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St. Stephen's Green Station – Mined Options Review

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Executive Summary

This review documents the work undertaken by Jacobs Idom to identify St. Stephen's Green mined station concepts to reduce the impact on St. Stephen's Green Park, and their evaluation, if considered feasible, against the current proposed St. Stephen's Green Station Preliminary Design, which is a cut and cover station partially located within the Park (Figure 1.1 and Appendix A).

A significant volume of work has been previously undertaken to identify and evaluate the options and selected location for St. Stephen's Green Station, covering alignment, station location, and a specific study to determine the feasibility of containing St. Stephen's Green Station wholly within the carriageway of St. Stephen's Green East, that also included consideration of mined station options. The purpose of this document is not to repeat that work, but to test again whether St. Stephen's Green would be better served by a mined station, applying the four-stage options assessment methodology set out below:

- Stage 1: review of the receiving environment to identify constraints;
- Stage 2: identification of mined station concepts that minimise the impact on the Park;
- Stage 3: preliminary analysis of the identified concepts to assess their feasibility having regard to Project Objectives, Engineering, Economy and Environmental criteria; and
- Stage 4: Multi Criteria Analysis (MCA). Comparative analysis of the short-listed feasible options and the Preliminary Design, using more detailed assessment criteria (see section 3.5.1).

A good understanding of MetroLink station requirements and the receiving environment, including St. Stephen's Green, a designated National Monument, has been attained previously. This was combined with examining other project examples, in particular mined stations with side platform configurations, and possible locations for construction, passenger access, intervention, and ventilation, resulting in four core mined concepts being identified:

- Option 1 – access from the path on St. Stephen's Green North, via an access shaft located in the current entrance Plaza to the Park, to the platform cavern containing a concourse leading to the side platforms;
- Option 2 – as Option 1 but with an island platform configuration requiring enlarged running tunnel transitions to allow the track to bifurcate to serve the island platform;
- Option 3 – access from the path of St. Stephen's Green East via a narrow box to platform concourse leading across to the platform cavern to descend to the island platforms; and
- Option 4 - a 'pure' mined option, with entrances located north and south of the station, one in the current Park entrance Plaza, and one on built-up land bounded by Earlsfort Terrace and Lesson Street Lower. Access is via passageways (mined tunnels) leading to the platforms.

Further detail of these concepts can be found in section 5.1 and Appendix B. All options were subjected to a Stage 3 Analysis, the result of which determined Option 1 and 3 should be taken forward to the Stage 4 MCA for further evaluation against the current St. Stephen's Green Station Preliminary Design, termed Option 0. (Option 2 was not progressed due to its island platform configuration and requiring construction of 150m+ long running tunnel transitions, and Option 4 due to providing a poor architectural concept and passenger experience).

When this review was initiated, it was assumed that mined tunnel construction would be a 24-hour construction operation, however subsequent noise and vibration modelling has shown that mining will result in ground borne noise peaking at 44dBA at sensitive receptors, compared to a threshold night-time level limit of 40dBA. This represents an exceedance of 50% over that considered acceptable and therefore Option 1 and 3 have been evaluated assuming 12-hour/dayshift working, the same as the current Preliminary Design, Option 0. This has a significant impact on the programme and cost quantification of these options.

While none of the options brought forward to Stage 4 require the demolition of buildings, an exercise was undertaken to determine an order of cost magnitude if a 1000m^2 site currently occupied by existing St. Stephen's buildings was acquired. Based on an assumed cost of €10,000/m^2 and 6 stories, property acquisition is estimated to be in the order of €60m plus €2-2.5m for demolition. Combined with the fact most of the buildings along the east and north side of St. Stephen's Green are designated Protected Structures in a Georgian conservation area, meant the option of acquiring a built-up site was not further progressed.

The Stage 4 MCA concluded that Option 0, the current Preliminary Design, performs much better than Options 1 and 3 for reasons of providing:

- a cost (direct cost of St. Stephen's Green Station only) and programme envelope which offers significantly greater value for money than either Option 1 - 10.5 years (+2 years compared to Option 0) and €296m (+71%), and Option 3 - 12.25 years (+3.75 years compared to Option 0) and €331m (+91%).

- a high-quality station with a positive passenger experience and good accessibility which neither Option 1 nor 3 can provide; and

- a significantly better construction solution due to it being the shallowest station by circa 10m and employing top-down diaphragm wall construction rather than open face mined tunnel construction constrained to 12-hour/dayshift working with its associated programme management complexities.

It is however of note that Option 0 has been assessed to perform the worst of the three options environmentally with regards to 'Property Impact on SSG Park', 'Biodiversity', 'Landscape and Visual', 'Archaeology/Cultural Heritage', and 'Architectural Heritage' criteria.

Importantly though, Option 0 also presents some advantages environmentally, namely, traffic and transport (maintaining three traffic lanes and two cycle lanes during construction along St. Stephen's Green East), a significantly reduced carbon footprint [Option 1 (+40% increase in concrete, +50% increase in excavated material) and Option 3 (+50% increase in concrete, +55% increase in excavated material)], reduced construction duration and therefore a reduced environmental impact duration, and a more efficient operational station. It is therefore not appropriate to conclude its environmental performance is weak.

Nonetheless it is recognised that construction of the current proposed Preliminary Design, Option 0, will have a significant impact on St. Stephen's Green Park. However, through good design of the station 'pop-ups' and replanting of trees and vegetation it is considered that a high-quality environment can be achieved to mitigate the long-term impact of the Station.

This needs to be balanced against delivering on the cost, programme, and benefits objectives of the MetroLink Project, recognising a compromise would significantly increase the cost and duration of MetroLink, as well as delivering a sub-optimal system that would be in place for many decades.

1. Introduction

1.1 Purpose and Structure of Document

The purpose of this document is to consolidate the work undertaken by Jacobs Idom over the period January to April 2022 under TII instruction 'CN 124 SSG Mined Station Proposal' to identify feasible mined station concepts that could reduce the impact on St. Stephen's Green Park. The performance of these identified feasible mined station concepts has been evaluated against the current Preliminary Design proposal for St. Stephen's Green Station – a cut and cover station that lies partially within St. Stephen's Green Park (Figure 1.1).

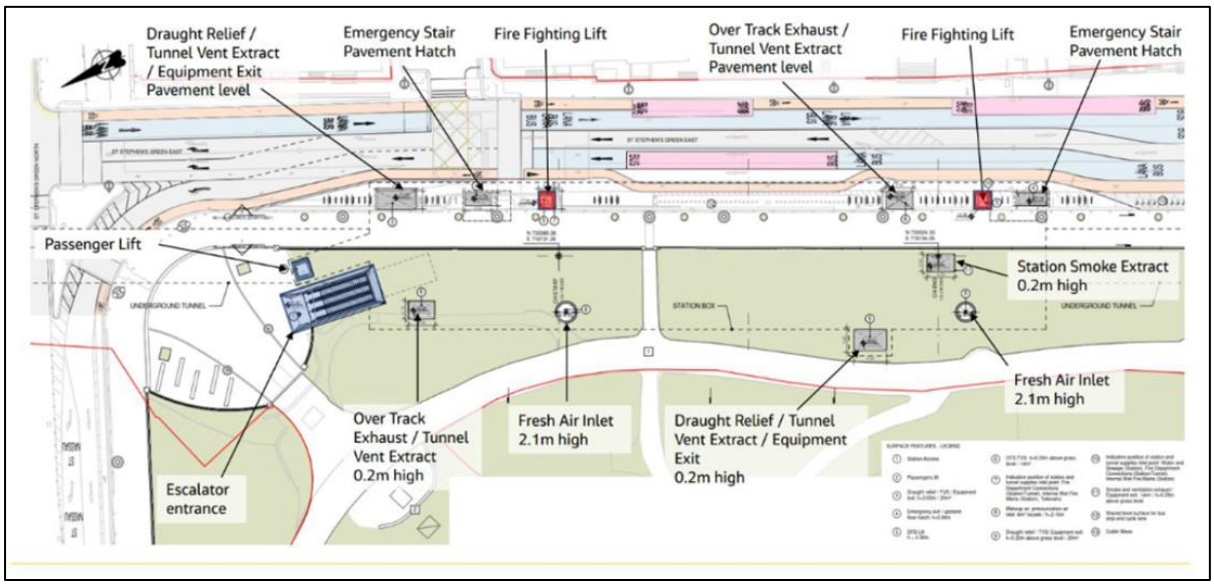


Figure 1.1: St. Stephen's Green Station – Current MetroLink Preliminary Design (also see Appendix A)

It is of note that significant work has already been undertaken to identify and evaluate options for a MetroLink station at St. Stephen's Green. This document builds on that previous work, notably the following:

i. National Transport Authority. New Metro North, Alignment Options Report, Volume 1: Main Report, 252252-00, Issue 1.

ii. Transport Infrastructure Ireland. St. Stephen's Green Station Study, Alternative Station Location within SSG East Carriageway, March 2021.

- Appendix A: St. Stephen's Green Station in Carriageway Construction Approach.
- Appendix B: St. Stephen's Green Station Study Location Assessment Report, Revision P02, superseded by (iii) below.

iii. Jacobs Idom. St. Stephen's Green Station Study Location Assessment Report, Revision P04.

The purpose of this document is therefore not to repeat that work, but rather to focus further in greater detail on mined station option(s) for St. Stephen's Green to check that the previous option evaluation conclusions drawn that led to the selection of the current Preliminary Design are sound. With this in mind the document has been structured as follows:

1. Introduction (document purpose, project overview, review objectives, and station requirements)
2. St. Stephen's Green Station Development History Summary

3. Options Assessment Methodology
4. Receiving Environment and Constraints Summary
5. Stage 3 Preliminary Analysis (sifting of the initial mined station concepts identified)
6. Stage 4 Multi Criteria Assessment (MCA) – evaluation of the mined station concepts brought forward from Stage 3 against the current St. Stephen's Green Station Preliminary Design.
7. Conclusions

1.2 MetroLink Project Overview

Project Ireland 2040 and the National Development Plan (2018-2027) promoted MetroLink as a fast, high capacity, high frequency, modern and efficient public transport Light Rail service for people travelling along the Swords/Airport to City Centre corridor. The commitment to MetroLink was again confirmed in the recent 2022-2042 Greater Dublin Area Transport Strategy Update.

The route from Estuary to Charlemont (Figure 1.2) is approximately 19km in length and the completed system will have 16 Stations, and a journey time of approximately 25 minutes.

The NTA commissioned Arup Consulting Engineers to undertake a Route Alignment Options Study for the Scheme in 2016. The objective of the study was to identify an Emerging Preferred Route (EPR). It was completed at the end of February 2018 and included a Concept Design for the EPR. The document 'New Metro North Alignment Options Report, Volume 1: Main Report' identified and assessed a number of alternative route options for the Metro scheme through the city centre. In January 2018, the NTA/TII commissioned Jacobs/Idom to provide ongoing engineering design services through to scheme completion. This document focuses on the proposed St. Stephen's Green Station.

Figure 1.2: MetroLink Route – Estuary to Charlemont

1.3 SSG Mined Station Location Review Objectives

Following NTA/OPW discussions regarding the location of the proposed St. Stephen's Green MetroLink station, TII instructed their Engineering Designer Jacobs Idom late December 2021 to develop a mined station design and construction methodology for this station, taking account of the following core principles:

- main entrance point and Park entry Plaza improvements to be as the current Preliminary Design (Figure 1.1 and Appendix A);
- assume all physical infrastructure (vents/extraction fans etc) to be located outside the St. Stephen's Green Park fence line;
- assume main footprint of the station box is to be as per current design i.e., predominantly located beneath the Park along the centreline of the current alignment;
- assume the current station box will have to be significantly redesigned to take account of the various mined options available; and
- assume that minimum traffic lanes to be maintained on St. Stephen's Green East are a single bus and a single car lane northbound, cycle lane northbound, single bus lane southbound, single cycle lane southbound. Left turn on to St. Stephen's Green North to be maintained.

It is of note that as the review progressed, these core principles were challenged, for example maintaining a main entrance in the Plaza area and traffic management arrangements to deliver on the objectives listed below.

As previously noted, a considerable body of work has already been undertaken to determine the most appropriate option for St. Stephen's Green Station. This review is now a check of that work with a particular focus on identifying feasible mined station solution(s) for St. Stephen's Green Station that can:

- integrate appropriately into the existing public realm;
- minimise the environmental impacts on the natural and built environment and the community, including St. Stephen's Green Park (construction and operational phases);
- enable the Station to be planned, constructed, and operated in an environmentally and economically sustainable manner whilst having regard to the identified constraints;
- provide value for money within acceptable cost, programme, and risk envelopes; and
- ensure the Station satisfies the overall project needs from an operational and safety perspective.

1.4 SSG Station Requirements

From the previous St. Stephen's Green Station optioneering and design development work undertaken there is a good understanding of MetroLink Station requirements, including:

- Architectural Vision/Operation System/Functional Plan [Front of House (FOH) and Back of House (BOH)]/Passenger Experience and Wayfinding Concept/Public Realm/Minimising Environmental Effects/Fire Safety and Evacuation Strategy.

The Jacobs Idom document ' Preliminary Design Report, Volume 4, Chapter 6, Sub-Surface Stations, ML1-JAI-SGN-MS15_XX-RP-Z-00001, P03 provides further detail of the operational and technical requirements that need to be accommodated by the station design.

The MetroLink architectural station vision is for the creation of a large, enclosed void that provides passengers with a quick understanding of the station. An important element of this is that the MetroLink underground

stations follow a consistent theme so that passengers can quickly understand and navigate the MetroLink stations. This will be explored further by this document, but clearly an architectural concept that significantly moves away from this, such as a mined station will detract from this key project requirement. For similar reasons the typical MetroLink station canopy entrance also needs to be maintained.

The station functional and operational requirements will remain equally necessary for any station option developed, including the fire and evacuation strategy principles but it is of note that some station layout options are likely to be more optimal and advantageous than others.

2. SSG Station Development History

2.1 Summary

St. Stephen's Green is a 9-hectare 17th century park situated at the southern end of Grafton Street in the city centre of Dublin. In its current form it has been used as a public park since 1880, following re-development it is enclosed by a plinth wall with railings next to which are planted a variety of trees including large mature specimens. The perimeter fence and vegetation acts as a barrier from the busy road and urban environment outside of the green space inside. The Park interior has a Victorian layout which includes a lake, children's playground, and numerous monuments, and of significant note is that St. Stephen's Green Park is a National Monument (RMP DU018-020334-). Included within the National Monument curtilage is the footpath to the road edge surrounding the Park. This area incorporates fence railings, a plinth wall, bollards, and lampposts all of which are protected structures.

St. Stephen's Green East is bordered on one side by St. Stephen's Green Park and on the other by a mixture of Georgian and modern buildings. The carriageway of St. Stephen's Green East includes three northbound traffic lanes and a cycle lane, and a southbound bus lane and cycle lane.

The EPR route was developed by Arup via a two stage Multi Criteria Analysis (MCA) which divided the route between Estuary and Charlemont into three study areas, A, B and C. St. Stephen's Green East Station (as it was called, now called St. Stephen's Green) was in Study Area A and its location was determined primarily as an intermediate station location between two critical interchange points at Charlemont (tie in with Luas Green Line) and Tara Street (DART interchange).

Following an options selection evaluation, the current Preliminary Design was confirmed as the preferred location and configuration for a station at St. Stephen's Green (Reference: Jacobs Idom. St. Stephen's Green Station Study Location Assessment Report, Revision P04). The assessment had shown that while this location impacts directly on St. Stephens Green East and St. Stephen's Green Park, it avoided the most significant impacts when compared to other locations, having particular regard to landscape and visual impacts, impacts on transport and traffic, and the requirement for significantly challenging utility diversions.

Following consultation with representatives of the Office of Public Works (OPW) and the Department of Culture, Heritage and the Gaeltacht (DCHG), the OPW informed TII in June 2020 that the St. Stephen's Green Station proposal was not acceptable and must not infringe on St. Stephen's Green Park. Further analysis on a possible alternative option to construct the station box within the carriageway and pathways of St. Stephen's Green East was undertaken, as well consideration of whether there was a feasible mined station solution. Both were concluded not to have advantages over the proposed station location (Figure 2.1). - (Reference: Transport Infrastructure Ireland. St. Stephen's Green Station Study, Alternative Station Location within SSG East Carriageway, March 2021 - Appendix A: St. Stephen's Green Station in Carriageway Construction Approach.)

2.2 Previous SSG Station Option Assessments

2.2.1 St. Stephen's Green Park

St Stephen's Green is located in the heart of Dublin and its location and layout is central to providing the character and identity to this area of the city. St Stephen's Green consists of a high-quality urban space, which provides an attractive location for those living, working, and visiting the city. St. Stephen's Green also functions to provide space for the movement and circulation of people through and around the area. The road network around St. Stephen's Green Park provides critical access points into to the City Centre for public transport systems and for other transport modes.

St. Stephen's Green Park is Irelands best known public park and consists of a 9-hectare park area that maintains its late Victorian layout to this day, with shrub planting, extensive flower beds and perimeter tree planting and a substantial ornamental lake. The Park is also home to many monuments and sculptures as well

as other elements of archaeological, architectural, and cultural heritage such as the decorative railings that surround the Park.

The Park functions as one of the principal amenity sites in Dublin City Centre, offering the public a peaceful refuge from the city, with attractors such as a Children's playground, a bandstand (regularly used for events) and the multitude of gardens within the boundaries of the Park.

St. Stephen's Green Park is also a designated National Monument, the extent of which is defined by the kerb line of the perimeter footpath. The background to the Park's cultural heritage is provided in Section 2.2.1 of the 'Jacobs Idom, St. Stephen's Green Station Study Location Assessment Report.

2.2.2 Proposed Station and St. Stephen's Green

The eastern side of St. Stephen's Green was identified as the optimum location for the MetroLink station as it would best serve passenger demand from the retail, commercial and cultural trip attractors in the vicinity. Further, the alignment from Tara Station (where MetroLink interchanges with DART and Irish Rail services) towards its terminus at Charlemont imposes turning constraints on the tunnel boring machine (TBM) that favour the eastern side of St. Stephen's Green as an appropriate location.

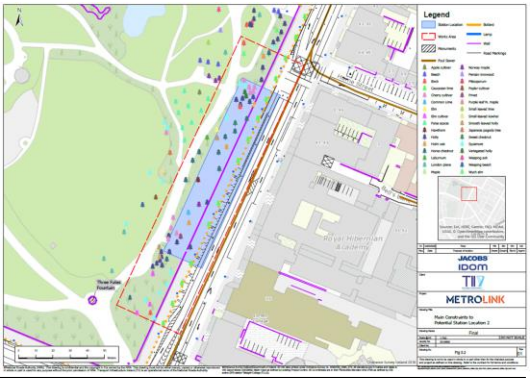
The Emerging Preferred Route for MetroLink (Arup March 2018) proposed locating the station mainly underneath the roadway and footpath on St. Stephen's Green East, but with part of the construction zone extending into the Park. However, as the design developed, the costs, complexity, and constraints of this position, including the Victorian masonry sewer running along St. Stephen's Green East, became apparent, resulting in the station being moved westwards so that it was partially located within St. Stephen's Green Park and partially under the adjacent footpath/roadway. This location was included in the Preferred Route for MetroLink.

2.2.3 St. Stephen's Green East – Station Location Assessment Report

Following the identification of St. Stephen's Green East as the best general location for a MetroLink station, a multi-disciplinary analysis was undertaken (Reference: Jacobs Idom, St. Stephen's Green Station Study Location Assessment Report, Revision P04) to identify the optimum location for a station at St. Stephen's Green East having regard to Engineering, Environmental and Economy criteria.

Seven potential station locations were identified on St. Stephen's Green East and Earlsfort Terrace. These are detailed in Section 5 (figures 5.1 to 5.7) of the Jacobs Idom, St. Stephen's Green Station Study Location Assessment Report, Revision P04 and summarised over the page.

Location 1 - situated primarily within the carriageway of St. Stephen's Green East.



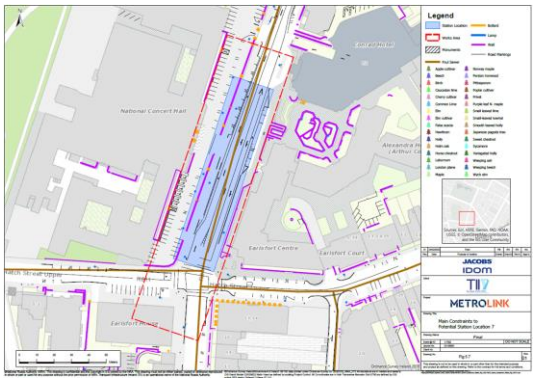
Location 2 - partially within St. Stephen's Green East and partially within the Park.

Location 3 - situated entirely within St. Stephen's Green Park.

Location 4 – same as Location 1 but 31m further north.

Location 5 - partially in St. Stephen's Green Park with 3 lanes of traffic remaining open.

Location 6 - located entirely within the Park to avoid impacting St. Stephen's Green East.



Location 7 - Earlsfort Terrace road and footprint of buildings either side of street.

The location options were assessed having regard to the following:

- The importance of St. Stephen's Green Park as an historical public park which maintains its Victorian layout and features extensive tree, shrub and flower planting that enhance the architectural features of the park. The Park is one of the most important green spaces in the centre of Dublin and attracts significant numbers of visitors each year;

- The Architectural Heritage of the area having particular regard to St Stephen's Green Park which is designated as a National Monument (RMP DU018-020334) and is listed on the Dublin City Council Record of Protected Structures (RPS 7751-7761). Furthermore, there are a number of buildings on the east side of St. Stephen's Green which may be impacted by potential station locations as they feature extensive cellars that protrude underneath the roadway;

- The importance of St. Stephen's Green East as a transport corridor for public transport, private vehicles, cyclists, and pedestrians. (During the AM peak hour, 384 buses use the corridor to access the City Centre);

- The presence of multiple utilities underneath the roadway on St. Stephen's Green East and the requirement for major diversions of those utilities. Particular attention was given to the potential requirement to divert the 1,800mm brick "ovoid" Victorian sewer located under St Stephen's Green East and a 1,710mm reinforced plastic mortar ovoid sewer situated underneath Hume Street since diversions of these utilities could extend the construction period by 12 months or more, causing significant additional impacts; and

- The requirement for an intervention shaft between the St. Stephen's Green Station and Tara Street in the event that the distance between these stations is greater than 1,000m. An intervention shaft is a significant structure that would be required to allow for emergency services to access the MetroLink tunnel in the event of an emergency, provide for passenger evacuation if required and support ventilation requirements. The intervention shaft would need to be located between Tara and St Stephen's Green Stations and would cause significant additional impacts if required.

2.2.4 St. Stephen's Green East - Preferred Station Location

A number of the potential station locations (Locations 1, 2, 3 and 7) were identified as being more than 1000m from Tara Station. This would mean that an intervention shaft would be required. The most appropriate location for an intervention shaft would be any available open spaces i.e., Trinity College Dublin or Merrion Square. This requirement resulted in these locations performing poorly against several criteria in the preliminary assessment. In particular, the locations performed poorly against Economy and Environmental criteria due to the increased capital cost and environmental impacts associated with construction of an intervention shaft at identified sensitive locations.

Given these unfavourable factors, locations 1-3 and 7 were not progressed for further analysis. It should also be noted that station location 7 (Earlsfort Terrace) would also require the diversion of the Victorian sewer along Earlsfort Terrace which meant this option performed poorly against Economy and Environmental criteria due to a prolonged construction period resulting in additional costs and environmental impacts. Finally, location 7 performed poorly against the overall Project Objective criteria as a station located at Earlsfort Terrace would not provide a good public transport network legibility due a lack of key trip attractors. In this regard it is significantly inferior to options on St. Stephen's Green East.

Location 4 is situated beneath the roadway on St. Stephen's Green East and would require the 1,800mm ovoid Victorian sewer and the Hume Street sewer to be diverted to allow for the construction of this station. This is considered very technically challenging and would require an extended construction period of 12 months.

This station location also performed poorly against the environmental criteria because of the requirement to close St. Stephen's Green East and Hume Street to public transport and traffic during construction, as well as the potential direct impacts on properties on the east side of St. Stephen's Green which are listed on the Record of Protected Structures (RPS). In terms of the economy criterion, the cost of utility diversions would

be significant, and this caused this location to perform moderately in regard to this. As a result of the poor performance against the engineering (constructability) and environmental criteria, Location 4 was not progressed for further analysis.

Locations 5 and 6 were brought forward for further analysis involving a further multicriteria analysis (MCA) using Environmental and Economy criteria. Both station locations would have a direct impact on St. Stephen's Green Park, but due to the proposed station locations they avoid the following impacts;

- diversion of the Victorian sewer in St. Stephen's Green East and the sewer in Hume Street, and the associated impacts resulting from a more extensive construction area and duration;
- the closure of St. Stephen's Green East to public transport and traffic during the construction phase; and
- direct impacts on buildings listed on the RPS on St. Stephen's Green East.

The outcome of the further MCA analysis of Location 5 and 6 was that Location 5 was chosen as the preferred location for the proposed MetroLink station as it significantly reduced the impact on St. Stephen's Green Park when compared to Location 6. Location 5 results in the requirement for less tree felling and vegetation removal when compared with Location 6. In addition, the long-term impacts on St. Stephen's Green Park are significantly less for Location 5 as the main surface elements of the proposed station are largely located outside of the current extent of St. Stephen's Green Park.

Furthermore, the choice of Location 5 allows for the long-term impacts of the station to be significantly mitigated by replanting trees and other vegetation, in addition to the reinstatement of existing elements of architectural heritage. In addition, high-quality design of station "pop-ups" would allow for the development of a high-quality urban environment in the north-eastern corner of St. Stephen's Green.

However, Location 6 performed better against the economic criteria than Location 5 as the station is located entirely under St. Stephen's Green Park which would significantly lower the construction, reinstatement of roadway and utility diversion costs.

Overall, Location 5 (Figure 2.1) was chosen as the preferred station location for St. Stephen's Green East (now called St. Stephen's Green Station) to mitigate the potential impacts on St. Stephen's Green Park by only partially infringing into the Park, whilst reducing the overall construction phase impacts by avoiding the requirement for an intervention shaft and significant utility diversions, and retaining transport and traffic movements on St. Stephen's Green East during the construction phase.

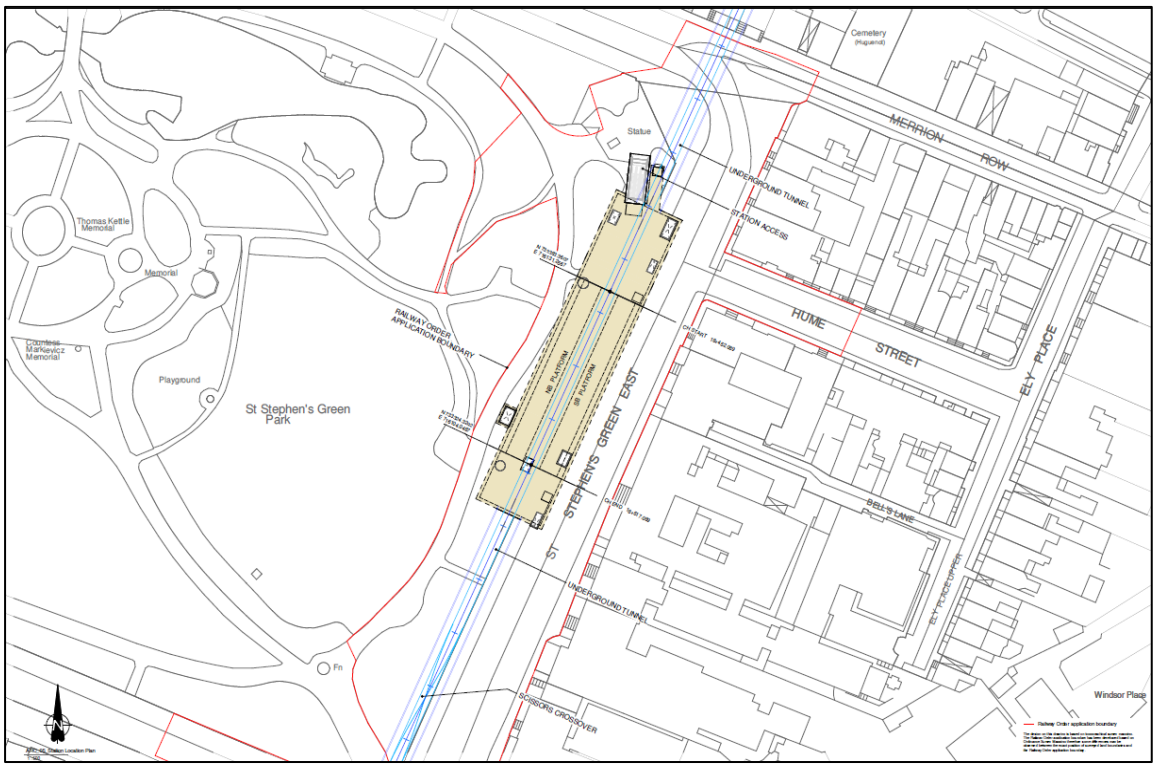


Figure 2.1: St. Stephen's Green Station Preferred Location (Option 5)

2.2.5 Consultation with Office of Public Works (OPW) and Department of Culture, Heritage and the Gaeltacht (DCHG)

Following consultation with representatives of the Office of Public Works (OPW) and the Department of Culture, Heritage and the Gaeltacht (DCHG), the OPW formally informed TII (10 June 2020) that the MetroLink proposals were unacceptable and required that 'the project does not infringe on the boundary of St. Stephen's Green or alter the historic landscape in any way'.

