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URS

York Street Interchange

Co-financed by the European Union

Trans-European Transport Network (TEN-T)

Proposed Scheme Report: Part 2
Engineering, Traffic and Economic Assessment Report
Volume 1: Main Body

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INVESTORS IN PEOPLE

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About Transport NI

Transport NI, formerly branded as Roads Service, is a business unit within the Department for Regional Development (DRD), playing a significant role in facilitating the safe and conveninent movement of people and goods throughout the province and the safety of road users, through the delivery of road maintenance services and the management and development of the transport network. It also informs the Department's policy development process to ensure that measures to encourage safe and sustainable travel are practical and can be delivered.

Transport NI is responsible for the maintenance of over 25,000km of public roads together with about 9,700km of footways, 5,800 bridges, 271,000 street lights and 367 public car parks. It also has responsibility for the development of the transport network and a range of transport projects designed to improve network safety, sustainability and efficiency.

The key objectives of Transport NI are to:

- Manage, maintain and improve the transport network to keep it safe, efficient, reliable and sustainable;
- Promote increased customer satisfaction with the services delivered by Transport NI;
- Work constructively with Transport NI's key stakeholders to support the delivery of high quality services;
- Develop Transport NI's capacity and capability to meet objectives;
- Ensure effective management of Transport NI's budget, assets and corporate governance arrangements; and
- Improve Transport NI's resilience in responding to emergencies.

For the purposes of this report, references to Transport NI shall be read as references to its former Roads Service brand.

Further information about Transport NI is available on the Department for Regional Development website, please visit **www.drdni.gov.uk**.

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1. INTRODUCTION

1.1 The Project Brief

A York Street Interchange is proposed by Transport NI as a long-term Strategic Road Improvement (SRI) scheme to improve links from the A12 Westlink (the Westlink) to the M2 and M3 motorways in Belfast. The existing at-grade signalised York Street junction links the Westlink, the M2 and the M3 through a complex arrangement of traffic signals that interface with the surface street network that includes York Street, York Link, Great George's Street and Nelson Street. Road users currently experience long delays and congestion at peak periods travelling through this signalised gyratory system. The scheme is strategic in nature and is considered necessary in the longer term for the development of the Belfast Metropolitan Area (BMA) beyond 2015.

The general location plan of the existing York Street junction relative to the surrounding strategic road network in the BMA is shown in **Figure 1.1.1**. The general study area is shown in **Figure 1.1.2**.

URS was appointed in June 2008 to take forward Design Manual for Roads and Bridges (DMRB) Stage 1 and Stage 2 Scheme Assessments for a scheme to alleviate congestion in the vicinity of the York Street junction. Following the announcement of the Preferred Option for the scheme in December 2012, URS' commission was extended to include the preliminary design of the scheme, now termed the Proposed Scheme, ahead of a Stage 3 Scheme Assessment. In parallel with this process, URS was also commissioned to undertake the preparation of a draft Designation Order, a draft Vesting Order and an Environmental Statement.

A copy of the original Project Brief is included in **Appendix A** of this report.

1.2 Proposed Scheme Report Structure

This Proposed Scheme Report has been prepared in accordance with the general requirements for a Stage 3 Scheme Assessment Report set out in DMRB TD 37/93 entitled "Scheme Assessment Reporting" (DMRB 5.1.2), the Project Brief and Transport NI Policy and Procedure Guide (RSPPG) E030 entitled "Major Works Schemes: Inception to Completion". In accordance with the requirements of the DMRB, the report has been structured into two distinct parts:

- **Part 1**, the Environmental Statement; and
- **Part 2**, a report encompassing all other aspect of assessment.

This report shall form **Part 2** of the overall Proposed Scheme Report. Within this report:

- **Section 1** presents an introduction and background to the scheme. The scheme's objectives are described along with a review of the scheme's strategic context in relation to the region's transport strategy and policy.
- **Section 2** provides assessment of the existing conditions within the study area including engineering and traffic conditions and relevant local policies and plans affecting the study area.
- **Section 3** provides a description of the various scenarios considered for assessment.
- **Section 4** provides an engineering assessment of the Proposed Scheme.

- **Section 5** includes a traffic and economic assessment of the Proposed Scheme.
- **Section 6** summarises the key issues and sets out the recommendations, based on the assessed performance of the scheme against the established objectives.

Appendices to the report are included within **Volume 2**, whilst the Assessment Summary Table referred to in **Section 6** is included in the separately published **Volume 3**. Engineering Drawings referenced in **Section 2**, **Section 3** and **Section 4** of this report are also published in **Volume 3** along with the various Figures referenced in **Section 1**, **Section 2** , and **Section 5** of this report.

1.3 Scheme Objectives

The objectives for the scheme at a high-level reflect the Government's five main objectives for transport outlined in its 1998 White Paper entitled "A New Deal for Transport: Better for Everyone"[1] and detailed in the Regional Strategic Transport Network Transport Plan 2015[2] as:

- Environment - to protect the built and natural environment;
- Safety - to improve safety;
- Economy - to support sustainable economic activity and get good value for money;
- Accessibility - to improve access to facilities for people with disabilities and those without a car and to reduce severance; and
- Integration - to ensure that all decisions are taken in the context of the Government's integrated transport policy.

1.3.1 *Scheme Specific Objectives*

The following scheme specific objectives have been identified:

- to remove a bottleneck on the strategic road network;
- to deliver an affordable solution to reduce congestion on the strategic road network;
- to improve reliability of strategic journey times for the travelling public;
- to improve access to the regional gateways from the Eastern Seaboard Key Transport Corridor;
- to maintain access to existing properties, community facilities and commercial interests;
- to maintain access for pedestrians and cyclists; and
- to improve separation between strategic and local traffic.

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[1] "A New Deal for Transport: Better For Everyone" CM3950, ISBN 0 10 139502 7. July 1998.

[2] "Regional Strategic Transport Network Transport Plan 2015", Department for Regional Development (DRD). March 2005.

These high-level and specific objectives have been used in the development of the Proposed Scheme ahead of assessment.

1.4 Strategic Context

1.4.1 *European Union Policy*

European Union (EU) policy for transportation was first established in 1993, with the creation of the trans-European networks (TENs) in transport (TEN-T), energy and telecommunications based on Title XVI, Articles 170-172 of the Treaty on the Functioning of the European Union. The TENs allow the internal market to function, link European regions with each other and connect Europe with other parts of the world. The main EU-wide instruments of the TENs policy are:

- Union Guidelines, which set out objectives, priorities and outlines of measures for establishing and developing networks, to create the framework for identifying projects of common interest; and
- an EU infrastructure fund to support projects of common interest. These projects are prepared and implemented following the subsidiarity principle and in compliance with the relevant rules and procedures of the Member States on whose territories the projects are located.

In the transport sector, the first guidelines were adopted by the European Parliament and the Council in 1996; the first regulation for EU funding was adopted in 1995. TEN-T policy has a rising importance today, against a background of three major enlargements and evolving economic and political situations during its 20 years of existence. A substantial policy review was launched in 2009 and led to a new legislative framework that came into force in January 2014. The current provisions set out the framework for policy development in transport up to 2030/2050 are therefore:

- Regulation (EU) No **1315/2013** of the European Parliament and of the Council of 11 December 2013 on Union guidelines for the development of the trans-European transport network and repealing Decision No 661/2010/EU; and
- Commission Delegated Regulation (EU) No 473/2014 of 17 January 2014 amending Regulation (EU) No 1315/2013 of the European Parliament and of the Council as regards supplementing Annex III thereto with new indicative maps.

The TEN-T is a network which comprises roads, railway lines, inland waterways, inland and maritime ports, airports and rail-road terminals throughout the 28 Member States. This is a key factor for the network's efficient, safe and secure operation, using seamless transport chains for passengers and freight. It builds on existing and planned infrastructure in these States which has been identified on the basis of a single methodology and which has to comply with common requirements/standards (set out in the TEN-T Guidelines). The TEN-T consists of two planning layers:

1. The **comprehensive network:** a multi-modal network of relatively high density which provides all European regions (including peripheral and outermost regions) with accessibility that supports their further economic, social and territorial development as well as the mobility of their citizens. Its planning has been based on a number of common criteria (e.g. volume thresholds for terminals or accessibility needs). The total length of the comprehensive network amounts to:
    - 138,072km of railway lines;

  - 136,706km of roads; and
  - 23,506km of inland waterways.

2. The **core network:** a part of the comprehensive network, distinguished by its strategic importance for major European and global transport flows. It results from a single European planning methodology (SWD(2013) 542 final) developed by the European Commission and subjected to broad consultation among Member States and other stakeholders. The total length of the core network amounts to:

  - 68,915km of railway lines;
  - 59,630km of roads; and
  - 23,506km of inland waterways.

The Connecting Europe Facility (CEF) governs EU funding in transport, energy and telecommunications sectors during the period 2014-2020 and was implemented by Regulation (EU) No. 1316/2013 of the European Parliament and of the Council of 11 December 2013. For the purposes of facilitating a co-ordinated implementation of the core network, the concept of "core network corridors" was introduced in Annex I to the CEF Regulation to focus EU support from the CEF to:

- remove bottlenecks;
- build missing cross-border connections; and
- promote modal integration and interoperability.

Nine core network corridors have been identified by the CEF Regulation which include a list of projects pre-identified for potential EU funding, with a work plan existing for each corridor that establishes the current status of its infrastructure and a schedule for the removal of physical, technical and operational bottlenecks.

Of these nine corridors, the North Sea-Mediterranean Corridor runs from Cork, through Dublin and into Northern Ireland to Larne, before crossing the Irish Sea to run from Scotland through England and Wales and connecting to continental Europe, where it continues through the Netherlands, Belgium and Luxembourg to the Mediterranean Sea in the south of France. This is shown in **Figure 1.4.1.**

This multi-modal corridor encompasses a number of Priority Projects which have been identified by the CEF Regulation that will upgrade and improve connections from the British Isles to continental Europe. Of this list of projects, Priority Project 26 seeks to upgrade port and multi-modal connections in Belfast, with the proposed York Street Interchange scheme included on the developed list of active projects (reference 2011-UK-93016-S). The identified purpose of the scheme is to improve access to and from the Port of Belfast and to remove a major bottleneck (i.e. the existing York Street junction).

1.4.2 *United Kingdom Policy*

1.4.2.1 *A New Deal for Transport: Better for Everyone*

The Government's White Paper entitled '*A New Deal for Transport: Better for Everyone*' (1998) sets out a new approach to transport policy that has relevance throughout the entire

UK. It embodied new, modern thinking on integrating transport with other aspects of Government policy.

It recognised that different parts of the UK have differing transport needs and that the devolved regions would consider their own transport priorities and separate documents would be published for Scotland, Wales and Northern Ireland.

It also noted that a New Approach To Appraisal (NATA) was being developed for the appraisal of differing transport problems. NATA was designed to draw together the large amount of information collected as part of the appraisal of a transport problem and alternative solutions. This information is set against five criteria adopted for the review of trunk roads as noted in **Section 1.3** (i.e. Environmental Impact, Safety, Economy, Accessibility and Integration).

In response to this White Paper, the "Moving Forward: The Northern Ireland Transport Policy Statement" published in 1998 outlined a strategy for implementing the Government's objectives in the special context of Northern Ireland. This informed the Regional Strategies for Northern Ireland set out below.

1.4.3 *Northern Ireland Policy*

1.4.3.1 *Moving Forward: The Northern Ireland Transport Policy Statement*

This policy statement outlined a strategy for implementing the objectives of the White Paper in a way that reflected the particular circumstances of Northern Ireland.

It noted that transport in Northern Ireland was predominately based on cars, buses and lorries using the road system and that this approach would continue to provide for transport needs for many years but greater emphasis would be given to the needs of the pedestrian, cyclist and public transport – both bus and rail. It is also noted that "*it is clear that simply continuing to expand the road network to meet ever increasing demands from the private car would not meet the Region's social and economic requirements or secure mobility that is sustainable in the long term*".

In summary, the main elements of the approach included recognition that:

- cars will remain a significant feature of passenger transport in Northern Ireland for the foreseeable future;
- the road network will continue to carry the vast bulk of freight within Northern Ireland and to customers beyond; and
- substantial further investment will be needed in the strategic road network in the first quarter of the 21st Century in the interests of economic growth, for environmental and quality of life reasons and to improve safety.

The Policy Statement proposed a series of specific measures to help develop a more integrated, balanced and effective transport system for the whole of Northern Ireland which would offer people a balanced variety of transport options and recognise the transport needs of business. Such a system would be designed to limit transport-generated air pollution and transport's contribution to the threat of climate change, protect the amenity of residential areas and contribute to the development of a more inclusive society. In summary, these measures would include:

- the development of a more strategic approach to Northern Ireland's transportation needs through the preparation of a Regional Transport Plan, with the first 'formal' plan in place for the financial year 2001-02. This plan would determine and co-ordinate all transport activities including transport infrastructure development and traffic management initiatives to be taken forward over the next five years;

- better integration of the transport system and development of the region's land uses within the context of the Regional Strategic Framework, published by the Department; and
- better integration of transport policy with other Government policies designed to create a fairer, more inclusive, healthier and prosperous society.

The Policy Statement contained other important recommendations relating to partnerships, education and awareness. The measures would be put into effect through the Regional Transport Plan process which would contain a number of implementation programmes and targets for specific measures in particular areas.

1.4.4 *Regional Strategies*

1.4.4.1 *The Regional Development Strategy (RDS) 2035 – Building a Better Future*

The RDS (2035) provides an overarching strategic planning framework to facilitate and guide the public and private sectors. It does not redefine the other Government Departments' strategies but compliments them with a spatial perspective. It revises the original RDS 2025 strategy published in 2001 and amended in 2008 and whilst many of the objectives of the previous strategy are still valid, this document now replaces it.

The RDS influences various government strategies including:

- the Programme for Government (PfG); and
- the Investment Strategy for Northern Ireland (ISNI).

The Strategy takes account of key driving forces such as population growth and movement, demographic change, the increasing number of households, transportation needs, climate change and the spatial implications of divisions that still exist in our society. It is a framework which provides the strategic context for where development should happen, however it does not contain operational planning policy which is issued through Planning Policy Statements (PPSs) published by the Department of the Environment (DOE).

The RDS has a statutory basis under the Strategic Planning (Northern Ireland) Order 1999, which requires Government Departments to "*have regard to the Regional Development Strategy*" in exercising any functions in relation to development.

1.4.4.1.1 *Key Elements*

The Strategy has four key elements:

- a **Spatial Framework** which divides the region into 5 components based on functions and geography;
- **Guidance** at two levels:
  - Regional level that is to be applied to all parts of the region; and
  - Specific guidance for each element of the Spatial Framework.

- a **Regionally Significant Economic Infrastructure** section which identifies the need to consider strategic infrastructure projects; and

- **Implementation** which sets out how the strategy will be implemented.

1.4.4.1.2 *Aims*

The eight aims of the revised RDS are to:

1. Support strong, sustainable growth for the benefit of all parts of Northern Ireland;

2. Strengthen Belfast as the regional economic driver and Londonderry as the principal city of the North West;

3. Support our towns, villages and rural communities to maximise their potential;

4. Promote development which improves the health and wellbeing of communities;

5. Improve connectivity to enhance the movement of people, goods, energy and information between places;

6. Protect and enhance the environment for its own sake;

7. Take actions to reduce our carbon footprint and facilitate adaption to climate change; and

8. Strengthen links between north and south, east and west, with Europe and the rest of the world.

1.4.4.1.3 *The Spatial Framework*

Implementation of the vision and aims of the RDS requires a Spatial Framework to enable strategic choices to be made in relation to development and infrastructure investment. The key issues which influenced the Spatial Framework within the RDS are the:

- importance of Belfast City, at the heart of a Metropolitan area, as the major driver for regional economic growth; its population has declined but it remains the regional focus for administration, commerce, specialised services and cultural amenities;

- significant role which Londonderry has to play as the principal city of an expanding North West region; its recognition as the UK City of Culture 2013, will add impetus to the integrated approach to regeneration being taken forward in the 'One Plan' (One City One Plan One Voice: Regeneration Plan for Derry~Londonderry);

- importance of Main Hubs and Clusters well placed to benefit from and add value to regional economic growth; and that critical mass to attract growth can be created by the identification of clusters;

- need to build on the approach to urban renaissance of developing compact urban form by further integrating key land uses with transportation measures. The focus should be on the use of land within existing urban footprints, particularly within the hubs;

- new emphasis on how to reduce dependence on the car and change travel behaviour; and

- importance in all aspects of forward planning to address the consequences of climate change; this means an even greater focus on where people live and work and how transport and energy needs are planned.

Chapter 3 of the RDS sets out the strategic guidance specific to these areas, focusing on the key principles of the economy, society and the environment. The guidance is also split into Regional Guidance (RG) and Spatial Framework Guidance (SFG) some of which is specifically applicable to the Proposed Scheme as described below.

1.4.4.1.4 *Regional Guidance*

1.4.4.1.4.1 *Economy*

RG2: Deliver a balanced approach to transport infrastructure – the focus of this guidance is on managing the use of the road and rail space and how it can be used in a better, smarter way. The New Approach to Regional Transportation develops this guidance further (as noted in **Section 1.4.4.2.1**). Accordingly, the Proposed Scheme should aim to:

- improve connectivity;
- maximise the potential of the RSTN;
- use road space more efficiently;
- improve social inclusion;
- manage the movement of freight;
- improve access to our cities and towns; and
- improve safety by adopting a 'safe systems' approach to road safety.

1.4.4.1.4.2 *Society*

RG7: Support urban and rural renaissance – in urban areas this guidance focuses on the process of development and redevelopment in urban areas to attract investment and activity, foster revitalisation and improve the mix of uses. Accordingly, the Proposed Scheme should aim to:

- reduce noise pollution.

1.4.4.1.4.3 *Environment*

RG9: Reduce our carbon footprint and facilitate mitigation and adaptation to climate change whilst improving air quality – this guidance focuses on reducing air pollution and greenhouse gas emissions and preparing for the impacts of climate change. These include the effects on species and habitats and on health as a result of warmer temperatures, storms, floods and coastal erosion. Accordingly, the Proposed Scheme should aim to:

- reduce greenhouse gas emissions from transport;
- reduce noise and air pollution from transport;
- protect Air Quality Management Areas; and
- minimise development in areas at risk from flooding from rivers, the sea and surface water run-off.

RG11: Conserve, protect and, where possible, enhance our built heritage and our natural environment - in accordance with this guidance, the Proposed Scheme should provide effective care for the built and natural environment, in terms of improving health and well-being, promoting economic development and addressing social problems which result from poor quality environment. In accordance with this guidance, the Proposed Scheme should aim to:

- identify, protect and conserve the built heritage, including archaeological sites and monuments and historic buildings;
- identify, protect and conserve the character and built heritage assets within cities;
- maintain the integrity of built heritage assets, including historic landscapes;
- sustain and enhance biodiversity;
- identify, establish, protect and manage ecological networks;
- protect and encourage green and blue infrastructure within urban areas;
- protect and manage important geological and geomorphological features; and
- recognise and promote the conservation of local identity and distinctive landscape character.

RG12: Promote a more sustainable approach to the provision of water and sewerage services and flood risk management - in accordance with this guidance, the Proposed Scheme should aim to:

- integrate water and land-use planning; and
- encourage sustainable surface water management.

1.4.4.1.5 *Special Framework Guidance*

The spatial framework has the following five components:

- The Metropolitan Area centred on Belfast;
- Londonderry - principal city of the North West;
- Hubs and Clusters of Hubs;
- The Rural Area; and
- Gateways and corridors.

1.4.4.1.5.1 *The Metropolitan Area centred on Belfast*

The Belfast Metropolitan Urban Area (BMUA) is at the centre of the regional transport network and is the major gateway for national and international trade. The BMUA has a major role in the European network of City Regions with vital links to Dublin, Britain and continental Europe. Belfast's airports and sea port serve the Region as gateway links to the world.

SFG1: Promote urban economic development at key locations throughout the BMUA and ensure sufficient land is available for jobs - significant investment will be required to sustain and grow the BMUA. Employment opportunities should be planned in a way that recognises the roles that the component parts play; builds on planned regeneration initiatives and maximises the use of existing and planned infrastructure provision, including public transport.

SFG2: Grow the population of the City of Belfast - an efficient public transport system will provide the connections to jobs, services and amenities.

SFG4: Manage the movement of people and goods within the BMUA - recognises that transport has a key role to play in developing competitive cities and regions. An efficient transport infrastructure is not only important for a successful economy but it can also help promote social inclusion by providing an affordable alternative to the private car.

SFG5: Protect and enhance the quality of the setting of the BMUA and its environmental assets - the BMUA has a significant natural setting surrounded by hills. It is important to recognise the significance of the existing environmental assets and protected areas of high scenic value.

1.4.4.1.5.2 ***Gateways and Corridors***

Gateways are strategically important transport interchanges which are important for economic development, freight distribution activities and additional employment generation. The quality of connection from the air and sea ports to the internal transport network is crucial for economic competitiveness and the convenience of the travelling public.

Belfast is the major Regional City Gateway with the principal sea port of Northern Ireland and a city airport.

Economic Corridors have been identified based on the RSTN and have a fundamental role to play in regional growth. They can help strengthen economic competitiveness, increase the attractiveness of Belfast, provide access to the air and sea ports and are essential for providing access to the gateways.

SFG15: Strengthen the Gateways for Regional Competitiveness - Gateways should be able to deal with goods and passenger traffic efficiently and be considered as an asset by potential investors and local firms. Many of the gateways are intrinsically linked to important nature conservation sites or the aquatic environment and their development must be appropriately managed to take account of this.

- Provide high quality connections to and from the air and sea ports.
- Enhance gateways and their environmental Image.

1.4.4.1.6 ***Regionally Significant Economic Infrastructure***

Chapter 4 of the RDS states that spatial planning and related infrastructure development is essential to enable a working economy. Being part of an island, air and sea ports and land gateways are of fundamental importance to the region. Gateways should be able to cope with the volume and variety of traffic passing through them. They should also aim to accommodate businesses that benefit from proximity to the point of entry/departure.

Gateways are where first impressions are formed and should provide a high quality experience for the traveller.

- Transport linkages to and from the air and sea ports should be of the highest quality;

- Improving key transport corridors enhances accessibility to regional services and reduces peripherality. This means high quality road and, where available, rail links; and
- The transportation networks help to deliver balanced economic growth.

The five KTC's link people and freight to Northern Ireland's main cities, air, and sea ports and provide a framework around which economic corridors can develop. The KTC comprises 3% of all Northern Ireland's roads, but carries 26% of the traffic. Investment in the Key Corridors and in the rail infrastructure is desirable to ensure the efficient movement of goods and people.

Specific programmes (i.e. York Street Interchange) will be dependent on the availability of resources and the strategic direction of the new RTS.

As one of Northern Ireland's economic drivers, an efficient transport system in Belfast is essential to allow people and goods to move quickly around the city and to commute to and from it. High quality public transport for Belfast is therefore also necessary for regional prosperity.

1.4.4.2 *The Regional Transportation Strategy 2002-2012*

The RDS published in 2001 described how the RTS is an integral part of it and set the vision for it *"to have a modern, sustainable, safe transportation system which benefits society, the economy and the environment and which actively contributes to social inclusion and everyone's quality of life*". This vision is still appropriate for the New Approach to Regional Transportation (discussed further below). The RTS has guided investment decisions up to 2015. Following this the Strategic Document, *'Ensuring a Sustainable Transport Future - A New Approach to Regional Transportation'* will be used for decision making.

An integral feature of the RDS (2001) was the production of the Regional Transportation Strategy for Northern Ireland 2002 to 2012. This identified strategic transportation investment priorities and considered potential funding sources and affordability of planned initiatives over a ten year period. The overall development of this strategy was based on the Guidance on the Methodology for Multi-Modal Studies (GOMMMS), an objective led approach to seeking solutions to transport-related problems. The Government's five key objectives of environment, safety, economy, accessibility and integration were adopted and were central to the development of the RTS. Following extensive consultation on transportation issues facing the region an understanding was formed of the current constraints of the transportation system and requirements for future growth in line with the RDS. By comparing perceived problems to potential solutions a comprehensive list of potential transportation initiatives was drawn up.

The RTS was then implemented through three Transport Plans:

- the RSTNTP;
- the BMTP; and
- the Sub-Regional Transport Plan.

These Transport Plans present detailed programmes of major schemes and transport initiatives that support the objectives of the RTS and contribute to the RTS targets, taking full account of relevant Development Plans (i.e. the Belfast Metropolitan Area Plan (BMAP) 2015).

Within the RTS the importance of a strategy to remove bottlenecks is recognised. In particular this focuses upon strategic road improvements to upgrade the Key Transport Corridors and the other routes on the RSTN. The RTS also defines the bottlenecks as structural deficiencies where lack of capacity causes undue congestion and thereby delays for freight, public transport and cars.

The transportation initiatives from the RTS did not specifically refer to the York Street Interchange scheme. Instead with regard to funding for the strategic road network, it was envisaged that (subject to full assessment and statutory procedures) the strategy would focus on inter-urban routes with the development of high-quality dual carriageways and the removal of structural deficiencies (bottlenecks) where lack of capacity causes undue congestion.

1.4.4.2.1 *Ensuring a Sustainable Transport Future – A New Approach to Regional Transportation*

The current Regional Transportation Strategy 2002-2012 was successful in securing high levels of public funding to improve transportation infrastructure. However, the speed and direction of change in society prompted the need for review. The increase in population and vehicles has placed significant pressures on transportation networks coupled with fiscal constraints and the need to reduce environmental impacts.

A revised strategy document, '*Ensuring a Sustainable Transport Future – A new Approach to Regional Transportation*', was launched in March 2012. The new approach to regional transportation compliments the RDS and aims to achieve its vision for transportation. One of the main Strategic Objectives of the Strategy is to 'improve connectivity within the region' by completing the work identified in the current RSTNTP (as detailed below) and Strategic Road Improvement (SRI) Programme.

The New Approach essentially builds on what has been achieved. It emphasises the need to concentrate on moving people rather than vehicles, creating space on the networks for people and also for freight and on maintaining what is in place and using it in a smarter way. It is different from the current strategy in that it is not constructed on schemes and projects. Rather it sets the High Level Aims and Strategic Objectives for transportation in Northern Ireland that form the basis for future decision-making on DRD's transportation funding priorities.

The New Approach compliments the revised RDS 2035 and does not include details of schemes or projects, instead sets a visionary target "*to have a modern, sustainable, safe transportation system which benefits society, the economy and the environment and which actively contributes to social inclusion and everyone's quality of life*". To achieve this, three high level aims for transportation along with twelve supporting Strategic Objectives, covering the economy, society and the environment have been set. The High Level Aims and Strategic Objectives are:

A. Support the Growth of the Economy:

- improve connectivity within the region;
- use road space and railways more efficiently;
- better maintained transport infrastructure;
- improve access in our towns and cities;
- improve access in rural areas; and
- improve connections to key tourism sites.

B. Enhance the quality of life for all:

- improve safety;
- enhance social inclusion; and
- develop transport programmes focused on the user.

C. Reduce the Environmental Impact of Transport:

- reduce greenhouse gas emissions from transport;
- protect biodiversity; and
- reduce water, noise and air pollution.

The new approach starts with the assumption that the decision to travel has been made. It seeks to provide the infrastructure and services that will ensure that travel and transport are as sustainable as possible.

This Strategic Document considers a number of key trends in transportation, such as:

- the number of vehicles has increased and is over 1million;
- up to 2007, the volume of freight was increasing; and
- by 2031 the population is forecast to be over 2 million.

The York Street Interchange scheme clearly compliments the Strategic Objectives of this Strategy, in particular, improving connectivity within the region, improved access in our towns and cities and improved connections to key tourism sites.

1.4.5 *Transport Plans*

1.4.5.1 *Overview*

As noted above, a number of Transport Plans were developed to implement the RTS and will continue until 2015. Beyond this period, the Department will prepare a long list of possible strategic transport interventions. This will be a substantial exercise and work has already started looking at the existing plans to see what has yet to be delivered. The Department will undertake an initial sift, removing strategic transport interventions which would be obviously unaffordable and seek to combine others to develop Strategic Programmes of Interventions where possible.

The next stage would be to apply the Prioritisation Framework to the list of possible strategic transportation interventions and arrive at an Initial Prioritised List, which would then be subject to Transport Appraisal.

1.4.5.2 *The Regional Strategic Transport Network Transport Plan 2015*

The RSTNTP sets out how the RTS will be implemented and confirms the individual schemes and projects to be implemented (subject to economic assessments, statutory processes and availability of resources) to support the RDS (2025 version) and RTS objective and targets. The RSTN incorporates 5% of the road network, which carried around 37% of total road traffic movements, and all of the rail system. The RSTNTP aimed to develop a RSTN based on the five KTCs identified in the RDS.

The RSTN included the complete rail network and the strategic road network. The strategic road network is comprised of the combined network formed by the KTCs, Link Corridors and Trunk Roads as shown on **Figure 1.4.2**.

The RSTNTP includes a programme for the implementation of SRIs to remove bottlenecks on the network where lack of capacity is causing serious congestion, and to improve the environment by providing bypasses of towns situated on the RSTN, thus relieving the effects of heavy through traffic. Although the York Street Interchange scheme was not specifically presented as one of these improvements, in line with Tran 1.2 of SPG-TRAN 1 from the RDS (to develop a Regional Strategic Transport Network based on key transport corridors, to enhance accessibility to regional facilities and services) to develop and maintain the identified RSTN to enhance accessibility on an integrated basis for all users including freight, the aims are to:

- incorporate quality public transport elements along the corridor routes with multi-modal interchange facilities, including provision for walking and cycling;
- target improvements to upgrade the network, road and rail, giving priority to the Key, Link and Metropolitan Transport Corridors; and
- upgrade Westlink as a priority to reduce impacts of congestion and facilitate through traffic and freight movement, particularly that associated with the Ports of Belfast and Larne.

1.4.5.3 *The Belfast Metropolitan Transport Plan*

Prepared by DRD, the BMTP is a local non-statutory transport plan for the BMA, which takes forward the strategic initiatives of the RTS and sets out transport proposals for the BMA which people can expect to see implemented by 2015. The BMTP and BMAP are mutually supportive and integrated documents, with the former acting as a Technical Supplement to the latter in relation to transportation.

The overall development of the BMTP was based on GOMMMS, ensuring that a comprehensive range of solutions had been considered covering all modes of transport. It also ensured integration between transport and land use. Development of the BMTP was especially influenced by the guidance provided by the RDS and RTS, and enabling the generic multi-modal study process to be focused on the particular needs and special context of the BMA. An extensive consultation exercise was also undertaken, ensuring that the views of a wide range of stakeholders were taken into account in the development of the Plan. The consultation process built upon the extensive consultation exercise undertaken to support the RDS and RTS.

The BMTP identified a road hierarchy within the BMA, comprising the Strategic Highway Network linked to the wider RSTN in the RSTNTP and a Non-Strategic Highway Network. The Strategic Highway Network identified by the BMTP includes the Westlink, M2 and M3, and a series of improvements are identified on the M1/Westlink and M2 routes to remove identified bottlenecks. With regards to the planned improvements to the M1/Westlink, the BMTP cautioned that:

"*the improvements to the M1/Westlink will require further consideration to be given to improving the capacity and operation of the signalised junctions at York Street/Westlink and Nelson Street/York Link/Great George's Street*."

1.4.6 *Development Plan*

1.4.6.1 *A Strategic Planning Policy Statement for Northern Ireland (SPPS) Planning for Sustainable Development (Draft)*

The draft Northern Ireland SPPS was published in February 2014 and was subject to a three month consultation period. The draft SPPS consolidates 20 separate policy publications into one document setting out the core planning principles to underpin delivery of reformed two-tier planning system from April 2015. The final SPPS will come into effect on the 31st March 2015 with the transfer of planning to councils and will be an essential, key element of the broader planning and local government reform programme setting the direction for new councils to bring forward detailed operational policies within future local development plans. The draft policy has not been reviewed in this Environmental Statement as its adopted status is not confirmed at the time of writing.

1.4.6.2 *Belfast Metropolitan Area Plan 2015*

The DOE, under the provisions of Part III of the Planning (Northern Ireland) Order 1991, has adopted the Belfast Metropolitan Area Plan (BMAP) to the extent approved and endorsed in The Belfast Metropolitan Area Plan Adoption Statement 2014.

The Plan, as adopted, became operative on 09 September 2014 covering the City Council areas of Belfast and Lisburn, and the Borough Council areas of Carrickfergus, Castlereagh, Newtownabbey and North Down, and comprises seven volumes:

- Volume One consists of Parts One, Two, and Three which deal with the Plan Area as a whole; and
- Volumes Two to Seven comprise Part Four (the District Proposals) which set out the site-specific proposals for individual Council areas.

The purpose of the Plan is to inform the general public, statutory authorities, developers and other interested bodies of the policy framework and land use proposals that are used to guide development decisions within the BMA over the Plan period.

The Plan is prepared within the context of the priorities of the Northern Ireland Executive as set out in the Programme for Government, taking into account European, National and Regional policies which have implications for the future pattern of development within the BMA. The Plan establishes policy guidelines within which more detailed development proposals can be determined. It assists public agencies (i.e. Transport NI) in decisions concerning infrastructure improvements and also assists private developers in reaching their land use based decisions over the Plan period.

As noted earlier, the RDS sets out a dynamic strategic spatial planning framework for Northern Ireland to guide physical development within the region until 2035 and provides an overarching strategic framework for development plans. The aim of BMAP is to provide a planning framework which is in general conformity with the RDS in facilitating sustainable growth and a high quality of development in the BMA throughout the Plan Period, whilst protecting and where appropriate, enhancing the natural and man-made environment of the plan area.

The RDS recognises the important role Belfast plays in generating regional prosperity. It seeks to maximise the use of existing infrastructure and services. The Strategy also recognises that policies for physical development have far-reaching implications. It therefore addresses economic, social and environmental issues aimed at achieving sustainable development and social cohesion.

It highlights the need to build on the approach to urban renaissance of developing compact urban form by further integrating key land uses with transportation measures. The focus should be on the use of land within existing urban footprints.

DRD has determined, in accordance with Article 28(7) of the Planning (Amendment) (Northern Ireland) Order 2003, that BMAP is in general conformity with the RDS 2035. As such, the Plan has a significant role to play in achieving the vision of the RDS through the Plan Strategy and Plan Proposals.

1.4.6.3 *Belfast Metropolitan Area Plan 2015 – District Proposals Belfast*

The Belfast City Strategy has been determined to reflect the strategic vision and framework which flows from it. The strategy is made up of the following planning actions:

- Promoting Urban Renewal in the City through:
  - accommodating the majority of housing growth within the urban footprint;
  - designating the majority of employment opportunities in locations which will help secure regeneration and revitalisation;
  - a wide range of designations, policies and zonings which will help revitalise the City Centre; and
  - designations and policies which will promote revitalisation of Arterial Routes in the City.
- Enhancing the Quality of Life in the City through:
  - providing an urban design framework for the City Centre;
  - protecting the built heritage through the designation of 51 Areas of Townscape Character;
  - Metropolitan Development Limit designation which prevents suburban sprawl and protects the unique and striking setting of the City;
  - protecting existing parks, green areas, the coastline and designating 68 Local Landscape Policy Areas, 34 Sites of Local Nature Conservation Importance, nine Community Greenways and four Urban Landscape Wedges;
  - protecting six sites for proposed health facilities and two sites for proposed education facilities; and
  - providing greater certainty about the locations where various forms of development are likely to take place over the Plan period.
- A Focus For Economic Development in the City through:
  - City Centre designations, policies and zonings including five Development Opportunity Sites;

  - close linkage between employment opportunities and regeneration needs;
  - the designation/zoning of employment sites and mixed-use sites in the City along with a substantial employment potential identified at Titanic Quarter; and
  - confirming existing employment land in various locations.
- Promoting Equality of Opportunity for All Sections of the City Population through:
  - providing a wide range of opportunities for house building and job creation throughout the City;
  - designating/zoning employment sites in North, West and East Belfast in line with government's Anti-Poverty and Social Inclusion Strategy, along with providing substantial development opportunities in central locations accessible to all sections of the community;
  - promoting public transport and equitable access to services, facilities and employment opportunities for all the community; and
  - specific zonings both for social housing and accommodation for the Travelling Community.
- Protecting the City's Natural Environment through:
  - the focus of development opportunities within the urban footprint to reduce the need for greenfield expansion and accordingly to protect the quality landscapes that provide the unique city setting;
  - positive protection of the Lagan Valley Regional Park;
  - protecting existing parks, green areas and the shores of Belfast Lough;
  - designating 18 Historic Parks, Gardens and Demesnes;
  - designating 68 Local Landscape Policy Areas to protect areas of distinctive landscape and amenity;
  - designating 34 Sites of Local Nature Conservation Importance to enhance the conservation of bio-diversity and protect priority habitats; and
  - designating nine Community Greenways and four Urban Landscape Wedges.
- Promoting an integrated and inclusive Transport System, consistent with the City's role as a major gateway to Northern Ireland and as the heart of the Regional Strategic Transport Network (RSTN) through:
  - effective integration of land use and transportation;
  - promoting the use of public transport with requirements for provision of facilities in conjunction with development in certain land use zonings;
  - seeking to reduce the number of car journeys made during peak periods by controlling non-operational car parking within designated Areas of Parking Restraint in Belfast City Core, City Fringe and in Commercial Nodes on Arterial Routes;

- promoting walking and cycling through two proposed additional bridge crossings over the River Lagan; and
- protection for strategic and non-strategic road schemes in the City.

Although not identified as a strategic road scheme proposal within Part Four of BMAP, a number of strategic transportation schemes have been identified within Part Three of the Plan, including:

- York Street Interchange (Westlink/M2/M3 junction); underpasses under Lagan road and Dargan rail bridges; and new bridges at York Street and Dock Street.

The movement of goods to, from and within the Plan Area is a fundamental element of the economy of the area and the wider Region. Proposed enhancements to the Strategic Highway Network will facilitate safe and efficient long distance movements of people and freight within the Plan Area.

Measures proposed will benefit freight transport, building upon the wider commitment of the RTS to improve the Region's Strategic Highway Network. The measures include improvements to the BMA's Strategic Road Network with particular emphasis on relieving existing bottlenecks and provision of better access to Regional Gateways and Major Employment Locations.

1.4.6.4 *Belfast Metropolitan Area Plan 2015 Judicial Review*

In October 2014 Arlene Foster, Minister for the Department of Enterprise, Trade and Investment publically announced her intention to Judicial Review (JR) the approval of the BMAP without the agreement of the full Northern Ireland Executive. Should an application for leave and subsequent JR be successful, the status of the plan would revert to draft and new consultation processes would be put in place to bring it forward to adoption once again. At the time of writing the ES, BMAP is the finally adopted plan and has not yet been subjected to any JR process; it has therefore been fully considered. As the Belfast Metropolitan Transportation Plan is a separate document, any judicial challenge on BMAP will not affect the assessment of the Proposed Scheme.

1.4.6.5 *The Investment Strategy for Northern Ireland*

The Programme for Government (PfG) 2011-2015 document published in March 2012 sets out the Northern Ireland Executive's strategic priorities and key plans for investment in Northern Ireland for 2011-2015. This PfG has been used to update the priorities contained within the Investment Strategy for Northern Ireland (ISNI) for 2011-2021.

The ISNI (originally launched in December 2005), set a new, comprehensive approach to be used by government to make informed decisions as to the investment priorities for Northern Ireland for the ten year period from 2005-2015.

The ISNI confirmed that implementation of the existing RTS was already bringing considerable investment in the roads network across Northern Ireland. To achieve the aspirations of the economic vision for Northern Ireland required an even more forward looking approach, to ensure key infrastructure was in place so that Northern Ireland is prepared for inward investment. ISNI confirmed plans to commence additional investment that would result in higher standard roads providing improved access for commercial traffic, buses and private cars, mainly on the KTC's connecting Northern Ireland's major cities, including key cross border routes. This would be the start of what could become a £1bn investment on the strategic network that would allow additional major improvement schemes over and above those identified in the RSTN TP.

A revised ISNI, for the ten year period 2008 to 2018, was published in 2008 and indicated an investment of £3.1bn in roads infrastructure. Approximately £2.5bn was targeted at the Strategic Road Network and included major schemes on the key strategic routes.

A daughter document of ISNI, the DRD Investment Delivery Plan (IDP) for Roads, provides additional detail on future infrastructure investments, organisational capacity and delivery arrangements for the strategy envisaged in ISNI.

In October 2012, the ISNI 2011-2021 was published. This document updated the Investment Strategy in line with the new budget period and reflects the priorities of the PfG. It highlights progress made to date and sets out the next phase of investment in key projects and programmes. While the resolve to invest remains resolute, the scale and focus on investments is updated to reflect the economic climate, with a shift in focus to protecting jobs, fostering economic recovery and protecting public services. The decision of the Coalition Government in Westminster to cut public spending meant that there would be less money than had been previously been anticipated. The Strategy is focused on prioritising infrastructure programmes that will deliver the best return in the period ahead.

The ISNI 2011-2021 confirms that investment in efficient, reliable, competitive and sustainable networks (roads, public transport, gateways, telecoms, energy) is critical to the growth of a dynamic and innovative economy. Investment on the roads network will reduce journey times, improve safety and provide enhanced access to urban centres and inter-regional gateways.

In terms of on-going work, the strategy notes that development work will continue on a range of major projects including the A6 between Derry~Londonderry and Dungiven, and Westlink/York Street junction.

1.5 Network Constraints

1.6 Proposed Scheme Context

1.6.1 *Expanding the Strategic Road Improvement Programme 2015 – Consultation Document*

The launched ISNI (published in December 2005), identified an additional £400M for the Transport NI SRI Programme that was in place at the time of publication. In response to this expanded programme of investment, Transport NI developed a list of additional SRIs as part of an Expanded SRI Programme.

The proposed Expanded SRI Programme, like the RSTNTP, was based on the guidance set out in the RDS and the RTS. The selection was based on the Government's five key objectives for transport of environment, safety, economy, accessibility and integration. It built upon the extensive work undertaken for the RSTNTP and among other objectives aimed to address bottlenecks on the strategic road network, giving priority to the KTCs, Link Corridors and then the Trunk Roads.

The Expanded SRI Programme was balanced across Northern Ireland and included major improvements necessary to deal with bottlenecks and safety concerns. As part of these improvements a grade separated junction was identified at York Street. This was set out within Annex B of the published consultation document as detailed in Table **1.6.1**.

Table 1.6.1: Extract from Annex B of Expanding the SRI Programme 2015 Consultation Document

Proposed additional SRI schemes to be added to programme subject to consultation		
Scheme	Description	Cost (£ M)
Eastern Seaboard Corridor		
Westlink/York St flyover	Provide grade separated junction at the last remaining part of Westlink which has a traffic signalled junction	£ 50M

The consultation process for the Expanding the Strategic Road Improvement Programme 2015 – Consultation Document commenced on 31 July 2006 and continued until 29 September 2006. The document was consulted upon widely and during this period there were no adverse reactions to the programme of works proposed at York Street.

Based on the above, the Expanded SRI programme builds on the RDS and RTS and therefore is considered to have the same strategic policy status.

1.6.2 *Expanding the Strategic Road Improvement Programme 2015 – Draft Environmental Report*

A draft Environmental Report for the Strategic Environmental Assessment of the Expanded SRI Programme was prepared and published for consultation in July 2006. The consultation process for the draft Environmental Report also commenced on 31 July 2006 and continued until 29 September 2006.

The draft Environmental Report noted that the Expanded SRI Programme was one aspect of the ISNI which was multi-modal in nature. The ISNI proposed investment in rail network renewal and new buses to improve travel times and accessibility by all modes across Northern Ireland.

The expanded SRI programme was based on the RDS, the RTS and the RSTNTP. Improved strategic road links have the potential to provide beneficial impacts across the Government's five key criteria.

The document was adopted by the Department and included Summary Tables indicating the Environmental Assessment Impacts of the schemes. The assessment for the Westlink/York Street Flyover is reproduced in **Table 1.6.2**.

Table 1.6.2: Extract from Annex B of Expanding the Strategic Road Improvement Programme 2015 Consultation Document

Eastern Seaboard Corridor – Westlink/York Street Flyover				
Theme	Appraisal Criteria	Effects	Summary of Effects	Comments
Environment	Biodiversity	0	In general, proposed works are within an urban environment and will have no impact on biodiversity.	
	Countryside	0	Proposed works are within an urban environment and will have no impact on the countryside.	
	Climate Change & Air Pollution	✓	Proposed works will relieve congestion in an urban area. This is expected to result in improved air quality in this vicinity. Air quality will be the subject of assessment as part of the detailed scheme appraisal process. It should be noted that the additional capacity provided by proposals may also lead to induced traffic which may erode benefits to climate change.	
	Management of the Water Environment	0	In general, proposed road scheme is within an urban environment and does not include a significant increase in impermeable surfaces and will have no noticeable impact on the water environment.	
	Mineral Resources (Mineral Conservation)	X	The construction of proposed new highway schemes will increase the use of mineral reserves.	Use recycled materials where practicable.
	Waste Disposal	X	The construction of proposed new highway schemes will result in waste material.	Recycle waste material where practicable.
	Energy Efficient Transport Modes	X	Proposed works will not formally promote efficient transport modes and have the potential for encouraging further car use.	
	Built and Archaeological Heritage	0	Proposed works do not impact on designated sites of national and international importance.	

Eastern Seaboard Corridor – Westlink/York Street Flyover				
	Urban Environmental Quality	✓	Proposed works will improve the access arrangements to the Strategic Highway Network and reduce congestion and may be associated with local urban regeneration.	
Quality of Life	Current Needs	✓	Proposed new highway schemes will provide for the needs of the current generation.	
	Unemployment/Poverty	✓	The construction of proposed new highway schemes will provide substantial employment opportunities. The proposals would contribute to the removal of bottlenecks within settlements and would therefore permit more reliable journey times for business and freight movement.	
	Education	-	Proposed new highway schemes will have no impact on education.	
	Crime	-	Proposed new highway schemes will have no impact on crime.	
	Housing Conditions	-	Proposed new highway schemes will have no impact on housing conditions.	
	Public Health	✓	Proposed works will remove a congested signalised arrangement connecting three strategic routes and replace this with a grade separated solution. This should have a positive impact on road casualties.	
Key to Effects:				
✓	Positive			
X	Negative			
o	Neutral relationship			
-	No relationship			
?	Relationship uncertain			

The draft Environmental Report highlighted the positive and negative aspects of the scheme including the improved access arrangements to the strategic road network with reduced congestion and possible urban regeneration, but noted that the scheme would not formally promote efficient transport modes and had the potential for encouraging further car use.

The Expanded SRI Programme, which focuses on road improvements, is one aspect of the ISNI. In addition, the ISNI also proposes investment in rail and new buses to improve travel times and accessibility by all modes across Northern Ireland.

The scheme should also deliver benefits to public transport bus services that are currently delayed when passing through the series of signalised junctions to contribute towards the ISNI objectives for improved travel times by all modes of transport.

Following closure of the consultation period, the scheme was included in the Investment Delivery Plan (IDP) for Roads document.

1.6.3 *Investment Delivery Plan for Roads*

The IDP for Roads indicates that Transport NI, in developing a SRI Programme, has ensured that the contribution to the Northern Ireland Executive's three cross-cutting strategic objectives of ISNI (economic, societal and environmental) has been maximised.

The SRI Programme is managed under the categories set out in RSPPG_E030, namely the Construction Programme, the Preparation Pool and the Forward Planning Schedule.

The IDP for Roads indicates that:

"The Strategic Road Improvement Programme is based on the guidance set out in the Regional Development Strategy and the Regional Transportation Strategy and builds on the work of the Regional Strategic Transport Network - Transport Plan. The Programme aims to develop the strategic road network, targeting bottlenecks, in order to make all areas of the Province readily accessible to the Regional Gateways and the Belfast Metropolitan Area; and thus endeavouring to help the region realise its economic potential and make it as attractive as possible to future investors."

Transport NI has set in place a strategy to ensure the delivery of unprecedented levels of capital roads investment envisaged through ISNI.

Annex 1 in the IDP for Roads shows the programme of SRIs that are proposed over the 10 years of the ISNI period to 2017/18. This includes a summary of major investment in roads and confirms that the grade-separated junction for the York Street/M2/M3 intersection on the Westlink is included in the IDP as extracted into **Table 1.6.3** below.

Table 1.6.3: Extract from Annex 1 of the Investment Delivery Plan for Roads

Profile Title and Description	Capital Value (£m) Current Prices	Anticipated Procurement Route[1]	Indicate Next Gateway Stage[2]	Anticipated Date of Advertisement to market	Estimated Completion Date / Delivery Date	Location
Westlink / York Street Flyover *Grade separated junction for the York St/M2/M3 intersection on the Westlink*		D&B	Gateway 1	2013/14 to 2017/18		Belfast

Notes:	
1	Procurement route stated is most likely option from (a) PFI/PPP; (b) Design and Build; (c) Conventional Procurement
2	Gate 0: Strategic Assessment Gate 1: Business Justification Gate 2: Procurement Strategy Gate 3: Investment Decision Gate 4: Readiness for Service Gate 5: Benefits Evaluation

1.7 Alternatives Considered

1.7.1 *Introduction*

The Environmental Impact Assessment process has been conducted and the subsequent Environmental Statement prepared in accordance with the guidelines detailed in DMRB Volume 11, which sets out the methods to be used and the level of detail required when assessing the environmental aspects under consideration. Assessment of major road schemes can be summed up in the following three stages:

- Stage 1 Scheme Assessment – identification of the environmental, engineering, economic and traffic advantages, disadvantages and constraints associated with broadly defined improvement strategies. This concludes in the selection of a number of potential routes or scheme options.
- Stage 2 Scheme Assessment – identification of the factors to be taken into account in choosing alternative routes or improvement schemes and to identify the environmental, engineering, economic and traffic advantages and constraints associated with those routes or schemes. This concludes in the selection of a preferred route or scheme option.
- Stage 3 Scheme Assessment – clear identification of the advantages and disadvantages, environmental, engineering, economic and traffic terms of the preferred route or scheme option. A particular requirement at this stage is an assessment of the significant environmental effects of the project, in accordance with the requirements of Part V of The Roads (Northern Ireland) Order 1993 as substituted by the Roads (Environmental Impact Assessment) Regulations (Northern Ireland) 1999 and amended by The Roads (Environmental Impact Assessment) Regulations (Northern Ireland) 2007, implementing EC Directive 85/337/EEC as amended by Council Directive 97/11/EC and 2003/35/EC.

1.7.2 *Stage 1 Scheme Assessment*

As noted above, the DMRB approach to a Stage 1 Scheme Assessment requires the identification of a number of broad improvement strategies. A number of alternative schemes were initially considered, including:

- light rail transit;
- Bus-based Rapid Transit (BRT);
- Quality Bus Corridors (QBCs);
- Park and Ride facilities;
- widening of the Westlink;
- a tunnel linking the Westlink to the M2;
- traffic management options; and
- grade separation.

The assessment of the alternative schemes, identified that the identified scheme objectives could not be met through such measures alone without removing the bottleneck that is the existing signalised junction. Accordingly, a number of grade separation options were developed and assessed.

When developing the grade separation options, the conventional concept of route corridors presented a challenge. Typically route options within the confines of a number of identified route corridors are assessed. In the case of a rural bypass scheme, this approach would require designers to look at corridors that would divert traffic around the area to be bypassed. For this particular scheme, the identified site constraints were such that this approach had to be revised, with the identification instead of route corridors that followed the same general direction (in plan), with varying alternative vertical alignments. The existing Lagan and Dargan bridges provided a point of reference for these corridors and so, the concept of “elevated”, “depressed” and “combined” corridors was established for the links between Westlink and M2 relative to these structures. Elevated corridors were those where the links between Westlink and M2 were vertically aligned above the existing Lagan and Dargan Bridges, with depressed corridors in contrast being those where the links were vertically aligned below the existing bridges. Some options used elements of both corridors and so, these were termed “combined” corridors.

On the basis of this approach, six preliminary options were identified that comprised elevated, depressed and combined corridors and these were subject to separate engineering, environmental, traffic and economic assessments. In March 2009, URS completed its Stage 1 Scheme Assessment with the findings from the assessment reported in the Preliminary Options Report of March 2009. The report identified that the scheme would provide significant benefits to the region and recommended:

- the shortlisting of four of the identified six Preliminary Options as options to provide full or partial grade separation;
- further consideration be given to maximising land availability and access to isolated parcels of land;
- the adoption of appropriate design standards to reflect driver perception, the provision of maintenance access and the extension of the Active Traffic Management system on the Westlink to maximise capacity; and
- further consideration of the buildability of the scheme, the phasing of various elements and disruption due to construction.

The recommendations of the report were endorsed by the Transport NI Board at its meeting of 26 March 2009.

1.7.3 *Stage 2 Scheme Assessment*

Further to the recommendations arising from the Stage 1 Scheme Assessment, four of the six Preliminary Options were shortlisted for further assessment in line with the recommendations of the Preliminary Options Report. The engineering designs of the options were developed in more detail through consultations with various statutory and non-statutory bodies, with a formal public consultation period held in June 2011 to allow members of the public to view and comment upon the proposals.

The developed four options, termed Options A, B, C and D, proposed the introduction of grade separation at the existing junction using various alignments.

Option A proposed the partial grade separation of the junction. Grade separation was provided for movements between Westlink and M2 via alignments in underpasses below the existing Lagan Bridge carrying the M3 and the Dargan Bridge carrying the railway line. The Westlink to M3 movement was also grade separated via a new underpass. York Street was partially raised to accommodate the underlying links. The M3 to Westlink movement, however, remained subject to signal control at Nelson Street and York Street. All north facing sliproads at Clifton Street remained open in the proposed layout.

Option B proposed the full grade separation of movements between the Westlink, M2 and M3. Grade separation was provided via alignments in both underpasses below and overbridges above the Lagan Bridge and Dargan Bridge. York Street was raised relative to its current position to facilitate the underlying links with the overbridges spanning over the street. All north facing sliproads at Clifton Street remained open in the proposed layout.

Option C proposed the full grade separation of movements between the Westlink, M2 and M3. Grade separation was provided via underpasses below the Lagan Bridge and Dargan Bridge. York Street was partially raised to accommodate the underlying links. All north facing sliproads at Clifton Street remained open in the proposed layout.

Option D proposed the partial grade separation of movements between the Westlink, M2 and M3. The movements between the Westlink and M2 in both directions were proposed via road alignments on overbridges above the Lagan Bridge and Dargan Bridge. A grade-separated M3 to Westlink movement was provided with an overbridge above York Street. The provision of links between the Westlink and M2 allowed York Street to remain at its current level, minimising the works required at the junction. However, it was not possible to grade separate the Westlink to M3 movement in this option, with the movement subject to signal control at York Street and Nelson Street. To facilitate the proposed Westlink to York Street slip road and in turn, to facilitate the Westlink to M3 movement, it was necessary to close the northbound on-slip from Clifton Street, in the direction of the M2 and M3. The off-slip from Westlink to Clifton Street remained open.

Following their identification and refinement, the options were subject to separate engineering, environmental, traffic and economic assessments in accordance with the requirements of the DMRB. The findings from these assessments were reported in the Preferred Options Report of October 2012.

The economic assessment found that Option D would not provide economic benefits to the region if selected as the Preferred Option. The assessed economic disbenefits for Option D outweighed its assessed benefits by a ratio of approximately 2:1. It was considered that the proposed closure of the Clifton Street on-slip and the resulting reassignment of traffic onto the Inner Ring contributed to its assessed economic performance. In light of the economic findings, it was recommended that Option D should not form the Preferred Option for the scheme.

The assessed economic performance of Options A, B and C remained positive, with all the remaining options presenting an overall economic benefit if selected as the Preferred Option for the scheme.

To distinguish the options, the scheme objectives were reviewed with the findings from the engineering, environmental, traffic and economic assessments. Views on the scheme options expressed in response to the public consultation were also taken into account. The review found that the options perform at a broadly similar level, with each option having respective advantages and disadvantages.

Taking into consideration its overall performance across the scheme objectives and the views raised in response to the public consultation, it was recommended that Option C be selected as the Preferred Option for the scheme and further developed in line with the engineering standards set out in the DMRB to a level sufficient for a Stage 3 Scheme Assessment.

In developing the option further, it was recommended that the following engineering and operational issues be given further consideration:

- The potential reintroduction of two-way running on York Street to provide a southbound lane. The use of the southbound lane should reflect Transport NI transport policy for the Belfast City Centre.
- The protection of the underpass, so that it remains operational during a Q100 river flood event or a Q200 coastal flood event.
- The links and junctions identified to be over-capacity in the 2034 design year by the traffic and economic assessment.
- The proposed drainage system and outfall arrangements, in consultation with NI Water.
- The operational capacity of the interchange, through specialist micro-simulation modelling.
- The engineering solutions to the proposed underpasses and bridges, through consultation with specialist contractors.
- The proposed replacement of the retaining walls on Little George’s Street and Great George’s Street.
- The proposed diversion of existing utilities, through consultation with the various utility providers.
- The temporary traffic management measures required to build the scheme whilst mitigating disruption to road users.

The recommendations of the report were endorsed by the Transport NI Board at its meeting of 26 October 2012. The Minister for Regional Development subsequently made the public announcement of the Preferred Option for the scheme on 6 December 2012.

2. EXISTING CONDITIONS

2.1 Engineering

2.1.1 *Road Network*

2.1.1.1 *Overview*

This section provides a broad engineering assessment of the existing roads on the strategic road network (Westlink, M2 and M3) and local city centre streets not included in the strategic road network (York Street, Great George's Street, York Link, Nelson Street, Little York Street, Shipbuoy Street, Dock Street, Corporation Street, Trafalgar Street, Whitla Street, Garmoyle Street, North Queen Street and Clifton Street).

The existing road network is illustrated in **Figure 2.1.1.**

The assessment considers the following areas:

- route descriptions for the Westlink, M2, and M3;
- horizontal alignment and junction standards on the Westlink, M2 and M3;
- vertical alignment standards on the Westlink, M2 and M3;
- route descriptions for local city centre streets;
- horizontal alignment standards on local city centre streets;
- vertical alignment standards on local city centre streets; and
- route length summary.

The assessment of the Westlink will be curtailed to the extent of the study area at Clifton Street grade separated junction. The assessment of the M2 will be curtailed to the extent of the study area at Junction 1A (Duncrue Street) to the north and the Lagan Bridge to the south. Commentary is provided on the adjacent sections on the Westlink and M2 outside the study area that have undergone significant improvements carried out as part of the Transport NI DBFO Package 1 Contract. The assessment of the M3 will be curtailed to the extent of the study area at the Lagan Bridge.

The Design Speed used in assessing the layout and standard of the existing junction is based upon the speed limit applied to the section of the main carriageways (Westlink, M2 and M3) under analysis and the requirements, in particular, of TD 9/93 entitled "Highway Link Design" (DMRB 6.1.1). The Design Standard TD 22/06 entitled "Layout of Grade Separated Junctions" (DMRB 6.2.3) is also referenced in the following text.

An initial assessment of the alignment of the main carriageways on the strategic road network (Westlink, M2 and M3) has been made based upon the speed limit applied to the section of the main carriageways under analysis and the requirements, in particular, of TD 9/93.

It should be noted that the Westlink, M2 and M3 motorways are operated and maintained by Highway Management (City) Limited under the terms of its DBFO Contract with the Department for Regional Development. Under the terms of the DBFO Contract, the concessionaire would not be liable for reductions in lane availability due to temporary traffic management for the proposed interchange scheme.

2.1.1.2 *Westlink*

2.1.1.2.1 *Westlink Route Description*

The Westlink was built between 1979 and 1983, commencing at Junction 1 of the M1 motorway (Broadway) in south Belfast and terminating at the York Street junction to the north of the city centre. The route provides strategic links from the M1 to the M2, the M3 and the Shore Road in both north-bound and south-bound directions. It is part of the strategic road network, located on the Eastern Seaboard Key Transport Corridor, as identified in the RSTNTP and the majority of its length is designated as a "special road". A "special road" is a road which, under the terms of The Roads (Northern Ireland) Order 1997 has legal restrictions on its use by specific categories of road vehicles and on the placement of services by the various utility companies.

The Westlink forms part of the Euro Route E01 defined by the United Nations Economic Commission for Europe (UNECE) and forms part of the Priority 9, 13 and 26 axes on the Trans-European Transport Network (TEN-T). It is also part of the North Sea Mediterranean Corridor which stretches through Northern Ireland and the Republic of Ireland, and from the north of the UK through Netherlands, Belgium and Luxembourg to the Mediterranean Sea in the south of France. This multimodal corridor comprises Priority Projects 2, 13, 14, 26, 28 and 30 on the TEN-T also.

As part of the Transport NI DBFO Package 1 Contract, the Westlink has been subject to major improvements over some of its length. Completed in early 2009 the Westlink has been upgraded to a Dual 3 Lane Urban All-Purpose (D3UAP) section, as defined in DMRB TD 27/05 entitled "Cross Sections and Headrooms" (DMRB 6.1.2), from its start at a grade separated junction at Broadway to the existing grade separated junction at Divis Street. It should be noted that the finished lane widths do not meet the minimum requirements for a D3UAP section as set out in TD 27/05. A lane gain/lane drop arrangement reduces the route to a Dual 2 Lane Urban All-Purpose (D2UAP) section beyond the existing Divis Street junction and represents the extent of the recent improvements. At this point a narrow concrete safety barrier provides the central median with narrow hardstrips in each direction. To the north of Divis Street this D2UAP provision is maintained under the existing Peter's Hill overbridge, with direct taper merges and diverges on both carriageways to the Clifton Street grade separated junction. Again, the cross-section provided does not meet the minimum requirements for a D2UAP section set out in TD 27/05.

Immediately north of the Clifton Street junction, a lane gain to the nearside from Clifton Street provides three lanes heading north-bound out of the depressed section and onto the existing North Queen Street underbridge along with a narrow hard shoulder. These north-bound lane widths are substandard, with lane widths of 2.85m (lane 1), 2.75m (lane 2) and 3.0m (lane 3) on the North Queen Street Bridge. The carriageway runs north on an embankment beyond the North Queen Street underbridge. Upon its final approach to the York Street junction, a direct taper from the offside of the north-bound carriageway provides separation for M3-bound traffic.

In June 2009, improvements were carried out to the intersection of the Westlink with York Street at the York Street junction. The works were designed by URS under this commission and completed in September 2009 by John McQuillan (Contracts) Ltd under an existing Transport NI term contract. The works comprised widening of the existing Westlink approach to York Street on the south side, into the Northside Park and Ride overflow car park, to provide six lanes on approach to the junction. The additional lane provided is a dedicated left-turn lane for traffic intending to travel to York Street from Westlink. Three lanes are maintained for onward travel from the Westlink to the M2, with an additional two lanes on the offside separated by a traffic island and designed for the M3 and city centre onward destinations. The junction is traffic signal controlled, with a staggered pedestrian crossing provided across the Westlink following completion of the widening works.

The south-bound carriageway from the intersection of the Westlink with York Street at the York Street junction comprises three lanes, merging to two lanes south of the junction. The carriageway runs south on embankment with two lanes provided on North Queen Street underbridge. This provision is maintained as the carriageway enters into a depressed section south-bound to the Clifton Street junction, where a taper diverge provides a connection to Clifton Street, with the city centre as an onward destination. Two lanes are provided south-bound from the Clifton Street junction towards the Peter's Hill overbridge, with taper merges and diverges to the previously identified lane gain arrangement on the south-bound carriageway at Divis Street.

2.1.1.2.2 *Westlink Horizontal Alignment and Junction Standards*

The Westlink is restricted to a speed limit of 50mph. In accordance with TD 9/93, this equates to a Design Speed of 85A kph and the existing alignment has been assessed to this standard.

As stated previously, a considerable section of the Westlink has undergone significant improvements under the M1/Westlink Improvements SRI. Although outside the study area considered, it is important to include the horizontal alignment delivered through these improvements within the overall assessment of the horizontal alignment of the route.

Following completion of the improvements on the Westlink the route has an alignment comprising a series of relatively short straights connected by a number of tight horizontal radii. The minimum horizontal curvature provided to link these straights is 150m, a total of Three Steps below the Desirable Minimum standard. It should be noted that this sub-standard radius occurs outside the study area, at the Mulhouse Road/Roden Street junction. Within the study area, north of Clifton Street junction, the Westlink is subject to a substandard right-hand curve with a horizontal radius of approximately 350m. A curve radius of 350m is Two Steps below the Desirable Minimum standard. This curve reverses immediately east of North Queen Street underbridge, with the north-bound carriageway subject to a reverse left-hand curve of approximately 350m. The curve transitions to a straight immediately upon approach to the existing York Street junction. The south-bound carriageway forks from the north-bound carriageway and appears to maintain a curve with a radius of approximately 350m, transitioning to a straight alignment in advance of its intersection with the existing York Street junction.

Grade separated junctions have been provided at all conflict points, with the exception of the Mulhouse Road/Roden Street junction where an at-grade left-in, left-out arrangement is provided. Weaving lengths between all successive merges and diverges are below the Absolute Minimum standard of 240m for the 85A kph Design Speed. Furthermore, the positioning of successive merges on the south-bound carriageway at Grosvenor Road junction and Mulhouse Road/Roden Street junction is approximately 295m, less than the required 319m (3.75 x Design Speed) as set out in TD 22/06.

Table 2.1.1 summarises the horizontal alignment and the weaving lengths provided on the Westlink:

Table 2.1.1 Horizontal Alignment and Weaving Length provision on Westlink (Post Improvements)

Section Start	Section End	Minimum Horizontal Radius	Minimum Weaving Length	Distance between successive Merges	Distance between successive Diverges
Broadway Underpass	Mulhouse Road/Roden Street junction	320m	470m	N/A	N/A
Mulhouse Road/Roden Street junction	Grosvenor Road junction	150m	150m	295m	N/A
Grosvenor Road junction	Divis Street junction	1800m	N/A	N/A	690m
Divis Street junction	Clifton Street junction	350m	300m	N/A	N/A
Clifton Street junction	York Street junction	350m	N/A	N/A	N/A

2.1.1.2.3 *Westlink Vertical Alignment Standards*

As stated previously, the Design Speed for the Westlink is 85A kph. It is noted that on the section of the Westlink outside the designated study area, a minimum K value of 13 has been provided on sag curves and this corresponds to One Step below the Absolute Minimum K value set out in TD 9/93. In a similar manner, a minimum K value of 17 has been provided on crest curves and this corresponds to Two Steps below the Desirable Minimum K value of 55. An instantaneous gradient of approximately 6% is provided on the carriageway at the transition between sag and crest curves between the Divis Street junction and the Clifton Street junction. Within the study area, crest curves have been provided on the depressed section of the route that appear to coincide with a One Step reduction in the Desirable Minimum K value, with a maximum gradient of approximately 5% at the transitions between sag and crest curves. The carriageway approaches the York Street junction at a relatively flat gradient of approximately 2%.

