT1-JA-RTA-ROUT_XX-DR-Y-5001 to 5008 in Appendix B for further details. At each of the station locations on this route, the following values have been achieved as shown in Table 5-13.

Table 5-13 S4 R16 Station Specific Track Alignment Values

S4 R16 Station Specific Track Alignment Values	
Heuston	
Track interval	39.112m
Horizontal alignment	Straight
Vertical alignment	0.2% grade
Christchurch	
Track interval	51.646m
Horizontal alignment	Down Main Underground: 10000m radius*
Vertical alignment	0.2% grade
St. Stephen's Green	
Track interval	Start: 63.446m
Horizontal alignment	Straight
Vertical alignment	0.2% grade
Pearse	

S4 R16 Station Specific Track Alignment Values	
Track interval	Start: 51.239m
Horizontal alignment	Down Main Underground: 10066m radius*
Vertical alignment	0.2% grade
Docklands	
Track interval	28.393m
Horizontal alignment	Down Main Underground: 10000m radius*
Vertical alignment	0.2% grade

*it is recommended that these values are reviewed at a subsequent design stage to determine whether these stations can be provided on straight horizontal alignments.

5.3.1.2 Tunnelling and Geotechnical Situation

Alignment R16 is identical to R09 except that it terminates just beyond Pearse station and does not extend under the River Liffey to the Docklands area. Therefore, the geotechnical considerations will be the same as shown in Section 5.2.5.2 .

In common with route R09, the alignment for R16 will have underground stations at Heuston, Christchurch, St Stephen's Green and Pearse. These have already been described in the previous sections for route S1 R03 and R09 and so will not be repeated here. The only significant difference is at Pearse station where the tunnel will terminate in a turnback facility just beyond the station.

Turnback Facility: In order to achieve the desired service capacity, the tunnel must extend beyond Pearse Station to allow the empty trains to turn back onto the other line. The 2017 Tunnel Configuration study for the NTA by Arup identified that a cavern 347m in length and wide enough for three tracks (19m) and supporting infrastructure such as service walkways would be sufficient for this purpose as shown in Figure 5-58.

In addition, a ventilation and escape shaft would be provided at the far end of the cavern and short stub tunnels for the burial of the TBMs would be needed beyond the shaft. The whole cavern would need to be positioned 173m beyond the end of the station to allow the two lines to converge into the cavern.

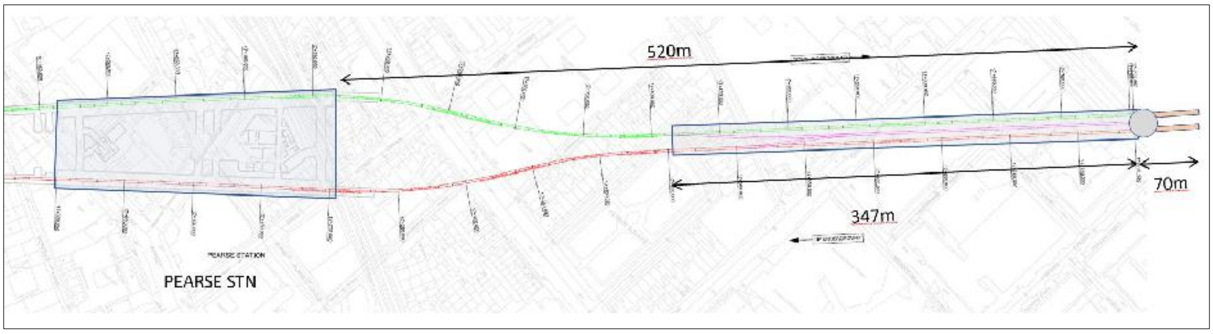


Figure 5-58 Turnback at Pearse

The location of the ventilation shaft of likely diameter 15m would be on the south bank of the River Liffey close to the intersection between Sir John Rogerson's Quay and Asgard Road. The stub tunnels for TBM burial would extend out beneath the river. Interpolating from the R09 alignment suggests that the cavern and the stub tunnels would be constructed within rock. A number of construction methodologies could be employed for the excavation of the caverns including a trinocular excavation supported with sprayed concrete, or a series of headings. Construction access will be challenging as will incorporation of the cavern into the shaft at the northern end.

Other significant risks associated with this element of the works include:

- Accuracy of the current interpolation of the rockhead, with the possibility the rock cover above the cavern might be considerably thinner than required, or non-existent.
- Significantly greater levels of ground movement associated with this larger structure causing unacceptable surface settlement.
- Logistics associated with the likely requirement for some form of ground treatment

5.3.1.3 Civil Engineering for Stations

In this option, 4 no. new stations are proposed along the route starting at the west, with Heuston, Christchurch, St Stephens Green and Pearse. Details on each of the stations are noted below.

5.3.1.3.1 Heuston Station

Refer to S1 R01 description in 11.2.1.3

5.3.1.3.2 Christchurch Station

Refer to S1 R01 description in 11.2.1.3

5.3.1.3.3 St Stephens Station

Refer to S1 R03 description in 11.2.3.3

5.3.1.3.4 Pearse Station

Refer to S1 R09 description in 11.2.4.3

5.3.1.4 Rail Operational Efficiency

In this scenario, the DART+ Tunnel links the Kildare Line at the western tie-in at Heuston Pearse Station on the Loop Line, where passengers can interchange for South Eastern Line services..

Northern Line services would continue to operate via Connolly and therefore still interface here with services from the Maynooth Line. Conflicts at Connolly are therefore not removed but direct services are retained between the Northern Line and Loop Line stations with trains extended to the South Eastern Line to maintain through journey opportunities.

Kildare Line services via Phoenix Park Tunnel and Connolly can be diverted via DART+ Tunnel to Pearse. The space created through Glasnevin and Connolly can be used by operating additional Maynooth Line services.

Existing Kildare Line services to Heuston will be extended via DART+ Tunnel.

8tph could operate via DART+ Tunnel between Heuston and Pearse. At Pearse, the terminal station, trains will have to turnaround – either in the platforms or via new turnback sidings which will need to be constructed in the tunnel. The capacity to turn trains around will determinate the overall capacity of DART+ Tunnel.

Concerns for option R16 in Scenario 4 include:

- Conflicts at Connolly with Maynooth / Northern Line services not removed
- Number of trains via DART+ Tunnel determined by terminal capacity and the ability to turn trains around at Pearse
- Makes for inefficient use of rolling stock with trains having to turnaround at Pearse

5.3.1.5 Transport Planning

Trips by mode and mode share

The number of daily public transport trips undertaken in the R16 scenario and in the Do Minimum scenario in 2035 and 2050 is shown in Figure 5-59. The R16 route alignment option would increase the number of daily public transport trips by 3,626 (+0.36%) in 2035 and 5,104 (+0.42%) in 2050.

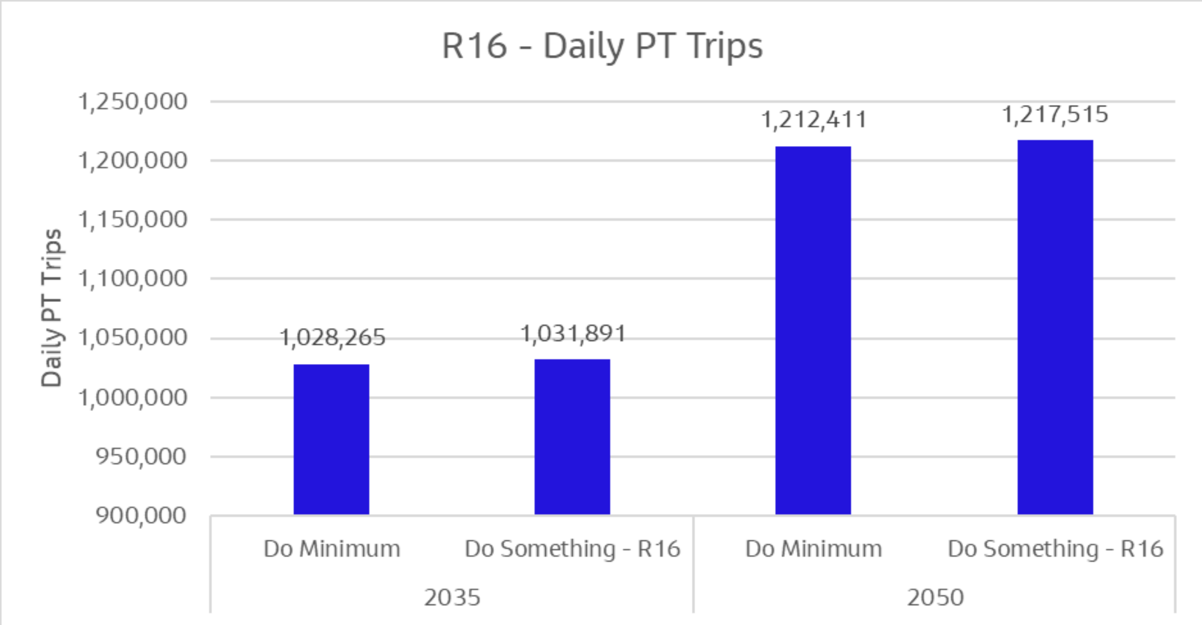


Figure 5-59: Daily Public Transport trips of R16 and Do Minimum in 2035 and 2050

In 2035 the R09 route alignment has a 0.04 percentage point increase in public transport mode share in comparison to the Do Minimum scenario. Of this, a 0.03 percentage point is from Cycle, a 0.01 percentage point comes from Car, and a 0.01 percentage points is from the Walk mode share. In 2050, the R09 route alignment has a 0.05 percentage point increase in public transport mode share in comparison to the Do Minimum scenario. Of this, a 0.03 percentage points is from Cycle, a 0.02 percentage point comes from Car, and a 0.01 percentage points is from the Walk mode share. These mode share changes are presented in Figure 5-60.

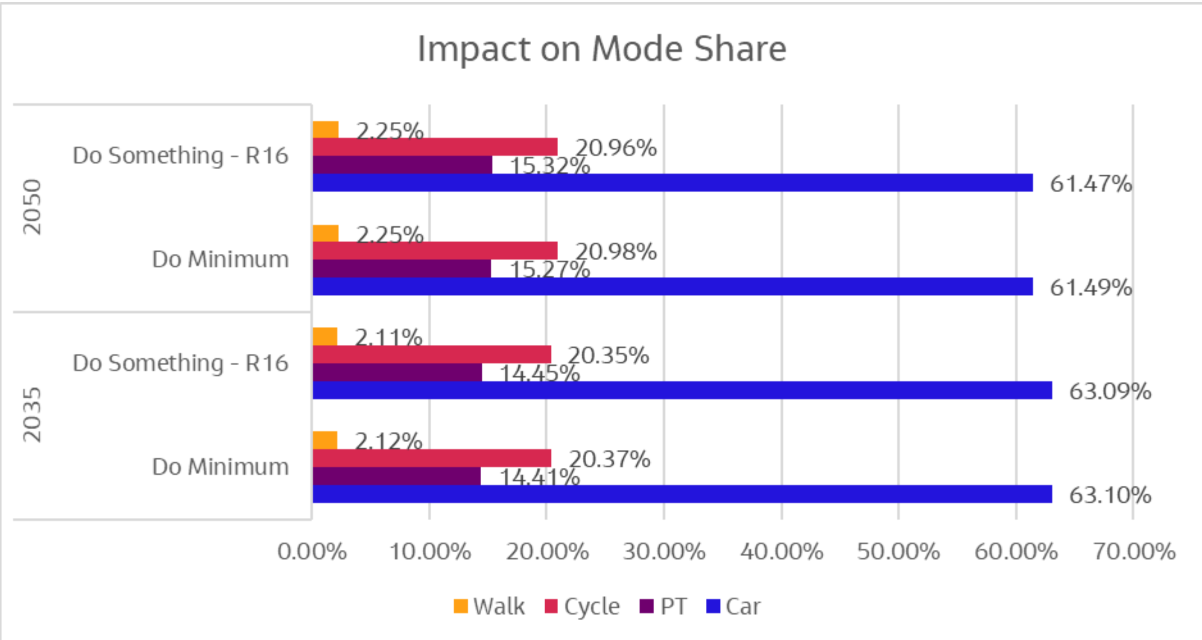


Figure 5-60: Mode Share of R16 and Do Minimum in 2035 and 2050.

Rail passenger volumes

Figure 5-61 shows the percentage change in daily rail passenger volume when comparing route alignment R16 to the Do Minimum Scenario in 2035. As can be seen in the figure there is an estimated daily passenger volume flow of up to 27,000 in 2035 along this route alignment (both directions combined).

In the R16 scenario, the daily passenger volume along the Phoenix Park Tunnel and all Luas lines are much lower as compared to the Do Minimum. The number of daily passengers using the Phoenix Park Tunnel is estimated to decrease by as much as 66% in 2035. The Luas line experiences a reduction in passenger volume of up to 12% in 2035 as compared to the Do Minimum. On the Northern Line there is very little change as compared to the Do Minimum.

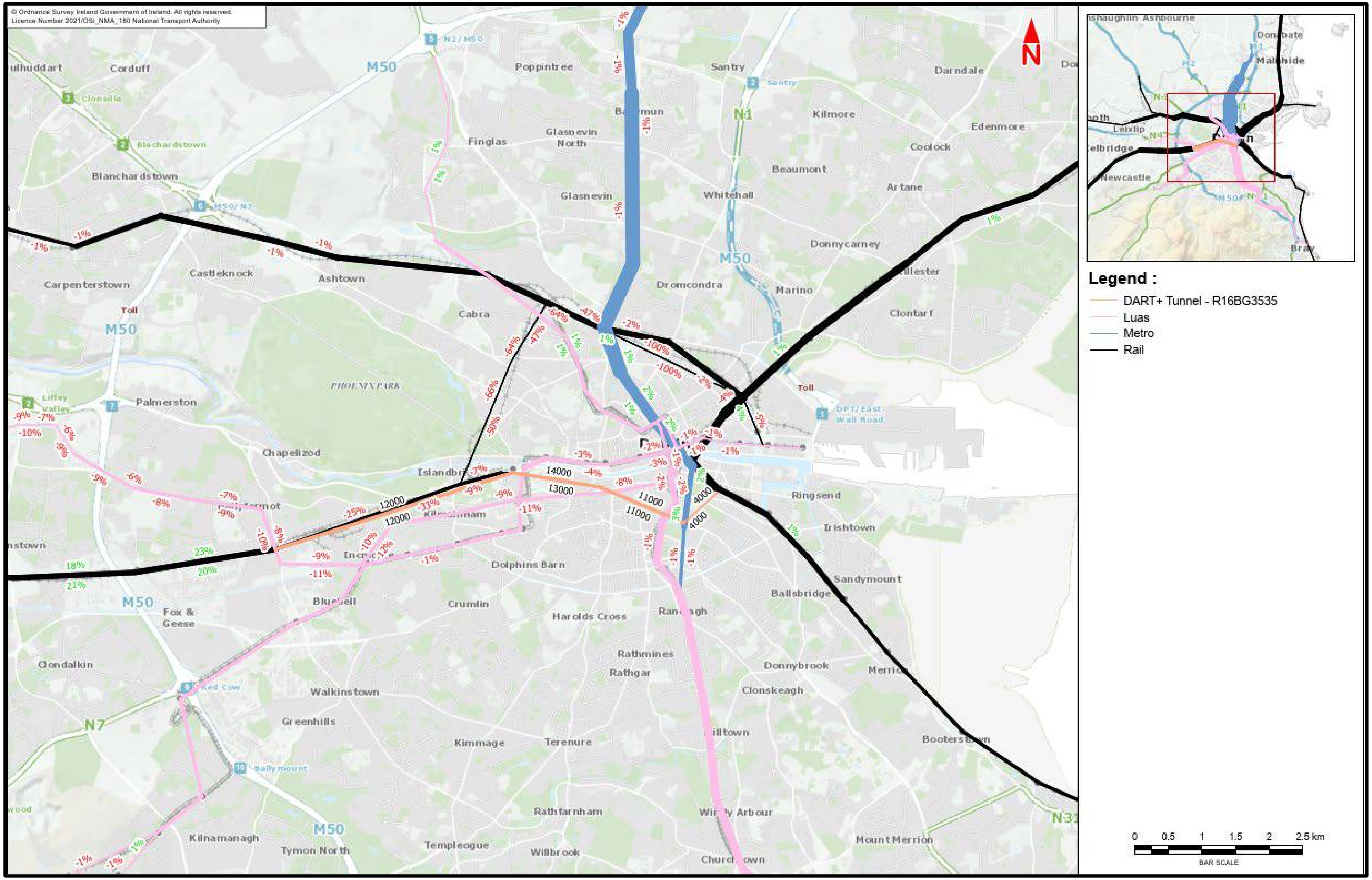


Figure 5-61: Difference in Daily Rail Passenger Volume between R16 and Do Minimum in 2035

Boarding and Alighting

This section summarises the AM peak boarding and alighting movements that arise from the catchment area of each station. Figure 5-62 shows the number of AM peak hour boarding and alighting movements by station for the R16 route alignment scenario. The station with the highest alighting movements is St. Stephen's Green underground station, noted to be a highly used station due to the presence of both the Luas stop and MetroLink station at the same location for interchange..