In response, Jacobs Idom undertook further analysis on a possible alternative option to construct the 116m long by 25m wide station box wholly within the carriageway and pathways of St. Stephen's Green East using diaphragm walls and top-down construction techniques (Reference: Transport Infrastructure Ireland. St. Stephen's Green Station Study, Alternative Station Location within SSG East Carriageway, March 2021, Appendix A: St. Stephen's Green Station in Carriageway Construction Approach.), the key findings of which were:

1. **Increased Direct Cost** - the overall relative direct cost comparison of the station will increase by about 67%;

2. **Time Delay** - complexity of the alternative construction methodology and the need to carry out extensive service diversions will increase the overall construction programme by about 15 months. With a further 12 months of time risk allowance added to reflect the risk and complexity of the works, this results in an overall duration increase of 2 years and 3 months;

3. **Impact on Buildings and Population** – due to the close proximity of the station box to buildings along St. Stephen's Green East, (many of which are architecturally and historically significant), parts of these buildings will require extensive strengthening in advance of construction works, necessitating the relocation of the occupants.

Furthermore, since the construction footprint of the station box occupies the entire carriageway and footpath of St. Stephen's Green East, it will not be possible to maintain access to the front of the

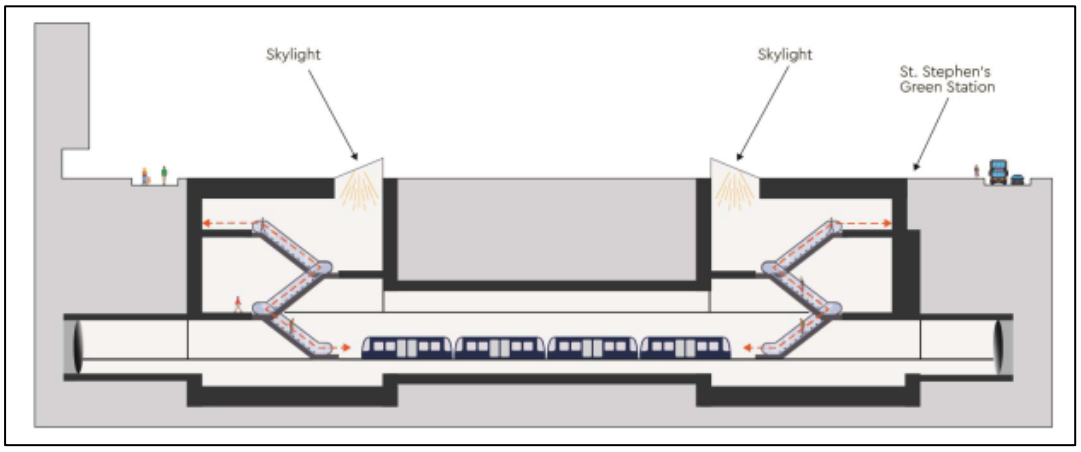
buildings or to maintain utility service connections. Coupled with the further impact of noise, dust, and vibration on building occupants, it is extremely likely that the buildings will need to be vacated and the occupants relocated;

4. **Utilities** - services, which would otherwise not require diverting, will need to be diverted if the station box is to be located entirely within the carriageway. This will include the temporary diversion of two large Victorian ovoid sewers to facilitate construction, a 1.2km diversion of a high voltage ESB cable and numerous other critical services. These are complex, difficult diversions which will cause extensive disruption. The gravity sewers will need to be replaced by pumping stations and rising mains with standby capacity to mitigate the risk of flooding.

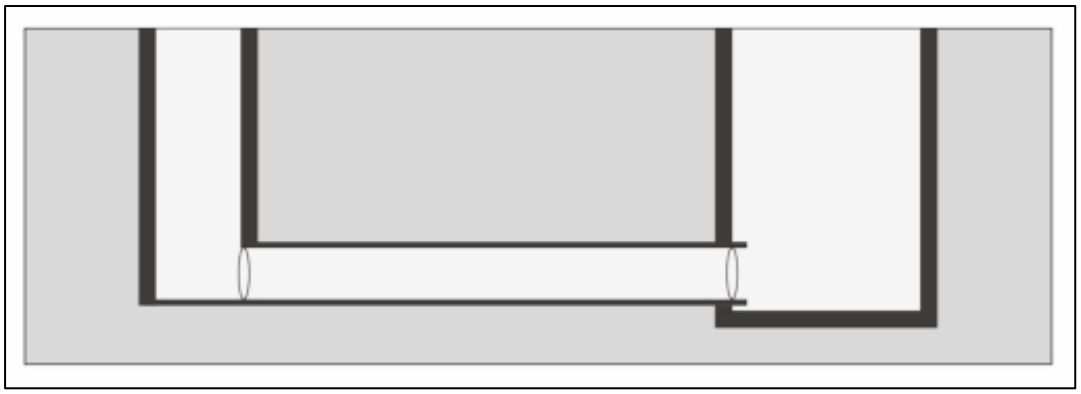
5. **Traffic** - closure of St. Stephen's Green East and Hume Street during construction would require the diversion of all traffic and pedestrians, including 384 bus services across multiple bus routes. As well as inconveniencing car traffic, these alterations will significantly increase journey times for many bus passengers across the city.

It is also of note that Section 3 of 'Appendix A, St. Stephen's Green Station in Carriageway Construction Approach' considered whether a St. Stephen's Green mined station configuration could feasibly avoid infringement of St. Stephen's Green Park. The mined station options considered were:

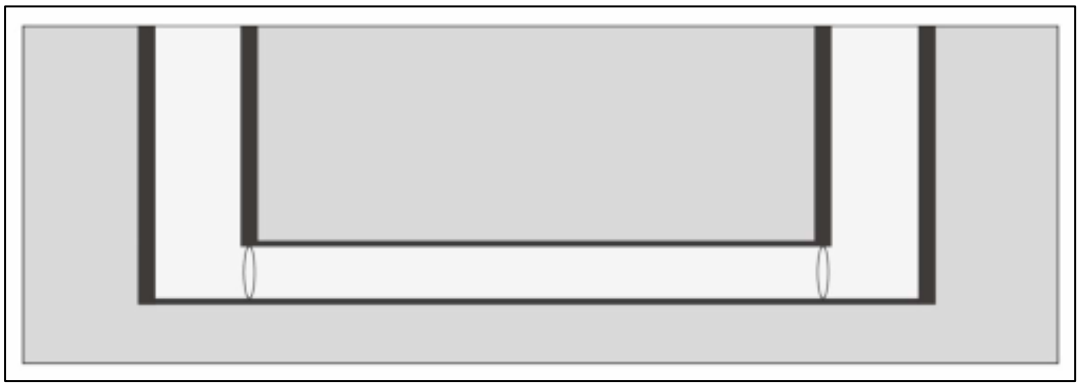
- Option A: Mined platform cavern between rectangular 'vertical circulation' boxes at either end;



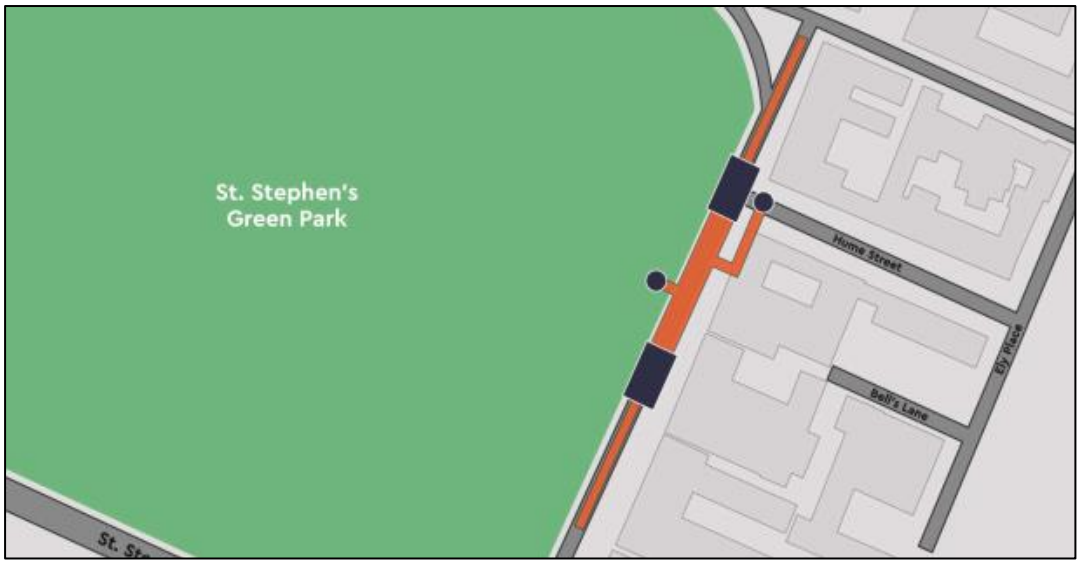
- Option B: Mined platform cavern between a rectangular 'vertical circulation' box and an intervention 'type' shaft;



- Option C: Mined platform cavern ‘enlarged’ from the TBM bored tunnel; and



- Option D: Mined station from offline construction shafts.



All of the mined tunnel options were considered not to have advantages over the proposed station location (Figure 2.1) or a cut and cover station constructed wholly under St. Stephen’s Green East. All would need surface interventions to facilitate construction and permanent station facilities, either with significant impacts on the Park and adjacent roads, or with disruption to St. Stephen’s Green East itself, significantly impacting utilities, pedestrian, and traffic access. Programme benefits were slight or would significantly increase construction durations.

When the additional construction challenges, increased risk of damage to buildings, to utilities, and disruption to local residents, pedestrians, bus services and general traffic flows were considered, it was concluded that a station box within the carriageway and pathways of St. Stephen’s Green East did not justify containing all the construction works outside of the Park and wholly under St. Stephen’s Green East. In addition, the significant cost and programme implications of this option were prohibitive in comparison to the proposed option (Figure 2.1).

3. Options Assessment Methodology

3.1 Approach Overview

The options assessment methodology has been developed in line with The Common Appraisal Framework 2016 (CAF) for Transport Projects and Programmes which develops a common framework for the appraisal of transport investments. It is consistent with the PSC (Public Spending Code). The TII Project Appraisal Guidelines for National Roads (PAG) translate the requirements of CAF in relation to National Road infrastructure Projects and Programmes.

An assessment system of multi-criteria analysis (MCA) is typically employed to develop a common framework for appraising transport investments in accordance with the Public Spending Code for Ireland. This section sets out the assessment methodology developed for this review.

To assess the performance of the mined station options identified, a four-stage options analysis assessment was undertaken to review the mined station location options at St. Stephen's Green East:

- **Stage 1**: Review of the receiving environment to identify constraints to the provision of a proposed station;
- **Stage 2**: Identify and describe additional mined station location options that minimise impact on St. Stephen's Green Park;
- **Stage 3**: Preliminary analysis to assess the feasibility of the proposed new options having regard to the Project Objectives, Engineering, Economy and Environmental criteria; and
- **Stage 4**: Multi Criteria Analysis (MCA): Comparative analysis of the short-listed options to the current Preliminary Design, using more detailed assessment criteria.

3.2 Stage 1: Review of the Receiving Environment

The Jacobs Idom, St. Stephen's Green Station Study Location Assessment Report, Revision P04 included a detailed review of the receiving environment and identifies the principal constraints that should be considered when selecting the preferred location for a station on St. Stephens Green East. These have been summarised in Section 4 and taken account of in developing the mined station options.

3.3 Stage 2: Identification and Description of Potential Station Locations.

As described in the previous section 'SSG Station Development History', the EPR station location was identified in the National Transport Authority, New Metro North, Alignment Options Report, Volume 1: Main Report, 252252-00, Issue 1. This was followed by the Jacobs/Idom, St. Stephen's Green Station Study Location Assessment Report, (current version Revision P04) which concluded with the identification of Location 5 (see Figure 2.1) as the preferred location for a MetroLink Station at St. Stephen's Green.

This review continues the above work and identifies and examines further possible mined options for the station (see 5.1) with the aim of minimising the impact on the Park.

3.4 Stage 3: Preliminary Analysis

The preliminary analysis comprises a qualitative assessment of potential station locations based on the criteria identified in the TII 2016 Project Appraisal Guideline, Table 3.1. Environmental criteria suggested in the document reflect those topics that are required to be assessed under the EIA Directive when preparing an Environmental Impact Assessment Report.

The preliminary assessment is made against relevant criteria, in particular the Key Project Objectives to ensure the mined options developed align with them. The objective of this review is to identify and assess mined options for St. Stephen's Green Station that:

- integrate appropriately into the existing public realm and minimise ingress into the Park;
- are planned, constructed, and operated in an environmentally and economically sustainable manner; and
- satisfy the overall project needs from an operational and safety perspective.

In addition to Project Objectives, Environment, Engineering and Economy were also identified as key criteria for consideration when differentiating between the mined station options identified. Table 3.1 summarises.

Table 3.1: Preliminary Assessment Criteria

Criteria	Sub-Criteria	Criterial Description
Project Objectives	1. Design to integrate appropriately into the existing public realm. 2. Planned, constructed, and operated in a sustainable manner. 3. Satisfy the overall project needs from an operational and safety perspective.	
Environment	Potential for adverse impacts	Minimise the potential for adverse impact on the natural and built environment and the community.
Engineering	Constructability	Considers if the station option can be constructed having regards to the identified constraints.
Economy	Cost, schedule, and risk	Considers the cost, schedule, and associated risk of each of the proposed mined station options.

All mined station locations identified in Stage 2 have been assessed against the relevant sub criteria shown by Table 3.1 with the objective of identifying locations that are feasible, demonstrate good or moderate performance and are therefore worthy of being subjected to a more rigorous MCA process in Stage 4.

The performance of the mined options identified for preliminary assessment have been evaluated against the above criteria using a colour coded three-point scale (Table 3.2), ranging from an overall good performance to an overall poor performance.

Table 3.2: Stage 3 Preliminary Assessment Criteria Scoring

Description	Colour
Overall good performance against the criteria	
Overall moderate performance against the criteria	
Overall poor performance against the criteria	

The Stage 3 evaluation of the mined options identified can be found in section 5 of this document.

3.5 Stage 4: Multi Criteria Assessment (MCA)

Stage 4 involved taking the locations which remained following the Stage 3 Preliminary Assessment and subjecting them to a more detailed MCA comparative analysis (Stage 4) to identify the preferred station location option. Unlike Stage 3, this evaluation now also included an assessment of the performance of the current Preliminary Design (Figure 1.1 and Appendix A) against the mined station options brought forward to Stage 4.

3.5.1 and 3.5.2 below set out the; MCA Thematic Grouping and Evaluation Scoring respectively that have been applied to complete the Stage 4 MCA. The evaluation was also divided between construction and operation to provide further clarity in understanding the performance of the mined options and the current Preliminary Design.

3.5.1 MCA Thematic Groupings

Criteria	Sub-Criteria	Criterial Description	Criteria
Project Objectives	Integrate appropriately into the existing public realm. Planned, constructed, and operated in a sustainable manner. Satisfy the overall project needs from an operational and safety perspective.		• Architectural Vision; • Passenger Experience and Wayfinding; • Accessibility, including PRM; • Integration with Other Public Transport Services; • Emergency Intervention, Access / Egress; • Ventilation; • Functional Plan and Operations; and • Public Realm.
Environment	Potential for adverse impacts	Minimise the potential for adverse impact on the natural and built environment and the community.	• Property Impact to SSG; • Noise and Vibration; • Traffic and Transport; • Groundwater; • Bio-Diversity; • Climate (carbon); • Dust/Air; • Landscape and Visual; • Construction Resources and Waste; • Archaeology/Cultural Heritage; and • Architectural Heritage.

Criteria	Sub-Criteria	Criterial Description	Criteria
Engineering	Constructability	Considers if the station option can be constructed having regards to the identified constraints and opportunities.	• Constructability; • Disposal/Haulage; • Ground Movements and Geology; • Vertical and Horizontal Alignment; • Demolition or Buildings Required or Impacted; and • Utilities.
Economy	Cost, schedule, and risk	Considers the cost, schedule, and associated risk of each of the proposed station options.	• Programme / Schedule; • Cost (CAPEX & OPEX); and • Cost and Schedule Risk.

3.5.2 Stage 4 MCA Evaluation Scoring

The options identified for the detailed assessment have been assessed equally using a five-point colour coded scale (Table 3.3) to rank each option in terms of advantages / disadvantages over all other options, including the current St. Stephen's Green Station Preliminary Design. Also, as previously noted, construction and operational performance has been evaluated separately to provide further clarity in understanding how the options perform during the construction and operational phases.

Table 3.3: Stage 4 MCA Scoring

Significance (Advantages/Disadvantages)	Assessment Score for Individual Assessment Criteria
Significant advantages over other options	
Some advantages over other options	
No disadvantages or advantages	
Some disadvantages over other options	
Significant disadvantages over other options	

The Stage 4 Assessment undertaken along with the results of the assessment are set out in section 6 of this document.

It is also of note that there are no weightings applied to the evaluation criteria, however the "overall factors" of Project Objectives, Environment, Engineering and Economy have a different number of sub criteria, thereby in effect introducing weighting:

- Project Objectives: 8 No. criteria

- Environment: 11 No. criteria
- Engineering: 6 No. criteria
- Economy: 3 No. criteria

From the above it can be seen that in effect this is adding a weighting to environmental criteria for the assessment. To determine the overall evaluation for each of the 4 core thematic groups the predominant colour coding across the sub-criteria is adopted.

4. Receiving Environment and Constraints

A summary of the receiving environment and key constraints is provided below. Further detail can be found in the Jacobs Idom, St. Stephen's Green Station Study Location Assessment Report, Revision P04.

1. **Utilities** - the masonry ovoid sewer running within St. Stephen's Green East will be a key constraint. Even with a mined option, the necessary surface penetrations for construction, access and ventilation will require numerous service diversions as well as possible protection from ground movements and vibration.

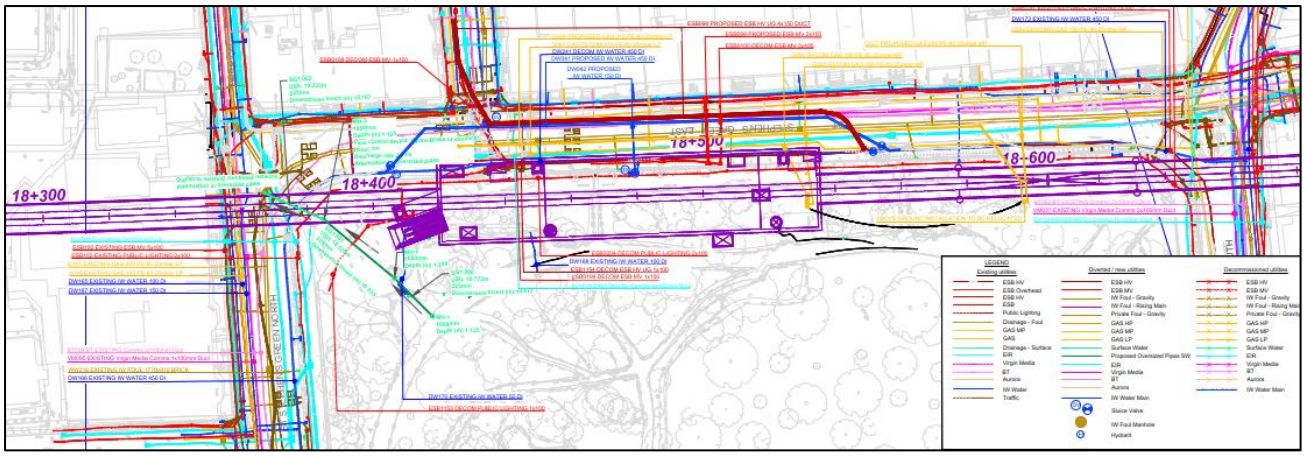


Figure 4.1: St. Stephen's Green East Utility Plan

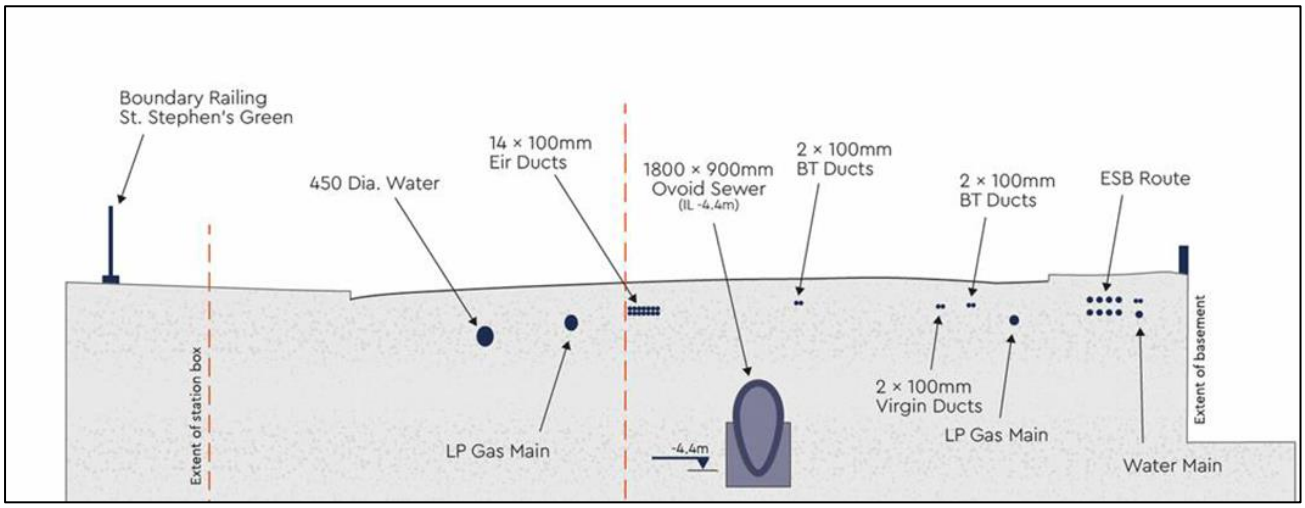


Figure 4.2: St. Stephen's Green East Utilities (shows masonry ovoid sewer and extent of the diaphragm wall of the current St. Stephen's Green Station Design Preliminary Design)

2. **Geology** - rockhead is circa. 10m below ground level (Figure 4.3) and groundwater ranges from 5 to 6m below ground level, both particularly significant for tunnel construction employing open face mining techniques. Assuming an excavated station platform cavern span of c.22m by 15m high, with 15m of rock cover to the tunnel excavation would increase rail level from 23m (current design) to 34m below ground level.

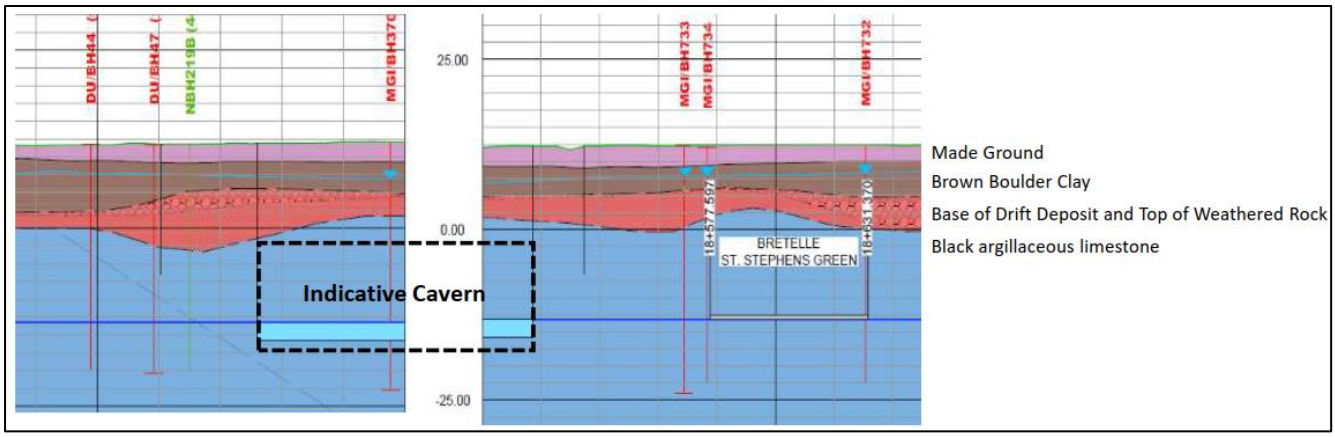


Figure 4.3: St. Stephen's Green Geological Profile (indicative platform cavern shown imposed on current MetroLink rail level)

3. **Traffic, Access, and Space for Construction & Logistics** (C&L) – St. Stephen's Green East is a busy route providing bus, car, cycle, and deliveries for businesses. With no space available within the Park, it is unlikely it will be possible to maintain three traffic lanes and two cycle routes during the construction phase along St. Stephen's Green East.

4. **Environment** (natural, built and community)

a) **Architectural Heritage**

- St. Stephen's Green is a designated National Monument extending to the edge of the pavement. The Park's railings will need to be protected during construction or possibly removed to ensure their protection. In addition, removal and storage of monuments (Wolfe Tone Monument, Hungry Heart), paving stones, bollards and other elements of street furniture will need consideration.

- Buildings (with cellars/basements) on the east side of St. Stephen's Green are on the Record of Protected Structures (RPS).

b) **Archaeology** - Potential to encounter the 17th century perimeter wall and ditch.

c) **Landscape** - Trees are an important feature on St. Stephen's Green East and space is required to ensure that trees are not damaged during construction by ensuring roots can remain established with a drainage system in place to prevent soil from drying out.

d) **Population** - The area is sensitive due to the presence of a school, hotels, and residents – potential for noise, vibration, and dust to impact if not mitigated. The amenity value of St. Stephen's Green is of critical importance.

e) **Property/Land Take** – The area surrounding St. Stephen's Green is urban and the location of vent shafts etc have potential to impact on private property.

5. Stage 3 Preliminary Analysis

5.1 Identified Mined Concepts

Prior to developing potential concept design ideas, Jacobs Idom examined together with the understood station requirements and receiving environment constraints:

- other project examples of mined station layouts (single bore side platform arrangements are less common than twin bore running tunnel configurations); and
- possible locations for construction, passenger access, intervention, and ventilation.

The concepts identified are schematically summarised by Figure 5.1 and described below, with further detail provided in Appendix B for each of these concept options, including a location plan, and plans and sections.

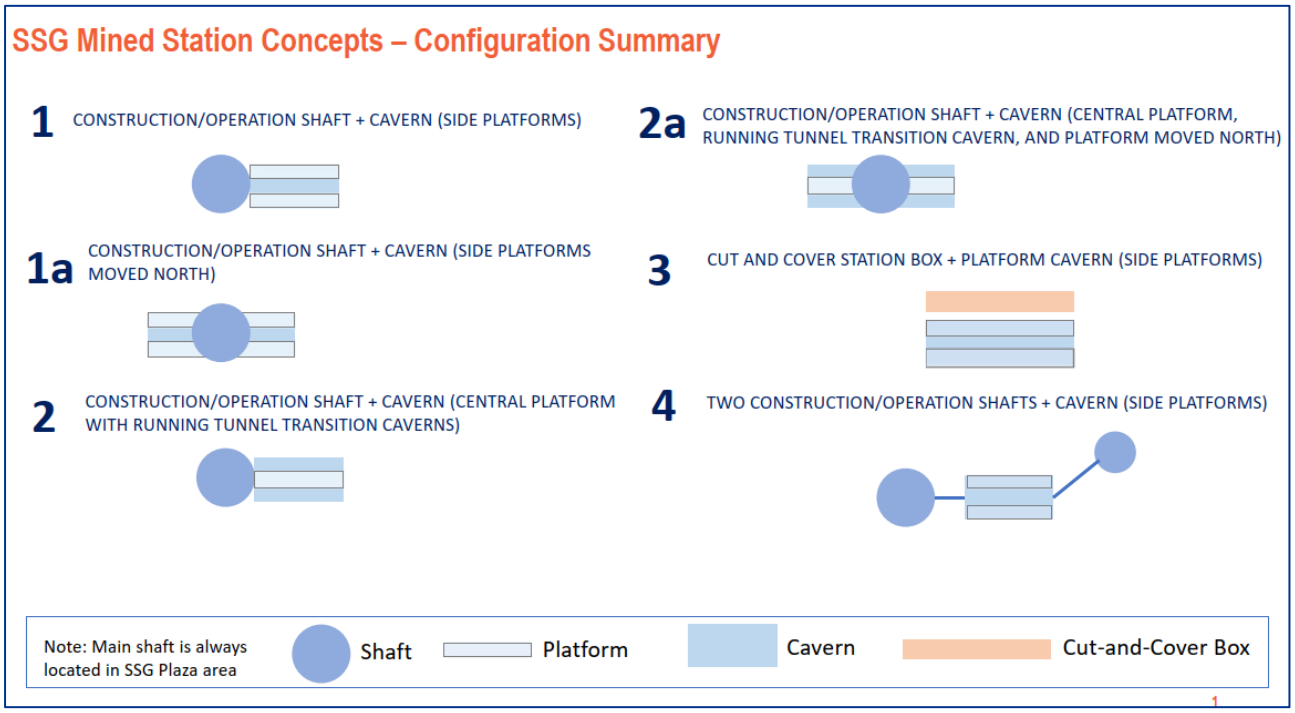


Figure 5.1: Mined Station Concepts

Option 1, Construction / Operation Shaft + Cavern (side platforms)

The entrance to the station is located within the footpath of St. Stephen's Green North. This connects to the main access shaft located in the Park entrance Plaza area which in turn leads to the platform concourse (located in the mined platform cavern) via three tiers of escalators and a passenger lift from which access is then provided via lifts and escalators down to the station platforms.