2.1.1.3 *M2 Motorway*

2.1.1.3.1 *M2 Route Description*

The M2 was also constructed between 1979 and 1983, with the foreshore section between Junction 1A (Duncrue Street) and the Lagan Bridge completed most recently. The M2 forms part of the strategic road network.

The foreshore section of the M2 included within the study area was constructed essentially as advance works in anticipation of the onward connection to the future Lagan Bridge. To avoid differential settlement of the 8m embankment the earthworks were pre-consolidated using a number of techniques.

The M2 foreshore section is located on the Eastern Seaboard Key Transport Corridor, as identified in the RSTNTP and is part of the T7 Trunk Road. The route north of the study area has also been subject to major improvements under the Transport NI DBFO Package 1 Contract which involved major widening and other improvements. The M2 also forms part of the Euro Route E01 defined by UNECE; the North Sea Mediterranean Corridor and therefore is part of the Priority Projects 2, 9, 13, 14, 26, 28 and 30 axes on the TEN-T.

The foreshore section of the M2 immediately north of Junction 1A characterises a dual 5 lane urban motorway, with the north-bound and south-bound carriageways described further below.

The south-bound carriageway of the M2 within the study area commences with a lane drop at Junction 1A (Duncrue Street) designated for city centre and docks traffic, which reduces the number of lanes to four on the south-bound carriageway. Of the four south-bound lanes, lanes three and four are designated for onward travel to the M3 whilst lanes one and two are designated for onward travel to the city centre and the Westlink. A hard shoulder is provided on the nearside, with a hardstrip provided on the offside. A wide central median is provided including safety barrier. The existing steel safety barrier system has been replaced by the DBFO Co. with a concrete step barrier system. The south-bound carriageway continues from Junction 1A on embankment to its crossing of Dock Street at the Dock Street underbridge. Immediately south of the Dock Street underbridge, lanes 1 and 2 south-bound diverge from the carriageway down a steep gradient into a lane gain arrangement with Nelson Street at street level. The remaining two south-bound lanes continue on embankment to the Lagan Bridge, where they become the start of the M3 south-bound carriageway. A narrow hard shoulder is provided to the nearside with a narrow hardstrip provided to the offside.

The north-bound carriageway commences on the Lagan Bridge, immediately north of Junction 1A on the M3. This structure is bounded to the west by the Dargan Bridge, which runs in parallel. The carriageway comprises two lanes with a narrow hard shoulder to the nearside and a narrow hardstrip to the offside. The Dargan Bridge continues to run parallel to the carriageway, to the lane gain arrangement from the York Street junction, where an additional three lanes join the north-bound carriageway in an alignment passing under the Dargan Bridge. This five-lane carriageway continues north on embankment to its crossing of Dock Street at the Dock Street underbridge. Immediately north of the Dock Street underbridge, the railway line carried on the Dargan Bridge provides a boundary to the west. The five lanes continue north beyond the study area.

Of the five north-bound lanes, lanes four and five are designated for onward travel to the M5 motorway, lanes two and three are designated for onward travel on the M2 and lane one is designated for onward travel to the Shore Road at the next exit at Junction 1 (Fortwilliam).

2.1.1.3.2 *M2 Horizontal Alignment and Junction Standards*

The M2 is subject to the national speed limit over the majority of its length and therefore a Design Speed of 120A kph can be used for assessment of the existing horizontal alignment from the northern boundary of the study area to the merge and diverge arrangements at Junction 1A. As with the assessment of the Westlink, the M2 has undergone significant improvements as part of Transport NI DBFO Package 1 Contract. Although outside the study area considered, it is important to include the horizontal alignment delivered through these improvements within the overall assessment of the horizontal alignment of carriageway.

The improvements to the M2 comprise on-line widening of the south-bound carriageway and accordingly no significant improvements have been made to the existing horizontal alignment. The horizontal alignment over the existing “hill section” is sub-standard with curves below the

Desirable Minimum value. The existing horizontal alignment at Greencastle Interchange is also sub-standard, with the horizontal geometry on the main links approximately Three Steps below the Desirable Minimum value. South of Greencastle Interchange, the carriageway has an almost straight alignment on the foreshore section. The existing Dock Street underbridge carries the M2 over the Dock Street junction. Junctions are positioned such that the minimum weaving lengths and required spacing between successive diverges exceed the required standard.

Table 2.1.2 summarises the horizontal alignment and the weaving lengths provided on the M2:

Table 2.1.2: Horizontal Alignment and Weaving Length provision on M2 Motorway (Post Improvements)

Section Start	Section End	Minimum Horizontal Radius	Minimum Weaving Length	Distance between successive Merges	Distance between successive Diverges
Sandyknowes junction	Greencastle Interchange	550m	4400m	N/A	N/A
Greencastle Interchange	Fortwilliam junction	430m	1155m	N/A	N/A
Fortwilliam junction	Duncrue Street junction	Straight	1190m	N/A	N/A
Duncrue Street junction	York Street junction	570m	N/A	N/A	595m

2.1.1.3.3 *M2 Vertical Alignment Standards*

The identified Design Speed for the M2 is 120A kph. It is noted that on the foreshore section of the M2, the vertical alignment is relatively flat with a typical 0.5% instantaneous gradient, increasing to an instantaneous 3% gradient on approach to the Dock Street underbridge. Over the structure the alignment transitions to a crest curve with a K value of approximately 20, five-steps below the Desirable Minimum, with an instantaneous gradient of approximately 5% as it transitions into a sag curve on the embankment north of the Lagan Bridge, where it becomes the M3. The gradient on the off-slip from the M2 to Nelson Street is approximately 8%.

2.1.1.4 *M3 Motorway*

2.1.1.4.1 *M3 Route Description*

The M3 was constructed in the 1990s as part of the Lagan Bridge and Dargan Bridge works, with completion of Phase 2 of the works in 1998. The route is part of the strategic road network, located on the T1 Trunk Road network and provides a strategic link between Belfast and North Down.

The section of the M3 within the study area comprises a Dual 4 Lane Urban Motorway (D4UM), as defined in TD 27/05 at its south-east extent. Narrow hard shoulders and hardstrips are provided on the nearside and offside of both carriageways respectively. The majority of this section is elevated above street level on the Lagan Bridge and bounded to the west by the Dargan Bridge, with the track elevated to a similar level. On the north-bound carriageway, lanes one and two form a lane drop arrangement at Junction 1A. These two lanes continue north on a ramp structure where widening is provided to increase the lanes available to four. The four lanes continue in an alignment under the Dargan Bridge to the intersection at street level with Nelson Street, where an additional left-turn filter lane is provided. This junction is signal controlled. The two remaining north-bound lanes on the mainline continue on the structure to form the start of the M2 immediately north of Junction 1A. On the south-bound carriageway, the M3 commences immediately south of Junction 1A on the M2, with two lanes continuing south to a lane gain arrangement at Junction 1A. At this point, two lanes travelling south from a street level signal controlled junction with Nelson Street join the elevated carriageway in structure, with four lanes continuing south beyond the extents of the study area.

2.1.1.4.2 *M3 Horizontal Alignment and Junction Standards*

The M3 is restricted with a 50mph speed limit within the study area and therefore a Design Speed of 85A kph can be used for assessment of the existing horizontal alignment.

From the eastern boundary of the study area, the M3 comprises a right-hand curve of approximately 320m radius as the carriageway is carried on the existing Lagan Bridge. A 320m curve radius is 2-steps below Desirable Minimum for the identified Design Speed.

Within the study area, there are no successive merges and diverges on the M3 to allow an assessment of weaving lengths. However, if the assessment of the M3 is extended to the east to include the existing Middlepath Street junction, a weaving length of approximately 350m exists on the north-bound carriageway between the lane gain at Middlepath Street and the lane drop to the existing York Street junction. This is in excess of the 240m Absolute Minimum weaving length required for this 85A kph Urban Road. In a similar manner on the south-bound carriageway between the lane gain at York Street junction and the lane drop at Middlepath Street, a weaving length of approximately 290m is provided, again in excess of the 240m Absolute Minimum.

Table 2.1.3 summarises the horizontal alignment and the weaving lengths provided on the M3:

Table 2.1.3: Horizontal Alignment and Weaving Length provision on M3 Motorway

Section Start	Section End	Minimum Horizontal Radius	Minimum Weaving Length	Distance between successive Merges	Distance between successive Diverges
Middlepath junction	York Street junction	320m	290m	N/A	N/A

2.1.1.4.3 *M3 Vertical Alignment Standards*

The identified Design Speed for the M3 is 85A kph owing to the imposed speed limit of 50mph. The vertical alignment on the M3 in a south-bound direction from the M2 starts with a sag curve with a K value of approximately 13, on the embankment north of the Lagan Bridge. The sag curve connects into a 4% gradient on the Lagan Bridge which connects into a further series of crest and sag curves which meet or exceed standard K values.

2.1.1.5 *York Street Route Description*

York Street runs in a generally south to north direction to form the western side of the signalised gyratory system. At its start at the intersection with Great Patrick Street five one-way lanes are provided to its intersection with Great George's Street at a signal controlled-junction. A left-turn filter lane provides access to a Transport NI public car-park facility and onward travel to the Westlink. North-east of this junction, six one-way lanes are maintained with access provided on the nearside to an existing Transport NI public car park. Lanes one and two continue to the intersection with Westlink and York Link, with onward travel through a signal controlled junction whilst lanes three, four and five are designated for onward travel to the M2 in a fork away from lanes one and two. To the offside, lane 6 provides a link to York Link at a priority junction. A dedicated access for buses is provided from lane 6 to an existing bus-stop at the corner of York Street and York Link. North of the York Street and York Link intersection, two one-way lanes provide onward north-bound travel and a single lane separated by a traffic island provides connection to the north-bound carriageway of the M2 via the M2 on-slip.

2.1.1.6 *Great George's Street Route Description*

Great George's Street runs in a generally east to west direction through the existing York Street junction and forms the southern side of the signalised gyratory system. A single carriageway, it commences at the intersection between Nelson Street and the off-slip from the M3 and comprises seven one-way lanes. Lane seven is a dedicated access to Little York Street. Six one-way lanes are maintained through to the intersection with York Street at a signal controlled junction. At this junction, lane one is designated for onward travel to North Queen Street, lanes two, three and four are designated for onward access to the Westlink and lanes five and six are designated for onward travel onto York Street, with the M2 and M3 as ahead destinations. The route then reduces to a single carriageway west of this junction, providing one-way access to existing housing developments. The route terminates at a priority junction with North Queen Street.

2.1.1.7 *York Link Route Description*

York Link runs in a generally west to east direction through the existing York Street junction and forms the northern side of the signalised gyratory system. A single carriageway, it commences at the intersection between the Westlink and York Street and comprises two one-way lanes initially. A third lane opens to provide three lanes under both the Lagan Bridge and Dargan Bridge and the route terminates at its intersection with Nelson Street at a signal-controlled junction. Lanes one and two at this point are designated for onward travel to the M3 via an on-slip ramp structure and lane three is designated for onward travel onto Nelson Street, with city centre as an ahead destination.

2.1.1.8 *Nelson Street Route Description*

Nelson Street comprises two one-way single carriageways travelling generally north and south away from its intersection with Dock Street. The north-bound Nelson Street carriageway comprises a single carriageway leading away from a signal controlled junction at Dock Street to Duncrue Street. Two lanes are provided in the north-bound direction with a dedicated bus-lane provided in a south-bound direction.

The south-bound Nelson Street runs in a generally north to south direction and forms the eastern side of the York Street signalised gyratory system. A single carriageway, initially two lanes are provided for onward travel to the city centre and M3 and a single lane diverges across a large traffic island to join the two lanes on the off-slip from the M2 in a lane gain arrangement. This traffic island continues to provide separation through to its intersection with York Link at a signal-controlled junction. South of this junction, the route travels under the Lagan Bridge and Dargan Bridge and intersects with Great George Street and the off-slip from the M3 at a signal controlled junction. Five lanes are provided, with two lanes remaining separated by a traffic island. These two lanes provide south-bound onward travel through the junction where the carriageway opens to provide a total of five lanes at its intersection with Great Patrick Street. The remaining three lanes at the junction provide onward access onto Great George Street.

2.1.1.9 *Little York Street Route Description*

Little York Street, also called Nile Street on existing BCC street signs, is a short length of narrow single carriageway that provides access to the existing Park-and-Ride facility (Northside) and Shipbuoy Street located in the centre of the York Street junction's signalised gyratory system. It has no through connection to York Link.

2.1.1.10 *Shipbuoy Street Route Description*

Shipbuoy Street is a short length of narrow single carriageway that is accessed from Little York Street. It serves as access for lands in the centre of the York Street junction and includes a large turning area as no through connection to Nelson Street is provided.

2.1.1.11 *Dock Street Route Description*

This route comprises a short length of single carriageway with two lanes in each direction separated by a traffic island running between two structures. The route passes under the Dargan Bridge and the M2 and terminates on each side at a signal-controlled junction.

2.1.1.12 *Corporation Street Route Description*

This route runs in a generally north to south direction from its intersection with Dock Street at a signal controlled junction to its intersection with Dunbar Link at another signal controlled junction. A single carriageway, it comprises two south-bound lanes with two lanes in the opposite north-bound direction reverting to a single lane north-bound for buses only at the entrance to Clarendon Dock. It should be noted that road traffic with the exception of buses can only travel north along this route to Clarendon Dock. The route passes under the Lagan Bridge with a signal controlled junction provided at the intersection with Corporation Square. The route also provides access in the north-bound direction to a small Transport NI public car park located underneath the M3 off-slip. The Transport NI Eastern Division's Belfast North Section Office, the Newtownabbey and Carrickfergus Section Office and the Department of the Environment's Road Transport Licensing Division are located to the west of Corporation Street in a shared depot.

2.1.1.13 *Trafalgar Street Route Description*

This short length of narrow single carriageway is accessed from Corporation Street and provides access to the rear of properties on Corporation Street, including the Transport NI Corporation Street Depot.

2.1.1.14 *North Queen Street Route Description*

The section of this route considered within the study area comprises a short length of single carriageway passing under the Westlink, running in a generally north to south direction. A wide carriageway is provided with a single lane running in each direction separated by hatched road markings.

2.1.1.15 *Clifton Street Route Description*

Within the study area, Clifton Street comprises a single carriageway running in a generally east to west direction. The route intersects the Westlink at the existing Clifton Street grade separated junction, with on-slips and off-slips providing access to and from the Westlink. These junctions are controlled by traffic signals. Typically two lanes are provided in each direction, with a ghost island used to facilitate right turns into Stanhope Street.

2.1.1.16 *Whitla Street Route Description*

Whitla Street comprises a single carriageway of approximately 130m length, providing connection in a one-way west to east direction between Nelson Street/Duncrue Street and Garmoyle Street. A total of three lanes are provided on the link, with direct accesses on opposite sides of the carriageway into the Whitla Street fire station and the Dufferin Road gate to the Port of Belfast. A priority junction provides connection for northbound traffic on Nelson Street to return south along the route. The carriageway is approximately 18.5m wide, with hatched road markings used to restrict the width to the available running lanes.

2.1.1.17 *Garmoyle Street Route Description*

Garmoyle Street comprises a single carriageway running in a one-way north to south direction between Whitla Street and Dock Street. The route intersects Dock Street at an existing signalised junction. Three lanes are provided initially on the link, opening to four lanes at the entrance to the Dufferin Road gate to the Port of Belfast. Of the four lanes provided, lanes 1 and 2 are designated for onward travel to the city centre, with lanes 3 and 4 designated for right turning traffic onto Dock Street. A traffic island is used to separate the movements at the Dock Street junction, with a filter lane provided on the nearside to facilitate left-turns onto Dock Street in the direction of the Port of Belfast.

2.1.1.18 *Local Roads – Horizontal Alignment Standards*

With the exception of the Westlink, M2 and M3, all other existing carriageways in the study area comprise single carriageways with horizontal alignments in keeping with their urban location and nature. The fixed speed limit on these restricted roads is 30mph, with 60B kph the appropriate Design Speed. The majority of these carriageways comprise horizontal curve radii that are less than the Desirable Minimum of 255m which is typical of carriageways in an urban environment. Junction arrangements are typical of those commonly found in urban locations primarily at-grade priority and signal controlled junctions.

2.1.1.19 *Local Roads – Vertical Standards*

With the exception of the Westlink, M2 and M3, all other existing carriageways in the study area comprise single carriageways with vertical alignments in keeping with the relatively flat topography of the study area in the vicinity of the York Street junction.

2.1.1.20 *Route Summary*

Table 2.1.4 summarises the type and approximate length for each road and street considered in this existing route assessment:

Table 2.1.4: Approximate Road/Street Lengths and Classification

Road / Street Name	Classification	Approximate Length (m)
Westlink	A12	570
M2	M2	560
M3	M3	660
York Street	A2	830
Great George's Street	A2	430
York Link	A2	150
Nelson Street	A2	840
Little York Street	U617/U618	80
Nile Street	U617	80
Shipbuoy Street	U617	80
Dock Street	A2	300
Corporation Street	A2	690
Trafalgar Street	U617	90
North Queen Street	B126	740
Clifton Street	A6	340

2.1.2 *Structures*

2.1.2.1 *Overview*

A number of structures exist within the extents of the scheme. These structures are identified on **Figure 2.1.2**. Brief summaries of the identified structures are included below.

2.1.2.2 *Lagan Bridge*

The Lagan Bridge was constructed between 1991 and 1994 as part of the Cross-Harbour Links contract. The main bridge comprises a viaduct structure with associated ramp structures which cross over numerous city streets and the River Lagan, supporting the M3 motorway. The bridge deck for the structure generally comprises of post-tensioned precast concrete box segments and is supported in turn on reinforced concrete piers. The piers are supported on piled foundations, typically bored CFA piles to a depth of approximately 30m below existing ground level (c. -28mAOD). It is noted that Transport NI's Director of Engineering Memorandum DEM 5/99 of 1999 enacted a moratorium of the future construction of post-tensioned grouted duct concrete bridges such as this bridge and the Dargan Bridge. The moratorium remains in effect at this time.

2.1.2.3 *Dargan Bridge*

The Dargan Bridge operated by Translink was constructed as part of the same works contract as the Lagan Bridge and comprises a viaduct structure which crosses over both city streets and the River Lagan. The bridge supports a single track railway line with passing points, opening to twin tracks on the main river span. The bridge is of similar construction to the Lagan Bridge, with the deck comprising of a series of post-tensioned precast concrete box segments supported on reinforced concrete piers and piled foundations.

2.1.2.4 *Dock Street Bridge*

Dock Street Bridge is a continuous four span precast composite concrete simply supported structure carrying twin 7.3m wide carriageways (the M2). The structure has varying spans, with a south span of 10.4m, a north span of 12.6m, and two internal spans of 16.5m. The structure has zero skew.

The bridge was constructed between 1981 and 1982, with the northbound (western) carriageway subsequently widened in 1991. The bridge deck comprises precast prestressed M4 concrete beams supporting a cast in-situ concrete slab. At the internal supports, the deck is supported on in-situ concrete crosshead beams which are, in turn, supported on individual reinforced concrete columns. These columns are supported on piled foundations. At each end of each internal support, the last two columns are connected by reinforced concrete infill walls to enhance the resistance of the columns to vehicle impacts. The end supports comprise reinforced concrete abutments, which are piled. The crosshead beams and end diaphragms are post tensioned transversely. The structural connection between the original deck and the widened section is between the deck slabs only. There is no transverse post tensioning of the deck between the end diaphragms.

2.1.2.5 *North Queen Street Bridge*

North Queen Street Bridge is a single span precast composite concrete simply supported structure carrying twin 7.3m wide carriageways (the Westlink) with a 2.550m wide central reservation and 2.5 metre wide footways on each side. The bridge is skewed at an angle of 23º and has a skew span of 22.2m between bearing centres. The bridge deck comprises 24 No. precast prestressed M6 concrete beams supporting a cast in-situ concrete slab. The deck is supported on in-situ concrete abutments by 24 No. bearing pads. The abutments are carried on reinforced concrete spread footings. Record drawings for the structure are dated circa 1980 and it is thought that the bridge was constructed in the early 1980s.

It is noted that North Queen Street Bridge is situated on the site of the former McGurk's bar, which was destroyed in a terrorist bombing attack in 1971. A number of memorials to the victims have been erected over the years at the bridge structure. In 2001, a stone memorial was erected on the footway adjacent to the south east wingwall of the bridge. In December 2011, an additional memorial was erected on the south east wing wall by relatives of the victims which comprises a false façade depicting the original bar's appearance, fixed to the south east wingwall of the bridge.

2.1.2.6 *Dock Street Rail Bridge*

The Translink operated railway bridge at Dock Street was constructed as part of the Cross-Harbour bridge contract along with the Lagan and Dargan Bridges. It is a two span structure with varying skew and cross-section along its length. The structure comprises two longitudinal steel box girders with intermediate transverse cross-girders. Precast deck planks formed permanent formwork to the cast in-situ deck, which supports the rail ballast. The steel box girders are supported in the centre by two reinforced concrete piers, but insufficient record information exists to determine the nature of the foundation structure. However, it can be reasonably assumed that piled foundations have been used in a manner akin to the adjacent Dock Street road bridge.

2.1.2.7 *Whitla Street Subway*

Whitla Street subway was originally constructed in the 1980s as part of the M2 motorway. The structure comprises a reinforced concrete box section, supported on raked piled foundations. The original structure was widened in 1991 on the western side in accompaniment to the construction of the Dargan Bridge.

2.1.2.8 *Clifton Street Bridge*

Clifton Street Bridge was constructed in 1979 as part of the original Westlink construction. It comprises a single 21.5m span over the Westlink carriageway. The bridge deck comprises 25 No. precast M5 beams at 1.02m centres, supporting a cast in-situ concrete slab. The deck is supported on in-situ concrete abutments by 25 No. bearing pads, with the abutments carried on reinforced concrete spread footings.

2.1.2.9 *Westlink Retaining Walls*

The outer retaining walls on the Westlink depressed section at Clifton Street are of reinforced concrete construction and are of an inverted T type. Record drawings suggest that the walls have spread footings and bear directly onto placed fill. The retained height varies from approximately 2m to 5m over the length of the walls, with a typical stem width of 500mm.

2.1.2.10 *Little George's Street Retaining Walls*

The retaining walls at Little George's Street are located at the land boundary to the rear of existing domestic properties. The walls are of an inverted T type, with a reinforced concrete stem of approximately 450mm in width. The wall comprises a series of panels with a stepped top outline, with a brick outer skin provided on exposed faces. The retained height varies from approximately 1m to 2m over the length of the wall. The wall has spread footings and bears directly onto underlying strata. The retaining wall extends to a position near the new gantry base installed as part of the 2009 York Link improvement works, where a brick boundary wall commences and continues to York Street before turning northwards and continuing along the back of the footway on York Street to Henry Street.

2.1.2.11 *Great George's Street Retaining Walls*

The retaining walls at Great George's Street are of an inverted T type, with a reinforced concrete stem of approximately 450mm in width. The wall comprises a series of panels with a smooth top outline, with brick facings provided on exposed faces. The retained height varies from approximately 1m to 2m over the length of the wall. The wall bears directly onto underlying strata.

2.1.3 *Climate, Topography and Ground Conditions*

2.1.3.1 *Climate*

Information quoted within this Chapter is reproduced from the Met Office's climate summary for Northern Ireland, based on its records from the years 1971 to 2000[3].

[3] "Northern Ireland: Climate", http://www.metoffice.gov.uk/climate/uk/ni/, last accessed January 2012.

In general, Northern Ireland is cloudier than the rest of the United Kingdom, because of the hilly nature of the terrain and the proximity to the Atlantic Ocean. Even so, the coastal strip of County Down has an annual average total of over 1,400 hours of sunshine. The dullest parts of Northern Ireland are the more mountainous areas of the north and west, with annual average totals of less than 1,100 hours. Mean daily sunshine figures reach a maximum in May or June, and are at their lowest in December. The key factor is the variation in day length through the year, but wind and cloud are major controlling factors as well. Annual mean sunshine duration for the area would typically be between 1,250 and 1,300 hours.

Rainfall in Northern Ireland varies widely, with the highest average annual totals being recorded in the Sperrin, Antrim and Mourne Mountains, where the annual precipitation is approximately 1,600mm. Proximity to the Atlantic Ocean and the prevailing south-westerly low pressure systems are the cause of the comparatively high rainfall figures experienced in the west of the Province of up to 1,950mm of rainfall per annum, compared with just less than 800mm of rainfall per annum to the south of Lough Neagh and the east of the Province.

Seasonal rainfall variation in Northern Ireland is not large, but the wettest months are between October and January. This is partly a reflection of the relatively low frequency of thunderstorms in the Province and the high frequency of winter Atlantic depressions.

The occurrence of snow is closely linked to temperature and altitude being comparatively rare near sea level but much more frequent over the hills. The average number of days when snow falls varies between 10 near the east coast to over 35 in the mountains of Sperrin, Antrim and Mourne. The number of days on which snow lies varies from less than 5 days around the coast to over 30 days in the mountains. On rare occasions the snow has lain in excess of 30 days or indeed caused travel disruption for up to 5 days.

Throughout Northern Ireland, mean annual temperature varies little at low altitudes, averaging between 8.5°C to 9.5°C with the higher mean values occurring nearer to the coasts. As would be expected, the lowest mean annual temperatures are recorded with increasing height, therefore Slieve Donard (Northern Ireland's highest mountain) would have an average annual temperature of about 4.5°C. Due to the influences of the surrounding sea, Northern Ireland's winter temperatures are relatively mild, therefore inland areas generally experience colder temperatures than the coast, with the opposite being the case in the summer months. On average the area can expect a mean annual temperature of 8.5°C to 9.5°C.

Inland, generally January or February are the coldest months of the year with mean daily minimum temperatures being between 0.5°C in upland areas and about 2.0°C on the coast. July is the warmest month with the mean daily maximum temperatures being between 17.0°C in upland areas to almost 20.0°C.

In general, wind speed increases with height with the strongest winds being observed over the summits of hills and mountains. The coastal fringes of County Antrim and Down have about 15 gales per year, while the number of days decreases inland to five days or fewer. These are associated with the passage of deep depressions across or close to the British Isles and most frequently occurring in the winter months. In comparison with the rest of the British Isles, the frequency of gales experienced in Northern Ireland is relatively low due to the shielding effect that the rest of Ireland and some parts of Scotland has on decreasing wind speed.

2.1.3.2 *Topography*

The topography of the land traversed has an influence on the horizontal and vertical alignment of the routes considered. The natural topography within the study area is relatively flat, given its proximity to sea level, with typical levels at York Street junction being approximately 2.0m Above Ordnance Datum (AOD). The M2 is elevated to a level of approximately 10.0m AOD, approximately 8.0m above the surrounding streets from Dock Street underbridge and increases to tie-in with the Lagan Bridge and Dargan Bridge, which are elevated to approximately 12.0m AOD.

Within the study area, the M3 is supported on the Lagan Bridge. The Westlink is located at the west of the study area in a depressed section at Clifton Street, approximately 7m below the surrounding streets. The carriageway rises out of this cutting and approaches the existing York Street junction on an embankment falling from approximately 9.0m AOD at North Queen Street underbridge to meet the typical street level of 2.0m AOD at the York Street junction.

2.1.3.3 *Ground Conditions*

The solid and drift geology for the area is considered in more detail within **Section 4.6**.

2.1.4 *Hydrology and Drainage*

2.1.4.1 *Overview*

2.1.4.1.1 *Proximity to Existing Watercourses*

The low lying nature of the area and its close proximity to a tidal section of the River Lagan and Belfast Harbour has significantly influenced the development of drainage infrastructure within the study area over the years. Information relating to the existing drainage network in the area has been received from Department of Agriculture and Rural Development (DARD) Rivers Agency and NI Water.

Based on the data received and confirmed in consultations with all relevant authorities, with the exception of the River Lagan and the Mile Water River culvert, there are no other known open or culverted drains or rivers, either designated or otherwise, within the site extents. The Mile Water culvert flows from west to east and is located within the northern section of the site extents. The Farset River flows west to east approximately 200m south of the site extents. Both the Farset River and the Mile Water River culverts outfall, at locations which are downstream of the Lagan Weir structure, to Belfast Harbour.

2.1.4.1.2 *Flood Risk from Rivers and Sea*

The River Lagan, which sits outside of the immediate York Street Interchange site, is the significant waterway within the wider Belfast area. For some 5.6km upstream of the Lagan Bridge and the York Street Interchange site area, the River Lagan is subject to tidal influence. Existing ground levels within large parts of the site area are relatively flat with only minor undulations, the exception to this being the A12 Westlink to the west of the site which rises out of the floodplain. With the lowest level in the area being approximately 1.6 mAOD (Note: adjacent to the scheme extents the existing ground level is approximately 1 mAOD at the junction where Gamble Street meets Tomb Street) and the level of the flood protection structures adjacent to the River Lagan providing protection up to a level of 2.7 – 3.0 mAOD, then high tidal and flood events, when the peak river water levels rise above the level of the flood protection level would result in an inundation of the docklands area, and beyond, into the proposed site area and southwards into Belfast City Centre. Consequently, the River Lagan and its characteristics play a significant part in influencing the flood risk pertaining to the scheme study area.

The site area along with the greater Belfast City Centre area is currently being investigated and modelled in detail by Rivers Agency to gain a more comprehensive understanding of flood inundation flow patterns and extents and their likely frequency. Over the last 18 months Rivers Agency and Transport NI have been working collaboratively to fully understand the risk of flood inundation and its pattern. This has given Transport NI a comprehensive understanding of the areas of the YSI site which may potentially experience flooding as a result of their proximity to rivers or the sea. Ongoing consultations with Rivers Agency and review of the recently developed models suggest that the study area falls within the zone which is at risk of potential flooding if the existing flood defences were breached or overtopped. **Drawing YSI-URS-XX-XX-DR-DR-00038** illustrates the existing floodplain extents based on flood model data received from Rivers Agency with respect to the study area.

Apart from the River Lagan and Belfast Harbour, the majority of the York Street Interchange site area is lacking in the provision of existing storm culverts or open waterways. The guidance from Rivers Agency and NI Water in connection with the potential flood risk from sources within the site extents (other than the River Lagan and Belfast Harbour) indicates that the flood risk is only very minor and local in nature.

2.1.4.1.3 *Overview of Existing Sewerage*

Utilising the information received from the NI Water, Rivers Agency and Transport NI record drawings for recent schemes it has been ascertained that the drainage regime within the site area consists of a series of networks of road gullies and collector pipes. These networks collect runoff from the existing carriageways and adjacent areas and the storm water generated outfalls, by gravity, to the existing combined storm and foul water sewers which are in general owned and maintained by NI Water. The exceptions to this are a section of elevated M3 highway between the M3 Lagan Bridge and Nelson Street which drains to Belfast Harbour via NI Water combined sewer overflow culverts, and an area of the existing M2 motorway which drains to the Mile Water River culvert at the northern end of the site.

Buildings in the site area also discharge both storm water and foul sewage to this network of combined sewers.

NI Water has provided existing sewerage infrastructure records for the York Street area but it is noted that road drainage pipes are generally not shown on these records as they are installed and maintained by Transport NI and are generally of smaller diameter. As-built drawings for the Lagan and Dargan Bridges, constructed in the early to mid-1990s and the Westlink, constructed in the early 1980s have also been sourced. Information obtained from each of these various sources has been combined as shown on **Drawing YSI-URS-XX-XX-DR-DR-00039**. A schematic version of this drawing has been prepared to illustrate the main facilities including the main sewers and is included as **Drawing YSI-URS-XX-XX-DR-DR-00040**.

The NI Water Belfast Sewers Project was completed on 19 May 2010 and runs under Corporation Street and Garmoyle Street in a south to north direction. This scheme procured the installation of a large diameter tunnel at significant depth, i.e. greater than 20m below existing road level, to improve existing drainage infrastructure during severe rainfall events in the greater Belfast area. Information on the line and level of this tunnel has been sought and has been provided by NI Water. This information has also been included in **Drawings YSI-URS-XX-XX-DR-DR-00039 and YSI-URS-XX-XX-DR-DR-00040**.

The study area generally drains in an easterly direction from the western extents of the study area (i.e. Westlink towards the Belfast docks area) via road drainage infrastructure and NI Water combined sewerage. The existing network of NI Water pipes discharges into a large 2100mm diameter combined sewer, known as the Low Level Sewer, which gravitates in a northerly direction along Corporation Street. The completed Belfast Sewers Project storm tunnel follows roughly along the same line as this existing (Low Level) sewer but has been installed at considerably lower depth. These large scale sewers flow in a northerly direction out of the study area to Duncrue Street Wastewater Treatment Works, a facility which is owned, maintained and operated by NI Water. From a review of the existing records it appears that there is currently no pumped road drainage within the scheme study area.

2.1.4.1.4 *Flood Risk from Combined Storm and Foul Water Sewerage*

Aside from the potential for flooding within the site which exists due to the close proximity of the River Lagan and Belfast Harbour and the low lying nature of the site there is also a minor flood risk associated with the storm, foul and combined sewerage networks within, and in the surrounding areas adjacent to the site. NI Water has been consulted in connection with this possible flood risk. NI Water has provided output data from their hydraulic storm and foul sewerage modelling that demonstrates that there are areas present within York Street and Dock Street which could be subject to minor localised flooding under a 1 in 5 year return period design storm event. However NI Water has indicated that to their knowledge there are no recorded historical flooding incidents in the area of the proposed interchange location.

2.1.4.2 *Road Drainage – West-bound Westlink and Great George’s Street*

Close to the Westlink overbridge above North Queen Street, there is a high point in the existing vertical alignment of the Westlink. The drainage at this point breaks and the west-bound carriageway between North Queen Street and York Street is drained through gullies and collector pipes which flow east to the York Street/Great George’s Street junction where these outfall to a 600mm diameter combined sewer. This combined sewer flows in an easterly direction within Great George’s Street, picking up road drainage gullies before eventually connecting into the main Low Level Sewer in Corporation Street.

There are connections into the main 600mm diameter sewer in Great George’s Street at Little York Street and Nelson Street.

2.1.4.3 *Road Drainage – East-bound Westlink, York Street and Dock Street Drainage*

Close to the Westlink overbridge above North Queen Street, there is a high point in the existing vertical alignment of the Westlink. The drainage at this point breaks and the east-bound carriageway between North Queen Street and York Street is drained through a combination of gullies, collector pipes and combined kerb and drainage units which flow towards York Link before diverting north to the York Street/Henry Street junction, where these systems outfall to a 375mm diameter combined sewer. This sewer then outfalls to the 375mm combined sewer located in the centre of the York Street carriageway.

Within York Street there are two primary combined sewers which flow in a northerly direction. One of the sewers is indicated to be of 375mm diameter and is located in the centre of the York Street carriageway. This 375mm sewer gravitates into an adjacent sewer in York Street, which varies in size from 375mm diameter to 750mm diameter. This connection occurs in the vicinity of the Cityside Retail Park. The road gullies in York Street appear to discharge directly into these sewers.

At the York Street/Dock Street junction the 750mm diameter sewer connects into a larger 900mm diameter sewer, changes direction and continues in an easterly direction. It runs beneath the M2 and Dargan Bridge in the north footpath of Dock Street and connects into a larger 1050mm diameter sewer which in turn connects into the main Low Level Sewer in Corporation Street.

2.1.4.4 *Road Drainage - York Link Drainage*

York Link is drained as three separate catchments through a succession of gullies and combined sewers. The west section is drained via a 225mm diameter combined sewer which connects to the 600mm diameter sewer in York Street at the Henry Street junction.

The central section of York Link is drained by a 225mm diameter combined sewer which flows in an easterly direction and discharges into a 225mm diameter combined sewer in Nelson Street which flows to and connects into the Low Level Sewer in Corporation Street.

The east section of York Link is the on-slip ramp which rises towards the existing elevated highway. Runoff is collected by gullies and a collector pipe in the east verge which discharges to the same 225mm diameter combined sewer in Nelson Street as the central section, which ultimately discharges to the Low Level Sewer in Corporation Street.

2.1.4.5 *M2 and M3 Motorway Drainage and Nelson Street*

On the section of the M2/M3 that is within the study area i.e. from the bridge over Dock Street to the Lagan Bridge, highway runoff is again collected using gullies and discharged to collector pipes.

From a high point in the vertical road alignment at the Dock Street bridge, the west side of the M2, south of the high point, is drained down the off-slip to the Westlink and connects into the 600mm diameter combined sewer in York Street. The east side of the M2, south of the road high point, is drained to a road low point. From the low point, downstream pipe-work follows a path down the embankment and is shown to connect into a storm sewer in the east footway of Nelson Street.

The M2 off-slip onto Nelson Street and a central section of Nelson Street also drain to this storm sewer in the east footway of Nelson Street. From this manhole a 600mm diameter sewer traverses the Transport NI Depot car park and connects to the Low Level Sewer in Corporation Street.

At the north end of Nelson Street runoff is collected by gullies which discharge into the 1050mm diameter combined sewer in Dock Street. At the south end of Nelson Street, including part of the M3 off-slip, runoff is collected by gullies and connected into the 600mm diameter combined sewer in Great George’s Street. Both the 600mm and 1050mm diameter combined sewers connect at separate locations into the Low Level Sewer in Corporation Street.

The remaining existing drainage within the study area is that of the Lagan and Dargan Bridges which were constructed in the early to mid-1990s. Both the railway line and highway are elevated structures spanning between piers which are supported on pile caps and piles. The as-built drawings received for the project show that the highway sheds runoff to gullies which discharge to a single carrier drain within the hollow concrete deck. The carrier drain connects to down-pipes which have been cast in to certain concrete piers. These down-pipes then connect into carrier pipes at ground level which then outfall to adjacent NI Water sewers.

As-built drawings with respect to the ground level drainage and some details of elevated highway drainage have been sourced, however specific drainage drawings for the elevated highway and the railway line have not been obtained. An assumption has been made that a typical as-built drawing of drainage detail applies throughout the elevated highway.

From a high point in the vertical road alignment at approximately where the M3 crosses over Nelson Street, the M3 elevated highway and part of the M3 off-slip (to Great George’s Street), south of the high point slopes towards the M3 Lagan Bridge. Storm-water which is generated from this elevated section of highway is collected and discharged to ground level road drainage such as 150mm to 450mm diameter carrier pipes which discharge into the NI Water combined sewer overflow culvert(s). These culvert(s) then discharge to Belfast Harbour at the south side of the M3 Lagan Bridge.

2.1.4.6 *M2 Motorway from Dock Street to Mile Water Footbridge*

From the high point in the vertical road alignment at the Dock Street overbridge the M2, north of the high point, slopes towards a low point near where the Mile Water River culvert crosses beneath the M2. From the Mile Water footbridge the M2 falls in a southerly direction towards the same culvert. At this low point runoff which is collected from this M2 catchment area is discharged to the culvert which ultimately discharges to Pollock Dock.

2.1.4.7 *Belfast Sewers Project*

The main storm tunnel for the Belfast Sewers Project is a 4.05m internal diameter tunnelled pipeline which is located approximately 25m below existing ground level. Within the study area this tunnel is located under Corporation Street and Garmoyle Street and takes the form of a gravity sewer which falls in a northerly direction towards Duncrue Street Wastewater Treatment Works. A smaller 2.44m diameter tunnel is located in Donegall Quay which changes direction to flow in a westerly direction along Corporation Square where it connects into the main 4.05m diameter tunnel at the junction with Corporation Street. At this location there is a new 12.5m internal diameter shaft i.e. Shaft 10 as shown on **Drawing YSI-URS-XX-XX-DR-DR-00039** previously.

There are several existing combined sewer overflow culverts which are located in Frederick Street, Great Patrick Street and Gamble Street which currently outfall to the River Lagan. The flow of foul water sewage within these culverts was intercepted and diverted as part of the Belfast Sewers Project to Shaft 10 via a 1500mm diameter sewer installed just east of and parallel to Corporation Street. Downstream of this diversion the combined sewer overflow culverts still receive storm-water discharges via drainage connections from adjacent car parking areas and elevated road and rail structures.

2.1.5 *Public Utilities*

2.1.5.1.1 *Preliminary Service Enquiries*

Given the long history associated with development right up to the present day, it was anticipated that there would be an extensive network of underground utility service cables, ducts and pipes to be accommodated within the designated site area. In order to establish the extent of this network the existing known major utility providers were contacted to establish if they had apparatus within the study area and to request information on the location and type of any identified apparatus. A C2 Preliminary Enquiries letter was sent to the various utility providers in accordance with the Northern Ireland Roads and Utilities Committee (NIRAUC) agreement[4].

As a result of the C2 Preliminary Enquiries it has been established that utility infrastructure owned and maintained by a variety of utility companies e.g. gas, electricity, potable water, storm water, foul sewers, and telecommunications traverse the study area forming potential constraints upon any improvements scheme. The main concentrations of infrastructure are found within the footprints of the existing carriageways and footways in the study area.

The utility infrastructure present within the area serves not only the adjacent residential, commercial and industrial development but also similar developments beyond the study area.

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[4] "Measures Necessary Where Apparatus is affected by Major Works (Diversionary Measures) 2nd Edition", Northern Ireland Road Authority and Utilities Committee, May 2005.

Existing information has been received from the providers who own plant within the study area and these are summarised in **Table 2.1.5**:

Table 2.1.5: Responses to C2 Preliminary Service Enquiries

Service Provider	Response
Phoenix Natural Gas	Plant affected
Northern Ireland Electricity (NIE)	Distribution and High Voltage (HV) apparatus affected
Firmus Natural Gas	Unaffected
Police Service of Northern Ireland (PSNI) (Red Light Running Cameras)	Plant affected
Cable & Wireless	Plant affected
Rivers Agency	Plant affected
Ericsson Services	Plant affected
Meteor	Unaffected
NI Water	Plant affected
Eircom UK	Plant affected
British Telecom (BT) NI	Plant affected
Orange Mobiles	Unaffected
Virgin Media	Plant affected
Vodafone	Unaffected
O2	Plant affected
Transport NI: • Street Lighting • Motorway Communications • Traffic Signals	 Plant affected Plant affected Plant affected
PSNI Traffic Branch	Plant affected
National Grid Wireless	Unaffected

2.1.5.2 *Summary of Known Services*

From the information received, a breakdown of the service provider and the extent of their known infrastructure within each of the routes in the study area were identified and are detailed in **Table 2.1.6**.

The approximate locations of the existing services are detailed on the following drawings in **Appendix C**:

- **YSI-URS-XX-XX-DR-UT-00021 Stage 3 Buildability Assessment Existing Northern Ireland Water Utilities Infrastructure**;
- **YSI-URS-XX-XX-DR-UT-00022 Stage 3 Buildability Assessment Existing British Telecom Utilities Infrastructure**;
- **YSI-URS-XX-XX-DR-UT-00023 Stage 3 Buildability Assessment Existing Cable & Wireless Utilities Infrastructure**;
- **YSI-URS-XX-XX-DR-UT-00024 Stage 3 Buildability Assessment Existing Motorway Communications Utilities Infrastructure**;
- **YSI-URS-XX-XX-DR-UT-00025 Stage 3 Buildability Assessment Existing Eircom Utilities Infrastructure**;
- **YSI-URS-XX-XX-DR-UT-00026 Stage 3 Buildability Assessment Existing Mobile Telecoms Utilities Infrastructure**;
- **YSI-URS-XX-XX-DR-UT-00027 Stage 3 Buildability Assessment Existing Northern Ireland Electricity Utilities Infrastructure**;
- **YSI-URS-XX-XX-DR-UT-00028 Stage 3 Buildability Assessment Existing Street Lighting and Traffic Signals Utilities Infrastructure**;
- **YSI-URS-XX-XX-DR-UT-00029 Stage 3 Buildability Assessment Existing Phoenix Natural Gas Utilities Infrastructure**; and
- **YSI-URS-XX-XX-DR-UT-00030 Stage 3 Buildability Assessment Existing Virgin Media Utilities Infrastructure**.

Table 2.1.6: Apparatus in Scheme Study Area

Route	Utility Provider	Service Utility
York Street	NI Water	1 no. Distribution water main in west footway linking to Great George's Street. 2 no. water mains crossing Westlink to Henry Street junction; 1 no. Distribution Trunk of 300mm diameter in west side of road and 1 no. Distribution Main of 150mm diameter in east side of road. From Henry Street junction, 150mm and 300mm diameter Distribution Main and Trunk respectively combine in east side of road and continue as a 300mm diameter Distribution Trunk. 1no. Distribution Trunk of 300mm diameter from Henry Street continues in west side of road.
	NI Water	3 no. combined sewers; 1 no. 375mm diameter sewer in centre of road crossing Westlink increasing to 450mm diameter and 1 no. 375mm diameter sewer in east side of road crossing Westlink increasing to 600mm diameter, 1no. 225mm diameter sewer in east footway.
	Transport NI	Street lighting cables and associated lighting columns.
	Transport NI	Motorway communications cables.
	Transport NI	Traffic signal cables.
	Cable & Wireless UK	Apparatus/cables within east side of street.
	BT	Apparatus/cables within both sides of street in south side of Westlink. Only in west side, crossing Westlink.
	NIE	mV (lower to medium voltage), 6.6kV (high voltage) and 11kV (high voltage) underground cables adjacent to and crossing road. NIE substation to be relocated.

Route	Utility Provider	Service Utility
	Phoenix Natural Gas	Low pressure gas mains of 125mm diameter in both sides of street in south side of Westlink. Low pressure gas main of 250mm diameter and a historical main of 200mm diameter in west side of road, north of Westlink. Gas Medium Pressure Reducing Station (MPRS) located within Great George's Street car park would be affected,
York Link	NI Water	2 no. 225mm diameter combined sewers in south footway.
	Transport NI	Street lighting cables and associated lighting columns.
	Transport NI	Motorway communications cables.
	Transport NI	Traffic signal cables.
	NIE	mV, 6.6kV and 11kV underground cables adjacent to and crossing road.
Little York Street	NI Water	1 no. combined sewer of 300mm diameter and 1 no. collection sewer of 150mm diameter.
	NI Water	1 no. distribution main of 125mm diameter.
	BT	Apparatus/cables crosses street.
	NIE	mV underground cables adjacent to and crossing road.
Nelson Street	NI Water	1 no. combined sewer of 225mm diameter and 1 no. collection sewer of 150mm diameter.
	Transport NI	Street lighting cables and associated lighting columns.
	Transport NI	Motorway communications cables.
	Transport NI	Traffic signal cables.
	Cable & Wireless UK	Apparatus/cables within east side of street.
	NIE	6.6kV, 11kV, 33 kV and 110kV underground cables adjacent to and crossing road.
	BT	Apparatus/cables within both sides of street.
	Phoenix Natural Gas	Intermediate pressure (7 Bar) gas main of 250mm diameter within east side of street.
Westlink	Transport NI	Street lighting cables and associated lighting columns.
	Transport NI	Motorway communications cables.
	Transport NI	Traffic signal cables.
	Phoenix Natural Gas	Low pressure gas main of 250mm crossing Westlink.

Route	Utility Provider	Service Utility
M2 (on-slip)	Transport NI	Street lighting cables and associated lighting columns.
	Transport NI	Motorway communications cables.
	NIE	mV and 6.6kV cables crossing under road.
Corporation Street	NI Water	2 no. distribution water mains; 1 no. 225mm diameter increasing to 250mm diameter in west side of road and 1 no. 150mm diameter in east side of road.
	NI Water	1 no. approximately 2100mm (internal diameter) trunk combined sewer (known as ‘Low Level Sewer’) with other sewers connecting to trunk sewer.
	Transport NI	Street lighting cables and associated lighting columns.
	Transport NI	Traffic signal cables.
	Cable & Wireless UK	Apparatus/cables within west side of street.
	BT	Apparatus/cables within both sides of street.
	NIE	mV, 6.6kV, 11kV and 33kV underground cables adjacent to and crossing road.
	Phoenix Natural Gas	1 no. medium pressure gas main of 250mm in 450mm diameter cast iron sleeve in western side of street and 1 no. historical gas main of 200mm diameter in eastern side of street.
	Eircom UK	Apparatus/cables within east side of street and crossing street.
	Virgin Media	Apparatus/cables within west side of street and crossing street.
Great George’s Street	NI Water	1 no. combined sewer of 600mm diameter in middle of road.
	NI Water	1 no. distribution water main of 125mm diameter in south side of road.
	Transport NI	Street lighting cables and associated lighting columns.
	Transport NI	Traffic signal cables.
	BT	Apparatus/cables within both sides of street.
	Phoenix Natural Gas	1 no. medium pressure gas main of 315mm diameter and 2 no. historical mains of 150mm and 250mm diameter in south side of road.
	NIE	mV, 6.6kV, and 33kV underground cables adjacent to and crossing road.

Route	Utility Provider	Service Utility
M3 (Lagan Bridge)	Transport NI	Street lighting cables and associated lighting columns.
	Transport NI	Motorway communications cables.
Dock Street	NI Water	1 no. combined sewer of 750mm diameter increasing to 1050mm diameter in north side of road.
	NI Water	1 no. distribution trunk of 250mm diameter in south footway.
	Transport NI	Street lighting cables and associated lighting columns.
	Transport NI	Traffic signal cables.
	BT	Apparatus/cables in south side of street.
	Cable & Wireless UK	Apparatus/cables in south side of street.
	Virgin Media	Apparatus/cables in north side of street.
	Phoenix Natural Gas	Apparatus/cables crossing the road.
	NIE	mV, 6.6kV and 33kV underground cables crossing road. Redundant 110kV cable in south side of street.
Whitla Street Pedestrian Subway	NI Water	1 no. 300mm diameter distribution trunk.
	NIE	mV, 6.6kV, 33kV and 110kV underground cables within pedestrian underpass.
	BT	Apparatus located within pedestrian underpass

2.1.6 *Land Ownership*

A summary of the information available from Land and Property Services Northern Ireland (LPSNI) detailing land ownership within the proposed vesting outline is shown on **Drawing YSI-URS-XX-XX-DR-RE-LA007** in **Appendix D**.

2.2 Environmental

Existing environmental conditions are described in the Environmental Statement that forms **Part 1** of this Proposed Scheme Report.

2.3 Traffic

Existing conditions in the York Street area are subject to significant congestion during periods of peak traffic demand due to the convergence of traffic from the Westlink, the M2 and M3 and the local surface streets. This demand is controlled by a series of signalised junctions, where signal timings are monitored to improve traffic flow during peak periods. Existing traffic conditions are described in detail within **Section 5.2**.

3. DESCRIPTION OF PROPOSED SCHEME

3.1 Cost Benefit Analysis Scenarios

For the purposes of the Cost Benefit Analysis (COBA) of the scheme, as reported in **Chapter 5**, a number of preset “scenarios” require definition, namely the Do-Nothing, Do-Minimum and Do-Something scenarios.

No Do-Minimum scenario options have been developed as part of the Stage 3 Scheme Assessment process. Therefore, the Do-Minimum scenario is considered to equate to a Do-Nothing scenario.

The Proposed Scheme layout shall form the COBA Do-Something scenario, as more particularly described in **Section 3.2**.

3.2 Proposed Scheme

3.2.1 *General Scheme Description*

3.2.1.1 *Overview*

Table 3.2.1 presents a summary of drawings that illustrate the key features of the Proposed Scheme, with reference to the various Numbered Series of the Specification for Highway Works (SHW).

Table 3.2.1: Relevant Drawings Illustrating Proposed Scheme

Description	Relevant SHW Series No.	Relevant Drawing No(s).
Link Reference Plan	N/A	YSI-URS-XX-XX-DR-RE-IM000 YSI-URS-XX-XX-DR-RE-IM001
Structures Location Plan	N/A	YSI-URS-XX-XX-DR-SE-ST001
General Arrangement	N/A	YSI-URS-XX-XX-DR-RE-GE001 YSI-URS-XX-XX-DR-RE-GE002
Plan and Profiles	N/A	YSI-URS-XX-XX-DR-RE-GD001 to YSI-URS-XX-XX-DR-RE-GD011 inclusive
Cross-Sections	N/A	YSI-URS-XX-XX-DR-RE-GD100 to YSI-URS-XX-XX-DR-RE-GD165 inclusive
Design Speeds and Speed Limits	N/A	YSI-URS-XX-XX-DR-RE-GD201
Junctions	N/A	YSI-URS-XX-XX-DR-RE-GD300 to YSI-URS-XX-XX-DR-RE-GD315 inclusive
Temporary Traffic Management Arrangements	N/A	YSI-URS-XX-XX-DR-RE-TM001 to YSI-URS-XX-XX-DR-RE-TM014 inclusive

Description	Relevant SHW Series No.	Relevant Drawing No(s).	
Site Clearance	200	YSI-URS-XX-XX-DR-RE-SC001 to YSI-URS-XX-XX-DR-RE-SC017 inclusive	
Fencing	300	YSI-URS-XX-XX-DR-RE-FE001	
Road Restraint Systems	400	YSI-URS-XX-XX-DR-RE-RR101	
Drainage	500	YSI-URS-XX-XX-DR-DR-00022 YSI-URS-XX-XX-DR-DR-00024 YSI-URS-XX-XX-DR-DR-00025 YSI-URS-XX-XX-DR-DR-00027 YSI-URS-XX-XX-DR-DR-00028 YSI-URS-XX-XX-DR-DR-00039	YSI-URS-XX-XX-DR-DR-00040 YSI-URS-XX-XX-DR-DR-00041 YSI-URS-XX-XX-DR-DR-00203 YSI-URS-XX-XX-DR-DR-00206 YSI-URS-XX-XX-DR-DR-00207
Earthworks	600	YSI-URS-XX-XX-DR-RE-EW101 YSI-URS-XX-XX-DR-RE-EW102	YSI-URS-XX-XX-DR-RE-EW103 YSI-URS-XX-XX-DR-RE-EW201
Pavements, Kerbs, Footways and Paved Areas	700 1100	YSI-URS-XX-XX-DR-RE-PK001 to YSI-URS-XX-XX-DR-RE-PK019 inclusive	
Traffic Signs and Road Markings	1200	YSI-URS-XX-XX-DR-RE-RS001 YSI-URS-XX-XX-DR-RE-RS002	YSI-URS-XX-XX-DR-RE-RS003
Traffic Signals	1200	YSI-URS-XX-XX-DR-RE-TS001 YSI-URS-XX-XX-DR-RE-TS002	YSI-URS-XX-XX-DR-RE-TS003 YSI-URS-XX-XX-DR-RE-TS004
Road Lighting	1300 1400	YSI-URS-XX-XX-DR-YL-00000 to YSI-URS-XX-XX-DR-YL-00008 inclusive YSI-URS-XX-XX-DR-RE-LE001	
Motorway Communications	1500	YSI-URS-XX-XX-DR-EE-MC001 to YSI-URS-XX-XX-DR-EE-MC006 inclusive	
Bridges	1600-2500, 5000	YSI-URS-BR-01-DR-SE-00001 YSI-URS-BR-01-DR-SE-00002 YSI-URS-BR-2A-DR-SE-00001 YSI-URS-BR-2B-DR-SE-00001	YSI-URS-BR-03-DR-SE-00001 YSI-URS-BR-04-DR-SE-00001 YSI-URS-BR-05-DR-SE-00001 YSI-URS-BR-06-DR-SE-00001
Culverts	1600-2500, 2700	YSI-URS-CU-01-DR-SE-00001	

Description	Relevant SHW Series No.	Relevant Drawing No(s).	
Lagan Bridge Foundation Works	1600-2500	YSI-URS-FS-01-DR-SE-00001	
Dargan Bridge Foundation Works	1600-2500	YSI-URS-DF-XX-DR-SE-00001	
Pumping Station	500,1600-2500	YSI-URS-PS-01-DR-SE-00001	
Retaining Walls	1600-2500	YSI-URS-RW-01-DR-SE-00001 YSI-URS-RW-04-DR-SE-00001 YSI-URS-RW-07-DR-SE-00001 YSI-URS-RW-17-DR-SE-00001 YSI-URS-RW-18-DR-SE-00001 YSI-URS-RW-20-DR-SE-00001 YSI-URS-RW-21-DR-SE-00001 YSI-URS-RW-22-DR-SE-00001	YSI-URS-RW-24-DR-SE-00001 YSI-URS-RW-25-DR-SE-00001 YSI-URS-RW-26-DR-SE-00001 YSI-URS-RW-27-DR-SE-00001 YSI-URS-RW-28-DR-SE-00001 YSI-URS-RW-29-DR-SE-00001 YSI-URS-RW-34-DR-SE-00001
Underpasses	1600-2500	YSI-URS-UP-1A-DR-SE-00001 YSI-URS-UP-1A-DR-SE-00003 YSI-URS-UP-1B-DR-SE-00001 YSI-URS-UP-2A-DR-SE-00001	YSI-URS-UP-2B-DR-SE-00001 YSI-URS-UP-GE-DR-SE-00001 YSI-URS-UP-GE-DR-SE-00002
Variable Concrete Step Barrier	400 1700	YSI-URS-VC-01-DR-SE-00001	
Utilities	2700	YSI-URS-XX-XX-DR-UT-00011 YSI-URS-XX-XX-DR-UT-00043	YSI-URS-CU-01-DR-SE-00001
Landscaping and Ecology	3000	YSI-URS-XX-XX-DR-EN-LD001 to YSI-URS-XX-XX-DR-EN-LD007 inclusive	

3.2.1.2 *New Road Links*

The Proposed Scheme would provide a fully grade separated interchange to replace the existing signalised gyratory junction. Interchange links between the Westlink, the M2 and the M3 motorways would be provided in underpasses aligned underneath new bridge structures at York Street and under the existing Dargan and Lagan bridges. The existing North Queen Street and Dock Street bridges and the Whitla Street subway structure would be widened as necessary to accommodate the new road layout, with another new overbridge structure proposed at Dock Street. Retaining walls and piled embankments will be provided as required to support the new road alignments. Connections from the local street network to the new interchange links would be provided at Clifton Street, York Street, Dock Street and Duncrue Street in the form of on-slips. Connections from the strategic road network to the local street network would be provided in the form of off-slips from the interchange links at Clifton Street, York Street and Nelson Street. The existing north facing on and off slip roads at Clifton Street would remain open within the proposed road layout.

3.2.1.3 *Site Clearance*

Site clearance works would be required across the site to remove existing street furniture and where required, existing vegetation. The existing vegetation on the Westlink embankments at Little George’s Street and Great George’s Street will require removal, in addition to vegetation on the existing M2 embankment between the Lagan Bridge and Duncrue Street

The existing Transport NI section office and associated outbuildings at Corporation Street, in addition to the larger DVA office building, would also require demolition and removal. Other privately owned buildings scheduled for demolition would include the existing Focus Security Solutions premises at Corporation Street and the single storey buildings located to the north of Philip House at York Street.

3.2.1.4 *Fencing*

The Proposed Scheme would include provision of new boundary fencing and/or other suitable boundary treatment at the periphery of the scheme, necessary to secure the boundaries of the Westlink, M2 and M3. The proposed boundary treatment measures could include options such as post and rail fencing, paladin fencing or other bespoke solutions for future development opportunity sites post construction.

The Noise and Vibration assessment (as detailed within Chapter 13 of the Environmental Statement) has also identified that noise barriers would be required on the north and south side of Westlink (Link Nos. 1 and 2) either side of North Queen Street bridge.

3.2.1.5 *Road Restraint Systems*

The Proposed Scheme would include the provision of suitable road restraint systems, including vehicle restraint systems and pedestrian restraint systems in accordance with Standard TD19/06 of the DMRB. Within the various underpasses, the associated retaining walls would be provided with a smooth finish for a minimum height of 1500mm above the adjacent carriageway level without recourse to a steel safety barrier system. This provision is reflective of the provision on the existing Westlink, including recently upgraded sections. Away from the underpasses, steel safety barrier systems would be provided to provide normal containment for vehicles and to provide protection to both road users and existing bridge structures. The existing Vertical Concrete Barrier (VCB) forming the central reserve on the Westlink would be replaced with a Variable Concrete Step Barrier (VCSB) and a custom in-situ retaining wall (RW-004).

Parapets would be provided at all bridge structures and at a number of retaining walls to provide normal levels of containment.

At controlled crossing points, pedestrian restraint systems in the form of guardrails would be provided in accordance with Local Transport Note (LTN) 2/09.

3.2.1.6 *Drainage*

A pumped drainage system would service the proposed underpass structures, with a combination of drainage systems proposed to collect and convey stormwater run-off within the scheme. At this time, it is proposed that the system will pump collected stormwater to an existing combined sewer overflow at Gamble Street and outfall to Belfast Harbour.

The proposed drainage system is decribed in more detail in **Section 4.7**.

3.2.1.7 *Earthworks*

The vertical alignment of the proposed road links within the scheme would require the construction of various underpasses and embankment structures, as more particularly described in **Section 4.6**.

3.2.1.8 *Pavements*

A detailed assessment of the construction and resultant residual life of the existing road pavements in the vicinity of the site has not been carried out on the basis that the majority would require removal to make way for the new interchange links and slip roads that are in new horizontal or vertical positions. This is especially true for the existing pavements on Westlink, York Street, York Link, Great George's Street and Nelson Street that comprise the existing junction.

With regard to the condition and residual life of the Westlink, M2 and M3 carriageways beyond the extent of the scheme at the tie-in positions, it should be noted that these are under the management of Highway Management (City) Limited as DBFO concessionaire under the terms of its DBFO Contract. Under the provisions of this contract, the concessionaire is required to regularly inspect and report upon the condition of the existing carriageways and programme remedial works as required to achieve a suitable residual design life upon hand back to Transport NI at the end of the 30 year contract period (2036).

The proposed pavements for the new road links would be provided in accordance with Volume 7 of the DMRB and include a combination of flexible and rigid pavements. Surfacing options would be exclusive to those permitted by the DMRB including Hot Rolled Asphalt (HRA) and Thin Surface Course Systems (TSCS). The use of TSCS is proposed for the surfacing of the interchange links and slip roads for its noise reduction qualities, whilst HRA would be typically proposed for elements of the surface street network. High Friction Surfacing (HFS) would be provided in accordance with the requirements of the DMRB.

3.2.1.9 *Kerbs, Footways and Paved Areas*

As part of the proposed drainage scheme, upstand half battered kerbs would be provided generally throughout the scheme, with combined kerb drainage (CKD) units used at structures including the proposed bridges and underpasses, and at other areas in the scheme where advantageous to do so. Dropped kerbs would be provided at identified crossing points for pedestrians and other non-motorised users.

Footways would be provided on the new road links at York Street (Link No. 11) and the M3 to York Street off-slip (Link No. 7). It should be noted that footway provision on both sides of York Street would be a minimum of 3m in width over the new bridge structures.

With the removal of Great George's Street and York Link for the new interchange links and slip roads, the existing footways on these routes would be removed. In addition, the existing footpath between Corporation Street and Nelson Street, that runs under the Lagan Bridge, would be rendered redundant by the proposed road links and therefore would be removed. It would not be possible to replicate this lost provision within the proposed road layout, with the nearest alternative footways for east to west movements in the area the existing Dock Street, Little Patrick Street and Great Patrick Street footways.

Surfacing options for pavement areas would be in accordance with Volume 7 of the DMRB.

3.2.1.10 *Traffic Signs and Road Markings*

Traffic signs and road markings would comply with the specification and requirements outlined in the DMRB and prescribed by the Traffic Signs Regulations (Northern Ireland) 1997 (as amended). The location and type of traffic signs and markings would be developed at the detailed design stage. Traffic signs at the junctions and along the proposed road links would be located within the permanent fence line.

3.2.1.11 *Traffic Signals*

The proposed scheme would include the provision of new traffic signal controlled junctions at the following locations:

- York Street/Great George's Street;
- York Street/Westlink; and
- York Street/Cityside Retail Park/Galway House.

In addition, the following existing signal controlled junctions would require revision to reflect changes introduced by the Proposed Scheme:

- York Street/Great Patrick Street;
- York Street/Dock Street;
- Nelson Street/Great Patrick Street;
- Dock Street/Nelson Street; and
- Duncrue Street/M2 off-slip.

The existing controlled pedestrian crossing at Whitla Street subway on Nelson Street would also require revision as appropriate to reflect changes introduced by the scheme.

3.2.1.12 *Road Lighting*

As the scheme is located within an urban area, the proposed scheme would include the provision of a new road lighting system, with revisions to existing road lighting systems as required. All road links within the proposed scheme would be illuminated by road lighting. It should be noted that two separate lighting systems would be developed for the systems that would be maintained by Transport NI and the DBFO Co concessionare company for the DBFO Package 1 contract.

3.2.1.13 *Motorway Communications*

The Proposed Scheme would include the provision of motorway communications equipment for future operation of the scheme by Transport NI. The scope of proposed provision is more particularly described in **Section 4.9**.

3.2.1.14 *Structures*

The vertical alignment of the proposed road links within the scheme would require the construction of various structures, including bridges, underpasses, retaining walls, flood walls embankments, gantries and culverts, as more particularly described in **Section 4.5**.

3.2.1.15 *Utilities*

Significant diversions of utilities infrastructure would be required for the construction of the Proposed Scheme. Due to the nature of the scheme, these elements include retaining walls, underpasses, bridge piers, bridge abutments, embankments and other minor road alterations, such as kerb realignment and carriageway level alterations. Ground conditions in the study area generally at formation level have low bearing capacity and therefore it would be necessary for foundation strengthening works to be undertaken to provide support to foundations for the proposed retaining walls, bridge piers, bridge abutments and embankments. The intrusive nature of the works required to construct these individual elements would lead to severance of the existing utilities networks located within the study area therefore significant diversionary works and mitigation measures would be required to be undertaken to ensure supply networks and systems are not detrimentally affected. The scope of the proposed diversion works is more particularly described in **Section 4.8**.

3.2.1.16 *Landscaping and Ecology*

The Proposed Scheme design would include the provision of landscaping and ecological protection measures in accordance with the Schedule of Environmental Commitments included within the Environmental Statement.

3.2.2 *Detailed Scheme Description*

3.2.2.1 *Link Referencing System*

For the purposes of identification, the road links within the footprint of the future Proposed Scheme and its environs have been given a unique reference number as more particularly described on **Drawings YSI-URS-XX-XX-DR-RE-IM000** and **YSI-URS-XX-XX-DR-RE-IM001**. These reference numbers shall be used in the description of the key elements of the scheme. Proposed structures associated with the scheme have also been given a unique reference number as more particularly described on **Drawing YSI-URS-XX-XX-DR-SE-ST001**.

3.2.2.2 *Strategic Road Links*

3.2.2.2.1 *M2 to M3 (Link No. 8)*

The existing M2 motorway within the extents identified for the purposes of reference would remain largely unchanged, with the most significant change being the removal of the existing off-slip from the motorway to Nelson Street. It is not proposed to reduce the width of the existing Dock Street bridge by a corresponding amount and therefore, the remaining paved width on the existing bridge would remain as an isolated section of wide hard shoulder. It should be noted that a new permanent 50mph speed limit would apply to the section of motorway as part of the Proposed Scheme.