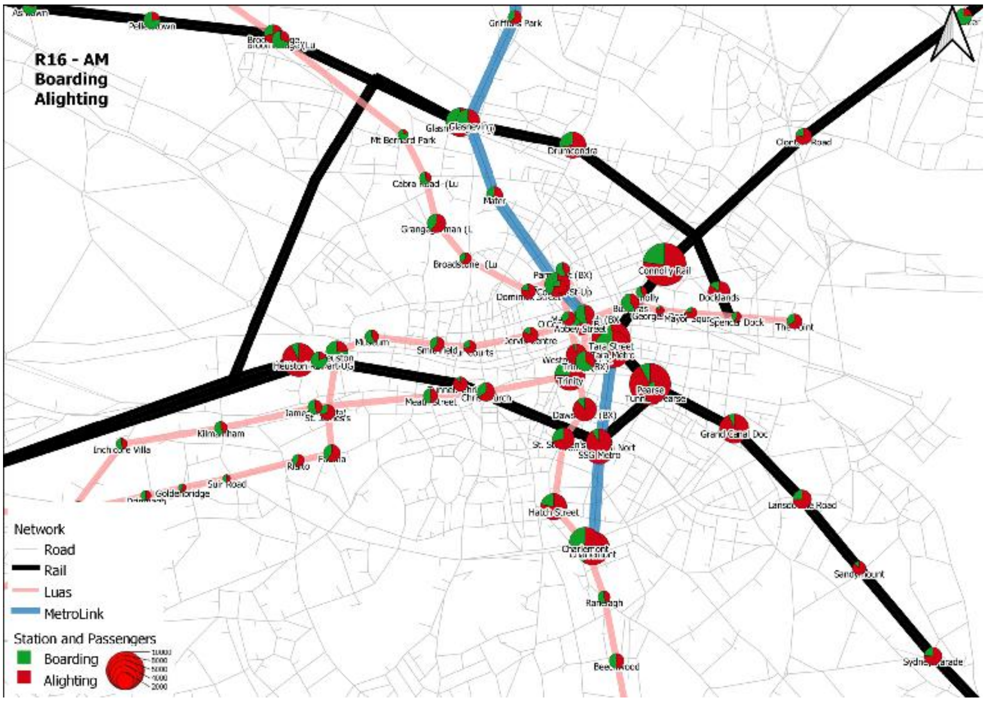


Figure 5-62: R16 AM peak Boarding and Alighting movements by station in the study area

Table 5-14 shows the comparison of boarding and alighting movements in the AM peak hour at key stations in 2035. The greatest change in boarding movements is at Heuston railway station where there is 63% less movements, and the greatest change in alighting movements is at Glasnevin railway station where there is 20% less than in the Do Minimum. There is also significant reductions at Connolly stations along the coastal DART line as compared to the Do Minimum. In contrast, Hazelhatch and the Luas stop at Heuston have a notable increase in the number of boarding and alighting movements due to them having a direct connection to the city centre. No significant impacts are seen in the number of boarding and alighting movements at the other Luas and MetroLink stations.

Table 5-14: Comparison of AM Peak boarding and alighting movements at key stations – R16 vs Do Minimum

Station Name	**Percentage of Increase and Decrease in Boarding and Alighting figures compared to Do Minimum Scenario**	
	Boarding	Alighting
Hazelhatch	+51%	+3%
Conolly Luas	-4%	+9%
The Luas stop at Heuston	+7%	+1%
Glasnevin Rail	-5%	-20%
Heuston Rail	-63%	-15%
Connolly Rail	-7%	-12%

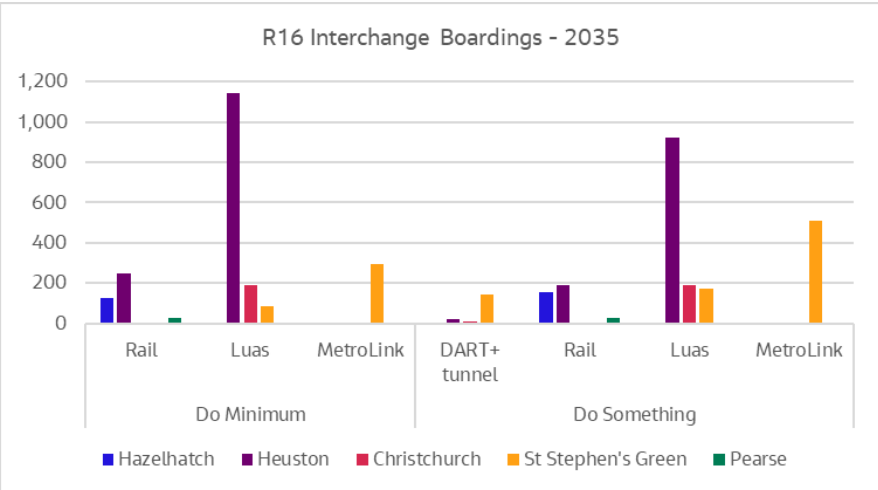
Interchange movements

This section summarises the boarding and alighting movements by station that arise from or to other transport modes (i.e., Rail, Luas and MetroLink). The number of 2035 AM peak hour interchange movements (by boarding and alighting) by station in the Do Minimum and R16 is shown in Figure 5-63.

On the introduction of R16, it is seen that St Stephen's Green underground heavy rail station is the most used station for interchange. There is a slight increase in interchange boarding and alighting at the MetroLink station at St. Stephen's Green of approximately 73% and 9% respectively.

A slight decrease in interchange boarding and alighting is observed at Heuston. The Heuston railway station experiences a 24% decline in interchange boarding and a 31% decline in interchange alighting. The Luas stop at Heuston notes a decrease in interchange boarding by 20% and no change in interchange alighting.

Usage of the Pearse underground heavy rail station for interchange has also been noted whilst very low usage of Heuston and Christchurch underground heavy rail station has been observed for interchange, as seen in Figure 5-52.



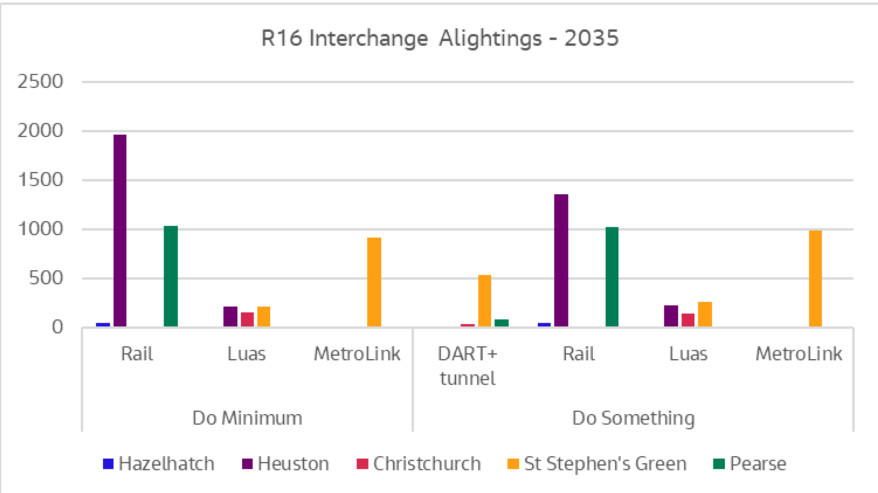
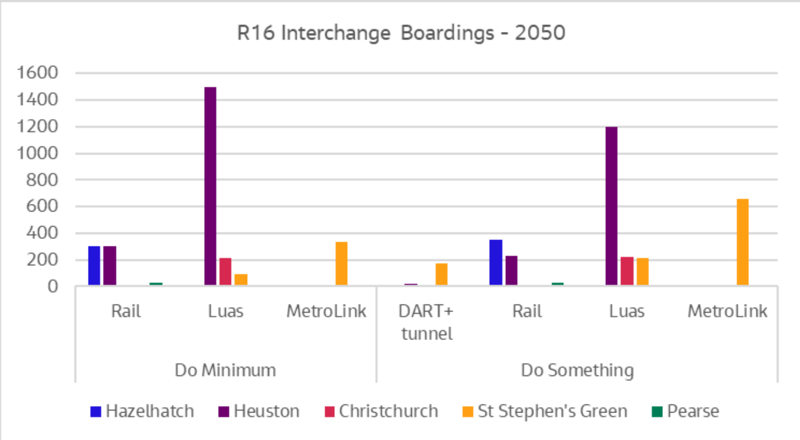


Figure 5-63: R16 AM Peak Hour Interchange Boarding and Alighting figures in 2035

A similar trend was observed for the boarding and alighting figures in 2050, where interchange boarding at the MetroLink station at St. Stephen's Green was increased by 96% when compared to the

Do Minimum in 2050. A decline of Heuston boarding and alighting was observed for both Rail and Luas.

Figure 5-64 shows the number of AM peak hour interchange boarding and alighting movements by station in 2050 for the Do Minimum and R16.



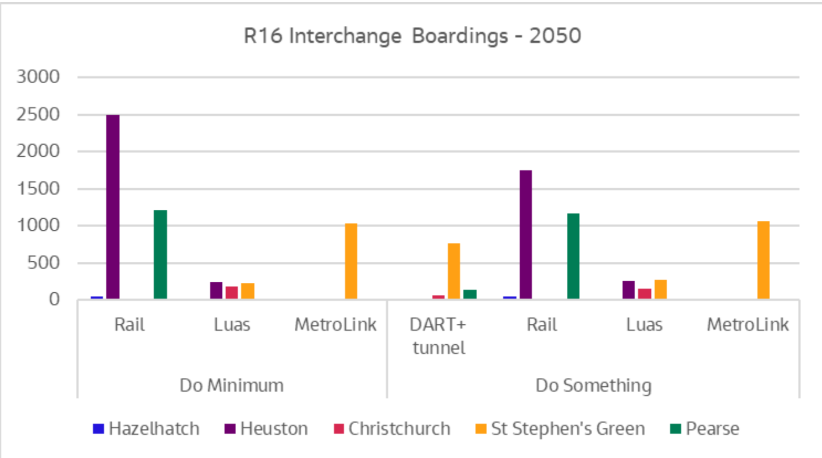


Figure 5-64: R16 AM Peak Hour Interchange Boarding and Alighting figures in 2050

Passenger loadings by line - Luas Services

Figure 5-65 presents the number of daily passengers travelling on each of the Luas lines (Red, Green, and Lucan) by stop (on departure from each respective stop) for the 2050 Do Minimum scenario and the 2050 R16 scenario. The stops are arranged from city limits stops to city centre stops from left to right. As shown in the figure, R16 generally results in less patronage on the Lucan Line but very similar flows on the Red and Green lines. On the Red line R16 patronage is generally the same between R16 and the Do Minimum expect on the section of line from Heuston stop to Jervis Centre stop where patronage is 2-3% lower in R16 than in the Do Minimum. The Lucan line has approximately 10% less passengers in the R16 scenario as compared to the Do Minimum across the majority of stops in the Lucan line. The Green line has typically less than 3% difference between the scenarios at all stops.

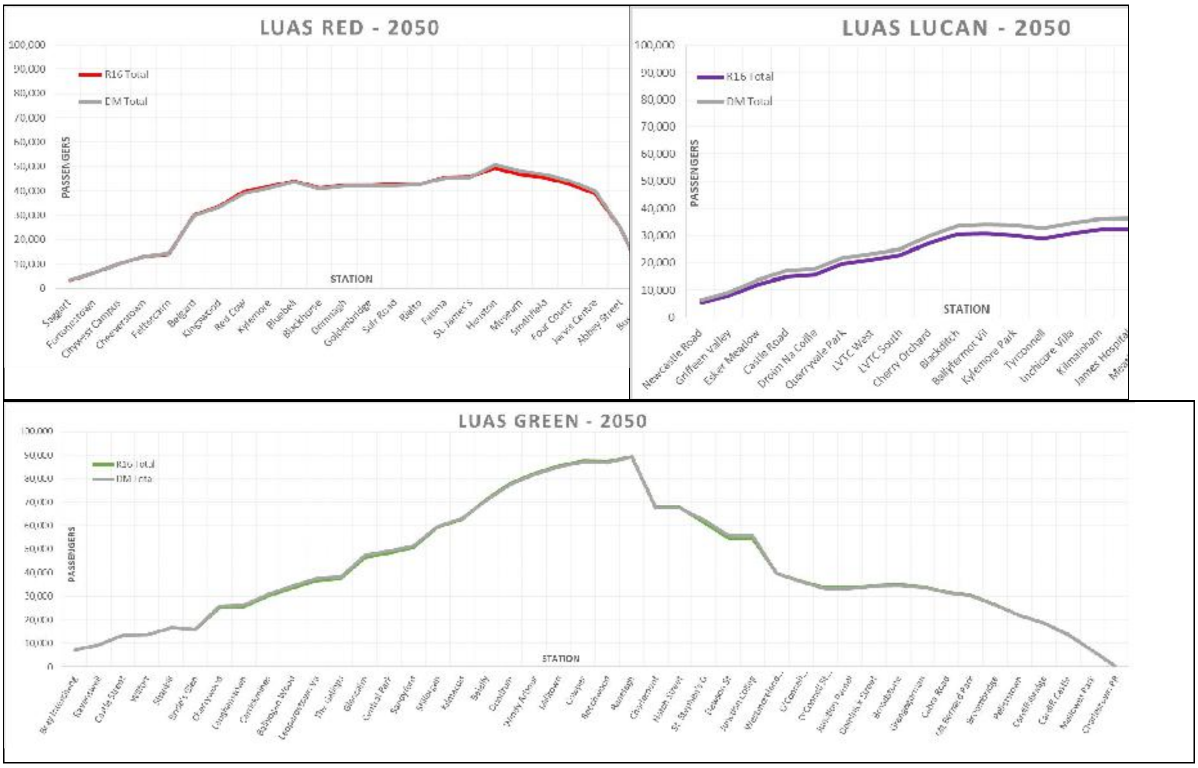


Figure 5-65: 2050 Luas Daily Passenger Flow R16 vs Do Minimum

Passenger loadings by line - MetroLink

Figure 5-66 presents the number of daily passengers travelling on MetroLink by station (on departure from each respective station) for the 2050 Do Minimum scenario and the 2050 R16 scenario. The stations are arranged from city limits stations to city centre stations from left to right.