Two access/egress intervention shafts and two dedicated Dublin Fire Brigade lifts are located along St. Stephen's Green East, one pair serves the south end of the station, and the other pair the north end, along with a ventilation shaft with grilles also serving the southern end of the station. All are located outside of the St. Stephen's Green Park fence line. There are a further two ventilation grilles provided at the top of the main access shaft in the Plaza area to serve the northern end of the station.

Option 1a, Construction / Operation Shaft + Cavern (side platforms with platforms moved north)

The same as Option 1 except for:

- the platform cavern has been moved north so that the main access shaft is located in the centre of the station platform;

- only one emergency access/egress and dedicated Dublin Fire Brigade lift is now provided on St. Stephen's Green East. The ventilation shaft serving the south end of the platform also remains on St. Stephen's Green East;

- the other emergency access/egress and dedicated Dublin Fire Brigade lift is now provided in the main access shaft; and

- a ventilation shaft for the northern end of the station is provided north of St. Stephen's Green North in a built-up area.

Option 2, Construction / Operation Shaft + Cavern (central platform with running tunnel transition caverns)

The entrance to the station, route to platform concourse level and the provision of emergency access/egress intervention shafts, dedicated Dublin Fire Brigade lifts, and a ventilation shaft at the south end of the station along St. Stephen's Green East, with ventilation grilles positioned at the top of the main access shaft are the same as Option 1. With escalators and lifts leading from the platform concourse to the island platform.

The platform island configuration requires running tunnel transition enlargements (165m and 178m long north and south of the station respectively) to be constructed to allow the track to bifurcate to serve the island platform.

Option 2a, Construction / Operation Shaft + Cavern (central platform, running tunnel transition cavern, and platform moved north)

The same as Option 2 except for:

- the platform cavern has been moved north so that the main access shaft is located in the centre of the station platform;

- a ventilation shaft, emergency access/egress and a dedicated Dublin Fire Brigade lift remains on St. Stephen's Green East to serve the southern end of the station; and

- emergency access/egress and a dedicated Dublin Fire Brigade lift are now located on the north side of St. Stephen's Green North, with a ventilation shaft now provided in the built-up area north of St. Stephen's Green North to serve the northern end of the station.

Option 3, Cut and Cover Station Box + Platform Cavern (side platforms)

The aim of this option was to place every piece of station surface infrastructure outside of the St. Stephen Green Park fence line. It comprises a narrow box located on St. Stephen's Green East that provides an entrance to the station in the St. Stephen's Green East footpath down to platform concourse level from which passengers then travel across via a single passageway connection to the station platform cavern concourse before descending to the platforms via lifts and escalators.

Emergency access/egress, dedicated Dublin Fire Brigade lifts and station ventilation are all contained within St. Stephen's Green East outside of the Park's fence line, providing access and ventilation to the north and south ends of the station.

Option 4, Two Construction / Operation Shafts + Cavern (side platforms)

Option 4 was derived as a 'pure' mined option, with two station entrances located north and south of the station, one in the north-east entrance Plaza area of St. Stephen's Green Park, and one on land (currently

built upon) bounded by Earlsfort Terrace and Lesson Street Lower. Access at these two entrances is via escalators and lifts that connect to passageways (mined tunnels) leading to the station platforms.

Emergency access/egress, dedicated Dublin Fire Brigade access and station ventilation is provided via the two main access shafts for the north and south ends of the station.

5.2 Stage 3 Preliminary Analysis

In accordance with section 3.4, a Preliminary Analysis of each of the potential mined station concepts was undertaken, the results of which are summarised by Table 5.1. Appendix C provides the individual Stage 3 analysis undertaken for each mined station concept identified that supports this summary.

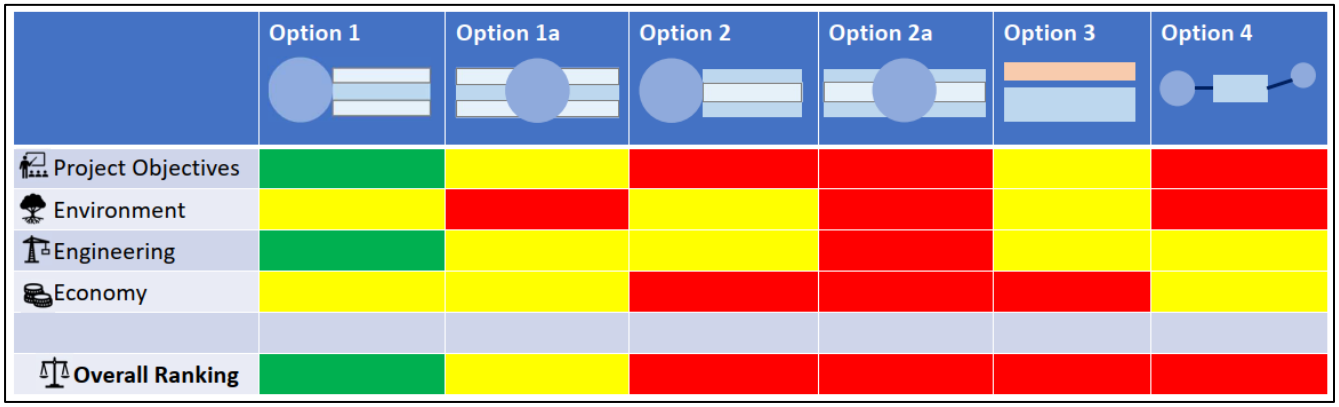


Table 5.1: St. Stephen's Green Mined Station Concept Analysis Results Summary

Description	Colour
Overall good performance against the criteria	
Overall moderate performance against the criteria	
Overall poor performance against the criteria	

5.3 Stage 3 Preliminary Analysis Conclusions

The summary conclusions drawn from this Stage 3 analysis are:

- Option 1 – The concept was considered to provide an acceptable and functional design solution with good constructability confidence. Cost and programme impact remains to be assessed. It does however also have considerable environmental impact during construction in terms of the need for 24-hour tunnel construction and the risk of generating noise and ground borne noise and vibration that has the potential to impact hotels and residents at this location.

- Option 1a – The moving of the platforms north generates greater risk and impact to overlying property and needs to be considered against any benefit resulting from having the opportunity to mine the platform cavern north and south simultaneously from the main construction shaft.

- Option 2 - Island platform configuration is a significant departure from the Metrolink design concept and would be the only station on the Line configured this way. Combined with the need for extensive mined cavern running tunnel transitions at the north and south of the station, this option is likely to have significant cost and programme implications with an increased construction risk profile.

- Option 2a - This option presents the same disbenefits as Option 2, plus moving of the platforms north generates greater risk and impact to overlying property and outweighs any benefit resulting from having the opportunity to mine the platform cavern and running tunnel transitions north and south

simultaneously from the main construction shaft.

- Option 3 - Extremely constrained construction access (c.6m clear space between diaphragm walls) and the necessary sequential working to construct the box will import significant programme challenges and possibly place the Station on the critical path of the construction programme. It will also likely be the most expensive option and presents significant passenger experience/wayfinding challenges.

- Option 4 - The architectural concept and passenger experience is considered to be poor and is a radical change from the overarching architectural vison for MetroLink. In addition, there is a need to acquire property to construct the southern access. The Station would however provide two entrances north and south and the opportunity for over site development (OSD) at the southern entrance.

Following discussion with TII and NTA it was agreed:

- Option 1 - should be taken forward to the Stage 4 MCA;

- Option 1a – it was considered that moving the platform tunnel north was unlikely to offer significant benefit but would be maintained under review should Option 1 eventually be taken forward for Preliminary Design development;

- Option 2 and 2a - due to offering an island platform configuration and requiring construction of 150m+ long running tunnel transitions, this option would not be pursued further;

- Option 3 - it was decided that this option should be refined further to see by how much the station box width within St. Stephen's Green East could be maximised reflecting this option minimised the impact on St. Stephen's Green Park; and

- Option 4 – would not be pursued further due to providing a poor architectural concept and passenger experience.

Stage 3 Analysis Conclusion: Options 1 and 3 will be taken forward to the Stage 4 MCA and their performance compared to the current St. Stephen's Green Station Preliminary Design, to be termed Option 0 for the purpose of this review.

6. Stage 4 Multi Criteria Assessment (MCA)

6.1 Assessment Overview

This section details the Stage 4 MCA undertaken for Options 1 and 3 brought forward from Stage 3, and their comparison to the current St. Stephen's Green Station Preliminary Design, Option 0. It has been divided in to three core sections:

1. Option 0, 1, and 3 Key Characteristics (section 6.3). Purpose is to provide a compare and contrast between the station options considered;

2. Option 0, 1, and 3 Stage 4 MCA, (section 6.4). Scored evaluation in accordance with the methodology set out by section 3.5; and

3. Supporting narrative (section 6.5) to further substantiate the key characteristics comparison, and the Stage 4 MCA.

6.2 Updates Following Stage 3 Preliminary Analysis

6.2.1 Option 0 - St. Stephen's Green Station Preliminary Design

The current proposed St. Stephen's Green Station (Preliminary Design) is shown by Appendix A. It comprises a cut and cover station partially located in St. Stephen's Green Park with the station entrance integrated into the north-east entrance Plaza area of the Park. Further details of the station characteristics are provided in section 6.3.

6.2.2 Option 3 Further Design Development

Following completion of the Stage 3 Preliminary Analysis, Option 3 was developed further to maximise the width of the cut and cover box in St. Stephen's East (internal width dimensions increasing from 6m to 12.5m) by moving the cut and cover box structure as close as possible to the Park's fence line along St. Stephen's Green East and the masonry ovoid sewer running along St. Stephen's Green East. Station access from street level to platform level was also improved. Appendix D shows the updated concept for Option 3 that has been taken forward to the Stage 4 MCA.

6.2.3 Stage 4 MCA Assumptions

In undertaking this Stage 4 MCA the following has been assumed:

- All options have been assessed based on the Option 2 Trinity College Alignment (horizontal radius curve 350m);

- DART Underground/St. Stephen's Green Station connectivity is excluded from the evaluation;

- The north-east Plaza area in St. Stephen's Green Park is available for construction – the option evaluation does however take account of and consider the assessed impact on the Plaza and the Park;

- Traffic management, Options 1 and 3 – two traffic lanes (one northbound and one southbound) and a southbound cycle lane are maintained on St. Stephen's Green East, with a single cycle lane diverted through or around St. Stephen's Green Park.

- Drill and blast will be used to excavate the limestone. The productivity of roadheaders has been assessed to be approximately 50% of that assumed for drill and blast and is therefore not preferred, whilst also noting that roadheaders will generate ground borne noise and vibration;

- The St. Stephen's Green railings and associated foundation will be temporarily removed for all options to ensure their protection;
- Wolfe Tone Monument and Famine Memorial – Option 0 it is relocated, Option 1 removed and reinstated, and for Option 3 it is not impacted; and
- assumes an Enforceable Railway Order is the same for all options for comparative purposes.

Important Note:

When this review was initiated, it was assumed that subject to confirming the environmental impact of ground borne noise and vibration, 24-hour mining would be permitted, with only blasting limited to the day shift. Following detailed noise and vibration modelling this has been found not to be the case (see 6.5.2, Noise and Vibration), and as a result Options 1 and 3 have been evaluated assuming 12-hour/dayshift working, the same as for the current St. Stephen's Green Preliminary Design, Option 0.

6.3 Key Characteristics of Station Options

Figure 6.1 summarises the St. Stephen's Green Station options. Larger scale drawings of each of the options can be found in the appendices (Option 0 see Appendix A, Option 1 see Appendix B, and Option 3 see Appendix D). Table 6.1 summarises the key characteristics of each station option.

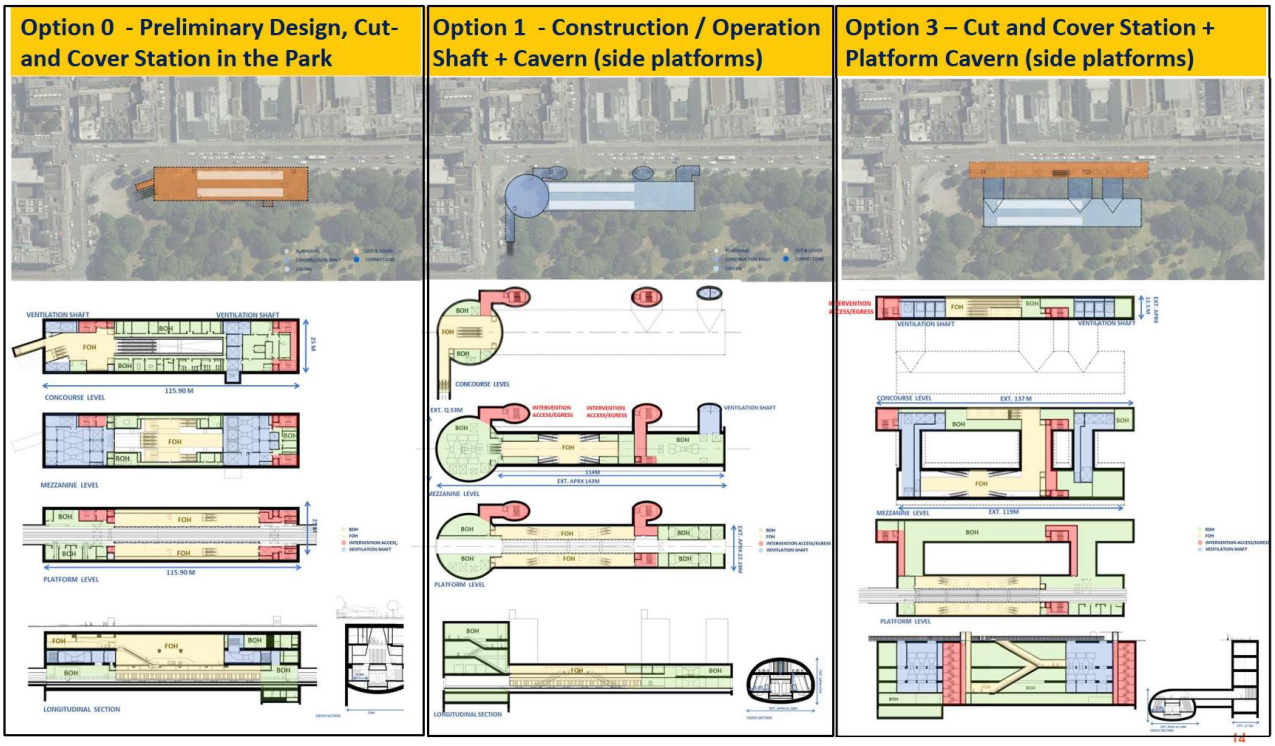


Figure 6.1: St. Stephen's Green Station Options 0, 1, and 3

Table 6.1: Station Option Key Characteristics (1 of 4)

Characteristic	Option 0 – Preliminary Design, Cut and Cover Station in the Park	Option 1 - Construction / Operation Shaft + Cavern (side platforms)	Option 3 – Cut and Cover Station + Platform Cavern (side platforms)
Design	• **Design complies with the TII Grimshaw Metrolink prototype station design except for** providing natural light to platform level**.** • **Station entrance is integrated into the Plaza area** of the Park. • **Five ventilation 'pop ups' in the Park.** • **Wolfe Tone Monument and Famine Memorial is relocated within the Park.**	• 'Pure' mined station option **designed to reduce incursion into the Park.** • **Main shaft is located in the Plaza, with the station entrance located in SSG North sidewalk**. • The shaft is capped off with **two ventilation grilles and one lift shaft remaining within the Plaza on completion**. • **Two intervention shafts, evacuation hatches and ventilation grilles are located within SSG East footpath.** • **Air intakes** associated with the intervention shafts **are located outside of the Park.** • **Wolfe Tone Monument and Famine Memorial is temporarily removed and then reinstated.**	• Developed to **minimise impact on the Park**. • Incorporates a **12.5m wide box** (within SSG East and the footpath) **linked to a mined cavern by three mined passageways (1 for passenger access, 2 for ventilation).** • In addition to the station entrance, **all the installation facilities** (Intervention lifts, evacuation hatches and ventilation shafts) are **aligned along the SSG East footpath**. • **Wolfe Tone Monument and Famine Memorial is not impacted.**
Construction	• The **box is formed of full depth diaphragm walls** and is constructed top-down. • **Excavation** within the box through the **rock is assumed to be undertaken using drill and blast**. • The **station is constructed in advance of the arrival of the TBM.**	• The **shafts** are **formed by full depth secant piles,** subsequently **lined with insitu concrete**. • The **tunnels** are formed using **SCL + rockbolts**. • To facilitate the safe excavation of the tunnels the overall **alignment** was **lowered by c.10m to ensure sufficient cover of competent rock**. • **Allowances for dewatering and fissure grouting for anticipated water ingress have been made.** • Shaft **excavation in rock and mining** the cavern will be **undertaken using drill and blast**. • **Platform tunnel is constructed after the TBM has passed** (due to day shift working only), **significantly impacting programme and cost.**	• Requires a **slender box** to be **constructed similar to Option 0 utilising d/walls, with mined tunnels as per Option 1**. **Both using drill and blast techniques.** • The **slim site is difficult for d/wall operations and together with an increase in depth of 10m there is a direct impact on the commencement of the cavern construction**. • **Allowances for dewatering and fissure grouting for anticipated water ingress have been made.** • **Platform tunnel is constructed after the TBM has passed** (due to day shift working only), **significantly impacting programme and cost.**

Table 6.2: Station Option Key Characteristics (2 of 4)

Characteristic	Option 0 – Preliminary Design, Cut and Cover Station in the Park	Option 1 - Construction / Operation Shaft + Cavern (side platforms)	Option 3 – Cut and Cover Station + Platform Cavern (side platforms)
Traffic	• Construction methodology and **logistics based on construction traffic entering and exiting through the Park area** and therefore **maintaining 3 public traffic lanes and 2 cycle lanes along SSG East.**	• **2 public traffic lanes together with 1 cycle lane are maintained along SSG East.** • Second cycle lane is maintained by diverting through or around the Park (subject to agreement). • Additional measures are required along SSG North to facilitate the escalator box construction and to provide sufficient space for construction logistics.	• **Traffic and cycle routes identical to Option 1.** • Additional measures are required along SSG North to provide sufficient space for construction logistics.
Principle External Dimensions	• **Station Box: 115m x 24m x 25m (top of rail)**	• **Main Shaft: circa 33m OD x 34m (top of rail)** • 3no. Vent/Egress Shafts: circa 17.5m OD x 35m (shaft base slab) • **Cavern: 112m x 22m x 15m high** • Entrance box: 27m long x 9.5m wide x 12m deep	• **Station Box: 137m x 14.5m x 34m (top of rail)** • **Cavern: 119m x 22m x 15m high**
Station Surface Footprint	• Total construction area = 6800m^2 • **Total construction area within the SSG Park fence line and Plaza = 3600m^2** • Total permanent land take = 3050m^2 • **Total permanent surface land take within the SSG Park fence line = 196m^2**	• Total construction area = 7600m^2 • **Total construction area within the SSG Park fence line and Plaza = 1300m^2** • Total permanent land take = 4050m^2 • **Total permanent surface land take within the SSG Park fence line = 40m^2**	• Total construction area = 5500m^2 (plus potential for offsite offices and welfare) • **Total construction area within the SSG Park fence line and Plaza = 0m^2** • Total permanent land take = 5100m^2 • **Total permanent surface land take within the SSG fence line = 0m^2**

Table 6.3: Station Option Key Characteristics (3 of 4)

Characteristic	Option 0 – Preliminary Design, Cut and Cover Station in the Park	Option 1 - Construction / Operation Shaft + Cavern (side platforms)	Option 3 – Cut and Cover Station + Platform Cavern (side platforms)
Principal Quantities	• Requires c.30,000m^3 of concrete to be delivered • Requires the removal of c.75,000m^3 of excavated material. • **Least concrete to be used, least excavation, least dewatering, least fissure grouting, no SCL wastage.** • **Least impact on carbon, C&L, and traffic on the roads.**	• **40% increase in concrete required to be delivered. c.42,000m^3** • **50%, increase in excavated material (c.112,000m^3) to be removed.** • Estimated 100% increase in dewatering and 180% increase in grouting. • High wastage from temporary use of sprayed concrete. • **Significantly impacts carbon, C&L, and traffic on the roads.**	• **50% increase in concrete required to be delivered. c.45,000m^3** • **55%, increase in excavated material (c.116,000m^3) to be removed.** • Estimated 70% increase in dewatering and 150% increase in grouting. • High wastage from temporary use of sprayed concrete. • **Significantly impacts carbon, C&L, and traffic on the roads.**
Schedule	• Station box is completed before TBM arrival, station completed on schedule. • Duration: ERO to Opening = **8.5 years**	• The cavern cannot be completed prior to TBM arrival and hence it is completed by enlarging the running tunnel after the TBM has reached its final location and has been buried. There is a delay to both station completion and subsequent route wide elements. • Duration: ERO to Opening = **10.5 years**	• Option 1 plus Option 3 schedule is further impacted by reduced productivity because of the need to undertake diaphragm walling on a severely constrained site, with sufficient space for only one Hydrofraise and one grab. • Duration: ERO to Opening = **12.25 years**
Direct Cost	**€174M**	**€296M (+71%).** Excludes any other Project delay cost arising from the above overall extension to the Construction Phase.	**€331M (+91%).** Excludes any other Project delay cost arising from the above overall extension to the Construction Phase.

Table 6.4: Station Option Key Characteristics (4 of 4)

Characteristic	Option 0 – Preliminary Design, Cut and Cover Station in the Park	Option 1 - Construction / Operation Shaft + Cavern (side platforms)	Option 3 – Cut and Cover Station + Platform Cavern (side platforms)
Working Hours	• **Standard working hours (12-hour/dayshift)** with exception of 24/7 working for: 1. TBM traverse through the station box 2. MEP station works	• **Standard working hours (12-hour/dayshift)** with exception of 24/7 working for: 1. TBM passing the station site (running tunnel enlarged to form the station cavern) 2. MEP station works	• **Standard working hours (12-hour/dayshift)** with exception of 24/7 working for: 1. TBM passing the station site (running tunnel enlarged to form the station cavern) 2. MEP station works

6.4 Stage 4 MCA and Evaluation Results

Each of the identified sub criteria falling under the overall factors of Project Objectives, Environment, Engineering and Economy (see 3.5.1 above) have been assessed in accordance with Table 3.3 for both construction and operational phases of the station option considered. A summary of the results of the MCA evaluation is shown by Table 6.5, with the back-up to this assessment provided by Appendix E.

Table 6.5: Stage 4 MCA Evaluation Summary

Construction Phase Summary			
Criteria	**Option 0**	**Option 1**	**Option 3**
1. Project Objectives			
a) Architectural Vision		Not Applicable	
b) Passenger Experience and Wayfinding		Not Applicable	
c) Accessibility, including PRM.		Not Applicable	
d) Integr'n with Other Public Transp Services		Not Applicable	
e) Emergency Intervention, Access / Egress		Not Applicable	
f) Ventilation		Not Applicable	
g) Functional Plan and Operations		Not Applicable	
h) Public Realm			
Project Objectives Overall			
2. Environment			
a) Property Impact to SSG Park			
b) Noise and Vibration			
c) Traffic and Transport			
d) Groundwater			
e) Bio-Diversity			
f) Climate - Carbon			
g) Dust/Air			
h) Landscape and Visual			
i) Construction Resources and Waste			
j) Archaeology/Cultural Heritage			
k) Architectural Heritage			
Environment Overall			
3. Engineering			
a) Constructability			
b) Disposal/Haulage			
c) Ground Movements and Geology			
d) Vertical and Horizontal Alignment			
e) Demol'n of Buildings Req'd or Impacted	No Impact (impact on SSG Park considered above)		
f) Utilities			
Engineering Overall			
4. Economy			
a) Programme / Schedule			
b) Cost/CAPEX/OPEX			
c) Cost and Schedule Risk			
Economy Overall			

Operational Phase Summary			
Criteria	**Option 0**	**Option 1**	**Option 3**
1. Project Objectives			
a) Architectural Vision			
b) Passenger Experience and Wayfinding			
c) Accessibility, including PRM.			
d) Integr'n with Other Public Transp Services			
e) Emergency Intervention, Access / Egress			
f) Ventilation			
g) Functional Plan and Operations			
h) Public Realm			
Project Objectives Overall			
2. Environment			
a) Property Impact to SSG Park			
b) Noise and Vibration			
c) Traffic and Transport			
d) Groundwater	Design will limit water ingress to the same level for all options.		
e) Bio-Diversity			
f) Climate - Carbon			
g) Dust/Air		Not Applicable	
h) Landscape and Visual			
i) Construction Resources and Waste		Not Applicable	
j) Archaeology/Cultural Heritage		Not Applicable	
k) Architectural Heritage			
Environment Overall			
3. Engineering			
a) Constructability		Not Applicable	
b) Disposal/Haulage		Not Applicable	
c) Ground Movements and Geology		Not Applicable	
d) Vertical and Horizontal Alignment			
e) Demol'n of Buildings Req'd or Impacted		Not Applicable	
f) Utilities		Not Applicable	
Engineering Overall			
4. Economy			
a) Programme / Schedule		Not Applicable	
b) Cost/CAPEX/OPEX			
c) Cost and Schedule Risk			
Economy Overall			

Significance (Advantages / Disadvantages)	Assessment Score for Individual Assessment Criteria
Significant advantages over other options	2
Some advantages over other options	1
No disadvantages or advanatages	0
Some disadvantages over other options	-1
Significant disadvantages over other options	-2

6.5 Evaluation Commentary

This section expands on the key characteristics comparison (6.3) and the tabulated Stage 4 MCA (6.4) undertaken by considering each of the sub-criteria falling under the core themes of Project Objectives, Environment, Engineering and Economy in accordance with 3.5.1.

6.5.1 Project Objectives

At its highest level the Project Objectives cover:

- Design to integrate appropriately into the existing public realm.
- Planned, constructed and operated in a sustainable manner.
- Satisfy the overall project needs from an operational and safety perspective.

Considering the sub-criteria that comprise the Project Objectives individually the following is observed. It is of note that except for 'Public Realm' the Project Objective sub-criteria only apply to the operational phase of the station.

Architectural Vision

The MetroLink architectural vision is centred around the creation of a large void that will provide passengers with a feeling of space, light and a quick understanding of the station. A cut-and-cover station box configuration lends itself to being able to provide this and hence the current St. Stephen's Green Station Preliminary Design.

In contrast, a station that is designed around a cavern platform arrangement, such as is the case for Options 1 and 3 presents a significantly different and sub-optimal architectural vision and feeling of space when considering how passengers will access and egress the stations, and the space they will be confronted with as they travel through and use the station.

In the case of Option 1, the passengers will enter the station from an entrance located in the footpath of St. Stephen's Green North footpath, travel along a passage to the main access shaft, before descending to the platform cavern via 3 tiers of escalators that reverse back upon one another, before reaching the mezzanine concourse (contained within the mined cavern) and taking further escalators to platform level.

Similarly for Option 3, passengers will enter the station from an entrance in St. Stephen's Green East footpath before descending via two tiers of escalators within a slim box structure, and therefore by its nature a compromise on the feeling of space and light that is provided by the current Preliminary Design, before landing on the intermediate concourse and then being funnelled through a single cross passage into the platform cavern and onto the platform concourse before finally descending to platform level.

For both options 1 and 3, providing station canopy architecture that is consistent with other station entrances on the MetroLink system will be challenging because of the station entrances being located in the St. Stephen's Green footpaths, and thereby resulting in a compromise with regards to passenger wayfinding and MetroLink branding.