3.2.2.2.2 *M3 to M2 (Link No. 9)*

The existing M2 motorway within the extents identified for the purposes of reference would remain unchanged from its current layout.

3.2.2.3 *Interchange Links*

3.2.2.3.1 *Westlink to M2 (Link No. 1)*

The link commences at the existing Clifton Street north-bound on-slip merge nose, with online widening of the Westlink and North Queen Street Bridge (BR-001) on the northern side to facilitate a new four-lane weaving section arrangement, where lane widths shall be limited to

3.25m, slightly wider than the existing provision, but less than standard lane widths. This requires demolition and replacement of existing retaining walls adjacent to the Westlink and North Queen Street. West of BR-001, the link lowers into a depressed section underneath the new York Street to York Road link (Link No. 11), carried on a new bridge (BR-002B).

To facilitate the online widening between BR-001 and BR-002B, the associated Westlink embankment requires modification. To avoid works to replace the existing Little George's Street retaining wall, a strengthened earthwork (EB-001) is proposed on the northern side of the link between BR-001 and BR-002B for a distance of approximately 100m, with a steepened side slope. Construction of this strengthened earthwork would require a suitable working platform for piling operations and this would, in turn, require temporary removal of a significant portion of the existing embankment during the construction process.

To provide sufficient headroom to BR-002B, Link No. 1 is lowered by approximately 3m below existing ground level. An underpass structure is proposed, with a single lane diverge to the M3 and two lanes continuing towards the M2. As the link approaches the Dargan Bridge, it rises to match levels on the existing M2 on-slip, with approximately 400mm cover provided to the underlying pile caps. The link then matches the existing alignment on the on-slip to provide a 2-lane lane gain onto the north-bound M2 foreshore.

3.2.2.3.2 *M2 to Westlink (Link No. 2)*

The link commences with a two-lane lane drop from the M2 motorway on approach to the existing Dock Street Bridge, with the link passing on a straight overbridge structure over Dock Street (BR-004).

As the link passes over Dock Street, it continues to drop below until it passes below existing ground level in an underpass (UP-001A) underneath Dock Street to M3 (Link No. 6), Westlink to M3 (Link No. 3) which are carried on a roof slab (BR-003). Two lanes are maintained in the direction of the Westlink. To facilitate this alignment, a number of existing properties would require demolition, including the existing Transport NI depot at Corporation Street.

As the link passes under the Lagan Bridge, the cross-section of the link reduces in width to fit through a pinch point created by the existing substructure, particularly the pile caps and piers of the Lagan Bridge. In order to fit through this pinch point, verge widths are reduced and the nearside hard shoulder is discontinued. The reduction in cross-section has direct impacts on the Stopping Sight Distances achieved on the link.

A pinch point is encountered when passing under the Lagan Bridge, where clearances to existing bridge substructure are between 400-500mm. At its lowest point, the finished road level on the link is approximately 9m below existing ground level.

The link rises upon departure from the pinch point, passing under the York Street to York Road link (Link No. 11) carried on BR-002A and rises to tie in with existing levels at North Queen Street Bridge, where widening of the existing bridge (BR-001) is required on the southern side. This requires works to demolish and replace existing retaining walls on North Queen Street. In a similar manner to the Westlink to M2 link (Link No. 1), it is proposed to construct a strengthened earthwork (EB-002) to minimise the extent of works on Great George. The construction of this strengthened earthwork would again require the excavation of part of the existing Westlink embankment to form a suitable platform for piling operations. West of the widened North Queen Street Bridge (BR-001), a lane drop is maintained to Clifton Street, with two lanes continuing south-bound on Westlink.

3.2.2.3.3 *Westlink to M3 (Link No. 3)*

Link No. 3 commences as a single lane diverge from the Westlink to M2 alignment (Link No. 1) that passes under BR-002B in an underpass structure (UP-002B). At its lowest point, the finished road level in the underpass is approximately 3m below existing ground level. To the west of BR-002B, the link rises to provide 400mm cover to existing underlying pile caps of the Dargan and Lagan Bridges. The link is carried over the M2 to Westlink link (Link No. 2) UP-001A on the proposed bridge BR-003. A lane gain from Dock Street (Link No. 6) converges with the link, with the two resulting lanes continuing onto the existing on-ramp structure towards the M3 motorway. Away from BR-003, a new flood wall (RW-025) is proposed to prevent coastal inundation on its southern perimeter.

3.2.2.3.4 *M3 to Westlink (Link No. 4)*

The link commences on the existing Lagan Bridge off-ramp structure, with white lining used to reduce the overall number of lanes on the existing motorway off-slip to two. On approach to the Dargan Bridge, a new link is created in an offline position that passes between existing bridge piers at approximately ground level. West of Dargan Bridge, the link drops below existing ground level in an underpass (UP-001B) with a low point located to the east of BR-002A. On approach to BR-002A the link rises and is approximately 3.6m below existing ground level as it passes under the bridge. The link continues to rise to join the M2 to Westlink (Link No. 2) alignment west of bridge BR-002A with a single lane gain arrangement.

3.2.2.4 *Slip Roads*

3.2.2.4.1 *Westlink to York Street (Link No. 5)*

The link comprises a lane drop from the Westlink to M2 alignment (Link No. 1), with a single lane drop opening to two lanes on approach to a new signalised junction with the York Street to York Road alignment (Link No. 11). The alignment is initially in cutting relative to existing ground level, before rising to approximately 4.2m above existing ground level at its junction with York Street. The existing Little George's Street retaining wall is maintained within the layout, with the extent of the existing boundary wall from house nos. 39 to 47 (odd nos.) inclusive also retained within the layout. However, on approach to York Street, the section of existing boundary wall to the north of the link requires demolition and replacement with a new retaining wall (RW-007) to support the raised alignment.

3.2.2.4.2 *Dock Street to M3 (Link No. 6)*

The new link provides a direct connection from Dock Street to the M3 motorway, with some horizontal and vertical realignment of the existing link required to facilitate a two-way section away from its junction with Dock Street to facilitate access to a future development opportunity site (Link No. 39). From this junction arrangement, a single lane continues to form a lane gain with the Westlink to M3 link (Link No. 3), passing over underpass UP-001A via new bridge BR-003. A new retaining wall (RW-025) is proposed to support the raised alignment on its approach to BR-003, with a new flood wall (RW-026) proposed to prevent coastal inundation of the link along its northern perimeter.

3.2.2.4.3 *M3 to York Street (Link No. 7)*

The link commences with a single lane diverge from the M3 to Westlink link (Link No. 4) and is at existing ground level as it passes under the Dargan Bridge at a new left-in/left-out junction with Nelson Street (South) (Link No. 12). The link subsequently rises to meet the raised alignment of York Street (Link No. 11) and is approximately 2.3m above existing ground level at the junction between the links.

3.2.2.4.4 *Duncrue Street to Westlink (Link No. 31)*

The new link provides a parallel merge arrangement onto the M2 to Westlink link (Link No. 2), commencing from a revised signalised junction arrangement at the M2/Duncrue Street offslip (Link Nos. 32 and 29). In order to provide the link within the space available, it is proposed to cut into the existing M2 embankment, with the M2 supported in lieu by a new retaining wall RW024. The finished road level on the link is approximately 2m below the existing M2 adjacent to this retaining wall. The link rises as it continues south, with widening of Whitla Street subway (BR-006) required on its eastern extent (including associated replacement of wingwalls) to accommodate the new link. Widening of the subway has implications for a number of service corridors that are located within the existing underpass structure, significantly a number of 110kV cables that would require substitute connections, diversion and protection for the duration of the works. It is expected that given the nature of these electrical supply cables and cooling systems, the lead-in times for these operations could be significant for the overall construction programme.

3.2.2.4.5 *M2 to Duncrue Street (Link No. 32)*

The existing horizontal and vertical alignment of the link is unaffected by the proposals, however, the carriageway width of the ahead movement to Duncrue Street (Link No. 64) is reduced on the offside with a relocated kerbline. For the left-turn to Duncrue Street from the slip road, the white lining shall be revised to provide only a single lane for the movement.

3.2.2.4.6 *Clifton Street On-Slip (Link No. 40)*

The existing slip road, within the extents identified, would remain open and unchanged as a result of the works. Changes downstream of the merge nose would modify its merge arrangement with the Westlink, with a lane gain arrangement maintained with substandard (3.25m) lane widths.

3.2.2.4.7 *Clifton Street Off-Slip (Link No. 41)*

The existing slip road, within the extents identified, would remain open and unchanged as a result of the works. Changes upstream of the diverge nose would modify its diverge arrangement from the Westlink, with a lane drop arrangement maintained with standard (3.65m) lane widths.

3.2.2.5 *Non-Strategic Road Links*

3.2.2.5.1 *Dock Street (Link No. 10)*

The majority of changes to Dock Street are associated with modifications to its junction with Nelson Street. At this junction, the positioning of piers for BR-004 require several traffic islands to be increased in size, therefore requiring the realignment of approaches to the junction from Nelson Street North (Link No. 29). In addition, the introduction of a two-way section on Dock Street to M3 (Link No. 6) would also require changes to traffic islands at the junction to accommodate outbound movements.

It should also be noted that the existing Dock Street Bridge (BR-005) requires widening on its western side to accompany the new road layout, which would create further restriction on headroom to the underlying Dock Street. Based on the current layout, headroom would reduce to a minimum of 5.3m over the carriageways, and a minimum of 5.03m over the central island and footways. It should be noted that 5.03m is the minimum maintained headroom requirement of the the DMRB and so the bridge would not require signing as a “low bridge”.

3.2.2.5.2 *York Street to York Road (Link No. 11)*

The works comprise a vertical and horizontal realignment of York Street to provide headroom for new bridges BR-002A and BR-002B over the proposed underpasses. The vertical realignment of the link starts on approach to the proposed junction with the M3 to York Street link (Link No. 7), with the link raised by approximately 1.8m at the junction, supported by new retaining walls RW-006, RW-028, RW-031 and RW-033. The link continues to rise to a maximum of approximately 5m above existing ground level and is supported by retaining walls RW-032 and RW-034 between BR002A and BR-002B, before lowering back to tie in with existing levels at a position adjacent to the current entrance to Cityside Retail Park (Link No. 28). A new retaining wall RW-007 would be required adjacent to the existing Cityside complex to support the raised alignment, with a new signalised access provided for Yorkgate Business Park (Link No. 27). This would require works at street level to widen York Street on the eastern side (through narrowing of the adjacent footway) to provide the necessary central traffic island widths.

It should be noted that the proposed changes to York Street would reintroduce two-way running of a form to provide a new bus/cycle lane in the southbound direction. The southbound bus/cycle lane would be provided from the new signalised junction at the connection with the York Street to M2 on-slip (Link No. 15) and would terminate at the the Inner Ring. Provision of the southbound bus/cycle lane would require an associated reduction in the northbound lane provision, with three lanes proposed, opening to four at the junction with the M3 off-slip to York Street (Link No. 7). In addition, a northbound cycle lane of 1.5m in width would be included, with footways widened to 3m where possible within the existing building constraints and reflected in the proposed cross-section on the new bridges (BR-002A and BR-002B).

3.2.2.5.3 *Nelson Street (South) (Link No. 12)*

Changes to the southern section of Nelson Street are associated with the proposed reintroduction of two-way running on the route to maintain access to existing properties. Accordingly, at its junction with Great Patrick Street (Link No. 13), the existing signalised junction arrangement is changed to provide turning facilities from Dunbar Link (Link No. 63) into Nelson Street. The cross-section of Nelson Street would be changed to accompany the proposed two-way arrangement, with a single lane provided in the northbound direction provision of a new left-in, left-out arrangement with the new slip road from M3 to York Street (Link No. 7). Southbound, a single lane would also be provided, opening to two lanes at the junction with Dunbar Link. The proposed junction arrangement would maintain access to properties along Nelson Street, with the reduction in carriageway width proposed to discourage through traffic to the Shore Road or M2 using the route in lieu of the proposed route for strategic traffic via Great Patrick Street and York Street.

3.2.2.5.4 *Great Patrick Street to Dunbar Link (Link No. 13)*

The existing link would be maintained in its current form, with a minor revision to route destination road markings on approach to the junction with York Street. The revision would complement changes to York Street to York Road (Link No. 11), with a reduction in the number of lanes turning right onto York Street to three, with lanes one and two to be signed for onward travel to Frederick Street (Link No. 14). At its junction with York Street, the left turn splitter island for left-turning traffic into the City Cente would be subject to minor modification to complement onward movement from the proposed bus lane on York Street to York Road (Link No. 11).

3.2.2.5.5 *Frederick Street (Link No. 14)*

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.6 *York Street (South) to M2 (Link No. 15)*

The link commences at a signalised junction with Link No. 11 with two lanes provided on a downhill gradient under the Dargan Bridge, with a minimum of 400mm cover to existing bases. The link rises to merge into the M2 foreshore at Dock Street Bridge (BR-005), which would be widened to accommodate the link on its western side. The link would be supported by retaining walls RW-020 and RW-021 on its approach to the structure. On approach to the widened bridge, the two lanes on the link reduce to provide a single lane gain onto the M2 foreshore (Link No. 1).

3.2.2.5.7 *York Street (North) to M2 (Link No. 16)*

The existing provision for southbound traffic on York Street is maintained in the new layout, with modificiations as required to complement the revised horizontal and vertical layout of York Street to York Road (Link No. 11) and York Street to M2 (Link No. 15). A new signalised junction is provided as part of the proposals such that the movement from York Street to the M2 is signal controlled. This is considered necessary given the reduced sight distance available for traffic at the junction, and the proposed incorporation of a crossing for non-motorised users.

3.2.2.5.8 *Great George's Street (Link No. 17)*

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.9 *Little Patrick Street (East) to Nelson Street (Link No. 18)*

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.10 *Little Patrick Street (West) to Nelson Street (Link No. 19)*

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.11 *Little Patrick Street to York Street (Link No. 20)*

Works to the existing link comprise minor changes at street level to reflect the revised horizontal and vertical alignment of York Street to York Road (Link No. 11).

3.2.2.5.12 *Little York Street (South) (Link No. 21)*

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.13 *Little York Street (South) (Link No. 22)*

The link would require horizontal and vertical alignment at its northern end to complement the alignment of the M3 to York Street link (Link No. 7) and a new access arrangement for lands remaining adjacent to Philip House.

3.2.2.5.14 *Thomas Street (Link No. 26)*

Works to the existing link comprise minor changes at street level to reflect the revised horizontal and vertical alignment of Great George's Street (Link No. 17).

3.2.2.5.15 *Nelson Street (North) (Link No. 29)*

In order to facilitate the new Duncrue Street to Westlink (Link No. 31), the section of Nelson Street north of Dock Street junction requires realignment to accommodate a new retaining wall (RW-022). At its junction with Dock Street, the link is realigned east of its existing position, requiring land take from the adjacent weighbridge area. North of the junction, the link is realigned to follow its existing alignment, with existing private accesses (Link Nos. 36 and 37) maintained. The revised cross-section on the link provides for a single northbound lane for all vehicles and a single southbound lane for use by buses only. On the western side of the link, a new footway of 2m minimum width is provided adjacent to the new retaining wall (RW-022).

On approach to its termination with Duncrue Street (Link No. 64), the link is realigned west of its current position into lands adjacent to Whitla Street fire station, to incorporate a new junction arrangement and a pedestrian crossing at the entrance to Whitla Street subway.

3.2.2.5.16 *Garmoyle Street (Link No. 30)*

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.17 *Whitla Street (Link No. 33)*

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.18 *Dufferin Road (Link No. 34)*

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.19 *Brougham Street (Link No. 42)*

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.20 *Corporation Street (Link No. 43)*

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.21 *North Queen Street (Link No. 45)*

The existing layout of the link would remain unchanged by the Proposed Scheme, however, it should be noted that the widened bridge structure over North Queen Street (BR-001) would reduce headroom over the adjacent footway and require replacement of wingwalls on both sides of the bridge. Headroom over the carriageway would remain above a minimum of 5.03m, however, over the eastern footway, headroom would reduce to approximately 4.8m. To protect the structure, it is proposed to introduce a deterrent to drivers from mounting the eastern footway, such as the provision of pedestrian guardrail or bollards.

On the south-east wingwall of the bridge, it is noted that there are several memorials associated with the McGurk's Bar bombing. All such memorials would require removal as part of the works, this will be undertaken in consultation with community representatives and Transport NI.

3.2.2.5.22 *Henry Street (Link No. 46)*

The existing layout of the link would remain unchanged by the Proposed Scheme. At the eastern end of Henry Street, a new retaining wall (RW-007) is proposed to support the vertical realignment of the York Street to York Road link (Link No. 11). To facilitate this retaining wall, the existing boundary wall would be demolished. Pedestrian access from Henry Street to York Street would be maintained via a section of the existing footway adjacent to Cityside Retail Park, which would be retained and run parallel to RW-007.

3.2.2.5.23 *Edward Street (Link No. 47)*

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.24 ***McGurks Way (Link No. 48)***

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.25 ***Portland Place (Link No. 49)***

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.26 ***North Hill Street (Link No. 50)***

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.27 ***Southwell Street (Link No. 51)***

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.28 ***Earl Close (Link No. 52)***

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.29 ***Molyneaux Street (Link No. 53)***

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.30 ***Academy Street (Link No. 54)***

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.31 ***Great Patrick Street (North) (Link No. 59)***

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.32 ***Little George's Street (Link No. 62)***

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.33 ***Dunbar Link (Link No. 63)***

The existing layout of the link would remain unchanged by the Proposed Scheme.

3.2.2.5.34 ***Duncrue Street (Link No. 64)***

To facilitate the proposed Duncrue Street to Westlink link (Link No. 31), it is proposed to remove the large traffic island between opposing flows on Duncrue Street in conjunction with the reduction in the number of lanes on the southbound movement to two. The additional space created through this changes facilitate the new slip road, with two lanes provided in the northbound direction to the junction with the M2 off-slip (Link No. 32).

The proposed changes in the horizontal and vertical alignment of the link requires further changes to the existing controlled pedestrian crossing at Whitla Street subway, with a replacement controlled crossing proposed with an additional pedestrian refuge island. At this time, an onward connection to the National Cycle Network NCN Route 93, on the eastern side of the link, has not been specifically incorporated within the scheme, however, the opportunity exists to incorporate such a crossing using the traffic island at Whitla Street.

At its junction with the M2 off-slip (Link No. 32), a revised junction arrangement is proposed to reflect changes to lane provision on the link and indeed, the off-slip from the M2. Importantly, a right-turn facility is proposed for southbound movements on Duncrue Street at the junction to facilitate onward travel to the new slip road to the Westlink (Link No. 31). The proposed junction arrangement would maintain existing movements for non-motorised users.

3.2.2.6 *Other Existing Roads to be Abandoned and Removed*

The following existing roads and streets would be abandoned and removed as part of the proposed works:

- York Link;
- Nile Street/Little York Street;
- Shipbuoy Street; and
- Trafalgar Street.

3.2.2.7 *Private Accesses*

3.2.2.7.1 *Nelson Street Development Access (Link No. 23)*

The existing access would be maintained within the Proposed Scheme.

3.2.2.7.2 *Philip House Car Park (Link No. 24)*

The existing access to the car peak to the rear of Philip House would be revised to complement the revised alignment of the Little York Street (North) link (Link No. 20).

3.2.2.7.3 *Great George's Street Car Park Access (Link No. 25)*

The existing access to the car park would be relocated to Great George's Street (Link No. 17) at a position close to the junction between Great George's Street and York Street.

3.2.2.7.4 *Galway House Access (Link No. 27)*

The existing private access onto York Street for Galway House would be removed as part of the scheme to accommodate the new York Street to M2 link (Link No. 15). To maintain access to the current development and indeed, any future development within the overall business park, a new access is proposed at the north-west corner of the existing car park to Galway House. For safety reasons, it is proposed to signalise the access in conjunction with a revised access arrangement for CItyside Retail Park (Link No. 28) in accordance with Transport NI policy.

3.2.2.7.5 *Cityside Retail Park Access (Link No. 28)*

The existing left-in, left-out access arrangement for Cityside Retail Park cannot be retained within the scheme, owing to its proximity to the relocated access for Galway House. Accordingly, the scheme would provide a new signalised access for Cityside Retail Park which would, in turn, require accommodation works to relocate signage and modify internal car parking arrangements within the site.

3.2.2.7.6 *Weighbridge Access from Dock Street (Link No. 35)*

The existing access to the weighbridge facility from Dock Street would be retained within the scheme, with modification as required in line with other proposed changes to the signalised junction between Dock Street and Nelson Street. It should be noted that the revised junction arrangement would maintain the existing uncontrolled pedestrian crossing across the entrance.

3.2.2.7.7 *Weighbridge Access from Nelson Street (Link No. 36)*

The existing access to the weighbridge facility to Nelson Street would be retained within the scheme, with modification as required in line with other proposed changes to Nelson Street (North) (Link No. 29).

3.2.2.7.8 *Trouw Nutrition Nelson Street Access (Link No. 37)*

The existing access would be retained within the scheme, with modification as required in line with other proposed changes to Nelson Street (North) (Link No. 29).

3.2.2.7.9 *Pumping Station Access Road (Link No. 38)*

All proposed underpasses within the scheme would drain to a single wet well at a location near to the low point of the M2 to Westlink (Link No. 2) alignment. A pumping station facility would be constructed to discharge stormwater from the wet well and requires a suitable access road. Given the location of the pumping station, it is proposed to provide a new access road within the site of the Corporation Street car park, which would be closed as part of the proposals to ensure access to the facility is available on a 24/7 basis, for both planned and emergency maintenance. The access road will therefore utilise the existing access to Corporation Street underneath the Lagan Bridge, with a new road alignment aligned around its existing piers. A single passing point is proposed on the access road, with the carriageway of the road sized to facilitate the swept path of a 75 tonne mobile crane, the largest crane anticipated to require access to the site for maintenance purposes. Sufficient headroom exists to the existing Lagan and Dargan Bridges to accommodate such a vehicle in its transport position. A large turning head facility is provided to provide for associated turning movements and to provide a suitable area for craning operations as necessary.

3.2.2.7.10 *Nelson Street Access Road (Link No. 39)*

Lands located between the M2 to Westlink link (Link No. 2) and the Dock Street to M3 link (Link No. 6) have been identified as having potential opportunities for development if disposed of by Transport NI following completion of the scheme. To maximise the potential of the land, access has been enhanced through the proposed introduction of a short section of two-way running from the junction with Dock Street. The proposed two-way section would terminate at a new access arrangement to the land, with a priority junction proposed.

3.2.2.7.11 *Trouw Nutrition Garmoyle Street Access (Link No. 44)*

The existing access would be maintained within the Proposed Scheme without modification.

3.2.2.7.12 *Magnet House Car Park Access (Link No. 55)*

The existing access would be maintained within the Proposed Scheme without modification.

3.2.2.7.13 *Great Patrick St Private Car Park Access (Link No. 56)*

The existing access would be maintained within the Proposed Scheme without modification.

3.2.2.7.14 *T&T Clothing Co. Access (Link No. 57)*

The existing access would be maintained within the Proposed Scheme without modification.

3.2.2.7.15 ***CPA Access No. 1 (Link No. 58)***

The existing access would be maintained within the Proposed Scheme without modification.

3.2.2.7.16 ***Pollock Road Entrance to Harbour Estate (Link No. 60)***

The existing access would be maintained within the Proposed Scheme without modification.

3.2.2.7.17 ***Weighbridge access from Garmoyle Street (Link No. 61)***

The existing access would be maintained within the Proposed Scheme without modification.

3.2.3 *Proposed Scheme Cost Estimate*

A cost estimate has been prepared for the Proposed Scheme in accordance with the published Transport NI policy and procedure guide RSPPG_E058 - "Major Works Estimates" dated June 2011. The results are summarised in **Table 3.2.2**. Estimates have been prepared with reference to Spon's Civil Engineering and Highway Works Price Book 2014 using May 2013 as a base year for estimation purposes along with market rates at November 2014. The cost estimate outlined below has been independently reviewed by the appointed cost consultant, Bruce Shaw Partnership.

It should be noted that the cost estimate presented in **Table 3.2.2** comprises those costs associated with the road scheme and the likely discharge arrangement for stormwater from the scheme to the Gamble Street CSO (subject to agreement with NI Water). Costs associated with the Dargan Bridge foundation strengthening works, which are intended to be completed as part of the same construction contract, are estimated at approximately £4m. However, these costs are for elements of the works independent of Transport NI' promoted scheme and are therefore not included in **Table 3.2.2**.

The prepared cost estimate has informed the Cost Benefit analysis carried out on the Proposed Scheme, as reported in **Section 5**. It should be noted that the methodology for preparing cost estimates required by Transport NI in its RSPPG E058 differs from the methodology required by the COBA analysis software for economic assessment of the scheme. Accordingly, some adjustments have been made to the above estimate to facilitate entry into the COBA software.

For the purposes of the economic assessment reported in Section 5, it was agreed that the NI Water and Translink construction costs and benefits would be excluded from the standard transport cost benefit analysis, as the respective parties would be funding these works separately and the benefits would not be transport related. Further details of the resulting economic assessment are provided in **Section 5**.

Table 3.2.2: Proposed Scheme Cost Estimate

Item	Sub-Item	2014 Proposed Scheme Estimate (rounded up to nearest £0.1m)
Construction Costs	Preliminary Works	13.9

Item	Sub-Item	2014 Proposed Scheme Estimate (rounded up to nearest £0.1m)
	Road Works	21.6
	Structures	40.1
	Utilities	7.8
	Other Costs	0.0
Land Costs	Land Purchase Cost	7.9
	Disturbance / Severance / Injurious Affliction / Part 2 Claims	0.5
Consultant Costs	Preparation Costs	5.5
	Supervision Costs	4.6
Risk and Optimism Bias	Risk Allowance	5.6
	Optimism Bias (16.5%)	17.7
	Land Optimism Bias (0%)	0.0
	Programme Scheme Estimate:	**125.2**
	Estimate Range:	
	Lower Bound Optimism Bias Estimate (15%)	**123.7**
	Upper Bound Optimism Bias Estimate (45%)	**164.7**

The Estimate Range for the Proposed Scheme is accordingly **£ 120m** to **£ 165m**.

4. ENGINEERING ASSESSMENT

4.1 Introduction

This section presents the findings of the engineering assessment of the Proposed Scheme. This engineering assessment covers a number of aspects, including road geometry, junction geometry, pavement design, ground conditions, drainage, public utilities and structures.

The geometry of the links and junction arrangements provided in the Proposed Scheme are reported along with an assessment against the relevant engineering standards for road and junction geometry and pavement design in the DMRB. An assessment of required Departures from Standard for these aspects is included for information. This assessment has been completed in a manner commensurate with the level of design detail at this stage and focuses on Departures from the key engineering standards that the line and level of the roads are developed against.

The climate of the study area is reported along with an assessment of the impact of the scheme options on the existing topography. Based on the published Preliminary Sources Study of 2008 and subsequent investigations, an assessment of the impact of the expected ground conditions is made, along with an assessment of the proposals to deal with surface water run-off.

4.2 Road Geometry

4.2.1 *Relevant Geometry Standards*

The DMRB provides a suite of engineering documents to be used for the development of trunk road schemes in the United Kingdom. The DMRB comprises several volumes, of which Volume 6, Road Geometry, is most relevant to road designers when developing the layout of a scheme such as the proposed interchange.

The documents in the DMRB fall under two categories, Standards and Advice Notes. Standards establish requirements for trunk road schemes and, since 2006, have taken the form of a combined document that provides advice and guidance to designers along with mandatory requirements (as outlined within the Standard through use of black outline boxes). These mandatory requirements must be complied with unless mitigated through the Relaxations or Departures from Standards process. In comparison, Advice Notes give advice on particular requirements of the Design Standards. The information contained within the various Advice Notes is treated as guidance to designers and is therefore not subject to the Relaxations and Departures process.

The Proposed Scheme has been developed using the various Standards (TDs) and Advice Notes (TAs) in Volume 6 as appropriate. However, for the purposes of the Stage 3 engineering assessment of the road geometry of the Proposed Scheme, the following TDs are considered in particular:

- TD 22/06 – “Layout of Grade Separated Junctions”;
- TD 27/05 – “Cross Sections and Headrooms”; and
- TD 9/93 – “Highway Link Design”.

Across these standards, reference is made to a common set of key parameters used by designers in road design, namely:

- Design Speed;

- Horizontal Alignment;
- Vertical Alignment; and
- Sight Distance.

These parameters are briefly explained in **Section 4.2.2**.

4.2.2 *Design Parameters*

4.2.2.1 *Design Speed*

Research carried out in the development of the DMRB has shown that road users adjust their travelling speed in response to their perception of the road ahead. This perception is influenced by constraints on both the layout (including the width or the road and the frequency of accesses) and the alignment (including the bendiness of the road and average visibility). For any given road the Design Speed is considered to be, based on driver perception of the constraints ahead, the speed at which 85% of all drivers are expected to be travelling at or under on any given road. It is accordingly termed the 85th percentile speed.

Within the DMRB, Design Speed is an index which links road function, traffic flow and terrain to the design parameters of sight distance and curvature to ensure that a driver is presented with a reasonably consistent speed environment. In practice, most roads will only be constrained to minimum parameter values over short sections or on specific geometric elements.

The selected Design Speed should be consistent with the speeds that drivers are likely to expect on a given road. The Design Speed of a road has a direct impact on the cost, safety and quality of the finished project. In the designs developed, the Design Speed selected was as high as practicable to attain a specified degree of safety, mobility and efficiency while taking into consideration constraints of environmental quality, social and political impacts, economics and aesthetics.

The relevant engineering standard in the DMRB for the selection of Design Speeds for interchange links is TD 22/06. In accordance with paragraph 4.5 of this standard, a Design Speed of 85A kph was selected for the urban Westlink and M3 mainlines with the M2 mainline initially assigned a Design Speed of 120 kph.

Under paragraph 4.5 of TD 22/06, Design Speeds on connector roads within interchanges are determined on the basis of the connecting mainline and the nature of the connector road.

4.2.2.2 *Horizontal Alignment*

The horizontal alignments of road links are a careful compromise between safety, cost and environmental impact. For all new road schemes, designers will attempt to create alignments that minimise the impact on the existing natural and built environment, using circular curves in the horizontal plane linked to other circular curve or straight line elements by way of clothoid curves called transitions. The resultant alignment is considered the master control string, or “master string”, about which all other aspects of the road design are based.

Design Standard TD 9/93 of the DMRB establishes a standard approach to the selection of curves used in horizontal alignment design taking into account the requirements for both drainage and safety. To this end, the concepts of camber, crossfall and superelevation are introduced along with requirements for their application.

On a straight, or nearly straight, single carriageway road, camber of 2.5% is required such that the control line, known as the “master string” which forms the road centreline is higher than the two outer channels, thereby generating a crown in the centre of the road. The camber introduced encourages the removal of surface water run-off from the crown to the outer channels where it can be collected, treated and ultimately discharged in an appropriate manner.

On dual carriageways, with one-way travel along each carriageway, the master string is typically located in the central reserve, beyond the channels. Where dual carriageways are horizontally aligned in a straight or nearly straight manner, a normal crossfall of 2.5% is required such that the offside channel is higher than the nearside channel, creating a fall across the carriageway. Surface water run-off is accordingly collected at the lower nearside channel, treated and subsequently discharged.

Where horizontal curves are used, Design Standard TD 9/93 of the DMRB introduces the V^2/R criterion to determine at what point transition curves and superelevation must be used to enable road users to negotiate the curve comfortably. In this criterion, the V element is the Design Speed of the road in kilometres per hour and R is the radius of the curve in metres.

Transition curves are spiral curve elements used to allow road users to adjust to the change in direction in a comfortable manner, based on accepted rates of centripetal acceleration. A basic minimum length for transitions curves is established in the DMRB as a function of the radius of the curve and the rate of centripetal acceleration, with a recommendation to limit their length where the curves are substandard. This is to limit driver acceleration approaching the horizontal curve.

Over transition curves, designers typically remove camber or normal crossfall and replace it with superelevation, whereby the outer channels are lifted/lowered in an appropriate manner to provide a crossfall towards the inside of the curve. Superelevation is introduced and removed gradually within recommended limits to ensure a smooth change in the edge profile of the channels whilst providing a minimum longitudinal gradient for drainage purposes. The basic minimum transition length calculated using the formula in the DMRB is often insufficient to provide a change in edge profile within the recommended limits and so the transitions are lengthened as appropriate.

Therefore, for any given horizontal curve on a road, the following approach is taken:

- if the curve’s $V^2/R < 5$, the road can remain in camber/normal crossfall and will not require transitions;
- if the curve’s V^2/R is between 5 and 7, transitions should be provided with adverse camber removed and replaced with favourable crossfall of 2.5%; and
- if the curve’s $V^2/R > 7$, transitions should be provided with superelevation of more than 2.5%.

A maximum limit exists for superelevation such that it is limited in rural areas to 7%, whilst in urban areas with at-grade junctions and side accesses it is limited to 5%.

The curve at which $V^2/R = 14.14$ is termed the Desirable Minimum radius, corresponding with a superelevation of 5%. A procedure exists within the DMRB to permit a relaxed standard of provision, in number of steps below the established Desirable Minimum. Dependant on the number of steps below the Desirable Minimum standard, a Relaxation or Departure from Standard is required which requires the prior approval of Transport NI as the Overseeing Organisation. With regard to horizontal alignments, an Absolute Maximum radius is established at typically 1 step below the Desirable Minimum radius, such that the resultant

V^2/R >20. Depending on the radius of the horizontal curve, designers are required to allow for the swept path of longer vehicles and so lane widths are increased accordingly. Furthermore, in order to provide the required Sight Distance, as described in **Section 4.2.2.4**, verge widths must be increased by an appropriate amount. Therefore, a substandard horizontal alignment can have a major impact on cost, land take and environmental impact.

Under the Design Standard TD 22/06 that applies to grade separated junctions, designers are required to develop horizontal alignments that are compliant with TD 9/93, unless a lesser standard has been agreed with Transport NI through the Relaxations and Departures process.

4.2.2.3 *Vertical Alignment*

To produce a control master string, a vertical alignment is applied to the horizontal alignment developed within the constraints. The vertical alignment of a road must be carefully designed around the existing topography and ground conditions to achieve a cut/fill balance whilst maintaining an adequate longitudinal profile for drainage and appropriate sight distance. Limits are established in DMRB TD 9/93 for minimum and Desirable Maximum longitudinal gradients. A minimum longitudinal gradient of 0.5% applies to all types of road, whilst the Desirable Maximum gradient can lie between 3% and 6%, depending on the road category. The use of gradients in excess of the Desirable Maximum can make significant savings in construction or environmental costs, but will reduce the benefits offered to the road user in terms of delays (due to slower moving vehicles), fuel economy and safety. Accordingly, TD 9/93 establishes an Absolute Maximum gradient, which is linked to the type of road. The same Departure from Standards process exists to permit a further increase in gradients above the stated Absolute Maximum, which will require the approval of Transport NI.

For a vertical alignment to exist, changes in longitudinal gradients are connected by vertical parabolic curves large enough to provide comfort and sight distance. Design Standard TD 9/93 establishes permitted vertical curve radii that will normally provide the necessary sight distance, so long as the interaction between the cross-section, superelevation and obstructions does not combine to reduce it.

The appropriate length of curve to be used is a function of a criterion known as the “K value” included in TD 9/93. The minimum curve length can then be determined by multiplying the K value for the relevant Design Speed by the algebraic change of gradient expressed as a percentage.

Two types of curves exist; crest curves used to link an uphill gradient with a downhill gradient in the forward direction and sag curves used to link a downhill gradient to an uphill gradient in the forward direction. For crest curves, two factors affect the choice of crest curvature, visibility and comfort. For Design Speeds of 50kph and above the crest in the road will reduce forward sight distance to the Desirable Minimum value and consequently the K values derived are based upon visibility criteria.

For sag curves, visibility is not normally obstructed unless overbridges, signs or other features are present. For these curves, K values are derived on the basis of accepted comfort criteria. However, for Design Speeds less than or equal to 70kph, the Absolute Minimum K values to be used ensure that, in unlit conditions, vehicle headlamps illuminate the road surface for a distance which is not more than 1 step below the Desirable Minimum Stopping Sight Distance.

Vertical curvature is subject to both the Relaxations and Departure from Standards process set out in the DMRB whereby a lesser provision can be made with the prior approval of Transport NI.

Under the Design Standard TD 22/06 that applies to grade separated junctions, designers are required to develop vertical alignments that are compliant with TD 9/93, unless a lesser standard has been agreed with Transport NI through the Relaxations and Departures process. However, it should be noted that TD 22/06 increases the Absolute Maximum gradient for motorway connector roads from the 4% stated in TD 9/93 to 6%.

4.2.2.4 *Sight Distance*

Sight Distance is the forward visibility provided to drivers as they travel along a road to enable them to respond to the conditions ahead. Two types of Sight Distance are set out in Design Standard TD 9/93 of the DMRB:

- Stopping Sight Distance (SSD); and
- Full Overtaking Sight Distance (FOSD).

Stopping Sight Distance is the theoretical forward sight distance required by a driver in order to stop when faced with an unexpected hazard on the carriageway. The distance is the sum of the following components:

- the distance travelled from the time when the driver sees the hazard and realises that it is necessary to stop – the perception distance;
- the distance travelled during the time taken for the brakes to be applied to the vehicle – the reaction distance; and
- the distance travelled whilst slowing the vehicle to a stop – the braking distance.

Stopping Sight Distance is measured within an envelope such that drivers of low vehicles can see other low objects whilst drivers of high vehicles can see a significant portion of other vehicles. The envelope comprises a driver's eye height of between 1.05m and 2.0m and an object height of 0.26m to 2.0m, both measured above the road surface and separated by the required SSD.

With regard to the eye height range, the lower bound value of 1.05m has been arrived at following UK research into the distribution of driver eye heights, with 95% of drivers eye heights found to be above this minimum value. The upper bound value of 2.0m is considered to represent the eye height of a driver of a large vehicle.

The lower bound 0.26m object height is considered to represent the rear tail lights of other vehicles, with a 1.05m object height considered to present the tops of other vehicles. The upper bound 2.0m object height ensures that a significant portion of a vehicle ahead can be seen to identify it as such.

Stopping Sight Distance is directly related, on a straight section of road, to the vertical and horizontal alignments provided and accordingly it is checked in both planes in the centre of each running lane. A Desirable Minimum SSD is established in TD 9/93 for various Design Speeds that is required along each lane. In order to provide the required SSD on horizontal curves, it is necessary to provide additional verge widening and the relocation of street furniture or other obstructions beyond the SSD envelope.

The same hierarchy for Relaxations and Departures from Standards is available to designers for use with regard to SSD in difficult circumstances, subject to the approval of Transport NI.

Full Overtaking Sight Distance (FOSD) is relevant to the design of single carriageways. The provision of FOSD on sections within an alignment provides, where traffic flows permit, 85% of drivers with a reasonable degree of safe overtaking opportunities, thereby improving safety and journey time reliability. It is measured using a similar envelope approach to that of SSD, but the object height requirement is relaxed to a height between 1.05m and 2.0m. Design Standard TD 9/93 requires various minimum FOSD distances to be provided on overtaking sections, relative to the Design Speed, to which the Relaxations and Departures hierarchy does not apply. Since FOSD is considerably greater than SSD, it can normally only be provided in relatively flat terrain where the combination of vertical and horizontal alignment permits the design of a flat and relatively straight road design.

As the majority of links within the proposed interchange are one-way connector roads between the three mainlines, SSD provision is more relevant than FOSD provision. Under the Design Standard TD 22/06 that applies to grade separated junctions, designers are required to provide the Desirable Minimum SSD on all connector roads, unless a lesser standard has been agreed with Transport NI through the Relaxations and Departures process.

With regard to SSD provision over merge and diverge arrangements within a grade separated junction, designers must make reference to both standards. Design Standard TD 9/93 establishes requirements for Stopping Sight Distance on the approach to merges and diverges, whilst TD 22/06 makes provision for Stopping Sight Distance over merges and diverges within a grade separated junction and onward connector roads.

In accordance with Design Standard TD 9/93, the SSD on the mainline upstream of the tip of a diverge nose or the back of a merge nose must attain the Desirable Minimum value over a distance equivalent to 1.5 times the SSD value.

Design Standard TD 22/06 requires that, for diverges, the SSD for the mainline design speed, termed SSD_1, is maintained through the diverge to the back of the diverge nose. Beyond the back of the diverge nose, there must be clear visibility along the connector road to a position equal to SSD_1. In addition, the reduced SSD for the reduced Design Speed on the connector road, termed SSD_2, must be provided from a distance equal to the difference between SSD_1 and SSD_2 downstream of the back of the diverge nose. This reduced SSD_2 must then be maintained through to the end of the link. In the case where the distance between the back of the diverge nose and its termination with an at-grade junction is less than SSD_1, then the full SSD_1 must be provided from the give way line to a position at a distance of SSD_1 upstream of the give way line. Figures 4/3A and 4/3B of TD 22/06 illustrate these requirements.

In contrast, for merges, TD 22/06 requires that the SSD on the connector road is maintained up to the back of the merge nose, at which point the SSD for the mainline must be provided through the merge arrangement.

4.2.3 *Assessment of Do-Something Scenario*

4.2.3.1 *Design Speeds*

In the Proposed Scheme, links to and from the three mainlines are considered interchange links, as defined by paragraph 1.16 of TD 22/06.

Based on the initially selected upstream mainline Design Speed of 120A kph (for the M2), a Design Speed of 85 kph was accordingly identified for the M2 to Westlink link (Link No. 2). However, given the substandard geometry and cross-section of the underpass links provided in the Proposed Scheme, it was discussed and agreed with Transport NI that such links should be subject to speed restriction in the interests of road user safety. A speed limit of 40mph was selected as being the most appropriate to the underpasses. Consideration was also given to the introduction of a short 50mph buffer zone on the city (south) bound carriageway of the M2 motorway from Duncrue Street to help road users adjust their speed ahead of entry into the underpass. This was also discussed and agreed with Transport NI. In the opposite direction, on the country (north) bound carriageway, it was agreed that the carriageway should remain subject to national speed limits without speed restriction.

Following agreement on the introduction of speed limits, the selected Design Speed for the city (south) bound carriageway of the M2 mainline from Duncrue Street was reassessed on the basis of its reclassification as an urban motorway subject to speed limits. In accordance with Table 4.1 of TD 22/06, a Design Speed of 85 kph was selected. This would accordingly reduce the Design Speed of Link No. 2 to 70 kph. Link No. 2 was accordingly designed on this basis.

Following agreement on the speed limits to be introduced, Link No. 1, the Westlink to M2 link, was assigned a Design Speed of 70kph along with Link No. 3 between the Westlink and M3 and Link No. 4 between the M3 and the Westlink.

All other links to or from the three mainlines have been considered to be slip roads, rather than interchange links, in accordance with paragraph 1.30 of TD 22/06. They have therefore been typically assigned a Design Speed of 60 kph.

The existing streets within the Proposed Scheme, including Link No. 11 between York Street (South) and York Street (North) are considered urban single carriageways and therefore subject to a Design Speed of 60 kph.

Table 4.2.1 summarises the selected Design Speeds for the various links in the Proposed Scheme. These Design Speeds and the proposed locations of speed limits have been illustrated on **Drawing YSI-URS-XX-XX-DR-RE-GD201**.

Table 4.2.1: Proposed Scheme Speed Limits and Design Speeds

Link No.	From	To	Relevant Mainline and Design Speed	Road Classification	Design Speed	Speed Limit
1	Westlink	M2	Westlink Urban 85 kph	Interchange Link	70 kph	40 mph
2	M2	Westlink	M2 Urban 85 kph	Interchange Link	70 kph	40 mph
3	Westlink	M3	Westlink Urban 85 kph	Interchange Link	70 kph	40 mph
4	M3	Westlink	M3 Urban 85 kph	Interchange Link	70 kph	40 mph
5	Westlink	York Street	Westlink Urban 85 kph	Slip Road	60 kph	40 mph / 30 mph
6	Dock Street	M3	M3 Urban 85 kph	Slip Road	60 kph	40 mph
7	M3	York Street	M3 Urban 85 kph	Slip Road	60 kph	30 mph

Link No.	From	To	Relevant Mainline and Design Speed	Road Classification	Design Speed	Speed Limit
11	York Street (South)	York Street (North)	York Street Urban 60 kph	Single Carriageway	60 kph	30 mph
15	York Street	M2	M2 Rural 120 kph	Slip Road	70 kph	40 mph / National
31	Duncrue Street	Westlink	Westlink Urban 85 kph	Slip Road	60 kph	40 mph

4.2.3.2 *Alignments*

4.2.3.2.1 *Link No. 1 (Westlink to M2)*

Master String Location

The master string for Link No. 1 is situated on the offside edge of lane 2, commencing on the Westlink, approximately 20m south of the back of the existing merge nose from Clifton Street at Ch 0+160 and terminating at the back of the existing merge nose from York Street onto the M2 foreshore (Ch 0+814). All horizontal and vertical radii reported in the assessment of the link are relative to this master string.

Horizontal Alignment

Link No. 1 commences with a right hand curve of 350m radius that transitions at North Queen Street Bridge into a left hand curve of 360m radius. The 350m radius is Two Steps Below Desirable Minimum for the 85kph Design Speed and One Step Below Desirable Minimum for the 70kph Design Speed. The 360m radius achieves the Desirable Minimum value for the 70kph Design Speed. This radius is maintained through the proposed underpass to a position west of the Dargan Bridge. From this point the alignment transitions into a left hand curve of 180m radius to allow the link to fit between the existing Dargan Bridge substructure. This radius is Two Steps below Desirable Minimum. On approach to the merge nose with the motorway, the alignment transitions into a straight and terminates at the back of the merge nose.

Vertical Alignment

The vertical alignment matches that of the existing road level before transitioning into a crest curve with a K value of 25, which is One Step below the Desirable Minimum value. This crest curve continues for 105m on the alignment before a 6% downhill gradient is introduced. This gradient extends for 94m, leading into a sag curve with a K value of 13 at the lowest point in the underpass. The proposed radius is One Step below the Absolute Minimum value of 20 for the proposed Design Speed. To the east of the underpass a crest curve with a K value of 10 is introduced followed by a sag curve with a K value of 10 which provides a minimum cover of 370mm to the existing bases to the Dargan Bridge. On approach to the tie in with the M2 motorway, the vertical alignment follows a crest curve with a K value of 10. The crest/sag curves with K values of 10 are Two Steps below Desirable Minimum and Absolute Minimum respectively for the 70kph Design Speed. The link ties in with the M2 motorway via a short section of 0.5% downhill gradient.

The proposed use of a 6% maximum gradient is in accordance with paragraph 4.7 of TD 22/06 for motorway connector roads.

Stopping Sight Distance

The Stopping Sight Distance (SSD) on the link is substandard in a number of locations and would require Departures from Standard given the frequency of merges and diverges along the alignment. At the start of the alignment, the existing 90m SSD is maintained over North Queen Street and on the downhill gradient through to a position beneath the proposed York Street overbridge. This SSD is One Step below Desirable Minimum and would require a Departure from Standard on the approach to both the York Street diverge and the M3 diverge. Upon exit from the underpass, the SSD reduces to 70m (Two Steps below Desirable Minimum) under the Dargan Bridge. This is due to the limited nearside verge width and the constraint introduced by the vehicle restraint system proposed adjacent to the bridge piers. The Stopping Sight Distance increases from here on approach to the merge nose to a minimum of 160m. At the back of the merge nose onto the M2 motorway this would be Two Steps below Desirable Minimum for the proposed Design Speed of 120kph and would require a Departure from Standard.

Transitions and Superelevation

Transitions have been provided in accordance with the requirements of TD 9/93.

Superelevation of up to 5% has typically been provided on the link based on the radii of selected horizontal curves. This is considered appropriate given the urban nature of the site and the prescence of at-grade junctions, in accordance with the requirements of paragraph 3.2 of TD 9/93. The proposed superelevation would fall below the requirements of Table 3 of TD 9/93 at two locations along the alignment and require Departures from Standard. These are located at the tie in points where the geometry is matching the existing Westlink and M2 alignments.

Combination Departures

The proposed combination of horizontal alignment, vertical alignment and SSD would fall below the requirements of paragraph 1.24 of TD 9/93 at eight locations along the alignment and require Departures from Standard.

Reduced SSD and/or K Value over Junction Approaches

The combination of substandard SSD and/or K values over the identified approaches to junctions, including merge and diverge arrangements, would fall below the requirements of paragraph 1.26 of TD 9/93 at thirteen locations and require Departures from Standard.

Summary Departures from Standard TD 9/93

A summary of required Departures from Standard TD 9/93 for the link is included as Table 2.0 in **Appendix H**.

4.2.3.2.2 *Link No. 2 (M2 to Westlink)*

Master String Location

The master string for Link No. 2 is situated on the offside edge of lane 2, commencing at the back of diverge nose from the M2 motorway (Ch 0+000) and terminating on the Westlink at the eastern abutment of North Queen Street Bridge (Ch 0+903). All horizontal and vertical radii reported in the assessment of the link are relative to this master string.

Horizontal Alignment

The horizontal alignment commences with a 245m straight two-lane drop arrangement from the M2 motorway across a new Dock Street overbridge. On approach to the proposed underpass, the alignment transitions into a right hand curve of 150m radius, as measured on the offside hard strip. The proposed 150m radius is Three Steps below the Desirable Minimum radius of 360m for the proposed 70kph Design Speed. The right hand curve terminates at the entrance to the underpass beneath the links to the M3 motorway. The alignment transitions beyond this into a nearly straight right hand curve of 1020m to a position east of North Queen Street Bridge. The alignment transitions to match the existing alignment of the Westlink over North Queen Street Bridge, with a left hand curve of 350m. This radius, to match the existing alignment, is One Step below Desirable Minimum.

Vertical Alignment

The vertical alignment comprises a 2.7% uphill gradient, to tie into the existing M2 motorway. Following this a crest curve is proposed (at the location of the proposed Dock Street overbridge) with a K value of 20, leading into a 6% downhill gradient into a sag curve in the underpass, with a K value of 13. The crest curve is One Step below Desirable Minimum and the sag curve is One Step below Absolute Minimum. The sag curve continues to a point east of the proposed York Street overbridge at which point a 6% uphill gradient is proposed, leading to a crest curve with a K value of 30 that ties into the existing Westlink alignment at the eastern extent of North Queen Street Bridge.

The proposed use of a 6% maximum gradient is in accordance with paragraph 4.7 of TD 22/06 for motorway connector roads.

Stopping Sight Distance

The Stopping Sight Distance (SSD) on the link is substandard in a number of locations and would require Departures from Standard given the frequency of merges and diverges along the alignment. For the diverge arrangement from the M2, the proposed crest curve on the new Dock Street overbridge limits forward SSD from 120m (Desirable Minimum for 70kph) to 90m. This is One Step below Desirable Minimum and would require a Departure from Standard given its location over a diverge arrangement.

On approach to the underpass, SSD gradually reduces from 90m to 70m, limited by the offside verge width as the alignment passes through the pinch point under the Lagan Bridge. This reduction in SSD to 70m extends over 60m of the alignment. On exiting this pinch point the SSD increases to 160m, in excess of the Desirable Minimum requirement. This 160m SSD is continued under the proposed York Street overbridge to the back of merge nose from Link No. 4. From this point the SSD gradually reduces to 90m (One Step below the Desirable Minimum) to a point east of North Queen Street Bridge. This SSD would require a Departure from Standard as it is present on the approach to the Clifton Street diverge.

Transitions and Superelevation

Transitions have been provided in accordance with the requirements of TD 9/93.

Superelevation of up to 5% has typically been provided on the link based on the radii of selected horizontal curves. This is considered appropriate given the urban nature of the site and the prescence of at-grade junctions, in accordance with the requirements of paragraph 3.2 of TD 9/93. The proposed superelevation would fall below the requirements of Table 3 of TD 9/93 at the tie in point with the existing Westlink alignment and require a Departure from Standard.

Combination Departures

The proposed combination of horizontal alignment, vertical alignment and SSD would fall below the requirements of paragraph 1.24 of TD 9/93 at six locations along the alignment and require Departures from Standard.

Reduced SSD and/or K Value over Junction Approaches

The combination of substandard SSD and/or K values over the identified approaches to junctions, including merge and diverge arrangements, would fall below the requirements of paragraph 1.26 of TD 9/93 at six locations and require Departures from Standard.

Summary Departures from Standard TD 9/93

A summary of required Departures from Standard TD 9/93 for the link is included as Table 2.0 in **Appendix H**.

4.2.3.2.3 ***Link No. 3 (Westlink to M3)***

Master String Location

The master string for Link No. 3 commences at the back of the diverge nose from Link No. 1 (Ch 0+000) and is situated along the nearside edge of lane 1 on the link, becoming the centreline of the two lane slip road to M3 that terminates at the back of the merge nose on the Lagan Bridge. The link ties into the existing M3 on-slip at Ch 0+290. All horizontal and vertical radii reported in the assessment of the link are relative to this master string.

Horizontal Alignment

The link commences with a short left hand curve of radius 361m which transitions into a right hand curve of 90m. The proposed radius is limited by the proximity of the Dargan Bridge substructure and is Four Steps below Desirable Minimum. It is noted that radii as low as 50m are permitted for loops from All-Purpose mainline roads in accordance with paragraph 4.9 of TD 22/06, subject to the provision of full visibility across the extent of the loop. However, the link cannot be considered a loop as it does not comply with any of the layouts shown in Figure 4/1 of TD 22/06 (owing to the proposed offside diverge). Therefore, a Departure from Standard is required for the proposed 90m horizontal radii on the link. Beyond the 90m radius, the alignment transitions into a right hand curve of 1474m for a short length before reducing slightly to a right hand curve of radius 1020m to tie in with the existing M3 on-slip ramp structure.

Vertical Alignment

The vertical alignment of the link is constrained by the requirement to achieve cover to the existing bases of the Dargan Bridge and the M2 to Westlink underpass over a relatively short horizontal alignment. At the start of the alignment, the link is on a 5.13% downhill gradient for a short length followed by a sag curve with a K value of 13. This K value is One Step below the Absolute Minimum value for the 70kph Design Speed. The alignment transitions to a crest curve on exit from the nunderpass, with a K value of 10. This value is Two Steps below the Desirable Minimum value for the Design Speed, however is essential to achieve the necessary cover to the existing bases of the Dargan Bridge. The alignment continues with a sag curve (K value of 10), at the merge nose with Link No. 6. This K value is Two Steps below the Absolute Minimum value required for the Design Speed. To achieve tie-in with the existing road level on the ramp structure, a 5.63% uphill gradient is proposed.

Stopping Sight Distance

The Stopping Sight Distance (SSD) on the link is substandard in a number of locations and would require Departures from Standard given the frequency of merges and diverges along the alignment. Over the diverge nose from Link No. 1, the SSD is 120m, reducing gradually to 90m and then 70m on approach to the Dargan Bridge. The piers to the Dargan Bridge present obstructions that reduce the SSD at this pinch point. The proposed crest curve, necessary to achieve suitable cover to the existing bridge foundations, limits SSD to 65m over a short length of 20m. This is Three Steps below Desirable Minimum and would require a Departure from Standard. Beyond this point, the SSD increases to a minimum of 120m at the merge nose on the M3 on-slip. From the tie in point (Ch 0+290) the SSD reduces to 90m due to the existing vertical crest curve. Given the proximity of the merge nose from Dock Street to the pinch point, a number of Departures from Standard would be required for the locations where Desirable Minimum SSD is not achieved.

Transitions and Superelevation

Transitions have been provided in accordance with the requirements of TD 9/93.

Superelevation of up to 5% has typically been provided on the link based on the radii of selected horizontal curves. This is considered appropriate given the urban nature of the site and the prescence of at-grade junctions, in accordance with the requirements of paragraph 3.2 of TD 9/93. The proposed superelevation would fall below the requirements of Table 3 of TD 9/93 at the tie in point with the existing M3 on-slip and require a Departure from Standard.

Combination Departures

The proposed combination of horizontal alignment, vertical alignment and SSD would fall below the requirements of paragraph 1.24 of TD 9/93 at nine locations along the alignment and require Departures from Standard.

Reduced SSD and/or K Value over Junction Approaches

The combination of substandard SSD and/or K values over the identified approaches to junctions, including merge and diverge arrangements, would fall below the requirements of paragraph 1.26 of TD 9/93 at eight locations and require Departures from Standard.

Summary Departures from Standard TD 9/93

A summary of required Departures from Standard TD 9/93 for the link is included as Table 2.0 in **Appendix H**.

4.2.3.2.4 *Link No. 4 (M3 to Westlink)*

Master String Location

The master string for Link No. 4 is situated on the offside edge of lane 1, commencing at the top of the M3 off-slip embankment (Ch 0+115) and terminating at the back of merge nose with Link No. 2 (Ch 0+436). All horizontal and vertical radii reported in the assessment of the link are relative to this master string.

Horizontal Alignment

The horizontal alignment commences with a right hand curve of 1440m radius, matching the existing radius on the M3 off-slip and exceeding the Desirable Minimum requirement for the 70kph Design Speed. The curve transitions into a smaller left hand curve of 195m radius beyond the back of the diverge nose and is limited by the Dargan Bridge substructure. This radius is Two Steps below the Desirable Minimum for the selected Design Speed and would require a Departure from Standard due to the proximity to the merge with Link No. 2. This curve is maintained to a position east of the underpass, where it transitions into a right hand curve of radius 1173m which is maintained up to the back of merge nose.

Vertical Alignment

The vertical alignment of the link seeks to match the existing vertical alignment of the existing diverge and off-slip to York Street. To that end, the vertical alignment at the existing embankment comprises a sag curve with a K value of 26.2, in excess of the Absolute Minimum required for the 70kph Design Speed. Beyond this, a further sag curve with a K value of 9 (Two Steps below Absolute Minimum for the Design Speed) is introduced on approach to the Dargan Bridge. A Departure from Standard would be required due to the proximity to the diverge nose. At this point a crest curve with a K value of 17 continues the alignment beneath the Dargan Bridge and on to a point approximately equal distances from the Dargan Bridge and the proposed York Street overbridge. To maintain the necessary headroom through the underpass, a sag curve is proposed with a K value of 9, again Two Steps below the Absolute Minimum for the Design Speed. A Departure from Standard would be required due to the proximity of the approach to the merge with Link No. 2. Upon exciting the underpass an uphill gradient of 6.16% is introducted to tie in with the Link No. 2 mainline over the short remaining distance. This gradient is in excess of the 6% limit for gradients on motorway connector roads (paragraph 4.7 of TD 22/06) and would require a Departure from Standard.

Stopping Sight Distance

The Stopping Sight Distance (SSD) on the link is initially limited by the existing Dargan Bridge substructure, however this is similar to the existing layout. Therefore, the SSD is initially a minimum of 90m, One Step below Desirable Minimum for the 70kph Design Speed. This would require a Departure from Standard due to the proximity to the diverge nose to Link No. 7. The SSD of 90m is maintained through to a point approximately equal distance from the Dargan Bridge and the proposed York Street overbridge where it increases gradually to 160m on the downhill alignment into the underpass. This SSD is in excess of the Desirable Minimum for the Design Speed and is maintained through the underpass to a point west of the proposed York Street overbridge. At the point the SSD is limited to 120m due to the 6.16% uphill gradient proposed to tie in with the Link No. 2 mainline.

Transitions and Superelevation

Transitions have been provided in general accordance with TD 9/93 however, the entry and exit transitions to/from the curve with 195m horizontal radius are 70m in length, greater than the 68.4m limit required in accordance with paragraph 3.16 of TD 9/93. A Departure from Standard would be required for these locations.

Superelevation of up to 5% has typically been provided on the link based on the radii of selected horizontal curves. This is considered appropriate given the urban nature of the site and the prescence of at-grade junctions, in accordance with the requirements of paragraph 3.2 of TD 9/93. The proposed superelevation would fall below the requirements of Table 3 of TD 9/93 at the tie in point with the existing M3 off-slip and require a Departure from Standard.

Combination Departures

The proposed combination of horizontal alignment, vertical alignment and SSD would fall below the requirements of paragraph 1.24 of TD 9/93 at five locations along the alignment and require Departures from Standard.

Reduced SSD and/or K Value over Junction Approaches

The combination of substandard SSD and/or K values over the identified approaches to junctions, including merge and diverge arrangements, would fall below the requirements of paragraph 1.26 of TD 9/93 at five locations and require Departures from Standard.

Summary Departures from Standard TD 9/93

A summary of required Departures from Standard TD 9/93 for the link is included as Table 2.0 in **Appendix H**.

4.2.3.2.5 *Link No. 5 (Westlink to York Street)*

Master String Location

The master string for Link No. 5 is situated on the offside of lane 1 of the slip road, commencing at the back of the diverge nose from Link No. 1 (Ch 0+000) and terminating at the signalised junction with York Street (Link No. 11) at Ch 0+148. All horizontal and vertical radii reported in the assessment of the link are relative to this master string.

Horizontal Alignment

The alignment commences with a left hand curve of 526m radius, in excess of the Desirable Minimum value for the 60kph Design Speed. This curve transitions into a left hand curve of 255m radius, the Desirable Minimum value for the selected Design Speed and is continued to the end of the alignment.

Vertical Alignment

The vertical alignment ties into the diverge nose from the Link No. 1 mainline with a gradient of approximately 5.8%. Beyond this a sag curve with a K value of 8, Two Steps below Absolute Minimum, is introduced followed by a crest curve with a K value of 7.5 which is continued to tie in with Link No. 11. This crest curve is Two Steps below Desirable Minimum. A number of Departures from Standard would be required due to the proximity of the approach to the junction with Link No. 11.

Stopping Sight Distance

Over the diverge arrangement from the Westlink to M2 mainline (Link No. 1), a 120m SSD is provided on the link that meets the Desirable Minimum value. On the slip road, where the Design Speed is reduced to 60kph, the SSD is gradually reduced to 90m, the Desirable Minimum value. This provision is maintained to the end of the alignment.

Transitions and Superelevation

Transitions have been provided on the link in general accordance with TD 9/93. It should be noted however, the transition length provided between the two left hand curves has been calculated using a q value of 0.6 m/sec^3.

Superelevation of up to 5% has been provided on the link based on the radii of selected horizontal curves. The proposed superelevation would not meet the requirements of Table 3 of TD 9/93 at the tie in point with Link No. 1 and would require a Departure from Standard.

Combination Departures

The proposed combination of horizontal alignment, vertical alignment and SSD would not fall below the requirements of paragraph 1.24 of TD 9/93 along the alignment.

Reduced SSD and/or K Value over Junction Approaches

The combination of substandard SSD and/or K values over the identified approaches to junctions, including merge and diverge arrangements, would fall below the requirements of paragraph 1.26 of TD 9/93 at two locations and require Departures from Standard.

Summary Departures from Standard TD 9/93

A summary of required Departures from Standard TD 9/93 for the link is included as Table 2.0 in **Appendix H**.

4.2.3.2.6 *Link No. 6 (Dock Street to M3)*

Master String Location

The master string for Link No. 6 commences at the Dock Street junction (Ch 0+000) and is situated on the offside of lane 1 of the slip road, becoming the centreline of the two lane slip road to M3 that terminates at the back of the merge nose on the Lagan Bridge. The link ties into the existing M3 on-slip at Ch 0+385. All horizontal and vertical radii reported in the assessment of the link are relative to this master string.

Horizontal Alignment

The alignment commences with a left hand curve of 720m away from the Dock Street junction, followed by a right hand curve of the same radius. Both of these achieve the Desirable Minimum value for the 60kph Design Speed. The 720m right hand curve continues for approximately 170m before transitioning into a left hand curve of 100m radius, which forms the merge nose onto Link No. 3. The Design Speed on the link changes from 60kph to 70kph at the back of merge nose (Ch 0+300) and as such the horizontal curve falls (to differing levels) below the Desirable Minimum. The proposed 100m radius is Three Steps below Desirable Minimum for the 60kph Design Speed and Four Steps below Desirable Minimum for the 70kph Design Speed. Departures from Standard would be required for each. The alignment continues from the tip of the merge nose with a right hand curve of 1474m radius, followed by a futher right hand curve of 1020m radius and ties into the existing M3 on-slip.

Vertical Alignment

The vertical alignment commences with a sag curve (K value of 9) leading away from Dock Street. The K value is One Step below the Absolute Minimum value for the 60kph Design Speed at this location and would require a Departure from Standard given the proximity to the proposed access/turning arrangement along this link. The alignment transitions into a crest curve with a K value of 30 to a point north of the underlying Link No. 2. This K value exceeds the Desirable Minimum requirement. A sag curve with a K value of 10 carries the alignment over the underpass and onto the approach with the merge with Link No. 3. This K value is One Step below the Desirable Minimum and would require a Departure from Standard give the proximity to the merge junction. The vertical alignment ties back into the existing M3 on-slip with a 5.5% uphill gradient.

Stopping Sight Distance

Stopping Sight Distance is 160m initially on departure from Dock Street, reducing through 120m to 90m prior to the access/turning arrangement along the link. The available SSD is constrained by the proposed crest curve and the limited available nearside verge width. The 90m SSD reduces further to 70m on the approach to the merge nose due to the limited nearside verge width, which is constained by headroom requirements to the underlying link. The proposed SSD is One Step below Desirable Minimum for the 60kph Design Speed at this location. As the link approaches the existing M3 on-slip, the SSD increases to 120m, the Desirable Minimum for the selected 70kph Design Speed at this location. At the tie in with the existing alignment, the SSD reduces again to 90m matching the existing provision.

Transitions and Superelevation

Transitions have not been provided in accordance with TD 9/93 due to the horizontal alignment constraints. The transition proposed at Ch 0+219 (50m) is longer than the maximum length allowed (49m) in accordance with paragraph 3.16 in TD 9/93 and a Departure from Standard would be required. In addition, no exit transition has been provided following the left hand curve of 100m radius. A further Departure from Standard would be required.

Superelevation of up to 5% has been provided on the link based on the radii of selected horizontal curves. The proposed superelevation would not meet the requirements of Table 3 of TD 9/93 at two locations on the approach to the tie in on the M3 on-slip and a Departure from Standard would be required.

Combination Departures

The proposed combination of horizontal alignment, vertical alignment and SSD would fall below the requirements of paragraph 1.24 of TD 9/93 at two locations along the alignment and require Departures from Standard.

Reduced SSD and/or K Value over Junction Approaches

The combination of substandard SSD and/or K values over the identified approaches to junctions, including merge and diverge arrangements, would fall below the requirements of paragraph 1.26 of TD 9/93 at four locations and require Departures from Standard.