As shown in the figure, R16 results in approximately 2,000 additional passengers (+3%) than the Do Minimum on the section of line from Glasnevin station to Tara Street MetroLink station. This additional patronage in R16 (notably at Glasnevin station) is likely to be the result of the operation changes applied to the Northern Line in the R16 scenario while the Phoenix Park Tunnel services are significantly reduced which has discouraged people to transfer between MetroLink and DART at Glasnevin.

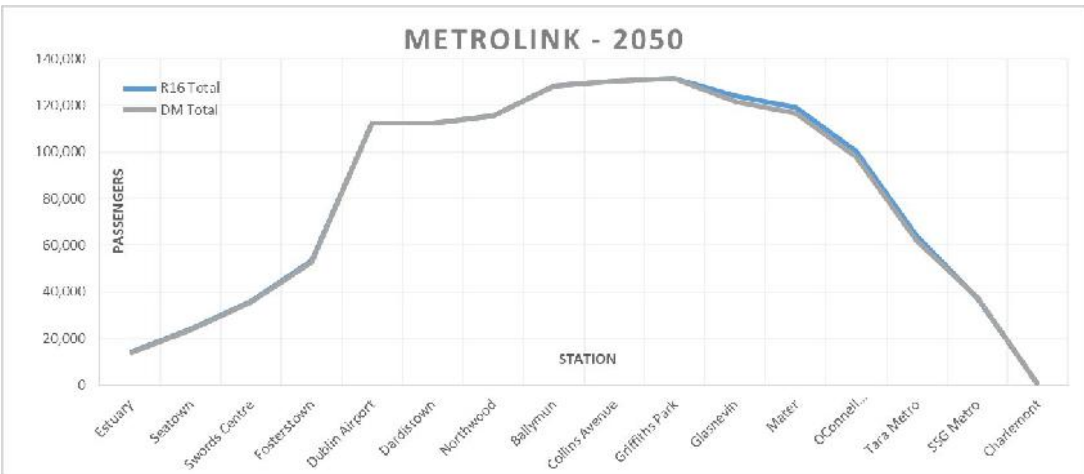


Figure 5-66: 2050 MetroLink Daily Passenger Flow R16 vs Do Minimum

Passenger loadings by line - Rail

Figure 5-67 presents the number of daily passengers travelling on the Northern Line and South Eastern Line. The figures are presented by station (on departure from each respective station) for the 2050 Do Minimum scenario and the 2050 R16 scenario. The stations are arranged from city limits stations to city centre stations from left to right.

As shown in the figure, R16 has very similar patronage on the Maynooth Line (except between Glasnevin Station and the City Centre), the Northern Line, and the Southern Line compared to the Do Minimum scenario, but more patronage on the Kildare Line.

Maynooth Line attracts very slightly more passengers (+1%) in the R16 scenario than in the Do Minimum scenario except between Glasnevin Station and the City Centre where the R16 has approximately 7,500 less passengers (12%) than the Do Minimum . The reduction between Glasnevin Station and the City Centre is because the Phoenix Park Tunnel services which run through this station are significantly reduced when the DART+ Tunnel scheme is in place.

Passenger volume on the Northern Line in the R16 scenario is generally within 2% of the passenger volume in the Do Minimum scenario.

The Kildare Line corridor is the line that is most affected by the scheme. The demand along the Kildare Line is much greater in the R16 scenarios as compared to the Do Minimum. At the City Centre patronage is approximately 11,100 more passengers (+18%) in R16 than in the Do Minimum. Passengers using the Phoenix Park Tunnel in the Do Minimum are diverted to the DART+ Tunnel in R16 and approximately 10,800 passengers remain on services through the Phoenix Park Tunnel (down 60%).

Passenger volume on the South Eastern Line in the R16 scenario is generally within 1% of the passenger volume in the Do Minimum scenario.

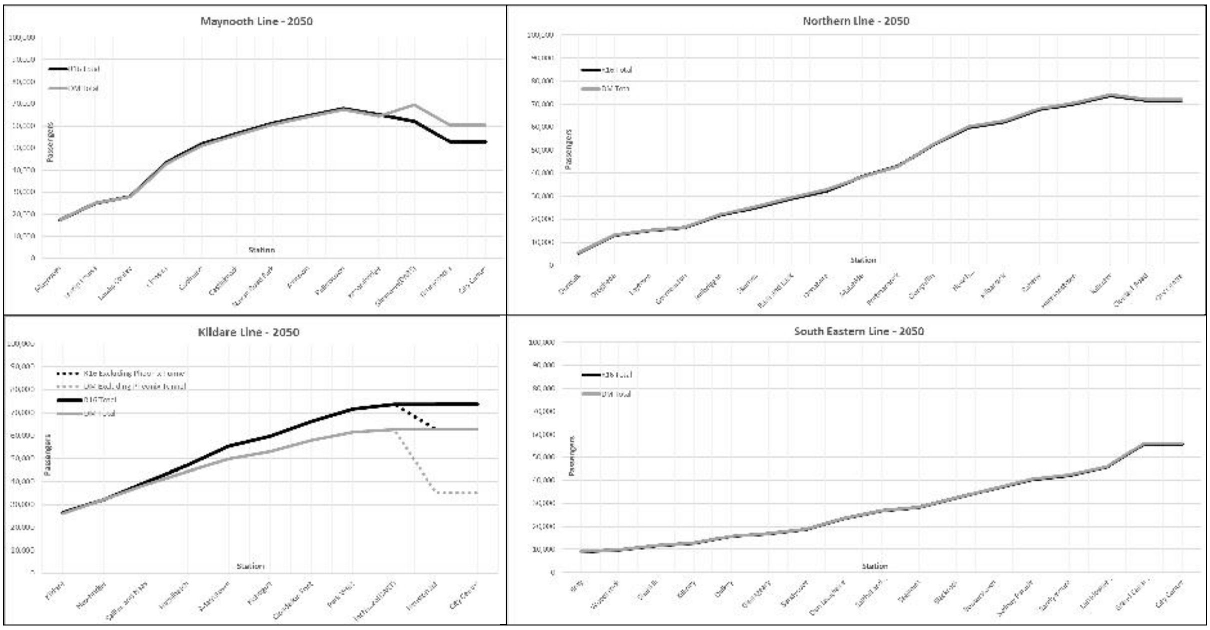


Figure 5-67: 2050 Rail Daily Passenger Flow R16 vs Do Minimum

5.3.1.6 Environment

St. Stephen's Green and Pearse underground station locations are situated within the Historic Centre of Dublin City Designated Site, and Christchurch is located within the zone of archaeological potential for at least one RMP site. No direct ecological constraints were identified. All proposed stations are situated in built up areas of an urban landscape environment, however one of them is located within St

Stephen's Green, which will likely impact the visual amenity of the area. The proposed station at Pearse Station could also encroach into Merrion Square which is of notable architectural heritage value.

All proposed stations are situated close to high density residential and commercial properties, allowing for the potential of disruption to communities and businesses. The proposed station at Pearse Station is adjacent to a number of educational institutions (Westland Row CBS, Saint Andrews National School and Trinity College Dublin).

5.3.1.6.1 Heuston Station

Refer to S1 R01 description in 5.2.2.6.1

This station is in all five options – S1 R01, S1 R02, S1 R03, S1 R09, and S4 R16.

5.3.1.6.2 Christchurch Station

Refer to S1 R01 description in 5.2.2.6.2

5.3.1.6.3 St Stephen's Green Station

Refer to S1 R03 description in 5.2.4.6.3

This station is in three of the options –S1 R03, S1 R09, and S4 R16.

5.3.1.6.4 Pearse Turnback

The Turnback Facility is located at a depth at which there will likely be little surface works aside from ventilation and fire exit shafts, allowing for limited environmental impacts. There will be significant works associated with this facility.

5.4 Intermediate Shaft Provision

Typically, intermediate shafts are provided for the following purposes: i) at low points to enable the discharge of infiltration water collected in the tunnel, ii) to provide emergency access/egress and iii) to provide ventilation.

5.4.1 Low Point Sump shafts

It is assumed for the purpose of this study, if a low point must be provided between stations for alignment purposes, then any infiltration water will be pumped to the nearest station for discharge and a dedicated shaft would not be required.

5.4.2 Emergency Access/Egress

Regarding the location of ventilation/intervention shafts, it is noted that BS9992 prescribes a 1km separation whereas the European Regulation 402/2013 (amended by Regulation (EU) N°2015/1136) will allow 2km provided that this is supported through a risk assessment, such that the resulting design provides a level of safety equivalent to that in a station or tunnel that complies with recognised prescriptive codes. This may include comparison with similar systems.

Precedence is available from other schemes such as Crossrail and HS2 where 3km between shafts is deemed to provide sufficient comparison. Future stage work may include analytical justification to demonstrate safety is not compromised even when more than one train circulates in a single ventilation section. Table 5-15 provides the distances between escape facilities assumed to be near platform ends for the different alignment options:

Table 5-15 Escape and Ventilation Spacing

Section lengths between Underground Station Platform Ends/ Portals				
S1 R01	S1 R02	S1 R03	**S1 R09**	**S4 R16**
Portal	Portal	Portal	Portal	Portal
1620	1620	1630	1630	1630
Heuston Station				
1270	1100	1280	1280	1280
Christchurch Station				
1050	860	970	960	960
Tara Street	St. Patrick's Cathedral	St. Stephen's Green	St. Stephen's Green	St. Stephen's Green
1290	1570	1630	800	800
Docklands Station	Charlemont Station	Grand Canal Dock Station	Pearse Station	Pearse Station
140	1580	730	880	620
Portal	Grand Canal Dock Station	Docklands Station	Docklands Station	Turnback End
	710	170	170	
	Docklands Station	Portal	Portal	
	170			
	Portal			

This table demonstrates that at no point are the ventilation shafts at platform ends of stations / portals more than 1750 apart and therefore the European Regulation could be satisfied.

5.4.3 Ventilation

The fire strategy for the scheme will require that there is no more than one train per ventilation section. With planned headways of 3 minutes, inclusive of dwell times of 60 seconds, 20 trains per hour could feasibly operate. Trains would likely require 228 seconds to cover a distance of 1750m (inclusive of a station stop and acceleration) at an average speed of 50kph assuming trains pass the western tie-in at line speed. Trains operating every 3 minutes would mean no more than one train per ventilation shaft.

6. Stage 2 Assessment

6.1 Introduction

The five short-listed route options were analysed in a detailed MCA (Stage 2) in order to determine a best performing option. The short-listed routes were analysed in terms of their performance against the criteria cited in Section 6.2, the results of which were then fed into the MCA assessment.

6.2 Stage 2 Assessment Criteria

The work for Stage 2 assessed the route options based on Economy, Safety, Integration, Environment, Accessibility and Social Inclusion. These criteria have been adopted from the Common Appraisal Framework for Transport Projects and Programmes (CAF) and are summarised here.

The appraisal of economic impacts utilises both qualitative and quantitative data and considers the potential economic impacts that might be delivered through a more efficient and effective transport network. At this stage we did not consider the full potential welfare gain from the project and we are primarily aiming to ascertain the option that is the most efficient and effective solution.

There are a number of sub-criteria considered as part of this as listed below:

- **Overall Cost –** This criterion considers the overall construction and operational cost of the proposed route option.
- **Journey Time Saving –** This identifies the public transport journey time saving delivered by the route option.
- **Rail Operational Efficiency –** This considers what potential operational efficiency to the overall rail network is provided by the different options.
- **Assessment of Costs and Benefits –** This monetises the transport benefits provided by the route option along with the construction and operational costs of the route. It presents the transport user Present Value of Benefits and identifies an overall Benefit to Cost ratio.
- **Safety –** Safety is considered for the construction and operating periods with Safety & Design utilised for Operation and Maintenance Safety and Construction Safety.
- **Integration –** The integration criteria considered the extent to which the proposed schemes integrated with the receiving public transport network and aligned with Government policies. The local policy integration sub-criterion assessed the integration of route alignment with local area plans (LAPs), Strategic Development Zones (SDZs), and the Dublin City Development Plan 2016-2022. It also assesses the ability of each route option to support existing and established land uses, urban regeneration, urban consolidation, housing, employment, economic and recreation opportunities.
- **Environment criteria -** The approach to the environmental appraisal is to identify the feasible options and allow those to be taken forward to the next stage of the project for further design and assessment. This is a phased approach to the assessment and is the standard approach taken on large infrastructure projects. The key differentiators that have been identified for assessment are:
    - **Population**: all aspects of the human environment – general amenities; places of work, worship, commercial and residential receptors, etc.;
    - **Archaeology, Architectural and Cultural Heritage**: protected and important features of the built environment;
    - **Landscape and Visual**: the quality of the landscape or townscape and its appearance;
    - **Biodiversity**: protected and important features of the built environment;
- **Accessibility and Social Inclusion -** Government objectives for reducing social exclusion have been set out in the National Action Plan for Social Inclusion 2007-2016 (NAPSI), along with the update to the plan during 2015 -2017. The NAPSI strategy aims to reduce, and ideally, eliminate poverty and social exclusion which affects vulnerable groups. The term vulnerable

groups can include vulnerable women, children, young people, older people, people with disabilities, ethnic minorities, lower-income socio-economic groups and identified deprived areas. The following sub-criteria are used to examine improvements in Accessibility and Social Inclusion.

- **Accessibility to key trip attractors –** This considers how a route option improves access to key trip attractors, such as hospitals, within the study area.
- **Public Transport Accessibility –** This sub-criterion examines how a route option improves access to public transport services for residents within the study area.
- **Access to areas of low deprivation –** This criterion uses An Pobal's deprivation index to examine how a route option improve access to the areas with low deprivation index scores.

Table 6-1: Summary of Stage 2 Analysis Criteria

Stage 2 Analysis Criteria	Sub-criteria
Economy	Cost
	Journey Time savings
	Rail Operational Efficiency
	Assessment of Costs and Benefits
Safety	Operation and Maintenance Safety and Construction Safety
Integration	Land Use Policy Integration
	Public Transport Transfer Metrics
Environment	Material and Cultural Aspects (Archaeology, Architectural and Cultural Heritage)
	Biodiversity
	Population
Accessibility and Social Inclusion	Landscape and Visual
	Accessibility to key trip attractors
	Public Transport Accessibility
	Access to areas of deprivation.

The Banding Definition for Stage 2 assessment is as shown in Table 6-2.

Table 6-2: Banding Definition

Colour	Metric Definition
	Significant advantages over other options
	Some advantages over other options
	Comparable to other options
	Some disadvantages over other options
	Significant disadvantages over other options

Each of the Stage 2 Analysis Criteria are discussed in detail in the following Sections.