The conclusion drawn is that the space and station configuration provided by a mined station solution cannot comply with the Metrolink architectural vision since a platform cavern arrangement creates narrower enclosed access and egress routes and hence an architectural vision that would be unique and inconsistent with the rest of the MetroLink system. This is unlikely to be acceptable for the MetroLink Project since it is important that passengers can use a system that is consistent and familiar along the whole of the Line; passengers need to be able to quickly and easily navigate the station and the wider system; MetroLink needs to provide consistent messaging and branding; as well as providing a consistent and efficient approach to operation and maintenance. As a result, both Option 1 and 3 are considered to provide significant disadvantages over Option 0, the current Preliminary Design.

Passenger Experience and Wayfinding

The design layouts of the current Preliminary Design, Option 0, provide a predominance of horizontal straight routes and minimal changes of directions, which offers significant advantages for passenger's flows and movements over Options 1 and 3. The layouts of Option 1 and 3 cannot operate as efficiently as Option 0 in this regard and are considered sub-optimal.

Option 1 has a shaft with a long vertical route via three tiers of escalators requiring two 180 degree turns before reaching the platform concourse. Similarly with Option 3, from mezzanine to platform, access is via an isolated station box and two escalator flights to mezzanine with 180 degree turns to reach the platform concourse. Upon reaching the platform concourse, passengers will then travel across via a single passageway to the platform cavern and descend to the platforms. While at this early design stage it is not appropriate to undertake passenger modelling, these numerous turns and 'funnelling' into the passageway to reach the platform cavern are likely to present design challenges to alleviate passenger congestion in what is a high demand station.

As can be seen from Table 6.6, the overall time walking from surface to platform levels between Option 0, 1, and 3 is 1.64mins, 2.52mins and 2.72mins respectfully - there is a 153% and 173% difference in time lost between Option 0 and Options 1, and 3 respectively. This is a significant difference in walking journey time lost due to the deeper mined stations, especially in the context of over 90,000 passengers per day predicted to use this station in the 2057 future year scenario. Escape route distances (via emergency exit routes) in the event of a fire safety incident have also been estimated (Table 6.7) and are shown to increase by an estimated 14% and 30% for Option 1 and 3 respectively.

Table 6.6: Estimated Walking Time from Surface to Platform Option Comparison

	Considering 30 degrees on escalators						
	WALKING TIME TO REACH TO PLATFORM LEVELS						
	Walk Distances		Walking Time		TOTAL WALKING TIME		
		Escalator	@1.42m/sec	@0.65m/sec			
	Horizontal	Flight length	Horizontal	Escalators	seconds	minutes	% against Option 0
Option 0	32.37	49.00	22.80	75.38	98.18	1.64	0%
Option 1	70.50	66.00	49.65	101.54	151.19	2.52	153%
Option 3	87.30	66.00	61.48	101.54	163.02	2.72	173%

Table 6.7: Estimated Emergency Escape Route Distances

Emergency Route Distances				
	Escape Distance (platform to surface)			
	H	V	Total (m)	% against Option 0
Option 0	77.40	24.05	101.45	0%
Option 1	82.50	33.00	115.50	14%
Option 3	99.30	33.00	132.30	30%
Note: Time is not calculated because there are alternative esape routes - people can also escape by main entrances.				

Based on the above, Option 0 was assessed as having significant advantages over Options 1 and 3, while 1 and 3 themselves were considered to have significant disadvantages over Option 0 when the 150% plus increase in passenger walking travel time from surface to platform is considered.

Accessibility, including Persons with Reduced Mobility (PRM)

A direct connection to the interior of the station, the orientation of the accesses for the benefit of pedestrian traffic on the ground, and the provision of universal access were the main premises assumed by the Preliminary Design, Option 0. Both Option 1 and Option 3, due to their depth and the location of their accesses, provide a significant weaker performance and have therefore been assessed as having significant disadvantages over Option 0. This is supported by the estimated increase in passenger travel times and emergency route distances shown by Table 6.6 and Table 6.7 respectively.

Integration With Other Public Transport Services

Table 6.8 shows the plan distance to both LUAS and bus stops for each option from the Station entrance.

Table 6.8: Plan Distance of Options 0, 1, and 3 From Luas and Bus Stops

	To LUAS	To Bus SSG North	To Bus SSG East
Option 0	410m	110m	140m
Option 1	350m	50m	190m
Option 3	470m	170m	60m

Option 0 and 1 are placed nearest and better oriented to the LUAS and the bus stop on St. Stephen's Green North, with Option 1 being marginally better in terms of providing a more direct walk route to the LUAS and bus stop but this is offset by the increased vertical travel distance from surface to platform level thereby making the performance of both these options similar.

Option 3's access point on St. Stephen's East is the most distant from the LUAS and the bus stop on St. Stephen's Green North and has therefore been assessed as having some disadvantages over Options 0 and 1 when combined with its increased travel distance from surface to platform.

For access to the bus stop on St. Stephen's Green East, Option 3 is the best. Overall Option 0 and 1 are assessed as having a slight advantage over Option 3 given it provides better access to both LUAS and the bus stop on St. Stephen's Green North.

Emergency Intervention, Access/Egress

The Preliminary Design criteria for emergency and intervention were developed in coordination with the Dublin Fire Brigade (DFB).

Option 0 offers advantages over Options 1 and 3 as it complies with the DFB preferred layout of having vertical shafts all the way to platform level, i.e., no split separation of the shaft. Whereas for Option 1 and Option 3 the shafts have a horizontal split separation of 16.6m and 32.6m respectively and have therefore been assessed as having some disadvantages over Option 0 respectively. In particular, gaining approval from DFB is likely to be more challenging for these Options.

Ventilation

Option 0, Preliminary Design requires a very similar volume (c.10,000m3) of air and smoke to be managed by the ventilation system as for the other stations on the MetroLink network.

Options 1 and 3 designs impact the ventilation strategy significantly, requiring an estimated increase of air volume to be driven of 24,000m3 (240% increase) and 27,000m3 (270% increase) respectively and hence both options have been evaluated as having significant disadvantages compared to the Preliminary Design, Option 0, due to the additional space and plant requirements required to cater for these increased volumes. It is also of note that Option 3 has a more complicated indirect ventilation route and connections to street level because of the station layout (separate station box horizontally connected at platform concours level to the platform cavern).

Functional Plan and Operations

Facilities for passengers, technical and operation rooms need to be configured and arranged to achieve functional efficiency and rational relationships to economise on installation, operation, and maintenance ways of working and costs. The Option 1 lay-out is similar to Option 0 excepting the disadvantages due to the increase in the depth of the station.

Option 3, however needs to be arranged with several rooms in the cut and cover box, which in effect is isolated from the core of the station, hence creating significant distance to the technical rooms and challenges in terms of achieving an optimal relationship with the core of the station/platform cavern. In addition, this may also incur challenges in complying with DFB intervention requirements.

Option 0 is evaluated as having significant advantages over Options 1 and 3 as it allows the optimal configuration and arrangement of technical and operation rooms, while Option 1 in comparison is disadvantaged by the increased depth of the station, and Option 3 because of an increased depth and the separation of technical rooms accommodated in the slender cut and cover box from the core of the station.

Public Realm

Unlike the other Project Objectives sub-criteria, the evaluation of station option performance in terms of Public Realm is relevant to both the construction and operational phase, and hence each have been considered separately.

Construction Phase

For all options it is assumed that the St. Stephen's Green Park fence line (railings and foundations) will be temporarily removed during construction to ensure their protection and then subsequently reinstated on completion of station construction.

Option 0, the current Preliminary Design, has a greater impact on St. Stephen's Green Park than the mined options considered. The total estimated construction area for this option is 6800m^2, of which 3600m^2 (52% of the total construction area) lies with the Park's fence line and the entrance Plaza area. In contrast, Option 3 requires zero land take during construction within the Park's fence line, and Option 1 occupies 1300m^2 within the Plaza area of its total estimated 7600m^2 construction area required.

Public Realm also encompasses other public used spaces, including footpaths, roads, cycle ways, and parking. With this in mind, Option 1 is assessed as having some disadvantages since it impacts the Plaza area of the Park, reduces St. Stephen's Green East to two traffic lanes and a single cycle lane, and impacts St. Stephen's Green North footpath.

While Option 0 significantly impacts St. Stephen's Green Park and St. Stephen's Green East footpath, it maintains the existing traffic and cycle access along St. Stephen's Green East and is hence assessed overall to perform similarly to Option 1.

Option 3 impacts traffic on St. Stephen's Green East the same as Option 1, requires construction within St. Stephen's Green East footpath, but does not infringe on St. Stephen's Green Park and is therefore assessed to have some advantages over the other options.

Figure 6.2, Figure 6.3, and Figure 6.4 show the construction footprint of each option.

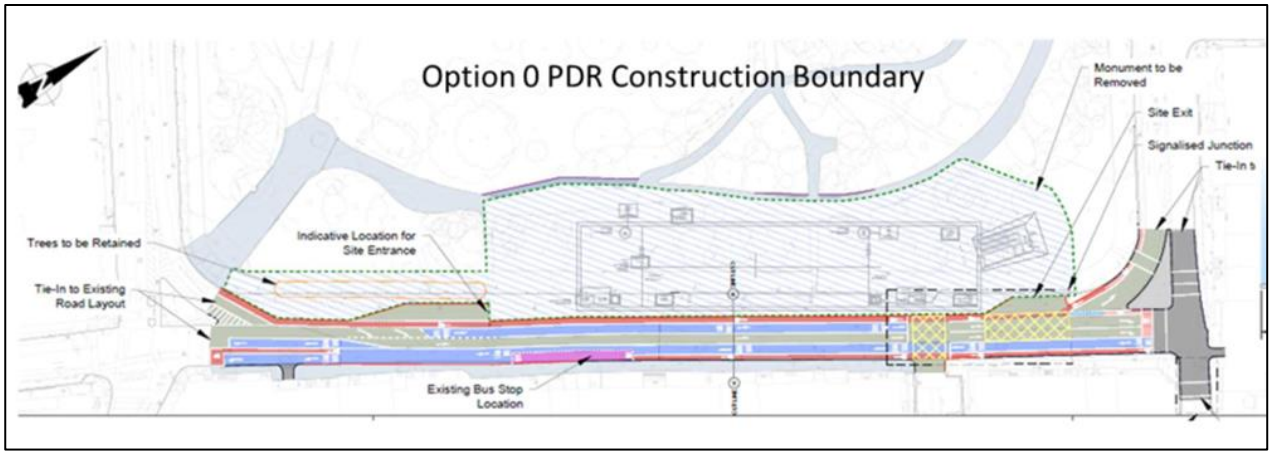


Figure 6.2: Option 0 (Preliminary Design) Construction Site Boundary (green dotted line)

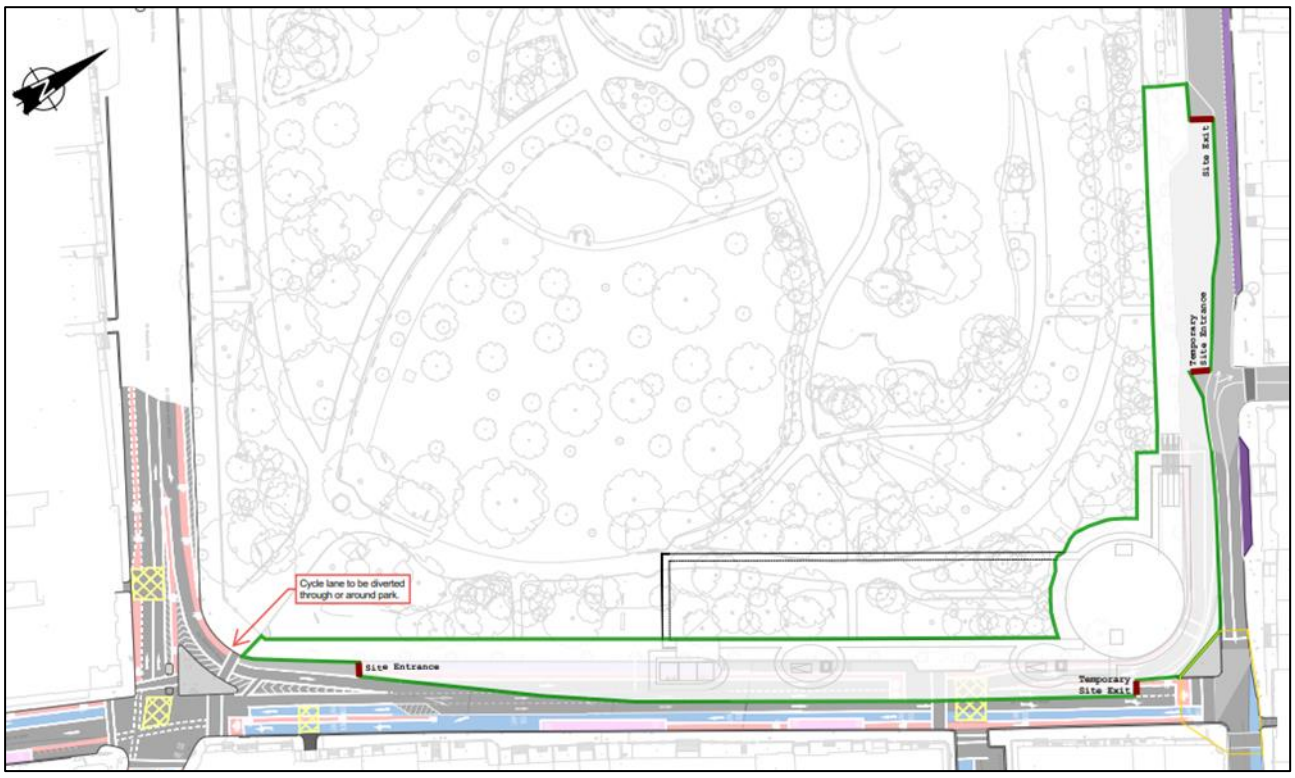


Figure 6.3: Option 1 Construction Site Boundary (green line)

Figure 6.4: Option 3 Construction Site Boundary (green line)

Operational Phase

Once operational, the Option 0 design provides a significant advantage over Options 1 and 3 as a result of the station entrance being fully integrated into the Plaza area rather than being within the footpath of St. Stephen's Green's North and East respectively. Having a station entrance located in these footpaths would result in poor integration with the public realm, constrain footpath access, and very likely cause pedestrian congestion on the footpath itself, compared to Option 0 where the Plaza provides a natural meeting place and reservoir holding area for people.

With regards to traffic, all options enable the full reinstatement of the current existing traffic and cycle lanes along St. Stephen's Green East, however there is some loss of parking along St. Stephen's Green East, with Option 3 resulting in a major loss of parking compared to the other options.

In terms of permanent surface land take areas, Option 0 is estimated to require 3050m^2, Option 1 - 4050m^2 (+33%), and Option 3 - 5100m^2 (+67%) and therefore overall Option 0 performs the best. However, when considering the permanent surface land take within the St. Stephen's Green Park fence line, Option 0 performs the worst with an estimated 196m^2, versus 40m^2 for Option 1 (occupation of the Plaza area) and 0m^2 for Option 3.

It is of note that Option 0 requires five ventilation 'pop ups' in the Park and hence the greater land take requirement in the operational phase, though it is considered that these can be designed to integrate into the local park landscape. Option 0 in addition incorporates the need to permanently relocate the Wolfe Tone Monument and Famine Memorial within the Park. While for Option 1, all the ventilation surface penetrations are located outside of the Park and the Wolfe Tone Monument and Famine Memorial is temporarily moved and then reinstated. For Option 3 the Wolfe Tone Monument and Famine Memorial is not impacted and all the station installation facilities (Intervention lifts, evacuation hatches and ventilation shafts) are aligned along the St. Stephen's Green East footpath outside of the Park.

The provision of the desired canopy structure over the station entrance, (an important element of the MetroLink architectural vision to achieve a high-quality passenger experience, good passenger wayfinding and consistent branding across the system) will also be challenging to provide for both Options 1 and 3 because of the station's entrance being located in the footpath.

Overall, when taking account of the above, Option 0 overall is assessed to have some advantages over the other options because of the station entrance being fully integrated into the urban realm compared to the other two options which do not achieve this as a result of the station entrance being located within the footpaths of St. Stephen's Green. Whilst Option 0 performs the worst in terms of permanent surface land take within the St. Stephen's Green Park fence line, this area is small and since overall Option 0 requires significantly less permanent land take than Option 1 or 3, it is assessed as having some advantages over the other options. It is also considered that good design of the station 'pop-ups' and replanting of trees and other vegetation will provide a high-quality environment in the reinstated area of St. Stephen's Green Park and therefore further mitigate the impact of Option 0.

Project Objectives Summary

Considering the evaluation of the options from an operational perspective, neither of the mined options (1 and 3) deliver a station that is considered acceptable, in particular:

- non-compliance with the MetroLink architectural vision as a result of not providing passengers with a feeling of space, light and a quick understanding of the station;
- poor passenger experience, wayfinding, and accessibility (including PRM) as a result of not providing a predominance of horizontal straight routes and minimal changes of direction for passengers; and.
- a significant increase in walking times from surface to platform level compared to Option 0.

It is essential passengers can access and use a system that is familiar and consistent across MetroLink to enable quick and easy navigation. It is also important that MetroLink provides consistent messaging and branding, and a consistent and efficient approach to operation and maintenance.

In terms of the station functional plan and operation, Option 0 provides an optimal configuration and arrangement of technical and operation rooms. Option 1 and 3 in comparison are disadvantaged by the increased station depth, and Option 3 further by the separation of technical rooms accommodated in the slender cut and cover box. The design of Options 1 and 3 also impacts the ventilation strategy, requiring a significant increase of air volume to be driven, requiring additional space and plant requirements to be provided.

With regards to emergency intervention, Option 0 offers advantages over Options 1 and 3 as it provides vertical lift shafts all the way to platform level, compatible with DFB desired requirements. Options 1 and 3 in contrast rely on shafts that have a horizontal split separation

Recognising that Public Realm encompasses public used spaces, including footpaths, roads, cycle ways, and parking, Option 1 is assessed as having some disadvantages during the construction phase since it impacts the Plaza area of the Park, reduces St. Stephen's Green East to two traffic lanes and a single cycle lane, and impacts St. Stephen's Green North footpath. While Option 0 significantly impacts St. Stephen's Green Park and St. Stephen's Green East footpath, it maintains the current existing traffic and cycle access along St. Stephen's Green East and is hence assessed overall to perform similarly to Option 1. Option 3 impacts traffic on St. Stephen's Green East the same as Option 1, requires construction within the St. Stephen's Green East footpath, and results in a major loss of parking along St. Stephen's Green East compared to the other options, but it does not infringe on St. Stephen's Green Park and is therefore assessed to have some advantages over the other options.

On the station becoming operational, Option 0 provides a significant advantage over Options 1 and 3 as a result of the station entrance being fully integrated into the Plaza area rather than lying within the St. Stephen's Green North or East footpath which is likely to constrain access along the footpath and cause pedestrian congestion as well as making it challenging to comply with the MetroLink architectural vision of a canopied station entrance (important for achieving a high-quality passenger experience, good passenger wayfinding and consistent branding across the system).

It is also of note that Option 0 requires significantly less permanent surface land take compared to Option 1 and Option 3, although it does require 196m^2 within the Park fence line as well as relocation of the Wolfe Tone Monument and Famine Memorial. Options 1 and 3 by contrast incorporate all station facilities aligned along the St. Stephen's Green East footpath outside of the Park.

Overall, Option 0, the current Preliminary Design performs considerably better operationally in achieving the MetroLink Project Objectives, with Option 1 and 3 being particularly deficient in terms of complying with the MetroLink architectural vison and not providing a high-quality passenger experience and good accessibility. However, Option 0 during the construction phase significantly impacts St. Stephen's Green Park. It is therefore the balance of this with delivering on the necessary project objectives over the lifetime of the system that needs to be reconciled, recognising a compromise would deliver a sub-optimal system that would remain in place for many decades, and that good design of the station 'pop-ups' and replanting of trees and other

vegetation will provide a high-quality environment in the reinstated area of St. Stephen's Green Park, mitigating the long-term impact of Option 0.

6.5.2 Environment

This considers the potential of, and minimisation of adverse impact on the natural and built environment and the community. Considering the sub-criteria that comprise Environment individually the following is observed.

Property Impact to SSG Park

The assessed performance of the options is a function of the temporary and permanent land take quantities within and outside of the Park as set out under section 6.5.1, Public Realm.

Option 3 performs the best in terms of minimising the impact on St. Stephen's Green Park both during the construction and operational phases, noting that during the construction phase the Park's railings would be removed temporarily to ensure they are protected. In contrast Option 0, the current Preliminary Design performs the worst by a considerable margin both during the construction and operational phases of the station compared to the other options, which includes for during construction a haul road and logistics being located within the Park, and five ventilation 'pop ups' in the permanent case (operational phase). Option 1, construction and permanent land take is confined to the Plaza area of the Park and also necessitates the removal of a section of the Parks railings.

Noise and Vibration

The construction of Option 0 is predominately based upon 12-hour/dayshift working with two exceptions, TBM passage through the box, and in the later stages the MEP fit out works. Neither are expected to generate disturbance with noise mitigation measures in place. (Option 0 does not exceed significance thresholds due to standard working hours).

Detailed assessment has been undertaken to assess the impacts of the works associated with Option 1 on the Shelbourne Hotel if 24-hour working was employed. It is the closest sensitive receptor to the main shaft (sited in the Plaza area), tunnelled cavern and the escalator box sited in St. Stephen's Green North. The impacts on adjacent properties will be similar to that assessed at the Shelbourne Hotel but it is used as a reference receptor due to the potential criticality of noise and vibration impacts on its business and customers. If there are other residential receptors nearby, they will be similarly impacted.

It has been assessed for Option 1 that if 24-hour working was employed this will result in an exceedance of significance thresholds to the Shelborne Hotel. Ground borne noise is predicted to peak at 44dBA compared to a threshold night-time level of 40dBA. This represents an exceedance of 50% over that considered acceptable. The noisiest activities contributing to this exceedance are during the excavation phase of the main construction shaft and the platform cavern in rock, including the breaking out of the temporary use shaft walls, spayed concrete linings and drilling associated with either blasting or installation of rock bolts. (Note blasting itself does not contribute as this is restricted to 12-hour/dayshift working.)

Option 3, while more distant from the Shelbourne Hotel is located close to Loretto College (boarders stay at the college), and again it is predicted that noise levels will also be exceeded at this location at night if 24-hour tunnelling is employed.

It is therefore concluded that continuous 24-hour working is not feasible at St. Stephen's Green and hence the overall assessment of Option 1 and 3 needs to be based on 12-hour/dayshift working only. This means all three options are similar in terms of overall noise and vibration impacts.

The limiting of tunnelling operations to 12-hour/dayshift only will have a significant impact on cost and programme (see 6.5.4) and will prolong the construction duration of the station and hence prolong the impact on the environment. It is therefore concluded that Option 1 and 3 have a slight disadvantage compared to Option 0.

During the operational phase, while Options 1 and 3 track levels are c.10m lower than Option 0, there will be no discernible difference felt by receptors and hence all three options are evaluated the same and hence this is not considered a differentiator.

Traffic and Transport

As a result of the station being partially constructed within the Park (see Figure 6.2), Option 0 can maintain three traffic lanes and two cycle lanes during the construction phase but does result in some parking being removed. In contrast as a result of limiting the construction impact on the Park, Options 1 and 3 restrict traffic to 2 lanes and a single cycle lane on St. Stephen's Green East (see Figure 6.3 and Figure 6.4).

Upon the station becoming operational Option 0 again performs the best of the three options as a result of the station entrance being integrated into the Plaza area of St. Stephen's Green Park. Options 1 and 3 have their station entrances located in St. Stephen's Green East and North footpaths respectively. This severely impacts the footpath level of service (LOS) as shown below. For all three options there is some permanent loss of parking along St. Stephen's Green East but noting that Option 3 results in a major loss of parking on St. Stephen's Green East compared to the other options.

Option 1: Station access in the footpath of St. Stephen's Green North.

Pedestrian modelling (2060 population plus Metro Boarding and Alighting (B&A)) indicates there would be approximately 2,600 people on this footway during the AM peak hour. To meet with the Dublin City Council (DCC) pedestrian space calculator, a minimum circulation zone (clear available footpath width excluding any street furniture) of 4m is recommended to comfortably accommodate this volume of pedestrians.

At present, the footway measures a total of 6m (including all street furniture/bollards etc), and therefore adding the station access would make the remaining available width insufficient according to the DCC guidance. This would also cause additional crowding on the Merrion Row crossing.

Option 3: Station access in the footpath of St. Stephen's Green East.

Pedestrian modelling (2060 population plus Metro B&A) indicates approximately 1,400 pedestrians on this footway during the AM peak hour. Again, for the same reasons as noted above, a minimum 4m circulation zone (excluding any street furniture) is required to maintain DCC recommended comfort levels.

St. Stephen's Green East footway currently measures approximately 6m in total (including street furniture/bollards), and therefore adding the station access would make the remaining available width insufficient according to DCC guidance, particularly for pedestrians heading south towards the crossings at Leeson Street/Earlsfort Terrace (approximately 1,350 modelled on Earlsfort Terrace and 1,400 on Leeson Street).

For both the construction and operational phase, Option 0 performs significantly better than Options 1 and 3 in terms of limiting the impacts on traffic and transport.

Ground Water

The station is to be constructed below the water table and hence all options will encounter groundwater but noting that options 1 and 3 are some 10 metres deeper and therefore will incur an additional 1 Bar of water pressure.

The Option 1 design makes use of a station box constructed using full depth diaphragm walls which effectively act as an aquiclude, minimising groundwater ingress during the subsequent excavation stages. The methodology also allows for grouting at the toe of the panels to minimise water ingress from beneath the panels.

Options 1 and 3 use open face tunnelling techniques to construct the platform cavern and connection tunnels (drill and blast, rock bolting and sprayed concrete, insitu secondary concrete lining) and as a result the exposed ground will lead to greater water ingress into the tunnel excavation. An allowance has been made for both ground treatment (drilling in advance and grouting fissure flows) and also for dewatering, but the risk of increased groundwater inflows remains along with the need for additional treatment, handling and disposal that accompanies these increased inflows.

As a result of Option 0 being 10 metres shallower (less water pressure) and employing the use of diaphragm walls to construct the station compared to the use of open face tunnelling techniques, the impact on the existing groundwater regime is significantly reduced compared to Options 1 and 3.

During the operational phase of the station, the design will limit water ingress to the same level for all options and is therefore not a differentiator.

Biodiversity

During the construction phase, Option 0 is assessed as having significant disadvantages over the other options as a result of the number of trees and shrubs that need to be removed from within St. Stephen's Green Park to enable its construction. In contrast Option 3 has the least impact on the Park since its construction is confined to outside of the Park's fence line. Option 1 has some advantages over Option 0 because of the incursion into the Park being limited to the Plaza area.

The operational phase assessment is similar, with Option 3 having significant advantages over the other options for the same reasons stated above, while Option 0 has some disadvantages as trees and shrubs will need time to re-establish.

Climate - Carbon

The principal quantities show Option 0 requires the least concrete, excavation, dewatering and fissure grouting compared to:

- Option 1 - 42,000m3/40% increase in concrete, 112,000m3/50% increase in excavated material, estimated 100% increase in dewatering and 180% increase in grouting; and
- Option 3 - 45,000m3/50% increase in concrete and 116,000m3/55% increase in excavated material, estimated 70% increase in dewatering and 150% increase in grouting.

Both Option 1 and 3 will also experience high wastage from the use of sprayed concrete to construct the platform cavern.

These quantities show that when comparing the three station options, Options 1 and 3 have a significantly increased construction phase carbon footprint compared to Option 0, which will also further negatively impact construction and logistics, and traffic on the roads.

During the operational phase of the station, Option 0 also performs the best as a result of being the shallowest station by c.10m, using shorter and less escalators (Option 0 - 11 No., Option 1 – 20 No., Option 3 – 14 No.), and reduced ventilation demands (see 6.5.1, Ventilation) resulting in less power being needed for operations compared to Options 1 and 3.

Dust/Air

All construction sites will produce dust to a greater or lesser extent, and thus this criterion is not considered a significant differentiator across the options. Options 0 and 3 are not considered to be materially different as both will involve open cut works (construction of a cut and cover box), while Option 1 performs slightly better as it will be easier to contain and enclose the main shaft construction shaft excavation and reduce the escape of dust.

During the operational phase of the station this criterion is not a differentiator.

Landscape and Visual (L&V)

Option 0 has significant disadvantages over the other options during the construction phase as a result of the excavation of the box being partially undertaken within the Park, as well as being the largest surface excavation of all the options. Option 1 has some disadvantages due to the shaft being constructed in the Plaza area. In contrast Option 3 does not infringe into the Park, and it also has a smaller open cut than Option 0 providing some advantages over the other options.