Summary Departures from Standard TD 9/93

A summary of required Departures from Standard TD 9/93 for the link is included as Table 2.0 in **Appendix H**.

4.2.3.2.7 *Link No. 7 (M3 to York Street)*

Master String Location

The master string for Link No. 7 is situated on the offside edge of lane 1, commencing at the back of the diverge nose on Link No. 4 (Ch 0+040) and terminating at a signalised junction with Link No. 11 (Ch 0+215). All horizontal and vertical radii reported in the assessment of the link are relative to this master string.

Horizontal Alignment

The link commences by matching the existing horizontal alignment through to the back of merge nose. From this point a left hand curve of 100m radius is introduced, Three Steps below Desirable Minimum for the 60kph Design Speed. The left hand curve leads onto a right hand curve of 720m radius, in excess of the Desirable Minimum, connecting into a straight on approach to the junction with Link No. 11.

Vertical Alignment

The vertical alignment commences on a downhill gradient of 2.75% that connects to a sag curve with a K value of 9. This K value is One Step below the Absolute Minimum value for the 60kph Design Speed and would require a Departure from Standard due to the proximity to the Nelson Street junction. The sag curve continues to a point adjacent to the exit from Nelson Street where it transitions into an uphill gradient of approximately 0.9% for 75m. From here, a further sag curve with a K value of 9 is introduced leading into a crest curve with a K value of 9 that ties into the junction with Link No. 11. This crest curve is Two Steps below Desirable Minimum for the 60kph Design Speed and would require a Departure from Standard due to the proximity to the junctions with Little York Street and York Street (Link No. 11).

Stopping Sight Distance

The Desirable Minimum Stopping Sight Distance (SSD) for the 60kph Design Speed is provided over the entire length of the alignment.

Transitions and Superelevation

Transitions have not been provided in accordance with TD 9/93 due to the horizontal alignment constraints. A Departure from Standard would be required for the lack of exit transition from the 100m left hand curve.

The proposed superelevation would not meet the requirements of Table 3 of TD 9/93 at the location of the 100m left hand curve and would require a Departure from Standard.

Combination Departures

The proposed combination of horizontal alignment, vertical alignment and SSD would fall below the requirements of paragraph 1.24 of TD 9/93 at one location along the alignment and require a Departure from Standard.

Reduced SSD and/or K Value over Junction Approaches

The combination of substandard SSD and/or K values over the identified approaches to junctions, including merge and diverge arrangements, would fall below the requirements of paragraph 1.26 of TD 9/93 at three locations and require Departures from Standard.

Summary Departures from Standard TD 9/93

A summary of required Departures from Standard TD 9/93 for the link is included as Table 2.0 in **Appendix H**.

4.2.3.2.8 *Link No. 11 (York Street (South) to York Street (North))*

Master String Location

The master string for Link No. 11 is situated on the offside edge of lane 1 (A2 bound), becoming the nearside edge of lane 1 (M2 bound) and terminating as the offside edge of lane 2 (A2 bound). The master string commences at the York Street junction with Great Patrick Street (Ch 0+000) and terminates at the junction with Dock Street (Ch 0+602). All horizontal and vertical radii reported in the assessment of the link are relative to this master string.

Horizontal Alignment

The link has a flowing, relatively straight horizontal alignment that introduces a series of left and right hand curves either side of the proposed York Street overbridge. It was considered that a straight horizontal alignment at the location of the overbridge would reduce the complexity of the design and construction of these structures. Briefly, the horizontal alignment commences with a straight section along York Street, before changing on approach to the junction with Great George's Street into a left hand curve of 360m radius followed by a right hand curve of 255m radius. This curve is the Desirable Minimum for the 60kph Design Speed selected and extends to a position south of the proposed York Street overbridge. A straight of 147m is introduced at the position of the proposed York Street overbridge leading into a left hand curve of 360m radius followed by a right hand curve of 720m radius which ties in with the existing centreline of York Street at the exit from Cityside Retail Park. The existing alignment is maintained through to the junction with Dock Street.

Vertical Alignment

The vertical alignment of the link is constrained by the requirements for headroom over a relatively short distance to the underlying links whilst tying in with the the existing vertical alignment at the junction with Little Patrick Street (to the south) and the access to Cityside Retail Park (to the north). Accordingly, the vertical alignment commences with a downhill gradient of 0.5% at the tie in with York Street to the southern extent, before continuing into a sag curve with a K value of 9. The proposed sag curve's K value is One Step below the Absolute Minimum value for the proposed 60kph Design Speed. The sag curve continues into a crest curve, with its high-point positioned above the Westlink to M3 link, with a K value of 15. The proposed K value is One Step below the Desirable Minimum value and creates an instantaneous gradient of 6.4%. The proposed gradient is in excess of the Desirable Maximum value of 6% on an All-Purpose single carriageway (ref TD 9/93, paragraph 4.1), but is less than the 8% threshold for a Departure from Standard (ref TD 9/93, paragraph 4.2). On the northern side of the bridge, a sag curve with a K value of 9, One Step below the Absolute Minimum value is proposed, creating an instantaneous gradient of 6.6%. This gradient is again in excess of the 6% Desirable Maximum value, but below the 8% threshold for a Departure from Standard. The sag curve continues with a downhill gradient of 0.16% to facilitate vertical tie-in with existing levels at the access to Cityside Retail Park.

Stopping Sight Distance

The proposed York Street layout introduces two-way running and as such the Stopping Sight Distance (SSD) must be assessed in both the northbound and southbound directions.

Travelling northbound from Great Patrick Street the SSD on the link is 160m, in excess of the Desirable Minimum value required for the 60kph Design Speed. The SSD reduces gradually through 120m, 90m to 70m on approach to the crest curve at the proposed York Street overbridge. The 70m SSD is maintained over the new overbridge into the new signalised junction with the off-slip from Westlink to York Street (Link No. 5). This SSD is One Step below the Desirable Minimum for the selected Design Speed. Coming off the crest curve, the

SSD increases up to 215m, in excess of the Desirable Minimum value of 90m. The SSD subsequently reduces to 160m and then 120m at the tie in point with the existing alignment.

Travelling southbound from Dock Street the SSD on the link is 160m, in excess of the Desirable Minimum value required for the 60kph Design Speed. The SSD reduces gradually to 70m on approach to the crest curve at the proposed York Street overbridge. The 70m SSD is maintained over the new overbridge to a point above the Westlink to M3 underpass (Link No. 3), where it gradually increases to 160m, in excess of the Desirable Minimum value of 90m. The SSD subsequently reduces to 120m and then 90m at the tie in point with the existing alignment.

Transitions and Superelevation

Transitions have not been provided in accordance with TD 9/93 at four locations, due to the horizontal alignment constraints. A Departure from Standard would be required for the lack of entry/exit transitions to/from the right hand curve of 255m radius to the south of the proposed overbridge and for the lack of entry/exit transitions to/from the left hand curve of 360m radius to the north of the proposed overbridge.

Normal camber of 2.5% has been provided on the link with superelevation of 2.5% introduced at the proposed overbridge. The proposed superelevation would not meet the requirements of TD 9/93 at four locations due to the radii of the curves provided and the need to tie in with the existing alignment.

Combination Departures

The proposed combination of horizontal alignment, vertical alignment and SSD would fall below the requirements of paragraph 1.24 of TD 9/93 at four locations along the alignment and require Departures from Standard.

Reduced SSD and/or K Value over Junction Approaches

The combination of substandard SSD and/or K values over the identified approaches to junctions, including merge and diverge arrangements, would fall below the requirements of paragraph 1.26 of TD 9/93 at ten locations and require Departures from Standard.

Summary Departures from Standard TD 9/93

A summary of required Departures from Standard TD 9/93 for the link is included as Table 2.0 in **Appendix H**.

4.2.3.2.9 ***Link No. 15 (York Street to M2)***

Master String Location

The master string for Link No. 15 is situated on the nearside edge of lane 1, commencing at the central traffic island on the York Street (southbound) junction with Link No. 15 (Ch 0+000) and terminating at the back of merge nose with the M2 foreshore (Ch 0+252). All horizontal and vertical radii reported in the assessment of the link are relative to this master string.

Horizontal Alignment

The link's horizontal alignment is dictated by the location of the existing Dargan bridge piers, requiring substandard elements to be used in order to fit the alignment within the space available. The link commences with a left hand curve of 150m radius, at a position close to the priority junction for the southbound lane on York Street. The 150m radius is maintained under the Dargan Bridge, before transitioning into a straight as the link continues toward Dock Street overbridge. On approach to Dock Street, the alignment matches the existing left hand curve on the M2, with a horizontal radius of approximately 585m.

Vertical Alignment

The vertical alignment of the link is constrained by the requirement for headroom over the underlying Westlink to M2 link (Link No. 1) at the start of the alignment and the subsequent requirement to achieve headroom to the Dargan Bridge over a short (70m) distance between the two structures. The link commences with a short crest curve with a K value of 10, before changing to a sag curve with a K value of 9. A change in Design Speed from 60kph to 70kph at approximately Ch 0+025 means the sag curve would increase from One Step to Two Steps below Absolute Minimum. The sag curve is necessary to achieve the required headroom under the Dargan Bridge. Beyond the Dargan Bridge, the alignment transitions into an uphill gradient of approximately 3.8% before tieing into the existing alignment over Dock Street Bridge with a crest curve (K value of 30).

Stopping Sight Distance

Stopping Sight Distance (SSD) on the link is limited initially by the width of the nearside verge and the presence of the existing Dargan Bridge piers to 70m. Given the change in Design Speed from 60kph to 70kph the SSD is a maximum of Two Steps below the Desirable Minimum value. As the link rises beyond the Dargan Bridge the SSD increases to a maximum of 160m, in excess of the Desirable Minimum value for the 70kph Design Speed. On approach to the Dock Street Bridge, the SSD reduces through 120m to 90m at the tie in with the existing M2 foreshore, due to the existing crest curve.

Transitions and Superelevation

Transitions have been provided on the link where possible in accordance with TD 9/93. However, an entry transition to the 585m left hand curve has not been provided due to the horizontal alignment constraints. This would require a Departure from Standard.

Superelevation on the link has been limited to 2.5% and a Departure from Standard TD 9/93 (Table 3) would be required at the location of the 150m left hand curve and at the location of the tie in with the existing alignment.

Combination Departures

The proposed combination of horizontal alignment, vertical alignment and SSD would fall below the requirements of paragraph 1.24 of TD 9/93 at six locations along the alignment and require Departures from Standard.

Reduced SSD and/or K Value over Junction Approaches

The combination of substandard SSD and/or K values over the identified approaches to junctions, including merge and diverge arrangements, would fall below the requirements of paragraph 1.26 of TD 9/93 at eight locations and require Departures from Standard.

Summary Departures from Standard TD 9/93

A summary of required Departures from Standard TD 9/93 for the link is included as Table 2.0 in **Appendix H**.

4.2.3.2.10 *Link No. 31 (Corporation Street to Westlink)*

Master String Location

The master string for Link No. 31 is situated on the offside edge of lane 1, commencing on Duncrue Street (Ch 0+000) and terminating at the back of merge nose with Link No. 2 (Ch 0+326). All horizontal and vertical radii reported in the assessment of the link are relative to this master string.

Horizontal Alignment

The link's horizontal alignment is dictated by the need to complete a 180° turn from Duncrue Street onto the new slip road (Link No. 31) that merges onto the M2 to Weslink link (Link No. 2). The horizontal alignment of this loop arrangement is restricted by the available cross-section between the M2 motorway and the Harbour Estate. The link commences with a left hand curve of 131m radius, to tie in with the proposed junction arrangement on Duncrue Street. This radius is Two Steps below the Desirable Minimum value for the 60kph Design Speed. The alignment continues into the loop arrangement with a left hand curve of 17m radius and would require a Departure from Standard. On the exit from the loop, a left hand curve of 720m is introduced, followed by a right hand curve of 720m which transitions into a straight prior to tie in with the back of merge nose with Link No. 2. The 720m radius curves are in excess of the Desirable Minimum for the selected Design Speed.

Vertical Alignment

The vertical alignment commences with an uphill gradient of 0.5% away from Duncrue Street. This gradient is maintained through the loop arrangement for a length of 100m. The alignment transitions into a sag curve with a K value of 15, in excess of the Absolute Minimum value for the 60kph Design Speed. A further uphill gradient of 3.5% is introduced at this point, followed by a crest curve with a K value of 30. This curve is in excess of the Desirable Minimum value for the selected Design Speed. On approach to the merge nose an uphill gradient of 2.5% is introduced to tie in with the proposed vertical alignment on the adjacent Link No. 2 mainline.

Stopping Sight Distance

Stopping Sight Distance (SSD) on the link is limited initially by the proposed loop arrangement, however visibility has been maintained across the nearside verge. From the proposed stop line on Duncrue Street, a SSD of 50m is achieved through to the mid-point of the loop at which point the SSD increases quickly to a minimum of 120m, in excess of the Desirable Minimum value for the 60kph Design Speed. The 50m SSD is Two Steps below the Desirable Minimum value and would require a Departure from Standard due to the proximity to the junction at Duncrue Street.

Transitions and Superelevation

Transitions have not been provided in accordance with TD 9/93 at two locations, due to the horizontal alignment constraints. A Departure from Standard would be required for the lack of entry/exit transitions to/from the left hand curve of 17m radius on the proposed loop arrangement.

Superelevation on the link has been limited to 2.5% and would require a Departure from Standard. The proposed superelevation would not meet the requirements of Table 3 of TD 9/93 at the location of the 17m left hand curve and at the location of the tie in with the existing Duncrue Street alignment.

Combination Departures

The proposed combination of horizontal alignment, vertical alignment and SSD would fall below the requirements of paragraph 1.24 of TD 9/93 at two locations along the alignment and require Departures from Standard.

Reduced SSD and/or K Value over Junction Approaches

The combination of substandard SSD and/or K values over the identified approaches to junctions, including merge and diverge arrangements, would fall below the requirements of paragraph 1.26 of TD 9/93 at two locations and require Departures from Standard.

Summary Departures from Standard TD 9/93

A summary of required Departures from Standard TD 9/93 for the link is included as Table 2.0 in **Appendix H**.

4.2.3.3 *Cross-Sections*

4.2.3.3.1 *Link No. 1 (Westlink to M2)*

Based on the projected traffic flows and the purpose of the link as an interchange link connector road from an urban all-purpose road, the link would be classified as IL2D in accordance with Table 3/1a of Design Standard TD 22/06. This requires the provision of a two lane interchange link with hardstrip.

With reference to Figure 4-4b of Design Standard TD 27/05, the required cross-section is therefore:

- 1 no. 1.0m wide nearside hardstrip
- 2 no. 3.65m wide traffic lanes
- 1 no. 0.3m wide offside hardstrip
- minimum 2m wide verges where communications ducting and chambers are provided.

The proposed cross-section on the link comprises, in summary:

- 1 no. 300mm wide nearside hardstrip, with a 1m wide nearside hardstrip provided in the proposed Westlink to M2 underpass
- 2 no. 3.65m wide traffic lanes, with 4 no. 3.3m lanes between North Queen Street Bridge and York Street
- 1 no. 300mm wide offside hardstrip, which is maintained through the proposed Westlink to M2 underpass
- nearside paved verges with a typical width of 1.5m, reducing to 1.05m at constrained positions
- offside paved verges with a typical width of 1.5m.

A 1m wide nearside hardstrip and full width 3.65m lanes cannot be provided on the Westlink mainline between North Queen Street bridge and York Street due to the limited space available to the rear of the residential properties along Little George's Street and the proposed retaining solution at this location. For this reason, the existing 300mm nearside hardstrip on

North Queen Street bridge has been maintained on the proposed widened structure with 3.3m wide lanes. Over the extent of the proposed underpass, a minimum paved width of 8.6m is maintained, with the New Construction Headroom of 5.3m (in addition to sag curve compensation). The proposed minimum verge width of 1.05m matches the verge provision on the recently completed Broadway and Grosvenor Road underpasses, which also housed communications ducting.

As the proposed provision does not match the requirements of TD 27/05, a Departure from Standard would be required.

A summary of required Departures from Standard TD 27/05 for the link is included as Table 3.0 in **Appendix H**.

4.2.3.3.2 *Link No. 2 (M2 to Westlink)*

Based on the projected traffic flows and the purpose of the link as an interchange link connector road from an urban motorway, the link would be classified as IL2B in accordance with Table 3/1b of Design Standard TD 22/06. This requires the provision of a two lane interchange link with urban hard shoulder.

With reference to Figure 4-2b of Design Standard TD 27/05, the required cross-section is therefore:

- 1 no. 2.75m wide hard shoulder
- 2 no. 3.65m wide traffic lanes
- 1 no. 300mm wide offside hardstrip
- minimum 2m wide verges where communications ducting and chambers are provided.

The proposed cross-section on the link comprises, in summary:

- 1 no. 2.75 wide hard shoulder, reducing to a 700mm wide hardstrip at the pinch point under the Lagan Bridge
- 2 no. 3.65m wide traffic lanes, with lane one widening to 3.7m from the merge nose with Link No. 4 and an additional nearside weaving lane (3.7m wide) between Link No. 4 and Clifton Street
- 1 no. offside hardstrip, of width 700mm, reduces to a minimum of 300mm at diverge nose from existing M2
- nearside paved verges with a typical width of 1.5m to 2.5m, reducing to 1.05m at constrained positions
- offside paved verges with a typical width of 2.0m, reducing to 1.0m at constrained positions.

Where the proposed provision falls below the minimum requirements, it is due to the constraints imposed on the depressed section as it passes between the substructure of the existing Lagan Bridge. Over the extent of this pinch point, a paved width of 8.7m is maintained with the required New Construction Headroom of 5.3m (in addition to sag curve compensation).

As the proposed provision does not match the requirements of TD 27/05, a Departure from Standard would be required.

A summary of required Departures from Standard TD 27/05 for the link is included as Table 3.0 in **Appendix H**.

4.2.3.3.3 *Link No. 3 (Westlink to M3)*

Based on the projected traffic flows and the purpose of the link as an interchange link connector road from an urban all-purpose road, the link would be classified as IL2D in accordance with Table 3/1a of Design Standard TD 22/06. This requires the provision of a two lane interchange link with hardstrip.

With reference to Figure 4-4b of Design Standard TD 27/05, the required cross-section is therefore:

- 1 no. 1.0m wide nearside hardstrip
- 2 no. 3.65m wide traffic lanes
- 1 no. 300mm wide offside hardstrip
- minimum 2m wide verges where communications ducting and chambers are provided.

The proposed cross-section on the link comprises, in summary:

- 1 no. 3.3m wide hard shoulder
- 1 no. 3.7m wide traffic lane, with curve widening to 3.95m
- 1 no. 1.0m wide offside hardstrip, reducing to a width of 300mm
- nearside paved verge with a typical width of 1.5m, reducing to a minimum of 1.4m
- offside paved verge with a typical width of 5m (for forward visibility), with a minimum of 1.05m provided.

Provision of two full width traffic lanes with a 1m nearside hardstrip cannot be achieved on the link due to the constraints imposed by the substructure of the existing Dargan/Lagan Bridges. Consequently, a single lane has been provided with a full width hard shoulder in accordance with classification IL1D (Figure 4-4b of TD 27/05). The proposed minimum verge width of 1.05m matches the verge provision on the recently completed Broadway and Grosvenor Road underpasses, which also housed communications ducting.

In addition, the available headroom at the back of the nearside verge beneath the Lagan Bridge would fall below the New Construction Headroom value required (5.3m) within Design Standard TD 27/05. A minimum value of 5.162m is provided and it should be noted that whilst this is below the New Construction Headroom value it is considerably larger than the Maintained Headroom value (5.03m).

As the proposed provision does not match the requirements of TD 27/05, a Departure from Standard would be required.

A summary of required Departures from Standard TD 27/05 for the link is included as Table 3.0 in **Appendix H**.

4.2.3.3.4 ***Link No. 4 (M3 to Westlink)***

Based on the projected traffic flows and the purpose of the link as an interchange link connector road from an urban motorway, the link would be classified as IL2B in accordance with Table 3/1b of Design Standard TD 22/06. This requires the provision of a two lane interchange link with urban hard shoulder.

With reference to Figure 4-2b of Design Standard TD 27/05, the required cross-section is therefore:

- 1 no. 2.75m wide hard shoulder
- 2 no. 3.65m wide traffic lanes
- 1 no. 300mm wide offside hardstrip
- minimum 2m wide verges where communications ducting and chambers are provided.

The proposed cross-section on the link comprises, in summary:

- 1 no. 3.3m wide hard shoulder, reducing to 2.3m at constrained positions
- 1 no. 3.7m wide traffic lane
- 1 no. 300mm wide offside hardstrip
- nearside paved verges with a typical width of 2m (minimum of 1.5m at Dargan Bridge)
- offside paved verge with a typical width of 1.5m.

Given the limitations on the southbound capacity of the Westlink, it is only possible to provide a single lane gain and therefore the number of traffic lanes on the new underpass below York Street is restricted. Accordingly, a single lane with hard shoulder has been provided in accordance with classification IL1B (Figure 4-2b of TD 27/05). Over the extent of the pinch point (with the Dargan Bridge), a paved width of 6.3m is maintained.

As the proposed provision does not match the requirements of TD 27/05, a Departure from Standard would be required.

A summary of required Departures from Standard TD 27/05 for the link is included as Table 2.0 in **Appendix H**.

4.2.3.3.5 ***Link No. 5 (Westlink to York Street)***

Based on the projected traffic flows and the purpose of the link as a slip road connector road from an urban all-purpose road, the link would be classified as DG1D in accordance with Table 3/1a of Design Standard TD 22/06. This requires the provision of a single lane slip road with hard shoulder.

With reference to Figure 4-4b of Design Standard TD 27/05, the required cross-section is therefore:

- 1 no. 3.3m wide hard shoulder
- 1 no. 3.7m wide traffic lane

- 1 no. 300mm wide offside hardstrip
- minimum 2m wide verges where communications ducting and chambers are provided.

The proposed cross-section on the link comprises, in summary:

- 1 no. 3.3m wide nearside hard shoulder, reducing to a 300mm nearside hardstrip
- 1 no. 3.7m wide traffic lane that opens out into 2 no. 3.65m wide traffic lanes
- 1 no. 300mm wide offside hardstrip
- nearside paved verge with a typical width of 3m
- offside paved verge with a minimum width of 1.5m.

Based on projected traffic volumes, the link should comprise a single traffic lane in accordance with the requirements of TD 22/06. However, the proposed provision has been selected to meet the minimum requirements for a two lane slip road with hardstrip from TD 27/05, i.e. DG2F. This was considered necessary to mitigate the risk that queues on the off-slip at the signal controlled junction extend back onto the Westlink mainline.

As the proposed provision does not match the requirements of TD 27/05, a Departure from Standard would be required.

A summary of required Departures from Standard TD 27/05 for the link is included as Table 3.0 in **Appendix H**.

4.2.3.3.6 *Link No. 6 (Dock Street to M3)*

Based on the projected traffic flows and the purpose of the link as a slip road connector road to an urban motorway, the link would be classified as MG1B in accordance with Table 3/1b of Design Standard TD 22/06. This requires the provision of a single lane slip road with hard shoulder.

With reference to Figure 4-2b of Design Standard TD 27/05, the required cross-section is therefore:

- 1 no. 3.3m wide hard shoulder
- 1 no. 3.7m wide traffic lane
- 1 no. 300mm wide offside hardstrip
- minimum 2m wide verges where communications ducting and chambers are provided.

The proposed cross-section on the link comprises, in summary:

- 1 no. 300mm wide nearside hardstrip leading onto a 3.3m wide nearside hard shoulder
- 1 no. 3.7m wide traffic lane
- 1 no. 300mm wide offside hardstrip
- nearside paved verge with a minimum width of 2m, with verge widening to improve forward visibility

- offside paved verge with a typical width of 1.5m.

The proposed provision is largely in accordance with the requirements of TD 27/05, albeit that the offside verge width would not meet the minimum requirements of 2m for communications ducting and cabling. The proposed minimum verge width of 1.5m is in excess of the verge provision (1.05m) on the recently completed Broadway and Grosvenor Road underpasses, which also housed communications ducting.

As the proposed offside verge provision does not match the requirements of TD 27/05, a Departure from Standard would be required.

A summary of required Departures from Standard TD 27/05 for the link is included as Table 3.0 in **Appendix H**.

4.2.3.3.7 *Link No. 7 (M3 to York Street)*

Based on the projected traffic flows and the purpose of the link as a slip road connector road from an urban mototrway, the link would be classified as DG1B in accordance with Table 3/1b of Design Standard TD 22/06. This requires the provision of a single lane slip road with hard shoulder.

With reference to Figure 4-2b of Design Standard TD 27/05, the required cross-section is therefore:

- 1 no. 3.3m wide hard shoulder
- 1 no. 3.7m wide traffic lane
- 1 no. 300mm wide offside hardstrip
- minimum 2m wide verges where communications ducting and chambers are provided.

The proposed cross-section on the link comprises, in summary:

- 1 no. nearside hardstrip of 1.3m width, which tapers away to allow development of a second traffic lane
- 1 no. 4m wide traffic lane, opening to two lanes (both 3.65m wide) on approach to the junction with York Street (Link No. 11)
- 1 no. offside hardstrip of 1.0m width, which tapers away to allow development of a second traffic lane
- nearside paved verge in excess of 2m
- offside paved verge with a minimum width of 2m.

The proposed provision maintains a minimum paved width of 6.3m past the pinch point at the back of the diverge nose however, a Departure from Standard would be required.

A summary of required Departures from Standard TD 27/05 for the link is included as Table 3.0 in **Appendix H**.

4.2.3.3.8 *Link No. 11 (York Street (South) to York Street (North)*

The proposed provision for York Street is a single carriageway, with four northbound traffic lanes and a single southbound lane. With reference to Figure 4-4a of TD 27/05, it is noted that the standard detail for a single carriageway is the provision of 3.65m traffic lanes without hardstrips. However, as the proposed horizontal alignment is reasonably straight, it is proposed to reduce northbound lane widths below the standard 3.65m to 3.25m on the proposed York Street overbridge structure. The proposed 3.25m width has been selected as it is the Desirable Minimum width prescribed by the legal requirements of Chapter 8 of the Traffic Signs Manual for traffic lanes being used by all vehicle types under any future temporary traffic management arrangements. The proposed lane width is within the 3-3.65m range permitted by TD 50/04 for signal controlled junctions. Hardstrips are not proposed.

With regard to the southbound lane a width of 3.5m has been selected over the majority of the link, with a minimum proposed lane width of 3m at the pinch point north of Galway House where an adjacent 1.5m cycleway is also proposed. However, at the location of the proposed York Street overbridge, where the southbound lane becomes a dedicated bus lane into the city centre, a minimum lane width of 3.5m has been selected. This would provide sufficient space, in conjunction with the proposed adjacent separation strip (1.6m), for one bus to safely pass another that has broken down or stopped.

The lane width provision in both directions is necessary to limit the overall width of the structure to provide headroom to the underlying links and also serves to limit the cost of the structure.

A footway of 3m width is generally provided on both the eastern and western sides of the carriageway, with a minimum width of 2.4m at the pinch point close to the junction with Great Patrick Street. This provision is in excess of the recommended minimum (2m) in Design Standard HD 39/01, however it is considered appropriate given the potential for increased NMU demand in the area.

A Departure from Standard (from TD 27/05) would be required for the sub-standard lane widths in both directions along York Street.

A summary of required Departures from Standard TD 27/05 for the link is included as Table 3.0 in **Appendix H**.

4.2.3.3.9 *Link No. 15 (York Street to M2)*

Based on the projected traffic flows and the purpose of the link as a slip road connector road to a rural motorway, the link would be classified as MG2C in accordance with Table 3/1b of Design Standard TD 22/06. This requires the provision of a two lane slip road with hard shoulder.

With reference to Figure 4-1b of Design Standard TD 27/05, the required cross-section is therefore:

- 1 no. 3.3m wide hard shoulder
- 2 no. 3.65m wide traffic lanes
- 1 no. 1m wide offside hardstrip
- minimum 2m wide verges where communications ducting and chambers are provided.

The proposed cross-section on the link comprises, in summary:

- 1 no. 1m wide nearside hardstrip, increasing to a 3.3m hard shoulder beyond the Dargan Bridge
- 2 no. 3.65m wide traffic lanes, reducing to a single 3.7m traffic lane in accordance with TD 22/06 on approach to the back of the merge nose with Link No. 1
- 1 no. 300mm wide offside hardstrip
- nearside paved verge with a minimum width of 1.5m under the Dargan Bridge
- offside paved verge with a minimum width of 1.05m.

A hard shoulder cannot be provided under the Dargan Bridge within the width available between adjacent bridge piers. Therefore a hardstrip has been provided that widens out to a hard shoulder beyond the pinch point. The hard shoulder is continued to tie in with the existing hard shoulder on the M2 foreshore carriageway. Over the extent of this pinch point, a paved width of 8.6m is maintained with the required New Construction Headroom of 5.3m (in addition to sag curve compensation). The proposed minimum verge widths is equal to the verge provision on the recently completed Broadway and Grosvenor Road underpasses, which also housed communications ducting.

As the proposed provision does not match the requirements of TD 27/05, a Departure from Standard would be required.

A summary of required Departures from Standard TD 27/05 for the link is included as Table 3.0 in **Appendix H**.

4.2.3.3.10 *Link No. 31 (Duncrue Street to Westlink)*

Based on the projected traffic flows and the purpose of the link as a slip road connector road to an urban all-purpose road, the link would be classified as MG1D in accordance with Table 3/1a of Design Standard TD 22/06. This requires the provision of a single lane slip road with hard shoulder.

With reference to Figure 4-4b of Design Standard TD 27/05, the required cross-section is therefore:

- 1 no. 3.3m wide hard shoulder
- 1 no. 3.7m wide traffic lane
- 1 no. 300mm wide offside hardstrip
- minimum 2m wide verges where communications ducting and chambers are provided.

The proposed cross-section on the link comprises, in summary:

- 1 no. 1m wide nearside hardstrip, increasing to a 3.3m hard shoulder beyond the loop arrangement
- 1 no. 3.7m wide traffic lane, with curve widening to 6.6m
- 1 no. 300mm wide offside hardstrip
- nearside paved verge with a minimum width of 2m

- offside paved verge with a typical width of 2m, reducing to a minimum of 0.58m.

The proposed provision is largely in accordance with the requirements of TD 27/05, albeit that the offside verge width would not meet the minimum requirements of 2m for communications ducting and cabling over a portion of the link. It is not anticipated that any communications ducting or cabling would be required at this location however, as the proposed provision does not match the requirements of TD 27/05, a Departure from Standard would be required.

A summary of required Departures from Standard TD 27/05 for the link is included as Table 3.0 in **Appendix H**.

4.2.3.4 *Junction Layouts*

4.2.3.4.1 *Grade Separation Provision*

The Proposed Scheme is a full interchange as movements between the three mainlines are grade separated.

4.2.3.4.2 *Clifton Street/Westlink Merge (Link No. 1)*

Merge Type

The Clifton Street on-slip is retained along with the existing lane gain onto the Westlink mainline (Link No. 1). With reference to Figure 2/3AP of TD 22/06, based on the projected traffic flows on the Link No. 1 mainline and the merging flows from Clifton Street, a type E lane gain to Figure 2/4.3 of TD 22/06 is the required provision, and therefore is compliant with standards. Furthermore, in accordance with TD 22/06, two lanes are provided upstream and three lanes downstream of the junction.

Merge Layout

The lane gain layout is set out in accordance with the geometric requirements of Table 4/3 of TD 22/06 for an urban road with a speed limit of 50mph or less, comprising a 40m long nose with a minimum nose ratio of 1:12. The existing geometric layout of the junction provides a nose length of 40m, however the nose ratio falls below the requirements, with a ratio of 1:16, consequently a Departure from Standard would be required.

A straight alignment of 40m length has been maintained in advance of the back of the merge in accordance with the requirements of paragraph 2.34 of TD 22/06.

Spacing to Adjacent Junctions

With regard to the requirements of paragraph 4.30 of TD 22/06 in relation to the spacing of successive merges or diverges on a connector road or mainline within an interchange, it is noted that the distance between the tip of the northbound diverge nose to Clifton Street and the retained northbound merge nose from Clifton Street is approximately 480m. This exceeds the 318.75m minimum requirement for the 85kph Design Speed over the majority of this location as per the requirements of paragraph 4.30 of TD 22/06.

Weaving Sections

The provision of the merge from Clifton Street creates a weaving section in conjunction with the downstream York Street diverge. The assessment of this weaving section is included in the assessment of the York Street diverge arrangement reported in **Section 4.2.3.4.3**.

SSD on Merge Arrangement

With regard to the provisions for SSD over the merge arrangement under TD 22/06, the requirement for unobstructed SSD (90m) along the connector road until the driver's eye is square with the back of nose is not met. Along the mainline, from the back of merge nose, the SSD also reduces below the Desirable Minimum (120m) due to the existing crest curve on the link. A Departure from Standard would be required.

Summary Departures from Standard

A summary of required Departures from Standard TD 22/06 for the junction is included as Table 4.0 in **Appendix H**.

4.2.3.4.3 ***Westlink/York Street Diverge (Link Nos. 1/5)***

Diverge Type

With regard to the layout of the diverge from Westlink to York Street (Link No. 5), based on the projected traffic flows on the Link No. 1 mainline and the diverging flows to York Street, with reference to Figure 2/5AP of TD 22/06, a type A taper diverge to Figure 2/6.1 of TD 22/06 should be provided. In addition, it is recommended that two lanes are provided on the mainline (Link No. 1) both upstream and downstream of the junction. The recommended number of lanes has been provided downstream; however, three upstream lanes are provided due to the single lane drop (similar to a type E two lane drop to Figure 2/6.4 of TD 22/06) diverge layout proposed to tie in with the existing lane gain from Clifton Street. This diverge arrangement would reduce the overall number of lanes on the mainline, which is necessary due to the geometry constraints downstream at the Dargan Bridge substructure. The proposed provision would require a Departure from Standard.

Diverge Layout

The lane drop layout is subject to the geometric requirements of Table 4/4 of TD 22/06 for an urban road with a speed limit of 50mph or less, comprising:

- a 40m long nose with a minimum nose ratio of 1:12
- a minimum 1000m radius on the edge line at the tip of the diverge nose.

In the proposed layout, a minmum 1000m radius on the edge line at the tip of diverge nose cannot be achieved and would require a Departure from Standard. All other geometry elements in the diverge layout have been provided in accordance with the above requirements.

A near straight alignment of 40m length has also been provided beyond the back of the diverge in accordance with the requirements of paragraph 2.46 of TD 22/06.

Spacing to Adjacent Junctions

The requirements of paragraph 4.30 of TD 22/06 do not apply to this scenario.

Weaving Sections

Identified Weaving Sections

The lane gain from Clifton Street, in conjunction with the diverge to York Street (Link No. 5) creates a weaving section on the Westlink mainline. Under TD 22/06, the process for designing a weaving section between merge and diverge layouts is to first determine the weaving flows and use this information to establish an actual weaving length that must be provided. Once this actual weaving length is determined, it is used with the weaving flows to calculate the number of lanes required over that weaving section. It should be noted that in accordance with TD 22/06, even the lowest weaving flow has an impact on traffic demand of up to three times its numerical value.

A calculation of the weaving flows has been completed based on origin/destination survey data obtained by URS in 2013.

Calculation of Actual Weaving Length

The length available for weaving is constrained by the close proximity of the Clifton Street on-slip to the diverge to York Street (Link No. 5). In accordance with Figure 4/10 of TD 22/06, the weaving section on the northbound carriageway comprises the Absolute Minimum weaving length of 170m for the selected Design Speed of 70kph, in addition to the required “d” distance of 50m, creating a total 220m weaving length between opposing merge/diverge noses.

The Desirable Minimum weaving length (L_{min}) was calculated using the total weaving flow and Figure 4/14 in TD 22/06. This indicates that the Desirable Minimum weaving length would be much less than the Absolute Minimum weaving length of approximately 170m and as such the use of the Absolute Minimum weaving length would appear to be compliant with standards.

Calculation of Number of Lanes on Weaving Section

In accordance with paragraph 2.67 and 2.71 of TD 22/06, the number of lanes required over the weaving section was calculated. This indicated that two lanes should be provided over the weaving section to facilitate weaving movements over the provided weaving length. A total of three lanes have been provided on this weaving section, with the nearside lane diverging to York Street as a proposed lane drop. A Departure from Standard with be required.

SSD on Diverge Arrangement

With regard to the provisions for SSD over the diverge arrangement under TD 22/06, the requirement for unobstructed SSD to a point 120m downstream of the back of the diverge nose is met, along with the requirement for a 90m SSD 30m downstream of the back of the nose.

All other SSD requirements have been considered in the respective alignment SSD assessments, with Departures from Standard TD 9/93 identified where necessary.

Summary Departures from Standard

A summary of required Departures from Standard TD 22/06 for the junction is included as Table 4.0 in **Appendix H**.

4.2.3.4.4 *Westlink/M3 Diverge (Link Nos. 1/3)*

Diverge Type

The proposed location of the diverge from the Westlink to the M3 is on the offside of Link No. 1. This reflects the existing junction arrangement whereby traffic intending to travel onwards to the M3 must diverge on the offside of lane 2 on the Westlink on approach to the York Street junction.

It is noted that the provision of offside diverges are not recommended, but not prohibited, by paragraph 2.10 of TD 22/06. In order to provide a grade separated movement between the

Westlink and M3, given the horizontal and vertical alignment of adjacent links, an offside diverge is the only feasible solution.

Based on the projected traffic flows on the Link No. 1 mainline and the diverging flows to the M3, with reference to Figure 2/5AP of TD 22/06, a type D lane drop layout should be provided. In addition, it is recommended that on the mainline three lanes are provided upstream and two lanes downstream of the junction. However, given the constraints on carriageway width, it is not possible to provide a lane drop. Instead, with reference to Figure 2/6.1 of TD 22/06, a single lane parallel diverge (similar to type B Option 2) has been provided. An auxiliary lane has been provided in accordance with paragraph 4.29 of TD 22/06. This provision would require a Departure from Standard.

Diverge Layout

The single lane parallel diverge layout is subject to the geometric requirements of Table 4/4 of TD 22/06 for an urban road with a speed limit of 50mph or less, comprising:

- a 75m exit taper
- a 100m (minimum) auxiliary lane
- a 40m long nose with a minimum nose ratio of 1:12
- a minimum 1000m radius on the edge line at the start of the taper
- a minimum 1000m radius on the edge line at the tip of the diverge nose.

In order to maximise the length of the auxilliary lane (135m), an exit taper of 10m is provided, requiring a Departure from Standard. The diverge nose provided exceeds the 40m length required, however the 1:12 nose ratio is achieved. A minimum 1000m radius on the edge line at the start of the taper and at the tip of the diverge nose cannot be achieved. A Departure from Standard would be required.

A near straight alignment of 40m length has also been provided beyond the back of the diverge in accordance with the requirements of paragraph 2.46 of TD 22/06.

Spacing to Adjacent Junctions

With regard to the requirements of paragraph 4.30 of TD 22/06 in relation to the spacing of successive merges or diverges on a connector road or mainline within an interchange, it is noted that the distance between the tip of the diverge nose to York Street and the tip of the offside diverge nose to the M3 is approximately 45m. This is below the 262.5m minimum requirement for the 70kph Design Speed and would require a Departure from Standard.

It is also noteworthy that the proposed separation between the two diverge points is shorter than the Absolute Minimum weaving length for a standard nearside merge/diverge layout at a Design Speed of 70kph (170m).

Weaving Sections

The proposed layout requires any driver wishing to cross from Clifton Street on-slip to the M3 to use the provided 265m of carriageway to weave from lane 1 to lane 4 prior to the tip of the diverge nose to the M3 underpass.

The Highways Agency have confirmed, that in layouts such as that proposed, the distance between the lane gain from Clifton Street and the diverge to the M3 is not considered a weaving length as defined on Figures 2/9 and 4/9 to 4/14 inclusive of TD 22/06. Accordingly, the Highways Agency has confirmed that the weaving length calculations referred to in TD 22/06 cannot be applied to such layouts. Therefore, whilst the offside diverge layout with total weaving length of approximately 265m is not advised by TD 22/06, it is not subject to a Departure from Standard.

SSD on Diverge Arrangement

With regard to the provisions for SSD over the diverge arrangement under TD 22/06, the requirement for unobstructed SSD to a point 120m downstream of the back of the diverge nose is met.

All other SSD requirements have been considered in the respective alignment SSD assessments, with Departures from Standard TD 9/93 identified where necessary.

Summary Departures from Standard

A summary of required Departures from Standard TD 22/06 for the junction is included as Table 4.0 in **Appendix H**.

4.2.3.4.5 ***M2 Merge (Link No. 1)***

Merge Type

Based on the projected traffic flows on the M2 mainline and the merging flows from Link No. 1, with reference to Figure 2/3MW of TD 22/06, a type F lane gain with ghost island merge layout to Figure 2/4.4 of TD 22/06 would appear to be the preferred provision. However, ghost island merges are not permitted on urban roads in accordance with paragraph 2.28 of TD 22/06. In addition, it is recommended that on the mainline two lanes are provided upstream and three lanes downstream of the junction. The recommended number of upstream lanes have been provided; however, as it is proposed to provide a type E double lane gain merge layout similar to that shown in Figure 2/4.3 of TD 22/06 (due to the number of vehicles anticipated) four downstream lanes are proposed. The proposed provision would require a Departure from Standard.

Merge Layout

With the retention of the national speed limits on the M2 mainline northbound carriageway, its classification remains that of a rural motorway, i.e. a motorway not subject to a speed limit, as defined in TD 22/06. Therefore the double lane gain merge layout is subject to the geometric requirements of Table 4/3 of TD 22/06 for a rural motorway within an interchange, comprising a 75m long nose with a minimum nose ratio of 1:25. The proposed merge arrangement has been designed to match the existing merge arrangement, to limit works. Accordingly, the existing nose length of 100m with a nose ratio of 1:25 has been maintained. This provision would require a Departure from Standard.

It is not possible to provide the required 75m long near straight on approach to the back of the merge nose in accordance with the requirements of paragraph 2.34 of TD 22/06, therefore a Departure from Standard would be required.

Spacing to Adjacent Junctions

With regard to the requirements of paragraph 4.30 of TD 22/06 in relation to the spacing of successive merges or diverges on a connector road or mainline within an interchange, it is noted that the distance between the tip of the diverge nose on Link No. 3 and the tip of the merge nose on Link No. 1 is approximately 420m, above the 262.5m minimum requirement for the 70kph Design Speed.

Weaving Sections

The alignment of the link is such that the merge from Link No. 1 matches the current position of the merge from York Street. Therefore the same weaving section between York Street and Fortwilliam is maintained with the same weaving length of approximately 1.9km. No Departures from Standard are considered necessary for maintaining the existing provision.

SSD on Merge Arrangement

With regard to the provisions for SSD over the merge arrangement under TD 22/06, the requirement for unobstructed SSD to a point 295m downstream of the back of the diverge nose (due to the 120kph Design Speed) is not met. A SSD of 160m is achieved at this location and a Departure from Standard would be required.

All other SSD requirements have been considered in the respective alignment SSD assessments, with Departures from Standard TD 9/93 identified where necessary.

Summary Departures from Standard

A summary of required Departures from Standard TD 22/06 for the junction is included as Table 4.0 in **Appendix H**.

4.2.3.4.6 *M2 Foreshore Diverge (Link No. 2)*

Diverge Type

Based on the projected traffic flows on the M2 mainline and the diverging flows to Link No. 2, with reference to Figure 2/5MW of TD 22/06, a type E two lane drop diverge should be provided in accordance with Figure 2/6.4 of TD 22/06. In addition, it is recommended that on the mainline four lanes are provided upstream and two lanes downstream of the junction. These requirements have been met.

Diverge Layout

With the introduction of a 50mph limit on the M2 mainline (from the off-slip to Duncrue Street), the classification of the M2 southbound carriageway becomes that of an urban motorway, i.e. a motorway with a speed limit of 60mph or less within a built up area, as defined in TD 22/06. Therefore, with reference to Table 4/4 of TD 22/06, the layout should comprise:

- a 40m long nose with a minimum nose ratio of 1:12
- a minimum 1000m radius on the edge line at the tip of the nose.

The required junction geometry has been provided in accordance with TD 22/06.

A 40m near straight has been provided beyond the back of the diverge nose, in accordance with the requirements of paragraph 2.46 of TD 22/06.

Spacing to Adjacent Junctions

The provision of the lane drop (Link No. 2) at the selected position reduces the distance between the lane drop to Duncrue Street and the existing lane drop to the Westlink by approximately 195m to approximately 400m (measured between tips of diverge noses). It should be noted that both are separate diverges that do not form part of the same interchange and are therefore not subject to minimum spacing distance requirements of TD 22/06.

Weaving Sections

No new weaving sections are created by the junction.

SSD on Diverge Arrangement

With regard to the provisions for SSD over the diverge arrangement under TD 22/06, the requirement for unobstructed SSD to a point 160m downstream of the back of the diverge nose (due to the 85kph Design Speed) cannot be met due to the vertical alignment of the link, which reduces the SSD to 120m. Therefore a Departure from Standard TD 22/06 would be required.

All other SSD requirements have been considered in the respective alignment SSD assessments, with Departures from Standard TD 9/93 identified where necessary.

Summary Departures from Standard

A summary of required Departures from Standard TD 22/06 for the junction is included as Table 4.0 in **Appendix H**.

4.2.3.4.7 *Duncrue Street/Westlink Merge (Link Nos. 31/2)*

Merge Type

Based on the projected traffic flows on the Link No. 2 mainline and the merging flows from Duncrue Street, with reference to Figure 2/3AP of TD 22/06, a type B parallel merge layout should be provided. In addition, it is recommended that two lanes are provided on the mainline (Link No. 2) both upstream and downstream of the junction. The recommended merge layout has been provided along with the recommended number of upstream and downstream lanes. A parallel merge has been provided to assist gap finding in the mainline flow and improve visibility.

Merge Layout

The parallel merge layout is subject to the geometric requirements of Table 4/3 of TD 22/06 for an urban road with a speed limit of 50mph or less, comprising:

- a 40m long nose with a minimum nose ratio of 1:12
- a 100m long auxiliary lane
- a 40m long auxiliary lane taper.

The proposed merge arrangement consists of a 75m long nose with a ratio of 1:13 and would require a Departure from Standard. An auxiliary lane of 185m is proposed, in excess of the minimum required, followed by a 40m long auxiliary lane taper.

A 40m near straight has been provided upstream of the back of the merge nose, in accordance with the requirements of paragraph 2.34 of TD 22/06.

Spacing to Adjacent Junctions

With regard to the requirements of paragraph 4.30 of TD 22/06 in relation to the spacing of successive merges or diverges on a connector road or mainline within an interchange, it is noted that the distance between the tip of the diverge nose on Link No. 2 and the merge nose on Link No. 31 is approximately 115m. This is less than the 262.5m minimum requirement for the 70kph Design Speed and a Departure from Standard would be required.

Weaving Sections

No new weaving sections are created by the junction.

SSD on Merge Arrangement

With regard to the provisions for SSD over the merge arrangement under TD 22/06, the requirement for unobstructed SSD to a point 120m downstream of the back of the diverge nose (due to the 70kph Design Speed) is met.

All other SSD requirements have been considered in the respective alignment SSD assessments, with Departures from Standard TD 9/93 identified where necessary.

Summary Departures from Standard

A summary of required Departures from Standard TD 22/06 for the junction is included as Table 4.0 in **Appendix H**.

4.2.3.4.8 ***Merge from M3 (Link No. 4)***

Merge Type

Based on the projected traffic flows on the Link No. 2 mainline and the merging flows from the M3, with reference to Figure 2/3AP of TD 22/06, a type G two lane gain with ghost island merge to Figure 2/4.5 of TD 22/06 would appear to be the preferred provision. In addition, it is recommended that two lanes are provided upstream of the junction and four lanes downstream. Ghost island merges are not permitted on urban roads in accordance with paragraph 2.28 of TD 22/06. Accordingly, it is proposed to provide a type E single lane gain merge layout to Figure 2/4.3 of TD 22/06 with two lanes upstream and three lanes downstream of the junction. This under provision would require a Departure from Standard.

Merge Layout

The lane gain merge layout is subject to the geometric requirements of Table 4/3 of TD 22/06 for an urban road with a speed limit of 50mph or less, comprising a 40m long nose with a minimum nose ratio of 1:12.

The proposed merge arrangement consists of a 47m long nose with a ratio of 1:10 and would require a Departure from Standard.

A 40m near straight has been provided upstream of the back of the merge nose, in accordance with the requirements of paragraph 2.34 of TD 22/06.

Spacing to Adjacent Junctions

With regard to the requirements of paragraph 4.30 of TD 22/06 in relation to the spacing of successive merges or diverges on a connector road or mainline within an interchange, it is noted that the distance between the tip of the merge nose from Link No. 4 and that of Link No.

31 is approximately 660m. This exceeds the 262.5m minimum requirement for the 70kph Design Speed.

Weaving Sections

The provision of the merge from the M3 creates a weaving section in conjunction with the downstream Clifton Street diverge. The assessment of this weaving section is included in the assessment of the Clifton Street diverge arrangement reported in **Section 4.2.3.4.9**.

SSD on Merge Arrangement

With regard to the provisions for SSD over the merge arrangement under TD 22/06, the requirement for unobstructed SSD to a point 120m downstream of the back of the diverge nose (due to the 70kph Design Speed) is met.

All other SSD requirements have been considered in the respective alignment SSD assessments, with Departures from Standard TD 9/93 identified where necessary.

Summary Departures from Standard

A summary of required Departures from Standard TD 22/06 for the junction is included as Table 4.0 in **Appendix H**.

4.2.3.4.9 *Westlink/Clifton Street Diverge (Link No. 2)*

Diverge Type

Based on the projected traffic flows on the Link No. 2 mainline and the diverging flows to Clifton Street, with reference to Figure 2/5AP of TD 22/06, a type C lane drop at taper diverge to Figure 2/6.2 of TD 22/06 would appear to be the preferred provision. In addition, it is recommended that three lanes are provided upstream of the junction and two lanes downstream. The required number of lanes has been provided; however, a single lane drop (similar to a type E two lane drop to Figure 2/6.4 of TD 22/06) is proposed. A Departure from Standard would be required.

Diverge Layout

The lane drop layout is subject to the geometric requirements of Table 4/4 of TD 22/06 for an urban road with a speed limit of 50mph or less, comprising:

- a 40m long nose with a minimum nose ratio of 1:12
- a minimum 1000m radius on the edge line at the tip of the diverge nose.

The existing geometric layout of the junction does not achieve the required standard, with a nose length of 35m and a ratio of 1:14. In addition, the required 1000m radii on the edge line at the tip of the diverge nose cannot be provided, with a 100m radius used in lieu. This would require a Departure from Standard TD 22/06.

A 40m near straight has been provided beyond the back of the diverge nose, in accordance with the requirements of paragraph 2.46 of TD 22/06.

Spacing to Adjacent Junctions

The diverge creates a weaving section, the assessment of which subsequently follows.

Weaving Sections

Identified Weaving Sections

The provision of the lane gain from Link No. 4 coupled with the proposed lane drop to Clifton Street creates a weaving section within the junction layout. Under TD 22/06, the process for designing a weaving section between merge and diverge layouts is to first determine the weaving flows and use this information to establish an actual weaving length that must be provided. Once this actual weaving length is determined, it is used with the weaving flows to calculate the number of lanes required over that weaving section. It should be noted that in accordance with TD 22/06, even the lowest weaving flow has an impact on traffic demand of up to three times its numerical value.

A calculation of the weaving flows has been completed based on origin/destination survey data obtained by URS in 2013.

Calculation of Actual Weaving Length

The length available for weaving is constrained by the proximity of the Clifton Street off-slip to the merge from the M3 (Link No. 4). In accordance with Figure 4/10 of TD 22/06, the weaving section on the southbound carriageway is 243m in length (greater than the Absolute Minimum weaving length of 170m for the selected Design Speed of 70kph), in addition to the required “d” distance of 50m, creating a total 293m weaving length between opposing merge/diverge noses.

The Desirable Minimum weaving length (L_{min}) was calculated using the total weaving flow and Figure 4/14 in TD 22/06. This indicates that the Desirable Minimum weaving length would be less than the Absolute Minimum weaving length of approximately 170m and as such the use of the Absolute Minimum weaving length would appear to be compliant with standards.

Calculation of Number of Lanes on Weaving Section

In accordance with paragraph 2.67 and 2.71 of TD 22/06, the number of lanes required over the weaving section was calculated. This indicated that three lanes should be provided over the weaving section to facilitate weaving movements over the provided weaving length. A total of three lanes have been provided on this weaving section, with the nearside lane diverging to Clifton Street as a proposed lane drop.

SSD on Diverge Arrangement

With regard to the provisions for SSD over the diverge arrangement under TD 22/06, the requirement for unobstructed SSD to a point 120m downstream of the back of the diverge nose is not met, however the requirement for a 90m SSD 30m downstream of the back of the nose is achieved. A Departure from Standard would be required for the substandard element.

All other SSD requirements have been considered in the respective alignment SSD assessments, with Departures from Standard TD 9/93 identified where necessary.

Summary Departures from Standard

A summary of required Departures from Standard TD 22/06 for the junction is included as Table 4.0 in **Appendix H**.

4.2.3.4.10 *Dock Street to M3 Merge (Link Nos. 6/3)*

Merge Type

Based on the projected traffic flows on Link No. 3 and the merging flows from Link No. 6, with reference to Figure 2/3MW of TD 22/06, a type E lane gain to Figure 2/4.3 of TD 22/06 is required, with a single mainline lane upstream of the junction and two lanes downstream. The proposed provision is compliant with standards.

Merge Layout

The layout requirement for the lane gain is, with reference to Table 4/3 of TD 22/06, a nose of 40m in length with a minimum angle of 1:12. The required nose length has been provided with a nose ratio of 1:3 to suit the alignment of the merging slip road. The nose ratio is is in excess of the minimum value required and is considered to provide a suitable means for vehicles to negotiate the change in direction. A Departure from Standard is not considered necessary. A 40m near straight cannot be provided upstream of the back of the merge nose, in accordance with the requirements of paragraph 2.34 of TD 22/06, requiring a Departure from Standard.

Spacing to Adjacent Junctions

With regard to the requirements of paragraph 4.30 of TD 22/06 in relation to the spacing of successive merges or diverges on a connector road or mainline within an interchange, it is noted that the distance between the tip of the diverge nose on Link No. 3 and the tip of the merge nose from Link No. 6 is approximately 305m, in excess of the 262.5m minimum requirement for the 70kph Design Speed. Similarly, the Link No. 3/Link No. 6 merge is approximately 305m upstream of the tip of the merge nose onto the Lagan Bridge, in excess of the 262.5m minimum requirement for the 70kph Design Speed.

Weaving Sections

No weaving sections are created by the junction.

SSD on Merge Arrangement

The requirements for SSD on approach to the merge arrangement on both the mainline and connector road have been considered in their respective alignment SSD assessments, with Departures from Standard TD 9/93 identified where necessary.

Summary Departures from Standard

A summary of required Departures from Standard TD 22/06 for the junction is included as Table 4.0 in **Appendix H**.

4.2.3.4.11 *M3 to York Street Diverge (Link No. 7)*

Diverge Type

Based on the projected traffic flows on the Link No. 4 mainline and the diverging flows to York Street, with reference to Figure 2/5MW of TD 22/06, a type A taper diverge to Figure 2/6.1 of TD 22/06 is required, with two mainline lanes upstream of the junction and a single lane downstream. The recommended number of lanes has been provided; however, a type D lane drop at parallel diverge is proposed, similar to Figure 2/6.3 of TD 22/06, which would require a Departure from Standard.

Diverge Layout

The lane drop at parallel diverge layout should be set out in accordance with the geometric requirements of Table 4/4 of TD 22/06 for an urban road with a speed limit of 50mph or less, comprising:

- a 40m long auxiliary lane taper
- a 100m long auxiliary lane
- a 40m long nose with a minimum nose ratio of 1:12
- a minimum 1000m radius on the edge line at the start of the taper
- a minimum 1000m radius on the edge line at the end of the taper
- a minimum 1000m radius on the edge line at the tip of the diverge nose.

Within the space available under the Dargan Bridge, the required 40m nose has been provided at a nose ratio of 1:6; however, the required length of taper and auxiliary lane are substandard at 15m and 40m respectively. In addition, the minimum radii on the edge line cannot be provided at the required locations. A Departure from Standard would be required.

The required near straight of 40m length beyond the back of the diverge nose has not been provided in accordance with the requirements of paragraph 2.46 of TD 22/06, therefore requiring a Departure from Standard.

Spacing to Adjacent Junctions

The distance between the tip of the diverge nose for the interchange link, on the Lagan Bridge, and the tip of the diverge nose to York Street is 225m, below the 262.5m minimum requirement for the selected 70kph Design Speed on the connector road. Therefore a Departure from TD 22/06 would be required.

The spacing between the tip of the diverge nose to York Street and the back of the merge nose with Link No. 2 is approximately 318.75m, exceeding the 262.5m minimum requirement for the selected Design Speed.

Weaving Sections

No new weaving sections are created by the junction.

SSD on Diverge Arrangement

With regard to the provisions for SSD over the diverge arrangement under TD 22/06, the requirement for unobstructed SSD to a point 120m downstream of the back of the diverge nose is met, along with the requirement for a 90m SSD 30m downstream of the back of the nose.

All other SSD requirements have been considered in the respective alignment SSD assessments, with Departures from Standard TD 9/93 identified where necessary.

Summary Departures from Standard

A summary of required Departures from Standard TD 22/06 for the junction is included as Table 4.0 in **Appendix H**.

4.2.3.4.12 *M2 Merge (Link No. 15)*

Merge Type

Based on the projected traffic flows on the M2 mainline and the merging flows from Link No. 15, with reference to Figure 2/3MW of TD 22/06, a type F lane gain with ghost island merge layout to Figure 2/4.4 of TD 22/06 would appear to be the preferred provision, comprising two lanes upstream of the junction and three lanes downstream. Ghost island merges are not permitted on urban roads in accordance with paragraph 2.28 of TD 22/06, therefore it is proposed to provide a two lane urban lane gain comparable to a type D/E layout similar to that shown in Figure 2/4.2 and 2/4.3 of TD 22/06. Four upstream lanes and five downstream lanes have been provided to match the existing provision. A Departure from Standard would be required.

Merge Layout

With the retention of the national speed limits on the M2 mainline northbound carriageway, its classification remains that of a rural motorway, i.e. a motorway not subject to a speed limit, as defined in TD 22/06. Therefore, with reference to Table 4/3 of TD 22/06 and Figure 10-4 of the Traffic Signs Manual Chapter 5, the layout should reflect that of a rural motorway within an interchange, comprising:

- a slip road reduction taper of between 1:40 (preferred minimum) and 1:30 (absolute minimum)
- a full reduction in lane width (to single lane) achieved 50m in advance of the back of merge nose
- a 75m long nose with a minimum nose ratio of 1:25

A 75m long nose with a nose ratio of 1:18 is proposed, however the slip road reduction taper has a ratio of 1:33 which in accordance with Table 4/3 of TD 22/06 would require a Departure from Standard.

The large radius required to provide a near straight of 75m length in advance of the back of merge nose cannot be achieved due to the 120kph Design Speed. A Departure from Standard would be required with reference to the requirements of paragraph 2.34 of TD 22/06.

Spacing to Adjacent Junctions

With regard to the requirements of paragraph 4.30 of TD 22/06 in relation to the spacing of successive merges on a connector road or mainline within an interchange, it is noted that the distance between the tip of the merge nose from Link No. 1 and that of Link No. 15 is approximately 118m, below the 450m minimum requirement for the 120kph mainline Design Speed. This is the maximum possible without widening the M2 northbound carriageway on the western side, which is not considered feasible. Therefore a Departure from Standard would be required.

Weaving Section

The alignment of the Link Is such that the merge from Link No. 15 is positioned approximately 118m north of the present merge from York Street. Therefore the same weaving section between York Street and Fortwilliam is maintained with a slightly reduced weaving length of approximately 1.8km. A Departure from Standard would be required for the reduction below 2km, the Desirable Minimum weaving length for a Rural Motorway, in accordance with paragraph 4.35 of TD 22/06.

<u>SSD on Merge Arrangement</u>

The requirements for SSD on approach to the merge arrangement has been considered in the respective alignment SSD assessment, with Departures from Standard TD 9/93 identified where necessary.

<u>Summary Departures from Standard</u>

A summary of required Departures from Standard TD 22/06 for the junction is included as Table 4.0 in **Appendix H**.

4.2.3.4.13 *Nelson Street Left-In/Left-Out Junction on Link No. 7*

In order to maintain access to existing properties on Nelson Street (south of the junction with Link No. 7) it is proposed to convert this remaining section of Nelson Street to two-way running and introduce a left-in/ left-out junction arrangement on Link No. 7. It is proposed to reduce the number of lanes along this section to one lane in either direction, with the southbound lane opening out to two lanes at Dunbar Link. Existing accesses along this section of Nelson Street (to Little Patrick Street) would be modified and maintained. The introduction of two-way running along this stretch would require some works to the existing junction on Dunbar Link to provide a right-turning facility and to ease the corner radius for the eastbound movement on Great Patrick Street. It is not proposed to provide physical separation between the flows.

Each of these access arrangements have taken cognisance of the relevant requirements of TD 41/95 and TD 42/95, in relation to the design of priority junctions and the requirements of TD 50/04, relevant to signal controlled junctions. Where specific Departures from Standard TD 41/95, TD 42/95 or TD 50/04 have been identified, these are included in **Appendix H** as Table 5.0.

4.2.3.4.14 *Access to Pumping Station*

In order to maintain access to lands at Shipbuoy Street/ Nile Street (location of proposed pumping station), it is proposed to construct a new access road located underneath the Lagan Bridge and Dargan Bridge. The access road would be aligned around the piers of these bridges and connect to Corporation Street at the existing entrance to the Transport NI Corporation Street car parks. These existing car parks would be closed to provide the necessary land for the access.

Where specific Departures from Standard TD 41/95 have been identified, these are included in **Appendix H** as Table 5.0.

4.2.3.4.15 *At-grade Junctions on York Street (Link No. 11)*

The design of the at-grade junctions on York Street (Link No. 11) has taken cognisance of the relevant requirements of TD 41/95 and TD 42/95, in relation to the design of priority junctions and the requirements of TD 50/04, relevant to signal controlled junctions.

Where specific Departures from Standard TD 41/95, TD 42/95 or TD 50/04 have been identified, these are included in **Appendix H** as Table 5.0.

4.2.3.4.16 *Access to Residual Lands on Link No. 6*

The design of the proposed at-grade junction on Link No. 6 has taken cognisance of the relevant requirements of TD 41/95, in relation to the design of priority junctions.

Where specific Departures from Standard TD 41/95 have been identified, these are included in **Appendix H** as Table 5.0.

4.2.3.4.17 ***Access to Commercial Lands on Nelson Street (North of Dock Street)***

The proposed modifications to the at-grade junctions on Nelson Street (North of Dock Street) has taken cognisance of the relevant requirements of TD 41/95, in relation to the design of priority junctions.

Where specific Departures from Standard TD 41/95 have been identified, these are included in **Appendix H** as Table 5.0.

4.2.3.4.18 ***Signalised Junction on Dock Street***

The proposed modifications to the signalised junction at the location of Dock Street, where it meets Nelson Street and Link No. 6, has taken cognisance of the relevant requirements of TD 50/04, in relation to the design of signal controlled junctions.

Where specific Departures from Standard TD 50/04 have been identified, these are included in **Appendix H** as Table 5.0.

4.2.3.4.19 ***Signalised Junction on Duncrue Street***

The proposed modifications to the signalised junction at the location of the M2 off-slip to Duncrue Street has taken cognisance of the relevant requirements of TD 50/04, in relation to the design of signal controlled junctions.

Where specific Departures from Standard TD 50/04 have been identified, these are included in **Appendix H** as Table 5.0.

4.2.4 ***Road Safety Audits***

In accordance with the requirements of Standard HD 19/03 of the DMRB, highway improvement schemes are subject to a Road Safety Audit during key stages in design and at the end of construction to identify potential road safety problems that may affect road users and to suggest measures to eliminate, or mitigate, those problems. It is important to note that as associated Departures or Relaxations from Standards are subject to separate justification, consideration and approval by Transport NI, Road Safety Audits do not typically include recommendations on these proposals, unless specifically requested by Transport NI.

All Road Safety Audits are carried out by Audit Teams with sufficient training, skills and experience to demonstrate competence to Transport NI, through similar roles in Accident Investigation and Road Safety Engineering. For schemes involving sections of the EU TEN-T network, one member of the Audit Team mush hold an associated Certificate of Competency, in accordance with EC Directive 2008/96/EC.

It is a fundamental principle of the audit process that the Audit Team is independent of the Design Team, such that the Audit Team's views are not influenced by familiarity or from natural "pride of ownership". It does not, however, preclude the appointment of an Audit Team from the same design organisation or company.

The audit process is informed by an Audit Brief issued by Transport NI to the Audit Team. The Audit Brief sets out the parameters of the audit and includes details of any relevant information, including recorded road traffic collision (RTC) statistics, detailed of approved or proposed Departures and Relaxations from Standards and information about proposed road geometry, structures, drainage, earthworks, traffic signs, vehicle restraint systems, street lighting etc. A walkover survey of the existing site is a requirement of the audit process. Following consideration of the design, the Audit Team undertake a process of problem identification and recommendation, with summary findings presented in an Audit Report delivered by the Audit Team to Transport NI.

Following receipt of the Audit Report, Transport NI are required to ensure that all problems raised by the Audit Team are given due consideration in consultation with their designer. Typically, the designer prepares its response to the recommendations of the Audit Team, where the associated merits, or indeed, impacts of the recommended changes are explained to Transport NI. If Transport NI consider that, on the basis of the information presented, that problems raised are insignificant, outside the terms of reference, or that the solutions recommended are not suitable given the relevant economic and environmental constraints, it will prepare an Exception Report giving reasons and proposing alternatives for submission to the relevant Divisional Roads Manager, with whom the final decision rests. All exceptions must be separately considered and approved. In all other cases, the design team are instructed by Transport NI to implement the changes as recommended.

For the Proposed Scheme, a Stage 1 Road Safety Audit was commissioned by Transport NI in January 2014 at time of completion of preliminary design. The Audit Team comprised members of URS independent of the design team, with the associated Audit Report issued to Transport NI in May 2014. The Audit Report identified 42 problems with the proposed layout, largely arising from limitations on road geometry due to identified site constraints. Of the identified problems, 41 were accepted by Transport NI.