7. Stage 2 – Economy

The impacts of each of the five short-listed route options on economic growth and competitiveness are assessed in this section. The sub-criteria used for the assessment are Scheme Cost, Public Transport, Journey Time Savings, Rail Operational Efficiency and the Assessment of Costs and Benefits. The options are then scored on each sub-criterion, and an average score for Economy overall is then assessed.

7.1 Cost

7.1.1 Capital Costs

During the Stage 1 Preliminary Options Assessment, comparative base cost estimates were developed for each route option using costing information from the following studies:

- DART Underground Western Tie-in Study (October 2017);
- Tunnel Configuration Study for the DART Underground (February 2017);
- DART Underground Railway Order reference design (June 2010), and;
- Interconnector Study – Stage 3 (June 2003).

The base cost data obtained were ultimately used to determine cost rates per linear metre of tunnel and station, which included preliminaries, contractor's overheads and profit insurance, design, project management, risk allowance (of 25%), and escalation to 2021.

At Stage 2, the comparative base cost estimates determined for each route option were refined to take account of the design work completed in firming up the route lengths, as well as other costs attributed to the construction complexities and constraints associated with the different route options, most notably the following:

- The route interface with the proposed Spencer Dock station (S1 RO1, S1 RO2, S1 RO3, S1 RO9);
- Construction in and adjacent to the Grand Canal (S1 RO2, S1 RO3);
- The route interface with the MetroLink scheme (all route options);
- The requirement for deep bored tunnels, lengthy passenger access routes and conflict with the existing elevated viaduct and the 2.4m trunk sewer, a major interface, at Tara Street Station (S1 RO1);
- Space constraints at St Patrick's Cathedral (S1 RO2);
- Space constraints at Christchurch Station (S1 RO1, S1 R02, S1 R03, S1 RO9, S4 R16).

The comparative capital costs for each route option are shown in Table 7-1. These are high level cost estimates reflecting concept design and do not include land and property acquisition costs, operation and maintenance (O&M) costs, VAT, inflation, and contingency/optimism bias. The inclusion of these additional elements could result in an ultimate budget for the DART+ Tunnel ranging between €5bn and €6bn. Given this early stage of the assessment, further development and refinement of the scheme's design would be required to adequately account for all cost elements and provide a more complete cost estimate.

Table 7-1 Comparative Capital Costs

Option		Stations on Route	Overall Route Length	No of Stations	Comparative Cost €Bn	Score
S1	R01	Heuston – Christchurch – Tara – Docklands	7.40	4	€2.40	
	R02	Heuston – Christchurch – St. Patrick's Cathedral – Charlemont – Grand Canal Dock – Docklands	9.97	6	€3.20	
	R03	Heuston – Christchurch – St. Stephen's Green – Grand Canal Dock – Docklands	8.55	5	€2.70	
	R09	Heuston – Christchurch – St. Stephen's Green – Pearse – Docklands	7.84	5	€2.60	
S4	R16	Heuston – Christchurch – St. Stephen's Green - Pearse	6.35	4	€2.30	

7.1.2 Operation and Maintenance Costs

A single annual figure for comparative O&M costs is provided for each route based on the 2014 Railway Order data for the DART Underground project which has been updated to Q3 2021 using indices provided by the Building Cost Information Service of The Royal Institution of Chartered Surveyors and earnings data from ROI Central Statistics Office. Comparative O&M Costs are shown in Table 7-2 .

Table 7-2 Comparative O&M Costs

Annual O&M Costs	Route				
	R01	R02	R03	R09	R16
	€M	€M	€M	€M	€M
Station Operations	2.30	3.46	2.88	2.88	2.30
Maintenance	11.39	15.34	13.16	12.06	9.77
Renewals	12.27	16.53	14.17	13.00	10.53
Central Admin.	0.14	0.19	0.16	0.15	0.12
Total	26.06	35.51	30.37	28.09	22.72
Score					

7.1.3 Summary

The band placement of the route alignment options in terms of cost is shown in Table 7-3.

Table 7-3: Summary of Costs banding

Option		Stations on Route	Capital Costs	O&M	Overall Cost
S1	R01	Heuston – Christchurch – Tara – Docklands			
	R02	Heuston – Christchurch – St. Patrick's Cathedral – Charlemont – Grand Canal Dock – Docklands			
	R03	Heuston – Christchurch – St. Stephen's Green – Grand Canal Dock – Docklands			
	R09	Heuston – Christchurch – St. Stephen's Green – Pearse – Docklands			
S4	R16	Heuston – Christchurch – St. Stephen's Green - Pearse			

7.2 Journey Time Saving

Figure 7-1 presents total journey time saved by each route option in 2050 as compared to the 2050 DoMinimum. This statistic is calculated by determining the difference between total Public Transport journey time (the sum of Public Transport journey time multiplied by Public Transport demand across all origin and destination pairs (ODs) in the 2050 DART+ Tunnel scenario) and total Public Transport journey time in the 2050 DoMinimum scenario.

This statistic differentiates options based the overall journey time impact. R02 and R09 have significant advantages over other options with over 4,500 hours of Public Transport journey time savings. R03 has some advantages over other options with 4,300 hours of Public Transport journey time savings. R16 has significant disadvantages over other options with the least time saving among all options.

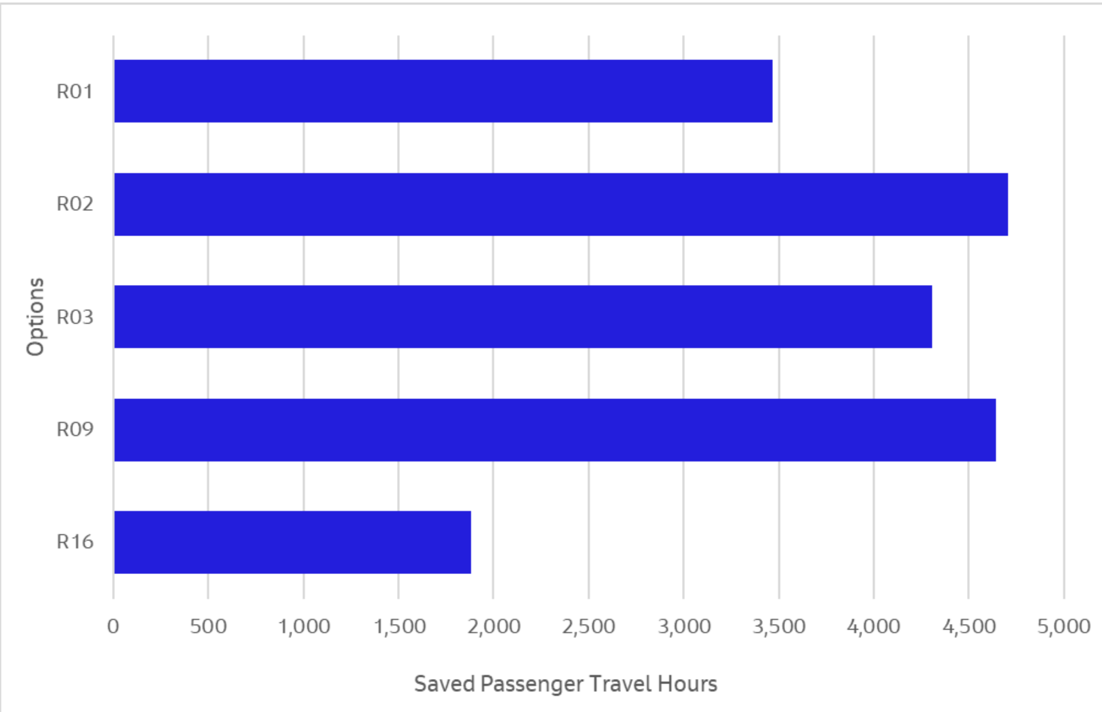


Figure 7-1 Public Transport Saved Passenger Travel Hours

Table 7-4 presents journey time savings scores for the five short-listed options. The scores are qualitatively determined and are based on the difference in journey time savings of the option from the average journey time savings across the five short-listed options.

Table 7-4: Journey time savings scores for the five short-listed options

Option		Journey time savings	Difference from average	Score
S1	R01	3,466	-335	
	R02	4,704	903	
	R03	4,309	509	
	R09	4,645	845	
S4	R16	1,880	-1,921	
Average		**3,801**		

7.3 Rail Operational Efficiency

The Rail Operational Efficiency for the Scenario 1 options – R01, R02, R03 and R09 – are previously described in section 5.2.2.4 and that for S4 R16 is described in 5.3.1.4. The scores for Rail Operational Efficiency are included in the overall summary for the Economy criteria in Table 7-6.

7.4 Assessment of Costs and Benefits

A public transport user benefits appraisal has been undertaken for each of the five-short listed options. The appraisal of each alignment option has followed the same defined process. The appraisal has been conducted using the NTA Appraisal toolkit and TUBA v1.9.13. The economics parameter file used has been updated in line with the most recent update of the Common Appraisal Framework (CAF) and guidance. Table 7-5 presents the Present Value of Benefits (PVB), Present Value of Costs (PVC), the Net Present Value (NPV) and an assessment of costs and benefits for each of the five short-listed options.

The data presented is for the transport user benefits only and is only intended the purpose of the comparative assessment for this Route Options and Feasibility report only. There are other benefits that would be identified and presented within a business case but these are beyond the scope of this report. As shown, R09 accrues the most benefits (just over €1 billion). R02 and R01 have the next highest PVB at €0.9 billion and €0.8 billion respectively. R03 has a PVB of €0.75 billion, and R16 has a PVB of just €60 million.

The options have present value of costs of between approximately €1.3 billion and €1.8 billion. R02 has the highest cost of €1.8 billion and R16 has the lowest cost of €1.3 billion (Note that costs exclude property and land acquisition costs). All options have an assessment of costs and benefits below 1. The average ratio of cost against benefit for the route alignment options under Scenario 1 is 0.57. S1 R09 provides the highest ratio of 0.7 whereas the route alignment option with the lowest ratio of 0.05 is S4 R16. S1 R01 has a ratio of 0.6, while S1 R02 and S1 R03 each have a ratio of 0.5.

Table 7-5: Assessment of Costs and Benefit scores for the five short-listed options

Option		PVB	PVC	NPV	BCR
S1	R01	€ 806m	€ 1,370m	-€ 746m	**0.6**
	R02	€ 905m	€ 1,854m	-€ 1,194m	**0.5**
	R03	€ 748m	€ 1,554m	-€ 1,012m	**0.5**
	R09	€ 1,071m	€ 1,502m	-€ 627m	**0.7**
S4	R16	€ 60m	€ 1,300m	-€ 1,412m	**0.05**

7.5 Banding Outputs

Table 7-6 presents a summary of the scores for each Economy sub-criteria for the five short-listed options, and then an overall band for Economy has been assessed. The result of this is that R09 has significant advantages over other options under the Economy criterion.

Table 7-6: Economy scores for the five short-listed options

Option		Costs	Journey time savings	Rail Operational efficiency	Assessment of Costs and Benefits	Average Demand Score
S1	R01					
	R02					
	R03					
	R09					
S4	R16					

8. Stage 2 – Safety

The Safety criterion assessment has been made against two sub-criteria, that is, for relative Operational & Maintenance (O&M) Safety, and for Construction Safety. These are discussed below.

8.1 O&M Safety

In Operational and Maintenance (O&M) safety, the assessment favours the run-through routes where train operations for the tunnel itself are at their simplest as trains progress under signalling control in a single direction through the system. For the R16 route, where a turnback is required, the scenario includes the following adverse risk factors:

- Conflicting train moves
- Crews changing ends on the turnback siding tracks
- Trains stabling in the confined turnback cavern
- Maintenance of the operationally critical Switch & Crossing work of the turnback for which there is no redundancy.

The redeeming feature for R16 is the avoidance of the need to integrate trains into the existing system operations from the Northern Line. However, this does not outweigh its disadvantages.

8.2 Construction Safety

In Construction Safety, the relative banding hinges on the following risk factors:

- The number of stations – each station being a separate construction site with all the interfaces and risks requiring mitigation to avoid hazards and loss.
- The number of interfaces between new tunnelling and groundworks and the historic railway infrastructure not benefitting from modern construction and sound records.
- Construction methodology and integration for the proposed underground station at Grand Canal Dock
- Integration of construction with other critical infrastructure such as the Victorian-built 8ft (approx. 2.4m) diameter trunk sewer on Townsend Street complicating the Tara Street works in R01 option.
- The settlement and construction risks requiring major mitigation for the construction of a turnback cavern beyond Pearse Station in the R16 option.

MetroLink will likely proceed before DART+ Tunnel, noting that the MetroLink Railway Order will be submitted shortly. It was felt that a construction exposure to the relatively new infrastructure of MetroLink created less of a risk, a) because there is opportunity to build mitigation into the MetroLink design, and b) because MetroLink will be well recorded and should present far fewer uncertainties for what is assumed to be prior to construction of the DART+ Tunnel works.

It is also the case that every route option has just one MetroLink interface and this therefore cannot be a route differentiator.

8.3 Banding

Under both sub-criteria, an assessment was made as to the relative safety of an option; with the safest category represented by dark green and the least safe being represented by red (as outlined previously in Table 6-2). Considering the result in each sub-criterion, an overall assessment was concluded on the same basis.

All of the route options contained at least one of the construction risk factors noted above, so none were scored dark green (i.e., as ideal options).

- Route R01 was assessed to have some advantages over other options in construction because it only has 4 stations and for construction works at the existing Tara Street station it has an interface with the sewer in Townsend Street and the existing DART infrastructure on Victorian arches above. Combined with it run through advantage in operation it was assessed as light green overall.
- Route R02 was assessed to have some disadvantages over other options in construction because it has 6 stations, the additional one most difficult to construct being Grand Canal Dock, where a number of additional safety hazards of integration with the dock operations will be present. Combined with its run through advantage in operation it was assessed as yellow overall.
- Route R03 was assessed to be comparable to other options in construction because it has 5 stations, the additional one also being at Grand Canal Dock where a number of additional safety hazards of integration with the Grand Canal Dock operations will be present. Combined with its run through advantage in operation it was assessed as yellow overall.
- Route R09 was assessed to have some advantages over other options in construction because it only has 4 stations but does require construction below the Victorian infrastructure of the existing DART system at Pearse. Combined with its run through advantage in operation it was assessed as light green overall.
- Route R16 was assessed to be comparable to other options in construction because while only having 4 stations it includes construction below the Victorian infrastructure at Pearse as well as the formation of the turnback cavern beyond Pearse Station. When combined with the disadvantages of the turnback train moves in the O&M safety sub-criterion, it was assessed as yellow overall.

Table 8-1: Safety scores for the five short-listed options

Option		Operations & Maintenance Safety	Construction Safety	Overall Safety Assessment
S1	R01			
	R02			
	R03			
	R09			
S4	R16			

9. Stage 2 – Integration

This chapter details the performance of the five short-listed route alignment options in terms of Land Use Policy Integration and Public Transport transfer.

9.1 Land Use Policy Integration

The five route alignment options have been assessed in terms of its ability to serve the land use and objectives in the Local Area Plans (LAPs) and Strategic Development Zones (SDZs). They have been analysed based on the extent to which these route alignment options integrate with the current and future policy through the strategic locations of the proposed stations, along with its capacity to provide interchange opportunities with the other transport modes specified in the Transport Strategy for the GDA 2016-2035.