Similarly, during the operational phase, Option 0 has significant disadvantages due to the station entrance being located in the Plaza area, loss of trees and shrubs prior to reestablishment, and permanent relocation of the Wolfe Tone and Famine Memorial. Option 1 is assessed as having some disadvantages due to the station entrance being located in the path on St. Stephen's Green North and the need for a small number of trees to be established in the area of the Plaza. Option 3 is assessed as having some advantages over the other options, in particular no infringement of the Park, but it does however have its entrance located in the St. Stephen's Green footpath.

Construction Resources and Waste

Options 1 and 3 require greater quantities of material to enable their construction than Option 0 as set out by 'Climate - Carbon' above. As previously noted, high wastage from the use of sprayed concrete for tunnelling is to be expected, and there is also the potential for the contamination of excavated material when demolishing temporary sprayed concrete (phased tunnel excavation to create headings, inverts, and side drifts to construct the cavern), potentially further impacting the unit cost of its disposal.

Archaeology/Cultural Heritage

Option 0 is assessed as having significant disadvantages over the other options during construction as a result of having a much greater excavation footprint than the other options, greater infringement into the Park, and the potential to impact the ditch below the railings. Option 1 and 3 are assessed as having some disadvantages due to the fact they could also potentially impact the ditch below the Park's railing.

Architectural Heritage

Option 0 has significant disadvantages compared to the other options during both the construction and operational phases due to the infringement of the station into the Park, resulting in the permanent relocation of the Wolfe Tone and Famine Memorial. Option 1 has some disadvantages over Option 3 due to its infringement into the Plaza area of the Park, and temporary removal of the Wolfe Tone and Famine Memorial. Option 3 has some advantages over the other options as construction is confined to outside of the Park and does not impact the Wolfe Tone and Famine Memorial, but there is an impact to the St. Stephen's Green East footpath.

Environment Summary

With regards to environmental impacts during the construction phase, overall Option 3 has been assessed to have some advantages, Option 1 some disadvantages, and Option 0 significant disadvantages.

Option 3 minimises the impact on St. Stephen's Green Park as a result of the construction not infringing beyond the fence line of the Park, this is evident in the evaluation of criteria; 'Property Impact on SSG Park', 'Biodiversity', 'Landscape and Visual', 'Archaeology/Cultural Heritage', and 'Architectural Heritage'. This contrasts with Option 0 where the station is partially constructed within the Park, and Option 1 which has the main construction shaft located in the Plaza area of St. Stephen's Green Park.

While Option 3 overall is assessed to perform better in terms of minimising the environmental impact during construction, it does however have some disadvantages of note:

- All options will need to be limited to day shift working to comply with noise and vibration environmental limits. This will prolong the Option 1 and 3 construction durations and therefore the environmental impact of Options 1 and 3;

- Option 0 can maintain three traffic lanes and two cycle lanes during the construction, whereas Options 1 and 3 are reduced to two traffic lanes and a single cycle lane in St. Stephen's Green East;

- Option 0 being 10 metres shallower (less water pressure) and employing the use of diaphragm walls to construct the station compared to the use of open face tunnelling techniques means it will be able to control groundwater ingress much better; and

- Option 0 performs the best in terms of carbon footprint compared to Option 1 and Option 3.

Similarly, during the operational phase, again Option 3 performs the best overall with some advantages over the other options because of it minimising the impact on St. Stephen's Green Park, again reflected by the evaluation of 'Property Impact to SSG Park', 'Bio-diversity', 'Landscape and Visual' and 'Architectural Heritage' criteria.

There are however some environmental areas where Option 3 does not perform as well as Option 0 during the operational phase, in particular:

- Traffic and transport - the Plaza area (Option 0) makes for a much better integrated entrance compared to Options 1 and 3 that have entrances located in the St. Stephen's Green North and East footpaths respectively, severely impacting their level of service. Option 3 also results in a significant loss of parking along St. Stephen's Green East; and

- Climate, Carbon - Option 0 performs the best as a result of being a shallow station by c.10m, using shorter and less escalators (Option 0, 11 No., Option 1 – 20 No., Option 3 – 14 No.), and having reduced ventilation demands resulting in less power being needed for operations compared to Options 1 and 3.

6.5.3 Engineering

This considers if the station option can be constructed having regards to the identified constraints. Considering the sub-criteria that comprise Engineering individually the following is observed.

Constructability (ease of construction)

The methodologies proposed for all three options are commonly used throughout the World to construct similar projects, however there are differentiators between the options with regards to the ease of construction.

Options 1 and 3 incorporate deeper stations, require the use of drill and blast, rock bolting, sprayed concrete, and the installation of insitu secondary tunnel linings, adding to the complexity of the construction. The caverns will also be excavated in water bearing rock, c.10m deeper than Option 0, presenting greater challenges in terms of controlling groundwater ingress compared to cut and cover construction employing diaphragm wall construction.

The construction of the caverns also presents additional logistical challenges in terms of new activities such as fissure grouting at the face of the excavations, provision of dewatering wells, settlement tanks and the disposal of the water. Additionally, for Option 3 the available site area is small in comparison to the size of the box to be constructed, and logistically this will pose difficulties in providing a reliable supply route through the site whilst maintaining productivity during the diaphragm walling phase of the project.

A critical differentiator between the mined options (1 and 3) and Option 0 (cut and cover) is that as a result of needing to limit the mined construction to day shift only (see 6.5.2, Noise and Vibration), noting that the mining operation is cyclical in nature (excavating, drilling, mixing and spraying of concrete) and there is requirement to ensure any excavated ground is not left 'open' and unsupported at the end of the dayshift - this will result in significant inefficiency and more complex construction planning to ensure the excavation is left "sealed" at the end of each shift.

Overall Option 0 is considered to be the simplest to construct due to it being the shallowest station, employing diaphragm walls to construct the station box that will also allow the ingress of groundwater during construction

to be closely controlled and limited. Option 1 is considered to be less easy to construct due to it requiring open face mined tunnel construction and being exposed to increased groundwater pressures, while Option 3 in addition to the construction challenges presented by Option 2 has a confined working area within which to construct the diaphragm walls presenting significant challenges. When coupled with the fact that the mining operation for both Option 1 and 3 will be limited to day shift only for the reasons noted above, it is concluded both Options 1 and 3 present significant disadvantages compared to Option 0.

Disposal/Haulage

Option 0 (30,000m^3 concrete, 75,000m^3 of excavated material) requires significantly less material to enable its construction than Option 1 (+40% concrete deliveries, +50% excavated material removal) and Option 3 (+50% concrete deliveries, +55% excavated material removal). This directly impacts the haulage volumes to and from site, and traffic on the road network with both evaluated as having disadvantages compared to Option 0.

It will also be necessary to rearrange the local traffic management at St. Stephen's Green if Option 1 or 3 is selected since the area in the Park used by Option 0 to manage the haul route through the station site will no longer be available. One option (Figure 6.5) would be to turn site traffic around via St. Stephen's Green North onto Dawson Street, Molesworth Street, Kildare Street and then back on to St. Stephen's Green North. Such a scheme would increase the impact on local businesses and residents and the local traffic network.

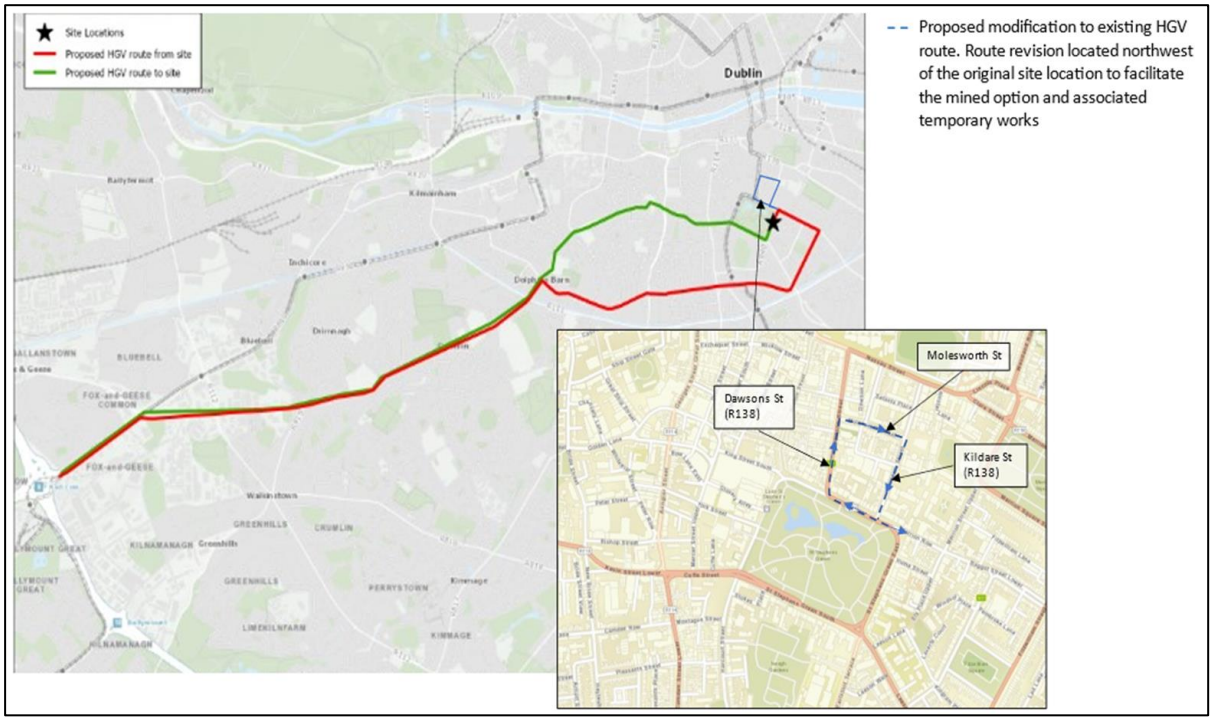


Figure 6.5: Located Traffic Management Adjustment to Accommodate Option 1 and 3 Construction

Ground Movements and Geology

Option 0, because it is the shallowest station and employs top-down construction using diaphragm walls (stiff structure and good control of ground water ingress), is the most advantageous in terms of minimising ground movements.

The construction of the station cavern (15m high x 22m wide) needs to be positioned in competent rock (see Figure 4.3 for the geological profile) with c.15m of rock cover to ensure the safety and security of the works during construction, including ensuring construction generated ground movements are controlled. The finalised position of the cavern would be subject to detailed design, but for this stage of scheme development this is a sensible assumption. This would place the station rail level c.10m below the current rail level of 23m below ground level.

The increase in station depth for Options 1 and 3 in tandem with the open-faced nature of the mined tunnel construction operation will result in encountering more groundwater at greater pressure (+1 Bar compared to Option 0) and hence a greater reliance during construction on groundwater control. Fissure grouting and dewatering have been included in the methodologies for Options 1 and 3. Any lowering of the water table will likely increase the zone of ground movement influence and risk increasing the number of properties potentially affected by the works.

The nature of mined tunnel construction carries with it a greater risk of construction generated ground movements than Option 0 which employs top-down diaphragm wall construction. However, it is recognised that the deeper station alignment for Option 1 and 3 will reduce the risk of running tunnel construction generated ground movements, but this reduction is considered negligible when taking account that the running tunnel will be constructed in rock using a TBM.

Vertical and Horizontal Alignment

The station vertical and horizontal track and tunnel alignments vary slightly between the three options. Option 1 is 9m to the west, and Option 3 is 24m to the west of Option 0 reflecting the station internal layout and route to / from platform level and the position of the station platforms beneath the St. Stephen's Green Park and the deeper alignment to enable cavern construction. (All options are based on the Option 2 Trinity College alignment, horizontal radius curve 350m).

Option 1 demonstrates a slight benefit over the other options as it reduces the potential impact on Leinster House. It is also a deeper alignment to enable construction of the platform cavern. Option 3 also avoids Leinster House and is a deeper alignment but passes beneath the National Concert Hall. Figure 6.6, Figure 6.7 and Figure 6.8 show the alignments.

All three alignments have a low point between Tara. and St. Stephen's Green stations that will pump waters towards Tara Station. As a result of Option 1 and 3 being deeper than Option 0, the low point will be slightly lower and further away from Tara Station, but this will not impact the size of the pumping chamber to be constructed and the additional power required for the pump is not considered significant.

In the operational scenario the shallower vertical alignment of Option 0 performs slightly better due to reduced power consumption, however this is considered negligible and not material for the additional power consumption required for Options 1 and 3 alignments with a change of 10m over 1km. There is also no discernible journey time impact between the options.

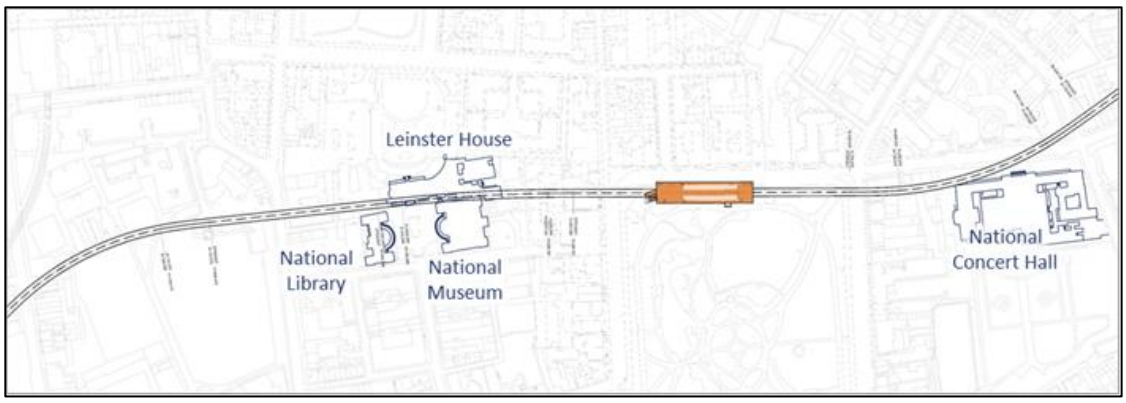


Figure 6.6: Option 0 Horizontal Alignment

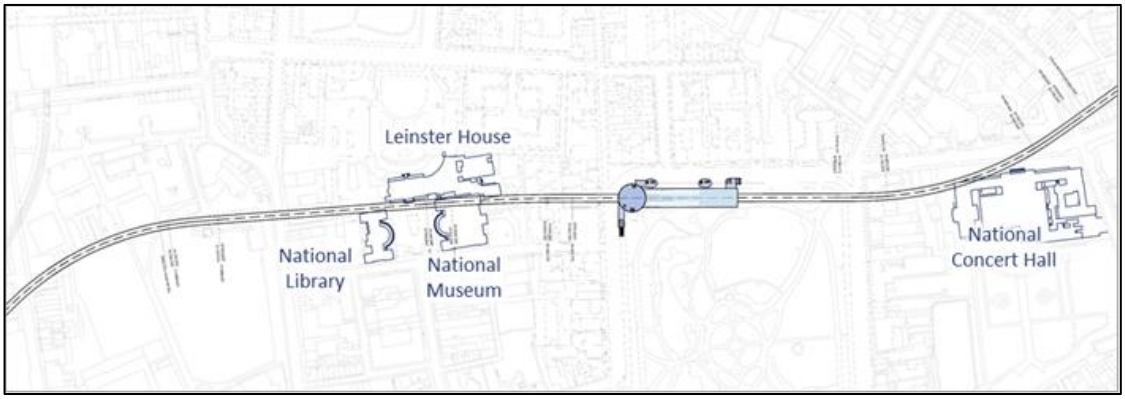


Figure 6.7: Option 1 Horizontal Alignment

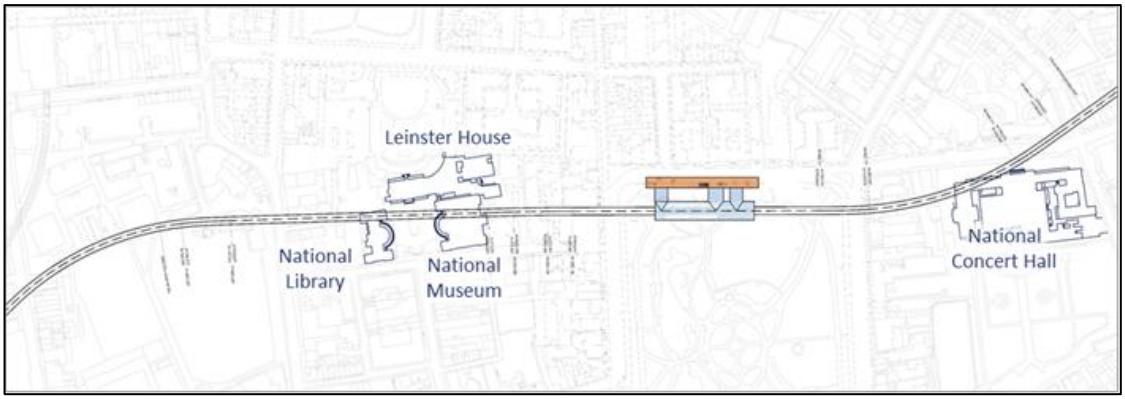


Figure 6.8: Option 3 Horizontal Alignment

Demolition of Buildings Required or Impacted

None of the options brought forward to the Stage 4 MCA require the demolition of buildings, however for note, if for example the Option 1 main construction shaft was located north or east of St. Stephen's Green to remove the need for using the Plaza area (approximately 1000m^2), it is estimated the cost of:

- property/land acquisition will be in the order of €40m-€60m (assumes 1000m2 x €10,000/m2 x 4 to 6 stories); and
- demolition will be €2-2.5m (including an allowance for the heritage nature of surrounding buildings). The Metrolink structures would preclude redevelopment of most of the acquired site, although there may be an opportunity for over site development (OSD).

It is also of note that the majority of buildings along the east and north side of St. Stephen's Green are designated Protected Structures as well as being located within a Georgian conservation area. Hence finding a suitable site that will provide an entrance that complies with the station design intent and is not protected, will be challenging.

Utilities

Significant utility diversion work (see Figure 4.1 and Figure 4.2) is anticipated for all options, however Option 0 requires slightly less work overall as the station box is partially located in St. Stephen's Green Park. Option 1 has a slight increase in complexity as the utilities in the Plaza area and St. Stephen's Green North need to be dealt with to accommodate the main access shaft and entrance in St. Stephen's Green North, while Option 3's cut and cover box extends further into St. Stephen's Green East, and as a result it clashes with more utilities than Option 0.

Engineering Summary

Option 0, the current Preliminary Design has been assessed as having an overall advantage over Options 1 and 3, in particular:

- Constructability – Option 0 is the shallowest station by circa 10m and employs top-down diaphragm wall construction to construct the station box. Options 1 and 3 are deeper stations involving open faced mined tunnel construction in water bearing ground adding to construction complexity. Option 3 is further complicated by having a confined working area within which to undertake diaphragm walling whilst maintaining productivity and a reliable supply route through the site.

- Critically, when coupled with the fact that the mining operation for both Option 1 and 3 will be limited to day shift only it is concluded both Options 1 and 3 present disadvantages compared to Option 0.

- Disposal/Haulage – volumes to and from site are significantly greater for Option 1 and Option 3.

- Control of ground movements – due to Option 0 being the shallowest station and employing top-down construction using diaphragm walls (stiff structure and good control of ground water ingress) it is the most advantageous in terms of controlling and minimising ground movements. Mined station construction in water bearing ground inherently carries a greater risk associated with the control of construction and ground movements.

While significant utility work is anticipated for all options, Option 1 requires slightly less work due to the station being partially located within St. Stephen's Green Park, but this difference is not considered material.

Option 1 also demonstrates a slight benefit over the other options as it reduces the potential impact on Leinster House. It is also a deeper alignment to enable construction of the platform cavern. Option 3 also avoids Leinster House and is a deeper alignment but passes beneath the National Concert Hall. However, when one takes account of the fact that the running tunnel will be constructed in rock using a TBM, the alignment is not considered a significant differentiator between the options. In the operational phase the additional power consumption required for Options 1 and 3 alignments is also not considered significant.

6.5.4 Economy

This considers if the station option provides value for money within acceptable cost, programme, and risk envelopes.

Programme / Schedule

The programme assessment for all options incorporates productivity rates that are consistent across the options and with Option 0, the Preliminary Design, to ensure a fair and consistent comparison has been undertaken between the different options.

An in-depth review of all civils and tunnelling has been undertaken for Options 1 and 3. Recognising that the designs are at a very early concept status and hence there is insufficient detail to fully analyse the back-end construction activities (e.g., MEP fit-out, architecture etc.), the assessment utilises previous durations with allowances made for clear differentiators (e.g., curved surfaces in the platform tunnels).

As noted under section 6.5.2, Noise and Vibration, it has also been assessed that Option 1 and Option 3 will result in the exceedance of acceptable ground borne noise thresholds at night-time and therefore 12-hour/dayshift working is assumed, the same as for Option 0. Figure 6.9 shows the overall programmes for Options 0, 1 and 3.

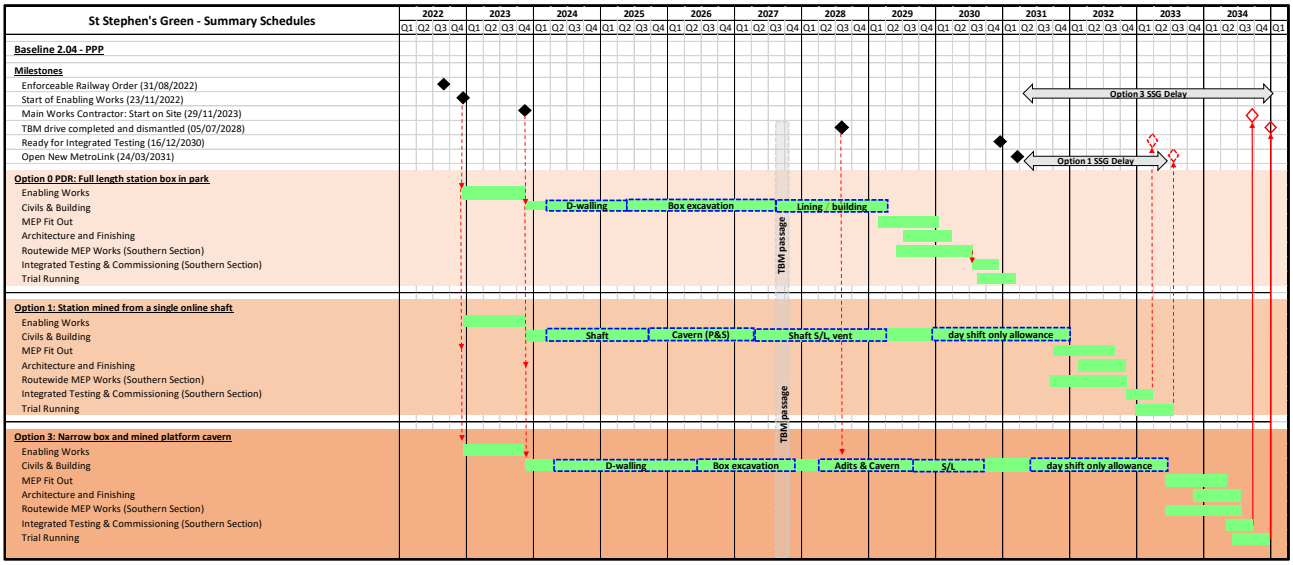


Figure 6.9: Options 0, 1 and 3 Delivery Programmes (construction through to trial running)

The Option 1 and 3 programmes were originally derived on the assumption that 24/7 working was permissible for mining operations, however following the assessment of the night-time ground borne noise and vibration impacts it has been assessed that the Option 1 and 3 programmes are impacted by circa 25 additional months due to limiting the available working hours. For clarity, this allowance and overlay has been shown at the back end of the tunnels and civils bar (Figure 6.9) but in reality it is spread across the preceding activities.

Working day shift only will not deliver the cavern in advance of the TBM arriving at St. Stephen's Green for either Option 1 or Option 3. This will mean instead the running tunnel will need to be enlarged to form the platform cavern after the TBM has reached its final destination south of Charlemont. This generates a significant extension to the programme and will require a blockade of the tunnel at St. Stephen's Green which is also likely to delay track installation.

This additional 25 months takes into consideration the reduced working hours and some disruption due to the stop start nature of the works impacting overall productivity. 24-hour working has been retained for MEP works in line with and the same as Option 0.

In summary the programme shows the following overall estimated durations from Enforceable Railway Order (ERO) to MetroLink Opening:

- Option 0 – 8.5 years
- Option 1 – 10.5 years
- Option 3 – 12.25 years

In addition to the constraint of 12-hour/dayshift working, the Option 3 programme is also impacted by reduced productivity due to the need to undertake diaphragm walling on a severely constrained site that only has sufficient space for one Hydrofraise and one grab, this compares to Option 0 which uses two Hydrofraises and one grab to construct the station box.

Finally, and importantly, it is not recommended that a non 24-hour working mined option is pursued. This work will require drilling, excavation, mixing and spraying of concrete below ground. It is cyclical, and to ensure the safety and security of the works any excavated ground needs to have been sprayed and monitored and not left "open". If these activities are limited to dayshift only, the efficiency of this is hugely impacted. The face could not be "opened" if there wasn't surety it could be "sealed" within the shift constraints and therefore there is further risk of downtime associated with 12-hour/dayshift working.

The overall conclusion with regards to the programme is that both Options 1 and 3 offer significant disadvantages compared to Option 0.

Costs (CAPEX and OPEX)

CAPEX

Options 1 and 3 are a direct cost comparison to the Capital Cost Estimate supporting the MetroLink Preliminary Business Case approach for underground stations and associated works. Reasonable allowances for temporary and permanent works methodologies are made within the quantity rate build ups used within these estimates.

All options are based on 12-hour/dayshift working, which for Options 1 and 3, as noted above has a significant direct impact on the programme duration and cost of these options. In this regard, an estimated 25-month further delay has been added to the associated preliminary costs for this Station as well as allowances for inefficiencies arising from the stop-start working due to the 12-hour regime in the mined tunnel. Table 6.9 shows how the options compare in terms of total direct cost.

Table 6.9: Option 0, 1 and 3 Direct Comparison

	Option 0, Cut and Cover Station in the Park **Preliminary Design**	**Option 1, Construction / Operation Shaft + Cavern** **Concept Estimate**	**Option 3, Cut and Cover Station Box + Platform** **Concept Estimate**
Total Direct Cost	€173.5M	**€295.9M**	**€330.9M**
	Variance to Option 0	**+71%**	**+91%**

Notes:

i. Option 0 is PBC PPP Version R04 2020
ii. Base Year in all estimates is Q4 2019
iii. A quantified risk assessment has not been carried out for Option 1 and 3 due to their early-stage Concept Design
iv. Estimated cost is the Direct Cost of St. Stephen's Green Station only

Option 1 and 3 cost significantly more than Option 0 and therefore present a significant disadvantage over Option 0 in terms of value for money.

OPEX

Options 1 and 3 will have higher operational and life cycle costs than Option 0 due to:

- deeper station and tunnel alignment impacting energy usage, traction power and pumping costs;
- increase in ventilation air volumes of 24,000m3 (240% increase) and 27,000m3 (270% increase) for Option 1 and 3 respectively;
- Option 3 has technical rooms accommodated in the slender cut and cover box away from the core of the station giving rise to inefficient operation and maintenance; and
- Options 1 and 3 have 20 and 14 No. escalators respectively, an increase over the total number of 11 escalators for Option 0.

Whilst it is evident that Options 1 and 3 will incur greater operational cost over their lifetime, at this early stage of the design it has not been possible to quantify how significant this is, but nonetheless these options do present some disadvantages compared to Option 0.

Risk - Cost and Schedule

Construction Phase

Option 0 is included in the overall MetroLink Risk Assessment (QCRA and QSRA). In contrast, due to the early stage of design development it is not possible at this stage to quantify the risk associated with Option 1 and 3, however the following additional risks will need to be managed and this places both of these options at a disadvantage compared to Option 0:

- **Design Development**: the design is at early concept status and further design input will be required to reduce the reliance on assumptions. There is a risk that resolution of assumptions and increased design maturity will add cost and time.
- **Groundwater Discharge**: it is inevitable that groundwater will be encountered during the mining operation. Allowances have been made in the estimate and programme, but the risk remains of greater groundwater quantities being encountered than anticipated (this is more challenging to deal with using open face tunnelling techniques than top-down diaphragm walling construction) which will also place an additional burden on the Dublin sewer system or require additional traffic movements to tanker water off site. It should be noted that dewatering would be required to operate continuously despite working dayshift only.
- **Ground Improvement Processes**: due to the nature of tunnelling in the rock and the proposed use of secant piled shafts for Option 1, there will be a need for grouting. Allowances have been made for in the estimate, but a risk remains that the control of water ingress is more demanding and onerous that assumed.
- **Ground Movement**: the provision of dewatering is proposed. There is risk of additional settlement associated with this which is assumed not to be excessive but may lead to further third-party agreement issues. It is also of note that mined tunnel construction carries with it a greater risk of construction generated ground movements than Option 0 which employs top-down diaphragm wall construction. Should issues arise there would also be an increased risk of additional stakeholder management, PR and reputational issues arising.
- **Tunnelling/programme down time**: Limiting mining operations to day shift only means the face should not be “opened” if there is not surety it could be “sealed” within the shift, thus there is risk of additional downtime and inefficiency associated with 12-hour/dayshift working. For this reason, it is not recommended that a non 24-hour working mined option is pursued.