The problem raised by the Audit Team not accepted by Transport NI related to the northbound weaving section on the Westlink between Clifton Street and York Street (Link No. 1). The Audit Team recommended the closure of the Clifton Street northbound on-slip due to the limited weaving length. The design team noted that the closure of the slip road was considered in the development of the scheme , however, the associated traffic, economic and environmental impacts of its closure were expected to have a major impact on the overall viability of the scheme. Whilst the on-slip had therefore remained within the Proposed Scheme, the design team had sought to mitigate the risk through the introduction of a 40mph speed limit over the weaving section. Based on the information available, Transport NI did not consider the recommendation suitable in line with the provisions of HD 19/06 and approved an associated Exception Report.

4.2.5 *Non-Motorised User Audits*

The DMRB recognises the importance of the needs of Non-Motorised User (NMUs) in highway schemes, with Standard HD 42/05 requiring the completion of NMU Audits at key stages in their development. NMU Audits consider the implications of the scheme for NMU accessibility, safety, comfort and convenience. While road safety and personal safety of NMUs are considered, it does not duplicate the separate independent Road Safety Audit process. Moreover, it seeks to complement the process by providing a means for Transport NI and its design team to identify and address problems for NMU provision ahead of a Road Safety Audit. Accordingly, the audit is carried out with the active involvement of the design team under the direction of a NMU Audit Leader appointed by Transport NI on the basis of their demonstrated competence.

Whilst standards for NMU provision within the DMRB would be considered, a NMU Audit is not intended to form a technical check on the layout of each item of NMU provision, but rather a broader review to ensure that the overall needs of all road users are being met within the scheme design.

A key point of reference in the NMU Audit process is the NMU Context Report, which provides a summary of all relevant information in relation to existing and potential patterns of use by NMUs within the design life of the scheme. Importantly, the NMU Context Report must also set out the opportunities and objectives to improve conditions for NMUs. The content of the NMU Context Report, including, specifically, the proposed scheme objectives for NMUs, must be prior approved by Transport NI ahead of scheme development.

At design stages specified by Transport NI, the NMU Audit Leader will complete an associated NMU audit of the scheme and summarise their findings in a NMU Audit Report. The NMU Audit Report shall note any material changes to the information in the NMU Context Report since its publication, confirm the NMU scheme objectives (as stated in the NMU Context Report) and confirm how these objectives NMU Context Report have been satisfied. Where the stated objectives are not being met, the NMU Audit Report must explain the reasons for failure. Any other issues identified for NMU provision should also be identified with associated recommended actions.

All NMU Audit Reports are submitted to Transport NI for review and approval ahead of completion of the next relevant stage in the Road Safety Audit process.

For the Proposed Scheme, a NMU Context Report was prepared in October 2012 ahead of the commencement of preliminary design. The NMU objectives included in the NMU Context Report drew on the overall scheme objectives identified in the Preliminary Options Report and Preferred Options Report for the scheme and comprised:

- The reintroduction of two-way running on York Street, if feasible within engineering standards, to enhance NMU access to the City Centre/Inner Ring. The layout of the two-way running proposal will require detailed consideration of pedestrian desire lines and future public transport provision.
- To consider further the provision for NMUs on the York Street overbridge.
- To consider pedestrian provision at all remaining controlled and uncontrolled crossing points in line with the DMRB requirements and published draft guidance.
- To consider the public realm works proposals for York Street being developed by the University of Ulster as part of its Greater Belfast Development and seek to reflect their proposed level of service on York Street.
- To consider NMU access to lands available for disposal within the scheme.
- To consider NMU provision during the construction of the works. Specific attention should be given to maintaining provision for NMUs at the proposed staircase access from Yorkgate platform onto Dock Street, should these works be constructed ahead of the scheme.

Following completion of preliminary design, a Preliminary Design NMU Audit was completed with the findings presented in the summary NMU Audit Report of October 2013, ahead of the Stage 1 Road Safety Audit in January 2014.

The audit reported that the NMU scheme objectives were being met within the proposed scheme layout, with fifteen issues identified for follow-up action by the design team as part of future design development. It was recognised that the changes to York Street to introduce a northbound cycle lane and a southbound bus/cycle lane had addressed several of the identified NMU objectives, improving connections for NMU users to the City Centre, despite constraints on footway width at a number of isolated positions. However, the number of east-west connections for NMU users remains an issue that cannot be fully addressed with the site constraints, with connections limited to the periphery of the scheme at Dock Street and Little Patrick Street. With regard to comfort and personal safety, the audit report recognised that the existing footways underneath Dock Street bridge (BR-005) and indeed, the existing Whitla Street subway (BR-006) would benefit from additional lighting and this was accepted as a matter for future development by the design team.

4.3 Earthworks Quantities

The vertical alignment and cross-section of the proposed road links within the scheme would require the excavation of large quantities of material from the site. From the identified ground conditions, it is anticipated that the majority of excavated material would be deemed unsuitable for reuse as fill material and will therefore require off-site disposal. The developed cost estimate for the scheme reflects this rationale.

It is understood that any excavated alluvium (sleech) material would qualify for the lower rate of landfill tax as inactive or inert material, however, it is noted that parts of the site are additionally underlain by peat deposits which would attract the standard rates for landfill tax.

It should be noted that the ground investigation contract included geo-environmental testing at identified areas of potential contamination. Although the results from testing indicated that contamination levels did not exceed relevant threshold levels, it has been assumed for the purposes of preparing the cost estimate that some arisings would contain contaminants and therefore require specialist handling and disposal.

As the majority of excavated material is unlikely to be suitable for reuse, it therefore follows that all embankments would require formation from imported fill, the costs of which are reflected in the scheme estimate.

A summary of the estimated bulk earthwork quantities is presented as **Table 4.3.1**.

Table 4.3.1: Estimated Earthwork Quantities

Cut Volume (m^3)	Fill Volume (m^3)
107,500	87,500

4.4 Land Use

The assessment of the impact of the Proposed Scheme on land within the study area is more particularly detailed in the separate Environmental Statement that forms Part 1 of this Proposed Scheme Report.

4.5 Structures

4.5.1 *Overview*

The scheme would require the construction of several significant structures, summarised below:

- four major underpasses, with retained heights of up to circa 10 metres;
- two twin span pre-stressed beam bridges, one highly skewed;
- a single span bridge supported on the walls of the largest underpass;

- a three span bridge carrying traffic over the Dock Street junction;
- two existing bridges to be widened, with parapet improvements, one adjacent to an existing raised railway structure;
- several retaining walls, several subject to collision loading and/or acting as flood protection walls;
- an extension to a pedestrian underpass;
- several services culverts;
- three overhead sign/signal gantries;
- structures associated with pumping stations required for scheme drainage;
- strengthening works to the foundations of Lagan Road Bridge; and
- strengthening works to the foundations of Dargan Rail Bridge.

Potential design options were identified for each of the structures, each option being defined by the following basic features:

- structural form;
- type of foundation;
- span arrangements;
- articulation; and
- choice of materials.

In most cases, several technical solutions presented themselves in which case the choice of the preferred solution was influenced by the following factors. In no specific order:

- disruption to the road network during construction;
- appearance and environmental impact;
- desire to maintain the appearance of a "family" of structures within the scheme;
- safety and ease of construction;
- foundation conditions;
- road geometry;
- future maintenance; and
- capital and whole life cost.

The preferred solution for each structure was developed and is presented in the drawings included for each structure in **Volume 3**. A reference plan for the various structures is included as Drawing **YSI-URS-XX-XX-DR-SE-ST001**.

All new works shall be designed to the Eurocodes, with their associated National Annexes and Published Documents. Existing structures shall be assessed either qualitatively, in accordance with BA 16 of the DMRB, or quantitatively in accordance with BD 21 and BD 44 of the DMRB. Wherever it can be demonstrated that loads applied to the existing structure have not increased, a qualitative assessment shall be considered adequate. If loading applied to an existing structure is increased, a quantitative assessment shall be undertaken.

A major consideration in the Stage 3 design development has been the requirement to minimise disruption to the road network during construction. Buildability and any temporary traffic management requirements have been considered in detail. Another challenge associated with the project is the poor ground. This means that the majority of structures require piling. This in itself makes limiting the disruption to existing roads more challenging, due to the logistics of installing piles. Many of the structures on the scheme are reinforced concrete retaining walls. Time may be saved constructing these walls if precast retaining walls were used. However, as the ground conditions on the scheme generally necessitate piled foundations, there is a challenge associated with the interface between standard precast cantilever retaining walls and piles. Options, such as the use of precast stem and cope units only, the use of insitu piled support slabs for precast concrete retaining wall units and the use of pocketed precast units with insitu stitch connections are available. The final preferred solution would be dependent on the successful Contractor's preference and economic considerations.

For the same reason, the structures drawings presented with this report do not specify either in-situ or precast forms of construction.

Interfaces with existing bridge foundations for the Lagan and Dargan Bridges form a constraint to both the road alignment and to the structural form of adjacent new works. In addition to strengthening works for certain foundations for the existing Lagan Road Bridge, which is detailed below, the final vertical road alignment w have to be sufficient to allow sufficient clearance over existing foundations to allow new embankment support structures and flood protection measure to be installed. In turn, the structural and geotechnical design of such structures and measures would have to take account of the location of the existing foundations. Stage 3 proposals have been developed to as stage where these Detailed Design criteria should be met.

The design adopted for each of the structures is discussed briefly in the following sections.

4.5.2 *Description of Structures*

4.5.2.1 *BR-001 – North Queen Street Bridge Extension*

The following summary should be read in conjunction with **Drawings YSI-URS-BR-01-DR-SE-00001 and YSI-URS-BR-01-DR-SE-00002**.

The existing North Queen Street Bridge carries the Westlink alignment over North Queen Street. It is a single span pre-stressed beam bridge with in-situ concrete deck. The beams are supported on elastomeric bearings on reinforced concrete abutments. A run-on slab is provided at the west side of the bridge, where deck movements due to thermal effects are accommodated by shear distortion in the bearings. The proposed Westlink cross-section is wider than the existing bridge, requiring it to be extended northwards and southwards by approximately 4 metres and 2.5 metres respectively. It is envisaged that the extensions shall be formed from reinforced concrete abutments dowelled into the existing abutments, with pre-stressed beams and an in-situ deck to match the existing structure. As settlement has already occurred beneath the existing bridge foundations, piled foundations are proposed beneath the extensions to prevent differential settlement.

The existing Westlink alignment needs to be retained during construction of the extensions and it is envisaged that this would be achieved using sheet-piling. The extent of disruption to the Westlink depends on whether piling platforms can be formed to allow piling rigs to work from the side of the Westlink rather than directly on it. Formation of these platforms would require disruption to the roads and pedestrian routes below the Westlink (North Queen Street, Great George's Street and the stairs and footpath area north-west of the bridge). The existing police station wall may facilitate forming a piling platform at the south-west corner of the bridge, potentially providing support to the south extent of the piling platform. At the north-east corner of the bridge a sheet pile wall would need to be installed from the Westlink, to allow extension of the bridge abutment. It is envisaged that this would be undertaken after the bridge has been extended southwards, to increase the space for re-configuration of lanes over the bridge.

Disruption to Great George's Street and North Queen Street would also occur during installation of permanent piles for the extensions to the existing wingwalls, including the replacement of a 10m section of the existing Great George's Street retaining wall adjacent to the widened bridge structure.

A detailed construction sequence is defined on the drawings for this bridge.

4.5.2.2 *BR-002A – York Street Underbridge (South)*

The following summary should be read in conjunction with **Drawing YSI-URS-BR-2A-DR-SE-0001**.

Bridge BR-002A carries York Street (Link No. 11) over underpasses UP-001A and UP-001B. It is integral with the diaphragm walls used to form the underpasses.

The bridge has a skew of 21 degrees with a total skewed length of approximately 34m. It has two spans, each formed from pre-stressed concrete beams with a reinforced concrete deck slab. Due to the modest skew and length, this bridge is required to be integral by the DMRB, hence the lack of movement joints or bearings in the design.

At the internal support, the diaphragm wall is continued up to existing ground level. This is attractive from a construction perspective because it allows underpasses UP-001A and UP-001B to be constructed separately. Above existing ground level, discrete columns are provided. This gives the structure a more open appearance, which is desirable from a driver comfort perspective. The columns would be formed from 20 equal facets to improve their aesthetics. The aesthetics could be further improved by breaking down the central diaphragm wall after the underpasses were formed. Full height columns could then be constructed, which would open the structure up further, although there would clearly be cost implications associated with this. This would also result in a very tall retaining wall east of the bridge. Currently it is assumed that the central diaphragm wall would not be broken down. The cross head at the column tops shall not protrude below the soffit of the beams and shall be integral. This is preferable to downstands below the beam soffits from an aesthetics perspective.

The upper part of the abutments and the deck are above ground level. They shall be formed after the underpass has been excavated and temporary props have been removed. This prevents the deck from acting as a prop in the short term (although in the long term, creep effects would result in a degree of propping action). The lack of propping is advantageous, because there would otherwise be a differential in stiffness at the ends of the bridge, which would apply significant loads to the underpass walls. While joints could be provided to accommodate differential movements, this would not be attractive in terms of sealing the underpass against groundwater ingress. Providing bearings was considered, because thermal movements and shrinkage of the deck would also apply significant loads to the underpass walls. However, it was judged that the magnitudes of displacements are such that the underpass walls could accommodate the associated load effects. Integral structures have significant benefits in terms of whole life cost and are likely to be Transport NI's preference.

Disruption associated with the construction of this bridge would be modest, and likely to coincide with closures required for the construction of underpass UP-001A.

4.5.2.3 *BR-002B– York Street Underbridge (North)*

The following summary should be read in conjunction with **Drawing YSI-URS-BR-2B-DR-SE-0001**.

Bridge BR-002B carries York Street (Link No. 11) over underpasses UP-002A and UP-002B. It is supported on the diaphragm walls used to form the underpasses.

Bridge BR-002B has two spans, which are formed from pre-stressed concrete beams with a reinforced concrete deck slab. It has a skew of approximately 45 degrees with a total skewed length of approximately 50m. Due to the high skew, it is not practical for the bridge to be integral, nor is it required to be by the DMRB; consequently, bearings are provided at the abutments and the columns. Movement joints are also required at each abutment. Inspection galleries are provided to allow access to the bearings and movement joints.

The articulation arrangement shall allow for thermal, shrinkage and live load induced movements of the deck and any deflection of the supporting diaphragm/ bored pile walls. The geometry of the abutments shall facilitate bearing replacement.

To minimise the construction depth, the beams shall be placed at closer than normal spacing, and higher grade concrete shall be used. The beams are sized to be the same as BR-002A, which has a significantly shorter span. This retains a constant beam depth when both bridges are viewed from the Westlink.

At the internal support, the diaphragm walls are continued up to existing ground level. This is attractive from a construction perspective because it allows underpasses UP-002A and UP-002B to be constructed separately. Above existing ground level, discrete columns are provided. This gives the structure a more open feel, which is desirable from a driver comfort perspective. The columns would be formed from 20 equal facets to improve their aesthetics. The aesthetics could be further improved by breaking down the central diaphragm wall after the underpasses were formed. Full height columns could then be constructed, which would open the structure up further, although there would clearly be cost implications associated with this. This would also result in a very tall retaining wall east of the bridge. Currently it is assumed that the central diaphragm walls would not be broken down. The cross head at the column tops shall not protrude below the soffit of the beams and shall be integral. This is preferable to downstands below the beam soffits from an aesthetics perspective.

Disruption associated with the construction of this bridge would be modest, and likely to coincide with closures required for the construction of underpass UP-01A.

4.5.2.4 *BR-003 – Underpass UP-001A Roof Slab*

The following summary should be read in conjunction with **Drawing YSI-URS-BR-03-DR-SE-0001**.

Bridge BR-003 carries the Westlink to M3 (Link No. 3) and Dock Street to M3 (Link No. 6) interchange links over underpass UP-001A. It is supported on the diaphragm walls which form the underpass UP-001A.

BR-003 is a single span portal structure which is integral with the diaphragm/bored pile walls of the underpass. It has a span of 13 metres and the deck is formed from in-situ reinforced concrete. Pre-stressed beams were considered but dismissed, on the basis that the limited headroom beneath existing structures would make crane operation problematical.

The bridge is approximately 55 metres wide, extending beyond the width required to support the link roads; this additional width is required to prop the underpass walls over the extent of the underpass coinciding with the foundations of the existing Dargan and Lagan bridges. Propping the underpass over this significant length minimises ground movements in the vicinity of these important structures. The additional width also safeguards against dropped items from the Dargan or Lagan bridges landing in the underpass.

In the vicinity of BR-003, the proposed diaphragm walls of underpass UP-001A are close to the piled foundations of the existing Lagan Bridge. Taking account of normal construction tolerances there should not be a clash between the proposed diaphragm walls and the existing foundations albeit the theoretical clearances are small. However, there is a possibility that the existing piles were not placed within tolerance, which could result in the new diaphragm wall clashing with the existing piles. If left un-checked, this could result in damage to the Lagan Bridge. The current scheme includes strengthening works to the foundations of the Lagan Bridge. These works shall ensure that damage to the existing Lagan Bridge piles closest to the proposed underpass would not result in the strengthened foundations becoming non-code compliant. The proposed strengthening works are discussed in detail later in this report.

4.5.2.5 *BR-004 Dock Street Overbridge*

The following summary should be read in conjunction with **Drawing YSI-URS-BR-04-DR-SE-0001**.

Bridge BR-004 carries the M2 to Westlink (Link No. 2) over the Dock Street junction.

Bridge BR-004 has 3 spans and is formed from pre-stressed concrete beams with a reinforced concrete deck slab. It has a skew of approximately 20 degrees with a total skewed length of approximately 80m. Due to its length, the bridge is not required to be integral by the DMRB. Consequently, bearings are provided at the abutments. Movement joints are also required at each abutment to accommodate thermal movements. Inspection galleries are provided to allow access to the bearings and movement joints for inspection and replacement. The articulation arrangement shall allow for thermal, shrinkage and live load induced movements of the deck. The geometry of the abutments shall facilitate bearing replacement.

At the internal supports, full height columns shall be provided. These shall be integral with the deck, minimising maintenance requirements at these locations, in the midst of a busy junction. The columns shall be 1.5m diameter and would be formed from 20 equal facets to improve their aesthetics and discourage graffiti. The location of the columns is determined by the traffic islands below. This has resulted in the outermost pre-stressed beams being offset transversely a significant distance from the columns below, with the result that the diaphragm at the columns has to cantilever significantly from the columns to support the outer beams. The stresses applied to the diaphragm are further increased by the 34m length of the central span and the 26m length of the longest end span. Currently, it is not clear that such a diaphragm would be practical from a structural engineering perspective without a downstand below beam soffit level. As there is sufficient clearance to the roads below, the current design shows a downstand crosshead at the columns. This may not be as aesthetically attractive as a no-downstand solution, but offers a robust engineering solution, which is preferred at this stage in the design development. The downstand also removes the requirement for temporary works to support the beams, which would be attractive from a traffic management perspective.

Further calculations at detailed design stage may confirm that the downstand is not required, but the associated temporary works are unlikely to be attractive, considering traffic management.

Piled foundations are required at this bridge. A single line of piles was considered for the column foundations, in an attempt to minimise disruption to the Dock Street junction. However, twin lines of piles are more efficient structurally, allowing smaller piles, smaller piling rigs, reduced placing time and less disruption. The single line of pile options would also result in a flexible structure during construction, requiring temporary works to limit deflections. These temporary works would also have implications for traffic management.

4.5.2.6 *Bridge BR-005 - Dock Street Bridge Extension*

The following summary should be read in conjunction with **Drawing YSI-URS-BR-05-DR-SE-0001**.

The existing Dock Street Bridge carries the M2 north-bound and M2 south-bound over Dock Street. It is a four span bridge, with a pre-stressed beam deck supported on bankseats at each end, with columns for internal supports. Piled foundations are provided throughout. Pre-stressing has been used to form crossheads at the columns, with soffit levels in line with the soffit of the pre-stressed beams. The original bridge was extended westward in the 1990’s.

The proposed re-alignment of the M2 south-bound requires the bridge to be extended further westwards. This would be achieved by extending the already once extended abutments and internal supports, removing the existing cope and extending the existing pre-stressed beam deck by approximately 6.3 metres, with similar beams. There would be significant disruption to Dock Street during this construction work, with some disruption to the M2 also. A single night-time, complete closure of Dock Street shall be required for erection of the pre-stressed beams. Aside from this complete closure, careful phasing of the works, sheet piling and traffic management (including contraflows) may be used to ensure a minimum of one lane shall remain open in each direction at all other times.

4.5.2.7 *Bridge BR-006 – Whitla Street Subway Extension*

The following summary should be read in conjunction with **Drawing YSI-URS-BR-06-DR-SE-0001**.

Currently the Whitla Street subway passes beneath the M2, providing pedestrian access between York Street and Nelson Street and Whitla Street. The proposed re-alignment of the M2 results in it widening at this location, requiring the subway to be extended. The subway also carries numerous services, including water, gas and electricity, buried between dividing walls, beneath the footpath of the subway.

It is proposed that the extension be made by continuing the piled reinforced concrete box structural form of the existing structure. Dowels shall be used to ensure a structural connection between the existing and new structures.

Disruption to the M2 during construction shall be minimised by sheet piling along the edge of the current M2 alignment, from a piling platform formed adjacent to Nelson Street using gabions or similar temporary works. Once the sheet piling is established, the existing retaining walls would need to be removed before constructing the new works.

4.5.2.8 *Retaining Wall RW-001*

The following summary should be read in conjunction with **Drawing YSI-URS-RW-01-DR-SE-0001**.

Retaining wall RW-001 provides retention to the soil supporting the north side of the proposed widening of the Westlink as it approaches Bridge BR-001 from the west. The wall reaches approximately 5.6 metres in height and is approximately 85 metres long.

Over the majority of its length, where it is sufficiently removed from the existing Westlink retaining walls, the proposed wall is a standard piled reinforced concrete cantilevered retaining wall. Wherever the new wall approaches the existing wall sheet piling would be required to prevent undermining of the existing wall. This shall require the formation of a piling platform and closures to the pedestrian footpath at this location. Towards the east end of the wall, where it interfaces with bridge BR-001, the base geometry would be reversed so that its toe is larger than its heel. This allows the wall to be constructed without demolishing the existing wall. Sheet piling would be required at this location to avoid undermining the existing retaining wall

It is likely that the existing retaining walls would require demolition down to a level sufficient to allow the new Westlink alignment to pass over them without formation of hard-spots.

4.5.2.9 *Retaining Wall RW-002*

Retaining wall RW-002 comprises the south-west wingwall to BR-001. Construction works associated with the wall are described on **Drawings YSI-URS-BR-01-DR-SE-00001** and **YSI-URS-BR-01-DR-SE-00002**.

4.5.2.10 *Retaining Wall RW-004*

The following summary should be read in conjunction with **Drawing YSI-URS-RW-04-DR-SE-0001**.

Retaining wall RW-004 has two functions. Firstly it acts as an earth retaining wall, allowing for the differences in levels between diverging underpasses UP-001A and UP-002B; secondly, it acts as a continuation of the concrete safety barrier VCSB-001 as it approaches the divergence.

The proposed wall is a reinforced concrete piled retaining wall, designed to resist collision loading. It is approximately 40 metres long and up to 2 metres high.

There is potential for collision loading to be applied from either side. Consequently, it would be optimum from a structural efficiency perspective for the design to be symmetrical. However, an asymmetric design is proposed, so that the larger heel can be constructed under a lane occupation necessitated for the construction of the neighbouring underpasses. Sheet piling, combined with a modest toe, would minimise disruption to the other underpass which would remain open. The wall is tapered over the likely collision height to allow the design of the wall to be as for a concrete parapet, in accordance with TD19/06 and BS 6779.

4.5.2.11 *Retaining Wall RW-007*

The following summary should be read in conjunction with **Drawing YSI-URS-RW-07-DR-SE-0001**.

Retaining wall RW-007 retains the west side of the proposed York Street (Link No. 11) road alignment and part of the Westlink to York Street (Link No. 5). The wall starts from the end of the existing brick boundary wall to the rear of nos. 39-47 (odds) inclusive of Little George's Street. It then runs parallel to the York Street (Link No. 11) alignment to a location near the revised access arrangement to Cityside Retail Park (Link No. 28).

The wall is a reinforced concrete cantilever retaining wall with piled foundations. It has a retained height of up to 5.1 metres, with an approximate length of 145 metres.

4.5.2.12 *Retaining Wall RW-017*

The following summary should be read in conjunction with **Drawing YSI-URS-RW-17-DR-SE-0001**.

Retaining wall RW-017 retains the east side of the embankment carrying the link road between the M2 and Westlink (Link No. 2) on its southern departure from Bridge BR-004. Earthworks could have been used to reduce the height of the wall, but the full height walls were selected to maximise the level ground available at finished ground level for future development.

RW-017 is a reinforced concrete cantilevered retaining wall on piled foundations. It reaches a height of 8.4m, over a length of 117 metres. The wall is bound at its north end by Bridge BR-004 and at its south end by Underpass UP-001A. At the interface between RW-017 and UP-001A, the wall is detailed to provide flood water retention up to 3.9mAOD. This shall prevent water from entering the underpass in the event of a 1in 200 year coastal flood event. Ground strengthening shall be required beneath the embankment behind the retaining wall.

Reinforced soil walls were considered as an alternative form of construction. These were rejected due to Transport NI concerns regarding wash-out of soil during an extreme flooding event. Voided box solutions were also considered but not developed further, in favour of a more traditional solution. It may be economical to use lightweight aggregate to form the abutment. This would depend on the savings in piled ground strengthening compared to the cost of the aggregate.

4.5.2.13 *Retaining Wall RW-018*

The following summary should be read in conjunction with **Drawing YSI-URS-RW-18-DR-SE-0001**.

Retaining wall RW-018 retains the west side of the embankment carrying the link road between the M2 and Westlink (Link No. 2) on its southern departure from Bridge BR-004. Earthworks could have been used to reduce the height of the wall, but the full height walls were selected to maximise the level ground available at finished ground level for future development.

RW-018 is a reinforced concrete cantilevered retaining wall on piled foundations. It reaches a height of 8.2m, over a length of 105 metres. The wall is bound at its north end by Bridge BR-004 and at its south end by Underpass UP-001A. At the interface between RW-018 and UP-001A, the wall is detailed to provide flood water retention up to 3.9mAOD. This shall prevent water from entering the underpass in the event of extreme flooding. Ground strengthening shall be required beneath the embankment behind the retaining wall.

Reinforced soil walls were considered as an alternative form of construction. They were rejected due to Transport NI concerns regarding wash-out of soil during an extreme flooding event. Voided box solutions were also considered but not developed further, in favour of a more traditional solution. It may be economical to use lightweight aggregate to form the abutment. This would depend on the savings in piled ground strengthening compared to the cost of the aggregate.

4.5.2.14 *Retaining Wall RW-020*

The following summary should be read in conjunction with **Drawing YSI-URS-RW-20-DR-SE-0001**.

RW-020 has two functions. Firstly it provides earth retention to accommodate the difference in level between two neighbouring roads:

- the east-bound link between the Westlink and the M2 heading north; and
- the link between the north-bound York Street and the M2 heading north.

RW-020 also acts as a safety barrier between the two roads.

The wall is a reinforced concrete cantilever retaining wall, on piled foundations. It is approximately 155 metres long with a maximum height of roughly 4.5 metres.

The tapered geometry of the top of the wall allows it to be designed to be compliant with TD19/06 and BS 6779. Although collision loading can be applied from both sides, the wall is designed with its heel pointing North West. Although this is not the most structurally efficient arrangement in terms of resisting collision loads, which can be applied from either side, the selected geometry would minimise disruption to the existing slip road from York Street to the M2 during construction.

4.5.2.15 *Retaining Wall RW-021*

The following summary should be read in conjunction with **Drawing YSI-URS-RW-21-DR-SE-0001**.

RW-021 provides retention to the proposed York Street (South) to M2 slip road (Link No. 15). It is a reinforced concrete cantilevered retaining wall on piled foundations. It interfaces with Bridge BR-005 at its northern end. The wall is approximately 130 metres long, typically 2-3 metres high, but rising to 6 metres where it ties into Bridge BR-005.

There is sufficient space to construct the wall with minimal disruption to the M2, apart from where it interfaces with Bridge BR-005. At Bridge BR-005 sheet piling is required to form the extension to the abutments. A minor extension to the sheet pile wall shall provide sufficient retention for the construction of retaining wall RW-021.

However, ground strengthening works may be required in this area, to support the widening of the embankment. The construction of the ground strengthening works may necessitate further sheet piling, possibly requiring more significant disruption to the M2.

4.5.2.16 *Retaining Wall RW-022*

The following summary should be read in conjunction with **Drawing YSI-URS-RW-22-DR-SE-0001**.

RW-022 retains the proposed embankment supporting the M2 to Westlink and Duncrue Street to Westlink alignments (Link Nos. 2 and 31 respectively). It is adjacent to Nelson Street and passes beneath the northern span of Bridge BR-004, adjacent to the north abutment of the bridge.

RW-022 is a reinforced concrete cantilever retaining wall on piled foundations. It approaches 8.5 metres in height and is approximately 185 metres long. At the south end of RW-022, it curves beneath Bridge BR-004, in front of its north abutment. There is potential for a clash between the foundations of Bridge BR-004 and the foundations of RW-022 at this location that would require further consideration at detailed design stage.

At the north end of RW-022, the wall interfaces with underpass BR-006 and is aligned close to the existing M2 motorway. To form the northern end of the wall would require a lane occupation to the M2.

Disruption to the existing Nelson Street during construction shall be minimised by sheet piling as close as possible to the toe of the wall, without hampering construction, but there would be a reduction in available carriageway width.

Reinforced soil was considered as an economical alternative, but this was rejected due to Transport NI concerns regarding wash out under coastal flood conditions.

4.5.2.17 *Retaining Wall RW-024*

The following summary should be read in conjunction with **Drawing YSI-URS-RW-24-DR-SE-0001**.

RW-024 retains the M2 (Link No. 2) and Duncrue Street to Westlink (Link No. 31) alignments at the northern extent of the scheme. It requires approximately 100 metres of piled reinforced concrete cantilever retaining wall, with a retained height of up to 2.8 metres.

Sheet piling is required, coupled with a hard shoulder closure on the M2, to allow construction of the wall while minimising disruption to the M2. This would require a piling platform, but there is sufficient space between the M2 and Duncrue Street for this to be achieved without disruption to Duncrue Street.

4.5.2.18 *Retaining Wall RW-025*

The following summary should be read in conjunction with **Drawing YSI-URS-RW-25-DR-SE-0001**.

RW-025 has two functions. It acts as a flood wall, preventing coastal flooding from entering the underpasses, and it also provides parapet edge protection to the proposed Dock Street to M3 alignment (Link No. 6) It is a reinforced concrete cantilever retaining wall formed on piled foundations. It would be constructed during a closure of Nelson Street, associated with its re-alignment, so there are no unusual construction challenges. The wall reaches a height of 5.1m, with a total length of 84.5 metres.

Where the stem of the wall extends above 3.9mAOD a metal parapet is proposed, to reduce collision loading. However, where the wall acts as a water retaining structure, clearly a solid reinforced concrete flood wall is required, and this doubles as a reinforced concrete parapet, resisting collision loading.

4.5.2.19 *Retaining Wall RW-026*

The following summary should be read in conjunction with **Drawing YSI-URS-RW-26-DR-SE-0001** and **Drawing YSI-URS-RW-26-DR-SE-0002**

RW-026 is located just south of Bridge BR-003 and acts as a flood wall, preventing coastal flooding entering the underpasses from its east side. It is a reinforced concrete cantilevered wall on piled foundations, and passes over Culvert CU-001. The wall reaches a height of 2.6m, with a total length approaching 65 metres. An outfall route passes close to the footprint of the retaining wall, at depth.

North of Culvert CU-001, the wall is arranged with its heel facing eastward, to minimise implications for road closures and improve efficiency for resisting overturning flood water loading. Two lines of smaller diameter piles are the most efficient solution. Where the retaining wall crosses Culvert CU-001, it is supported by the culvert, with no piling required. A water-tight joint shall be provided between the culvert and the retaining wall. South of Culvert CU-001, two lines of piles are not practical, due to the potential for piles hitting the outfall beneath the retaining wall. A single line of larger diameter piles are provided at this location.

The construction of this wall would require single lane closures to the existing M3 on-slip.

4.5.2.20 *Retaining Wall RW-027*

The following summary should be read in conjunction with **Drawing YSI-URS-RW-27-DR-SE-0001**.

Retaining wall RW-027 mirrors retaining wall RW-026, providing flood protection to the west side of the M3 on-slip, just south of Bridge BR-003. It crosses Culvert CU-001, and comes close to the planned strengthening works to one of the Lagan road bridge foundations.

The wall is a reinforced concrete cantilevered retaining wall on piled foundations. Where the retaining wall crosses Culvert CU-001, a horizontal structural stiffener is provided to transmit loads (particularly collision loads) across the culvert. A water-tight joint shall be provided between the culvert and the retaining wall.

The use of sheet piling during construction of this retaining wall would remove the need for closures to the Nelson Street to M3 south-bound slip road.

4.5.2.21 *Retaining Wall RW-028*

The following summary should be read in conjunction with **Drawing YSI-URS-RW-28-DR-SE-0001**.

RW-028 retains the proposed raised York Street (Link No. 11) and borders the existing car park, which is to be retained. The wall reaches a maximum height of approximately 2 metres, with a length of approximately 66 metres.

Where the walls have significant soil retention they are formed from reinforced concrete cantilevered retaining walls on piled foundations, with brick facings and a pedestrian guardrail mounted on top of the wall.

Due to the limited retained height relative to existing road levels, the walls can be constructed without lane occupations either to York Street or Great George’s Street, provided this is done before the road alignment is raised. Once the road alignment has been raised, they would clearly be retaining significantly more.

4.5.2.22 *Retaining Wall RW-029*

The following summary should be read in conjunction with **Drawing YSI-URS-RW-29-DR-SE-0001**.

RW-029 retains the proposed embankment supporting the M2 to Westlink (Link No. 2), north of Bridge BR-006, adjacent to Nelson Street.

RW-029 is a reinforced concrete cantilever retaining wall on piled foundations. It approaches 6 metres in height and is approximately 80 metres long. At the south end of RW-029, it interfaces with underpass BR-006.

Construction of this wall would require modest occupations to the M2 and Nelson Street to allow installation of sheet piles, which are required to minimise disruption to traffic during construction.

4.5.2.23 *Retaining Wall RW-030*

RW-030 is a proposed flood wall located to the nearside of the York Street (South) to M2 (Link No. 15) to prevent coastal flooding from entering Underpass UP-001A. The wall would be of modest height given projected flood levels at the location and so is anticipated to be a reinforced concrete cantilevered wall with a piled foundation, similar to RW-026.

4.5.2.24 *Retaining Walls RW-031 to RW-034*

Retaining walls RW-031 to RW-034 inclusive are proposed to limit the extents of proposed ground improvements at York Street. The walls would be of similar form to adjacent retaining walls and therefore are anticipated to be formed by reinforced concrete cantilevered walls on piled foundations.

4.5.2.25 *Services Culvert CU-001*

This services culvert provides the main route for services to pass beneath the M3 on-slip from Nelson Street and the Westlink. It carries significant, gas, electric and telecommunications services.

Despite its simple structural form, this structure is possibly the most challenging in terms of construction, due to implications for the road network.

The structure is formed from three reinforced concrete boxes, formed from lightweight aggregate concrete, to facilitate lifting of the structures. The three boxes are placed side by side, with access manholes at both ends. Sumps are provided at the lower ends of the boxes to facilitate pumping out in the event of flooding. The boxes are founded on pile caps at either end, with the boxes spanning longitudinally between the pile caps – placing piles beneath the road would not be practical within the duration of the closures. Elastomeric bearings support the boxes on the pile caps during installation, to be grouted up once the road is reinstated.

The proposed construction sequence is detailed on the drawings provided in **Volume 3**. In summary, the foundations are off-line, and with the use of temporary works, can be constructed without disruption to the roads network. The boxes would also be constructed off-line at a suitable location for a high capacity mobile crane to lift them into position. There is sufficient space for construction of the boxes, and a high capacity mobile crane, North-East of the final location of the culvert. During the first night closure, the existing road would be excavated with heavy plant. The three boxes would be lifted into position before temporary backfilling and re-instatement of the road surface. On the following night, another closure would be required to properly compact the backfill around the culverts and permanently reinstate the road surfacing.

4.5.2.26 *Services Culvert CU-002*

In a similar manner to Culvert CU-001, an additional service corridor crossing is required at the M3 off-slip. It is proposed that the form of this crossing would take the form of one or several new culverts of a similar form and construction to CU-002.

4.5.2.27 *Services Culverts CU-003 and CU-004*

Several services require diversion from York Street as part of the proposed works, to avoid the new diaphragm walls installed as part of the various underpasses. Given the number, complexity and lead-in times of such service diversions, it is proposed to undertake these service diversions at the onset of the contract, or potentially, as part of an advance works contract. As the contractor would then be required to construct the various ground improvements around the diverted services, there is a risk of accidental damage. Given the importance of the services to the surrounding areas, it is considered that this is not a risk that the service providers would be willing to accept unless a more pro-active form of protection is in place. Accordingly, it is proposed to construct a number of additional service culverts (CU-003 and CU-004) through which the diverted services would be routed, providing a more substantial form of protection. It is envisaged that these culverts would be of reinforced concrete construction, with precast sections expected to be promoted by the contractor to speed construction. The culverts would be constructed below existing ground level and are not anticipated to require their own piled foundations, subject to confirmation at detailed design stage. The culverts would then be covered by reinforced concrete slabs as part of the proposed ground improvements works as described in **Section 4.6**.

A typical section for the proposed culverts is included on **Drawing YSI-URS-XX-XX-DR-UT-0031**.

4.5.2.28 *Variable Concrete Step Barrier VCSB-001*

The following summary should be read in conjunction with **Drawing YSI-URS-VC-01-DR-SE-0001**.

A variable (height) concrete safety barrier (VCSB) shall be provided in the central reserve of the Westlink, west of retaining wall RW-004, extending to the most westerly extent of the scheme, west of Bridge BR-001. The purpose of the structure is to prevent errant vehicles from crossing the central reserve, and also to accommodate very modest differences in road levels either side of the VCSB. It replaces the existing safety barrier which would not be compliant with modern codes.

These structures are formed directly on top of road make-up by specialist contractors. Constructing the VCSB shall require lane occupations to the Westlink in both directions.

4.5.2.29 *Underpasses UP-001A, UP-001B, UP-002A and UP-002B*

The summary below should be read in conjunction with the following Drawings:

- **YSI-URS-UP-1A-DR-SE-00001**;
- **YSI-URS-UP-1A-DR-SE-00003**;
- **YSI-URS-PS-01-DR-SE-00001**;
- **YSI-URS-UP-1B-DR-SE-00001**;
- **YSI-URS-UP-2A-DR-SE-00001**;
- **YSI-URS-UP-2B-DR-SE-00001**;
- **YSI-URS-UP-GE-DR-SE-00001**; and
- **YSI-URS-UP-GE-DR-SE-00002.**

The link from the M2 to Westlink (Link No. 2) is initially elevated over modified and new roads (Link Nos. 6,10 & 29) before dropping in to a depressed section below existing ground level that passes under a combination of existing and new roads and structures (existing Lagan and

Dargan bridge structures and Link Nos. 3, 6 & 11). This depressed section is contained within Underpass UP-001A.

The link from the M3 to Westlink (Link No. 4) is depressed below existing ground level and passes under a combination of existing and new roads and structures (existing Dargan bridge structure and Link No. 11) and is contained within Underpass UP-001B.

Underpass structures UP-001A and UP-001B meet at a position adjacent to the west of proposed York Street overbridge (BR-002A).

The link from the Westlink to M2 (Link No. 1) is depressed below existing ground level and passes under a combination of existing and new roads and structures (existing Dargan bridge structure and Link No. 11) before rising to meet the existing elevated section at Dock Street (Link No. 10). The depressed section is contained within Underpass UP-002A.

The link from the Westlink to M3 (Link No. 3) is depressed below existing ground level and passes under the new York Street (Link No11) before rising back to existing ground level and passing under the existing Lagan and Dargan bridge structures and over new underpass UP-001A (Link No. 2). The depressed section is contained within Underpass UP-002B.

Underpass structures UP-002A and UP-002B meet at a position adjacent to the west of proposed York Street overbridge (BR-002A).

Underpass structures UP-001A, UP-001B, UP-002A and UP-002B finally all meet and merge into Link No. 1 and Link No. 2, as appropriate, before crossing over North Queen Street (Link No. 45) and prior to entering the Westlink.

As noted previously, due to the constrained nature of the site and the proximity of existing and future bridge substructures, the structural form of Underpass UP-001A has been subject to specific assessment, as summarised in the report included for information in **Appendix B.**

Owing to the constraints on cross-section and headroom, it is proposed to use diaphragm walling, constructed using specialist low-headroom plant, to construct the part of UP-001A that passes underneath and immediately adjacent to the existing Lagan and Dargan Bridges.

Away from this identified pinch point, it is proposed to continue with the use of diaphragm walling to form the remaining underpass retaining elements. Accordingly, the proposed structural form for all underpasses is that of diaphragm walls supported by a low level propping slab with an inner wall lining formed from GRC cladding panels or equivalent. The use of an inner lining will accommodate the appropriate tolerances on the diaphragm wall verticality, whilst providing a more aesthetically pleasing finish to be provided through the underpasses. The first 1.5m of the lining above finished road level will require to be plain finished insitu concrete upstand walls to comply with vehicular impact requirements of the DMRB. These concrete sections will extended from the lower propping slab level forming, in effect, a shallow trough section.

An alternative solution that may be considered is the provision of a 'twin structure' option consisting of an inner box or U-frame trough, as appropriate, within thinner diaphragm walling. Whilst there are benefits associated with both solutions, we believe that the successful Contractor is likely to proceed with the option shown on the drawings, as the twin structure option, whilst potentially a more robust watertight solution, is more associated with regions subject to seismic loading and would use more materials and take longer to construct.

To ensure an acceptable water-tightness of the final underpass structures, the performance requirements of the embedded retaining wall systems will have to be carefully specified in the Design and Build contract and particular care will be required during final design and construction to meet such requirements. It is recommended that the embedded retaining wall elements are constructed in accordance with the latest versions of the ICE Specification for piling and embedded retaining walls, BS 8007 Code of practice for the design of concrete structures for retaining aqueous liquids and BS 8102 Code of practice for protection of below ground structures against water from the ground.

It is suggested that the underpass structures are considered as Grade 2 structures utilising Type B protection under BS 8102.

If the above performance specification is adopted, it is not expected that there will be any significant seepage of groundwater through the retaining elements. Therefore, within the extents of the underpasses, it is not expected that there will be a requirement to collect and dispose of significant quantities of groundwater. The internal drainage system will be designed to cope with any small volumes of groundwater that may seep into the system over time, which will discharge into the main pumping station arrangement.

A single pumping station is proposed to cater for storm water run-off from all four underpasses. Underpasses UP-002A, UP-002B and UP-001B will drain by gravity into a single wet well adjoining Underpass UP-001A. This will require several crossings through the diaphragm walls by carrier drains, which require routes above the base slab within the watertight section of the underpass. To restrict the risk of leaks occurring at these penetrations of the diaphragm wall system, these crossings will all occur at bespoke connection chambers which will allow access to puddle flange connections, etc which would otherwise be buried. Accordingly, the formation level of the base slab has been lowered to ensure that all road drainage is carried within the inner frame of the underpass, to provide a sealed drainage system.

It is noted that that the successful Contractor may explore other forms of embedded retaining wall. From informal discussions with internationally recognised specialist piling contractors, we understand that the time and cost for the installation of diaphragm walls and secant pile walls in this location is broadly similar; however from an engineering perspective diaphragm walls provide a significantly more effective solution. It is also noted that the ground conditions to the east side of the scheme are not conducive to the use of unsleeved pile solutions, with associated limitations on the use of secant pile walls, should they be considered. Whilst temporary sleeves for bored piles may be considered, these will have negative time and cost implications, as well as a more complex construction sequence.

Regardless of the form of embedded retaining wall adopted, discrete tie-down piles may be required under the propping slab in certain locations to resist long-term uplift of the slab from both soil heave and floatation due to ground water pressure. Piles may also be required in the short-term to provide vertical support to the wet concrete of the propping slab during the construction phase to prevent plastic settlement of the slab concrete due to soft underlying ground conditions.

To assist the phased construction of the various underpasses, cross walls are proposed at a number of locations. These walls will serve both to assist the phasing of construction works and to help provide a watertight ‘bathtub’ section formed from the diaphragm walls, with the internal cross walls adding redundancy against any groundwater leakage that could possibly occur over time through the founding materials.

In order to protect the underpasses from coastal flooding, the above ground ‘stems’ of the retaining walls shall be extended to a minimum level of 3.9mAOD. To prevent flood water entering from the ends of any of the underpass sections, the shallow trough formed by the base slab and associated upstand walls should be continued beyond the underpass sections to beyond this level. Alternatively, a robust alternate water resisting system may be proposed by the successful contractor.

An option that may also be considered to remediate environmental impacts of vehicular traffic within the depressed underpass sections is the use of a photocatalytic material in the form of e-GRC or similar in the facing panels.

4.5.2.30 *Lagan Bridge Foundation Strengthening FS-001*

Two of the piled foundations of the existing Lagan Bridge are immediately adjacent to the proposed walls of underpass UP-001A. There is a concern that the new underpass walls could clash with existing piles, potentially damaging them and compromising the integrity and safety of the Lagan Bridge. Calculations show that, on the assumption that the existing Lagan Bridge piles were placed in accordance with standard tolerances and the proposed diaphragm walls would also be constructed to tolerance, there would be circa 165mm of clearance, assuming worst possible directions of out of tolerance etc. However, although unlikely, it is possible that the existing piles, and/or the new diaphragm walls, could be constructed out of tolerance.

Bearing in mind the importance of the Lagan Bridge, it is strongly recommended to remove the risk of the structural integrity of its foundations being compromised. This can be achieved by strengthening the Lagan Bridge foundations such that they remain code compliant in the event of the rows of piles closest to the diaphragm walls being rendered ineffective.

The proposed strengthening works comprise barrettes, or mini-piles, offset from the existing foundation piles, and the proposed underpass diaphragm walls. These are joined by an inverted reinforced concrete u-frame which partially encapsulates the existing foundation slab. Vertical load transfer is achieved by a combination of a modest nib and dowels fixed into the existing base acting in shear. The aggregate to the face of the existing pile cap would also be exposed to enhance interface shear resistance through concrete cohesion and granular interlock. The tendency for the strengthening works to open up, due to the eccentricity of the piles from the edge of the existing pile cap, is resisted both by u-frame action of the strengthening works, and dowels acting in direct tension.

A challenge associated with the strengthening works is that the proposed road alignment is not far above the existing foundations. As there is a requirement for the strengthening works to act as a u-frame above the existing pile cap, it is likely that there would be only 120mm of surfacing on top of the pile cap. This could present a hard spot in the new road alignment. To prevent this, run-on slab type geometry is proposed, combined with a slab spanning between the strengthening works and the underpass walls.

Clearly the strengthening works are required to be in place before construction of the sections of diaphragm walls close to the existing foundations. It is proposed that the strengthening works are undertaken either as an advanced works package or during an initial phase of the temporary traffic management plan, prior to the section of underpass wall close to the existing foundations is formed.

4.5.2.31 *Dargan Bridge Foundation Strengthening*

The proposed dualling of the Dargan Bridge, to provide a section of twin-track between Dock Street and Donegall Quay, has been identified as a long-term potential improvement scheme to the rail network in the BMTP.

It was recognised that the road alignments within the Proposed Scheme are constrained by the dimensions of the existing bridge foundations, including those of the Dargan Bridge. Any proposal to increase the loading on the Dargan Bridge through the provision of a dualled section would increase the loadings transferred to the underlying strata through its piled foundations. Depending on the changes to the bridge superstructure, the additional loading may require the strengthening of the existing Dargan Bridge foundations. The strengthening works would comprise additional piling and extension of existing pilecaps and some strengthening of the existing pier heads. The pilecap works are likely to be covered over when the works are completed although there is the possibility that some small visible plinths may be created around the stems of the piers; the precise details will not be determined until detailed designs are undertaken. It is hoped that strengthening works to the piers heads will be limited to carbon fibre wrapping of the existing reinforced concrete to a depth of ,say, 1.5m below the bearing shelf level. The carbon fibre wrapping is typically black in colour but, if desired, can be painted for aesthetic purposes.

The project team has consulted with Translink to discuss the Proposed Scheme and minimise any impact on overlying road alignments. Based on consultations thus far, it would appear that the proposed scheme to dual the Dargan Bridge is not presently a high priority scheme on their investment programme, with proposals at conceptual design stage and certainly not as advanced as those of the Proposed Scheme. However, Translink has recognised that the construction of the Proposed Scheme presents an invaluable opportunity to undertake any works to strengthen the existing Dargan Bridge foundations as a minimum, to minimise the overall impacts on road users in the long term.

Following further discussions between Translink and Transport NI, it has been agreed that the development of the Proposed Scheme is to proceed on the understanding that the works to the Dargan Bridge foundations, as a minimum, are to be incorporated into the future construction contract. It must however be stressed that any proposed works by Translink, although potentially accommodated by Transport NI within its construction contract, must remain subject to the satisfactory outcome of separate economic appraisal, statutory procedures and the availability of funding.

4.5.2.32 *Gantry GY-001*

A signal gantry is proposed on the Westlink approach to the scheme to provide advance directional signage and motorway control equipment for road users. A location has been identified for a new signal gantry (access type) to the west of North Queen Street Bridge (BR-001). The gantry would be accessed via a single maintenance layby on the M2 bound carriageway. The proposed gantry would take the form of a single span truss, similar to existing counterparts on the motorway network, with a clear span of 34m between supports.

4.5.2.33 *Gantry GY-002*

A sign gantry is proposed to the south of the York Street bridge BR-002 to facilitate advance directional signage for road users. No additional electronic signage is required at the location and accordingly, an access-type gantry is not proposed. The form of the structure could be one of several options, with a proposed clear span of 29.5m between supports.

4.5.2.34 *Gantry GY-003*

The existing access-type gantry at this location would require removal to accommodate the r proposed road layout. To reinstate advance direction signage and motorway control equipment, a replacement structure is proposed. To minimise the works required, and hence disruption to road users on the M2 motorway, it is proposed to retain the existing support plinth in the M2 central reserve and provide a structure with a larger span, to a new support arrangement on the nearside verge of the York Street to M2 link (Link No. 15). The replacement structure would be of a similar form to the existing structure and would have a clear span of 33m between supports. The structure would be accessed directly from the hard shoulder on the slip road from York Street. It would not be possible to provide a maintenance layby for the structure within current standards for the layout of the required vehicle restraint system.

4.5.2.35 ***Gantry GY-004***

Gantry GY-004 is an existing signal gantry on the M2 foreshore. To complement the proposed road layout, it would be necessary to alter advance direction signage on the gantry. Such works would present an opportunity for Transport NI to replace the older matrix motorway indicator electronic signs on the gantry, in addition to associated corrugated metal fascias as part of separate proposals to extend the managed motorway system to the M2 and M3 in the longer term.

4.5.2.36 ***Gantry GY-005***

Gantry GY-005 is an existing signal gantry on the M2 foreshore. To complement the proposed road layout, it would be necessary to alter advance direction signage on the gantry. Such works would present an opportunity for Transport NI to replace the older matrix motorway indicator electronic signs on the gantry, in addition to associated corrugated metal fascias as part of separate proposals to extend the managed motorway system to the M2 and M3 in the longer term.

4.5.2.37 ***Gantry GY-006***

Gantry GY-006 is an existing signal gantry on the M3 on-slip from York Street. To complement the proposed road layout, it would be necessary to alter advance direction signage on the gantry. Such works would present an opportunity for Transport NI to replace the older matrix motorway indicator electronic signs on the gantry, in addition to associated corrugated metal fascias as part of separate proposals to extend the managed motorway system to the M2 and M3 in the longer term.

4.5.2.38 ***Gantry GY-007***

Gantry GY-007 is an existing sign gantry on the M3 off-slip to Nelson Street. It is proposed to retain this structure within the proposed road layout, with modifications as required to the associated advance direction signage on the structure.

4.5.2.39 ***Gantry GY-008***

Gantry GY-008 is an existing signal gantry on the M3, spanning over the diverge nose for the off-slip from the M3 to Nelson Street. It is proposed to retain this structure within the proposed road layout, with modifications as required to the associated advance direction signage on the structure.

4.6 Geotechnics

4.6.1 *Geotechnical Design Rationale*

The geotechnical characteristics of the scheme have previously been covered within the Statement of Intent, Preliminary Sources Study Report (PSSR) and Ground Investigation Report (GIR). Reference should be made to these documents for additional information.

The geotechnical design aspect covers earthworks, buried structures, bridges and retaining structures of the scheme.

The information on the ground conditions on the site was primarily obtained from the ground investigation conducted in 2013 by Causeway Geotech Ltd. This included:

- twenty five cable percussion boreholes;
- rotary cored boreholes progressed from the base of twenty of the above boreholes;
- self-boring pressuremeter tests in three boreholes;
- twenty combined gas/groundwater monitoring installations with subsequent monitoring;
- ten static cone penetration tests (CPTs);
- push-in cone pressuremeter tests at six CPT positions; and
- laboratory test including: classification tests; compressibility tests: shear strength triaxial tests (total and effective stress); rock strength tests.

Additional information on the stratigraphy and strata properties was obtained from the reports of two earlier investigations:

- 1989 Belfast Cross Harbour Road and Rail Links, by Glover Site Investigations Ltd. (BH6/1 – BH6/14); and
- 2004 Belfast Sewer Project, by Glover Site Investigations Ltd (BHs 108, 112 and 205).

Drawings YSI-URS-XX-XX-DR-RE-EW001 to YSI-URS-XX-XX-DR-RE-EW008 in Appendix E illustrate the exploratory hole locations.

The general sequence of strata recorded beneath the site is shown in **Table 4.6.1**.

Table 4.6.1: Ground Summary

Strata	Description	Depth to Top (m)	Thickness (m)
Engineered Fill	Quarry Fill within the M2 and M3 road embankment	From Ground Level	0.1 – 5.50
Made Ground	highly variable materials from historical filling	From Ground Level	0.3 – 2.9
Estuarine Alluvium (Belfast Sleech)	very soft to soft sandy silts and clays with occasional sand lens	0.3 – 1.4	0.4 – 12.5
Peat	Friable sub-amorphous with decayed roots	7.4 – 12	0.15 – 1.83
Fluvial coarse-grained deposits	Sandy gravels and gravelly sand	7.8 – 12.2	0.3 – 10.21
Glacial Deposits	firm to stiff clay, occasionally with thin laminations	9.7 – 15.4	0.46 – 41.2
	glacial sand and gravel bands	Variable within clay	0.3 – 4.2
Sherwood Sandstone	weak occasionally very weak, to medium strong sandstone, mudstone, siltstone and conglomerate	1.65 – 54.7 (getting deeper to south east of site)	Not Proven
Mercia Mudstone	Very weak to weak to moderately weak mudstone		

Drawings YSI-URS-XX-XX-DR-GE-EW001 to EW008 in Appendix E provide:

- contoured plans of the top of: estuarine alluvium (base of Made Ground); fluvial coarse-grained deposits; glacial deposits; and bedrock
- isopachytes of the estuarine alluvium and fluvial coarse-grained deposits.

Detailed examination of the fieldwork and laboratory data allowed the estimation of the range of geotechnical parameters, considered during the scheme design, as indicated in **Table 4.6.2**.

Table 4.6.2: Range of Index and Strength Parameters

Properties	Made Ground	Belfast Sleech	Peat	Fluvial Gravels	Glacial Till
Moisture content (%)	15 – 50	15 - 146	16 - 192	-	12.7 - 42
Plastic limit (%)	18 - 20	15 - 46	-	-	12 - 32
Liquid limit (%)	33 - 34	23 - 86	-	-	25 - 69
Plasticity index (%)	13 - 16	12 - 40	-	-	11 - 43
SPT N Value (blows per 300mm)	3 - 50	1 - 18	14	4-50	8 - 54
Undrained shear strength (kPa)	-	8 - 66.5	37.5	-	16 - 532.5
Bulk density (Mg/m^3)	-	1.28 – 2.09	1.38	20.6	1.74 – 2.38
Peak internal angle of friction (degrees)	-	23 - 37	-	37	22 - 32
Apparent cohesion (kPa)	-	0 – 8	-	0	1 - 15
Deformation and stiffness parameters	E' = 23-25MPa	E_{50}^{ref} = 4.5MPa E_{oed}^{ref} = 2.5MPa E_{ur}^{ref} = 15.5MPa	N/A (Peat was merged with Sleech)	E' = 25MPa E_{50}^{ref} = 25MPa E_{oed}^{ref} = 25MPa E_{ur}^{ref} = 50MPa	E_{50}^{ref} = 12-13.3MPa E_{oed}^{ref} = 9-13.3MPa E_{ur}^{ref} = 30-33.1MPa

Published data and the findings of the ground investigations indicate that there are three groundwater systems present beneath the site, within the:

- bedrock: Sherwood Sandstone Group (an aquifer identified as having high productivity potential) and the Mercia Mudstone Group (with poor productivity potential)
- coarse-grained fluvial deposits
- estuarine deposits (‘sleech’).

Within the bedrock, groundwater elevations ranged between 4.55mAOD towards the west of the study area (BH221) and -0.13mAOD towards the east (BH205). The inferred direction of groundwater flow is towards the River Lagan to the southeast reflecting the regional topography.

Groundwater elevations of between 1.20mAOD adjacent to York Street and -0.49mAOD towards the east were recorded in the fluvial deposits Again, the inferred direction of groundwater flow is to the southeast. From the information available, the groundwater within the fluvial deposits is semi-confined by the overlying estuarine (‘sleech’) deposits; the extent of hydraulic connectivity between the bedrock and the fluvial deposits is uncertain.

Within the Belfast Sleech, groundwater elevations are between -0.53mAOD in BH201 to the northeast of the area of interest and 2.58mAOD in BH217 immediately to the west of York Street. The inferred direction of groundwater flow in the alluvium appears to be towards the northeast.

Groundwater monitoring of standpipes in eight boreholes over a period of approximately seven weeks recorded relatively static groundwater levels with a maximum variation of approximately 0.3m. A small-scale tidal influence was detected in the fluvial deposits in BH210.

4.6.2 *Earthworks and Associated Retaining Systems Design Rationale*

4.6.2.1 *Proposed Earthworks*

The proposed earthworks and associated retaining systems are illustrated in **Drawing YSI-URS-XX-XX-DR-SE-ST001** with **Drawings YSI-URS-XX-XX-DR-RE-EW101, 102** and **103**, illustrating the locations of the new embankments and all Retaining Wall drawings from **Table 3.2.1** and illustrating the proposed retaining structure locations.

Given the extent of earthworks supporting structures, this section of the report should be read in conjunction with **Section 4.5.2**, which relates to the retaining walls on the scheme. The proposed earthworks include new fill embankments as well as widening and extending of the existing embankments.

4.6.2.2 *Design Alternatives*

4.6.2.2.1 *Overview*

In cases where the subsoil is unable to resist the increased loading from the proposed earthworks, additional ground support or reinforcement measures will be required. A number of solutions could be considered for the proposed earthworks (i.e. embankment extensions and widening as well as the new embankments) which are as follows:

- Solution 1 – mainly for new embankments: piles supporting a load transfer platform (LTP) reinforced with high modulus geosynthetic layers.

- Solution 2 – mainly for new embankments: piles supporting a reinforced concrete slab.
- Solution 3 – mainly for embankment extensions and widening: deployment of reinforced concrete or reinforced soil walls with extended base slab to continue below the embankment extensions. This solution also covers tiered retaining walls supported on piles.

4.6.2.2.2 ***Solution 1***

a) This solution relies on arching mechanisms forming within the soil allowing the majority of the loading to be transferred onto the pile caps by a geotextile reinforced LTP.

b) To assist this process, a high friction fill shall be placed over the LTP, which with the arching effect over the pile caps sheds the load over the piles. The LTP minimises the load transfer on to the ground (and therefore the underlying soil).

c) Given the soft nature of the underlying soft superficial deposits (i.e. Belfast Sleech), a high modulus geosynthetic is required (BS8006-1:2010 recommends that reinforcement strain should be kept to ≤3%).

d) The temporary lateral loads acting on the individual piles when they are free headed (i.e. until the fill height reaches 2.7m and facilitates pile head fixity) should be considered in order to prevent piles being overstressed laterally.

e) The piling platform under the LTP is expected to continue settling therefore causing negative skin friction and lateral squeeze of the ground, which could generate net lateral load increase on the piles located under the embankment shoulders.

f) This negative skin friction loads should be considered in the pile buckling calculations.

g) The effects described in sub-paragraphs d), e) and f) resulted in use of steel tubular piles in similar ground conditions instead of precast concrete driven piles in various projects in Scotland and Northern Ireland.

h) Furthermore, with arching effects not fully mobilised at shallow fill heights, this solution is only viable for fill embankments greater than 2.7m in height (approximately 5m in the case of lightweight fill being used).

i) Therefore, this solution would only be applicable to the new embankments on this project with the piles having adequate bending capacity to resist temporary lateral loads when free headed.

4.6.2.2.3 ***Solution 2***

a) This solution is based on the LTP being be replaced by a reinforced concrete slab (RCS) helping reduce loading on the underlying soil.

b) The RCS will allow increased pile spacing and reduction in pile numbers and transfer the embankment loads entirely on to the piles.

c) The piling platform under the RCS is expected to settle under its own weight only.

d) Unlike the LTP case there will be no mechanisms to transfer vertical loads on to the subsoil and lateral loads on to the piles as part of the load shedding and strain compatibility mechanisms as described in BS8006-1:2010.

e) The RCS will also help to negate the adverse consequences of the catenary effects of the LTP (as in Solution 1) and the effects of the piling platform settlements that are described under sub-paragraph e) of **Section 4.6.2.2.2**.

f) The adverse temporary lateral load effects described under sub-paragraph e) of **Section 4.6.2.2.2** will also be minimised since the pile fixity will not depend on fill embankment height increase.

g) Reinforced concrete or soil retaining structures can be placed on the RCS to reduce the fill volumes and embankment footprint resulting in reduction of the number or piles required.

4.6.2.2.4 *Solution 3*

a) This solution combines Solution 2 with reinforced concrete retaining wall (RCRW) or reinforced soil retaining walls (RSRW) over areas of embankment widening and extensions.

b) This will however result in increased bending being induced in the slab and on the piles due to added fill behind the wall, leading to increased reinforcement requirements.

c) The RCS and RSRW width and fill volumes will decrease with some increases in reinforced concrete volumes due to the addition of the walls on to the slab.

d) The weight of the fill behind the RCRW or RSRW become critical depending on the fill height.

e) Therefore, the RCS would have to be extended into the embankment to provide the Ultimate Limit State (ULS) and Serviceability Limit State (SLS) compliance considering the added fill weight over the existing embankment. Location specific optimisations could include the use of piles to carry the added fill loads on the existing embankment slopes through the embankments to be widened (geotextile reinforcement layers could also be considered).

f) Alternatively, tiered RCRW supported on piles can be used as shown in **Drawings YSI-URS-XX-XX-DR-RE-EW201, YSI-URS-RW-03-SE-00001** and **YSI-URS-RW-05 -DR-SE-00001**.

4.6.2.3 *Proposed Solutions*

To help identify areas where treatment would not be required, ground models were created for sections with limited fill height requirements, which included the following:

a) V-DISP software was used to identify (by calculating the total settlements) the locations of new embankments and embankment extensions.

b) Two different settlement limits (25mm and 50mm) were later considered in the finite element (FE) analysis (PLAXIS models) to establish the extent of the areas requiring measures to comply with the ULS and SLS requirements (i.e. mainly controlling of settlements).

c) The FE analyses of new embankments (remote from existing embankments), highlighted Solutions 1 to 2 as workable solutions (whereas the Solution 3 presents an flexible option for the embankment widening).

d) While at this stage a piled slab is proposed as the preferred solution, it is recognised that the LTP (with geosynthetic reinforcements and piles) presents a viable alternative, which should be given further consideration during the detailed design stage by taking into consideration the adverse temporary lateral load effects on the piles (refer to **Section 4.6.2.2**).

e) To minimise piling requirements, lightweight fill (unit weight of 5kN/m^3) could be considered from 0.7m above the design flood level, extending upwards to 1m below the road surface (for Solutions 1-2 as per **Drawings YSI-URS-XX-XX-DR-RE-EW101, 102** and **103**). This fill provides a 75% reduction in loading in comparison to a typical Class 1 General Granular Fill.

f) It is important to note that all solutions must ensure that working platforms for safe piling operations are designed in accordance with fail safe requirements and incorporated into the permanent works through appropriate certification processes.

4.6.2.3.1 *New Embankments Up to 5m in Height*

a) As shown on **Drawings YSI-URS-XX-XX-DR-RE-EW101, 102** and **103**, embankments up to 5m high could be built over >0.45m diameter piles spaced in a square grid at ~1.8m centres (for central piles), connected by a >0.3m thick piled slab.

b) Where retaining walls are present, each wall can be supported by a minimum of three pile rows, of >0.6m diameter, positioned across its cross section at ~2.4m spacing. The retaining wall piles may be spaced at ~2.3m longitudinally and embedded a minimum of 3.5m into stiff to very stiff glacial deposits.

c) The central piles remote from the retaining walls could require >1m of embedment into stiff to very stiff glacial lithologies.

d) In locations where the layer of glacial sands and gravels is sufficiently thick (>5m) or bedrock is encountered, the above embedment ranges do not apply and shorter piles could be adequate.

e) The design process indicated the piles' end bearing resistance to be the critical design factor, with limited post-construction settlements of only 10mm depending on the finalised version of the Employer's Requirements.

f) The model presented in **Plate 4.6.1** below shows the likely ground displacements, which also correspond to regions of higher stress concentrations in the vicinity of the fill embankments.

g) The relatively close pile spacing generates raft effects over the bearing stratum at depth. The model comfirms the ULS requirements and the SLS requirements could be satisfied during the final design stages by optimising the pile group geometry, as illustrated in **Plate 4.6.1**. Dark blue to light blue zones indicate displacements ranges from <5mm to <15mm).