The following sub-sections provide detailed description of each relevant policy document in the context of a route alignment options performance.

9.1.1 St. George's Quay Local Area Plan

The area extent of St. George's Quay Local Area (LAP) plan extends from Hawkins Street on the west side to Lombard Street to the east and from the banks of the Liffey to Pearse Street north to south. Among the five route alignment options, R01 has the proposed Tara Street station within the LAP's extent while route options R09 and R16 have the proposed Pearse Station. This station is sufficiently close to the LAP boundary to provide connectivity and access to the LAP.

The DART+ Tunnel scheme (although separate from the DART+ Programme infrastructure works) is in alignment with the following objectives of the LAP:

- To support and facilitate the delivery of a strong character area, consolidating the area as a major employment hub benefiting from excellent public transport connectivity;
- To link the City Centre to Docklands area with a focus on sustainable development; and
- To seek active mixed uses at street level, attractive pedestrian and cycle linkages to and through the area linking key nodes and transport interchanges.

As a result, R01, R09 and R16 are considered to support the overall objectives of the LAP.

The future land use of St. George's Quay includes suitable locations for high quality, modern office uses to support city centre economic activity and mixed uses, with residential more prominent at the eastern end. The LAP cites that it is intended that the concentration of office uses to the west of the Loop Line would continue, and the use of this area for high quality, attractive new office type development will extend the city centre area deeper into the LAP and support existing connections and synergy along the riverside from the city centre towards the new business areas of the Docklands area.

There are a significant number of regeneration and redevelopment of areas within the George's Quay LAP that these route alignment options are expected to support. They are described in brief detail as follows:

- **Hawkins Street -** The redevelopment of the Hawkins Street block into a new regenerated street block providing key linkages and a more attractive and interesting setting for College Green is cited in the LAP;
- **New residential units -** The provision of new residential units within the George's Quay area to ensure the mixed-use character of the area is supported and balanced with new office and commercial uses.

- **City Quay** - The provision for a mix of uses on two sites in City Quay, with a minimum of 20% of the floor area devoted to uses other than the primary use sought. Of this 20%, up to 10% can be provided a new public open space provided by the site to the benefit of the public.
- **Tara Street Station Site –** The provision of a public plaza that coherently integrates public and private lands as part of an improved station concourse and responds to existing and future desire lines including a new pedestrian route.

The route alignment R01 has an underground station at Tara Street station, which is in close proximity to the three most significant development sites. Routes R09 and R16 have the proposed underground Pearse Station, which is expected to acknowledge the redevelopment aims of the LAP (even though it is not within the extent of the LAP).

All other route alignment options do not have any proposed stations within this Local Area Plan.

Table 9-1: Summary of stations within the St George's Quay LAP

Route Alignment	Station Names						Number of stations within LAP
R01	Heuston	Christchurch	Tara Street	Docklands			1
R02	Heuston	Christchurch	St. Patrick's Cathedral	Charlemont	Grand Canal Dock	Docklands	0
R03	Heuston	Christchurch	St. Stephen's Green	Grand Canal Dock	Docklands		0
R09	Heuston	Christchurch	St. Stephen's Green	Pearse	Docklands		1
R16	Heuston	Christchurch	St. Stephen's Green	Pearse			1

9.1.2 The Liberties LAP

The area extent of the Liberties, as described in Section 3.1.3.2, runs along the south bank of the Liffey from Heuston in the west to Christchurch in the east. The eastern edge is formed by Patrick Street and the western edge of St James's Hospital. To the south the boundary follows Mill Street and runs around Oscar Square and Brown Street South before joining Cork Street.

Route alignment options R01, R03, R09 and R16 have two proposed stations (at Heuston and Christchurch) that lie within the area extent of the LAP, whereas R02 has three proposed stations (at Heuston, Christchurch, and St. Patrick's Cathedral), all within the LAP.

The DART+ Tunnel is in alignment with the following objectives of the LAP:

- Improve employment opportunities in the digital media sector with Digital Hub development;
- Promote connectivity and enhance the legibility of the Liberties;
- Make connections to areas outside of the Liberties so that Local residents can avail of a wider range of facilities, public spaces and services;
- Facilitate the development of a rail interconnector between Heuston and Connolly Station through the Liberties with a stop at Christchurch; and

- Promote sustainable modes of transport by facilitating the provision of public transport.

As a result, all five route alignment options are considered to support the overall objectives of the LAP.

There are a significant number of regeneration and redevelopment of areas within the Liberties LAP that these route alignment options are expected to support. They are described in brief detail as follows:

- **Improvement in Housing:** Three areas in the Liberties where redevelopment has been decided and new accommodation is to be built while tenants are to be relocated.
- **Digital Hub**: Two significant development sites to the north and south of Thomas Street (around Christchurch) are being promoted for the digital media industry. This will support the development of the proposed high density, knowledge based, employment corridor and benefit local retailers. It will support the development of St. James' Hospital, a major employer of people living in the Liberties, as the premier teaching hospital.
- **Iveagh Market:** Improvement of public realm around Thomas Street (around Christchurch).
- **New Market**: To develop unique linkage to Meath Street, Francis Street, St Stephen's Green and wider city to increase its potential.
- **Distinct New City Quarter**: Brownfield land provided by Diageo and rationalization to re-integrate the former industrial land into the city fabric and creating new connections through.

As mentioned earlier, all route alignment options have at least two proposed stations (i.e. Heuston and Christchurch) within the LAP. The route alignments will provide good access to the developments cited in the LAP especially those near Heuston and Christchurch such as improvement in Iveagh Market, Housing and Digital Hub employment boost. R02, in particular, has an additional station at St. Patrick's Cathedral which will allow it to provide linkages to the New Market.

Table 9-2: Summary of stations within the Liberties LAP

Route Alignment	Station Names						Number of stations within LAP
R01	Heuston	Christchurch	Tara Street	Docklands			2
R02	Heuston	Christchurch	St. Patrick's Cathedral	Charlemont	Grand Canal Dock	Docklands	3
R03	Heuston	Christchurch	St. Stephen's Green	Grand Canal Dock	Docklands		2
R09	Heuston	Christchurch	St. Stephen's Green	Pearse	Docklands		2
R16	Heuston	Christchurch	St. Stephen's Green	Pearse			2

9.1.3 North Lotts and Grand Canal Dock Strategic Development Zone

The area extent of the North Lotts and Grand Canal Dock (SDZ) extends north and south of the River Liffey at a strategic location. North Lotts immediately adjoins the IFSC, and Grand Canal Dock is in close proximity to the city's central business district and south city retail core area.

All route alignment options under Scenario 1 have at least one station within the SDZ, with route alignment option R02 and R03 each having a station in the Docklands area and at Grand Canal Dock. Route alignment R16 has no proposed station within the area extent of the SDZ.

R09 and R16 have the proposed Pearse Station which is sufficiently close to the SDZ boundary to provide connectivity and access to the Grand Canal Dock area of the SDZ.

The DART+ Tunnel is in alignment with the following objectives of the SDZ:

- To promote community, cultural and recreational development on the peninsula site of the graving docks in the Grand Canal Dock, including the provision of generous landscaped amenity areas and public realm, optimising the unique setting and heritage value of the site and providing a neighbourhood-wide community and recreational resource as a unique attraction in the SDZ area;
- To continue to promote the modal shift from private car use towards increased use of more sustainable forms of transport such as cycling, walking and public transport; and
- To support the area to become one of the most accessible and connected part of the city and State, giving corporate occupiers access to the largest labour market in the country.

As a result, all four Scenario 1 route alignment options (i.e. R01, R02, R03 and R09) are considered to support the overall objectives of the SDZ.

There are a significant number of regeneration and redevelopment of areas within the SDZ that these route alignment options are expected to support. They are described in brief detail as follows:

- **Employment Hub**: There has been significant levels of public investment in enabling physical infrastructure, flagship public realm projects such as the Campshires and Grand Canal Plaza, as well as strategic assets such as the Convention Centre Dublin (CCD) and the Bord Gáis Energy Theatre. These have all underpinned the creation of a quality urban environment as an attractive employment hub, which can be supported by the DART+ Tunnel.
- **Financial and Global corporate innovation centre and business industrial parks Clusters**: Promotion of access to financial clusters such as Convention centre, PWC, Central Bank and global corporate innovation centres such as Google, Accenture and BT are cited within its aims.
- **Residential Provision**: Promotion of the expansion of the residential population in the SDZ and retain the existing population base as their life-cycle requirements change, by providing high quality adaptable homes and quality residential choices. New housing in the SDZ is expected to continue to aspire to create a lasting legacy and positive contribution to housing character in Dublin. These shall be provided in tandem with physical, social and amenity infrastructure including enhanced access to the facilities and amenities of the wider neighbourhood.
- **Retail**: The SDZ facilitates an appropriate level of retail provision commensurate with the growing population in the Docklands area as a newly emerging Key Development Area (KDA), with The Point Village as the designated District Centre.

As mentioned earlier, all route alignment options under Scenario 1 have at least one proposed station within the SDZ at the Docklands area, at the proposed Docklands Station. This location provide good access to the developments cited in the SDZ especially by providing access to hubs of retail, cafes and restaurant, along with the financial clusters stated above. The route alignments with a proposed underground station at Grand Canal Dock, R02 and R03, provide another linkage to digital media clusters as well.

Table 9-3: Summary of stations within the SDZ

Route Alignment	Station Names						Number of stations within LAP
R01	Heuston	Christchurch	Tara	Docklands			1
R02	Heuston	Christchurch	St. Patrick's Cathedral	Charlemont	Grand Canal Dock	Docklands	2
R03	Heuston	Christchurch	St. Stephen's Green	Grand Canal Dock	Docklands		2
R09	Heuston	Christchurch	St. Stephen's Green	Pearse (on boundary)	Docklands		1 and 1 on boundary
R16	Heuston	Christchurch	St. Stephen's Green	Pearse (on boundary)			1 on boundary

9.1.4 Summary

The band placement of the route alignment options in terms of land use policy integration is shown in Table 9-4 . As seen from the results, R02 has significant advantages over other options in terms of land use policy integration. This is because it has five proposed stations within a LAP and an SDZ. Three of its proposed stations lies in the Liberties areas which have been accounted to have significant regeneration of its unused lands whilst two of its proposed stations are within the SDZ.

Route alignment options R01, R03 and R09 are considered to have some advantages over other options as they have a total of four proposed stations within an LAP and an SDZ. Of these three route alignment options it should be acknowledged that R03 and R09 runs through 2 LAPs and 1 SDZ and have the capacity to integrate with all three policies. Although Pearse Station does not come directly within an LAP area, it has close proximity to the St George's Quay LAP extent as well as the North Lotts and Grand Canal Dock SDZ extent and hence it can facilitate connectivity and integration of both these policies. The positive benefits due to its location are considered to be equal to having a station directly within an LAP.

Table 9-4: Banding for Land Use Policy Integration

Route Align-ment	Station Names						Number of stations within LAP	Banding
R01	Heuston	Christchurch	Tara Street	Docklands			4	
R02	Heuston	Christchurch	St. Patrick's Cathedral	Charlemo nt	Grand Canal Dock	Docklands	5	
R03	Heuston	Christchurch	St. Stephen' s Green	Grand Canal Dock	Docklands		4	
R09	Heuston	Christchurch	St. Stephen' s Green	Pearse	Docklands		4	
R16	Heuston	Christchurch	St. Stephen' s Green	Pearse			3	

Index:	George's Quay LAP	The Liberties LAP	North Lotts and GCD SDZ

9.2 Public Transport Transfer Metrics

Two transport model outputs have been used to measure the integration of each option with the GDA public transport network.

The first output is the daily number of transfers between rail and all other modes. A higher number of transfers indicates greater integration with the public transport network. The second output is overall average transfer time, where a lower average transfer time indicates better integration of the option with the public transport network.

Figure 9-1 presents the daily transfers by type for each option in 2050. The options generally have similar number of transfers between bus and rail. R02 has a greater number of transfers between Luas and Rail than the other options, but less between MetroLink and Rail services. In terms of total number of daily transfers R02 has the most, followed by R01 and R09. R03 and R16 have fewer numbers of transfers but this is not significantly less than the other options.

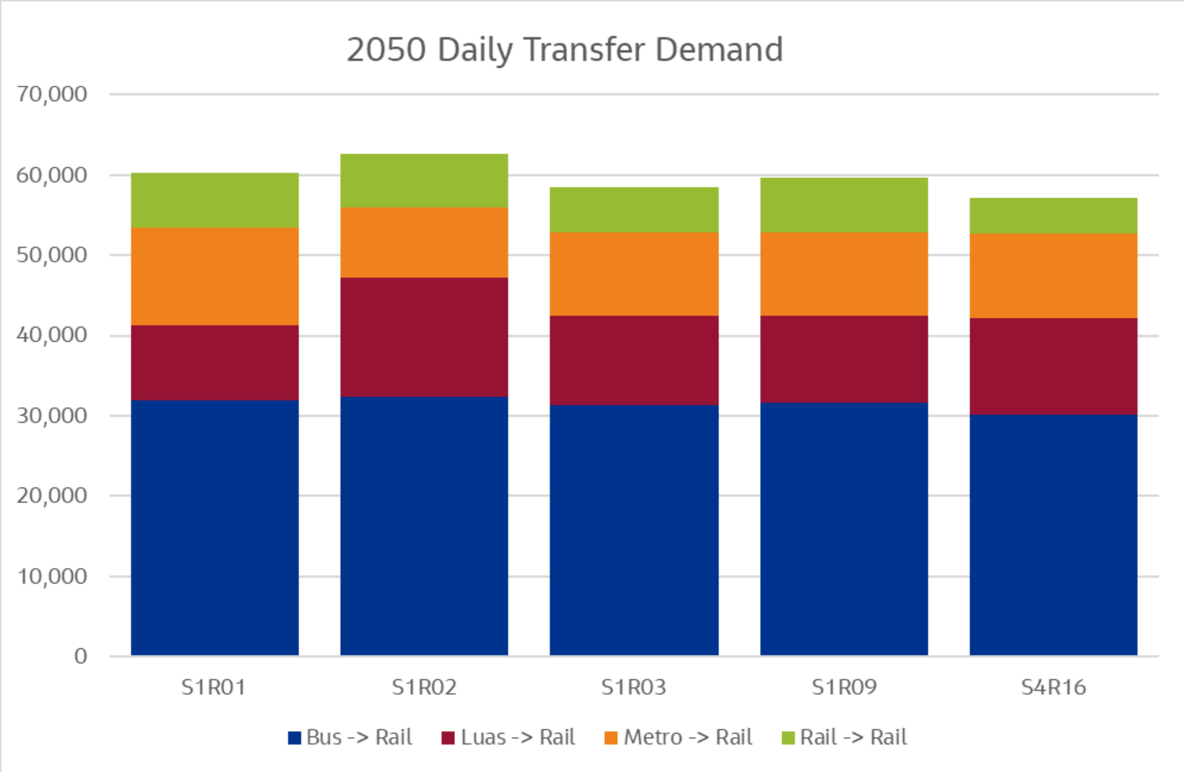


Figure 9-1 2050 daily transfer demand by option

Table 9-5 presents transfer banding for the five short-listed options. The bandings are qualitatively determined based on the difference in the number of transfers of each route option from the average number of transfers across the five short-listed options. For transfers, R02 has significant advantages over other options and R16 has significant disadvantages over other options.