Operational Phase

Option O has been developed to Preliminary Design level and is included in the Metrolink O+M and Life Cycle Risk Assessment. Although not addressed in Direct Costs, similar to the construction phase, there is a risk of further operational cost becoming apparent as the design matures, and therefore at this time Options 1 and 3 are assessed to have some disadvantages in terms of risk compared to Option 0.

It must also be recognised that if Option 1 or 3 was adopted, the station would become an outlier in terms of design from the standard. Standardisation brings commercial benefits across MetroLink and therefore there is a risk of additional cost to the PPP.

Economy Summary

Overall Option 1 and 3 are assessed as having significant disadvantages over Option 0, offering poor value for money for the following reasons:

- Programme – Options 1 and 3 mined cavern construction is constrained to day shift working to avoid breaching night-time ground borne noise thresholds. This significantly impacts construction and the overall ERO to MetroLink Opening duration:
    - Option 1 – 10.5 years (+2 years compared to Option 0 at 8.5 years)
    - Option 3 – 12.25 years (+3.75 years compared to Option 0 at 8.5 years)

      The cavern will not be constructed in advance of the TBM arriving at St. Stephen's Green for either Option 1 or Option 3. This will mean instead the running tunnel will need to be enlarged to form the platform cavern after the TBM has reached its final destination south of Charlemont and is therefore also likely to delay track installation.
- Cost – Option 1 is estimated to cost €295.9M and Option 3 €330.9M, +71% and +91% more than Option 0 respectively.
- Risk – There are several additional risks associated with Options 1 and 3, including:
    - Immature design - resolution of assumptions and increased design maturity have a greater impact than currently anticipated;
    - Increased groundwater quantities to deal with;
    - Ground treatment requirement is greater than anticipated;
    - Ground movement is greater or more extensive than anticipated;
    - Increased likelihood of tunnelling / programme down time due to having to adhere to day shift working and ensure the tunnel excavation is secured at the end of each day shaft.

7. Conclusions

Table 7.1: Stage 4 MCA 'Construction Phase' Results

Construction Phase Summary			
Criteria	Option 0	Option 1	Option 3
Project Objectives			
Environment			
Engineering			
Economy			

Significance (Advantages/Disadvantages)	Score
Significant advantages over other options	
Some advantages over other options	
No disadvantages or advantages	
Some disadvantages over other options	
Significant disadvantages over other options	

Table 7.2: Stage 4 MCA 'Operational Phase' Results

Operational Phase Summary			
Criteria	Option 0	Option 1	Option 3
Project Objectives			
Environment			
Engineering			
Economy			

Option 0, (Preliminary Design) - cut and cover station partially located in St. Stephen's Green Park - see Appendix A

Option 1, Construction / Operation Shaft + Cavern (side platforms) – see Appendix B

Option 3, Cut and Cover Station Box + Platform Cavern (side platforms) – see Appendix C

Table 7.1 and Table 7.2 summarise the results of the Stage 4 MCA evaluation from which the following conclusions can be drawn:

1. As a result of **ground borne noise and vibration limits constraining mined tunnel construction to 12-hour/dayshift working** due to the night-time impacts on residents, including the Shelborne Hotel (Option 1) and Loretto College (Option 3), **this generates a significant and unacceptable programme impact**, including delaying the platform cavern construction commencing until the TBM has reached is final destination south of Charlemont and therefore also likely delaying track installation, **resulting in the 'ERO to MetroLink Opening' duration for Option 1 increasing to 10.5 years (+2 years compared to Option 0), and Option 3 to 12.25 years (+3.75 years compared to Option 0**).

   This programme impact means it is **not possible for Option 1 or 3 to offer a value for money proposition**, when considering **Option 1 is estimated to cost €296m and Option 3 €331m, +71% and +91% more than Option 0 respectively**. (Estimated cost is the Direct Cost of St. Stephen's Green Station only)

   There are also additional risks associated with Options 1 and 3 such as an immature design, increased groundwater quantities to be managed, ground treatment is greater than anticipated, ground movement is greater or more extensive than anticipated, and increased likelihood of programme down time due to having to ensure the tunnel excavation is secured at the end of each day shaft, **placing further pressure on the cost and programme of these concepts.**

2. **The Project Objectives show that neither of the mined options (1 and 3) can provide a high-quality operational station** that achieves the MetroLink architectural vision. This is vitally important for the Project if passengers are to be provided with a feeling of space and light and are able to quickly and easily navigate the station that is also, importantly, consistent with the rest of the MetroLink system so that consistent messaging and branding, and an economical approach to the operation and maintenance of the system can be achieved.

   In contrast**, Option 0, the current Preliminary Design, provides for a high-quality station** achieving the aforementioned very effectively, **providing a predominance of horizontal straight**

routes for passengers, compared to the mined options that have an estimated 150% plus increase in walking times from surface to platform, accompanied by a significantly poorer passenger experience. This is made even more significant and critical given **St. Stephen's Green Station will be a high demand station, with over 90,000 passengers per day predicted to use this station in 2057**.

With regards to the Public Realm during construction, Option 0 significantly impacts St. Stephen's Green Park (3600m^2) as well as the St. Stephen's Green East footpath, but it does maintain three traffic and two cycle lanes along St. Stephen's Green East. Option 1 impacts the Plaza area, reduces St. Stephen's Green East to two traffic lanes and a single cycle lane, and impacts St. Stephen's Green North footpath, and therefore **both Option O and 1 are assessed to offer some disadvantages compared to Option 3, which impacts St. Stephen's Green East traffic the same as Option 1, requires construction within the St. Stephen's Green East footpath but does not infringe on St. Stephen's Green Park.**

However, **on the station becoming operational, Option 0 has a significant advantage over Options 1 and 3 because the station entrance is fully integrated into the Plaza area** rather than lying within the St. Stephen's Green North or East footpath which will constrain access and cause congestion, as well as making it challenging to comply with the MetroLink architectural vision of a canopied station entrance.

It is also of note that **Option 0 requires significantly less permanent surface land take overall at 3050m^2, compared to Option 1 - 4050m^2 (+33%), and Option 3 - 5100m^2 (+67%).** However, **when considering the permanent land take just within the St. Stephen's Green Park fence line, Option 0 performs the worst, although with only a small area (an estimated 150m^2) being required,** versus 40m^2 for Option 1, and 0m^2 for Option 3.

3. **Environmentally, Option 0 has been assessed to perform the worst of the three options,** both during the construction and operational phases as a result of the station being partially located in St. Stephen's Green Park, scoring poorly with regards to 'Property Impact on SSG Park', 'Biodiversity', 'Landscape and Visual', 'Archaeology/Cultural Heritage', and 'Architectural Heritage'. This is in contrast to Option 3 where the station is located wholly outside of St. Stephen's Green Park, and Option 1 that has its construction shaft / permanent passenger vertical access located in the entrance Plaza of St. Stephen's Green.

   However, **Option 0 does present some advantages environmentally, and therefore it is not appropriate to say the Option is environmentally weak** given it will maintain three traffic lanes and two cycle lanes during the construction (Options 1 and 3 are reduced to two traffic lanes and a single cycle lane), groundwater impacts are better controlled and minimised as a result of employing diaphragm wall construction rather than open face mining techniques, and the carbon footprint of the station is significantly less than Option 1 and Option 3. In the operational phase, being a shallower station with a better internal functional layout means less and shorter escalators, reduced power consumption and reduced ventilation requirements, as well as providing a much better environmentally integrated station entrance, compared to Options 1 and 3 which have entrances located in St. Stephen's Green North and East footpaths respectively where pedestrian congestion is likely.

4. **In terms of Engineering** and the construction phase, **Option 0 performs significantly better than the other options due to it being the shallowest station by circa 10m and employing top-down diaphragm wall construction** (stiff structure and good control of ground water ingress and ground movement) to construct the station box.

   Compared to undertaking mined station construction, as a result of being limited to day shift working, means there is significant complexity associated with managing the programme to ensure tunnel construction is secure at the end of each day shift, in addition to the increased management and construction control complexities associated with mining and the control of groundwater, ground movements and overall excavation phasing.

Reflecting the positive carbon footprint performance of Option 0 compared to the other options, **disposal and haulage of materials (concrete and excavated material) is significantly less for this Option compared to Options 1 or 3**.

Option 1 does however perform slightly better in terms of horizontal and vertical alignment north of St. Stephen's Green station during the construction phase as a result of reducing the potential impact on Leinster House but given the running tunnel will be constructed in rock using a TBM, the alignment is not considered a significant differentiator between the options. In the operational phase the additional power consumption required for Options 1 and 3 deeper alignments and associated increased gradients is also not considered significant.

Overall, Option 0, the current Preliminary Design performs much better than Options 1 and 3 for reasons of providing:

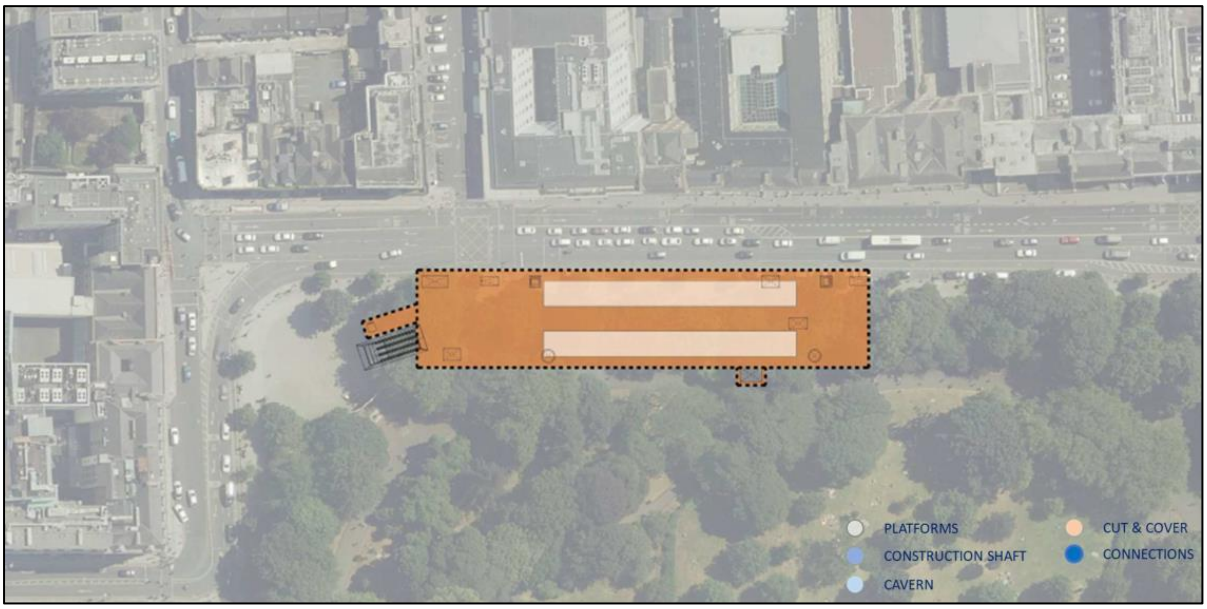
- a cost and programme envelope which offers significantly greater value for money than either Option 1, 10.5 years (+2 years compared to Option 0) and €296m (+71%), and Option 3, 12.25 years (+3.75 years compared to Option 0) and €331m (+91%). (Estimated cost is the Direct Cost of St. Stephen's Green Station only)
- a high-quality station with a positive passenger experience and good accessibility which neither Option 1 or 3 can provide; and
- a significantly better construction solution due to it being the shallowest station by circa 10m and employing top-down diaphragm wall construction rather than open face mined tunnel construction with its associated programme management complexities.

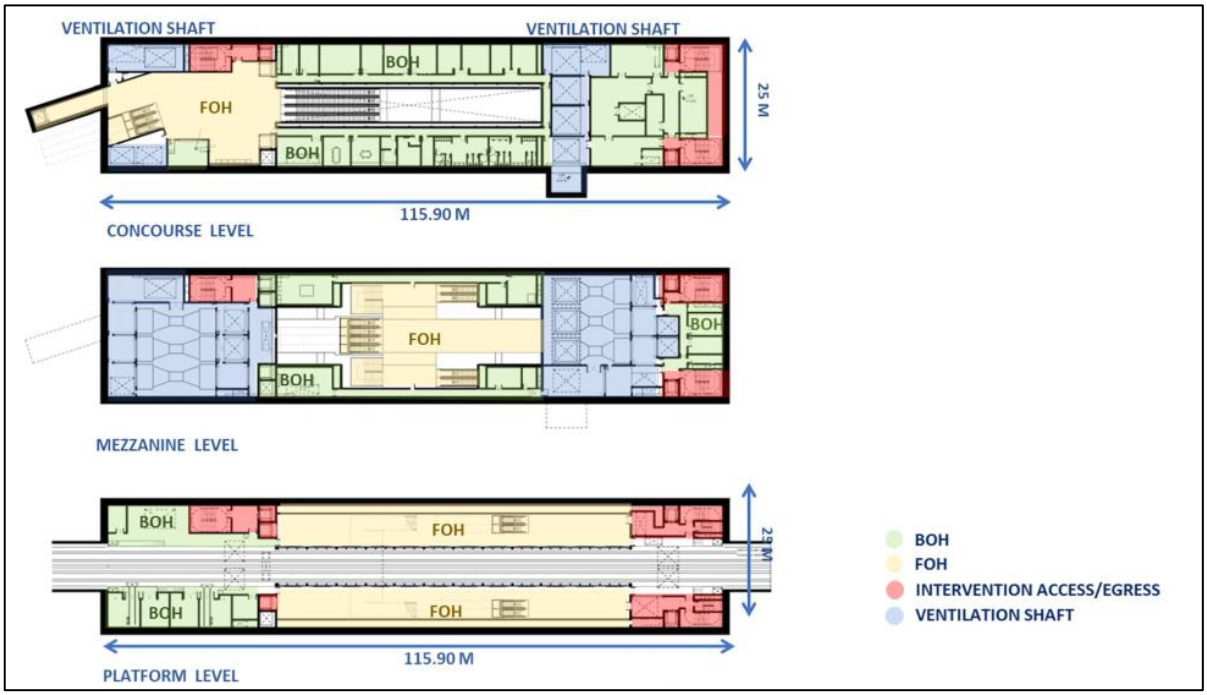
While environmentally, Option 0 has been assessed to perform the worst of the three options, Option 0 does present some advantages environmentally, namely, traffic and transport, a significantly reduced carbon footprint and a more efficient operational station, therefore it is not appropriate to conclude its environmental performance is weak.

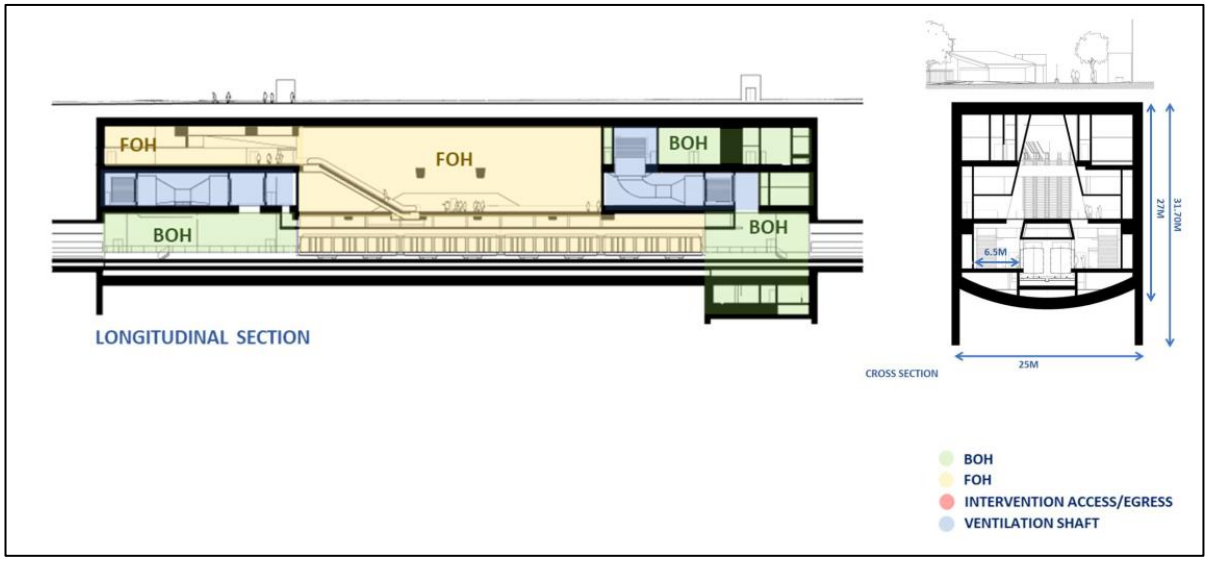
It is however recognised that the construction of Option 0 will have a significant impact on St. Stephen's Green Park, although through good design of the station 'pop-ups' and replanting of trees and vegetation a high-quality environment can be achieved to mitigate its long-term impact.

This needs to be balanced against delivering on the cost, programme, and benefits objectives of the MetroLink Project, recognising a compromise would significantly increase the cost and duration of MetroLink, as well as delivering a sub-optimal system that would be in place for many decades.

Appendix A – St. Stephen's Green Station – Current MetroLink Preliminary Design

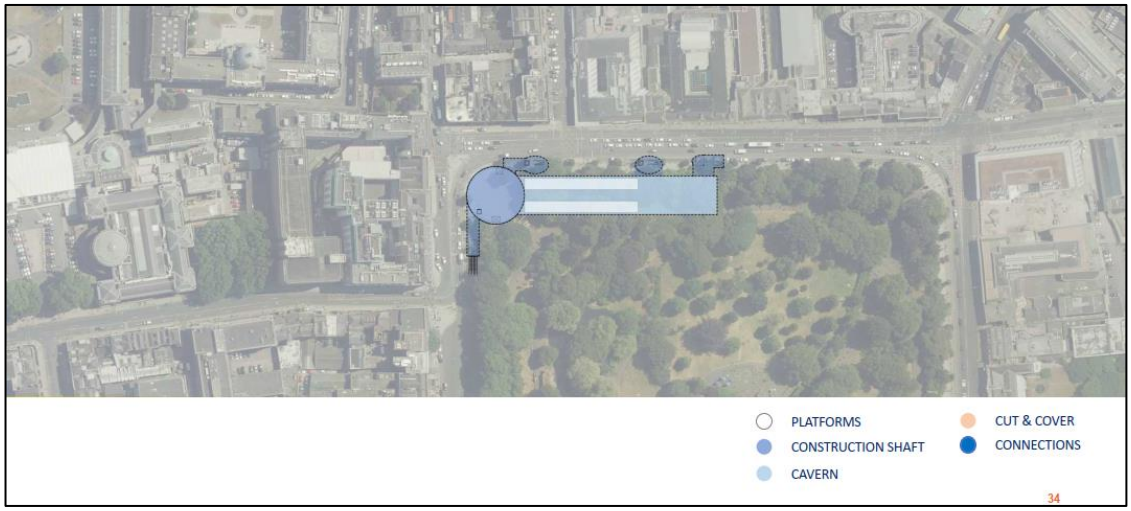


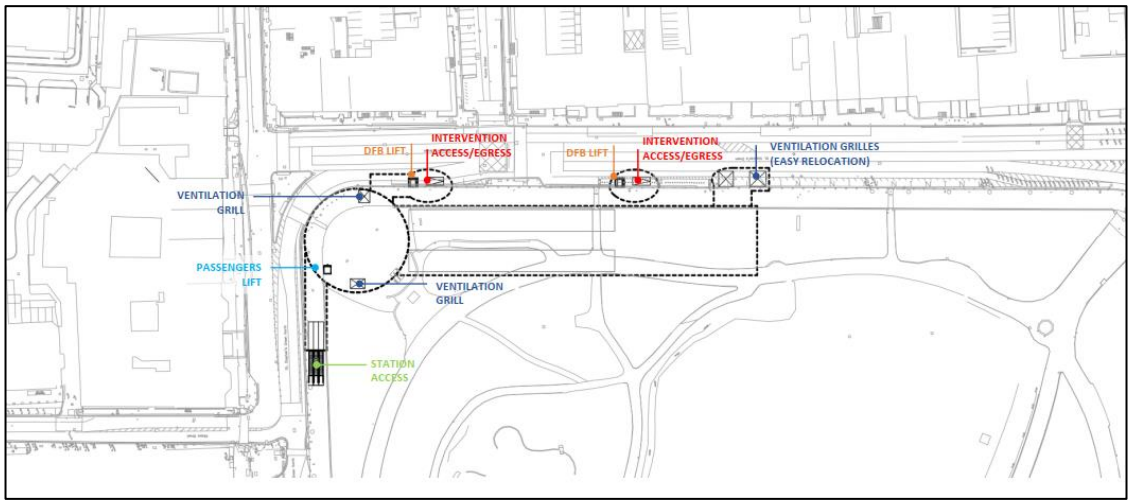


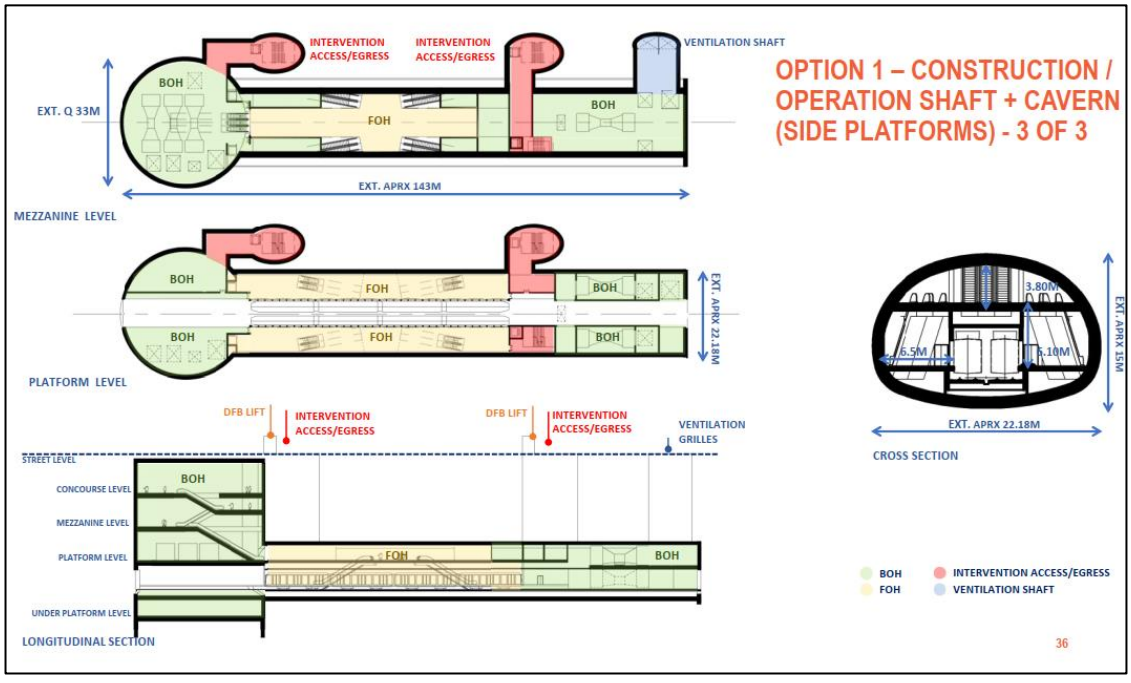

FOH
FOH
BOH
BOH
BOH
LONGITUDINAL SECTION
CROSS SECTION
6.5M
27M
31.70M
25M
BOH
FOH
INTERVENTION ACCESS/EGRESS
VENTILATION SHAFT

Appendix B – Identified Mined Station Concept Options

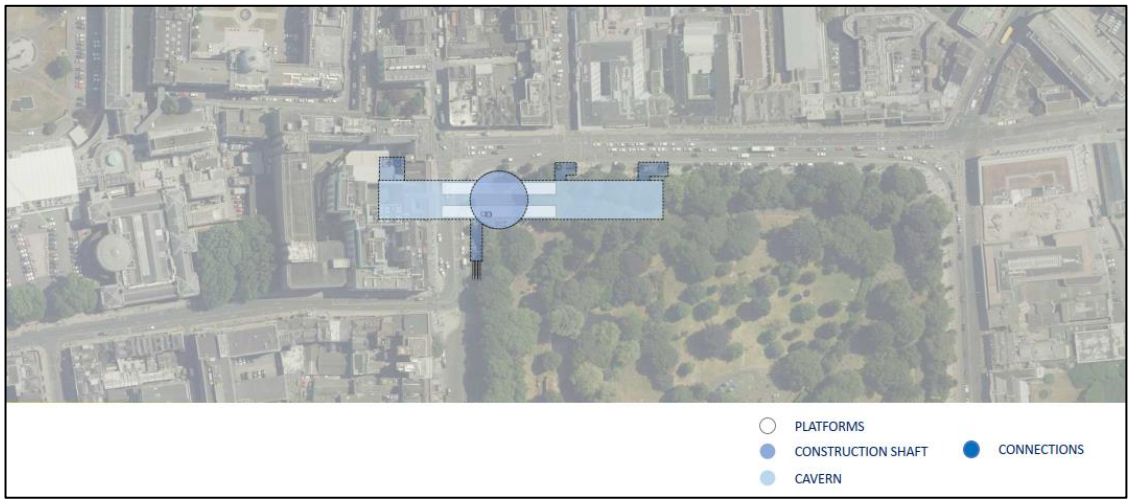
Option 1 - Construction / Operation Shaft + Cavern (side platforms)

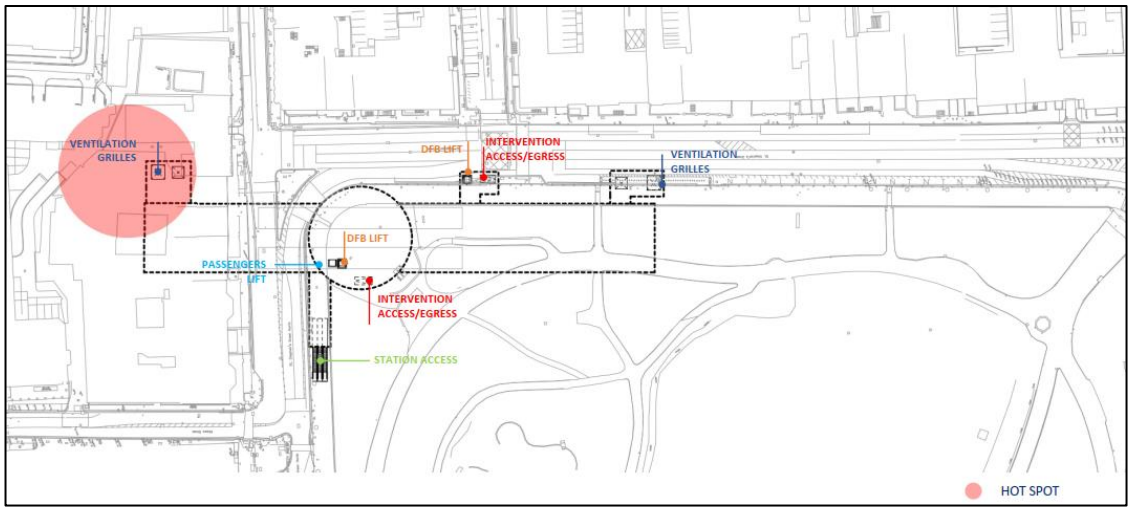


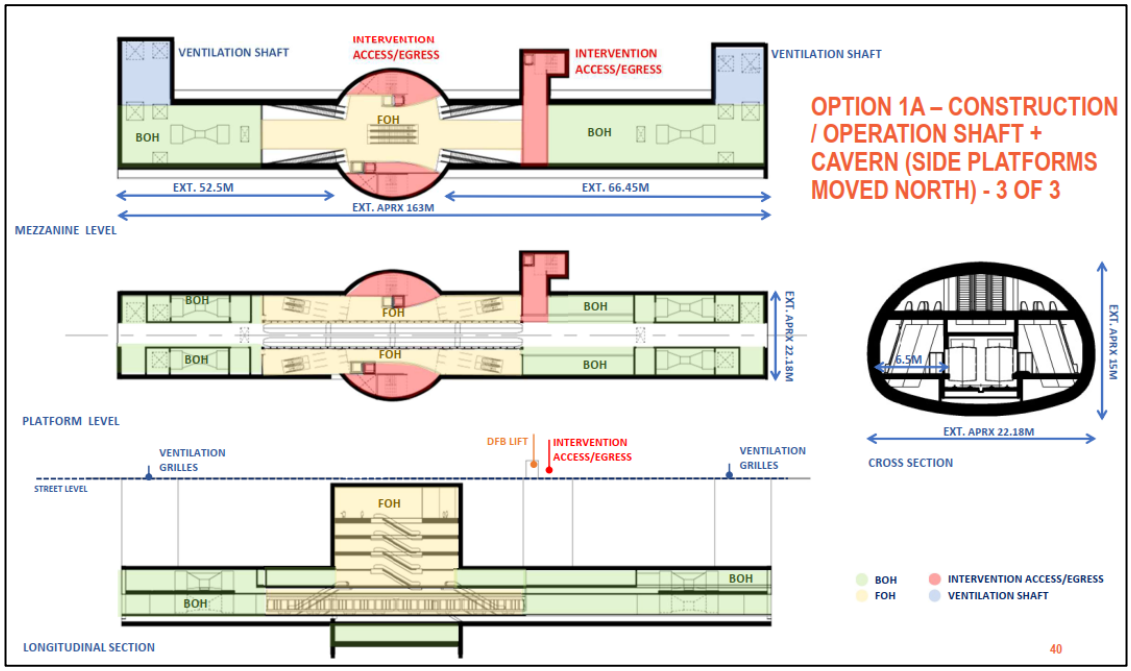




Option 1a, Construction / Operation Shaft + Cavern (side platforms with platforms moved north)