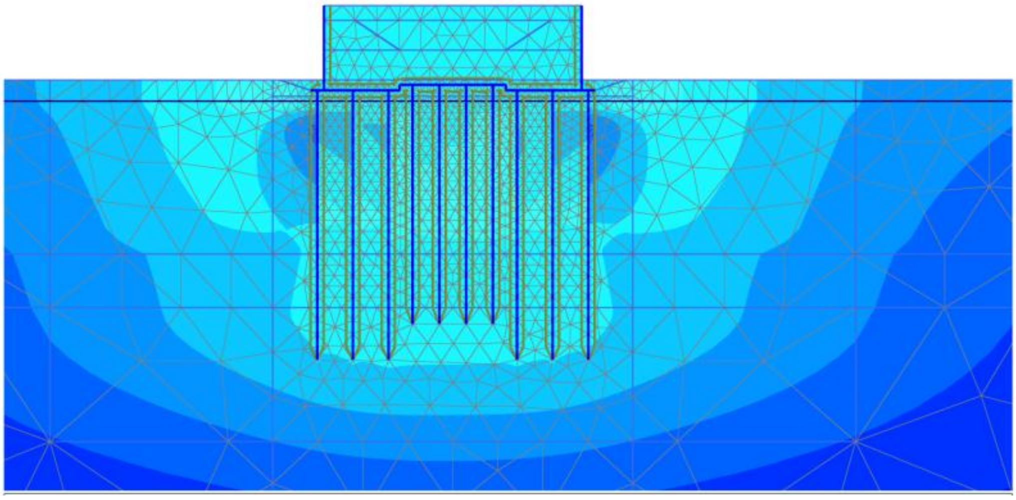

Plate 4.6.1 Potential ground displacements

4.6.2.3.2 *New Embankments Over 5m in Height*

a) For higher embankments (over 5m in height), a similar solution is proposed as illustrated on **Drawings YSI-URS-XX-XX-DR-RE-EW101, 102 and 103, YSI-URS-RW-18-DR-SE-00001; YSI-URS-RW-21-DR-SE-00001** and **YSI-URS-RW-22-DR-SE-00001**.

b) However, the retaining wall piles are expected to extend > 4m into the glacial clay due to increasing axial compressive loads, with the central embankment piles penetrating by > 2m.

c) Additionally, the longitudinal spacing is expected to be reduced to ~1.6m. As before, in cases where the glacial sands and gravels layer is sufficiently thick (>5m) or bedrock is encountered, shorter piles may be possible.

d) The anticipated post-construction settlements are expected be >15mm. The control of the settlements is obviously a function of pile group geometry and should be finalised during the final design stages in compliance with the Employer's Requirements.

4.6.2.3.3 *Embankment Extension and Widening*

a) Embankment extensions would require benching into existing highway embankments, the Solution 3 (in PLAXIS analyses) represents a flexible alternative that could accommodate varying geometry of embankment widening with added axial load transfer measures into the existing embankments.

b) Where the distance from the retaining wall to the toe of the slope exceeded a critical value, consideration was given to excavating into the slope, however, this was discarded given the costs involved and possibility of a deep-seated failure occurring below the existing highway.

c) This led to the adoption of Solution 3, with the retaining wall base extended towards the toe of the existing slope to provide a maximum separation of approximately >3.5m: requiring additional piles below the wall in places.

d) Preliminary investigations indicated horizontal displacements of the retaining wall were unacceptable and resulted in large displacements to the overlying road. Raking piles were, therefore, considered on the outer edge of the piled slab.

e) Numerical modelling indicated that the unsupported upper section of the slope for Solution 3 would undergo large time dependent settlements. While this could be mitigated using hold periods, dispersion of fill loading under the existing road induced total settlements in excess of 25mm.

f) Staged analyses (i.e. analyses modelling the construction stages) were carried out in order to identify stress redistributions and displacement ranges and variations, which indicated the critical widening zones between the retaining wall and the existing embankment where additional measures would have to be considered.

g) With the existing road having to remain operational throughout, it was concluded that an alternative solution was required (see the platel illustrating displacements; yellow, orange and red zones indicate displacements ranges from 15mm to <25mm).

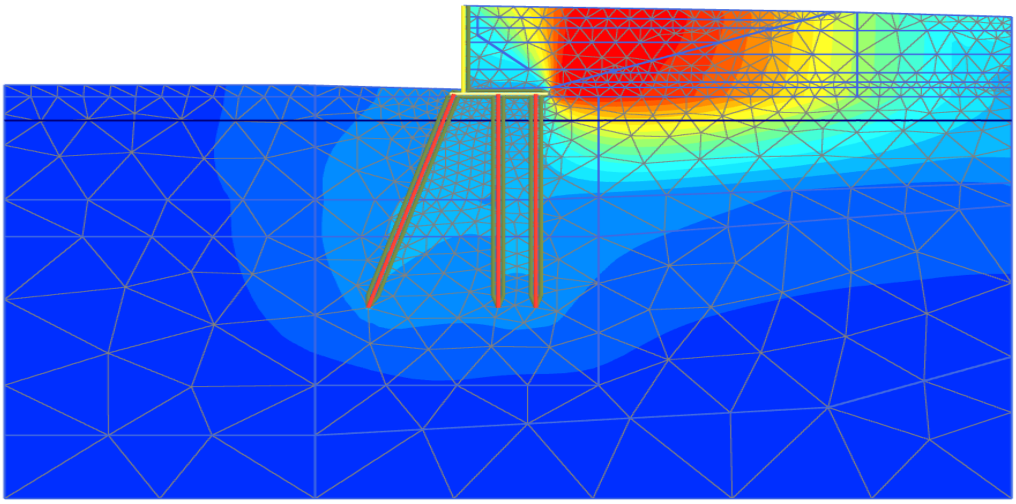

Plate 4.6.2 Potential ground displacements

h) Two new alternatives were considered; namely, a piled deck structure spanning from the piled retaining wall onto the existing embankment resting on a piled capping beam, and a series of piled platforms or a secondary piled retaining wall.

i) The first alternative requires extensive traffic management measures along with deployment of piling plant next to the existing traffic with temporary retaining measures to safeguard the stability of the exiting fill embankment under the piling plant loading.

j) For the latter alternative, it was concluded that bottom-up construction stages could be considered with staged deployment piles supported overlapping slabs, which could minimise the temporary works and traffic management challenges.

k) In order to minimise the piling related costs, >0.45m diameter Controlled Modulus Columns (CMC) could be used instead of piles.

l) Initial analyses focused on using one or two platforms. However, where loading was free to migrate to the underlying soft material, substantial movements were recorded, resulting in bending moments that exceeded CMC limits and large settlements occurring under the existing road.

m) Installing three platforms within the embankment reduced the unsupported areas and, therefore, lateral and vertical movements. Total settlements under the existing road were estimated to be in the region of 20mm as illustrated on Plate 4.6.3.

The findings of the ULS and SLS analyses concluded that staged piled slabs or a second tier piled wall alternatives combined with the primary retaining wall (founded on competent ground or piled) are more viable embankment extension solutions for the scheme as illustrated on **Drawing YSI-URS-XX-XX-DR-RE-EW201**.

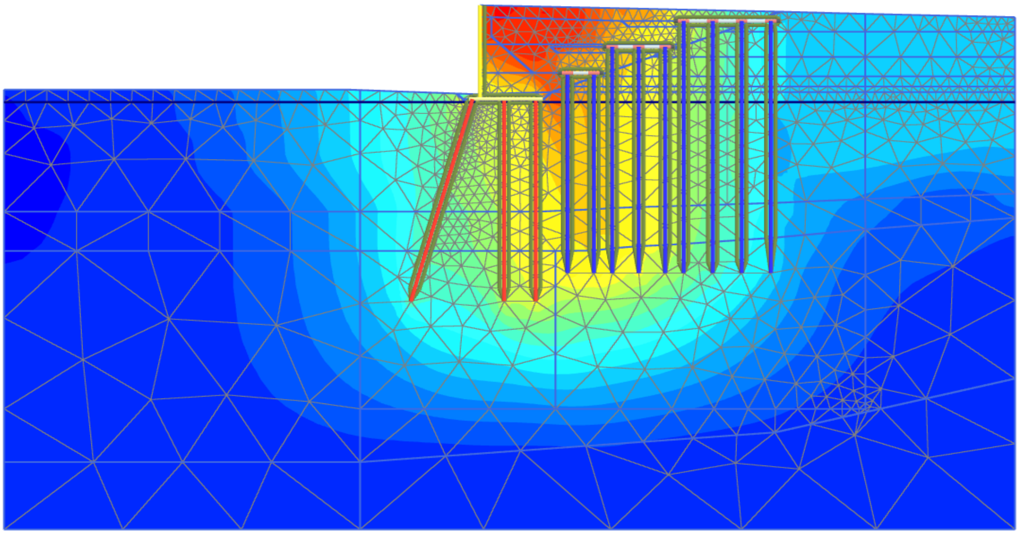

Plate 4.6.3 Potential ground displacements under three platform option.

The earth works and associated retaining structures are summarised in **Table 4.6.3** along with the required foundation measures, types and envisaged temporary works elements.

The proposals are illustrated on **Drawings YSI-URS-XX-XX-DR-SE-ST001, YSI-URS-XX-XX-DR-RE-EW101, YSI-URS-XX-XX-DR-RE-EW102, YSI-URS-XX-XX-DR-RE-EW103, YSI-URS-XX-XX-DR-RE-EW201, YSI-URS-BR-01-DR-SE-00002** and **YSI-URS-RW-01 to 26-DR-SE-00001**.

Table 4.6.3: Earthworks/Associated Retaining Structures Summary

Earthworks/ Structures Section	Foundation Measures	Foundation Type	Temporary Works Aspects	Approximate Extent of the Geo Structure
EB-001	N/A	N/A	-	Treated Area - 700m^2 Maximum Height of Fill - ~3m
EB-002	N/A	N/A	-	Treated Area - 699.3m^2 Maximum Height of Fill - ~4m
EB-003	Piled Slab (Solution 1)	Piled Slab	-	Treated Area - 2915m^2 Maximum Height of Fill - 4.6m
EB-004	Piled Slab (Solution 1 / 2)	Piled Slab	-	Treated Area - 573.3m^2 Maximum Height of Fill - 5.4m
EB-005	Piled Slab (Solution 1)	Piled Slab	-	Treated Area - 4799m^2 Maximum Height of Fill - 5m
EB-006	N/A	Piled Slab	-	Treated Area - 4570.5m^2 Maximum Height of Fill -
EB-007	Piled Slab (Solution 1 / 2)	N/A	-	Treated Area - 536.7m^2 Maximum Height of Fill - 8.9m
EB-008	Piled Platforms (Solution 3) / Bridge	Piled Slabs	-	Treated Area - 3526.5m^2 Maximum Height of Fill - 9.1m
EB-009	Piled Platforms (Solution 3) / Bridge	Piled Slabs	-	Treated Area - 1734.8m^2 Maximum Height of Fill – 5.8m
EB-010	N/A	N/A	-	Treated Area - 1733.2m^2 Maximum Height of Fill -
RW01	Cantilever Retaining Wall	Piled Foundation	Sheet Piling	Treated Area - 73.05m Maximum Retained Height - 5.57m
RW04	Tapered Cantilever Retaining Reverse L Wall	Piled Foundation or Shallow Structural Upfill	Sheet Piling	Wall Length - 40m Maximum Retained Height - 1.074m

Earthworks/ Structures Section	Foundation Measures	Foundation Type	Temporary Works Aspects	Approximate Extent of the Geo Structure
RW05	Cantilever Retaining Wall	Piled Foundation	Sheet Piling	Wall Length - 45m Maximum Retained Height - 2.2m (1:2 slope behind wall not considered)
RW07	Cantilever Retaining Wall	Piled Foundation	-	Wall Length - 145m Maximum Retained Height - 5.1m
RW017	Tapered Cantilever Retaining Reverse L Wall	Piled Foundation	-	Wall Length - 117m Maximum Retained Height - 8.4m
RW018	Tapered Cantilever Retaining Reverse L Wall	Piled Foundation	-	Wall Length - 105m Maximum Retained Height - 8.2m
RW020	Tapered Cantilever Retaining Reverse L Wall	Piled Foundation	Sheet Piling	Wall Length - 153.35m Maximum Retained Height - 2.35m
RW021	Cantilever Retaining Wall	Piled Foundation	-	Wall Length - 130.05m Maximum Retained Height - 5.95m
RW022	Cantilever Retaining Wall	Piled Foundation	Sheet Piling	Wall Length - 186m Maximum Retained Height - 9.4m
RW024	Cantilever Retaining Wall	Piled Foundation	Sheet Piling	Wall Length - 100m Maximum Retained Height - 2.775m
RW025	Cantilever Retaining/Flood Wall	Piled Foundation	Sheet Piling	<u>Flood Wall</u> Wall Length - 84.5m Maximum Retained Height - 1.96m <u>Wall With Parapet</u> Wall Length - 96.2m Maximum Retained Height - 5.1m
RW026	Cantilever Retaining Wall	Piled Foundation	Sheet Piling	Wall Length - 63.2m Maximum Retained Height - 0.75m

Earthworks/ Structures Section	Foundation Measures	Foundation Type	Temporary Works Aspects	Approximate Extent of the Geo Structure
RW027	Cantilever Retaining Wall	Piled Foundation	Sheet Piling	Wall Length - 61.8m Maximum Retained Height - 1.5m
RW028	Cantilever Retaining Wall	Piled Foundation	Sheet Piling	Wall Length - 41.15m Maximum Retained Height - 1.7m
RW029	Cantilever Retaining Wall	Piled Foundation	Sheet Piling	Wall Length - 79m Maximum Retained Height - 5.9m
RW031 to RW034	Cantilever Retaining Wall	Piled Foundation	Partly Sheet Piling	Wall Lengths – 031 to 033 vary between 8m and 15m and 034 is ~25m Maximum Retained Height – 3m and 4.5m

4.6.3 *Structures: Geotechnical Design Rationale*

4.6.3.1 *Underpass Structures*

a) The proposed underpasses UP-001A, 001B, 002A and 002B over most of their length are basically “U”- shaped reinforced concrete trough sections (RCT) formed by diaphragm walls with a propping slab below road level or by secant piles walls with a separate inner U-frame trough structure. At the location of, at Bridges 002A, 002B and 003 where the RCT will be covered by an in-situ reinforced concrete deck or precast beams integral with the walls such that it effectively becomes a cut and cover concrete tunnel (CCCT).

b) The proposed inner lining of the RCT and the CCCT can be constructed as shown in **Drawing YSI-URS-UP-GE-DR-SE-00001**.

c) Given the soft ground conditions, potential access constraints at Lagan and Dargan Bridges (discussed in the previous sections of this report) and the section stiffness inadequacies of pile walls, diaphragm walls are considered the optimum solution (alternate options were discussed in the previous sections).

d) In addition the limited headroom under the existing bridges rendered a secant pile option unviable from a construction viewpoint at these locations (CFA / bored pile rigs require headrooms in excess of 12m based on fail safe requirements during construction).

e) Underpass construction shall follow the ‘Bottom Up’ method, whereby upon completion of the diaphragm installation, the internal space shall be supported using temporary props throughout excavation until construction of base propping slab depending on the adopted final design approach.

f) Prop levels have been analysed to minimise potential stress redistribution around the piled foundations of Lagan Bridge piers B22 and C22, whilst also optimising the embedded wall thickness, which could reduce adjacent ground disturbance during the embedded wall installation.

g) The required embedment depth of the diaphragm walls was established using the PSEUDO-FE programme FREW. This provided a reliable initial determination of the embedded wall configuration along with deflections and prop force estimates which was progressed to detailed analysis using a FE Programme PLAXIS.

h) The potential eccentricity of transient loading represented an important design issue. Investigating the effects on the structure, the maximum traffic loading intensity was calculated (in accordance with BS EN 1991-2:2003+NA and DMRB BD31/01), allowing the various loading combinations to be analysed in PLAXIS helping obtain the critical loading combination.

i) At the base of the excavation, below proposed road level, a permanent propping slab will be installed, helping control lateral displacements and reducing moments on the diaphragm walls. The slab will be constructed using coupled reinforcement, thus forming an integral connection with the diaphragm walls.

j) The proposed construction consists of circa 1200mm diaphragm walls rather than the alternate combined thinner diaphragm and in situ cast inner wall option, albeit this is a detailed design and construction issue that should be finally addressed at the next stage.

k) The alternate option is based on the base slab facilitating the construction of the reinforced concrete inner trough structure, allowing the removal of the temporary props as the inner walls construction progresses upwards. The inner trough is designed to possess a wall thickness capable of resisting permanent long-term loads and helping achieve water tightness of the underpass. To provide additional water tightness, a separate waterproofing layer could be installed between the embedded walls and the inner trough.

l) The diaphragm wall thickness ranging between 800mm and >1200mm can be used depending on the plant headroom requirements and the adopted options listed above, which will affect the inner reinforced wall thickness that could range between 300mm and 700mm.

m) Given the potential effects of uplift/heave, a line of single piles may require to be placed under the propping slab (where necessary). In areas where the 1 in 200 year flood level exceeds the height of the underpass, the RCT shall extend upwards until all flood requirements are satisfied (flood level + 0.7m freeboard).

n) Treatment or replacement of existing ground under the propping slab was considered to improve the vertical load capacity of the existing ground and to facilitate installation of the storm water drainage measures that will be required. Details of further drainage measures are discussed within the drainage section of this report.

o) To best ensure the water tightness of the final underpass structures, the performance requirements of the embedded retaining wall systems will have to be carefully considered and controlled, with particular care taken during construction. It is recommended that the embedded retaining wall elements are constructed in accordance with the most current versions of the ICE Specification for piling and embedded retaining walls, BS 8007 Code of practice for the design of concrete structures for retaining aqueous liquids and BS 8102 Code of practice for protection of below ground structures against water from the ground.

p) It is suggested that the underpass structures are considered as Grade 2 structures utilising Type B protection under BS 8102.

q) The underpass and the reinforced concrete approaches will form a barrier effecting short term surface runoff and ground water connectivity in the area. The engineering effects of these have been considered and the following were incorporated into the design approach:

- Storm water runoff will be equalised by surface drainage measures,
- The ground water in the estuarine deposits will be effected in short term giving negligible rise in the upstream side, however underlying high permeability granular fluvial glacial deposits will help to equalise the levels,
- Hydraulic connectivity within the fluvial glacial deposits can be reinstated after the placement of the base slab within the underpass section by means of directional drilling,
- If the final design hydraulic connectivity analysis necessitates incorporating additional measures, directional drilling through the diaphragm walls below the base the slab could be adopted being the most commonly used measure in such cases ,
- The glacial deposits are not expected to be affected given their low to very low permeability,
- The likely existence of a confined aquifer in the bedrock (sedimentary rocks) is not expected to be a design consideration, since the thickness of the glacial deposits is adequate for the diaphragm or secant pile wall embedment.

Further details on underpass construction and suggested construction sequences are included in **Drawings YSI-URS-UP-1A-DR-SE-00001, YSI-URS-UP-1B-DR-SE-00001, YSI-URS-UP-2A-DR-SE-00001** and **YSI-URS-UP-2B-DR-SE-00001**.

Table 4.6.4 summarises the proposed underpass construction methods:

Table 4.6.4: Earthworks/Structures Summary

Structures Section	Type of Geo solution	Foundation Type	Temporary Works Aspects	Remarks
UP-001A	Diaphragm walls as included in proposed and alternate options	Embedded walls with a propping base slab supported by piles as necessary	1.Possible ground treatment of the estuarine deposits 2. Use of temporary props 3. Ground water control 4. Instrumentation and monitoring of the ground movements.	Proximity of existing structures and foundations is highlighted
UP-001B	As above	As above	As above	
UP-002A	As above	As above	As above	
UP-002B	As above	As above	As above	

4.6.3.2 *Construction Issues*

a) A topographical survey has been undertaken by the project team to establish available headroom at Lagan and Dargan bridges. This indicated that there will be height restrictions during construction at these locations. Therefore, the installation works for the diaphragm wall shall require a low-headroom diaphragm wall rig.

b) The available information on the existing Lagan and Dargan Bridge piles suggest that the piles are not reinforced along their entire length and it is expected that the reinforcement does not continue below the point where bending becomes zero.

c) Therefore, the piles are most vulnerable to lateral disturbance during the installation of the diaphragm walls, which would necessitate provisions for ground treatment at the concerned pier locations in order to improve surrounding superficial deposits.

d) As an alternative to the proposed embedded systems (i.e. diaphragm walls), the RCT sections could be formed by secant pile walls where there are no head room restrictions. The physical properties of the estuarine deposits (mainly sleech) at Interchange area are thought to be unsuitable for secant pile wall installations necessitating the use of temporary casing; therefore a ground treatment should be considered if secant pile walls are considered.

e) There are no pilling records suggesting likely existence of errant piles at the concerned pier locations (i.e. B22 and C22), pre-diaphragm wall installation investigations are advised to verify the as-built pile group geometries at the concerned pier locations.

4.6.3.2.1 *Interaction with Existing Structures*

a) Underpass UP-001A will pass directly adjacent to the Lagan and Dargan bridge foundations. As a result, due consideration had to be given to the short and long term effects of construction, in addition to a potential lack of verticality in future and historic pile/diaphragm wall installations. This could result in an existing pile being struck during the works, potentially damaging the existing structure (pier B22 and C22 of Lagan Bridge at particular risk),

b) The risk of encountering an errant pile at the existing Lagan Bridge was identified as a 'medium probability' risk in accordance with the project team's risk management procedures. Mitigation of this risk is proposed through the use of piles to prior underpin the Lagan Bridge bases B22 and C22 ahead of the installation, as described in **Section 4.5**.

c) Possible need for underpinning and ground improvement works at B22 and C22 foundation locations have also been considered and presented in **Drawings YSI-URS-FS-01-DR-SE-00001** and **YSI-URS-UP-1A-DR-SE-00003**.

4.6.3.2.2 *Bridge Structures*

a) The new bridges and bridge extensions are presented in **Drawings YSI-URS-BR-01-DR-00001, YSI-URS-BR-01-DR-SE- 00002, YSI-URS-BR-2A-DR-00001, YSI-URS-BR-2B-DR-00001, YSI-URS-BR-03-DR-00002, YSI-URS-BR-04-DR-00002, YSI-URS-BR-05-DR-00001** and **YSI-URS-BR-06-DR-00001**.

b) The ground conditions at the pier and abutment locations of the new bridges require use of pile groups under these foundations, which do not represent unusual engineering design and construction solutions.

c) Widely used driven, bored and CFA piles solutions can be optimised into various pile group geometry and implemented based on the locations specific ground condition needs.

4.7 Drainage, Hydrology and Hydrogeology

4.7.1 *Introduction*

As described in **Section 2.1.4** of this document, the location of the Proposed Scheme is at the existing converging points of the strategic routes of the M2, M3 and Westlink. As set out previously the natural topography of the study area is relatively flat and close to sea level. As a result of many years of development the area has a ground surface finish which is predominantly impervious in nature.

While there would be a need for further detailed consideration and development of the detailed construction proposals the complexity of establishing a compliant and optimum drainage solution within an already highly developed and very constrained site has presented numerous challenges which have been overcome. Establishing a viable method of collecting the surface water runoff for the proposed links associated with the Proposed Scheme has been one of these challenges. The complexities which the proposed layout would overcome include providing drainage facilities for underpasses which would have finished road levels some seven metres below any potential appropriate discharge location. The solution embedded in the Proposed Scheme is the inclusion of a centrally located storm water Pumping Station to collect the surface water drainage and convey the water to an appropriate outlet. Additional complexities include ascertaining appropriate rates and volumes of storm water discharge, and obtaining agreement with the appropriate authorities to the acceptable permitted quantity and quality of the drainage water to be discharged.

In the environment of the finished road, surface water run-off collection for the Proposed Scheme would be achieved through a combination of road drainage gullies and combined kerb and drainage (CKD) systems discharging to longitudinal collector pipes.

In seeking to develop a proposal which embraces all of the drainage challenges in the area consultations were carried out with NI Water to seek to achieve an agreed drainage strategy for the area of the York Street Interchange site which is outlined below. As described previously storm water falling on the scheme area currently drains to the local combined sewer network which then outfalls into the existing Low Level combined sewer in Corporation Street (Link No. 43). In keeping with best practice and to deliver improvement to the NI Water sewerage system the potential to separate storm water from and take it out of the combined sewers as part of the York Street Interchange Scheme was reviewed. It was agreed between Transport NI and NI Water that the optimum solution i.e. to seek to provide maximum available storm water separation within the York Street Interchange proposals, should be the basis of the drainage solution. In going forward in this way it was ascertained that there would be a significant reduction in storm water discharge from the wider scheme area which would lessen the frequency of surcharging within the existing NI Water sewerage network.

4.7.2 *Hydrology, Road Drainage and Floodplain Mitigation*

4.7.2.1 *Overview*

The potential impact of the Proposed Scheme on the existing coastal and river floodplain and the associated design and regulatory requirements of the Design Manual for Roads and Bridges and Rivers Agency's Planning Policy Statement 15 (PPS 15) 'Planning and Flood Risk' have been considered and assessed from two standpoints i.e.:

- impacts which the existing floodplain may have on the Proposed Scheme; and

- impacts which the Proposed Scheme may have on the existing floodplain and the current mechanisms and influences on flood progression.

Consultations including meetings and correspondence discussing various matters such as, achieving consent to discharge and flood risk, surrounding the Proposed Scheme have been carried out and are ongoing with Rivers Agency, Northern Ireland Environment Agency and NI Water.

It should be noted that significant existing building, industrial and transport infrastructure present within the greater study area, including parts of Belfast City Centre, is currently within the designated coastal and river floodplain and in specific circumstances would be subject to flood risk, see **Drawing YSI-URS-XX-XX-DR-DR-00203**. In undertaking this study existing floodplain information was verified using Flood Maps (NI) available from DARD (NI) Rivers Agency which identifies the River and Coastal floodplain for the River Lagan/Belfast Lough. The area is however protected as described in **Section 2.1.4.1.2**.

4.7.2.2 *Existing Floodplain Impacts on the Proposed Scheme*

The assessment of the Proposed Scheme and the potential vulnerability of the area to flooding focused on scheme areas which would be in or adjacent to existing floodplains and in particular significantly depressed elements of the Proposed Scheme. The operational requirements for the underpass structures and adjacent trunk road network have been explored with Transport NI. This review has resulted in Transport NI providing guidance which confirmed that the trunk road network should be protected from flood inundation for all events with flood levels up to those associated with a 0.5% Annual Exceedance Probability (AEP) (1 in 200 year) flood event.

In order to fully explore and assess the vulnerability of the Proposed Scheme within the coastal floodplain a Flood Risk Assessment was prepared (a copy of the summary Flood Risk Assessment Report is included in **Appendix F**). This report has identified and assessed the vulnerability which York Street Interchange and the surrounding area has to flooding. The report also assesses the impact which the proposed York Street Interchange scheme would have on the floodplain during flood events which would occur in excess of those currently afforded protection by existing coastal protection measures, and identifies proposed flood mitigation measures.

As a result of the awareness of impending works, created by the consultation process between Rivers Agency and Transport NI in connection with the flooding aspects in the area, Rivers Agency offered to provide Transport NI with a copy of their recently acquired InfoWorks Coastal and River Floodplain computer model of the River Lagan, Belfast Lough and Central Belfast. This significantly assisted Transport NI and URS in undertaking the appropriate level of flood assessment works. On behalf of Transport NI, URS carried out further model enhancement works focused on the road network aspects of the existing terrain, in order to assess existing conditions and Proposed Scheme impacts. The enhancement works undertaken included embedding information relating to Proposed Scheme features such as walls and roads into the model in order to assess potential scheme effects and inserting enhanced vertical road carriageway information.

Preventative design solutions and scenario testing has been undertaken using the Infoworks RS modelling software and this work has resulted in the inclusion of the following Proposed Scheme elements; the provision of flood retaining walls and sufficiently raised ramp approaches to prevent flood water ingress to underpasses, the provision of temporary flood barriers between the M3 to Westlink (Link No. 4), Nelson Street (south) (Link No. 12) and M3 to York Street (Link No. 7), specifically designed non back flow drainage and utilities infrastructure and a storm water Pumping Station incorporated with resilience measures and protection to minimise risk of failure during a future flood event. The investigative works undertaken indicate that it is feasible to exclude direct flood waters emanating from the Belfast Harbour which would flow above ground into the site area from the north and east, from impacting on the trunk road network and from entering the underpass links associated with the Proposed Scheme.

Whilst it is anticipated that it would be possible to prevent flood water inundation of future underpass features it should be noted that for the Proposed Scheme the remainder of the York Street Interchange site area with proposed finished levels below approximately 3.05 metres AOD could, based on current flood protection infrastructure remaining unchanged, be directly affected by any flooding event with an AEP equal to or less than 2% which would eventually breach the existing flood protection infrastructure. For information on the flood assessment works undertaken, refer to the Flood Risk Assessment Report included in **Appendix F**).

4.7.2.3 *Impacts of the Proposed Scheme on the Floodplain*

For the Proposed Scheme being assessed, consideration has also been given to the potential impact of the supressed and elevated links embedded within the design, on the existing floodplain. The impacting features of the Proposed Scheme include elevated bridges, new walls, raised roads and because of the protection built into the design, the new underpasses. The potential impacts on the existing floodplain of higher level road infrastructure, any structural piers and any proposed flood protection walls, located within the extents of the floodplain have been assessed as part of a Flood Risk Assessment.

The assessment considered how the various proposed features impacted on the floodplain and the flow characteristics of flood waters as they would progress through the site area for various flood events. As identified in the Flood Risk Assessment Report the works undertaken have sought to determine, at any location in the wider site area, the impact on flood levels which the Proposed Scheme would have on the ground and properties in the area. The outcome of the assessment concluded that the Proposed Scheme would have a neutral impact on existing flood levels during the design 0.5% AEP event.

Despite the above, some fundamental parts of HD 45/09: Road Drainage and the Water Environment cannot be fulfilled as it is not possible to relocate York Street Interchange out of the floodplain, nor because of the urban nature of the site would it be feasible to provide flood compensation areas and therefore a Departure from Standard is required.

4.7.3 *Road Drainage Strategy*

Whilst acknowledging that the scheme drainage proposals would be subject to detailed design development, the procedures utilised in the development of the drainage design at its current stage are consistent with the principles and requirements defined in the Design Manual for Roads and Bridges (DMRB) and relevant current Regulations, Orders and European Directives.

Based on the foregoing, the design has been developed in such a manner as to:

- address road safety issues pertaining to the accumulation of surface water as defined in the DMRB
- provide an effective system, using normally available and readily maintained components, for conveying surface water arising from the new road to the receiving watercourses, waterbodies or drainage systems

- incorporate facilities to inhibit discharge of sediments and significant volumes of hydrocarbons, prior to discharge to the receiving waterbodies or drainage systems
- provide facilities to isolate the drainage system from the receiving watercourses in the event of significant spillages of contaminants.

4.7.3.1 *Description of Proposed Drainage Infrastructure*

The nature of the road link alignments associated with the Proposed Scheme would result in significant lengths of new carriageway being constructed considerably below the existing ground levels in the area surrounding the site of the Interchange and well below any acceptable potential outfall location within the area. This situation presented a challenge to the development of a drainage network which met the requirements of the appropriate statutory bodies and design standards.

In the Proposed Scheme the underpasses would be drained through the use of combined kerb and drainage (CKD) systems which would in turn discharge to a system of carrier drains. Utilising CKD systems has been the basis of the underpass drainage design because their installation would assist in minimising the depth of drainage construction below carriageway surface levels.

The very depressed level of the network of carrier drains within underpasses which in turn would link between underpasses, necessitated the provision of a central storm water Pumping Station which would be constructed to lift storm water drained from the road carriageway upwards to a level where it would then discharge via a rising main outfall pipeline to the Belfast Harbour as seen on **Drawings YSI-URS-XX-XX-DR-DR-00024 and YSI-URS-XX-XX-DR-DR-00025**. The following points are a summary of the main features of the proposed storm water Pumping Station which would be developed as part of York Street Interchange:

- The outer structure (wet well and valve chamber) would be integral with underpass walls.
- The sump level in the storm water Pumping Station wet well = -14m AOD approx. (top of floor slab).
- The pumping installation would be designed to accommodate all road drainage discharges, emanating from the catchment areas, for all events up to a 1% AEP (1 in 100 year return period) design storm event, without the risk of flooding or surcharge occurring within the underpass structures. Road edge drainage detail within the underpasses would be designed to accommodate all rainfall intensities associated with all events up to a 1% AEP without surcharge onto the road carriageway.
- Two no. pump sets i.e. 2 high flow and 2 low flow pumps. The pumps proposed would be close coupled wet well submersible pumps.
- Two no. continuously rising outlet (1 low flow and 1 high flow) mains. Two pumping mains are proposed as this would deliver the optimum solution to cater for the large range in flows and minimise possible sedimentation problems which could arise if a single pumping main was to be installed.
- An outfall structure at the connection point to the proposed outlet which will utilise a redundant Combined Sewer Overflow (CSO) culvert near Gamble Street.
- A wet well which would facilitate the attenuation of peak flow discharges and thereby deliver a reduced size of outfall rising mains.

- The capability for total shut down of flow discharge in the event of an accidental spillage occurrence on the road carriageway.
- Flood resilience measures to ensure continuous operation of the Pumping Station would be maintained up to and during a 0.5% AEP (1 in 200 year) coastal flood event, including the provision of a permanent standby generator and dual network supplies from the electricity network.

The drainage solution developed for the project seeks to maximise the drainage catchment area that would discharge storm water to the Pumping Station and which would then be conveyed onwards via the new pumping main arrangement to the outlet point near Gamble Street. The existing redundant Combined Sewer Overflow culvert which would be utilised discharges through an outfall structure in the quay wall to Belfast Harbour. However the potential for coastal flooding (as described in **Section 4.7.2.2**) within the area together with other constraints has restricted the extents of the catchment areas to predominantly the trunk road network. This action was taken in order to ensure that the potential for the back flow of coastal flood waters is removed and the risk of compromising the underpass flood protection proposals is minimised.

The proposed location for the storm water Pumping Station is shown on **Drawing YSI-URS-XX-XX-DR-DR-00028**. The proposed storm water Pumping Station would be developed to ensure that the project complies with the core requirements of DMRB Volume 4 Section 2 HD 33/06 entitled “Surface and Sub-surface Drainage Systems for Highways”.

Where other road drainage outfalls would be required for connector roads adjacent to the Proposed Scheme outside the extents of underpasses and in areas where storm separation is not feasible, for example in the area of York Street, the associated storm drainage outfalls would be achieved through discharge to gravity pipe connections into the existing and proposed combined sewerage network as shown in **Drawing YSI-URS-XX-XX-DR-DR-00028**.

4.7.3.2 *Interconnecting Pipework Linking the Underpasses to the Pumping Station*

Incorporating a central storm water Pumping Station as described above into the proposed design, would result in the need for a number of suitably robust interconnecting storm water carrier pipelines at extremely low levels and at considerable depths below existing ground level. These interconnecting pipelines would provide links between each of the respective low points within the 4 No. proposed underpasses and the storm water Pumping Station. The proposed layout of these interconnecting pipes can be seen in **Drawing YSI-URS-XX-XX-DR-DR-00028**. In accordance with Chapter 6.4 of DMRB HD 33/06 Surface and Sub-Surface Drainage Systems For Highways, and through consideration of the risks associated with a flooding event within the York Street Interchange underpasses, arising from a rainfall event, the proposed carrier and interconnecting pipework and the Pumping Station wet well capacity and arrangement would be designed to accommodate a 1 in 100 year (AEP of 1%) road drainage design storm event.

4.7.3.3 *Road Edge Detail*

The proposed Stage 3 drainage design has sought to provide the optimum road edge detail whilst being mindful of the required vertical clearances between finished underpass carriageway levels and the top of structural slabs. In order to minimise this vertical clearance distance and therefore keep the level of the proposed structural propping slab as high as possible within the sections of the roadway in underpasses, the road edge detail proposed in the Stage 3 design has been progressed on the basis that Combined Kerb and Drainage (CKD) systems would be installed during the construction sequences.

Outside of the proposed underpass structure extents, the proposed road edge detail and carriageway drainage regime would be less restricted as it would not be subject to the structural constraints and depth restrictions outlined above.

4.7.3.4 *Proposed Road Drainage*

To minimise the number of points of discharge and the rates of discharge of flow being discharged to the combined sewerage system, the proposed Stage 3 design includes the provision of lengths of new storm water carrier drainage in addition to the combined NI Water sewer network up to the extremities of the anticipated site area. This proposed approach makes provision for future works by others who would be seeking to deliver further separation of storm water and foul sewage for the wider York Street/North Queen Street/Dock Street/Great George's Street area.

The drainage proposals described in the following paragraphs are shown on **Drawing YSI-URS-XX-XX-DR-DR-00028**. Information modelling location references Link Nos referred to below are taken from **Drawing YSI-URS-XX-XX-DR-RE-IM000** and bridge location references are taken from **Drawing YSI-URS-XX-XX-DR-SE-ST001**.

4.7.3.4.1 *Proposed Road Drainage – Westlink to M2 (Link No. 1) and M2 to Westlink (Link No. 2) (Between North Queen Street and York Street)*

With reference to **Drawing YSI-URS-XX-XX-DR-DR-00028** the catchment area draining from the high point includes North Queen Street Bridge (BR-001) which carries the Westlink, and the road carriageway which extends in an easterly direction towards the underpasses. The catchment for this contributing area would include drainage intercepted outside of the underpass retaining wall extents. Utilising CKD and conventional gullies the storm water collected would discharge to the storm water Pumping Station.

4.7.3.4.2 *Proposed Road Drainage – York Street to York Road (Link No. 11), M3 to York Street (Link No. 7), Great Patrick Street to Dunbar Link (Link No. 13) and Frederick Street (Link No. 14) Drainage*

On York Street Bridge (BR-002A&B) there would be a high point in the vertical alignment between the two bridge structures. The proposed drainage at this point would break and flow in opposing northerly and southerly directions. The northerly drainage is discussed in **Section 4.7.3.4.3**.

The section south of the high point would drain through CKD. The runoff collected along Great Patrick Street/Frederick Street (Link No. 13 & 14) and York Street to York Road (Link No. 11) (south of York Street Bridge (BR-002A&B)) would drain into new separate storm drainage systems upstream of connections into the existing or proposed combined sewer network and ultimately discharging into the Low Level Sewer in Corporation Street (Link No. 43).

4.7.3.4.3 *Proposed Road Drainage – Westlink to York Street (Link No. 5), York Street to York Road (Link No. 11) and Dock Street (Link No. 10) Drainage*

York Street to York Road (Link No. 11) (north of York Street Bridge (BR-002A&B)) would discharge into a new separate drainage collector pipe before discharging into the existing sewerage system at appropriate locations.

Westlink to York Street (Link No. 5) would discharge to a drainage collector pipe at the low point in the link and would be discharged to a suitable location on York Street to York Road (Link No. 11).

Within Dock Street (Link No. 10) collected storm water would discharge into the existing sewerage system at suitable connection points.

4.7.3.4.4 *Proposed Road Drainage – Westlink to M2 (Link No. 1), M2 to Westlink (Link No. 2), M2 to M3 (Link No. 8), M3 to M2 (Link No. 9) and York Street (South) to M2 (Link No. 15) Motorway Drainage*

Storm water generated from the area of Dock Street Bridge (BR-005) would be collected before being connected into networks of carrier drainage systems that would flow southwards towards the storm water Pumping Station. Numerous additional connections would be made to this collection system, upstream of its connection point to the Pumping Station, having carried surface water to low points in the vertical alignment through CKD or gullies.

In the proposed scenario the M2 motorway drainage, north of Dock Street Bridge (BR-005), would drain as it currently does to the Mile Water River Culvert. The northerly drainage will be discussed in **Section 4.7.3.4.7**. Similarly the elevated M3 Lagan Bridge would be drained to Belfast Harbour predominantly through the existing storm drainage network. Based on the adopted design approach, which seeks to maximise storm water separation from the sewerage system, within the Stage 3 design, it has been feasible to redirect discharge of the motorway area between the M2 and M3 transition, to the Pumping Station.

4.7.3.4.5 *Proposed Road Drainage – Dock Street to M3 (Link No. 6)*

The drainage surrounding Dock Street to M3 (Link No. 6) would have 3 different discharge points. The first discharge point would be close to Dock Street (Link No. 10) and would dispose of the surface water from the high point on the road into the existing combined sewerage system. The second and third proposed discharge points would be located at either side of the bridge over the M2 to Westlink (Link No. 2) and both would discharge to the storm water Pumping Station.

4.7.3.4.6 *Proposed Road Drainage – Nelson Street (North) (Link No. 29) Drainage*

In the area of Nelson Street (North) (Link No. 29) the storm water would drain towards low points and discharge at suitable discharge points into the existing combined sewerage system.

4.7.3.4.7 *Proposed Road Drainage – North of Dock Street Bridge (BR-005); Westlink to M2 (Link No. 1), M2 to Westlink (Link No. 2) and M2 to M3 (Link No. 8) Drainage*

From a high point in the vertical alignment north of the Dock Street overbridge (BR-005) the M2 carriageway slopes northwards towards a low point near where the Mile Water River culvert traverses beneath the M2. Proposed drainage solutions for these areas would involve surface water eventually discharging to the Mile Water River Culvert. The areas that would be drained by this network of drainage pipes and conduits are, the Westlink to M2 (Link No. 1) and the M2 to M3 (Link No. 8) north of Dock Street Bridge (BR-005) and M2 to Westlink (Link No. 2) north of Dock Street Bridge (BR-004).

4.7.3.4.8 *Proposed Underpass Link A Drainage – M2 to Westlink (Link No. 2)*

Storm water from the area of the new bridge over Dock Street (BR-004) would be collected and conveyed in a southerly direction; it would then be intercepted near where Link No. 2 is at grade (Approx. at the location of existing Trafalgar Street) and carried through a network of drainage pipes which would receive other drainage connections upstream of its point of discharge to the storm water Pumping Station. The remaining area of the underpass catchment would be drained by CKD before being discharged at the low point of the underpass into the collector network. Downstream of this low point, as with the other underpasses and owing to their associated alignment sag curves, the collector drainage would need to connect through the underpass wall to facilitate discharge to the storm water Pumping Station.

4.7.3.4.9 *Proposed Underpass Link B Drainage – Westlink to M2 (Link No. 1)*

Storm water generated within the underpass would be collected by CKD and discharged at the low point within the underpass to the carrier drainage system that would discharge to the storm water Pumping Station.

4.7.3.4.10 *Proposed Underpass Link C Drainage – Westlink to M3 (Link No. 3)*

Storm water from the area of the Westlink to M3 (Link No. 3) would have 3 different discharge points. The first would be located at the lowest point within the underpass and from this point a carrier drainage network would convey flow and would discharge to the storm water Pumping Station. The second and third discharge points would be located at either side of the proposed road bridge over M2 to Westlink (Link No. 2). These discharge points would dispose of runoff collected from outside of the underpass (area south of the underpass) and would ultimately discharge to the storm water Pumping Station.

4.7.3.4.11 *Proposed Underpass Link D Drainage – M3 to Westlink (Link No. 4)*

In the area of the M3 to Westlink (Link No. 4) this would have 3 discharge points. The first would be located at the lowest point within the underpass and the runoff collected from this area would discharge to the storm water Pumping Station. The second would also discharge storm water to the Pumping Station but in addition would collect storm water from outside of the underpass from the direction of the M3 Lagan Bridge to the south. The third would discharge runoff collected from the area of Great George’s Street towards M3 to York Street (Link No. 7) and would discharge the storm water into the existing combined sewerage system upstream of its connection to the Low Level Sewer in Corporation Street (Link No. 43). The reason for discharge of this area to the sewerage network being that it is outside of the area of the scheme which would be protected from inundation during a 0.5% AEP coastal flood event.

4.7.3.4.12 *Proposed Road Drainage – Duncrue Street to Westlink (Link No. 31)*

It is proposed that the area of Duncrue Street to Westlink (Link No. 31) and Duncrue Street (Link No. 29) would be drained in a northerly direction and would discharge to the Mile Water River Culvert as shown on **Drawing YSI-URS-XX-XX-DR-DR-00028**. This approach again seeks to limit the areas which would discharge to the sewerage system and to maximise storm water separation.

4.7.3.5 *Further Drainage Measures*

As described in Section 4.5 of this report, the underpasses would be designed as sealed structures with sufficient load bearing capacity and flexural strength to prevent flotation or seepage ingress from groundwater. This approach to the structural design of the underpasses would mean that within their structural formation between the finished road surface and the top of propping slab level, there would be no requirement to collect and dispose of significant quantities of groundwater.

In order to comply with DMRB, further drainage measures including surface and sub-surface water drainage solutions would be required for isolated portions of ground adjacent to the site which are not specifically highlighted in earlier paragraphs. These isolated portions of ground include the central part of the scheme site which has been designated for landscaping and would, for example, be included in the pumping station catchment area; land parcels where the adjacent ground slopes towards the scheme; sections of existing and proposed engineered/earthworks slopes; footways or finally paved areas within the site where storm water could potentially pond or accumulate.

4.7.4 *Hydrogeology*

4.7.4.1 *Assessment*

URS has undertaken a desk based assessment to identify potential implications on the groundwater regime in the vicinity of the Proposed Scheme. The work is required to support the separately published Environmental Statement which forms **Part 1** of this Proposed Scheme Report.

The assessment is based primarily on intrusive site investigation works undertaken by Causeway Geotech Ltd ('Causeway') between 21 January and 06 March 2013. The 2013 site investigation works were undertaken under the direction of URS. The findings of the Causeway investigation including all borehole records and test results are included in the Contractor's Factual Report . A plan showing exploratory positions is also included.

A series of historical site investigation reports for the general vicinity of the scheme have also been made available to URS. The majority of the historical information relates to the vicinity of the existing Westlink to the west of the Proposed Scheme.

A detailed technical Hydrogeological Technical Note has been prepared that considers baseline conditions and the predicted impacts of the Proposed Scheme in relation to hydrogeology, a copy of which is included in **Appendix G**.

4.7.4.2 *Conclusions*

Following the desk based assessment of the available information, the following conclusions were made:

- The hydrogeology in the vicinity of the scheme is relatively complex. Three main hydrogeological units were identified as follows:
  - Groundwater in bedrock comprising sandstones belonging to the Sherwood Sandstone Group to the east and mudstones belonging to the Mercia Mudstone Group to the west;
  - Groundwater in fluvial deposits largely of sand and gravel. These are absent towards the west but thicken towards the east. They appear to become more silty/sandy to the north and south; and
  - Groundwater in estuarine alluvium deposits ('Belfast sleech').
- Generally there appears to be an upwards vertical hydraulic gradient into fluvial deposits from the deeper bedrock. There is therefore a potential for recharge of the fluvial sands and gravels from the bedrock.
- There is a downwards vertical hydraulic gradient in the estuarine alluvium (sleech) to the fluvial deposits.
- The direction of groundwater flow in the bedrock and fluvial deposits is broadly south-east. The direction of groundwater flow in the estuarine alluvium is broadly northeast. It is possible that the low level sewer running along Corporation Street influences groundwater flow in the superficial deposits (and potentially in the underlying fluvial deposits).

- No in situ hydraulic conductivity testing has been undertaken. Hydraulic conductivities of the superficial groundwater units have therefore been estimated from empirical relationships, which are prone to error. The hydraulic conductivity of the estuarine alluvium is likely to be very low. Estimates of the hydraulic conductivity of the fluvial deposits based on gradings were highly variable. Loss of fines during drilling may affect the estimates, some of which appear high for the soils described.

- The estimated geometric mean for the transmissivity of the fluvial sand and gravel deposits was 1,400m^2/d. Based on Darcy's Law, the groundwater flow in the sand and gravel unit perpendicular to the north-south section of the M2 to Westlink underpass (UP-001A) and retaining walls was 2,250m^3/d.

- Based on the available information and proposed road layout, it is considered there is a potential for interception of groundwater flow within the fluvial deposits. It is estimated that more than one half of the available aquifer width will be intercepted. This may lead to back up of groundwater behind diaphragm walls and reversal of the vertical hydraulic gradient(s). The increased hydraulic head may be transmitted to the overlying estuarine deposits. Groundwater flow in the bedrock aquifer may also be affected where hydraulic connectivity is present.

- The potential hydrogeological effect described depends primarily on the width of the section of the aquifer intercepted in relation to the total aquifer width rather than on their hydraulic conductivity/transmissivity.

- Based on the available information, it is not known how or when any change in head in the fluvial deposits may manifest itself in the overlying estuarine alluvium. It is noted that groundwater levels in this unit are already shallow.

- At this stage, it is considered that potential mitigation measures may include provision of additional drainage at shallow depth.

4.7.4.3 *Recommendations*

The information presented above suggests that the Proposed Scheme may lead to a change in the local hydrogeological regime, potentially affecting groundwater flow in the fluvial deposits leading to changes in the hydraulic gradient and increased hydraulic heads that may be transmitted to the overlying deposits. At present, however, it is not possible to quantify this further and therefore the following recommendations are made:

- Further routine groundwater level gauging of boreholes installed during the Causeway investigation. It is recommended that weekly monitoring be undertaken over several weeks.

- In situ hydraulic testing of wells installed in the three hydrogeological units, i.e. the bedrock, the fluvial deposits and the estuarine alluvium.

- Numerical groundwater modelling to test the effects of deep foundation structures on the groundwater flow regime and to quantify the potential implications of head changes in the fluvial deposits on groundwater levels in the estuarine alluvium. A simple groundwater model can be developed to represent the generally understood geological units and with simple boundaries evaluate current and affected groundwater flow regimes. Such modelling will be reliant on the accuracy of understood aquifer permeabilities and is best undertaken only after such data is available. The modelling will assist with the design of appropriate mitigation measures such as additional drainage at shallow depth which can be incorporated into the detailed drainage design.

4.8 Public Utilities

4.8.1 *Overview*

Significant diversions of utilities infrastructure and mitigation measures would be necessary as a result of the various elements involved in the construction of the Proposed Scheme. Due to the nature of the scheme, these elements include retaining walls, underpasses, bridge piers, bridge abutments, embankments and other minor road alterations, such as kerb realignment and carriageway level alterations. Ground conditions in the study area generally at formation level have low bearing capacity and therefore it would be necessary for foundation strengthening works to be undertaken to provide support to foundations for the proposed retaining walls, bridge piers, bridge abutments and embankments. The intrusive nature of the works required to construct these individual elements would lead to severance of the existing utilities networks located within the study area therefore significant diversionary works and mitigation measures would be required to be undertaken to ensure supply networks and systems are not detrimentally affected.

Following the completed Stage 2 Scheme Assessment process, further consultations with affected utility providers have taken place as part of the Stage 3 Scheme Assessment process in order to establish the scale, scope and potential cost of mitigation measures which would be required to facilitate construction of the Proposed Scheme, whilst ensuring minimum disruption to their affected customers in the vicinity of the study area. Emerging out of these further consultations and from information provided by the various utility companies, it has been established that the majority of service utilities to be diverted would be located in York Street, North Queen Street, Great George's Street, Nelson Street, Dock Street, Duncrue Street and around York Link. Refer to **Section 2.1.5** which outlines the existing utilities infrastructure within the study area.

4.8.2 *Proposed Mitigation Measures for the Proposed Scheme*

Drawing YSI-URS-XX-XX-DR-UT-00011 shows proposed Service Routes which would be required to enable the diversion of severed utilities routes within the study area. **Table 4.8.1** summarises the proposed services to be diverted within each Service Route as well as outlining additional mitigation measures proposed to ensure connectivity of services. **Drawing YSI-URS-XX-XX-DR-UT-00043** shows cross section illustrations taken at certain locations along the main Service Routes for the scheme.

Table 4.8.1: Proposed Utility Diversionary Routes

Service Route	Approximate Location	Proposed Services to be diverted/protected
A (Pink)	York Street	• Phoenix Gas 75 mBar LP Main* • Northern Ireland Electricity (NIE) 11kV*, 6.6kV, lower voltage cables and spare ducting • Motorway Communications 4-Way • British Telecom (BT) 12-Way • Cable & Wireless (C&W) 4-Way *May alternatively be diverted in Service Route D Equipment to be relocated • Phoenix Gas Medium Pressure Reducing Station • NIE Substation
B (Purple)	York Street overbridge	Additional ducting supplied to accommodate services through bridge
C (Yellow)	York Street overbridge	Additional ducting supplied to accommodate services through bridge
D (Blue)	Great George's Street/ North Queen Street/ Henry Street	• Phoenix Gas 75 mBar LP Main* • NIE 11kV* cables • NI Water 355mm Ø water main *May alternatively be diverted in Service Route A
E (Peach)	Great George's Street	• Phoenix Gas 4 Bar MP Main, 7 Bar IP Main and 2No. historical mains (to be replaced with ducts of similar size, where these exist) • NI Water 600mm Ø combined sewer • NIE 33kV, 11kV and 6.6kV cables • Motorway Communications 4-Way • BT 4-Way • C&W 4-Way • NI Water 125mm Ø water main
F (Green)	Great George's Street to Dock Street	• Phoenix Gas 7 Bar IP Main • BT 4-Way • Motorway Communications 4-Way • C&W 4-Way • NIE 33kV and 6.6kV cables

Service Route	Approximate Location	Proposed Services to be diverted/protected
G (Brown)	Nelson Street (north) and Duncrue Street	• Phoenix Gas 7 Bar IP Main • NIE 110kV cables • NI Water 355mm Ø water main and water meter arrangement
Localised Diversions	North Queen Street (BR-001 extension works)	• Virgin Media 6-Way • BT 1-Way and 4-Way • NIE lower voltage cables • NI Water 1200mm Ø combined sewer
	Dock Street (BR-004 pier foundations and BR-005 extension works)	• NI Water 1050mm Ø combined sewer • Virgin Media 6-Way • BT 8-Way • NI Water 250mm Ø water main • C&W 4-Way
Protection Measures/Lowering (Proposed only if recommended by affected utility company during Stage 3 consultation process)	Duncrue Street	• Virgin Media 3-Way • NIE 33kV and lower voltage cables • BT 4-Way and 2-Way • Phoenix Gas 7 Bar IP Main
	Whitla Street underpass	• NIE lower voltage, 6.6kV, 33kV and 110kV (oil filled) cables • NI Water 355mm Ø water main • BT 6-Way • Historical Phoenix Gas (to be replaced by duct of equivalent size, where it exists)
	Pumping Station Access Road	• NIE 6.6kV, 11kV and 33kV cables • BT 4-Way • Eircom apparatus • Historical Phoenix Gas (to be replaced by duct of equivalent size, where it exists) • Virgin Media 6-Way
	North Queen Street	• BT 14-Way • NI Water 300mm Ø Ductile Iron Water Main
	Nelson Street (South)/Great Patrick Street to Dunbar Link	• BT Various • C&W 4-Way • NIE lower voltage, 6.6kV and 33kV cables • Virgin Media 4-Way

Service Route	Approximate Location	Proposed Services to be diverted/protected
	Cityside Retail Park Access	• BT 11-Way • Phoenix Gas 75 mBar LP Main • NIE lower voltage cables • NI Water 300mm Ø water main

Table Notes:

1. For example, 4-Way means 4 No. ducts, in a standard arrangement e.g. 2x2 or 4x1, with minimum internal diameter of each duct = 100mm.
2. Services networks which would need to be diverted but have not been included in the consideration above are street lighting, traffic signals or detailed consideration of motorway communications apparatus.
3. Local/private connections have not been included e.g. electrical supply connections to Proposed Scheme infrastructure is not shown.
4. Service access chambers to be located outside the proposed carriageway extents where feasible.

The construction of underpasses for the Westlink to M2 (Link No. 1), M2 to Westlink (Link No. 2), Westlink to M3 (Link No. 3) and M3 to Westlink (Link No. 4) would lead to the severance of the existing utility infrastructure routes within York Street and Nelson Street. Service Routes A to D are proposed to accommodate the diversion of utilities presently located within York Street as well as apparatus currently located within York Link between York Street and Nelson Street.

Service Route A is the main diversion corridor for the services located in York Street (Section 1 on **Drawing YSI-URS-XX-XX-DR-UT-00043**). This corridor is planned to accommodate significant Northern Ireland Electricity (NIE), British Telecoms (BT), Phoenix Gas and Cable & Wireless (C&W) apparatus. This corridor would involve connecting proposed utilities apparatus to existing infrastructure at appropriate locations (to be agreed with the various utility companies), where the scheme finished road levels are approximately at-grade with existing levels. The optimum site identified for this to take place is adjacent to a Transport NI car park located south west of the York Street/Great George's Street junction. The corridor would then be required to be constructed through this car park to connect to Great George's Street. This route through the car park was chosen to avoid the proposed piled load transfer slab which would be needed to support the embankment on the approach to the York Street overbridge structure. North of Great George's Street the services would be anticipated to be diverted west of the extents of the proposed underpass structures, across Westlink, then diverted in the Westlink to York Street link (Link No. 5) and reconnected back to existing or new utilities infrastructure located in the York Street to York Road link (Link No. 11). Over a section of Service Route A, on the approach to the York Street overbridge from the Westlink to York Street link (Link No. 5) and from the York Street to York Road link (Link No. 11), a piled load transfer slab has been proposed to support the embankment. Over this section any diverted services in this area would need to be protected from damage during foundation strengthening works or other construction activities and measures would need to be agreed with the individual utility providers.

The proposed Phoenix Gas low pressure (LP) main and NIE 11kV cable diversions in Service Route A can potentially use Service Route D as an alternative option to avoid this piled load transfer slab. The use of Service Route D for telecommunication diversions, including a BT 12-Way duct configuration, provided in Service Route A would be unlikely to be acceptable to the telecommunication companies due to a suggested drop in signal quality/system detriment caused by the increase in diversion length that would be apparent.

As part of the mitigation measures required for Service Route A, a Phoenix Gas Medium Pressure Reducing Station (MPRS), which is currently located in the Transport NI car park beside York Street, would be required to be relocated due to the construction of retaining wall RW-028. A NIE substation, currently located in close proximity to Galway House, would also be required to be relocated.

Service Routes B and C (within the proposed bridge structure) would become available for use following completion of the York Street overbridge construction. It is suggested that ducting for utilities could potentially be included within the structure of the overbridge, or within the footway pavement construction above the deck of the bridge, to accommodate service connections through the bridge but this would be a decision to be taken in the development of the detailed design.

Service Route D is to be used to accommodate diverted York Street utilities apparatus via Great George's Street, North Queen Street and Henry Street. This route was suggested as an alternative to Service Route A and the main benefits of using this corridor are that it would avoid the piled embankment slabs on the approaches to the York Street overbridge and also would avoid crossing strategic road links and areas of major works. Following discussions with the various utility providers, NI Water have stated that diversion of a 355mm diameter water main via this route may be possible. NIE and Phoenix Gas have also accepted the possibility of using this diversion route as an alternative to Service Route A for the proposed 11kV cables and LP gas main diversions. However, there are likely to be other constraints in North Queen Street and Service Route D such as other existing utilities present as well as taking into account the works associated with the extension of overbridge BR-001 for example.

Service Route E (Section 2 on **Drawing YSI-URS-XX-XX-DR-UT-00043**) is provided as a diversion corridor to re-connect severed York Link and Great George's Street utilities, linking from York Street to Nelson Street and Corporation Street. Commencing at the York Street/Great George's Street junction, the proposed utilities apparatus would be connected to existing infrastructure at appropriate locations (to be agreed with various utility companies), where scheme finished road levels are approximately at-grade with existing levels. The diversion of utilities proposed within Service Route A may also be required to continue east within Service Route E. Due to the envisaged construction sequence of the piled load transfer slab which would be required to support the approach embankment to the York Street overbridge, the utilities diversions are planned to be temporarily located outside the proposed footprint of this slab in the existing Pathways Project land between York Street and Little York Street, where feasible. After construction of the proposed piled load transfer slab is complete, permanent service diversions would then be installed immediately beneath the footprint of new footway above the piled embankment slab between York Street and Little York Street. This approach would seek to maximise the area available for future development in the area outside the scheme embankment extents. The exceptions to this are two services which currently are located in Great George's Street and traverse straight through the existing Great George's Street/York Street junction; these exceptions consist of a 600mm diameter combined sewer and a 4Bar medium pressure (MP) gas main. One option available would be to construct diversions of these utilities within protective service culverts beneath the piled embankment slab. Following discussions with NI Water, an alternative option available to divert the combined sewer would be to route the sewer via Thomas Street and Lancaster Street and then connect to an existing 600mm diameter combined sewer in Little Patrick Street. Continuing east from Little York Street, Service Route E would be located within the proposed footway locations on both sides of the M3 to York Street (Link No. 7) link. At the junction with Nelson Street the Service Route would intercept significant apparatus for NIE, BT, C&W and Phoenix Gas, including NIE 33kV cables and a 7Bar IP gas main, which would be diverted across the M3 to Westlink (Link No. 4) link. Across this link it is proposed that service culvert structures would be used, where agreed with the affected utility companies, to provide protection to the services and to facilitate future access to perform maintenance operations. From this point the services would either be re-connected to existing apparatus, diverted east towards tie in locations in Corporation Street or would be continued in Service Route F.

Service Route F (Section 3 on **Drawing YSI-URS-XX-XX-DR-UT-00043**) has been included as a services corridor to connect severed existing service routes in Nelson Street and York Link, to link between Great George's Street and Dock Street. Service Route F would connect to some of those proposed utilities diversions which follow Service Route E, including NIE 33kV cables and a 7Bar intermediate pressure (IP) gas main, at a location close to, or within, the access road for the proposed drainage pumping station. The route would follow the access road north and pass under the Westlink to M3 (Link No. 3) within proposed service culverts. The route would continue alongside the alignment of the M2 to Westlink (Link No. 2), determined with due consideration to construction of the underpass walls, before having to cross the link due to land constraints at a pinch point (corridor narrowing) located adjacent to the Stella Maris building. All utilities in this Service Route, except the 7Bar IP gas main diversion (which will be continued in Service Route G), would be re-connected at suitable locations to existing infrastructure located in Dock Street (Link No. 10).

Service Route G would include the continuation of the 7Bar IP gas main diversion from Service Route F, the diversion of a NI Water 355mm diameter water main, which crosses the M2 in the Whitla Street underpass, the relocation of a water main district meter setup, and the possible diversion of 110kV NIE apparatus. The 7Bar IP gas main diversion would follow the alignment of the proposed west footway of Nelson Street (north) (Link No. 29), Duncrue Street (Link No. 64) and would connect to the existing Phoenix Gas infrastructure close to the Duncrue Street to Westlink (Link No. 31) on-slip. Due to the proposed re-configuration of traffic islands to facilitate the proposed on-slip at Duncrue Street, NI Water metering equipment, currently located on a traffic island north of Whitla Street, would be required to be relocated to enable safe access to the apparatus. This apparatus would be relocated to a realigned traffic island south of the current position.

Following consultation with NIE a number of options have been discussed with regard to their high voltage 110kV infrastructure, which includes oil filled underground cables which are sensitive to vibration and that are currently located within the Whitla Street underpass. It may be possible to develop a solution, through consultation with NIE, which would cause minimal vibration and would involve construction of structures an appropriate distance away from NIE plant. Alternatively, to divert NIE 110kV oil filled cables would involve considerable lead-in times associated with ordering specialist cables and programming system outages for example. Access to areas of adjacent land would be required on a temporary basis to enable cable jointing to be carried out if NIE cable diversions were necessary. Lands agreements would need to be provided to facilitate the route of any permanent cable diversions.

Due to the alignment requirements of the Proposed Scheme, a new bridge is required to be built at Dock Street and bridge extension works are required at both Dock Street and North Queen Street. At Dock Street (Link No. 10), it is proposed to construct a new bridge to span over Dock Street (BR-004) as well as providing extension works to the west side of the existing overbridge structure (BR-005). Due to the locations of the proposed structural piers, foundations and anticipated enabling works e.g. temporary sheet piling works, there would be an impact on various utilities infrastructure. The affected utilities in Dock Street would include a NI Water 1050mm diameter combined sewer and 250mm diameter water main, 4-Way C&W, 6-Way Virgin Media and 8-Way BT apparatus. The utilities apparatus affected, which are located in both existing footways on the north and south side of Dock Street, would likely be required to be locally diverted to avoid all anticipated construction works at these locations.

At North Queen Street (Link No. 45), extension works to the existing overbridge on both the north and south side of the structure would be required. Due to the works associated with the proposed extended structural foundations and the construction of retaining wall RW-001, a number of utilities would be affected and would potentially require localised diversionary works to ensure supply connectivity is maintained. The apparatus in the east footway beneath the overbridge which would be affected and would require diversionary works include a Virgin Media 6-Way, BT 1 and 4-Ways and NIE lower voltage cables. A raised footway on the west side of North Queen Street beneath the structure contains significant BT infrastructure (14-Way) and other utilities. These utilities would be required to be locally protected during the extension works. A 1200mm diameter combined sewer would also be required to be diverted due to the construction of retaining wall RW-001 adjacent to the North Queen Street overbridge extension works.

A new road to supply access to the new drainage pumping station for the Proposed Scheme has been provided from Corporation Street (Link No. 43). Numerous utilities, including NIE 33kV cables, BT, Eircom, Phoenix Gas and Virgin Media apparatus, that are currently located in the footway in Corporation Street, would be required to be protected or lowered locally over the width of the proposed new access road. This change would come about as a result of the existing footway levels being lowered to tie the proposed road into existing carriageway levels and to facilitate pavement construction. Similarly, at Duncrue Street (Link No. 64), Nelson Street (south), Cityside Retail Park Access (Link No. 28) and Great Patrick Street to Dunbar Link (Link No. 13), due to the proposed re-configuration of traffic islands to facilitate the Proposed Scheme, several areas which are currently footway would be lowered to carriageway levels. Virgin Media, NIE, BT, C&W, NI Water and Phoenix Gas apparatus at these locations would be required to be locally protected or lowered, through consultation with the affected utility providers.

With the addition of the Duncrue Street to Westlink (Link No. 31) link at Stage 3, the Whitla Street underpass would be required to be extended as part of the Proposed Scheme (BR-006). Currently there is an extensive network of utilities within the underpass including NIE 110kV, 33kV, 6.6kV and lower voltage cables, BT 6-Way apparatus and a NI Water 355mm water main. It is proposed that the existing utilities located within this structure would not require to be diverted at this location and would be protected during the construction works of the underpass. In this case, if live service connections would be maintained, the utility providers would insist that only extremely limited works in proximity to their plant would be permitted and mitigation such as use of low vibration plant and construction methods would be necessary.

4.9 Motorway Communications

4.9.1 *Overview*

Intelligent Transport Systems (ITS) would form an integral part of this scheme throughout the new interchange, connecting the Westlink, M2 and M3 motorways. Therefore consideration has been given to the provision of technology at the interchange in line with current Design Manual for Roads and Bridges (DMRB) principles and standards, considering the current provision of technology and standards on the Westlink, M2 and the M3. The strategy would provide complimentary measures to support the operation of the Proposed Scheme, providing operational signing, traffic monitoring and CCTV surveillance during normal and abnormal conditions on the network.

In the wider context, the implementation of technology on the new sections of the network would allow the Proposed Scheme to be a managed interchange within the Belfast trunk road network.