Table 9-5: Transfer banding for the five short-listed options

Option		Bus -> Rail	Luas -> Rail	MetroLink -> Rail	Rail -> Rail	All ->Rail	Difference from average	% difference from average	Score
S1	R01	31,954	9,312	12,246	6,815	60,328	691	1.2%	
	R02	32,313	14,961	8,758	6,598	62,630	2,993	5.0%	
	R03	31,399	11,010	10,414	5,638	58,462	-1175	-2.0%	
	R09	31,685	10,818	10,324	6,798	59,625	-11	0.0%	
S4	R16	30,110	12,037	10,570	4,421	57,137	-2,499	-4.2%	
Average						**59,636**			

Figure 9-2 presents the average transfer time (waiting time and walking time) for each option in 2050. The options generally have similar average transfer times of approximately 7.6 minutes, and all are within 2% of the average transfer time across all options.

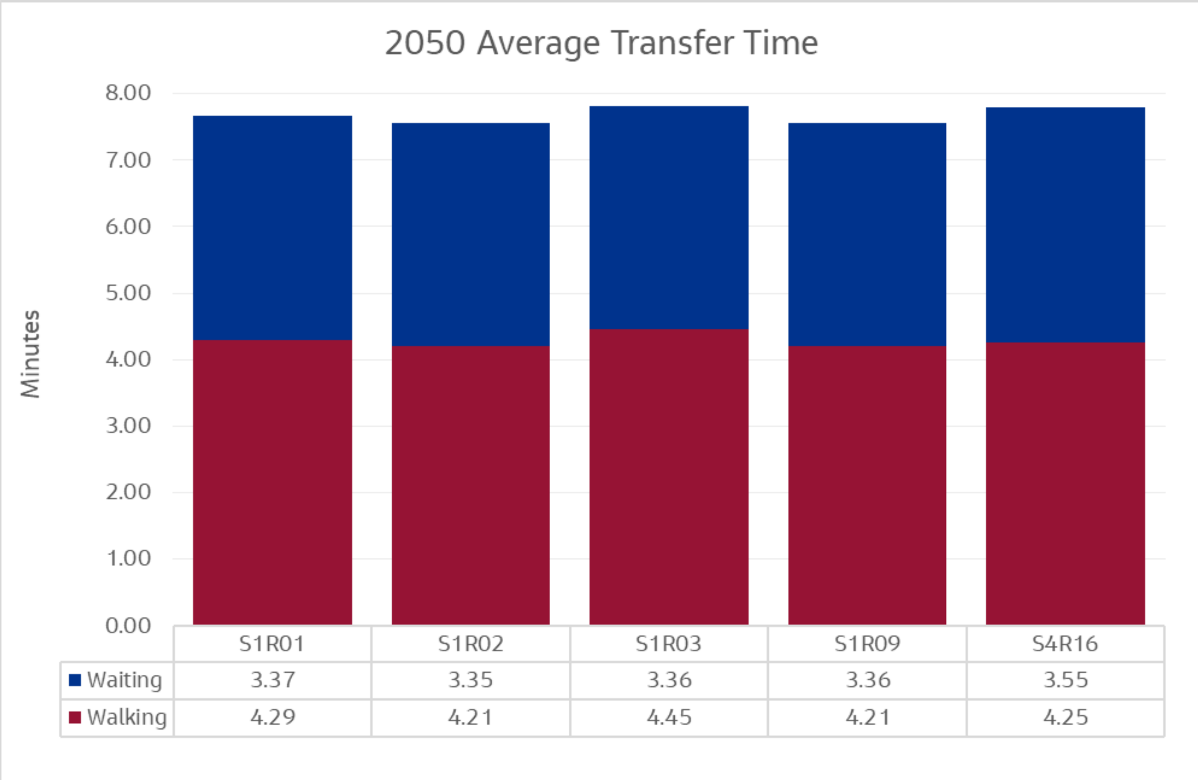


Figure 9-2 Average transfer time by option

Table 9-6 presents transfer time banding for the five short-listed options. The bandings are qualitatively determined based on the difference in average transfer time of the route options from the average transfer time across the five short-listed options.

Table 9-6: Transfer time for the five short-listed options

Option		Waiting time	Walking time	Total	Difference from average	% difference from average	Score
S1	R01	3.37	4.29	7.66	-0.02	-0.3%	
	R02	3.35	4.21	7.56	-0.12	-1.6%	
	R03	3.36	4.45	7.82	0.14	1.8%	
	R09	3.36	4.21	7.57	-0.11	-1.4%	
S4	R16	3.55	4.25	7.80	0.12	1.5%	
Average				**7.68**			

Table 9-7 presents transfer, transfer time and overall public transport integration banding for the five short-listed options.

Table 9-7: Transfer and Transfer time banding combined for the five short-listed options

Option		Transfers	Transfer times	Final Public Transport Integration Score
S1	R01			
	R02			
	R03			
	R09			
S4	R16			

9.3 Banding Outputs

Table 9-8 presents a summary of the scores for each Integration sub-criterion for the five short-listed options, and then an overall score for Integration. The result of this is that R02 has significant advantages over other options for the Integration criterion, this is followed by R01 and R09 that have some advantages over other options. R16 has significant disadvantages over other options.

Table 9-8: Integration scores for the five short-listed options

Option		Land use policy integration score	Public Transport integration score	Final Integration Score
S1	R01			
	R02			
	R03			
	R09			
S4	R16			

10. Stage 2 – Environment

10.1 Environmental Comparative Assessment

An environmental appraisal of the shortlisted route alignment options has been completed. As was completed at Stage 1, this assessment has focused on the key differentiator topics between the route alignment options so that the sifting process can be followed. These key differentiator topics are: Cultural Heritage, Biodiversity, Landscape and Visual, and Population and Human Health. Key considerations have been identified and a comparative assessment score provided for each topic.

A comparison of the comparative assessment between Stage 1 and Stage 2 will show that the assessment scores have changed. This will be because there are only five options to compare at Stage 2 and so the comparison is different. In addition, there is new design information available compared to Stage 1 that is commensurate with the project stage.

Section 11 of this report has provided a breakdown of the key features for each route alignment options and is not repeated here.

The following tables provide summaries of the Stage 2 Environment Assessment by stations, by topic, and provide an overall assessment of each route option alignment.

Table 10-1: Environmental Comparative Assessment of Proposed Stations

Route Option	Stations					
S1 R01	Heuston	Christchurch	Tara Street	Docklands		
S1 R02	Heuston	Christchurch	St. Patrick's Cathedral	Charlemont	Grand Canal Dock	Docklands
S1 R03	Heuston	Christchurch	St. Stephen's Green	Grand Canal Dock	Docklands	
S1 R09	Heuston	Christchurch	St. Stephen's Green	Pearse	Docklands	
S4 R16	Heuston	Christchurch	St. Stephen's Green	Pearse TB		

Table 10-2: Environmental Comparative Assessment of S1 R01

	Archaeology, Architectural and Cultural Heritage	Biodiversity	Landscape and Visual	Population
S1 R01 Heuston – Christchurch – Tara Street – Docklands	Impacts to Church of the Immaculate Conception but avoids other key sites impacted by other options.	Avoids St. Stephen's Green and Grand Canal Dock; however, potential impacts from 8-foot sewer.	Avoids St. Stephen's Green and Grand Canal Dock; but impacts from other stations.	Potential impact from the 8-Foot sewer, which serves 270,000 people.
This route option is considered to be comparable to other options ('yellow'). It will have likely significant effects; however, the banding is a comparative assessment at this stage of the DART+ Tunnel project. The proposed station locations are located in areas with significant cultural heritage designations but it avoids St. Stephen's Green. Christchurch will have advantages compared to others but impacts to the Church of the Immaculate Conception. Tara Street Station is considered to have significant disadvantages ('red'). This is because of the potential impacts to the 8-foot sewer. This could have significant effects on Dublin City. This route option has some advantages compared to other options - avoidance of St. Stephen's Green and Grand Canal Dock, lower number of stations, and uses the western portal as a lunching portal.				

Table 10-3: Environmental Comparative Assessment of S1 R02

	Archaeology, Architectural and Cultural Heritage	Biodiversity	Landscape and Visual	Population
S1 R02 Heuston – Christchurch Station – St. Patrick's Cathedral – Charlemont – Grand Canal Dock – Docklands	Avoids other key sites impacted by other options. Christchurch station location is adjacent to remains of Old Dublin City Walls.	Impacts to Grand Canal Dock (pNHA)	Impacts to Grand Canal Dock (pNHA)	Impacts to Grand Canal Dock (pNHA). Removal of residential and commercial properties at Christchurch station location.
This colour rating has changed from 'Red' at Stage 1 to Yellow' at Stage 2. This is a significant change but it is because of the nature of the comparative assessment and how the design has evolved from Stage 1. All of the options at Stage 2 will result in likely significant effects that require mitigation; however, the assessment is a comparative one. In comparing the short-listed options, Option S1 R02 does not have the same disadvantages as, for example, S1 R03, which impacts both a national monument and a pNHA. In addition, further design detail completed between Stage 1 and 2 has allowed a re-examination of the scale of impacts and the resulting advantages and disadvantages. Impacting Grand Canal Dock (pNHA) is a significant negative effect. However, the proposed method of construction would allow the canal to remain open which will reduce the biodiversity and population effects at the Grand Canal Dock and therefore the option is now considered to be more advantageous compared to the other options. The population impacts will be significant at the Christchurch station location involving the removal of buildings that will be required. This will have a major impact on those directly impacted and on the wider community.				

Table 10-4: Environmental Comparative Assessment of S1 R03

	Archaeology, Architectural and Cultural Heritage	Biodiversity	Landscape and Visual	Population
S1 R03 Heuston – Christchurch – St. Stephen's Green – Grand Canal Dock – Docklands	Impacts to St. Stephen's Green	Impacts to Grand Canal Dock and St. Stephen's Green	Impacts to Grand Canal Dock and St. Stephen's Green	Impacts to Grand Canal Dock and St. Stephen's Green
This route option has significant disadvantages over other options ('red') as the station location at Grand Canal Dock is to be located within the canal basin, which is also a designated pNHA, likely leading to significant ecological, landscape, and amenity impacts, making this route significantly disadvantageous when compared to others. Impacts to St. Stephen's Green will have significant disadvantages over other options.				

Table 10-5: Environmental Comparative Assessment of S1 R09

	Archaeology, Architectural and Cultural Heritage	Biodiversity	Landscape and Visual	Population
S1 R09 Heuston – Christchurch - St. Stephen's Green – Pearse – Docklands	Impacts to St. Stephen's Green and potentially to Merrion Square	Impacts to St. Stephen's Green	Impacts to St. Stephen's Green	Impacts St. Stephen's Green
This colour rating has changed from 'Red' at Stage 1 to 'Orange' at Stage 2. This is because of the nature of the comparative assessment. All of the options at Stage 2 will result in likely significant effects that require mitigation; however, the assessment is a comparative one. In comparing the short-listed options, Option S1 R09 does not have the same disadvantages as, for example, S1 R03, which impacts both a national monument and an NHA. In addition, further design detail completed between Stage 1 and 2 has allowed a re-examination of the scale of impacts and the resulting advantages and disadvantages. This route option has some disadvantages over other options ('orange') as a station location is to be located within St. Stephen's Green, likely leading to significant ecological, landscape, and population impacts.				

Table 10-6: Environmental Comparative Assessment of S4 R16

	Archaeology, Architectural and Cultural Heritage	Biodiversity	Landscape and Visual	Population
S4 R16 Heuston – Christchurch – St. Stephen's Green – Pearse Turnback	Western launch portal (increased working area close to Memorial Gardens) and impacts to St. Stephen's Green and possibly to Merrion Square	Western launch portal and impacts to St. Stephen's Green and shaft close to River Liffey.	Western launch portal and impacts to St. Stephen's Green and shaft close to River Liffey.	Western launch portal and impacts to St. Stephen's Green.
This route option has significant disadvantages over other options ('red') as while it has the same western portal location as S1 R01, it is likely to be a launch portal allowing for greater environmental impacts at this location (close to Memorial Gardens). Its eastern portal as well as its proposed station locations are in areas where there are greater potential impacts to cultural heritage, visual amenity, and sensitive locations (St. Stephen's Green, Merrion Square, Westland Row CBS, Saint Andrews National School and Trinity College Dublin (TCD)). Further constraining this route is the fact that the route terminates at Pearse Station, a considerably dense urban environment, likely making construction difficult but also spoilt extraction perspective. The turnback facility will have significant export of material and will have a large shaft located close to the River Liffey.				

10.2 Banding Outputs

Table 10-7 presents a summary of the scores for each Environmental sub-criterion for the five short-listed options, and then an overall band for Environment has been assessed.

The result of this is that S1 R01 and S1 R02 rank first as they are comparable to other options for the Environment criteria, this is followed by S1 R09, which has some disadvantages over other options, and then S1 R03 and S4 R16, both having significant disadvantages over other options.

Table 10-7: Environmental scores for the five short-listed options

Option		Population	Archaeology, Architectural and Cultural Heritage	Biodiversity	Landscape and visual	Overall Environment Score
S1	R01					
	R02					
	R03					
	R09					
S4	R16					

11. Stage 2 – Accessibility and Social Inclusion

The impacts of each of the five short-listed route options on accessibility and social inclusion are assessed in this section. The sub-criteria used for the assessment are “Accessibility to Key Trip Attractors”, “Public Transport Accessibility”, and “Improvement in Access to Areas of Deprivation”. The options are then banded based on each sub-criterion and an average score for Accessibility and Social Inclusion is then assessed.

11.1 Accessibility to Key Trip Attractors

This subsection describes the assessment carried out to analyse the impact of the five short-listed options on the accessibility to selected key trip attractors in the study area. The selection of the trip attractors was based on the most activity-dense zone under the land use categories of Education, Employment, Hospital, and Leisure. The assessment included the calculation of the population that resides in the areas from which one can travel to the four selected trip attractors within 60 minutes by public transport. The route alignments with a high number of persons that can reach the four selected trip attractors within 60 minutes using public transport are given higher scores and vice versa.

The four key trip attractors as shown in Figure 11-1 were selected to assess their accessibility after the introduction of the underground heavy rail link and they are also listed in Table 11-1.