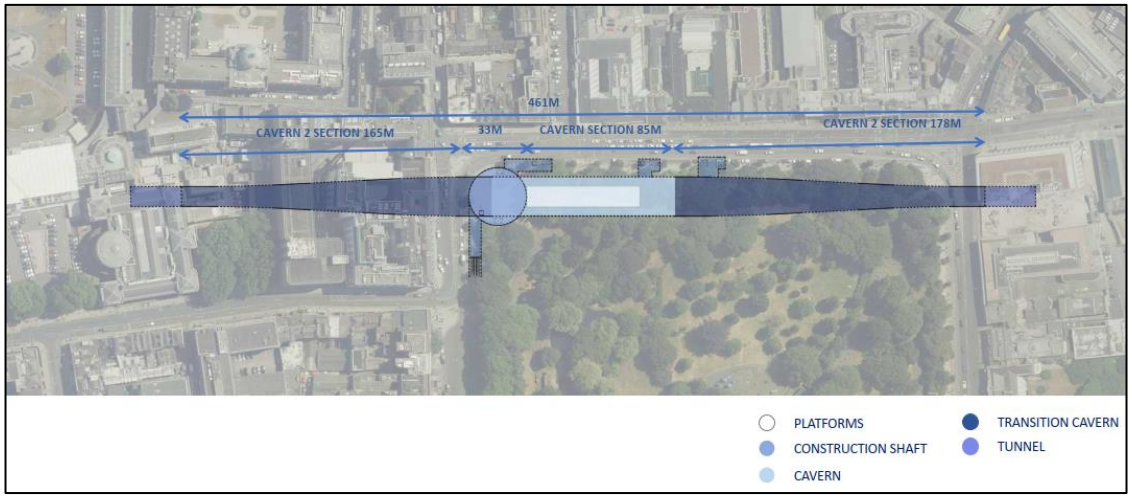


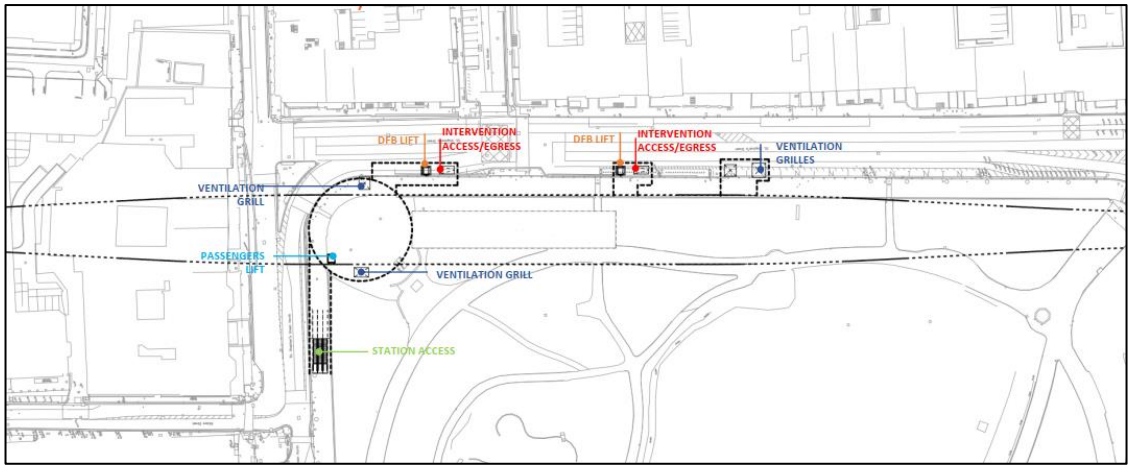


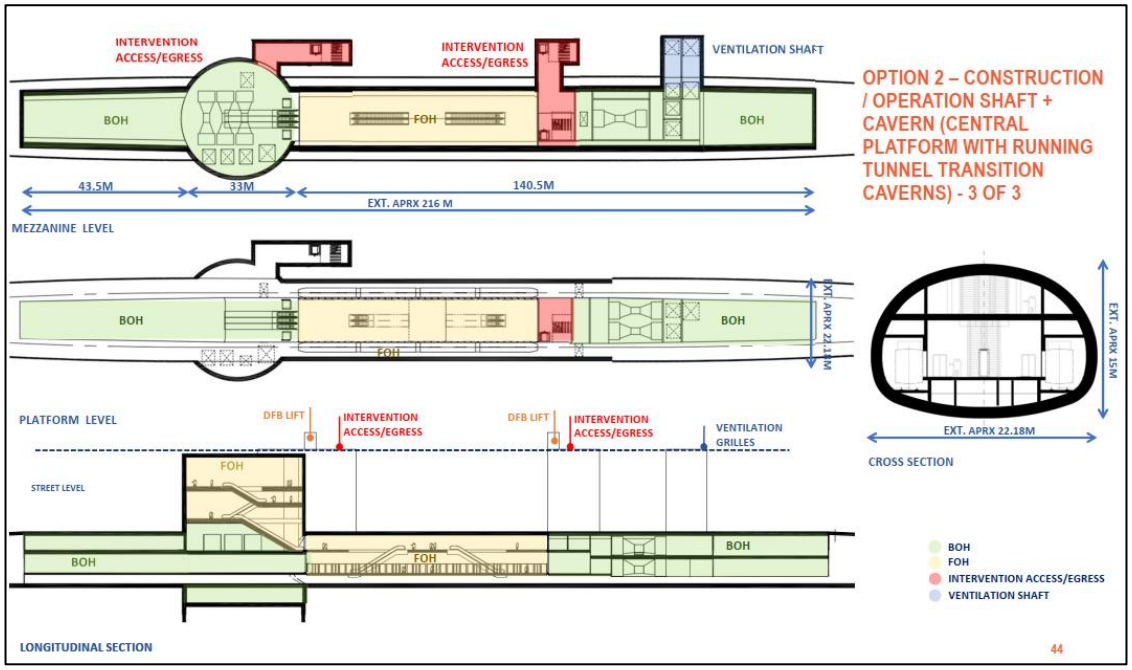


Option 2, Construction / Operation Shaft + Cavern (central platform

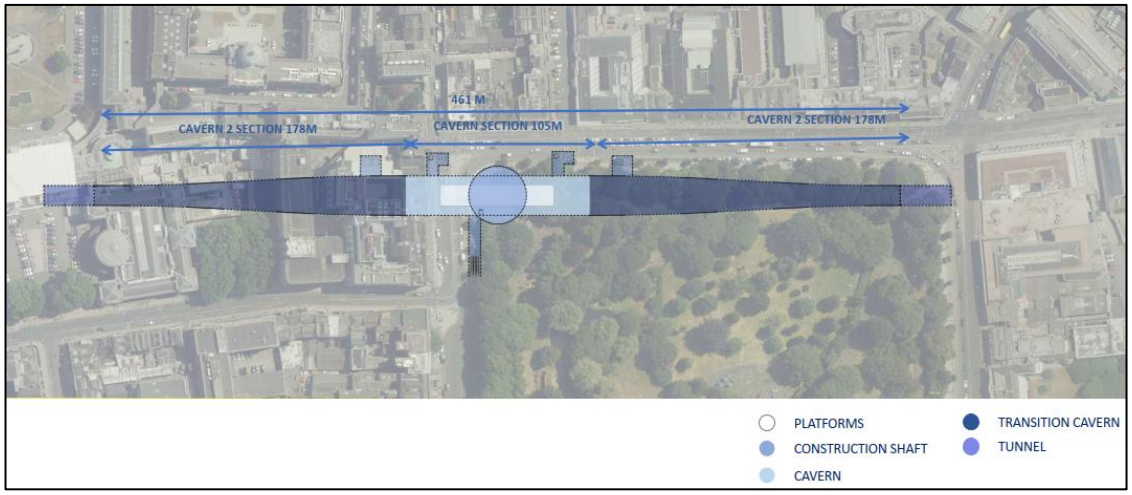
with running tunnel transition caverns)

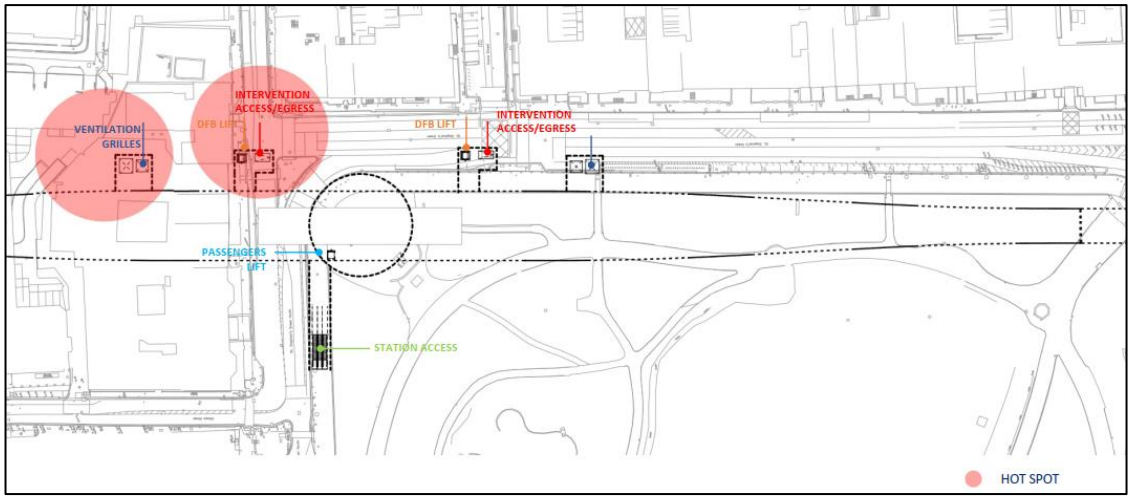


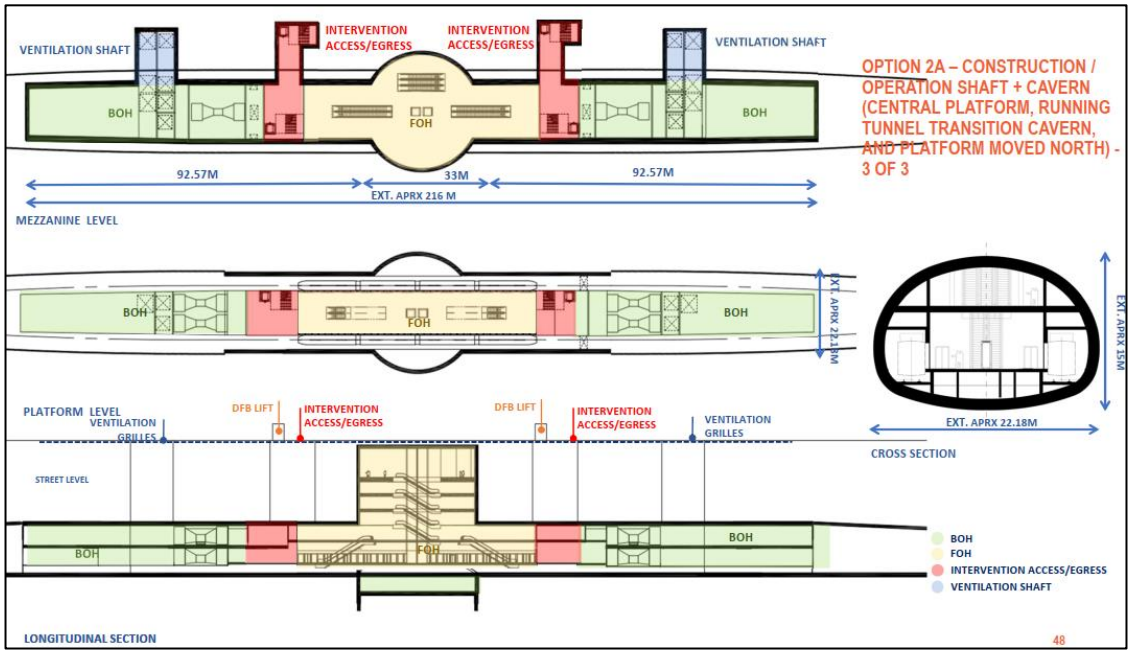




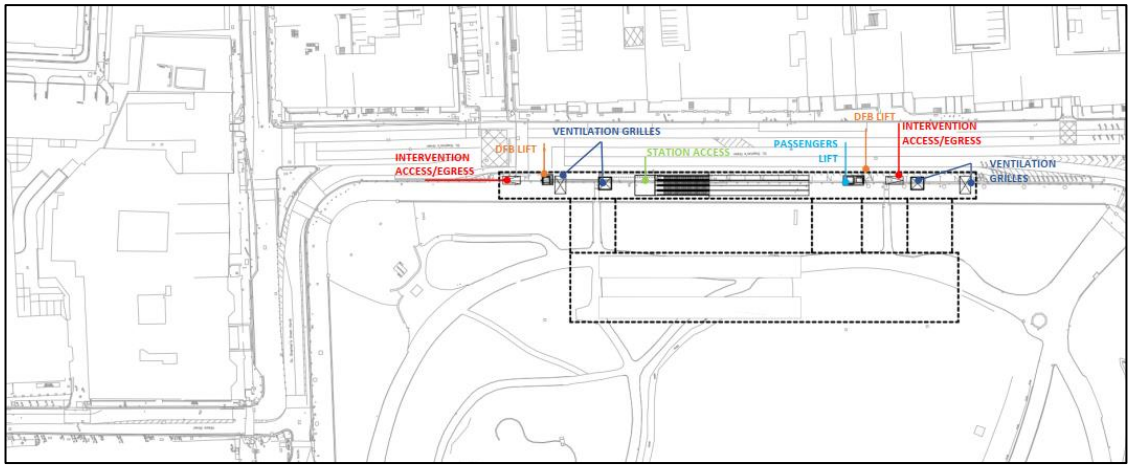
Option 2a, Construction / Operation Shaft + Cavern (central platform, running tunnel transition cavern, and platform moved north)

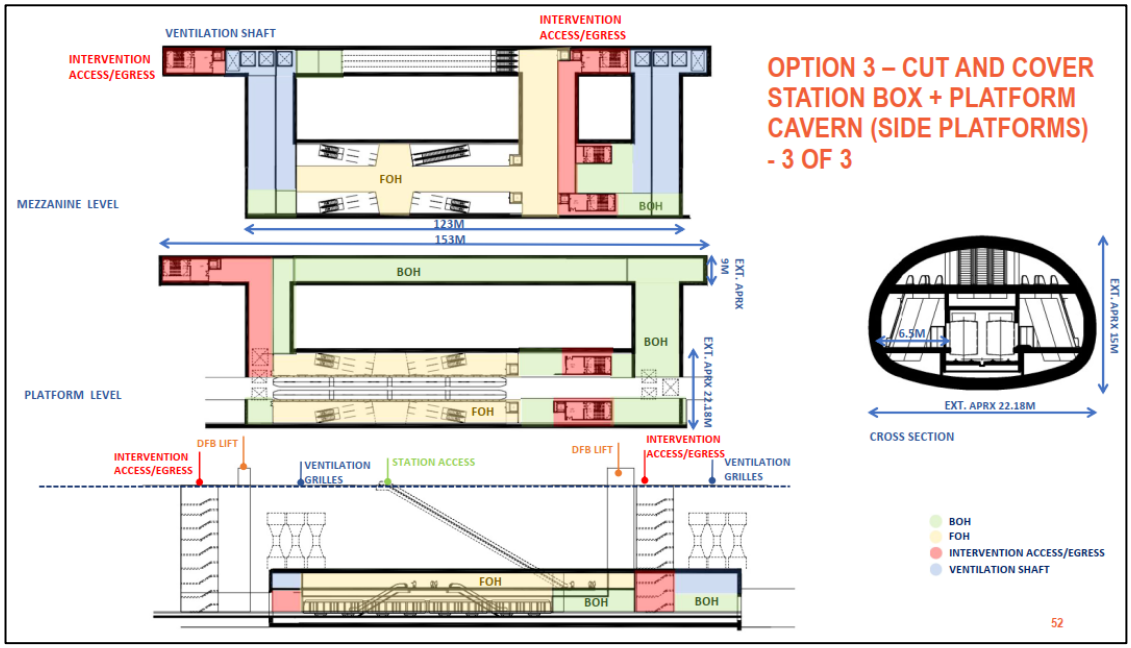




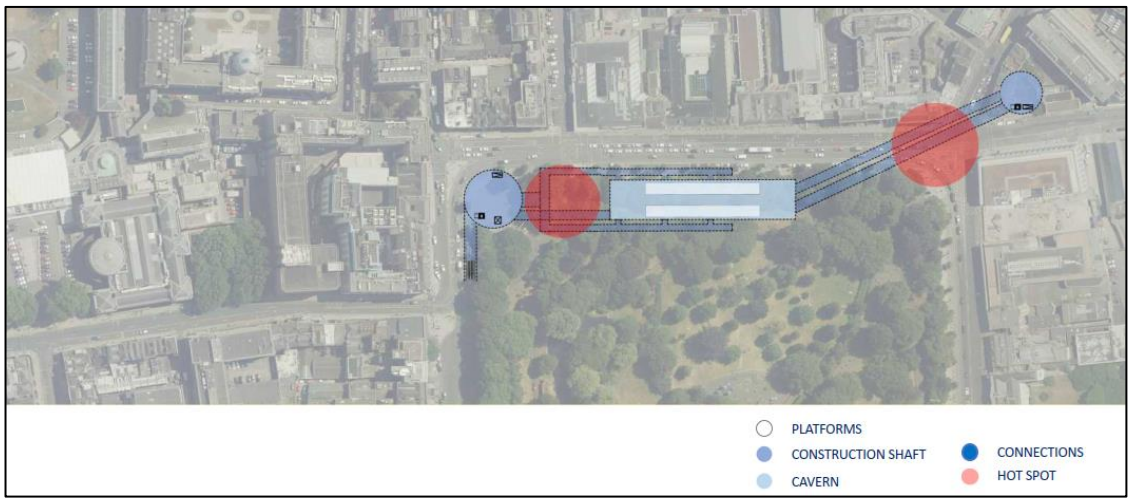


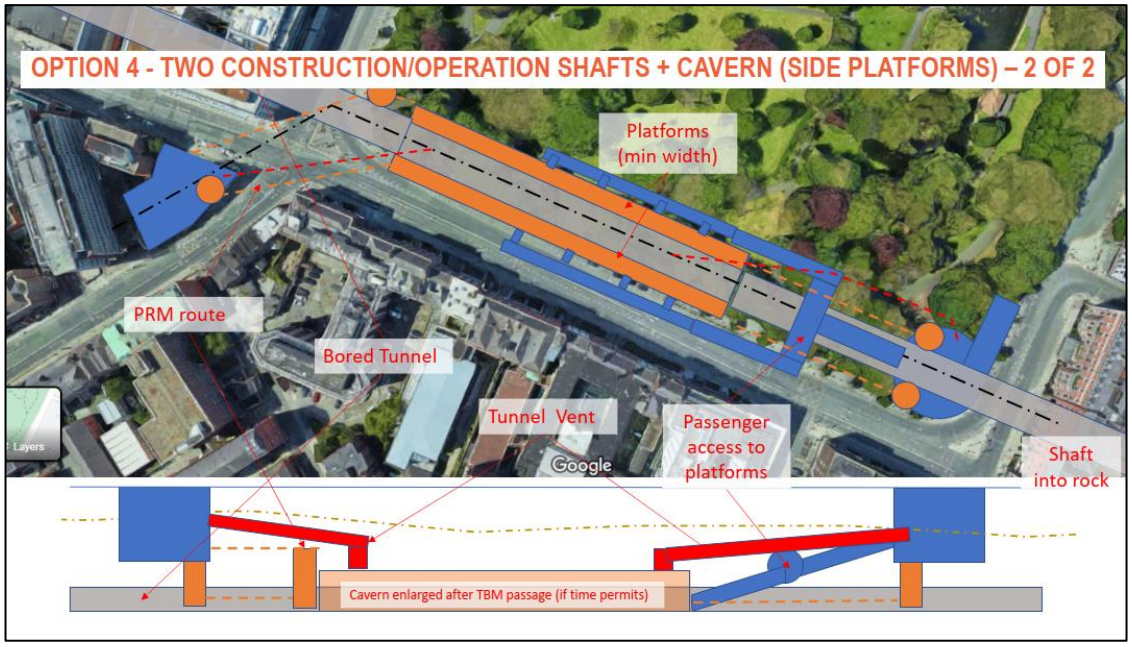
Option 3, Cut and Cover Station Box + Platform Cavern (side platforms)





Option 4, Two Construction / Operation Shafts + Cavern (side platforms)


PLATFORMS
CONSTRUCTION SHAFT
CAVERN
CONNECTIONS
HOT SPOT


OPTION 4 - TWO CONSTRUCTION/OPERATION SHAFTS + CAVERN (SIDE PLATFORMS) – 2 OF 2
Platforms (min width)
PRM route
Bored Tunnel
Tunnel Vent
Passenger access to platforms
Shaft into rock
Google
Cavern enlarged after TBM passage (if time permits)

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Appendix C – Stage 3 Preliminary Analysis

Criteria	Sub-Criteria	Option 1: Construction/Operation Shaft + Cavern (side platform) 
Project Objectives	1. Design to integrate appropriately into the existing public realm. 2. Planned, constructed and operated in a sustainable manner.	✓ Architectural Vision: Breaks the PD concept while also presenting an opportunity to develop a new interior atmosphere. ✓ Passenger Experience: Preserves operational arrangement, provides suitable way-finding but increased depth impacts negatively. ✓ Functional Plan: Station functional requirements can be accommodated. ✓ Ventilation Strategy: Preserves and complies with the PD requirements. ✓ Fire Safety: Despite the increase in depth, good safety performance is still considered likely. ✓ Public Realm: Impact of pop-up facilities is no greater than current cut and cover PD.
	Ranking	
Environment	Potential for adverse impacts (N&V is not an option differentiator)	✓ Traffic: Maintain 2 lanes SSG East and North. Cycle lane through park. Reduced construction traffic. X Noise: 24hr construction. Mitigate by noise enclosures. Potential for noise and groundborne N&V to impact hotels and residents. ✓ Amenity & Population: Very minor impact on trees, pollarding and root protection potentially needed. ✓ Heritage: Reducing the impact on the National monument (same for all options and not a differentiator)
	Ranking	
Engineering	Constructability	✓ Logistics: reduced daily movements, constrained site area. Mitigate by lorry holding areas, build up site set-up vertically. ✓ Cavern construction: Lower alignment to ensure competent rock, allow for ground treatment. ✓ Shaft construction: Secants in lieu of d/wall, allow for grouting and accommodation of space constraints.
	Ranking	
Economy	Cost, schedule and risk	✓ Cost: Tara St. mined station costing previously developed is comparable to box station – under review and development ✓ Schedule: Cavern construction before TBM arrival thought to be realistic – under review and development. ✓ Risk: Mining in rock acceptable. Reduced d/wall supply chain risk. SSG North and Plaza utilities require further investigation.
	Ranking	
Summary Conclusion		**Concept is considered to provide an acceptable and functional design solution with good constructability confidence. Cost and schedule impacts need to be assessed, however previous Tara St mined station assessment would indicate there is an even probability of this being acceptable.**
Overall Ranking		

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Criteria	Sub-Criteria	Option 1a: Construction/Operation Shaft + Cavern (side platform with platforms moved north) 
Project Objectives	1. Design to integrate appropriately into the existing public realm. 2. Planned, constructed and operated in a sustainable manner.	✓ Architectural Vision: Breaks the PD concept while also presenting an opportunity to develop a new interior atmosphere. ✓ Passenger Experience: Preserves operational arrangement, provides suitable way-finding but increased depth impacts negatively. ✓ Functional Plan: The cavern must be extended to accommodate ventilation rooms at both ends. ✓ Ventilation Strategy: Preserves and complies with the PD strategy. ✓ Fire Safety: Despite the increase in depth, good safety performance is still considered likely. X Public Realm: High impacts due to the station tunnels and pop-ups being moved northwards underneath a built-up area.
	Ranking	
Environment	Potential for adverse impacts (N&V is not an option differentiator)	✓ Traffic: Maintain 2 lanes SSG East and North. Cycle lane through park. Reduced construction traffic. Ventilation and evacuation shaft locations as a result of moving platforms northwards will further impact property. X Noise: 24hr construction - mitigate by noise enclosures. Northern vent shafts will be constructed close to property. X Amenity & Population: Very minor impact on trees, pollarding and root protection may be needed. Buildings may be impacted.
	Ranking	
Engineering	Constructability	✓ Logistics: Reduced daily movements, constrained site area. Mitigate by lorry holding areas, build up site set-up vertically. ✓ Cavern construction: Lower alignment to ensure competent rock, allow for ground treatment. Potential for more settlement impacts due to cavern location moving north under buildings. ✓ Shaft construction: Secants in lieu of d/wall, allow for grouting. Northern vent shafts will be adjacent to buildings.
	Ranking	
Economy	Cost, schedule and risk	X Cost: Greater than Option 1 – additional property costs associated with moving platforms north. ✓ Schedule: Cavern construction before TBM arrival thought to be realistic – under review and development. ✓ Risk: Mining in rock acceptable. Reduced d/wall supply chain risk. SSG North and Plaza utilities require further investigation. Third party risk to property due to moving platforms north.
	Ranking	
Summary Conclusion		**Moving the platforms north generates greater risk and impact to property and needs to be measured against any benefit resulting from having the opportunity to mine the platform cavern north and south simultaneously from the main shaft.**
	Overall Ranking	

Criteria	Sub-Criteria	Option 2: Construction/Operation Shaft + Cavern (central platform with running transition caverns)
Project Objectives	1. Design to integrate appropriately into the existing public realm. 2. Planned, constructed and operated in a sustainable manner.	X **Architectural Vision:** Strong break of design concept. It will be the only station with an island platform (different wayfinding). X **Passenger Experience:** Significantly modifies the PD station layout principles and will be very different from the rest of the line. X **Functional Plan:** The BoH needs to be accommodated in both transition caverns keeping it away from the center of operation. X **Ventilation Strategy** Preserves the PD Strategy but extends the length of connections and duplicates the OTEs. ✓ **Fire Safety:** Despite the increase in depth, good safety performance is still considered likely. ✓ **Public Realm:** Impact of pop-up facilities is no greater than current cut and cover PD.
	Ranking	
Environment	Potential for adverse impacts (N&V is not an option differentiator)	✓ **Traffic:** Maintain 2 lanes SSG East and North. Cycle lane through park. Running tunnel cavern transitions may increase traffic. X **Noise:** 24hr construction. Mitigate by noise enclosures. Potential for noise and groundborne N&V to impact hotels and residents. ✓ **Amenity & Population:** V/minor impact on trees, pollarding and root protection potentially needed. Transition cavern construction may impact property.
	Ranking	
Engineering	Constructability	✓ **Logistics:** Reduced daily movements, constrained site area. Mitigate by lorry holding areas, build up site set-up vertically. ✓ **Cavern construction + running tunnel enlargement:** Lower alignment to ensure competent rock, allow for ground treatment. Greater risk of ground movement impacts due to enlarging the running tunnels north and south of station. ✓ **Shaft construction:** Secants in lieu of d/wall, allow for grouting.
	Ranking	
Economy	Cost, schedule and risk	X **Cost:** Significant increased cost compared to option 1 due to c.165m and c.180m cavern transitions north and south respectively. X **Schedule:** Potential delay to the overall construction schedule due to the cavern transitions potentially being on the critical path. ✓ **Risk:** Mining in rock acceptable. Increased settlement impacts to 3rd parties. Reduced d/wall supply chain risk.
	Ranking	
Summary Conclusion		**Island platform configuration is a significant departure from the Metrolink design concept and would be the only station on the Line configured this way. Combined with the need for extensive mined cavern running tunnel transitions, this option is likely to have significant cost and schedule implications with an increased construction risk profile.**
Overall Ranking		