The design of this provision takes into account of the specific transport planning objectives of the scheme, with technology provided to support the wider scheme objectives.

4.9.2 *Operational Management*

Operational management of the Proposed Scheme would be developed to deliver optimum throughput of vehicular traffic within a safe, efficient and reliable environment; providing local and strategic traffic information to road users during normal and abnormal conditions. The operational management provided by the provision of technology assets would assist in the delivery of this objective. Operational management would be achieved under the operational regimes detailed in **Table 4.9.1** and monitored through the Transport NI Traffic Information and Control Centre (TICC).

Table 4.9.1: Operational Management Regimes

Operational Characteristic	Description
Normal Operation	Under normal operation conditions, the operational regime would provide coverage of the Proposed Scheme network assets and would integrate roadside infrastructure, with the existing TICC strategic driver information system allowing the control centre staff to monitor and respond to incidents or unusual traffic situations as they arise.
Journey Time Reliability	Variable Speed Limits can be set to provide consistent flow and journey time reliability during periods of congestion or anticipated heavy traffic.
Incident Control	Lane signalling and message signs would provide automatic incident management, queue protection and slip road management during incidents.

4.9.3 *ITS Components*

The ITS components that have been considered to be provided as part of the Proposed Scheme are detailed in **Table 4.9.2**:

Table 4.9.2: ITS Components in Proposed Scheme

ITS Component	Description
Lane Signalling	Overhead signalling deployed above each running lane for displaying lane control aspects, and advisory speed limits.
Variable Message Signs	Used for displaying strategic and tactical driver information messages.
Incident Detection	Uses MIDAS for real-time detection of traffic to identify incidents / events occurring on the interchange so that TICC control room staff can implement strategies to mitigate the effects and manage safety.
CCTV surveillance	For visual monitoring of the York Street Interchange, the Westlink, M2 and M3. This would allow the monitoring of traffic flow in real time.
Communications Network	To collect and disseminate real-time travel information and provide network control of signs, signals and other telecommunications equipment associated with the interchange.

ITS Component	Description
Entry control	Post mounted signals for entry stop and speed equalisation at the entry to slip roads, joining the interchange.
Telephones	These have not been considered as part of the proposals, having considered that the interchange does not allow for safe stopping locations within the scheme limits.

The following sections describe the proposed technology measures within the scheme.

4.9.4 *Westlink to the M2 and M3 Motorways*

To manage traffic from the Westlink to the M2 and M3 motorways it is proposed to provide lane and speed management. Lane control signals on the mainline carriageway over each lane would be provided using a new confirmatory gantry at the start of the scheme from the eastbound Westlink. The lane control signals would ensure a safe lead-in sequence prior to the interchange with the M2 and M3 motorways.

These signals would inform drivers of lane/road closures ahead and display speed limits following an incident or during periods of congestion on the York Street exit, M2 northbound and M3 eastbound carriageways.

Driver messaging would also be provided by variable message signing mounted on the new gantry. The variable message sign on this gantry would enable strategic and tactical messages to be relayed to road users on potential hazards on the road network further downstream as the Westlink diverges at the York Street exit, M2 northbound and M3 eastbound carriageways.

Detection loops would provide the Technology Communications Network with congestion alerts and would allow incidents or events to be identified and managed on the York Street exit slip road, M2 northbound and M3 eastbound carriageways.

A PTZ (Pan Tilt and Zoom) CCTV camera mounted on the new gantry would provide coverage of the approach to the new diverge with the M2/M3 and the York Street exit from the Westlink.

The camera would also provide overlapping coverage with the existing Westlink CCTV system and underneath the York Street Bridge.

4.9.5 *M3 / Westlink and York Street to the M2 North*

It is proposed to extend the existing intra-junction gantry on the M2 northbound carriageway to accommodate the new interchange road layout.

To manage traffic from the M3 / Westlink and York Street to the M2 northbound it is proposed to provide lane and speed management. Lane control signals on the mainline carriageway would be provided using the extended gantry located over the York Street on-slip and the merge point for the Westlink and M3 motorways. These lane control signals would ensure a safe lead-in sequence prior to the merge with the M2 motorway.

The lane control signals would inform drivers of lane/road closures ahead and display speed limits following an incident or during periods of congestion on the M2 northbound motorway. Driver messaging would be provided by a variable message sign mounted on the gantry. The variable message sign on this gantry would enable strategic and tactical messages to be relayed to road users on potential hazards on the road network further downstream as the Westlink, York Street entry slip road, and the M3 merge with the M2 northbound carriageways.

Prior to joining the M2 northbound from the York Street interchange, on-slip Advanced Motorway Indicators (AMIs) would inform road users of any speed restrictions/closures.

Detection loops would provide the Technology Communications Network with congestion alerts and would allow incidents or events to be identified and managed on the M3, Westlink and York Street entry slip road.

A PTZ CCTV camera mounted on the gantry would provide coverage between the Dargan Bridge and the M2/M3 interchange as well as the northbound M2 motorway.

4.9.6 *M2 Southbound to the Westlink and M3 Motorway*

It is proposed to utilise the two existing gantries on the M2 southbound carriageway. These gantries would accommodate the lane signalling and variable message signs.

To manage traffic from the M2 southbound to the Westlink and M3 motorway it is proposed to provide lane and speed management. Lane control signals on the mainline carriageway over each lane would be provided using the existing gantries located over the M2 southbound motorway. The lane control signals would ensure a safe lead-in sequence prior to the merge with the Westlink and M3 motorway.

The lane control signals mounted over each lane would inform drivers of lane/road closures ahead and display speed limits following an incident or during periods of congestion on the Westlink and M3 motorway. Driver messaging would be provided by a variable message sign mounted on the existing confirmatory gantry located on the M2 southbound prior to the Westlink off slip. The variable message sign on this gantry would enable strategic and tactical messages to be relayed to road users on potential hazards on the road network further downstream on the Westlink and M3 motorway.

Prior to joining the Westlink from the Duncrue Street interchange and the M3 from the Nelson Street interchange, on-slip AMIs would inform road users of any speed restrictions/closures.

Detection loops would provide the Technology Communications Network with congestion alerts and would allow incidents or events to be identified and managed on the M2 southbound, Westlink and M3 motorway.

4.9.7 *Standalone CCTV*

A PTZ CCTV camera mounted at the Duncrue slip road would provide coverage of the Duncrue Street junction, northbound and southbound M2 and the westbound Westlink entry slip from the Duncrue Street junction.

A second PTZ CCTV camera mounted in the centre of the westbound Westlink entry slip road would provide coverage of the M2 / Westlink from the M2 diverge to the underpass section beneath the Dargan and Lagan bridges. This camera would also provide coverage of the Dock Street and M3 entry slip road on Nelson Street.

A third PTZ CCTV camera mounted to the wall section of the westbound Westlink would provide coverage of the short underpass section of the entry slip road from the M2 to the Westlink as it passes beneath the M3 Lagan Bridge and the Dargan Bridge.

A fourth PTZ CCTV camera mounted in the centre of the York Street interchange would provide coverage between the York Street Bridge and the Lagan and Dargan bridges. This would include coverage of York Street, Great George Street, Nelson Street and Great Patrick Street.

4.9.8 *Communication Interrupters*

Communication Interrupters would be required to maintain the operability of the existing Technology Communications Network and Urban Traffic Control (UTC) of temporary traffic signals during the York Street Interchange construction works.

The Communication Interrupters would take the form of a direct temporary cable or link to other third party networks such as BT PSTN or wireless links, after consultation with the TICC and technology maintainers.

The following locations would require Communication Interrupters prior to the York Street Interchange works:

- the eastbound Westlink communications network upstream of the new gantry position;
- the southbound M2 communications network upstream of the Duncrue Street interchange; and
- the M3 eastbound communications network after the M2 / M3 motorway merge.

4.9.9 *Standards*

Requirements have been assessed and developed in accordance with the DMRB Volume 9 – Traffic Control and Communications.

In particular, the following DMRB sections and Highways Agency Standards have been used to develop the proposed ITS strategy:

- DMRB Volume 9 – Section 3 TD 17/85 (Requirements for CCTV);
- HA Specification MCH 2554 (Design for Roadside CCTV);
- DMRB Volume 9 – Section 3 HD 20/05 (Detector Loops);
- DMRB Volume 9 – Section 1 TD 45/94 (Motorway Incident Detection and Automatic Signalling (MIDAS));
- DMRB Volume 9 – Section 1 TD 46/05 (Motorway Signalling); and
- DMRB Volume 9 – Section 5 TA 77/97 (Infrastructure Design).

4.10 Health and Safety

Throughout the development of the scheme consideration has been given to health and safety risks during the full project lifecycle in accordance with the Construction (Design and Management) Regulations (Northern Ireland) 2007. Transport NI, as a duty-holder as ‘Client’ under the Regulations has appointed a CDM Co-ordinator from URS from the onset of the project. The appointed CDM Co-ordinator has submitted an initial notification of the project to the Health and Safety Executive for Northern Ireland (HSENI).

Given the complexity of the scheme, the design team has paid particular attention to risks during the construction phase of the scheme, with the completed buildability assessment including a consideration of risks to workers and road users during construction, with the appointed CDM Co-ordinator in attendance to advise the team as required. Throughout the preliminary design process, every effort has been made to eliminate foreseeable hazards and reduce risks where possible. However, this is not always achievable, and where hazards remain, measures to reduce the residual risks will be implemented.

As such the design team endeavoured to identify and address the significant health and safety risks which will be present during the construction, servicing / maintenance and future demolition of the structures. As with a project of this complexity many of risks are a combination of a number of factors, and so far as is reasonably practicable, measures such as the carrying out of additional surveys, site investigations, materials sampling and traffic studies have been carried out to mitigate against known hazards in the development of the design.

Due to the complexity of the scheme, there are likely to be a number of unforeseeable hazards and risks that may only materialise as a detailed design is developed. Such hazards and risks will be assessed as and when they are identified. To date a number of buildability workshops have been held to identify uncommon co-ordination issues between the different design elements to ensure that the programming and phasing of the works are achievable.

Buildability issues were assessed in conjunction with the programming and traffic management elements of the overall project. Elements such as available space for specific construction plant, for example machinery used in the placing of diaphragm walls and its associated production plant were assessed to enable phasing of the underpass works to proceed whilst minimising the movement of the concrete batching / pumping works, and endeavouring to avoid moves on and off site which could impact on programme, and also the positioning of routes for diverted traffic during each stage of construction. It has been acknowledged that the phasing of the works involves a complicated series of activities which run in conjunction and in sequence where the failure to adequately manage and coordinate interdependent activities could create serious consequences for the overall project. Construction

4.10.1 *Construction Sequence*

4.10.1.1 *Overview*

To demonstrate that the scheme could be built within its constraints whilst maintaining routes for traffic, a notional construction sequence was developed as illustrated on **Drawings YSI-URS-XX-XX-DR-RE-TM001 to TM013** inclusive.

In developing the construction sequence, cognisance was taken of the potential for works to strengthen the Dargan bridge foundations (to facilitate any future dualling scheme) to be undertaken as part of the construction constract. The sequence did not, however, consider the works to the superstructure to replace or otherwise widen the existing deck.

The priority of works elements that informed the developed notional construction sequence is outlined below:

1. The completion of site clearance works.

2. The completion of service diversions.

3. The construction of section of M2 to Westlink underpass (BR-003) under Lagan Bridge including prior foundation strengthening works (FS-001).

4. The construction of new bridges at York Street (BR-002A and BR-002B) and approaches.

5. The construction of Westlink to M2 and M3 underpasses (UP-002A and UP-002B).

6. The construction of remainder of M2 to Westlink underpass (UP-001A).

7. The construction of M3 to Westlink underpass (UP-001B).

8. The construction of Dock Street to M3 link (Link No. 6) and completion of pumped drainage outfall route.

Once site clearance works are complete, all proposed service diversion works would be carried out as the highest priority element of work, to allow subsequent works to be completed in cleared areas of the site. Once the service diversions are completed, works to complete the section of UP-001A under the Lagan and Dargan bridges, including prior foundation strengthening works would be prioritised as they will be complex and slow to progress with specialist plant, therefore presenting the biggest risks to overall duration.

Before the various underpasses can be constructed, it would be necessary to grade separate traffic flows through the works area. Accordingly, the completion of the York Street bridges (BR-001 and BR-002) would be considered the next priority element in the programme. With the bridge completed, traffic flows would be sufficiently separated to permit works to construct the underlying underpasses. Until such time as the underpasses were complete, however, the completed bridges (and approach embankments) at York Street would form key three-dimensional constraints to temporary traffic management arrangements.

This sequence was subject to external review by an appointed buildability adviser as part of a buildability assessment completed by URS, as reported in **Section 4.11.3** and informed the QUADRO modelling of the economic impact of the works. As reported in **Section 14.11.3**, the appointed advisor considered that the overall construction sequence appears feasible.

Whilst URS has developed a notional construction sequence, it must be borne in mind the actual construction sequence for the scheme would ultimately be determined by the appointed Contractor informed by contractual requirements in relation to lane availability on the existing network and a requirement that the strengthening of foundations to the existing Lagan Bridge are undertaken prior to the installation of new embedded retaining walls.

4.10.1.1.1 *Phase 1*

Phase 1 is illustrated on **Drawing YSI-URS-XX-XX-DR-RE-TM001**.

The first phase of the proposed construction sequence would involve site clearance, including the completion of any demolition works to existing buildings. These works would be undertaken using lane and hard shoulder closures on the existing routes as required. It should be noted that in order to provide access and egress to site clearance works on the Westlink, it would be proposed to close the north facing Clifton Street on and off slips.

Based on the developed construction programme, it is expected that these works would require a minimum of 5 weeks to complete.

4.10.1.1.2 *Phase 2*

Phase 2 is illustrated on **Drawing YSI-URS-XX-XX-DR-RE-TM002**.

The next phase of the proposed construction sequence would be the diversion of services in advance of the construction of the new bridge, underpass and wall structures.

In order to construct Service Route A to the west of the proposed York Street bridges (BR-001A and BR-002B), including the construction of culverts CU-003 and CU004, it would be proposed to temporarily realign the Westlink approach to York Street, to a position adjacent to the southbound Westlink carriageway. York Street would also be temporarily realigned between York Link and Cityside Retail Park to facilitate the works. In order to construct CU-004, it would also be necessary to close Great George's Street from York Street to Portland Place, with an alternative route for affected residents via temporary conversion of the remaining section to two-way running, with minor enabling works at the junction with North Queen Street. Works to complete the crossing of York Street for culvert CU-004 would be undertaken using full weekend closures of the junction with Great George's Street. In order to finalise connections to the relocated NIE substation at Galway House, it would be proposed to close access to the M2 via the existing southbound lane on York Street. The proposed traffic management arrangements would also provide the opportunity to construct the new retaining wall RW-007 at Molyneaux Street/Henry Street.

In order to construct Service Route E on Great George's Street, including the construction of culvert CU-002, it would be necessary to realign Great George's Street north of its current position. However, in order to complete all service crossings at Nelson Street, it would also be necessary to close the junction for a weekend.

Service Route F can be largely constructed from an offline position, however, a number of crossings are required that will require weekend closures of the connection of the on-slip from Nelson Street to the M3, with associated closures on approaches from Westlink and York Link. Similarly, works to complete crossings at Dock Street would require lane closures and/or a full closure of the junction.

Importantly, the proposed service diversions include works to relocate 110kV NIE power cables at Whitla Street subway, as part of Service Route G. The nature of these service diversion works would require the complete closure of the northern section of Nelson Street (between Dock Street and Duncrue Street), with the proposed re-routing of northbound traffic from Dock Street via a temporary two-way arrangement on Garmoyle Street and Whitla Street. Enabling works would be required to install the arrangement, with an associated loss of southbound capacity on the route from the M2 to City Centre.

The proposed closure of Nelson Street between Dock Street and Duncrue Street would provide the opportunity to construct other elements of the future M2 to Westlink (Link No. 2) and Duncrue Street to Westlink (Link No. 31) routes, including retaining walls RW-024 and RW-029, the extension to BR-006 and the northern abutment for BR-004. Works at Whitla Street would require the closure of the existing subway, with re-routing via Dock Street.

Elsewhere within the site, the proposed traffic management arrangements would provide the opportunity to commence the installation of a number of the underpass and pumping station retaining walls, once adjacent service diversions are complete. These would be typically constructed up to below ground level and covered over as required to facilitate future traffic management scenarios.

The construction of the pumped outfall route from the scheme to the existing Gamble Street CSO comprise off-line works would be commenced in parallel with these works, again in recognition of the potential for encountering unforeseen obstructions to the thrust boring operation.

Based on the developed construction programme, it is expected that these works would require a minimum of 27 weeks to complete.

4.10.1.1.3 *Phase 3*

Phase 3 is illustrated on **Drawing YSI-URS-XX-XX-DR-RE-TM003**.

The next phase of the construction sequence is the completion of the section of M2 to Westlink underpass (UP-001A) underneath the Lagan and Dargan bridges.

In order to provide sufficient working space for these works, it is proposed to temporarily realign the movement from M2 to Westlink into lands at Corporation Street, with an accompanying realignment of the movement from Westlink to M3 to the next “gap” south in the Lagan and Dargan bridge pier positions, at Shipbuoy Street.

York Street and Westlink would remain in their revised positions from Phase 2, with works commencing on the northern side of the Westlink to construct retaining wall RW-001 and the widening of North Queen Street bridge (BR-001). In addition, works to construct the proposed reinforced slope EB-001 to the rear of properties at Little George’s Street would also be undertaken. This would include any enabling works to excavate and remove part of the existing Westlink embankment to provide a piling platform for the works.

In order to construct retaining wall RW-020, it would be proposed to reduce the York Street on-slip to the M2 to two lanes, with the completion of the wall allowing works to construct the new slip road from York Street to M2 (Link No. 15) to proceed, along with works to widen the existing Dock Street bridge to the west (BR-005).

At Dock Street, the new element of work would be the construction of the central bridge piers for the new overbridge (BR-004). This would require the realignment of lanes at the Dock Street/Nelson Street junction and the continued closure of the northern section of Nelson Street between Dock Street and Duncrue Street, with substitute two-way arrangement on WHitla Street and Garmoyle Street. In conjunction with this closure, it would be necessary to close the southern section of Nelson Street between Dock Street and York Link to facilitate the construction of the new bridge piers and traffic islands. The connection between Dock Street and York Link would be provided via a substitute temporary arrangement from Corporation Street, which would require the temporary closure of the northbound bus lane from Clarendon Dock to Dock Street. Once the piers are in place, works would progress to form the remainder of the bridge, with the northern span first constructed, then followed by the southern and central spans. Works to construct the central spans would be carried out over the live underlying carriageway, with bridge beams craned into position using overnight or weekend closures of the junction.

Through discussions with the buildability advisor, it was noted that the use of temporary end walls would provide an opportunity to proceed with the construction of the various underpasses in isolated section. Based on this, it would be proposed to commence construction on an isolated section of the M2 to Westlink underpass (UP-001A) in an offline position at lands beside Corporation Street.

Based on the developed construction programme, it is expected that these works would require a minimum of 27 weeks to complete.

4.10.1.1.4 *Phase 4*

Phase 4 is illustrated on **Drawing YSI-URS-XX-XX-DR-RE-TM004**.

The next phase of the construction sequence is the commencement of works to construct the two new bridges at York Street (BR-002A and BR-002B) and associated embankments. On this basis, the next phase of temporary traffic management would involve the realignment of York Street east of its current position. The resulting space would be used to construct the southern abutment and piers to bridge BR-002A. The northern abutment to BR-002A would not be constructed at this time, with the Westlink to York Street alignment realigned to run over the location of the future abutment, thereby allowing construction of the new retaining walls RW-031 and RW-033. At the same time, the piers and abutments for bridge BR-002B would be constructed, along with some isolated sections of retaining walls.

Following the completion of widening works to the Westlink in the previous phase, the next phase of work at North Queen Street bridge (BR-001) would involve the realignment of traffic to the northern extents of the widened carriageway, providing space for works to widen the southern part of the bridge to commence. At the same time, works to construct RW-002 and the reinforced slope to the existing Great George's Street retaining wall (EB-002) would also br progressed, requiring the temporary excavation of part of the existing Westlink embankment to form a piling platform.

At Dock Street, with the construction of bridge BR-004 and the completion of works to widen the existing Dock Street bridge (BR-005), works would involve the construction of the new junction layout at Dock Street using overnight or weekend closures as appropriate. When the new junction arrangement and northern section of Nelson Street (Link No. 29) is substantially completed, the temporary two-way arrangement on Garmoyle Street and Whitla Street would be removed.

Based on the developed construction programme, it is expected that these works would require a minimum of 13 weeks to complete.

4.10.1.1.5 *Phase 5*

Phase 5 is illustrated on **Drawing YSI-URS-XX-XX-DR-RE-TM005**.

Following the construction of the southern bridge at York Street (BR-002A), works would progress to start construction of the southern approach embankment (EB-003) using piled load transfer slabs. The southern embankment would be completed in two "halves", with a south-west portion of the embankment initially constructed. To provide sufficient working space, it would be necessary to realign York Street into lands north of Philip House. It is this requirement for the construction of the embankment which has provided the basis for the inclusion of affected lands within the vesting outline and therefore, the need to demolish the existing single-storey buildings to the north of Philip House.

Based on the developed construction programme, it is expected that these works would require a minimum of 5 weeks to complete.

4.10.1.1.6 *Phase 6*

Phase 6 is illustrated on **Drawing YSI-URS-XX-XX-DR-RE-TM006**.

With works to construct the south-west portion of embankment EB-003 completed, the temporary traffic management layout on York Street would be switched to realign lanes into the existing car park at Great George's Street (Lancaster Street). This arrangement would provide the necessary working space to construct the south-east portion of the embankment using similar techniques, subject to an initial reduction in the number of lanes on York Street to three, opening to four lanes in due course. The reduction to three lanes would require associated lane closures on Great Patrick Street. It should be noted that, under the proposed arrangements, the distance between the two major temporary signalised junctions on York Street would be shortened and this may lead to potential operation issues.

The proposed traffic management arrangements would also provide the opportunity to commence works associated with the connection of the new interchange link from Westlink to M2 (Link No. 1) to the existing M2 countrybound carriageway.

Works would also be commenced at this time to alter the existing off-slip from the M3 to Nelson Street, with realignment of lanes on the off-slip as appropriate.

Based on the developed construction programme, it is expected that these works would require a minimum of 5 weeks to complete.

4.10.1.1.7 *Phase 7*

Phase 7 is illustrated on **Drawing YSI-URS-XX-XX-DR-RE-TM007**.

With works to construct the southern embankment to the York Street bridges BR-002A and BR-002B completed, works would then commence on the construction of the northern embankment EB-005. With retaining wall RW-007 in place, works would entail the similar construction of piled load transfer plaforms and the placement of imported fill to form the embankment structure. To support the placed fill, above ground elements of the Westlink to M2 underpass retaining walls would need to be constructed where possible. In order to maintain connection to York Street and the M2 during these works, it would be necessary to realign York Street to the east of the proposed bridge structures, with a temporary retaining solution required to support the construction of the northern embankment.

Based on the developed construction programme, it is expected that these works would require a minimum of 5 weeks to complete.

4.10.1.1.8 *Phase 8*

Phase 8 is illustrated on **Drawing YSI-URS-XX-XX-DR-RE-TM008**.

To complete the remainder of the northern embankment (EB-005) at York Street, traffic on York Street would be effectively split at the junction with Great George’s Street around the site of the future York Street bridges and new retaining walls. Two lanes would continue around the western side of the new bridges and retaining walls to provide connection to York Road, whilst a further two lanes, would provide connection from York Street to the M2. Changes would also be made to the layout of the major temporary signalised junctions on York Street, with an additional two junctions being required to facilitate the proposed realignment of York Street and the Westlink.

It should be noted that the proximity of several major temporary junctions, and the anticipated traffic flows, is likely to present operation problems for the junctions for the duration of this phase of traffic management.

In order to complete the section of the embankment, works would also include the construction of the final above ground section of the Westlink to M2 underpass (UP-002A) retaining wall, limiting the number of lanes joining the M2 from York Street to two.

Once the remainder of the embankment is in place, works would also include the completion of the new York Street to M2 slip road (Link No. 15) as necessary to complement the new embankment levels.

The proposed traffic management layout would also provide space for the completion of works to construct the new vertical concrete step barrier in the central reserve of the Westlink (VCSB-001). The works are facilitated by the prior widening of North Queen Street bridge, with lanes realigned to the northern and southern extents of the widened structure accordingly. In light of the temporary realignment of the lanes, it is proposed to close the north facing on and off slips at Clifton Street for the duration of these works.

Based on the developed construction programme, it is expected that these works would require a minimum of 5 weeks to complete.

4.10.1.1.9 *Phase 9*

Phase 9 is illustrated on **Drawing YSI-URS-XX-XX-DR-RE-TM009**.

With the embankments to the north (EB-005) and south (EB-003) of the proposed bridges at York Street completed, works would then commence to construct the remainder of the bridges and the infill section of embankment (EB-004) between the bridges, supported by retaining walls RW-032 and RW-034.

At this time, York Street would again be realigned to a new temporary position east of the future bridges, however, with the completion of the EB-003 and EB-005, the route will require vertical realignment as necessary between the embankments.

At this time, the movement from Westlink to the M2 would be realigned to the new off-slip from Westlink to York Street, with a temporary signalised junction proposed to provide onward connection to the new slip road from York Street to the M2. In conjunction with these works, the new signalised junction at Cityside Retail Park and Galway House would be constructed, along with works to narrow the eastern footway of York Street between Galway House and Dock Street.

Based on the developed construction programme, it is expected that these works would require a minimum of 11 weeks to complete.

4.10.1.1.10 *Phase 10*

Phase 10 is illustrated on **Drawing YSI-URS-XX-XX-DR-RE-TM010**.

With the new bridges BR-002A and BR-002B at York Street completed, traffic would be relocated to run over the new structure, with movements from to and from the Westlink facilitated by temporary junctions at the northern and southern extents of the bridges, with temporary realignment of lanes as appropriate. The new retaining wall RW-028 at the Great George's Street car park would be constructed at this time. At Cityside Retail Park, the construction of the new signalised junction arrangements on York Street would continue, along with the construction of other traffic islands included within the permanent works.

The grade separation provided by the new bridges would then allow works to commence on the excavation and construction of the new underpass structures, principally structures UP-001A, UP-002A and UP-002B. The construction of underpasses UP-002A and UP-002B would be a higher priority than the remainder of UP-001A, so that the works to complete the retaining walls between UP-002A and UP-001A can be completed in the next traffic management phase.

At this time, works would be undertaken on the southern section of Nelson Street and at the junction of Great Patrick Street and Dunbar Link to construct the new junction arrangement. Works required to reduce carriageway width on Nelson Street between Great George's Street and Great Patrick Street would also be undertaken at this time.

Based on the developed construction programme, it is expected that these works would require a minimum of 16 weeks to complete.

4.10.1.1.11 *Phase 11*

Phase 11 is illustrated on **Drawing YSI-URS-XX-XX-DR-RE-TM011**.

Once the new underpasses from Westlink to M2 and M3 (UP-002A and UP-002B respectively) are completed, the traffic management layout would switch to that shown as Phase 11. It should be noted that, under this phase, two lanes would be provided for the movement from Westlink to M3, subject to signal control at a temporary signalised junction with Nelson Street.

The removal of M2 and M3 bound traffic from the junction to the north of bridge BR-002B would permit the completion of the final junction arrangement for the Wesltink to York Street slip road. On the southern section of York Street, works would be commenced to construct the traffic islands at the junctions with Little Patrick Street and Great Patrick Street, requiring the reduction in the number of lanes to three, opening to four where possible. Lane closures would also be required on Great Patrick Street to facilitate these works.

The construction of the M2 to Westlink underpass (UP-001A) would continue under this phase, including the construction of the proposed pumping station. During this phase, works would also commence on the construction of the adjoining M3 to Westlink underpass (UP-001B) and the final tie-in between the two underpasses to the west of bridge BR-002A.

The opportunity would also be taken at this time to commence the construction of the left-in, left-out arrangement on the M3 to York Street slip road using lane closures as required on the southern section of Nelson Street.

Based on the developed construction programme, it is expected that these works would require a minimum of 12 weeks to complete.

4.10.1.1.12 *Phase 12*

Phase 12 is illustrated on **Drawing YSI-URS-XX-XX-DR-RE-TM012**.

With the M2 to Westlink underpass UP-001A complete, the new bridge at Dock Street (BR-004) would be opened to allow traffic to use the new underpass. At this time, works would then focus on the completion of the M3 to Westlink underpasse UP-001B, with the final section at the Dargan Bridge to be completed. In the meantime, Westlink bound traffic from the M3 would continue through a temporary junction to the south of York Street bridge BR-002A, with an additional temporary signalised junction arrangement where traffic flows meet with those joining the Westlink from the M2 in underpass UP-001A.

With the opening of the new bridge at Dock Street, the opportunity would be taken to construct the new slip road arrangement from Dock Street to the M3 (Link No. 6) which would require the removal of the disused Nelson Street off-slip from the M2 and the closure of access to Nelson Street from Dock Street. Works would include the construction of associated flood walls RW-025 and RW-026.

The construction of RW-026 would be completed from the M3 on-slip, with temporary excavation of the existing M3 on-slip embankment to form a suitable working platform for its construction. The temporary works required would require the reduction in lanes on the Westlink to M3 slip road to a single lane, albeit without signal control due to the removal of conflicting flows on Nelson Street. It should be noted that this temporary arrangement would be reflective of the final layout.

In parallel with these works, the opportunity would be taken to complete the construction of the pumped drainage outfall route and associated shafts, with the pumping station and associated access road under Corporation Street completed.

Temporary traffic management would also be required on the southern section of York Street to continue with the construction of the final traffic islands and junction layout with the M3 off-slip (Link No. 7) requiring lane closures in turn on Great Patrick Street.

Based on the developed construction programme, it is expected that these works would require a minimum of 8 weeks to complete.

4.10.1.1.13 *Phase 13*

Phase 13 is illustrated on **Drawing YSI-URS-XX-XX-DR-RE-TM013**.

At this stage, the majority of the permanent works elements would be completed, with the exception of the M3 to York Street off-slip (Link No. 7). Once the M3 to Westlink underpass (UP-001B) is completed, the underpass will open and provide a new grade separated connection to the Westlink in a free-flow manner. This would then create the opportunity to construct the final off-slip arrangement from the M3 to York Street and complete associated embankment works to the west of York Street bridge BR-002A.

With the construction of retaining wall RW-026 and the new slip road from Dock Street to the M3 (Link No. 6) complete, the lanes would be realigned to their final layout, providing the opportunity to construct the flood wall RW-027.

Final works to finish the southern section of York Street would be completed during this phase, with associated closures on Great Patrick Street.

Based on the developed construction programme, it is expected that these works would require a minimum of 6 weeks to complete, at which point all elements of the permanent works would be completed and the scheme completed.

4.10.1.2 *Temporary Speed Limits*

The proposed temporary speed limits, and location of terminal signs, are shown on **Drawing YSI-URS-XX-XX-DR-RE-TM014**. As illustrated on the drawing, due to the layout of the proposed temporary traffic management arrangements and the proximity to several ongoing live work zones, it is proposed to implement a blanket 30mph temporary speed limit throughtout the works, complemented with a buffer 50mph zone on the M2 foreshore citybound carriageway. The proposed 50mph buffer zone reflects the proposal, as part of the scheme, to introduce a permanent 50mph speed limit on the citybound carriageway on approach to the interchange to moderate vehicle speeds.

The proposed temporary speed limits on the M2 foreshore section will be subject to further review as part of detailed design development.

4.10.1.2.1 *Existing Car Parking Facilities*

It should be noted that all public car parks affected by the works, i.e. the Northside Park & Ride car parks, the Great George's Street (Lancaster Street) car park and the Corporation Street car park would be closed from the onset of the construction period.

4.10.2 *Construction Programme*

It is anticipated that the scheme would require a minimum period of just over 3 years (38 months) to complete, subject to the advance completion of service diversion works or advance placement of service diversion orders with the relevant utility providers.

In line with government policy, the proposed form of contract for any future contract would be the New Engineering Contract (NEC3). Under the provisions of this form of contract, the Contractor and Client are encouraged to manage risks and opportunities to the construction programme and construction cost in a partnering approach. Therefore, whilst opportunities may arise to enable early completion of the scheme, it must also be noted that, conversely, unforeseeable issues may arise during construction that may require the extension of the overall construction period.

4.10.3 *Buildability Assessment*

4.10.3.1 *Introduction*

Gareloch Consult Ltd, was engaged by URS as a buildability advisor to the project team. IN this role, the advisor undertook a buildability assessment of the Proposed Scheme to include:

- the review of engineering drawings to identify potential show-stoppers;
- the identification of key construction issues and possible mitigation measures;
- the review of TTM phasing drawings (to inform QUADRO modelling);
- the development and issue of a feasible construction programme;
- the identification of value engineering opportunities;
- the identification of key residual risks with regard to construction; and
- assisting the project team to summarise the overall assessment findings.

The appointed buildability advisor reviewed the information available and met with the project team over the course of several workshops to identify the potential issues facing a contractor in the construction of the scheme. The advisor considered that design carried out to date was reasonably advanced and at this stage is more than adequate to assess the buildability of the works.

From the workshop it became apparent that the major factors affecting the schemes construction were:

- services;
- traffic management;
- ground conditions;
- stability of existing structures;
- design; and
- public relations.

These issues are described further in **Sections 4.13.2.2 to 4.13.2.7** .

4.10.3.2 *Services*

A key area of concern for the advisor was the number and nature of the service diversions required for the construction of the scheme and in turn, the considerable lead-in times required with the service providers. With regard to the major service diversions proposed, although the advisor considered the diversion proposals to be feasible, concerns were raised over the required lead-in times for the diversion of services for BT and Phoenix Natural Gas around UP-001A (9 months and 38 weeks respectively). Furthermore, the proposed diversion of oil-filled 110kV NIE power cables at Whitla Street subway (BR-006) would require a lead-in time of 1 year. These lead-in times would form a controlling factor in the early stages of construction and therefore, present considerable a risk to the overall construction programme if delayed.

Options proposed by the advisor to mitigate the risks of associated delays included the advance ordering of service diversions by Transport NI, or the completion of such works as an advance contract ahead of the main works contract. Both options have their respective advantages and disadvantages and it was agreed that both should be considered as part of the procurement strategy for the scheme going forward and indeed, be extended to consider options to enhance, or otherwise, incentivise the performance of affected utility providers.

4.10.3.3 *Traffic Management*

The buildability advisor noted that suitable consideration had been given to how the scheme could be built whilst maintaining access to the strategic routes and the proposed traffic management arrangements appeared feasible. However, the need to maintain road links would prolong the completion of piling works due to the inability to access certain parts of the site (due to the requirements of the proposed diaphragm walling technique) and therefore dictate the overall construction programme. In the adviser's opinion, the potential use of secant piled walls should be considered to create opportunities to complete elements of the underpass piling works using overnight closures.

The advisor also noted that the proposed temporary traffic management arrangements would have an impact on traffic patterns in the area which in turn would limit the speed at which excavated material could be disposed off, although this would be a matter that the contractor would address through the provision of additional plant to maintain progress. As an alternative, the advisor proposed the option of undertaking such excavation works during off-peak or night-time periods, when traffic flows on adjacent routes would be lower, however, this may not be possible given the potential for disruption to adjacent properties and indeed, the availability of licensed disposal sites during off-peak or overnight periods.

4.10.3.4 *Ground Conditions*

The buildability advisor considered that the proposed underpass structures and construction techniques, using diaphragm walls, appear a feasible solution to the site constraints and ground conditions. As noted, the opportunities for the use where possible of secant piled walls should be considered, to maximise the rate of overall progress. A further recommendation made by the advisor was the use of temporary end-walls, to provide opportunities to complete the excavation of the underpasses in sections.

For the proposed embankments, the advisor considered the proposed ground improvement measures appropriate and proposed the use of light weight aggregate (LWA) fill where possible.

4.10.3.5 *Stability of Existing Structures*

The works in proximity to and works to, the existing Dargan Bridge and Lagan Bridge respectively were reviewed by the buildability advisor. Although there were identified to be elements that required careful monitoring of the existing structures, they were not, in principle, considered to be elements of work that could not be carried out.

4.10.3.6 *Design*

Whilst the advisor considered that the design team had progressed the design of the scheme to a relatively advanced level, it was recognised that further detailed design work would be required. The lead-in times for the development and approval of a Contractor's design, as part of of a Design and Build procurement strategy were noted as having a potential for delays to the construction programme and so, the advisor promoted the option for some elements of the works to be "Client Design" and therefore designed, detailed and approved ahead of the construction period.

4.10.3.7 *Public Relations*

Given the nature of the scheme and its urban setting, the buildability advisor recognised the importance of communications with road users and local communities. The advisor noted that consultations with affected parties had been commenced in line with the overall Communications Plan for the scheme and considered that other measures should be explored as part of a wider public relations exercise to develop wider options for traffic management and indeed, to provide regular updates to the public on the progress of the scheme.

4.11 Departures from Standard

4.11.1 *Road Geometry*

A broad assessment of the key Departures from Standards TD 9/93, 27/05 and 22/06 has been undertaken for the Proposed Scheme. A number of additional Departures from other Standards (TD 41/95, TD 42/95 and TD 50/04) have been identified relevant to the geometry of the proposed priority junctions and signal controlled junctions. Relaxations from Standard have not been identified at this time. This assessment has been carried out to a level of detail commensurate with their level of development.

The Departures identified have been scheduled relative to the respective Standards and included in **Appendix H**. A summary is presented in **Table 4.12.1**.

Table 4.12.1: Summary of Road Geometry Departures from Standard

		No. of Departures per Link No.									
Standard	Element	1	2	3	4	5	6	7	11	15	31
TD 9/93	Horizontal Radius (Hr)	0	0	1	0	0	1	0	0	0	1
	K Value	0	0	0	0	0	0	0	0	1	0
	Stopping Sight Distance (SSD)	0	0	1	0	0	0	0	0	2	0
	Combination of Hr/K /SSD	8	6	9	5	0	2	1	4	8	2
	Substandard K and/or SSD on approach to junction	15	6	8	5	2	4	3	10	9	2
	Superelevation	1	1	1	1	1	1	1	1	1	1
	Transition Lengths	0	0	0	1	0	1	1	1	1	1
	Sub-Total (per Link)	***24***	***13***	***20***	***12***	***3***	***9***	***6***	***16***	***22***	***7***
	Sub-Total	***132***									
TD 27/05	Cross-Section	1	1	1	1	1	1	1	1	1	1
TD 22/06	Grade Separated Junction Design	13	9	0	3	0	1	2	0	5	0
TD 41/95	Direct Access Design	0	0	0	0	0	1	1	1	0	2
TD 42/95	Priority Junction Design	0	0	0	0	0	0	3	2	0	0
TD 50/04	Signal Controlled Junction Design	0	0	0	0	0	1	1	1	0	0
	Total (per Link)	**38**	**23**	**21**	**16**	**4**	**13**	**14**	**21**	**28**	**10**
	Total	**188**									

4.11.2 *Structures*

No Departures from Standard have been identified at this preliminary stage in design development of the structures. However, it is noted that the Highways Agency is currently developing revised series of the Specification for Highway Works which are consistent with the Eurocode execution standards. In the interim, it is a requirement of DEM 134 that Departures from Standards should be sought for the use of project specific specifications aligned with the

Eurocode execution standards. Revised Specifications and Notes for Guidance for Series 1700, Series 1800 and Series 1900 would be prepared (as appropriate) for this scheme based upon the latest Highways Agency draft of the documents, for issue as part of the tender package for this scheme.

4.11.3 *Geotechnics*

No Departures from Standard have been identified at this preliminary stage in design development of the various geotechnical solutions.

4.11.4 *Drainage*

Further to the completed Flood Risk Assessment, it is noted that a Departure from Standard HD 45/09, specifically the requirements of paragraph 2.37 (ii), will be required for the scheme. The Departure is necessary as the provision of flood protection to the proposed underpasses would create a loss of existing coastal floodplain adjacent to Belfast Lough.

4.11.5 *Road Lighting*

No Departures from Standard have been identified at this preliminary stage in design development of the road lighting system.

4.11.6 *Traffic Signals*

No Departures from Standard have been identified at this preliminary stage in design development of the signalised junctions, other than those relevant to the proposed geometry.

4.11.7 *Motorway Communications*

No Departures from Standards are envisaged at this preliminary stage in design development.

5. TRAFFIC AND ECONOMIC ASSESSMENT

5.1 Introduction

The existing York Street junction in the centre of Belfast is one of the most heavily trafficked junction arrangements in Northern Ireland.

Operating conditions in the York Street area of Belfast, at the intersection of the strategic Westlink, M2 and M3 motorways, are such that road users experience significant delays and congestion during periods of peak traffic demand.

As a result of a programme of ongoing improvements in the area, traffic conditions have changed significantly over the past few years. The M1 / Westlink improvement was completed in March 2009 and delivers traffic more efficiently to the York Street area. The M2 motorway widening, which was completed in August 2009, also improves the flow of traffic heading towards the existing York Street junction.

The study area for the traffic and economic assessment focuses on the immediate area around York Street, York Link, Nelson Street and Great George's Street. This area has been extended to include modelling of the key junctions along Dock Street in the north, Great Patrick Street in the south and the Clifton Street slips in the west to allow consideration of the wider traffic effects of the proposed York Street improvements. The survey area also extends to the Fortwilliam junction to allow modelling of the effects of the proposed changes to the speed limits on the M2 motorway and the effects of potential traffic redistribution at Duncrue Street.

In October 2012, URS published a Preferred Options Report that presented the results of the operational and economic assessment of the options considered for the scheme that ultimately led to the selection of Option C as the Preferred Option, now termed the Proposed Scheme.

The primary objective of this report is to describe existing traffic conditions in the York Street area, to outline the indicative costs, risks and optimism bias associated with the Proposed Scheme and to describe the modelling work undertaken to develop the computer models. This section also considers future traffic conditions over the economic life of the scheme and presents the results of an operational and economic assessment of the Proposed Scheme. Given the uncertainty in predicting future traffic conditions, the results from a series of sensitivity tests have also been reported in this section.

A general location of the existing York Street junction and the surrounding road network area is shown in **Figure 5.1.1**. A more detailed key location plan is shown in **Figure 5.1.2**.

5.2 Existing Conditions

Existing conditions in the York Street area are subject to significant congestion during periods of peak traffic demand due to the convergence of traffic from the M1 Westlink, the M2 and M3 motorways and the local surface streets. This demand is controlled by a series of signalised junctions, where signal timings are monitored and adjusted regularly to improve traffic flow during peak periods. The key junctions in the immediate area around York Street are described below.

At the York Street / Great George's Street signalised junction, northbound traffic on York Street approaches Great George's Street in five lanes with an additional left-turn lane to access both Great George's Street (west) and the Westlink. Great George's Street is six lanes wide at the junction, with the left lane dedicated for Great George's Street (west), three lanes continuing through to Westlink and two lanes accommodating right-turn manoeuvres on to York Street.

At the Westlink / York Street / York Link junction, traffic approaches from Westlink in six lanes. The left lane is dedicated for traffic turning left on to York Street. Three lanes continue through to the M2 motorway northbound on-slip and the remaining two lanes continue on to York Link. The five lanes approaching the junction from York Street separate to provide two straight-through lanes continuing along York Street and three right-turn lanes on to the M2 motorway northbound on-slip. An additional slip lane is available for traffic turning right on to York Link.

At the York Link / Nelson Street junction, York Link approaches the junction in three lanes, two of which continue to the M3 motorway eastbound on-slip. The remaining lane turns right on to Nelson Street and the surface street network. The Nelson Street approach from the north provides a total of five lanes, three of which continue through the junction heading towards the right turn on to Great George's Street and two of which are divided between the left turn movement on to the M3 motorway eastbound on-slip and the straight though movement on to Nelson Street heading towards the Dunbar Link.

At the M3 motorway / Nelson Street / Great George's Street junction, traffic approaches the junction in four lanes from the M3 motorway off-slip which widens to create an additional left turn lane on to Nelson Street. The Nelson Street approach is separated by a raised kerb with three lanes turning right on to Great George's Street and a further two lanes continuing through the junction on to Nelson Street heading towards the Dunbar Link.

The existing junction layout and lane configuration is shown in **Figure 5.2.1**.

To assist in establishing traffic conditions at the key junctions, a programme of traffic surveys was undertaken in 2012. Details of the traffic surveys are described in **Section 5.3**.

5.3 Data Collection Surveys

5.3.1 *Introduction*

A programme of data collection surveys was undertaken in 2012 to assist in establishing traffic volumes, turning flows and vehicle proportions at key junctions in the York Street area.

In summary, the survey data included the following:

- Manual Classified Counts;
- Queue Surveys;
- Automatic Traffic Counters; and
- Journey Time Surveys.

5.3.2 *Manual Classified Counts*

5.3.2.1 *Methodology*

A programme of Manual Classified Counts (MCCs) was carried out at twenty nine locations within the study area on Tuesday 29 May and Wednesday 30 May 2012 to define current traffic volumes and turning movements. This included twenty Junction Turning Counts, three Link Counts and six In/Out Manoeuvre Counts.

The Junction Turning Count MCCs were undertaken at the following locations:

- J1 – York Street / M2 Motorway On-Slip / York Link / Westlink;
- J2 – York Street / Westlink / Great George’s Street;
- J3 – Nelson Street / Great George’s Street;
- J4 – Nelson Street / York Link;
- J5 – Corporation Street / Clarendon Road;
- J6 – Corporation Street / Corporation Square;
- J7 – Nelson Street / Dock Street / Garmoyle Street / Corporation Street;
- J8 – York Street / Dock Street / Brougham Street;
- J9 – Duncairn Gardens / North Queen Street / Brougham Street;
- J10 – North Queen Street / Great George’s Street;
- J11 – Clifton Street / A12 Westlink;
- J12 – Clifton Street / North Queen Street/ Frederick Street / Carrick Hill;
- J13 – Corporation Street / Great Patrick Street / Tomb Street;
- J14 – Frederick Street / York Street / Great Patrick Street;
- J15 – Nelson Street / Dunbar Link / Edward Street;
- J16 – Corporation Street / Dunbar Link;
- J17 – M2 Motorway Junction 1 Fortwilliam;
- J18 – North Queen Street / New Lodge Road;
- J19 – North Queen Street / Victoria Parade; and
- J20 – M2 Motorway Off-Slip / Duncrue Street.

The Link Count MCCs were undertaken at the following sites:

- L1 – York Street to M2 Motorway On-Slip;
- L2 – M2 Motorway Off-Slip at Nelson Street; and
- L3 – Dock Street / Corry Road.

The In/Out Manoeuvre Counts were undertaken at the following sites:

- C1 – York Street;

- C2 – Little York Street;
- C3 – Cityside Retail Park Car Park (York Street);
- C4 – Cityside Retail Park Car Park (Brougham Street);
- C5 – Docks Access, Garmoyle Street;
- C6 – Docks Access, Pollock Road.

The MCC data for all sites were collected in 15-minute intervals between 07:00 hours and 19:00 hours during the weekday surveys to provide a 12-hour record of turning movements and link flows.

It should be noted that incomplete data was recorded between 18:45 hours and 19:00 hours at Sites J18 and J19, both of which are located on North Queen Street, due to equipment damage. As a result, the flows for this 15-minute period have been infilled to provide a more accurate representation of conditions at these Sites.

It should also be noted that in order to compensate for fluctuations in adjacent counts and to compensate for the effects of events experienced during the days of survey, the observed traffic counts at two locations were adjusted. At Site J1, which is the York Street / M2 motorway On-Slip / York Link / Westlink junction, the northbound flow on York Street was increased slightly to achieve an improved correlation with the flow at J8, which is the York Street / Dock Street / Brougham Street junction. At Site J4, which is the Nelson Street / York Link junction, the southbound flow on Nelson Street was adjusted slightly to compensate for the effects of masked vehicles during the day of survey and to achieve an improved correlation with the observed flows at the adjacent junctions.

The standard COBA 5-vehicle classification was adopted for the MCCs at Junction Turning Count Sites J1 to J4, Link Count Site L3 and In/Out Manoeuvre Count Sites C5 and C6. This included the following vehicle types:

- Cars;
- Light Goods Vehicles (LGV);
- Other Goods Vehicles 1 (OGV 1);
- Other Goods Vehicles 2 (OGV 2); and
- Buses and Coaches (PSV).

At all other MCC Sites, a simpler vehicle classification than the standard COBA 5-vehicle classification was adopted due to the anticipated volumes of traffic. The vehicle types recorded were as follows:

- Light Vehicles (LV) = Car and LGV;
- Heavy Goods Vehicles (HGV) = OGV1 and OGV2; and
- Buses = Buses and Coaches.

5.3.2.2 *MCC Locations*

The locations of the MCCs are shown in **Figure 5.3.1**.

Full turning counts of all movements were undertaken at all MCC Sites, excluding MCC Sites C1 to C6 where in/out turning manoeuvres only were recorded.

5.3.2.3 *MCC Results*

The observed 12-hour traffic flows for all vehicles derived from the MCC surveys for all Sites are summarised in **Figures 5.3.2(a)** and **5.3.2(b).** The observed a.m. and p.m. peak hour traffic flows based on 08:00 hours to 09:00 hours and 16:45 hours to 17:45 hours are shown in **Figures 5.3.3(a) and 5.3.3(b) to 5.3.4(a) and (b)** respectively.

A summary of the MCC data is also shown in **Tables 5.3.1(a) to 5.3.1(c)**.

Table 5.3.1(a): Summary of 12-Hour Traffic Volumes: JTC Sites

Site	Traffic Flow Through Junction
J1	55,928
J2	55,557
J3	43,578
J4	44,621
J5	9,893
J6	10,072
J7	25,654
J8	25,106
J9	20,491
J10	13,319
J11	30,111
J12	29,104
J13	10,217
J14	26,230
J15	23,795
J16	25,218
J17	97,557*
J18	13,953
J19	12,938
J20	13,573

Note: *Flow at J17 is a two-way flow

Table 5.3.1(b): Summary of 12-Hour Traffic Volumes: Link Count Sites

Site	Traffic Flow on Link
L1	1,374
L2	17,653
L3	2,088

Table 5.3.1(c): Summary of 12-Hour Traffic Volumes: In/Out Count Sites

Site	Traffic Flow In	Traffic Flow Out
C1	40	39
C2	307	305
C3	2,348	1,149
C4	4,101	4,859
C5	-	1,429
C6	692	474

A summary of the MCC 12-hour junction flows and vehicle proportions is shown in **Tables 5.3.2(a) to 5.3.2(c)**.

Table 5.3.2(a): Summary of MCC 12-Hour Junction Flows and Vehicle Proportions: JTC Sites (3-Vehicle Type Classification)

Site	Units	LV	HGV	Bus	Total
J1	Flow	51,710	3,583	635	55,928
	%	92.5	6.4	1.1	100.0
J2	Flow	51,356	3,643	558	55,557
	%	92.4	6.6	1.0	100.0
J3	Flow	39,545	3,414	619	43,578
	%	90.7	7.8	1.4	100.0
J4	Flow	40,525	3,461	635	44,621
	%	90.8	7.8	1.4	100.0
J5	Flow	9,507	240	146	9,893
	%	96.1	2.4	1.5	100.0

Site	Units	LV	HGV	Bus	Total
J6	Flow	9,689	236	147	10,072
	%	96.2	2.3	1.5	100.0
J7	Flow	22,690	2,281	683	25,654
	%	88.4	8.9	2.7	100.0
J8	Flow	23,067	1,490	549	25,106
	%	91.9	5.9	2.2	100.0
J9	Flow	19,958	333	200	20,491
	%	97.4	1.6	1.0	100.0
J10	Flow	13,028	217	74	13,319
	%	97.8	1.6	0.6	100.0
J11	Flow	28,576	840	695	30,111
	%	94.9	2.8	2.3	100.0
J12	Flow	27,879	513	712	29,104
	%	95.8	1.8	2.4	100.0
J13	Flow	9,846	231	140	10,217
	%	96.4	2.3	1.4	100.0
J14	Flow	24,689	616	925	26,230
	%	94.1	2.3	3.5	100.0
J15	Flow	22,748	447	600	23,795
	%	95.6	1.9	2.5	100.0
J16	Flow	24,467	466	285	25,218
	%	97.0	1.8	1.1	100.0
J17	Flow	90,033	6,712	812	97,557
	%	92.3	6.9	0.8	100.0
J18	Flow	13,602	263	88	13,953
	%	97.5	1.9	0.6	100.0
J19	Flow	12,671	195	72	12,938
	%	97.9	1.5	0.6	100.0
J20	Flow	12,101	1,120	352	13,573

Site	Units	LV	HGV	Bus	Total
	%	89.2	8.3	2.6	100.0
Overall	**Flow**	**547,687**	**30,301**	**8,927**	**586,915**
	%	**93.3**	**5.2**	**1.5**	**100.0**

Table 5.3.2(b): Summary of MCC 12-Hour Junction Flows and Vehicle Proportions: Link Count Sites (3-Vehicle Type Classification)

Site	Units	LV	HGV	Bus	Total
L1	Flow	1,223	145	6	1,374
	%	89.0	10.6	0.4	100.0
L2	Flow	15,877	1,728	48	17,653
	%	89.9	9.8	0.3	100.0
L3	Flow	1,490	551	47	2,088
	%	71.4	26.4	2.3	100.0
Overall	**Flow**	**18,590**	**2,424**	**101**	**21,115**
	%	**88.0**	**11.5**	**0.5**	**100.0**

Table 5.3.2(c): Summary of MCC 12-Hour Junction Flows and Vehicle Proportions: In/Out Count Sites (3-Vehicle Type Classification)

Site	Units	LV	HGV	Bus	Total
C1	Flow	79	0	0	79
	%	100.0	0.0	0.0	100.0
C2	Flow	608	4	0	612
	%	99.3	0.7	0.0	100.0
C3	Flow	3,482	14	1	3,497
	%	99.6	0.4	0.0	100.0
C4	Flow	8,870	78	12	8,960
	%	99.0	0.9	0.1	100.0
C5	Flow	887	521	21	1,429
	%	62.1	36.5	1.5	100.0
C6	Flow	720	404	42	1,166
	%	61.7	34.6	3.6	100.0
Overall	**Flow**	**13,039**	**96**	**13**	**13,148**
	%	**99.2**	**0.7**	**0.1**	**100.0**

As traffic conditions around the York Street gyratory are of most significance, the COBA 5-vehicle type classification data for Sites J1 to J4 are shown in **Table 5.3.3**.

Table 5.3.3: Summary of MCC 12-Hour Junction Flows and Vehicle Proportions: JTC Sites J1-J4 (COBA 5-Vehicle ype Classification)

Site	Units	Cars	LV	OGV1	OGV 2	PSV	Total
J1	Flow	45,624	6,086	1,847	1,736	635	55,928
	%	81.6	10.9	3.3	3.1	1.1	100.0
J2	Flow	45,445	5,911	1,908	1,735	558	55,557
	%	81.8	10.6	3.4	3.1	1.0	100.0
J3	Flow	34,712	4,833	1,697	1,717	619	43,578
	%	79.7	11.1	3.9	3.9	1.4	100.0
J4	Flow	35,613	4,912	1,655	1,806	635	44,621
	%	79.8	11.0	3.7	4.0	1.4	100.0
Overall	**Flow**	**161,394**	**21,742**	**7,107**	**6,994**	**2,447**	**199,684**
	%	**80.8**	**10.9**	**3.6**	**3.5**	**1.2**	**100.0**

Based on the above information, the following overall vehicle classification percentages were derived for JTC Sites J1 to J4:

- 80.8% Cars;
- 10.9% Light Goods Vehicles (LGV);
- 3.6% Other Goods Vehicles 1 (OGV1);
- 3.5% Other Goods Vehicles 2 (OGV2); and
- 1.2% Buses and Coaches (PSV).

In addition, to take into account the higher volume of heavy vehicles around the Docks area, the COBA 5-vehicle type classification data for Sites L3, C5 and C6 are shown in **Table 5.3.4**.

Table 5.3.4: Summary of MCC 12-Hour Junction Flows and Vehicle Proportions: Sites L3, C5 and C6 (COBA 5-Vehicle Type Classification)

Site	Units	Cars	LV	OGV1	OGV 2	PSV	Total
L3	Flow	1,281	209	115	436	47	1,281
	%	61.4	10.0	5.5	20.9	2.3	61.4
C5	Flow	733	154	100	421	21	733
	%	51.3	10.8	7.0	29.5	1.5	51.3
C6	Flow	538	182	151	253	42	538
	%	46.1	15.6	13.0	21.7	3.6	46.1
Overall	**Flow**	**2,552**	**545**	**366**	**1,110**	**110**	**2,552**
	%	**54.5**	**11.6**	**7.8**	**23.7**	**2.3**	**54.5**

The observed 2-way 12-hour link flows recorded for all vehicles are shown in **Figures 5.3.5(a) and 5.3.5(b)**.

5.3.3 *Queue Surveys*

5.3.3.1 *Methodology*

A programme of Queue Surveys was undertaken at four locations within the study area on Tuesday 29 May 2012 to assist in assessing operating conditions around the York Street gyratory.

The Queue Surveys were undertaken at the following locations:

- Q1 – Westlink Off-Slip, at York Street / M2 motorway On-Slip / York Link / Westlink Junction;
- Q2 – York Street, at York Street / Westlink / Great George's Street Junction;
- Q3 – Nelson Street, at Nelson Street / Great George's Street Junction; and
- Q4 – M3 motorway Off-Slip, at Nelson Street / York Link Junction.

The Queue Survey data for all sites were recorded in number of vehicles for each approach at each location at 15-minute intervals throughout the survey period, separately for each direction from the appropriate stop line, between 07:00 hours and 19:00 hours during the weekday surveys to provide a 12-hour record of queue lengths.

Due to the anticipated volumes of traffic a simpler vehicle classification than the standard COBA 5-vehicle classification was adopted at each of the Queue Survey sites. The vehicle types recorded were as follows:

- Light Vehicles (LV) = Car and LGV;
- Heavy Goods Vehicles (HGV) = OGV1 and OGV2; and
- Buses = Buses and Coaches.

5.3.3.2 *Queue Survey Locations*

The locations of the Queue Surveys are shown in **Figure 5.3.6**.

5.3.3.3 *Queue Survey Results*

A summary of the Queue Survey data is shown in **Tables 5.3.5 to 5.3.8**.

Table 5.3.5: Summary of 12-Hour Queue Data: Site Q1 – Westlink Off-Slip

Time	To York Link			To M2 Motorway On-Slip				To York Street	Total Queue at Site Q1
	Lane 1	Lane 2	Total	Lane 3	Lane 4	Lane 5	Total	Lane 6	
07:00	18	19	37	15	7	4	26	3	**66**
07:15	21	25	46	12	10	6	28	7	**81**
07:30	20	25	45	15	11	4	30	3	**78**
07:45	16	19	35	16	8	9	33	6	**74**
08:00	17	23	40	14	8	9	31	5	**76**
08:15	18	22	40	10	10	8	28	3	**71**
08:30	20	16	36	15	10	5	30	4	**70**
08:45	20	17	37	9	9	8	26	7	**70**
09:00	18	15	33	11	10	10	31	8	**72**
09:15	13	13	26	11	8	9	28	8	**62**
09:30	20	17	37	10	8	6	24	5	**66**
09:45	18	16	34	13	12	5	30	6	**70**
10:00	8	9	17	7	5	4	16	5	**38**
10:15	5	7	12	5	6	3	14	2	**28**
10:30	8	10	18	4	5	6	15	2	**35**
10:45	5	8	13	7	7	5	19	4	**36**
11:00	6	12	18	10	5	3	18	4	**40**
11:15	6	9	15	5	9	4	18	5	**38**
11:30	11	13	24	9	8	7	24	6	**54**
11:45	11	11	22	3	8	4	15	6	**43**
12:00	8	14	22	7	7	6	20	5	**47**
12:15	11	20	31	4	7	6	17	1	**49**

Time	To York Link			To M2 Motorway On-Slip				To York Street	Total Queue at Site Q1
	Lane 1	Lane 2	Total	Lane 3	Lane 4	Lane 5	Total	Lane 6	
12:30	6	15	21	6	9	6	21	5	**47**
12:45	13	12	25	6	8	6	20	4	**49**
13:00	10	12	22	6	8	4	18	5	**45**
13:15	11	16	27	7	7	5	19	3	**49**
13:30	12	9	21	6	9	4	19	7	**47**
13:45	10	14	24	9	7	5	21	4	**49**
14:00	7	9	16	10	8	6	24	5	**45**
14:15	5	7	12	10	12	5	27	4	**43**
14:30	10	14	24	14	9	6	29	3	**56**
14:45	7	7	14	16	11	8	35	5	**54**
15:00	9	8	17	15	8	11	34	5	**56**
15:15	11	9	20	17	9	9	35	3	**58**
15:30	10	7	17	22	9	11	42	2	**61**
15:45	13	15	28	24	12	11	47	7	**82**
16:00	14	14	28	25	11	13	49	11	**88**
16:15	12	9	21	18	15	16	49	6	**76**
16:30	10	12	22	18	13	11	42	2	**66**
16:45	11	12	23	22	18	7	47	4	**74**
17:00	13	26	39	17	14	7	38	3	**80**
17:15	10	15	25	24	15	7	46	3	**74**
17:30	9	16	25	19	14	7	40	3	**68**
17:45	14	13	27	24	15	6	45	3	**75**
18:00	14	20	34	15	11	7	33	3	**70**
18:15	10	19	29	10	13	6	29	1	**59**
18:30	12	15	27	6	8	2	16	0	**43**
18:45	11	13	24	8	8	3	19	3	**46**

Note: The darker shaded areas indicate the maximum queue (in vehicles) per lane during the survey period.

Table 5.3.6: Summary of 12-Hour Queue Data: Site Q2 – York Street

Time	To M2 Motorway On-Slip & York Link				To York Street			To Westlink & Great George's Street	Total Queue at Site Q2
	Lane 1	Lane 2	Lane 3	Total	Lane 4	Lane 5	Total	Lane 6	
07:00	4	5	2	11	4	2	6	2	**19**
07:15	4	5	4	13	4	2	6	2	**21**
07:30	7	6	5	18	4	2	6	4	**28**
07:45	7	8	4	19	5	4	9	5	**33**
08:00	11	5	7	23	6	3	9	5	**37**
08:15	10	9	5	24	7	5	12	5	**41**
08:30	8	5	7	20	5	3	8	6	**34**
08:45	6	8	9	23	9	5	14	7	**44**
09:00	8	7	4	19	6	5	11	5	**35**
09:15	6	6	4	16	5	7	12	6	**34**
09:30	6	5	5	16	4	6	10	7	**33**
09:45	10	7	4	21	6	7	13	7	**41**
10:00	7	5	3	15	4	6	10	6	**31**
10:15	5	7	3	15	4	7	11	5	**31**
10:30	5	7	8	20	3	4	7	6	**33**
10:45	7	6	5	18	4	6	10	5	**33**
11:00	9	6	6	21	6	6	12	4	**37**
11:15	7	7	6	20	4	7	11	7	**38**
11:30	8	6	6	20	5	7	12	5	**37**
11:45	9	8	7	24	4	8	12	3	**39**
12:00	10	7	6	23	4	6	10	6	**39**
12:15	10	5	5	20	4	6	10	6	**36**
12:30	8	6	6	20	5	7	12	5	**37**
12:45	7	8	7	22	6	8	14	6	**42**
13:00	8	7	6	21	5	8	13	6	**40**

Time	To M2 Motorway On-Slip & York Link				To York Street			To Westlink & Great George's Street	Total Queue at Site Q2
	Lane 1	Lane 2	Lane 3	Total	Lane 4	Lane 5	Total	Lane 6	
13:15	7	6	6	19	4	8	12	8	**39**
13:30	10	7	7	24	6	4	10	3	**37**
13:45	9	7	8	24	7	5	12	9	**45**
14:00	10	7	6	23	7	6	13	9	**45**
14:15	12	8	7	27	6	7	13	6	**46**
14:30	13	9	7	29	7	6	13	4	**46**
14:45	11	6	6	23	5	4	9	6	**38**
15:00	10	7	7	24	6	6	12	7	**43**
15:15	13	8	7	28	6	6	12	6	**46**
15:30	14	16	7	37	5	6	11	4	**52**
15:45	16	12	7	35	8	5	13	4	**52**
16:00	22	13	14	49	6	7	13	4	**66**
16:15	21	14	16	51	7	7	14	10	**75**
16:30	19	16	14	49	8	9	17	17	**83**
16:45	21	17	18	56	9	8	17	11	**84**
17:00	21	16	13	50	7	9	16	16	**82**
17:15	23	16	15	54	8	10	18	8	**80**
17:30	22	16	15	53	9	9	18	10	**81**
17:45	23	17	16	56	9	8	17	9	**82**
18:00	23	16	16	55	7	10	17	5	**77**
18:15	16	7	6	29	7	4	11	7	**47**
18:30	13	5	7	25	4	5	9	6	**40**
18:45	6	6	5	17	3	4	7	5	**29**

Note 1: The darker shaded areas indicate the maximum queue (in vehicles) per lane during the survey period.
Note 2: It should be noted that Lane 6 is only approximately 0.05 kilometres in length, therefore vehicles wishing to travel from York Street to Westlink and Great George Street may also be queuing in adjacent lanes.