Table 11-1 Selected key trip attractors

Land Use Category	Selection measure	Selector key trip attractor (zone with highest demand in the category)
Education	Education enrolment and jobs	Trinity College Dublin
Employment	Number of employees	East Point Business Park
Hospital	The hospital with the most health jobs	St James’s Hospital
Leisure	Leisure trips	Iveagh Gardens and surrounds

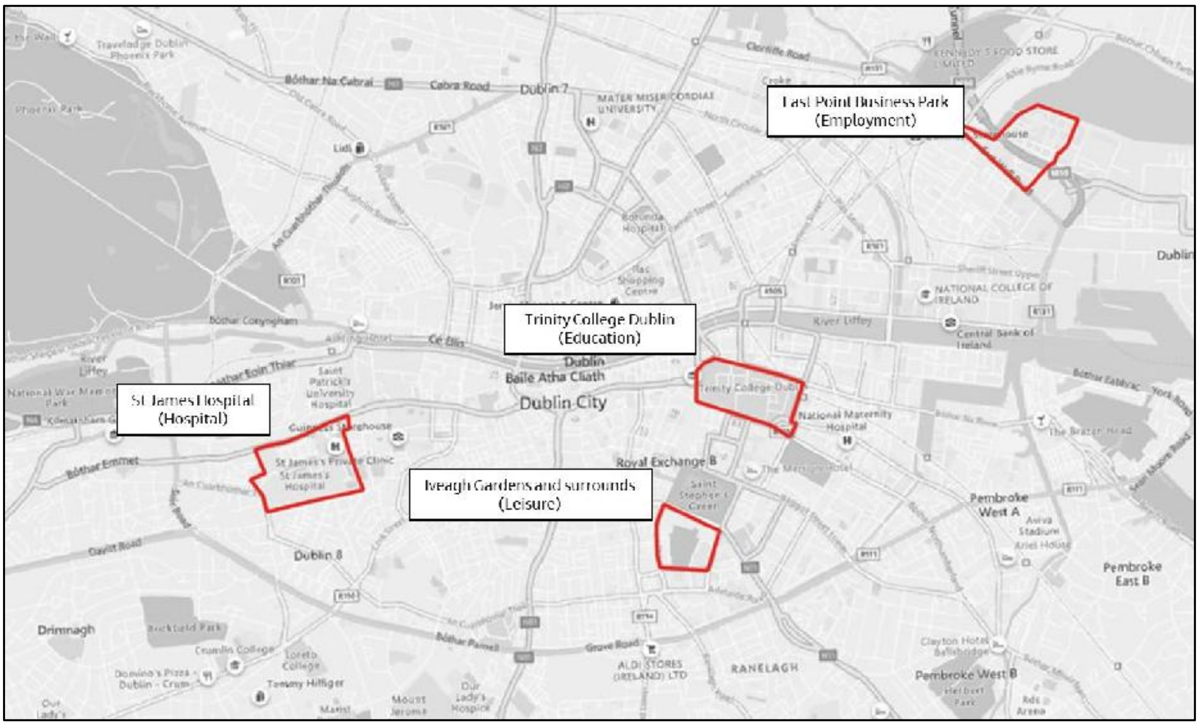
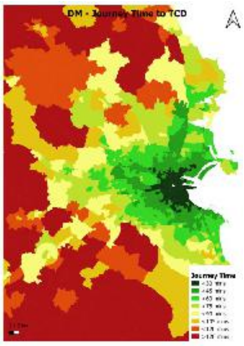
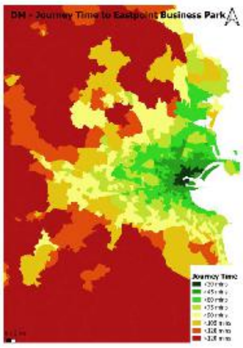
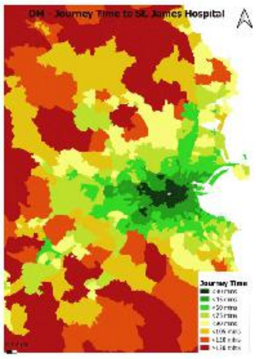
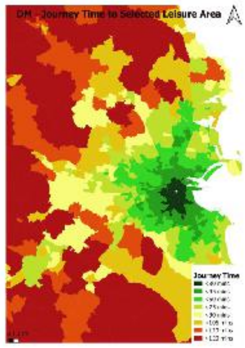
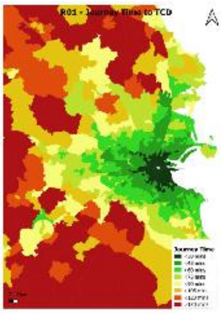
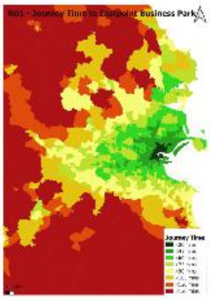
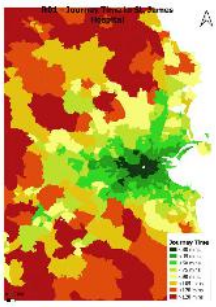
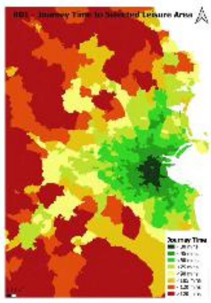
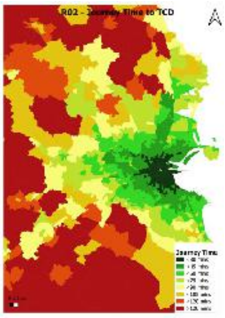
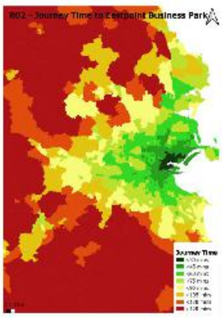
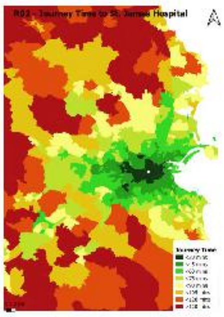
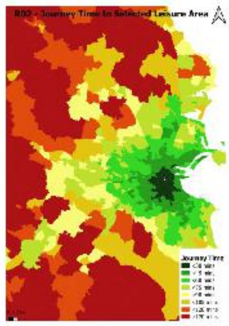
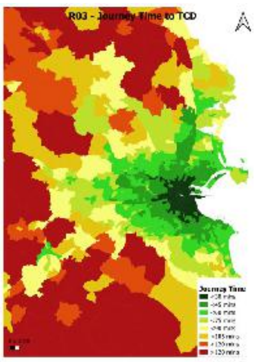
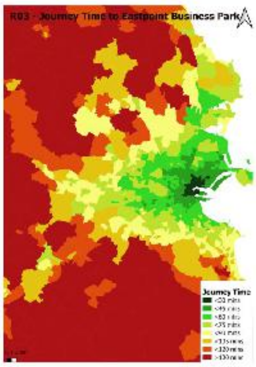
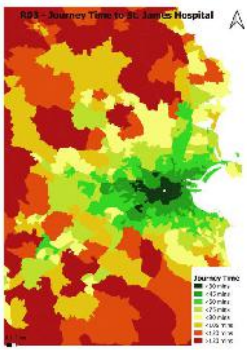
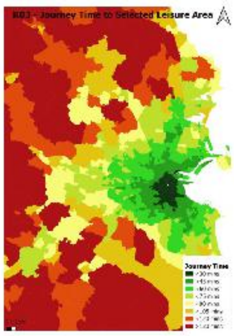


Figure 11-1 Selected Key Trip Attractors

Figure 11-2 shows the heat maps which display the boundaries of journey time to each key trip attractor by 15 minutes intervals. Each option's accessibility to the selected location is measured by the population that lives within 60 minutes by public transport from the selected location, as displayed in Figure 11-3.

Trip Attractor	Trinity College Dublin	East Point Business Park	St. James's Hospital	Iveagh Gardens and surrounds
Do Minimum				
S1 R01				
S1 R02				
S1 R03				

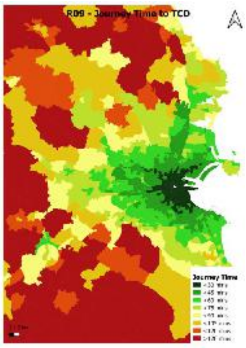
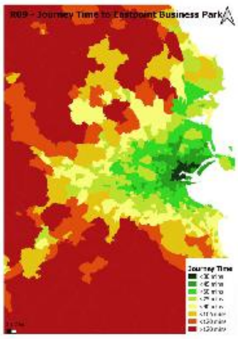
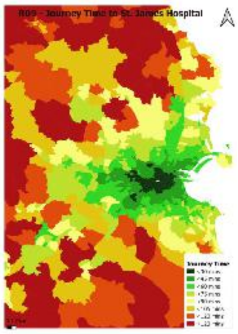
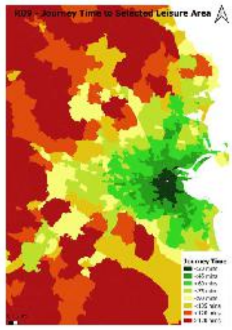
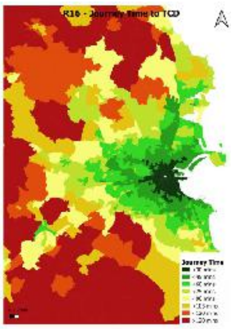
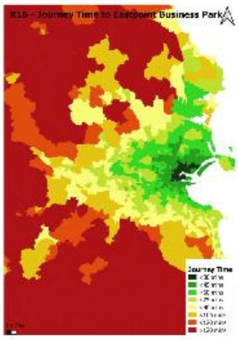
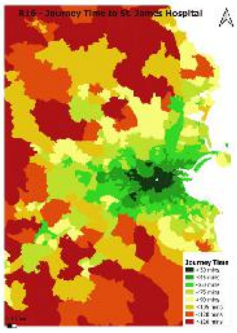
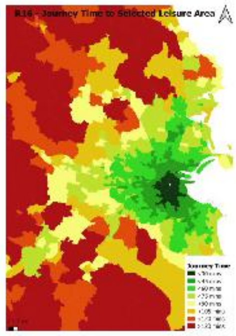
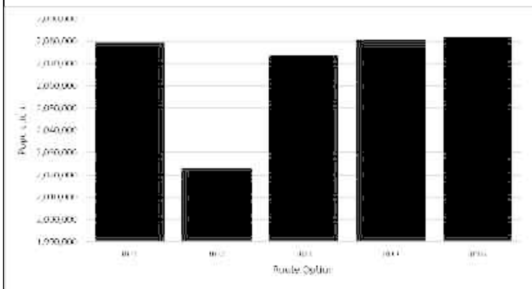
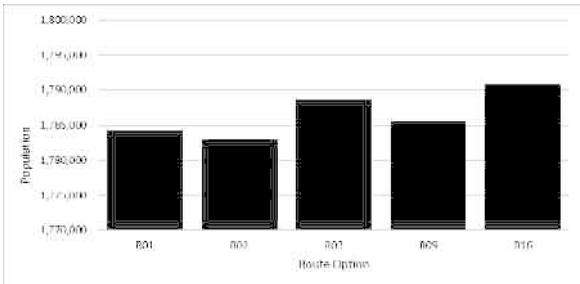
Trip Attractor	Trinity College Dublin	East Point Business Park	St. James's Hospital	Iveagh Gardens and surrounds
S1 R09				
S4 R16				

Figure 11-2 2050 Journey time to selected key trip attractor

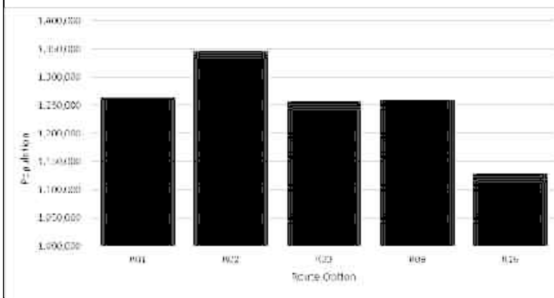
Trinity College Dublin



St. James's Hospital



East Point Business Park



Selected Leisure Area – South to GDC

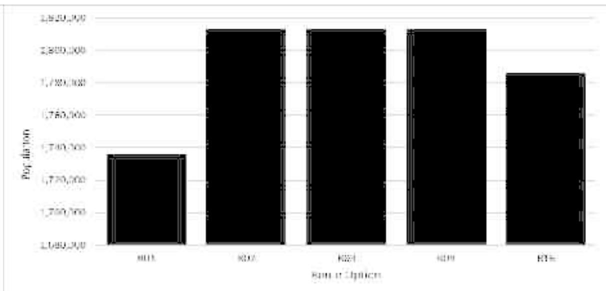


Figure 11-3 2050 population within the area which can access selected key trip attractors within 60 minutes by Public Transport

Table 11-2 shows the total population that resides in areas that can reach the selected key trip attractor within 60 minutes by public transport. From Figure 11-3 and Table 11-2, it is shown that R02 provides the best accessibility to the selected trip attractors, followed by R09.

R02 has 1% greater than average population that has good accessibility to Trinity College Dublin, East Point Business Park, St. James's Hospital and Iveagh Gardens and surrounds.

R09 has 0.5% greater than average accessibility to the five end points. The least performing option in terms of accessibility is R16 as it has the lowest number of people who can reach the key trip attractors within 60 minutes by public transport.

Table 11-2 Public transport accessibility banding for the five short-listed options

Alignment	TCD	East Point Business Park	St. James's Hospital	Iveagh Gardens and surrounds	Total	Difference from Average		Banding
S1 R01	2,079,631	1,263,539	1,784,193	1,736,485	6,863,847	-33,941	-0.5%	
S1 R02	2,023,276	1,347,178	1,783,051	1,813,502	6,967,006	69,218	1.0%	
S1 R03	2,073,593	1,257,015	1,788,745	1,812,733	6,932,085	34,297	0.5%	
S1 R09	2,080,512	1,259,182	1,785,529	1,812,733	6,937,955	40,167	0.6%	
S4 R16	2,082,047	1,129,286	1,790,764	1,785,951	6,788,048	-109,740	-1.6%	
Average					6,897,788			

11.2 Public Transport Accessibility

The five short-listed options have been assessed against each other using the criteria of public transport accessibility. To measure the level of public transport accessibility of each option, the number of public transport accessible destinations per origin zone has been determined. The Eastern Regional Model (ERM) splits the Greater Dublin Area and the rest of country into 1,993 zones comprised of 1,907 internal zones and 86 external zones. There are a total 3,972,049 origin zone to destination zone pairs.

Public Transport accessible origin-destination (OD) pairs are defined as OD pairs where the modelled public transport journey time between the zone origin and the destination zone (including access time, wait time and walk time) is less than 60 minutes. The total number of public transport accessible (OD) pairs is then divided by the number of zones (1,993) to calculate the number of public transport accessible destinations per origin zone.

Figure 11-4 shows the average number of public transport accessible destinations per zone of the five short-listed options and the Do Minimum scenario. There is generally very little difference between the options, with all having approximately 1,560 public transport accessible destinations per zone (approximately 78% of zones).

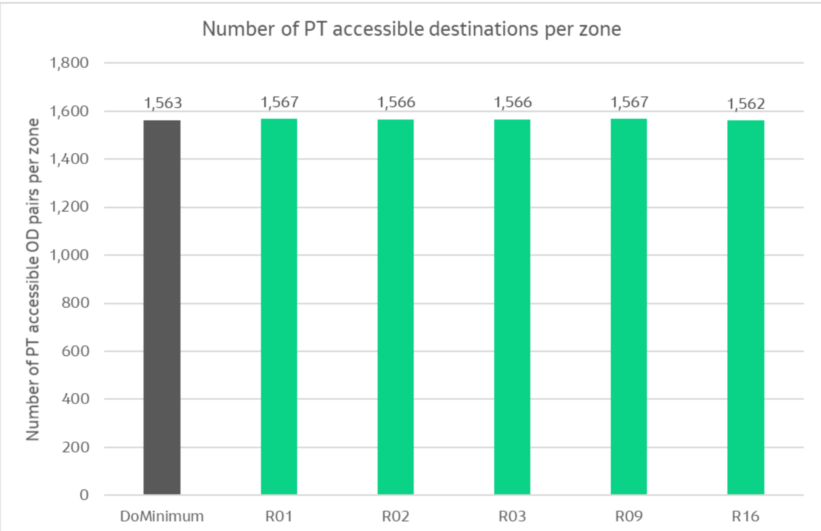


Figure 11-4 Public transport accessible destinations per zone

Table 11-3 presents public transport accessibility banding for the five short-listed options. The banding is determined qualitatively based on the difference in public transport accessible destination per zone of the option from the across the five short-listed options. R01, R02, R03 and R09 are comparable to other options while R16 has some disadvantages over other options.