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Criteria	Sub-Criteria	Option 2a: Construction/Operation Shaft + Cavern (central platform, running tunnel transition caverns, and platforms moved north) 
Project Objectives	1. Design to integrate appropriately into the existing public realm. 2. Planned, constructed and operated in a sustainable manner.	X **Architectural Vision:** Strong break of design concept. It will be the only station with an island platform (different wayfinding). X **Passenger Experience:** Significantly modifies the PD station layout principles and will be very different from the rest of the line. X **Functional Plan:** The BoH needs to be accommodated in both transition caverns keeping it away from the center of operation. X **Ventilation Strategy:** Over Track Exhausts duplicated ✓ **Fire Safety:** Longer intervention evacuation route at norther end. X **Public Realm:** High impacts due to the station tunnels and pop-ups being moved northwards underneath a built-up area.
	Ranking	
Environment	Potential for adverse impacts (N&V is not an option differentiator)	✓ **Traffic:** Maintain 2 lanes SSG East and North. Cycle lane through park. Running tunnel cavern transitions may increase traffic. Ventilation and evacuation shaft locations at north end of station is likely to impact property and buildings. X **Noise:** 24hr construction - mitigate by noise enclosures. Ventilation and evacuation shafts at north end will be closer to property. X **Amenity & Population:** Very minor impact on trees, pollarding and root protection may be needed. Buildings may be impacted.
	Ranking	
Engineering	Constructability	✓ **Logistics:** Reduced daily movements, constrained site area. Mitigate by lorry holding areas, build up site set-up vertically. X **Cavern construction + Running tunnel enlargement:** Lower alignment to ensure competent rock, allow for ground treatment. Greater risk than Option 2 of ground movement impacting overlying property due to moving the platforms north. ✓ **Shaft construction:** secants in lieu of d/wall, allow for grouting vent shaft adjacent to buildings.
	Ranking	
Economy	Cost, schedule and risk	X **Cost:** Increased cost over Options 1 or 2 due to the increased risk of more buildings being impacted. X **Schedule:** Potential delay to the overall construction schedule due to the cavern transitions potentially being on the critical path. X **Risk:** Mining in rock acceptable. Increased settlement impacts to 3rd parties. Reduced d/wall supply chain risk.
	Ranking	
Summary Conclusion		**This option presents the same disbenefits as Option 2, plus moving of the platforms north generates greater risk and impact to overlying property and outweighs any benefit resulting from having the opportunity to mine the platform cavern and running tunnel transitions north and south simultaneously from the main construction shaft.**
Overall Ranking		

Criteria	Sub-Criteria	Option 3: Cut-and-Cover Station Box + Platform Cavern (side platform configuration)
Project Objectives	1. Design to integrate appropriately into the existing public realm. 2. Planned, constructed and operated in a sustainable manner.	✓ Architectural Vision: Breaks the PD concept while also presenting an opportunity to develop a new interior atmosphere. ✓ Passenger Experience: Weak spatial perception. X Functional Plan: BoH needs to be accommodated in the parallel cut and cover box keeping it away from the center of operation. ✓ Ventilation Strategy: Preserves the Preliminary Design Strategy ✓ Fire Safety: Likely feasible but needs an interface study with other disciplines. ✓ Public Realm: Higher impact on SSG road due to the entrance location.
	Ranking	
Environment	Potential for adverse impacts (N&V is not an option differentiator)	✓ Traffic: Maintain 2 lanes SSG East and North. Cycle lane through park. . X Noise: 24hr construction. Mitigate by noise enclosures. Potential for noise and groundborne N&V to impact hotels and residents. ✓ Amenity & Population: Very minor impact on trees, pollarding and root protection potentially needed.
	Ranking	
Engineering	Constructability	✓ Logistics: Long thin box – very constrained site area. Mitigate by lorry holding areas, build up site set-up vertically. ✓ Cavern construction and connection tunnels: Lower alignment to ensure competent rock, allow for ground treatment. ✓ Box construction: Extensive d/walling in very tight site, sequential working likely to be required.
	Ranking	
Economy	Cost, schedule and risk	✓ Cost: No apparent benefits over option 1 or 2. X Schedule: Potential to delay overall Metrolink critical path due to box programme (Sequential d/walling and thin width of box) ✓ Risk: Mining in rock acceptable. D/wall supply chain risk remains
	Ranking	
	Summary Conclusion	**Extremely constrained construction access (c.6m clear space between d/walls) and the necessary sequential working to construct the box will import significant schedule challenges and possibly place the Station on the construction critical path.**
	Overall Ranking	

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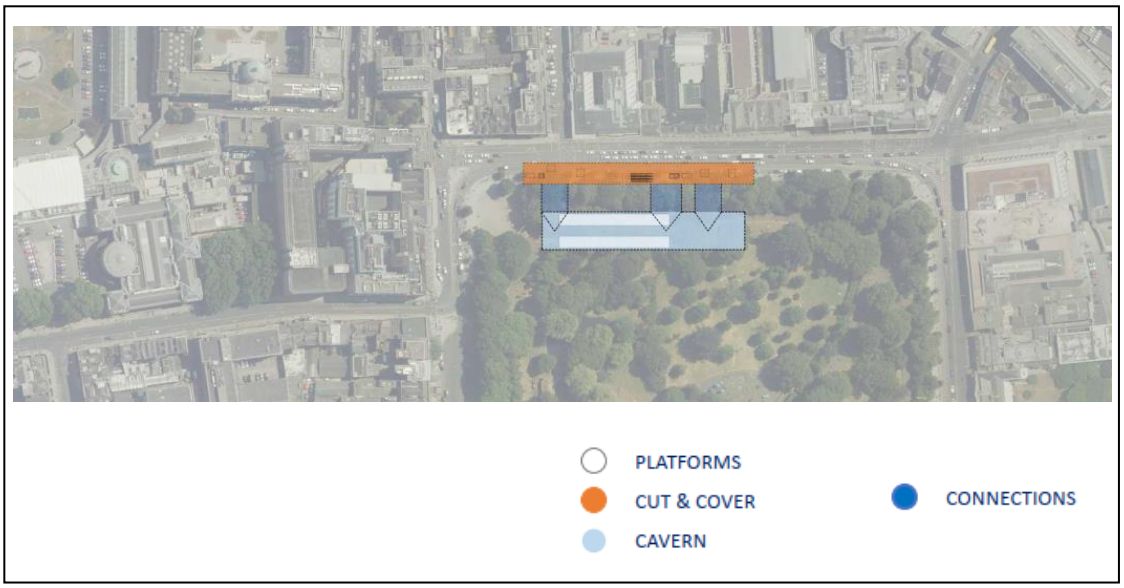
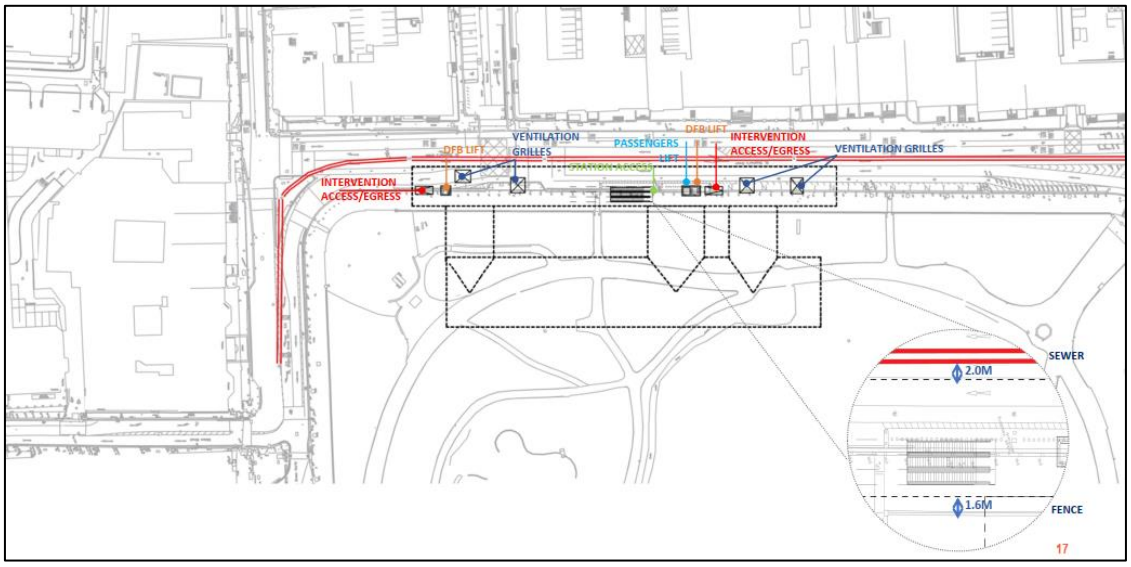
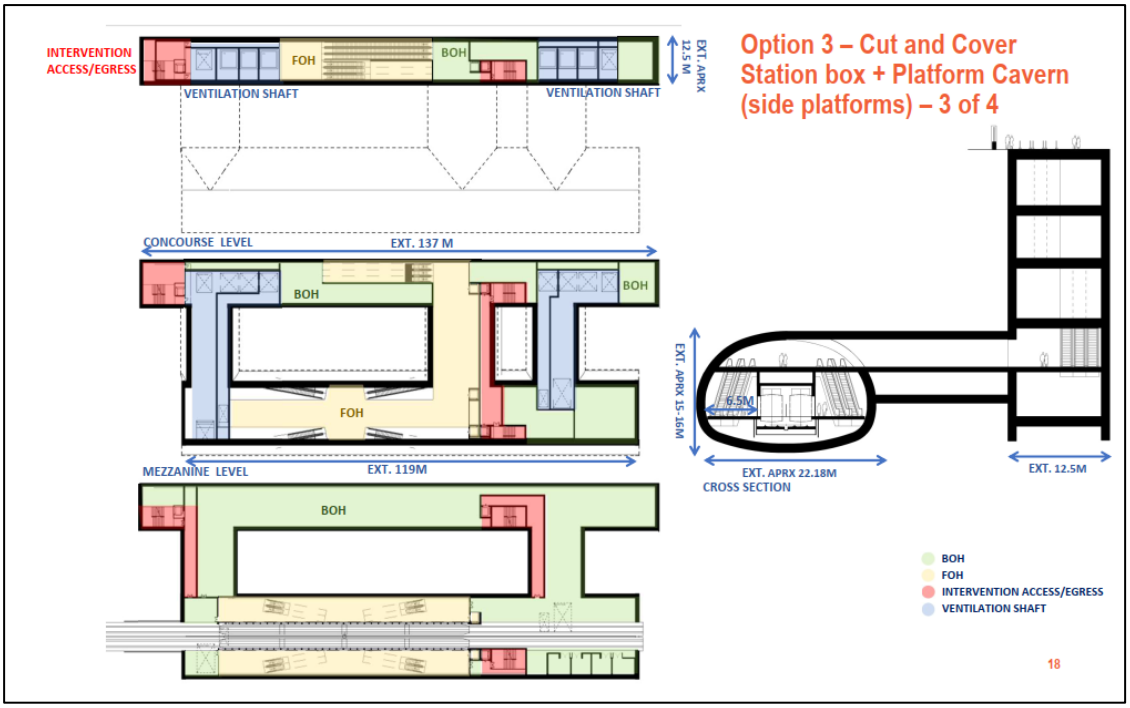
Criteria	Sub-Criteria	Option 4 Two Construction/Operation Shafts + Cavern (side platform configuration) 
Project Objectives	1. Design to integrate appropriately into the existing public realm. 2. Planned, constructed and operated in a sustainable manner.	X **Architectural Vision:** Radical change of design concept. X **Passenger Experience:** High impact due to the extended passenger travel routes. X **Functional Plan:** The BoH needs to be accommodated in the shafts keeping it away from the center of operation. ✓ **Ventilation Strategy:** The ventilation would be feasible having secondary shafts. X **Fire Safety:** Significant risk of non-compliance with Fire standards due to the extended passenger travel routes. X **Public Realm:** Higher impact due to the additional access to the south requiring property and land and land to be acquired.
	Ranking	
Environment	Potential for adverse impacts (N&V is not an option differentiator)	✓ **Traffic:** Maintain 2 lanes SSG East and North. Cycle lane through park. Reduced construction traffic.. X **Noise:** 24hr construction - mitigate by noise enclosures. Southern shaft closer to residents and risk of significant impact. X **Amenity & Population:** Very minor impact on trees, pollarding and root protection may be needed. Land acquisition and demo.
	Ranking	
Engineering	Constructability	✓ **Logistics:** Reduced daily movements, constrained site area. Mitigate by lorry holding areas, build up site set-up vertically. Southern shaft is likely to add complexity to the management of C&L and TM. ✓ **Cavern construction and tunnels:** Lower alignment to ensure competent rock, allow for ground treatment. Risk of clashes and complex tunnel arrangements from southern shaft. ✓ **Shaft construction:** Secants in lieu of d/wall, allow for grouting.
	Ranking	
Economy	Cost, schedule and risk	X **Cost:** Increase over Option 1 due to acquisition and demolition, and construction of a second access shaft. ✓ **Schedule:** Cavern construction before TBM arrival thought to be realistic – under review and development. ✓ **Risk:** Mining in rock acceptable. Reduced d/wall supply chain risk. Utility diversions for both shafts requires further investigation.
	Ranking	
Summary Conclusion		**The architectural concept and passenger experience is considered to be poor and is a radical change from the overarching architectural vison for MetroLink. In addition there is a need to acquire property to construct the southern access. The Station would however provide two entrances north and south and the opportunity for OSD at the southern entrance.**
Overall Ranking		

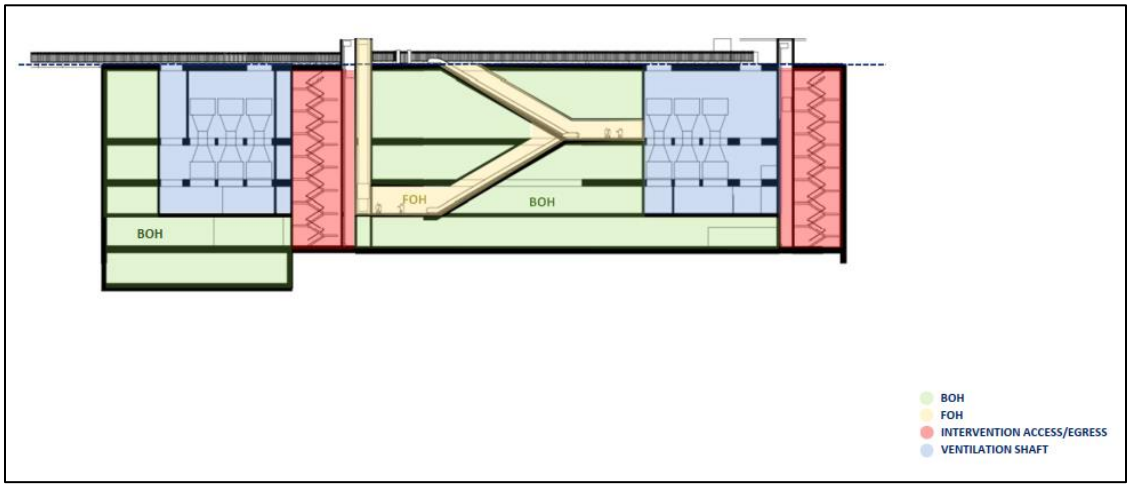
Appendix D – Option 3 Further Development

[Cut and Cover Station Box + Platform Cavern (side platforms)]






Option 3 – Cut and Cover Station box + Platform Cavern (side platforms) – 3 of 4
INTERVENTION ACCESS/EGRESS
FOH
BOH
VENTILATION SHAFT
VENTILATION SHAFT
EXT. APRX 12.5 M
CONCOURSE LEVEL
EXT. 137 M
BOH
BOH
FOH
MEZZANINE LEVEL
EXT. 119M
BOH
EXT. APRX 15-16M
6.5M
EXT. APRX 22.18M
CROSS SECTION
EXT. 12.5M
BOH
FOH
INTERVENTION ACCESS/EGRESS
VENTILATION SHAFT
18


FOH
BOH
BOH
BOH
FOH
INTERVENTION ACCESS/EGRESS
VENTILATION SHAFT

Appendix E – Stage 4 MCA Evaluation

Overall Factor - Project Objectives		Option 0 – Preliminary Design, Cut and Cover Station in the Park	Option 1 - Construction / Operation Shaft + Cavern (side platforms)	Option 3 – Cut and Cover Station + Platform Cavern (side platforms)
Architectural Vision	Construction	Not applicable to construction phase.		
	Operation	Compliant with TII Grimshaw concept, with exception of no natural light to platform.	Non-compliant with Grimshaw Metrolink prototype.	Non-compliant with Grimshaw Metrolink prototype.
Passenger Experience and Wayfinding	Construction	Not applicable to construction phase.		
	Operation	Closer to surface, less/shorter escalators, shorter walk distances (0 turns)	Increased depth, deeper escalators/lifts, significantly longer walk distances (3 turns)	Increased depth plus significantly longer distances (3 turns)
Accessibility, including PRM.	Construction	Not applicable to construction phase.		
	Operation	Closer to surface. Single entrance point.	Increased depth. Surface elevator separated from escalators; no clear point of entrance.	Single entrance point. Increased depth. Longer walk distances.
Integration With Other Public Transport Services	Construction	Not applicable to construction phase.		
	Operation	Walk connections to LUAS and bus stop on SSG North and SSG East.	More direct walk route to LUAS and bus stop on SSG North but longer vertical transfer due to increased depth.	More difficult walk connection to LUAS, longer vertical transfers due to increased depth.
Emergency Intervention, Access/ Egress	Construction	Not applicable to construction phase.		
	Operation	Same strategy for all options. Shortest routes.	Same strategy for all options. Longer routes.	Same strategy for all options. Longest routes.
Ventilation	Construction	All options can be constructed with a safe system of work.		
	Operation	Ventilation strategy in relation to air/smoke volume fits with prototype and design principles (10,000m^3)	Ventilation strategy is highly impacted by the increase of air/smoke volume to be driven (24,000m^3).	Ventilation strategy is highly impacted by the increase of air/smoke volume to be driven (27,000m^3).
Functional Plan and Operations	Construction	Not applicable to construction phase.		
	Operation	Suitable for accommodation and functional plan (11 escalators).	Operations are affected by the depth. Suitable for accommodation and functional plan (20 escalators)	Operations are affected by the depth. Technical rooms away from operation area, extended installations required. (14 escalators)
Public Realm	Construction	Significantly impacts SSG Park, SSG East footpath, but maintains existing traffic and cycle access along St. Stephen's Green East.	Impacts the Plaza area, reduces SSG East to two traffic lanes and a single cycle land, and impacts SSG North footpath.	Impacts traffic on SSG East the same as Option 1, requires construction within the SSG East footpath, but avoids infringing on SSG Park.
	Operation	The station entrance is integrated in the Plaza - most advantageous public realm solution.	Use of SSG North pavement for station entrance has greater impact on public realm	Use of SSG East pavement for station entrance leads to greater impact on public realm.

Overall Factor – Environment (1 of 2)		Option 0 – Preliminary Design, Cut and Cover Station in the Park	Option 1 - Construction / Operation Shaft + Cavern (side platforms)	Option 3 – Cut and Cover Station + Platform Cavern (side platforms)
Property Impact to SSG Park	Construction	Impact to SSG Park with the removal of, railings and works in SSG park.	Property take due to construction works in the Plaza and temporary removal of some sections of railings.	Minor property take due to requirement for temporary removal of section of the railings.
	Operation	Escalators in Plaza, vents in SSG Park.	Lift shaft and grills in Plaza	No incursion into SSG Park or Plaza.
Noise and Vibration	Construction	Based on day time working.	Proximity of the Shelbourne Hotel means daytime working only. Extends the schedule and duration of environmental impacts.	Proximity of the Loretto College means daytime working only. This extends the schedule and duration of environmental impacts.
	Operation	Metrolink station standard.	Slight reduction/advantage in deeper tunnel but difference will not be discernible to receptors.	Slight reduction/advantage in deeper tunnel but difference will not be discernible to receptors.
Traffic and Transport	Construction	3 traffic lanes maintained on SSG East. Cycle lanes maintained both directions. Parking removed.	2 traffic lanes maintained on SSG East, with NB cycle lane through SSG (OPW need to agree), SB is maintained, parking removed.	2 traffic lanes maintained on SSG East, with NB cycle lane through SSG (OPW need to agree), SB is maintained, parking removed.
	Operation	Escalator in Plaza. Doesn't affect pedestrian footpath LOS. Some parking loss on SSG East.	Escalator in SSG North, impact to footpath LOS. Some parking loss on SSG East.	Escalator in SSG East, major impact to footpath LOS. Major parking loss on SSG East.
Ground Water	Construction	Less ground water handling	Ground water - potential for more discharge due to secants, cavern construction and groundwater control.	Ground water - potential for more discharge due to cavern construction and groundwater control.
	Operation	Design will limit water ingress to the same level for all options. Not a differentiator.		
Biodiversity	Construction	Numerous trees / shrubs removed in SSG Park.	Less impact on SSG Park. Less impact on trees.	Least impact on trees and shrubs.
	Operation	Trees in SSG Park have to re-establish, vent grilles in SSG Park.	Only a few trees affected and will have to be re-established.	Trees in SSG Park not affected.
Climate - Carbon	Construction	Least concrete to be used, least excavation, least dewatering, least fissure grouting.	40% increase in concrete required, 50% increase in excavated material.	50% increase in concrete required, 55% increase in excavated material.
	Operation	Uses less power for operations.	Deeper station will require greater pumping and ventilation effort. More escalators and increased lift travel length.	Deeper station will require greater pumping and ventilation effort. Longer escalators and increased lift travel length.
Dust/Air	Construction	More dust generated from open cut works.	Least dust in mined cavern, however some from intervention shaft construction.	More dust generated from open cut works. (Negligible decrease from Option 0)
	Operation	Not applicable in operational phase.		

Overall Factor – Environment (2 of 2)		Option 0 – Preliminary Design, Cut and Cover Station in the Park	Option 1 - Construction / Operation Shaft + Cavern (side platforms)	Option 3 – Cut and Cover Station + Platform Cavern (side platforms)
Landscape and Visual (L&V)	Construction	Open cut site / intruding into SSG Park.	Limited open cut for Plaza shaft. Temporary removal of Wolfe Tone/ Famine memorial.	Site doesn't affect SSG Park or Plaza. Smaller open cut than Option 0.
	Operation	Entrance in Plaza, impact on L&V due to loss of trees prior to reestablishment. Permanent removal of Wolfe Tone and Famine memorial.	Entrance in public footpath, impact on a small number of trees until fully reestablished.	Entrance in public footpath.
Construction Resources and Waste	Construction	Least concrete to be used, least excavation, least dewatering, least fissure grouting, no SCL wastage.	40% increase in concrete required, 50% increase in excavated material, 100% increase in dewatering and 180% increase in grouting. High wastage from temporary use of sprayed concrete.	50% increase in concrete required, 55% increase in excavated material, 70% increase in dewatering and 150% increase in grouting. High wastage from temporary use sprayed concrete.
	Operation	Not applicable in operational phase.		
Archaeology/Cultural Heritage	Construction	Greater footprint with risk of more archaeological finds - Impact on (potential) ditch below railing.	Impact on (potential) ditch below railing and Plaza.	Impact on (potential) ditch below railing and road.
	Operation	Not applicable in operational phase		
Architectural Heritage	Construction	Ingress beyond railings to Park and monuments in Plaza.	Impact on monuments in Plaza, escalator box in SSG North.	Better than Options 0 and 1.
	Operation	Greater footprint in Park with structures in the park (which is a National Monument), Wolfe Tone/Famine monument permanently re-located.	Wolfe Tone/Famine Memorial re-instated in Plaza, but there is an impact to footpath and setting of the National Monument. .	No impact on Plaza area but there is an impact to footpath and setting of the National Monument.

Overall Factor – Engineering		Option 0 – Preliminary Design, Cut and Cover Station in the Park	Option 1 - Construction / Operation Shaft + Cavern (side platforms)	Option 3 – Cut and Cover Station + Platform Cavern (side platforms)
Constructability (ease of construction)	Construction	Reduced depth, working from the surface down.	Mining limited to day shift only will result in significant inefficiency and more complex planning to ensure the excavation is left "sealed" at the end of each shift.	Undertaking d/walls in limited space along with mining limited to day shift only will result in significant inefficiency and more complex construction planning.
	Operation	Not applicable in operational phase.		
Disposal/Haulage	Construction	Requires circa 30,000m^3 of concrete to be delivered and will require the removal of circa 75,000m^3 of excavated material.	40% increase in concrete deliveries, 50% increase in excavated material vehicles.	50% increase in concrete deliveries, 55% increase in excavated material.
	Operation	Not applicable in operational phase.		
Ground Movements and Geology	Construction	Shallowest station, least hard rock / water pressure, d/walls distant from buildings, "impermeable" walls.	10m deeper, increased water pressure, excavation in rock. Potential increase in movements due to groundwater management. Note deeper tunnels under buildings north and south of SSG is an advantage.	10m deeper, increased water pressure, excavation in rock. Potential increase in movements due to groundwater management. Note deeper tunnels under buildings north and south of SSG is an advantage.
	Operation	Not applicable in operational phase as any movements are assumed to have ceased prior to opening.		
Vertical and Horizontal Alignment	Construction	Passes under Leinster House.	Minimises the potential impact on Leinster House	Avoids Leinster House but passes beneath the National Concert Hall.
	Operation	No operational impact.	Negligible additional power consumption for change of 10m over 1km.	Negligible additional power consumption for change of 10m over 1km.
Demolition of Buildings Required or Impacted	Construction	No impact (Impact on St Stephens Green dealt with above.)		
	Operation	Not applicable in operational phase.		
Utilities	Construction	Slight advantage over Option 1 and 3.	Slight increase in cost and complexity around Plaza area.	Slight increase in cost and complexity due to box location.
	Operation	Not applicable in operational phase		

Overall Factor – Economy		Option 0 – Preliminary Design, Cut and Cover Station in the Park	Option 1 - Construction / Operation Shaft + Cavern (side platforms)	Option 3 – Cut and Cover Station + Platform Cavern (side platforms)
Program / Schedule	Construction	Station box is completed before TBM arrival, station completed on schedule. Duration: ERO to Opening = **8.5 years**	Working day shift only will not deliver the cavern in advance of the TBM arriving at St. Stephen's Green. This will mean instead the running tunnel will need to be enlarged to form the platform cavern after the TBM has reached is final destination south of Charlemont. This generates a significant extension to the programme and will require a blockade of the tunnel at St. Stephen's Green which is also likely to delay track installation. Duration: ERO to Opening = **10.5 years**	As Option 1 plus: Option 3 schedule is also impacted by reduced productivity as a result of the need to undertake diaphragm walling on a severely constrained site, with sufficient space for only one Hydrofraise and one grab. Duration: ERO to Opening = **12.25 years**
	Operation	Not applicable in operational phase		
Costs/CAPEX/OPEX	Construction	SSG Direct Cost Estimate = €174M	SSG Direct Cost Estimate = €296M (+71%)	SSG Direct Cost Estimate = €331M (+91%)
	Operation	Shallower station and tunnel alignment. Lower; ventilation, pumping, general operation, and maintenance costs.	Deeper Station and Tunnel Alignment. Higher ventilation, pumping, general operation, and maintenance costs.	Deeper Station and Tunnel Alignment. Higher ventilation, pumping, general operation, and maintenance costs.
Cost and Schedule Risk	Construction	This option is included in the overall Metrolink Quantified Risk Assessment (QRA both QCRA and QSRA) which is currently valued at 56% of overall direct Capital Cost Estimate for this stage of the Project.	Following risks would need to be assessed in any updated design and subsequent QRA update if concept is progressed: 1.Further schedule and cost impact due to early concept design being used as basis of estimate. (Design immaturity). 2.Increased cost and delay associated with control of groundwater, ground movement and associated 3rd party interfaces. 3.Greater quantity of ground improvement / treatment is required than anticipated. 4. Risk of additional downtime and inefficiency associated with 12-hour working.	Following risks would need to be assessed in any updated design and subsequent QRA update if concept is progressed: 1.Further schedule and cost impact due to early concept design being used as basis of estimate. (Design immaturity). 2.Increased cost and delay associated with control of groundwater, ground movement and associated 3rd party interfaces. 3.Greater quantity of ground improvement / treatment is required than anticipated. 4. Risk of additional downtime and inefficiency associated with 12-hour working.
	Operation	Included in the Metrolink O+M and Life Cycle Risk Assessment, currently valued at 30% of direct Capital Cost Estimate.	Further operational cost impact due to early concept design being used as basis of estimate. (Design immaturity).	Further operational cost impact due to early concept design being used as basis of estimate. (Design immaturity).