Table 11-3: Transfer banding for the five short-listed options

Option		Number of public transport accessible destinations per zone	Difference from average	Banding
S1	R01	1,567	2	
	R02	1,566	1	
	R03	1,566	1	
	R09	1,567	2	
S4	R16	1,562	-3	
	Average	**1,565**		

11.3 Access to Areas of Deprivation.

The Pobal HP Deprivation Index is a series of maps measuring the relative affluence or disadvantage of a particular geographical area in Ireland, using data compiled from various censuses. The 2016 Pobal HP Deprivation Index for Electoral Division [2] is the latest available data for this report. The index is categorised into eight bands as presented in Table 11-4. The intervals from the average is the standard deviation value of samples.

Table 11-4 Setup of HP Deprivation Index Category

Category	Index (from)	Index (to)
Extremely Affluent	23.1	100
Very Affluent	14.9	23.1
Affluent	6.8	14.9
Marginally above Average	2.7	6.8
Marginally below Average	-1.3	2.7
Disadvantaged	-9.5	-1.3
Very Disadvantaged	-17.6	-9.5
Extremely Disadvantaged	-100	-17.6

2 Pobal HP Deprivation Index data resource: http://trutzhaase.eu/deprivation-index/the-2016-pobal-hp-deprivation-index-for-small-areas/

Figure 11-5 is the 2016 Deprivation Index map of ERM zone boundary.

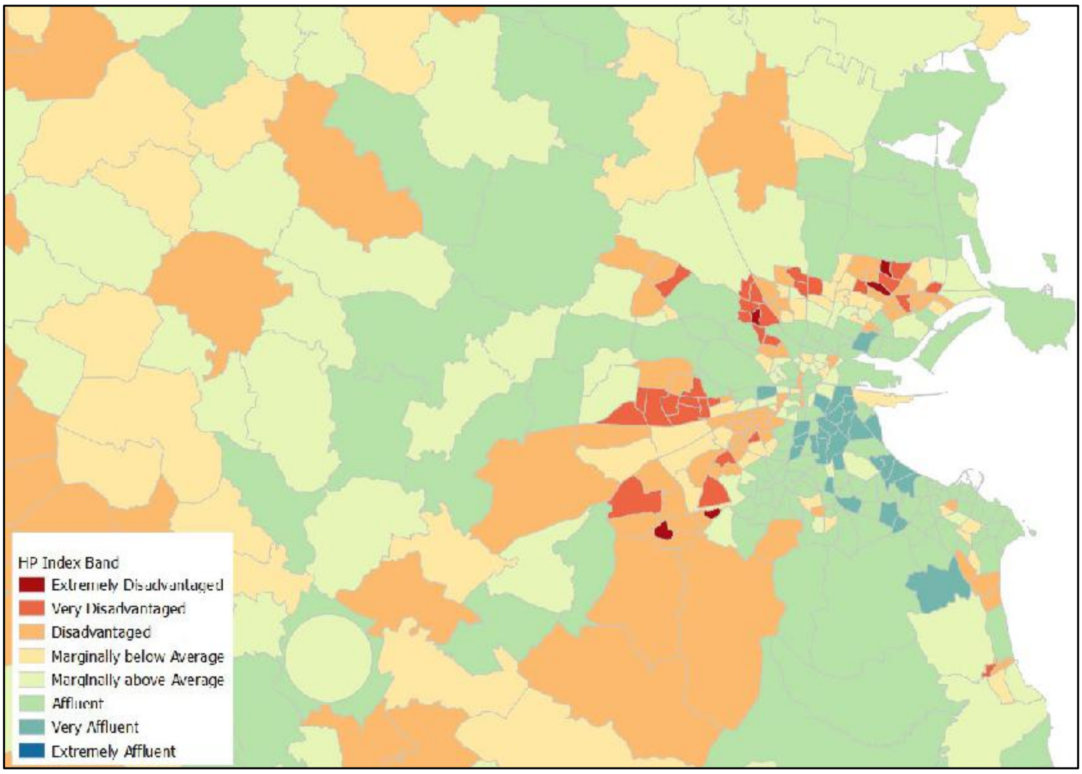


Figure 11-5 2016 Relative HP Index by Electoral Division

Table 11-5 tabulates, for each option and the Do Minimum scenario, the total number of persons that live in zones where the average public transport trip journey time is less than 60 minutes in duration, classified by each HP deprivation index category.

The five short-listed options have improved public transport accessibility in areas that are above average on the deprivation index, and the Marginally Below Average category, and the Very Disadvantaged category. All five short-listed options do not improve public transport accessibility in the Disadvantaged category and the Extremely Disadvantaged category.

Table 11-5 2050 Population of average 60-mininute public transport Zones by HP Index Band

Alignment	Extremely Affluent	Very Affluent	Affluent	Marginally Above Average	Marginally Below Average	Disadvan-taged	Very Disadvan-taged	Extremely Disadvan-taged
S1 R01	0	173,426	819,332	411,581	243,663	310,744	223,574	12,006
S1 R02	0	173,426	822,348	411,581	237,385	310,744	223,574	12,006
S1 R03	0	173,426	819,332	411,581	238,435	310,744	223,574	12,006
S1 R09	0	173,426	820,377	411,581	243,663	309,337	223,574	12,006
S4 R16	0	173,426	829,291	411,581	243,663	312,467	223,574	12,006
Do-Minimum	0	165,396	773,983	358,094	208,926	334,150	186,694	17,786

The scoring of the Deprivation Index sub-criteria will focus on the level of public transport accessibility for population in the areas that a classified as below average HP index (i.e., the Marginally Below Average category, the Disadvantaged category, the Very Disadvantaged category, and the Extremely Disadvantaged category).

Figure 11-6 presents, for each option and the Do Minimum, the total number of persons that live in zones where the average public transport trip journey time is less than 60 minutes in duration for each of the four 'Below Average and Disadvantaged' classifications.

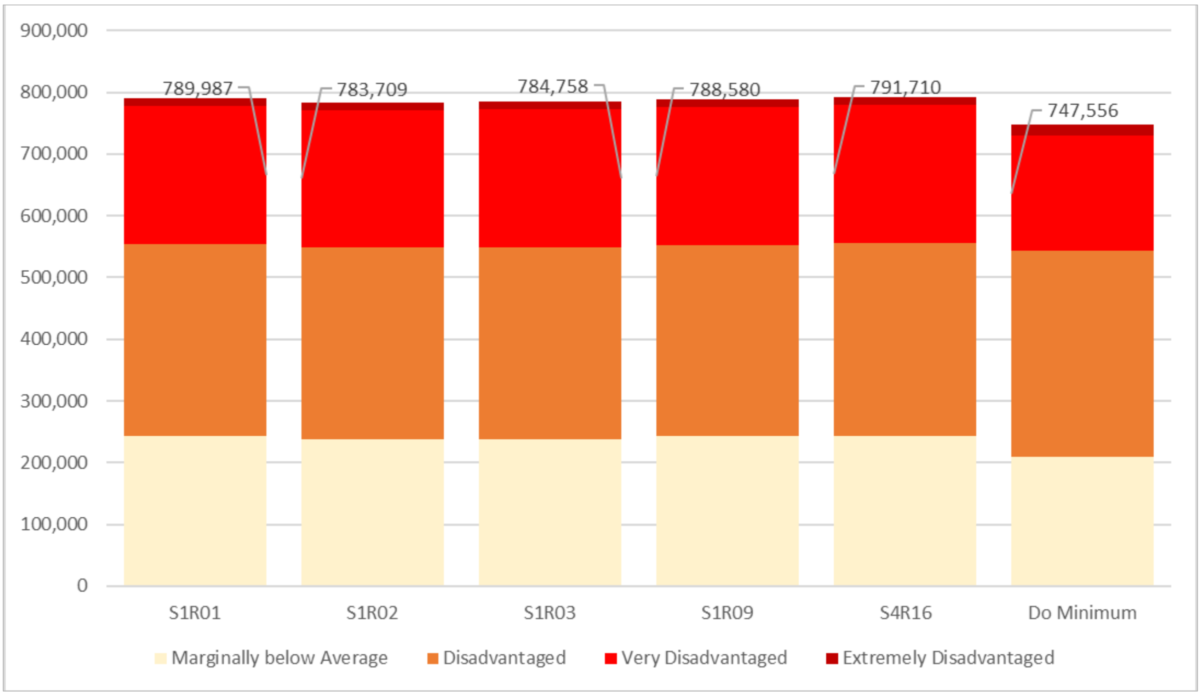


Figure 11-6 Population from Below average and Disadvantaged Areas where the average public transport journey time is less than 60 minutes.

Table 11-6 presents the Deprivation Index banding for the five short-listed options. The banding is determined qualitatively based on the difference in population from Below average and Disadvantaged Areas where the average public transport journey time is less than 60 minutes of the option from the average across the five short-listed options.

Table 11-6 Deprivation Index scores

Alignment	Total Below Average and Disadvantaged Population	Difference from Average	Score
S1 R01	789,987	0.28%	
S1 R02	783,709	-0.51%	
S1 R03	784,758	-0.38%	
S1 R09	788,580	0.11%	
S4 R16	791,710	0.50%	
Average	**787,749**		

11.4 Banding Outputs

Table 11-7 presents a summary of the banding for each Economy sub-criteria for the five short-listed options, and then an average band for Economy has been assessed. The result of this is that R01, R02, R03 and R09 all are comparable to other options and R16 has some disadvantages over other options.

Table 11-7: Accessibility and Social Inclusion scores for the five short-listed options

Option		Accessibility to Key Trip Attractors	Public Transport Accessibility	Access to Areas of Deprivation	Final Accessibility and Social Inclusion Score
S1	R01				
	R02				
	R03				
	R09				
S4	R16				

12. Summary of Stage 2 Route Assessments

12.1 Summary Table

Table 12-1 presents the banding for each of the five assessment criteria for the five short-listed options. The overall banding for each option based on the five criteria is shown in the last column.

S1 R09 is the best performer under the Economy and Accessibility and Social Inclusion criteria. S1 R09 is also equal best performer under the Safety criterion alongside S1 R01. Option S1 R01 is also equal best performer under the Environment criteria alongside S1 R02.

While S1 R01 is very close to S1 R09 across the five criteria, there is significant construction related risk associated with S1 R01 concerning the proximity of a station box to a 2.4m diameter Victorian trunk sewer line estimated to serve a population of 270,000. S1 R09 is scored as having some disadvantages over other options under the Environment criterion, however none of the options are considered to have any advantages over other options under this criterion. R02 is scored highest for the Integration criterion, followed by S1 R01 and S1 R09.

Based on this assessment S1 R09 has been selected as the best performing route because it the best or equal best performer under three of the five criteria, as well as the fact that it does not have the same level of construction risk as S1 R01 in relation to its proximity to the 2.4m Victorian-built trunk sewer.

Table 12-1: Summary of Stage 2 Criteria scores and overall scores

Option		Economy	Safety	Integration	Environment	Accessibility and Social Inclusion	Overall
S1	R01						
	R02						
	R03						
	R09						
S4	R16						

12.2 Best Performing Route

Based on the multi criteria assessment that best performing route option for the DART+ Tunnel is route S1 R09, with five new underground stations at Heuston, Christchurch, St. Stephen's Green, Pearse and Docklands.

This 7.83km route is similar to the previously approved DART Underground route. The alignment starts at the western tie-in and travels in a south-eastern direction towards the northern side of St. Stephen's Green via Heuston and Christchurch. After this, the route runs along Merrion Square to Pearse Station in a north-eastern direction. The route then crosses the River Liffey prior to connecting to the Northern Line in the Docklands area.

The S1 R09 route alignment is shown in Figure 12-1 with its underground stations and interchanges located at Heuston (interchange with rail, Luas and BusConnects), Christchurch (interchange with BusConnects), St. Stephen's Green (interchange with MetroLink, Luas and BusConnects), Pearse (interchange with rail and BusConnects), and Docklands (interchange with Luas and BusConnects).

Based on the high level cost estimate for construction and including for land and property acquisition costs, operation and maintenance (O&M) costs, VAT, inflation and contingency/optimism bias, it is estimated that the capital cost for the delivery of the DART+ Tunnel ranges between €5bn and €6bn.

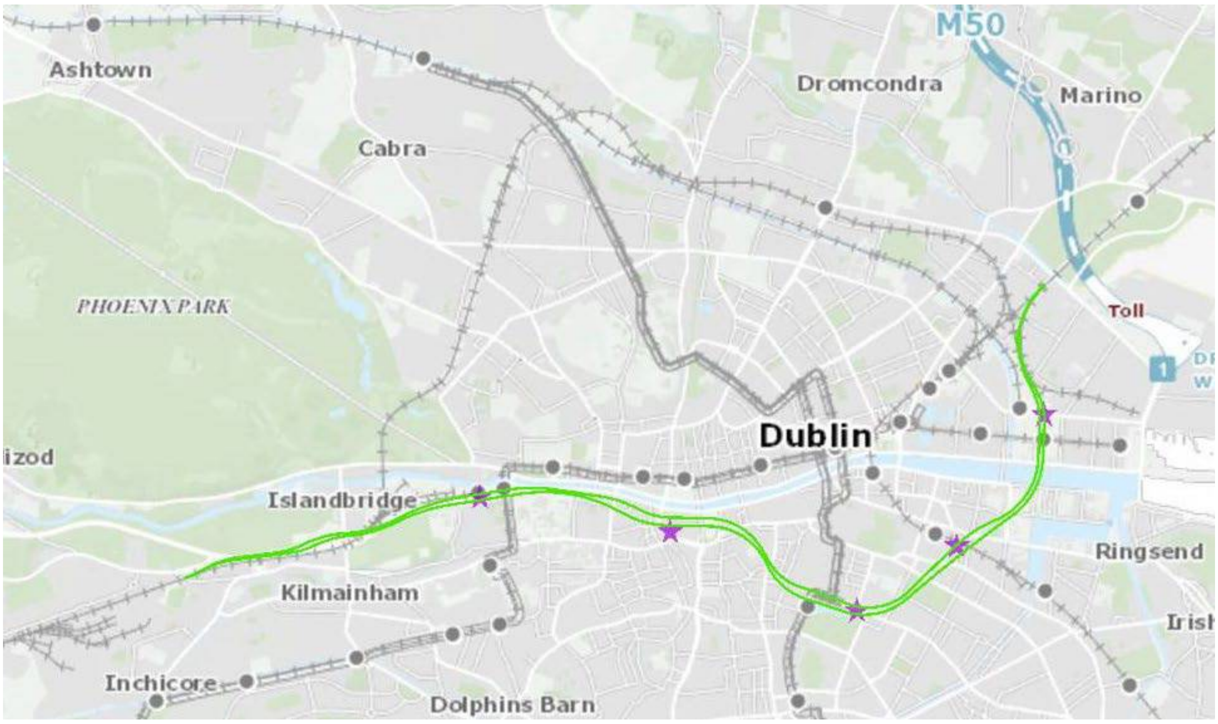


Figure 12-1 Best Performing Route Option with Underground Station Locations

Appendix A. Transport Modelling Report

Appendix B. Assessment Options Drawings

Appendix C. Environmental Constraints Report