Table 5.3.7 Summary of 12-Hour Queue Data: Site Q3 – York Street

Time	To Great George's Street					To Nelson Street	Total Queue at Site Q3
	Lane 1	Lane 2	Lane 3	Lane 4	Total	Lane 5	
07:00	7	6	11	13	37	1	**38**
07:15	10	12	17	10	49	1	**50**
07:30	15	16	14	10	55	1	**56**
07:45	12	17	17	11	57	1	**58**
08:00	15	17	16	11	59	1	**60**
08:15	12	16	15	11	54	1	**55**
08:30	11	8	15	9	43	2	**45**
08:45	15	12	15	12	54	3	**57**
09:00	15	12	16	11	54	4	**58**
09:15	13	15	17	10	55	2	**57**
09:30	14	16	17	12	59	3	**62**
09:45	8	7	14	9	38	2	**40**
10:00	9	9	8	8	34	4	**38**
10:15	9	4	10	7	30	1	**31**
10:30	6	5	6	7	24	2	**26**
10:45	5	5	8	7	25	1	**26**
11:00	7	4	10	5	26	1	**27**
11:15	4	4	8	8	24	2	**26**
11:30	8	6	9	10	33	1	**34**
11:45	6	6	13	9	34	1	**35**
12:00	9	9	7	10	35	1	**36**
12:15	5	7	11	10	33	0	**33**
12:30	6	3	12	11	32	0	**32**
12:45	6	4	10	8	28	1	**29**
13:00	6	8	10	9	33	2	**35**
13:15	6	8	9	9	32	2	**34**

Time	To Great George's Street					To Nelson Street	Total Queue at Site Q3
	Lane 1	Lane 2	Lane 3	Lane 4	Total	Lane 5	
13:30	7	6	9	10	32	0	**32**
13:45	6	9	12	10	37	2	**39**
14:00	5	6	10	10	31	3	**34**
14:15	5	7	13	12	37	1	**38**
14:30	5	8	6	8	27	0	**27**
14:45	8	8	8	9	33	0	**33**
15:00	5	8	11	8	32	1	**33**
15:15	5	6	10	9	30	1	**31**
15:30	13	14	17	9	53	1	**54**
15:45	8	17	12	13	50	1	**51**
16:00	8	17	15	10	50	1	**51**
16:15	9	18	16	11	54	0	**54**
16:30	15	20	14	13	62	2	**64**
16:45	11	16	13	10	50	1	**51**
17:00	9	10	12	10	41	1	**42**
17:15	13	15	12	11	51	0	**51**
17:30	11	10	14	11	46	0	**46**
17:45	5	14	12	11	42	1	**43**
18:00	7	6	13	12	38	0	**38**
18:15	8	12	10	11	41	0	**41**
18:30	9	10	13	10	42	0	**42**
18:45	5	4	7	6	22	0	**22**

Note 1: The darker shaded areas indicate the maximum queue (in vehicles) per lane during the survey period.
Note 2: It should be noted that Lane 5 is only approximately 0.04 kilometres in length, therefore vehicles wishing to travel from the M3 motorway to Nelson Street may also be queuing in adjacent lanes.

Table 5.3.8: Summary of 12-Hour Queue Data: Site Q4 – M2 Off-Slip / Nelson Street

Time	To Nelson Street (From M2 Motorway Off-Slip)			To Nelson Street (From Nelson Street)	To M3 Motorway On-Slip & Nelson Street			Total Queue at Site Q4
	Lane 1	Lane 2	Total	Lane 3	Lane 4	Lane 5	Total	
07:00	10	12	22	8	4	9	13	**43**
07:15	10	16	26	12	6	9	15	**53**
07:30	11	17	28	18	10	4	14	**60**
07:45	15	16	31	20	9	24	33	**84**
08:00	14	16	30	20	14	9	23	**73**
08:15	17	16	33	20	8	6	14	**67**
08:30	15	18	33	17	10	5	15	**65**
08:45	11	14	25	20	13	5	18	**63**
09:00	12	16	28	15	10	4	14	**57**
09:15	15	23	38	13	6	5	11	**62**
09:30	13	13	26	15	9	10	19	**60**
09:45	12	11	23	15	7	9	16	**54**
10:00	13	14	27	10	9	9	18	**55**
10:15	16	14	30	10	5	6	11	**51**
10:30	8	13	21	13	7	10	17	**51**
10:45	7	10	17	11	9	7	16	**44**
11:00	9	11	20	12	3	5	8	**40**
11:15	9	8	17	11	5	7	12	**40**
11:30	11	13	24	12	5	8	13	**49**
11:45	12	10	22	13	6	8	14	**49**
12:00	8	11	19	9	3	9	12	**40**
12:15	11	11	22	9	6	10	16	**47**
12:30	9	10	19	10	3	10	13	**42**
12:45	8	10	18	10	2	8	10	**38**
13:00	9	10	19	8	4	9	13	**40**

Time	To Nelson Street (From M2 Motorway Off-Slip)			To Nelson Street (From Nelson Street)	To M3 Motorway On-Slip & Nelson Street			Total Queue at Site Q4
	Lane 1	Lane 2	Total	Lane 3	Lane 4	Lane 5	Total	
13:15	7	7	14	11	4	9	13	**38**
13:30	8	10	18	12	7	6	13	**43**
13:45	9	11	20	10	4	9	13	**43**
14:00	9	12	21	12	6	9	15	**48**
14:15	10	10	20	9	5	6	11	**40**
14:30	11	9	20	10	2	7	9	**39**
14:45	6	9	15	9	7	10	17	**41**
15:00	7	10	17	11	6	15	21	**49**
15:15	7	10	17	10	5	7	12	**39**
15:30	9	11	20	14	5	14	19	**53**
15:45	8	17	25	12	5	17	22	**59**
16:00	9	11	20	15	7	18	25	**60**
16:15	9	12	21	14	6	10	16	**51**
16:30	13	15	28	13	10	14	24	**65**
16:45	16	14	30	16	14	16	30	**76**
17:00	18	17	35	18	16	18	34	**87**
17:15	18	15	33	15	6	18	24	**72**
17:30	17	15	32	18	7	16	23	**73**
17:45	20	19	39	16	6	10	16	**71**
18:00	19	18	37	15	5	12	17	**69**
18:15	18	22	40	17	7	9	16	**73**
18:30	13	14	27	10	3	6	9	**46**
18:45	10	10	20	5	4	6	10	**35**

Note: The darker shaded areas indicate the maximum queue (in vehicles) per lane during the survey period.

Examination of the above information indicates that at Site Q1, which is the Westlink approach to York Street, the maximum queue length was recorded at 16:00 hours where 88 vehicles were observed queuing.

At Site Q2, which is on York Street, the maximum queue length was recorded at 16:45 hours where 84 vehicles were observed queuing.

At Site Q3, which is the M3 motorway off-slip to Nelson Street, the maximum queue length was recorded at 16:30 hours where 64 vehicles were observed queuing.

At Site Q4, which is on Nelson Street, the maximum queue length was recorded at 17:00 hours where 87 vehicles were observed queuing.

The distribution of the queue lengths observed during the Queue Survey at each of the four Sites, as well as the corresponding traffic flows observed during the MCC Survey, are shown in **Figures 5.3.7 to 5.3.10**.

5.3.4 *Automatic Traffic Counts*

5.3.4.1 *Temporary Automatic Traffic Count Locations*

Six temporary Automatic Traffic Counters (ATCs) were installed during the survey period at key locations within the study area to define directional, hourly and daily variations in traffic flows.

The temporary ATCs were undertaken at the following locations:

- ATC Site 1 – York Street, north of York Gate exit;
- ATC Site 2 – M2 Motorway Southbound Off-Slip at Nelson Street;
- ATC Site 3 – Nelson Street (Right Hand Lane);
- ATC Site 4 – Nelson Street (Left Hand Lanes);
- ATC Site 5 – Great George's Street, adjacent to Car Park; and
- ATC Site 6 – York Street, adjacent to Car Park.

The locations of the temporary ATC Sites are shown in **Figure 5.3.11**.

5.3.4.2 *Temporary Automatic Traffic Counts*

The temporary ATCs provide a record of traffic flows generally over a 14 day period between Monday 28 May and Sunday 10 June 2012. It should be noted that the data recorded at temporary ATC Sites 2, 5 and 6 were fragmented with some missing data. Some of this data has therefore been infilled and some has been excluded from the analysis. For the purpose of defining baseline conditions, the ATC at Site 6 was extended for a further week to provide additional information on traffic flows.

The temporary ATC information recorded at ATC Sites 1 to 4 were based on the following vehicle classification:

- Class 1 – Motorcycles;
- Class 2 – Passenger cars or light pickup, car with trailer;
- Class 3 – Heavy pickup, pickup with trailer;
- Class 4 – Buses and Coaches;

- Class 5 – 2-Axle Heavy Goods Vehicles plus with trailer;
- Class 6 – 3-Axle Heavy Goods Vehicles;
- Class 7 – 4-Axle Heavy Goods Vehicles;
- Class 8 – 2, 3 & 4-Axle single trailer Heavy Goods Vehicles;
- Class 9 – 5-Axle single trailer Heavy Goods Vehicles;
- Class 10 – 6-Axle single trailer Heavy Goods Vehicles;
- Class 11 – 5-Axle multiple section Heavy Goods Vehicles;
- Class 12 – 6-Axle multiple section Heavy Goods Vehicles; and
- Class 13 – Heavy Goods Vehicles of any format with 7 or more axles.

The temporary ATC information recorded at ATC Sites 5 and 6 were based on the standard COBA 5-vehicle vehicle classification which includes the following vehicle types:

- Cars;
- Light Goods Vehicles (LGV);
- Other Goods Vehicles 1 (OGV 1);
- Other Goods Vehicles 2 (OGV 2); and
- Buses and Coaches (PSV).

5.3.4.3 *Temporary Automatic Traffic Count Results*

The 12-hour, 16-hour, 18-hour and 24-hour traffic flows recorded in May / June 2012 by the temporary ATCs are summarised in **Tables 5.3.9 to 5.3.14**.

Table 5.3.9: Two-Way ATC Traffic Volumes: ATC 1 – York Street, North of York Gate Exit

WEEK 1	Mon 28/05	Tue 29/05	Wed 30/05	Thu 31/05	Fri 01/06	Sat 02/06	Sun 03/06	5-Day Avg.	7-Day Avg.
12-Hour	12,400	12,826	13,040	13,696	13,807	8,270	5,483	13,154	11,360
16-Hour	14,212	15,053	15,333	16,152	16,195	9,894	6,862	15,389	13,386
18-Hour	14,663	15,763	15,972	16,774	16,917	10,559	7,331	16,018	13,997
24-Hour	15,066	16,164	16,425	17,209	17,502	11,267	8,085	16,473	14,531
16 / 12	**1.15**	**1.17**	**1.18**	**1.18**	**1.17**	**1.20**	**1.25**	**1.17**	**1.18**
24 / 18	**1.03**	**1.03**	**1.03**	**1.03**	**1.03**	**1.07**	**1.10**	**1.03**	**1.04**
24 / 12	**1.22**	**1.26**	**1.26**	**1.26**	**1.27**	**1.36**	**1.47**	**1.25**	**1.28**
24 / 16	**1.06**	**1.07**	**1.07**	**1.07**	**1.08**	**1.14**	**1.18**	**1.07**	**1.09**
WEEK 2	Mon 04/06	Tue 05/06	Wed 06/06	Thu 07/06	Fri 08/06	Sat 09/06	Sun 10/06	5-Day Avg.	7-Day Avg.
12-Hour	7,526	8,399	12,784	13,296	13,767	8,622	5,446	13,282	10,783
16-Hour	9,087	10,128	14,865	15,573	16,026	10,216	6,764	15,488	12,689
18-Hour	9,527	10,666	15,401	16,213	16,663	10,819	7,158	16,092	13,251
24-Hour	10,069	11,133	15,885	16,683	17,247	11,420	7,877	16,605	13,822
16 / 12	**1.21**	**1.21**	**1.16**	**1.17**	**1.16**	**1.18**	**1.24**	**1.17**	**1.18**
24 / 18	**1.06**	**1.04**	**1.03**	**1.03**	**1.04**	**1.06**	**1.10**	**1.03**	**1.04**
24 / 12	**1.34**	**1.33**	**1.24**	**1.25**	**1.25**	**1.32**	**1.45**	**1.25**	**1.28**
24 / 16	**1.11**	**1.10**	**1.07**	**1.07**	**1.08**	**1.12**	**1.16**	**1.07**	**1.09**

Note: Monday 04 June and Tuesday 05 June 2012 were Bank Holidays and therefore the traffic flows recorded do not represent typical conditions. This data has therefore been excluded from the calculation of the 5-day and 7-day averages.

Table 5.3.10: One-Way ATC Traffic Volumes: ATC 2 – M2 Motorway Southbound Off-Slip at Nelson Street

WEEK 1	Mon 28/05	Tue 29/05	Wed 30/05	Thu 31/05	Fri 01/06	Sat 02/06	Sun 03/06	5-Day Avg.	7-Day Avg.
12-Hour	16,109	16,443	16,449	16,338	16,326	14,475	10,442	16,333	15,226
16-Hour	19,300	19,865	19,988	19,950	19,935	17,116	12,896	19,808	18,436
18-Hour	20,007	20,639	20,766	20,928	20,967	17,994	13,612	20,661	19,273
24-Hour	20,739	21,401	21,566	21,749	21,902	19,076	14,701	21,471	20,162
16 / 12	**1.20**	**1.21**	**1.22**	**1.22**	**1.22**	**1.18**	**1.24**	**1.21**	**1.21**
24 / 18	**1.04**	**1.04**	**1.04**	**1.04**	**1.04**	**1.06**	**1.08**	**1.04**	**1.05**
24 / 12	**1.29**	**1.30**	**1.31**	**1.33**	**1.34**	**1.32**	**1.41**	**1.31**	**1.32**
24 / 16	**1.07**	**1.08**	**1.08**	**1.09**	**1.10**	**1.11**	**1.14**	**1.08**	**1.09**
WEEK 2	Mon 04/06	Tue 05/06	Wed 06/06	Thu 07/06	Fri 08/06	Sat 09/06	Sun 10/06	5-Day Avg.	7-Day Avg.
12-Hour	13,876	14,396	16,217	16,346	16,805	13,894	11,001	16,456	14,853
16-Hour	16,671	17,224	19,451	19,972	20,337	16,383	13,475	19,920	17,924
18-Hour	17,496	17,944	20,220	20,795	21,369	17,179	14,299	20,795	18,772
24-Hour	18,161	18,646	21,027	21,591	22,319	18,261	15,409	21,646	19,721
16 / 12	**1.20**	**1.20**	**1.20**	**1.22**	**1.21**	**1.18**	**1.22**	**1.21**	**1.21**
24 / 18	**1.04**	**1.04**	**1.04**	**1.04**	**1.04**	**1.06**	**1.08**	**1.04**	**1.05**
24 / 12	**1.31**	**1.30**	**1.30**	**1.32**	**1.33**	**1.31**	**1.40**	**1.32**	**1.33**
24 / 16	**1.09**	**1.08**	**1.08**	**1.08**	**1.10**	**1.11**	**1.14**	**1.09**	**1.10**

Note 1: Partial / Zero data were recorded between 20:45 hours on Friday 08 June 2012 and 10:45 hours on Saturday 09 June 2012. This data has therefore been infilled to provide a complete 24-hour record.
Note 2: Monday 04 June and Tuesday 05 June 2012 were Bank Holidays and therefore the traffic flows recorded do not represent typical conditions. This data has therefore been excluded from the calculation of the 5-day and 7-day averages.

Table 5.3.11: One-Way ATC Traffic Volumes: ATC 3 – Nelson Street (Right Hand Lane)

WEEK 1	Mon 28/05	Tue 29/05	Wed 30/05	Thu 31/05	Fri 01/06	Sat 02/06	Sun 03/06	5-Day Avg.	7-Day Avg.
12-Hour	2,993	3,249	3,233	3,596	3,318	1,298	826	3,278	2,645
16-Hour	3,257	3,608	3,588	3,949	3,690	1,485	1,011	3,618	2,941
18-Hour	3,316	3,688	3,667	4,027	3,791	1,552	1,078	3,698	3,017
24-Hour	3,389	3,771	3,752	4,116	3,930	1,651	1,174	3,792	3,112
16 / 12	**1.09**	**1.11**	**1.11**	**1.10**	**1.11**	**1.14**	**1.22**	**1.10**	**1.11**
24 / 18	**1.02**	**1.02**	**1.02**	**1.02**	**1.04**	**1.06**	**1.09**	**1.03**	**1.03**
24 / 12	**1.13**	**1.16**	**1.16**	**1.14**	**1.18**	**1.27**	**1.42**	**1.16**	**1.18**
24 / 16	**1.04**	**1.05**	**1.05**	**1.04**	**1.07**	**1.11**	**1.16**	**1.05**	**1.06**
WEEK 2	Mon 04/06	Tue 05/06	Wed 06/06	Thu 07/06	Fri 08/06	Sat 09/06	Sun 10/06	5-Day Avg.	7-Day Avg.
12-Hour	1,462	1,507	3,490	3,826	3,654	1,213	709	3,657	2,578
16-Hour	1,683	1,785	3,874	4,197	4,027	1,392	875	4,033	2,873
18-Hour	1,739	1,866	3,961	4,276	4,107	1,457	930	4,115	2,946
24-Hour	1,826	1,974	4,069	4,397	4,250	1,555	1,019	4,239	3,058
16 / 12	**1.15**	**1.18**	**1.11**	**1.10**	**1.10**	**1.15**	**1.23**	**1.10**	**1.11**
24 / 18	**1.05**	**1.06**	**1.03**	**1.03**	**1.03**	**1.07**	**1.10**	**1.03**	**1.04**
24 / 12	**1.25**	**1.31**	**1.17**	**1.15**	**1.16**	**1.28**	**1.44**	**1.16**	**1.19**
24 / 16	**1.08**	**1.11**	**1.05**	**1.05**	**1.06**	**1.12**	**1.16**	**1.05**	**1.06**

Note: Monday 04 June and Tuesday 05 June 2012 were Bank Holidays and therefore the traffic flows recorded do not represent typical conditions. This data has therefore been excluded from the calculation of the 5-day and 7-day averages.

Table 5.3.12: One-Way ATC Traffic Volumes: ATC 4 – Nelson Street (Left Lanes)

WEEK 1	Mon 28/05	Tue 29/05	Wed 30/05	Thu 31/05	Fri 01/06	Sat 02/06	Sun 03/06	5-Day Avg.	7-Day Avg.
12-Hour	7,797	8,178	8,265	8,681	8,575	5,054	3,244	8,299	7,113
16-Hour	8,785	9,329	9,472	9,931	9,806	5,870	3,981	9,465	8,168
18-Hour	8,979	9,653	9,759	10,221	10,108	6,150	4,165	9,744	8,434
24-Hour	9,163	9,797	9,937	10,362	10,319	6,487	4,518	9,916	8,655
16 / 12	**1.13**	**1.14**	**1.15**	**1.14**	**1.14**	**1.16**	**1.23**	**1.14**	**1.15**
24 / 18	**1.02**	**1.01**	**1.02**	**1.01**	**1.02**	**1.05**	**1.08**	**1.02**	**1.03**
24 / 12	**1.18**	**1.20**	**1.20**	**1.19**	**1.20**	**1.28**	**1.39**	**1.19**	**1.22**
24 / 16	**1.04**	**1.05**	**1.05**	**1.04**	**1.05**	**1.11**	**1.13**	**1.05**	**1.06**
WEEK 2	Mon 04/06	Tue 05/06	Wed 06/06	Thu 07/06	Fri 08/06	Sat 09/06	Sun 10/06	5-Day Avg.	7-Day Avg.
12-Hour	4,582	4,346	8,226	8,377	8,568	5,120	3,340	8,390	6,726
16-Hour	5,379	5,191	9,322	9,604	9,751	5,951	3,960	9,559	7,718
18-Hour	5,599	5,447	9,562	9,875	10,016	6,217	4,154	9,818	7,965
24-Hour	5,817	5,633	9,736	10,047	10,245	6,476	4,485	10,009	8,198
16 / 12	**1.17**	**1.19**	**1.13**	**1.15**	**1.14**	**1.16**	**1.19**	**1.14**	**1.15**
24 / 18	**1.04**	**1.03**	**1.02**	**1.02**	**1.02**	**1.04**	**1.08**	**1.02**	**1.03**
24 / 12	**1.27**	**1.30**	**1.18**	**1.20**	**1.20**	**1.26**	**1.34**	**1.19**	**1.22**
24 / 16	**1.08**	**1.09**	**1.04**	**1.05**	**1.05**	**1.09**	**1.13**	**1.05**	**1.06**

Note: Monday 04 June and Tuesday 05 June 2012 were Bank Holidays and therefore the traffic flows recorded do not represent typical conditions. This data has therefore been excluded from the calculation of the 5-day and 7-day averages.

Table 5.3.13: One-Way ATC Traffic Volumes: ATC 5 – Great George's Street, Adjacent to Car Park

WEEK 1	Mon 28/05	Tue 29/05	Wed 30/05	Thu 31/05	Fri 01/06	Sat 02/06	Sun 03/06	5-Day Avg.	7-Day Avg.
12-Hour	37,030	38,256	38,774	38,573	39,823	27,363	20,249	38,491	34,295
16-Hour	43,158	45,053	45,796	45,617	46,698	32,334	24,806	45,264	40,495
18-Hour	44,470	47,090	47,856	47,368	49,065	34,404	26,157	47,170	42,344
24-Hour	45,769	48,362	49,242	48,758	50,684	36,384	28,196	48,563	43,914
16 / 12	**1.17**	**1.18**	**1.18**	**1.18**	**1.17**	**1.18**	**1.23**	**1.18**	**1.18**
24 / 18	**1.03**	**1.03**	**1.03**	**1.03**	**1.03**	**1.06**	**1.08**	**1.03**	**1.04**
24 / 12	**1.24**	**1.26**	**1.27**	**1.26**	**1.27**	**1.33**	**1.39**	**1.26**	**1.28**
24 / 16	**1.06**	**1.07**	**1.08**	**1.07**	**1.09**	**1.13**	**1.14**	**1.07**	**1.08**
WEEK 2	Mon 04/06	Tue 05/06	Wed 06/06	Thu 07/06	Fri 08/06	Sat 09/06	Sun 10/06	5-Day Avg.	7-Day Avg.
12-Hour	26,451	27,536	37,902	39,395	39,690	26,543	20,554	38,996	32,817
16-Hour	31,384	32,854	44,362	46,264	46,053	31,120	25,065	45,560	38,573
18-Hour	32,867	34,238	45,836	48,260	47,650	32,540	26,446	47,249	40,146
24-Hour	34,075	35,526	47,147	49,594	49,296	34,114	28,427	48,679	41,716
16 / 12	**1.19**	**1.19**	**1.17**	**1.17**	**1.16**	**1.17**	**1.22**	**1.17**	**1.18**
24 / 18	**1.04**	**1.04**	**1.03**	**1.03**	**1.03**	**1.05**	**1.07**	**1.03**	**1.04**
24 / 12	**1.29**	**1.29**	**1.24**	**1.26**	**1.24**	**1.29**	**1.38**	**1.25**	**1.27**
24 / 16	**1.09**	**1.08**	**1.06**	**1.07**	**1.07**	**1.10**	**1.13**	**1.07**	**1.08**

Note 1: Partial / Zero data were recorded between 17:00 hours and 17:15 hours on Tuesday 29 May 2012. This data has therefore been infilled to provide a complete 24-hour record.
Note 2: Monday 04 June and Tuesday 05 June 2012 were Bank Holidays and therefore the traffic flows recorded do not represent typical conditions. This data has therefore been excluded from the calculation of the 5-day and 7-day averages.

Table 5.3.14: One-Way ATC Traffic Volumes: ATC 6 – York Street, Adjacent to Car Park

WEEK 1	Mon 28/05	Tue 29/05	Wed 30/05	Thu 31/05	Fri 01/06	Sat 02/06	Sun 03/06	5-Day Avg.	7-Day Avg.
12-Hour	19,334	20,162	19,095	19,860	19,498	13,246	8,765	19,590	17,137
16-Hour	22,440	22,825	22,101	23,606	22,570	15,619	10,576	22,708	19,962
18-Hour	23,547	23,767	23,271	24,814	24,039	16,928	11,168	23,888	21,076
24-Hour	24,062	24,299	23,833	25,333	24,926	18,167	12,664	24,491	21,898
16 / 12	**1.16**	**1.13**	**1.16**	**1.19**	**1.16**	**1.18**	**1.21**	**1.16**	**1.16**
24 / 18	**1.02**	**1.02**	**1.02**	**1.02**	**1.04**	**1.07**	**1.13**	**1.03**	**1.04**
24 / 12	**1.24**	**1.21**	**1.25**	**1.28**	**1.28**	**1.37**	**1.44**	**1.25**	**1.28**
24 / 16	**1.07**	**1.06**	**1.08**	**1.07**	**1.10**	**1.16**	**1.20**	**1.08**	**1.10**
WEEK 2/ WEEK 3	Mon 11/06	Tue 12/06	Wed 13/06	Thu 14/06	Fri 15/06	Sat 09/06	Sun 10/06	5-Day Avg.	7-Day Avg.
12-Hour	18,400	19,210	18,705	18,854	19,446	13,064	8,377	17,947	16,579
16-Hour	20,625	21,804	21,479	22,301	22,072	15,299	10,051	21,656	19,090
18-Hour	21,208	22,583	22,379	23,274	22,902	16,378	10,575	22,469	19,900
24-Hour	21,769	23,042	22,950	23,827	23,629	17,426	12,076	23,043	20,674
16 / 12	**1.12**	**1.14**	**1.15**	**1.18**	**1.14**	**1.17**	**1.20**	**1.21**	**1.15**
24 / 18	**1.03**	**1.02**	**1.03**	**1.02**	**1.03**	**1.06**	**1.14**	**1.03**	**1.04**
24 / 12	**1.18**	**1.20**	**1.23**	**1.26**	**1.22**	**1.33**	**1.44**	**1.28**	**1.25**
24 / 16	**1.06**	**1.06**	**1.07**	**1.07**	**1.07**	**1.14**	**1.20**	**1.06**	**1.08**

Note 1: Partial / Zero data were recorded between12:00 hours on Monday 28 May 2012 and 06:00 hours on Tuesday 29 May 2012, between 18:00 hours and 19:00 hours on Tuesday 29 May 2012 and between 12:00 hours and 13:30 hours on Monday 11 June 2012. This data has therefore been infilled to provide a complete 24-hour record.

The corresponding daily variations in traffic flows for the six temporary ATCs recorded in May / June 2012 are shown in **Figures 5.3.12 to 5.3.17** respectively.

A summary of the 5-day and 7-day average 24-hour flows recorded by the temporary ATCs over the survey period is shown in **Figure 5.3.18**.

Comparison of the temporary ATC 12-hour flows recorded on the day of the MCC survey indicates that the ATC flows at Sites 1 to 4 are within 7% of the MCC flows recorded at the neighbouring junctions. The flows on the gyratory at ATC 5 and ATC 6 are within 3%. This information is summarised in **Table 5.3.15**.

Table 5.3.15: Comparison of 12-Hour Flows on Day of MCC Survey

ATC	12-Hour Traffic Flow	MCC	12-Hour Traffic Flow	ATC / MCC
ATC 1	12,826	**Site J8**	12,690	1.01
ATC 2	16,443	**Site L2**	17,653	0.93
ATC 3	3,249	**Site J4**	3,431	0.95
ATC 4	8,178	**Site J4**	7,936	1.03
ATC 5	38,256	**Site J3**	38,567	0.99
ATC 6	20,162	**Site J2**	19,499	1.03

5.3.5 *Journey Time Surveys*

5.3.5.1 *Methodology*

A survey of current journey times was undertaken in the York Street area, including the Westlink, the M2 motorway and the M3 motorway, to assist in defining current operating conditions within the corridor.

The surveys were carried out on Tuesday 29 May and Wednesday 30 May 2012 using two survey vehicles over two routes, namely the Red Route and the Blue Route. Various runs were carried out for the two routes between 07:00 hours and 19:00 hours to record variations in journey times throughout the day. The survey periods were as follows:

- AM Peak Period: 07:00 hours – 10:00 hours;
- Interpeak Period: 11:00 hours – 15:00 hours; and
- PM Peak Period: 16:00 hours – 19:00 hours.

A total of fifty runs were carried out over the two days for the Red Route, with twenty six of the runs carried out on Tuesday 29 May 2012 and twenty four runs on Wednesday 30 May 2012. A total of sixty two runs were carried out over the two survey days for the Blue Route, with twenty nine of the runs carried out on Tuesday 29 May 2012 and thirty three runs on Wednesday 30 May 2012.

The survey was based on the standard moving observer technique to record journey times at each of the predefined measurement points along the route.

5.3.5.2 *Journey Time Survey Locations*

The limits of the Journey Time Survey routes and the locations of the measurement points are shown in **Figures 5.3.19(a) and 5.3.19(b).**

It should be noted that Red Route runs were incomplete on Tuesday 29 May and Wednesday 30 May 2012 as the survey vehicle followed the route between measurement points R19 and R24 travelling down Nelson Street as opposed to Corporation Street, therefore omitting measurement points R20 to R23.

The Red Route was therefore resurveyed between measurement points R14 to R29 on Wednesday 19 September and Thursday 20 September 2012 to provide journey times for the complete route. A total of forty five runs were carried out over the two days of the resurvey, with twenty one runs carried out on Wednesday 19 September 2012 and twenty four runs on Thursday 20 September 2012.

5.3.5.3 *Journey Time Survey Results – May 2012*

Delays were recorded at various times on each route during the days of survey.

The results from the May 2012 Journey Time Surveys for the Red Route are shown in **Tables 5.3.16(a) to 3.16(c).**

Table 5.3.16(a): Summary of May 2012 Journey Time Survey Results: Red Route – AM Peak Period

Measurement Points	Speed Limit (mph)	Average Time (hh:mm:ss)	JTS Length (km)	Average Speed (mph)	Average Speed (kph)
R1 – R2	50	00:00:58	0.621	24	39
R2 – R3	30	00:00:08	0.074	21	34
R3 – R4	70	00:00:42	0.840	45	72
R4 – R5	70	00:00:16	0.309	44	71
R5 – R6	30	00:01:09	1.336	43	69
R6 – R7	30	00:00:48	0.360	17	27
R7 – R8	70	00:01:16	1.345	40	64
R8 – R9	70	00:00:25	0.308	28	45
R9 – R10	70	00:02:24	0.643	10	16
R10 – R11	30	00:01:27	0.276	7	11
R11 – R12	30	00:00:18	0.104	13	21
R12 – R13	30	00:00:14	0.149	24	39
R13 – R14	50	00:01:32	0.573	14	23
R14 – R15	30	00:01:10	0.175	6	10
R15 – R16	30	00:00:21	0.234	25	40
R16 – R17	30	00:00:17	0.183	24	39
R17 – R18	30	00:01:05	0.318	11	18
R18 – R19	30	00:01:23	0.274	7	11
R19 – R24	30	00:02:17	0.777	13	21
R24 – R25	30	00:00:34	0.149	10	16
R25 – R26	30	00:01:39	0.304	7	11
R26 – R27	30	00:01:01	0.195	7	11
R27 – R28	30	00:00:27	0.155	13	21
R28 – R29	30	00:00:44	0.126	6	10
Total		**00:22:35**	**9.828**	**16**	**26**

Note 1: Recorded speeds include junction delays that are relevant to journey time route.
Note 2: R19 – R24 is based on the survey vehicle following R19 / B14 – B15 – B16 – B17 – B10 / R24 in error.

Table 5.3.16(b) Summary of May 2012 Journey Time Survey Results: Red Route – PM Peak Period

Measurement Points	Speed Limit (mph)	Average Time (hh:mm:ss)	JTS Length (km)	Average Speed (mph)	Average Speed (kph)
R1 – R2	50	00:00:57	0.621	25	40
R2 – R3	30	00:00:08	0.074	22	35
R3 – R4	70	00:00:43	0.840	44	71
R4 – R5	70	00:00:16	0.309	44	71
R5 – R6	30	00:01:05	1.336	46	74
R6 – R7	30	00:00:48	0.360	17	27
R7 – R8	70	00:01:00	1.345	50	80
R8 – R9	70	00:00:12	0.308	59	95
R9 – R10	70	00:02:19	0.643	10	16
R10 – R11	30	00:02:05	0.276	5	8
R11 – R12	30	00:00:41	0.104	6	10
R12 – R13	30	00:00:28	0.149	12	19
R13 – R14	50	00:01:37	0.573	13	21
R14 – R15	30	00:00:43	0.175	9	14
R15 – R16	30	00:00:24	0.234	22	35
R16 – R17	30	00:00:23	0.183	18	29
R17 – R18	30	00:01:04	0.318	11	18
R18 – R19	30	00:01:07	0.274	9	14
R19 – R24	30	00:02:37	0.777	11	18
R24 – R25	30	00:00:33	0.149	10	16
R25 – R26	30	00:02:09	0.304	5	8
R26 – R27	30	00:00:59	0.195	7	11
R27 – R28	30	00:00:32	0.155	11	18
R28 – R29	30	00:00:47	0.126	6	10
Total		**00:23:35**	**9.828**	**16**	**26**

Note 1: Recorded speeds include junction delays that are relevant to journey time route.
Note 2: R19 – R24 is based on the survey vehicle following R19 / B14 – B15 – B16 – B17 – B10 / R24 in error.

Table 5.3.16(c) Summary of May 2012 Journey Time Survey Results: Red Route – Full Day

Measurement Points	Speed Limit (mph)	Average Time (hh:mm:ss)	JTS Length (km)	Average Speed (mph)	Average Speed (kph)
R1 – R2	50	00:00:54	0.621	26	42
R2 – R3	30	00:00:08	0.074	20	32
R3 – R4	70	00:00:42	0.840	45	72
R4 – R5	70	00:00:16	0.309	44	71
R5 – R6	30	00:01:10	1.336	43	69
R6 – R7	30	00:00:49	0.360	16	26
R7 – R8	70	00:01:05	1.345	47	76
R8 – R9	70	00:00:15	0.308	45	72
R9 – R10	70	00:01:32	0.643	16	26
R10 – R11	30	00:01:19	0.276	8	13
R11 – R12	30	00:00:25	0.104	9	14
R12 – R13	30	00:00:19	0.149	18	29
R13 – R14	50	00:01:25	0.573	15	24
R14 – R15	30	00:00:57	0.175	7	11
R15 – R16	30	00:00:22	0.234	24	39
R16 – R17	30	00:00:19	0.183	22	35
R17 – R18	30	00:01:05	0.318	11	18
R18 – R19	30	00:01:15	0.274	8	13
R19 – R24	30	00:02:22	0.777	12	19
R24 – R25	30	00:00:34	0.149	10	16
R25 – R26	30	00:01:42	0.304	7	11
R26 – R27	30	00:01:01	0.195	7	11
R27 – R28	30	00:00:29	0.155	12	19
R28 – R29	30	00:00:57	0.126	5	8
Total		**00:21:23**	**9.828**	**17**	**27**

Note 1: Recorded speeds include junction delays that are relevant to journey time route.
Note 2: R19 – R24 is based on the survey vehicle following R19 / B14 – B15 – B16 – B17 – B10 / R24 in error.

The results from the May 2012 Journey Time Surveys for the Blue Route are shown in **Tables 5.3.17(a) to 5.3.17(c)**.

Table 5.3.17(a): Summary of May 2012 Journey Time Survey Results: Blue Route – AM Peak Period

Measurement Points	Speed Limit (mph)	Average Time (hh:mm:ss)	JTS Length (km)	Average Speed (mph)	Average Speed (kph)
B1 – B2	50	00:01:46	0.822	17	27
B2 – B3	30	00:01:55	0.595	12	19
B3 – B4	30	00:00:46	0.157	8	13
B4 – B5	50	00:00:42	0.420	22	35
B5 – B5a	40	00:00:19	0.315	37	60
B5a – B6	40	00:00:29	0.317	25	40
B6 – B7	30	00:03:00	0.740	9	14
B7 – B7a	40	00:00:18	0.180	22	35
B7a – B8	50	00:00:19	0.315	37	60
B8 – B9	30	00:01:08	0.367	12	19
B9 – B10	30	00:00:51	0.165	7	11
B10 – B11	30	00:00:46	0.149	7	11
B11 – B12	30	00:01:01	0.190	7	11
B12 – B13	30	00:00:32	0.122	8	13
B13 – B14	30	00:01:38	0.308	7	11
B14 – B15	30	00:00:34	0.146	10	16
B15 – B16	30	00:01:25	0.335	9	14
B16 – B17	30	00:00:18	0.104	13	21
B17 – B18	30	00:00:15	0.149	22	35
B18 – B19	50	00:00:41	0.556	30	48
B19 – B20	50	00:01:19	0.816	23	37
Total		**00:20:05**	**7.268**	**14**	**23**

Note: Recorded speeds include junction delays that are relevant to journey time route

Table 5.3.17(b): Summary of May 2012 Journey Time Survey Results: Blue Route – PM Peak Period

Measurement Points	Speed Limit (mph)	Average Time (hh:mm:ss)	JTS Length (km)	Average Speed (mph)	Average Speed (kph)
B1 – B2	50	00:01:22	0.822	23	37
B2 – B3	30	00:01:11	0.595	19	31
B3 – B4	30	00:00:23	0.157	15	24
B4 – B5	50	00:00:42	0.420	23	37
B5 – B5a	40	00:00:20	0.315	36	58
B5a – B6	40	00:00:31	0.317	23	37
B6 – B7	30	00:02:50	0.740	10	16
B7 – B7a	40	00:00:19	0.180	22	35
B7a – B8	50	00:00:21	0.315	34	55
B8 – B9	30	00:01:08	0.367	12	19
B9 – B10	30	00:00:56	0.165	7	11
B10 – B11	30	00:00:41	0.149	8	13
B11 – B12	30	00:00:54	0.190	8	13
B12 – B13	30	00:00:22	0.122	12	19
B13 – B14	30	00:01:00	0.308	11	18
B14 – B15	30	00:00:33	0.146	10	16
B15 – B16	30	00:02:01	0.335	6	10
B16 – B17	30	00:00:43	0.104	5	8
B17 – B18	30	00:00:30	0.149	11	18
B18 – B19	50	00:00:44	0.556	29	47
B19 – B20	50	00:01:15	0.816	24	39
Total		**00:18:45**	**7.268**	**15**	**24**

Note: Recorded speeds include junction delays that are relevant to journey time route

Table 5.3.17(c): Summary of May 2012 Journey Time Survey Results: Blue Route – Full Day

Measurement Points	Speed Limit (mph)	Average Time (hh:mm:ss)	JTS Length (km)	Average Speed (mph)	Average Speed (kph)
B1 – B2	50	00:01:15	0.822	25	40
B2 – B3	30	00:01:06	0.595	20	32
B3 – B4	30	00:00:36	0.157	10	16
B4 – B5	50	00:00:43	0.420	22	35
B5 – B5a	40	00:00:19	0.315	38	61
B5a – B6	40	00:00:29	0.317	24	39
B6 – B7	30	00:02:34	0.740	11	18
B7 – B7a	40	00:00:19	0.180	22	35
B7a – B8	50	00:00:19	0.315	36	58
B8 – B9	30	00:00:51	0.367	16	26
B9 – B10	30	00:00:58	0.165	6	10
B10 – B11	30	00:00:41	0.149	8	13
B11 – B12	30	00:00:56	0.190	8	13
B12 – B13	30	00:00:22	0.122	12	19
B13 – B14	30	00:01:15	0.308	9	14
B14 – B15	30	00:00:31	0.146	11	18
B15 – B16	30	00:01:23	0.335	9	14
B16 – B17	30	00:00:26	0.104	9	14
B17 – B18	30	00:00:21	0.149	16	26
B18 – B19	50	00:00:43	0.556	29	47
B19 – B20	50	00:01:15	0.816	25	40
Total		**00:17:22**	**7.268**	**16**	**26**

Note: Recorded speeds include junction delays that are relevant to journey time route

5.3.5.4 *Journey Time Survey Results – September 2012*

Delays were recorded at various times on each route during the days of survey.

The results from the September 2012 Journey Time Surveys for the Red Route are shown in **Tables 5.3.18(a) to 5.3.18(c).**

Table 5.3.18(a): Summary of September 2012 Journey Time Survey Results: Red Route – AM Period

Measurement Points	Speed Limit (mph)	Average Time (hh:mm:ss)	JTS Length (km)	Average Speed (mph)	Average Speed (kph)
R14 – R15	30	00:00:47	0.175	8	13
R15 – R16	30	00:00:28	0.234	19	31
R16 – R17	30	00:00:18	0.183	23	37
R17 – R18	30	00:01:00	0.318	12	19
R18 – R19	30	00:01:23	0.274	7	11
R19 – R20	30	00:01:12	0.217	7	11
R20 – R21	30	00:00:41	0.309	17	27
R21 – R22	30	00:00:19	0.133	16	26
R22 – R23	30	00:01:01	0.322	12	19
R23 – R24	30	00:01:07	0.199	7	11
R24 – R25	30	00:00:20	0.149	17	27
R25 – R26	30	00:01:32	0.304	7	11
R26 – R27	30	00:00:55	0.195	8	13
R27 – R28	30	00:00:30	0.155	12	19
R28 – R29	30	00:00:58	0.126	5	8
Total		**00:12:32**	**3.293**	**10**	**16**

Note: Recorded speeds include junction delays that are relevant to journey time route

Table 5.3.18(b): Summary of September 2012 Journey Time Survey Results: Red Route – PM Period

Measurement Points	Speed Limit (mph)	Average Time (hh:mm:ss)	JTS Length (km)	Average Speed (mph)	Average Speed (kph)
R14 – R15	30	00:01:16	0.175	5	8
R15 – R16	30	00:00:31	0.234	17	27
R16 – R17	30	00:00:18	0.183	23	37
R17 – R18	30	00:01:02	0.318	12	19
R18 – R19	30	00:01:09	0.274	9	14
R19 – R20	30	00:00:49	0.217	10	16
R20 – R21	30	00:00:28	0.309	24	39
R21 – R22	30	00:00:16	0.133	19	31
R22 – R23	30	00:01:07	0.322	11	18
R23 – R24	30	00:00:48	0.199	9	14
R24 – R25	30	00:00:23	0.149	14	23
R25 – R26	30	00:01:54	0.304	6	10
R26 – R27	30	00:01:13	0.195	6	10
R27 – R28	30	00:00:29	0.155	12	19
R28 – R29	30	00:00:49	0.126	6	10
Total		**00:12:31**	**3.293**	**10**	**16**

Note: Recorded speeds include junction delays that are relevant to journey time route

Table 5.3.18(c): Summary of September 2012 Journey Time Survey Results: Red Route – Full Day

Measurement Points	Speed Limit (mph)	Average Time (hh:mm:ss)	JTS Length (km)	Average Speed (mph)	Average Speed (kph)
R14 – R15	30	00:00:54	0.175	7	11
R15 – R16	30	00:00:29	0.234	18	29
R16 – R17	30	00:00:17	0.183	24	39
R17 – R18	30	00:01:06	0.318	11	18
R18 – R19	30	00:01:08	0.274	9	14
R19 – R20	30	00:00:54	0.217	9	14
R20 – R21	30	00:00:32	0.309	22	35
R21 – R22	30	00:00:14	0.133	21	34
R22 – R23	30	00:00:58	0.322	12	19
R23 – R24	30	00:00:55	0.199	8	13
R24 – R25	30	00:00:25	0.149	13	21
R25 – R26	30	00:01:43	0.304	7	11
R26 – R27	30	00:01:05	0.195	7	11
R27 – R28	30	00:00:31	0.155	11	18
R28 – R29	30	00:01:00	0.126	5	8
Total		**00:12:12**	**3.293**	**10**	**16**

Note: Recorded speeds include junction delays that are relevant to journey time route

5.3.5.5 *Comparison of May 2012 and September 2012 Journey Time Survey Results*

A comparison of the May 2012 and September 2012 Red Route Journey Time Survey results is shown in **Table 5.3.19**.

Table 5.3.19: Comparison of May 2012 and September 2012 Journey Time Survey Results: Red Route – Full Day

	Average Time (hh:mm:ss)		Difference		
Measurement Points	May 2012	September 2012	Average Time (hh:mm:ss)	Percentage (%)	Comments
R14 – R19	00:03:57	00:03:54	-00:00:03	-1%	Within 1%
R19 – R24	00:03:14	00:03:34	00:00:20	33%	Routes Differ
R24 – R29	00:04:43	00:04:44	00:00:01	0%	Within 1%

Note: Recorded speeds include junction delays that are relevant to journey time route

Examination of the above information indicates that the journey times recorded between measurement points R14 to R19 and R24 to R29 in September 2012 are within 1% of the journey times recorded between these measurement points in May 2012. It is therefore reasonable to assume that the journey times recorded between measurement points R19 to R24 in September 2012 are a reasonable reflection of what journey times would have been over this route in May 2012.

The overall Red Route results from the May 2012 and September 2012 Journey Time Surveys are shown in **Table 5.3.20(a) to 5.3.20(c).**

Table 5.3.20(a): Summary of Journey Time Survey Results: Red Route – AM Period

Measurement Points	Speed Limit (mph)	Average Time (hh:mm:ss)	JTS Length (km)	Average Speed (mph)	Average Speed (kph)
R1 – R2	50	00:00:58	0.621	24	39
R2 – R3	30	00:00:08	0.074	21	34
R3 – R4	70	00:00:42	0.840	45	72
R4 – R5	70	00:00:16	0.309	44	71
R5 – R6	30	00:01:09	1.336	43	69
R6 – R7	30	00:00:48	0.360	17	27
R7 – R8	70	00:01:16	1.345	40	64
R8 – R9	70	00:00:25	0.308	28	45
R9 – R10	70	00:02:24	0.643	10	16
R10 – R11	30	00:01:27	0.276	7	11
R11 – R12	30	00:00:18	0.104	13	21

Measurement Points	Speed Limit (mph)	Average Time (hh:mm:ss)	JTS Length (km)	Average Speed (mph)	Average Speed (kph)
R12 – R13	30	00:00:14	0.149	24	39
R13 – R14	50	00:01:32	0.573	14	23
R14 – R15	30	00:01:10	0.175	6	10
R15 – R16	30	00:00:21	0.234	25	40
R16 – R17	30	00:00:17	0.183	24	39
R17 – R18	30	00:01:05	0.318	11	18
R18 – R19	30	00:01:23	0.274	7	11
R19 – R20	30	00:01:12	0.217	7	11
R20 – R21	30	00:00:41	0.309	17	27
R21 – R22	30	00:00:19	0.133	16	26
R22 – R23	30	00:01:01	0.322	12	19
R23 – R24	30	00:01:07	0.199	7	11
R24 – R25	30	00:00:34	0.149	10	16
R25 – R26	30	00:01:39	0.304	7	11
R26 – R27	30	00:01:01	0.195	7	11
R27 – R28	30	00:00:27	0.155	13	21
R28 – R29	30	00:00:44	0.126	6	10
Total		**00:24:39**	**10.231**	**16**	**26**

Note: Recorded speeds include junction delays that are relevant to journey time route

Table 5.3.20(b): Summary of Journey Time Survey Results: Red Route – PM Period

Measurement Points	Speed Limit (mph)	Average Time (hh:mm:ss)	JTS Length (km)	Average Speed (mph)	Average Speed (kph)
R1 – R2	50	00:00:57	0.621	25	40
R2 – R3	30	00:00:08	0.074	22	35
R3 – R4	70	00:00:43	0.840	44	71
R4 – R5	70	00:00:16	0.309	44	71
R5 – R6	30	00:01:05	1.336	46	74
R6 – R7	30	00:00:48	0.360	17	27
R7 – R8	70	00:01:00	1.345	50	80
R8 – R9	70	00:00:12	0.308	59	95
R9 – R10	70	00:02:19	0.643	10	16
R10 – R11	30	00:02:05	0.276	5	8
R11 – R12	30	00:00:41	0.104	6	10
R12 – R13	30	00:00:28	0.149	12	19
R13 – R14	50	00:01:37	0.573	13	21
R14 – R15	30	00:00:43	0.175	9	14
R15 – R16	30	00:00:24	0.234	22	35
R16 – R17	30	00:00:23	0.183	18	29
R17 – R18	30	00:01:04	0.318	11	18
R18 – R19	30	00:01:07	0.274	9	14
R19 – R20	30	00:00:49	0.217	10	16
R20 – R21	30	00:00:28	0.309	24	39
R21 – R22	30	00:00:16	0.133	19	31
R22 – R23	30	00:01:07	0.322	11	18
R23 – R24	30	00:00:48	0.199	9	14
R24 – R25	30	00:00:33	0.149	10	16
R25 – R26	30	00:02:09	0.304	5	8
R26 – R27	30	00:00:59	0.195	7	11

Measurement Points	Speed Limit (mph)	Average Time (hh:mm:ss)	JTS Length (km)	Average Speed (mph)	Average Speed (kph)
R27 – R28	30	00:00:32	0.155	11	18
R28 – R29	30	00:00:47	0.126	6	10
Total		**00:24:27**	**10.231**	**16**	**26**

Note: Recorded speeds include junction delays that are relevant to journey time route

Table 5.3.20(c): Summary of Journey Time Survey Results: Red Route – Full Day

Measurement Points	Speed Limit (mph)	Average Time (hh:mm:ss)	JTS Length (km)	Average Speed (mph)	Average Speed (kph)
R1 – R2	50	00:00:54	0.621	26	42
R2 – R3	30	00:00:08	0.074	20	32
R3 – R4	70	00:00:42	0.840	45	72
R4 – R5	70	00:00:16	0.309	44	71
R5 – R6	30	00:01:10	1.336	43	69
R6 – R7	30	00:00:49	0.360	16	26
R7 – R8	70	00:01:05	1.345	47	76
R8 – R9	70	00:00:15	0.308	45	72
R9 – R10	70	00:01:32	0.643	16	26
R10 – R11	30	00:01:19	0.276	8	13
R11 – R12	30	00:00:25	0.104	9	14
R12 – R13	30	00:00:19	0.149	18	29
R13 – R14	50	00:01:25	0.573	15	24
R14 – R15	30	00:00:57	0.175	7	11
R15 – R16	30	00:00:22	0.234	24	39
R16 – R17	30	00:00:19	0.183	22	35
R17 – R18	30	00:01:05	0.318	11	18
R18 – R19	30	00:01:15	0.274	8	13
R19 – R20	30	00:00:54	0.217	9	14
R20 – R21	30	00:00:32	0.309	22	35
R21 – R22	30	00:00:14	0.133	21	34

Measurement Points	Speed Limit (mph)	Average Time (hh:mm:ss)	JTS Length (km)	Average Speed (mph)	Average Speed (kph)
R22 – R23	30	00:00:58	0.322	12	19
R23 – R24	30	00:00:55	0.199	8	13
R24 – R25	30	00:00:34	0.149	10	16
R25 – R26	30	00:01:42	0.304	7	11
R26 – R27	30	00:01:01	0.195	7	11
R27 – R28	30	00:00:29	0.155	12	19
R28 – R29	30	00:00:57	0.126	5	8
Total		**00:22:34**	**10.231**	**17**	**27**

Note: Recorded speeds include junction delays that are relevant to journey time route

Examination of the journey times recorded during the a.m. peak period, as shown in **Table 5.3.20(a)**, indicates that the average speed along the Red Route is 16 mph / 26 kph. Examination of the journey times during the a.m. peak period, as shown in **Table 5.3.17(a)**, also indicates that the average speed along the Blue Route is 14 mph / 23 kph.

Examination of the journey times recorded during the p.m. peak period, as shown in **Table 5.3.20(b)**, indicates that the average speed along the Red Route is 16 mph / 26 kph. Examination of the journey times during the p.m. peak period, as shown in **Table 5.3.17(b)**, also indicates that the average speed along the Blue Route is 15 mph / 24 kph.

Examination of the journey times for the full day, as shown in **Table 5.3.20(c)**, indicates that the average speed along the Red Route is 17 mph / 27 kph. Examination of the journey times for the full day, as shown in **Table 5.3.17(c)**, also indicates that the average speed along the Blue Route is 16 mph / 26 kph.

The average speeds observed during the journey time surveys for the full day are also shown in **Figures 5.3.20(a) to 5.3.20(c)**.

This information provides an indication of existing travel conditions within the study area against which the effects of the proposed improvement can be considered.

5.4 Indicative Costs, Risks and Optimism Bias

5.4.1 *Basis of Cost Estimates*

Cost estimates were prepared for the Proposed Scheme. These costs, which are based on current rates, were used to define both the total construction cost and total land cost for the Proposed Scheme.

In accordance with the procedures established by Transport NI policy and procedure guide RSPPG_E058, an appropriate allowance for risk was determined for the Proposed Scheme. These risk allowances are included in the estimated scheme costs shown in **Table 5.4.1.**

Consultations with both NI Water and Translink have identified an opportunity to introduce stormwater separation and to undertake strengthening works to several foundations of the Dargan Bridge as part of the Proposed Scheme.

Although these works will not provide benefits to transport users, these works have been incorporated into the overall scheme. As a result, this effectively increases the construction cost for the scheme, although there are no corresponding transport user benefits. As NI Water and Translink would be funding these works separately and the benefits would not be transport related, it was agreed that the NI Water and Translink construction costs and benefits would be excluded from the standard transport cost benefit analysis. This will ensure that the reported transport Present Value of Benefits are associated with the corresponding transport Present Value of Costs.

A breakdown of the estimated costs of the Proposed Scheme in Quarter 2, 2013 prices, including the NI Water and Translink construction costs, is shown in **Table 5.4.1**.

Table 5.4.1: Estimated Proposed Scheme Cost Summary, including NI Water and Translink Construction Costs

Item	Scheme Cost (£m's)
Total Construction Cost	£92.106
Total Land Cost	£8.395
Preparation (6% of Total Construction and Land Cost)	£6.030
Supervision (5% of Total Construction and Land Cost)	£5.025
Total Scheme Cost	**£111.557**

Note: All costs are in Q2, 2013 prices and exclude VAT

A breakdown of the estimated NI Water construction costs in Quarter 2, 2013 prices is shown in **Table 5.4.2**.

Table 5.4.2: Estimated Proposed Scheme Cost Summary for NI Water Construction Costs Only

Item	Scheme Cost (£m's)
Total Construction Cost	£4.393
Total Land Cost	-
Preparation (6% of Total Construction and Land Cost)	£0.264
Supervision (5% of Total Construction and Land Cost)	£0.220
Total Scheme Cost	**£4.876**

Note: All costs are in Q2, 2013 prices and exclude VAT

A breakdown of the estimated Translink construction costs in Quarter 2, 2013 prices is shown in **Table 5.4.3**.

Table 5.4.3: Estimated Proposed Scheme Cost Summary for Translink Construction Costs Only

Item	Scheme Cost (£m's)
Total Construction Cost	£3.110
Total Land Cost	-

Item	Scheme Cost (£m's)
Preparation (6% of Total Construction and Land Cost)	£0.187
Supervision (5% of Total Construction and Land Cost)	£0.156
Total Scheme Cost	**£3.453**

Note: All costs are in Q2, 2013 prices and exclude VAT

A breakdown of the estimated costs of the Proposed Scheme in Quarter 2, 2013 prices, excluding the NI Water and Translink construction costs, is shown in **Table 5.4.4**.

Table 5.4.4: Estimated Proposed Scheme Cost Summary, excluding NI Water and Translink Construction Costs

Item	Scheme Cost (£m's)
Total Construction Cost	£84.603
Total Land Cost	£8.395
Preparation (6% of Total Construction and Land Cost)	£5.580
Supervision (5% of Total Construction and Land Cost)	£4.650
Total Scheme Cost	**£103.228**

Note: All costs are in Q2, 2013 prices and exclude VAT

5.4.2 *Optimism Bias*

As there is a tendency for project appraisers to be overly optimistic when assessing total scheme costs, optimism bias has been included in the appraisal to increase the capital expenditure estimate of the Proposed Scheme and the potential for delays during construction, in accordance with the operational advice concerning H.M. Treasury's New Green Book on Appraisal and Evaluation in Central Government.

As schemes progress through the various stages from the identification of a general corridor to the development of various route options and finally the selection of the Proposed Scheme, the level of optimism bias is likely to reduce accordingly.

Current Transport NI guidance recommends that the costs used in the economic appraisal of schemes include an upper bound allowance. At this stage of the project, an allowance of 16.5% for optimism bias has been used.

A breakdown of the estimated costs of the Proposed Scheme, excluding the NI Water and Translink construction costs and including an allowance of 16.5% for optimism bias, is shown in **Table 5.4.5**. All costs are in Quarter 2, 2013 prices.

Table 5.4.5: Estimated Proposed Scheme Cost Summary, including 16.5% Optimism Bias

Item	Scheme Cost (£m's)
Total Construction Cost	£98.563
Total Land Cost	£9.780
Preparation (6% of Total Construction and Land Cost)	£6.501
Supervision (5% of Total Construction and Land Cost)	£5.417
Total Scheme Cost	**£120.261**

Note: All costs are in Q2, 2013 prices and exclude VAT

5.4.3 *Cost Profile*

For the purpose of the economic appraisal, the cost profile shown in **Table 5.4.6** has been adopted.

The Proposed Scheme is based on a three year construction period.

Table 5.4.6: Proposed Scheme Cost Profile

Year	Cost Profile	
	Construction	Land
2017	0%	100%
2018	30%	0%
2019	34%	0%
2020	33%	0%
2021	3%	0%

Note: The construction cost profile is based on typical profiles with a 3 year construction period.

5.5 Development of Computer Models

5.5.1 *Overview of Model Development*

The quantitative assessment of the transport economic efficiency and road safety aspects of a proposed road improvement scheme requires the development and application of various computer models. In the case of the York Street Interchange, this has involved the development of a COBA (Cost Benefit Analysis) model and QUADRO (Queues and Delays at Roadworks) model.

The COBA model was developed to compare the cost and road user benefits of the proposed Proposed Scheme taking into account both transport economic efficiency and road safety issues.

The QUADRO model was developed to provide an assessment of the economic effects of road user delays associated with the construction of the proposed improvement.

5.5.2 *The COBA Model*

COBA is the standard computer program introduced in the 1970s to examine proposed investments in the trunk road network by comparing the costs of the road scheme with the associated road user benefits. The procedures for developing and applying the COBA model are set out in Design Manual for Roads and Bridges (DMRB) Volume 13.

The overall geographical area of the model, which extends from the Fortwilliam junction in the north, to the M3 motorway slips in the east, to Dunbar Link in the south and to the Clifton Street slips in the west, was defined to encompass the effects of the improvement option being considered.

The modelled area is shown in **Figure 5.5.1**. Aerial views of the existing York Street junction captured from the 3-dimensional model of the area are shown in **Figure 5.5.2.**

The York Street Interchange models are based on the 12-hour traffic flows and turning movements observed in 2012.

The assessment is based on standard COBA default values where these have been considered appropriate. For example, the default proportion of in-work trips has been adopted and default accident rates have been applied to both the Do-Minimum and Do-Something networks.

5.5.3 *Appraisal and Evaluation in Central Government*

In 2003, HM Treasury published the revised Green Book – Appraisal and Evaluation in Central Government, which came into effect on 1 April 2003 and outlines the best practice guide to carrying out appraisal and evaluation of capital projects, and in particular, concentrates on economic appraisal in the form of cost-benefit analysis.

The main changes in the new procedures are a stronger emphasis on the identification, management and realisation of benefits, the introduction of a new 3.5% annual discount rate to replace the previous 6% rate, and the introduction of explicit adjustment procedures to redress the systematic optimism that historically has affected the appraisal process.

The Northern Ireland (NI) Practical Guide to the Green Book presented the Department of Finance and Personnel (DFP) guidance and requirements on the appraisal, evaluation, approval and management of policies, programmes and projects. The document, published in 2003, contains practical guidance tailored specifically to the needs of the Northern Ireland Department, such as DFP's approval requirements, local policies and institutional arrangements.

In September 2009, DFP launched the latest on-line guide to expenditure, appraisal, evaluation, approval and management. The Northern Ireland Guide to Expenditure Appraisal and Evaluation (NIGEAE) supersedes the NI Practical Guide to the Green Book. The guide notes that the government spends billions of pounds every year delivering public services in Northern Ireland. It is vital that this money is put to use in a way that delivers the maximum benefit to the local population. It is also important that all spending is accountable to the NI Executive and Assembly.

5.5.4 *COBA Do-Minimum Model*

5.5.4.1 *Do-Minimum Network*

When undertaking cost benefits analyses using the COBA computer model, three discrete scenarios need to be considered, namely the Do-Nothing scenario, the Do-Minimum scenario and the Do-Something scenario.

The Do-Nothing scenario represents the existing road network without any improvement.

The Do-Minimum network is the base road network against which the Do-Something network is assessed. In the case of the York Street Interchange, no specific changes to the base road network have been identified and consequently the Do-Minimum network is consistent with the existing Do-Nothing network.

The limits of the highway network defined for the Do-Minimum model were defined to encompass the area surrounding the York Street Interchange that is likely to be significantly affected by the potential reassignment of traffic on to the improved routes.

The location and identification of the various links and nodes which define the Do-Minimum COBA network are shown in **Figure 5.5.3**.

5.5.4.2 *Trip Matrix Building*

The traffic flows and junction turning movements defined in the COBA model were derived directly from the observed May 2012 traffic surveys using matrix estimation procedures. These procedures involved creating an origin-destination trip matrix of traffic movements within the modelled area which, when assigned to the road network, matched the observed traffic counts.

The origin-destination trip matrix developed for the assessment of the Proposed Scheme defined traffic movements within the modelled area over the 12-hour weekday period between 07:00 hours and 19:00 hours in the 2012 base traffic year.

Based on the MCC information collected within the study area, the 2012 12-hour weekday vehicle proportions defined in the COBA Do-Minimum model are as follows:

- 80.8% Cars;
- 10.9% Light Goods Vehicles (LGV);
- 3.6% Other Goods Vehicles 1 (OGV1); and
- 3.5% Other Goods Vehicles 2 (OGV2); and
- 1.2% Buses and Coaches (PSV).

5.5.4.3 *Trip Assignment*

A trip assignment model was created to assign the derived trip matrix on to the base network.

The computer model assigned trips on to the network based on the origin and destination of the trip and the availability and cost of competing routes between these points within the modelled network.

A comparison between the observed May 2012 12-hour traffic counts and the assigned 2012 12-hour modelled traffic flows is shown in **Figures 5.5.4(a)** and **5.5.4(b).** This information demonstrates that the assigned traffic flows correlate closely to and within 5% of the observed flows, and consequently that the model provides a reasonable representation of existing conditions.

5.5.4.4 *Traffic Annualisation Factors*

Traffic annualisation factors are used within the COBA model to derive total annual information from the observed daily traffic flow data.

In COBA, the 'E-Factor' is used to convert the 12-hour average weekday traffic flow to a corresponding 16-hour average weekday traffic flow and the 'M-Factor' is used to convert this 16-hour flow to a 24-hour total annual flow to provide a suitable basis for the 60-year economic appraisal of the Proposed Scheme.

Automatic Traffic Count (ATC) information is used in the calculation of the M-Factor. The temporary ATC information at Sites 5 and 6, which are located within the study area on Great George's Street and York Street respectively, has been used in the calculation of both the E-Factor and M-Factor.

To demonstrate that the information collected at temporary ATC Sites 5 and 6 is representative of local conditions, a comparison between the permanent ATC information on the Westlink at the Clifton Street on and off slips and the temporary ATC information at Site 5 was undertaken due to their relatively close proximity. This comparison found that the temporary ATC flows were within 3% of the permanent ATC flow information and therefore provides a reasonable representation of local conditions. As such, this information was used to calculate the local E-Factor and M-Factor.

5.5.4.4.1 *E-Factor*

The typical 5-day 12-hour and 16-hour flows from the temporary ATCs at Sites 5 and 6 installed during the May 2012 surveys provide a reasonable indication of traffic flows on the road network and the information is considered sufficient to derive a local 'E' factor.

A local E-Factor has been derived from the following available information:

- 12-Hour 2012 AAWDT Flow: 27,800 vehicles
- 16-Hour 2012 AAWDT Flow: 32,453 vehicles

This information is considered sufficient to derive a local E-Factor, which at 1.17 is similar to the default value of 1.15 for a Built-up Principal Network.

The E-Factor adopted for the COBA model is 1.17.

5.5.4.4.2 *M-Factor*

A local M-Factor has been derived to factor the estimated 16-hour flows to represent the total annual flow from the following available information:

- 16-Hour 2012 AAWDT Flow: 33,797 vehicles
- 24-Hour 2012 AADT Flow: 32,050 vehicles

This information is considered sufficient to derive a local M-Factor, which at 346 is similar to the default value of 349 for a Built-Up Principal Network in the month of May.

The M-Factor adopted for the COBA model is 346.

5.5.4.5 *Model Calibration and Validation*

The Do-Minimum COBA model was calibrated by varying the characteristics of the links and junctions to obtain a reasonable representation of observed conditions.

In the case of the Proposed Scheme, changes in travel times between the Do-Minimum and the Do-Something networks are likely to represent the most significant change in road user economic benefits. It is therefore important to demonstrate that the Do-Minimum model provides a reasonable basis to assess transport conditions within the study area.

To demonstrate that the model provides a reasonable representation of existing transport conditions in the area, the observed journey times and modelled times on the network derived from the COBA model were compared. The results of this comparison for the Red and Blue routes are shown in **Tables 5.5.1 and 5.5.2** respectively.

Table 5.5.1: Model Calibration and Validation: Comparison of Observed and Modelled Link Time – Red Route

Red Route	Average Total Time (secs)	Average Speed (kph)
Observed	1,304	27.2
Modelled	1,245	28.5
Difference	-59	1.3
% Difference	-4.5%	4.8%

Table 5.5.2: Model Calibration and Validation: Comparison of Observed and Modelled Link Time – Blue Route

Red Route	Average Total Time (secs)	Average Speed (kph)
Observed	840	25.8
Modelled	865	25.0
Difference	25	-0.8
% Difference	2.9%	-2.8%

The correlation between the observed times on both the Red and Blue Routes and the modelled times derived from the calibrated model confirms that the model provides a reasonable representation of actual operating conditions on the network.

5.5.5 *COBA Do-Something Model*

The general layout of the Proposed Scheme, including aerial views captured from the 3-dimensional model of the area, and the corresponding network diagram indicating the locations of the various links and nodes which define the highway network for the COBA Do-Something model, are shown in **Figures 5.5.5 to 5.5.7**.

The COBA Do-Something network consists of one discrete model for the Proposed Scheme.

Using the trip assignment model developed for the Do-Minimum scenario, the derived 2012 trip matrix was assigned to the Do-Something network to assist in defining changes in traffic flows and trip patterns resulting from the provision of the Proposed Scheme.

5.5.6 *The QUADRO Model*

An assessment of the economic effects of the road user delays associated with the construction of the Proposed Scheme has been undertaken using Release 12 of the computer program QUADRO 4 (Queues and Delays at Roadworks) model.

Given the location of the Proposed Scheme and the volume of traffic passing through the area on a daily basis, the QUADRO model has been used to estimate the effects of road user delays during the construction period.

For the purpose of the QUADRO assessment, it has been assumed that the construction period for the Proposed Scheme would be as shown in **Table 5.5.3**.

Table 5.5.3: QUADRO Do-Something Proposed Scheme Construction Period

Option	Construction Start Date	Construction End Date
Proposed Scheme	1 May 2018	18 February 2021

5.5.6.1 *Description of Traffic Management*

Traffic management would be in place for 24 hours per day, 7 days a week for the estimated 3 years construction programme. The traffic management would be implemented in 13 separate phases over a period of 149 weeks with each phase incorporating a series of traffic management measures. These measures would change as the construction of the Proposed Scheme proceeds.

To estimate the effects of delays during construction resulting from reduced capacity as a result of lane closures, the available link capacities have been calculated for each individual traffic management scenario. These capacities have been derived from DMRB guidance for the urban, suburban and motorway link types defined in the QUADRO models.

Blanket speed limits of between 30mph and 50mph have been applied across during the construction programme as shown in **Figures 5.5.8 and 5.5.9**.

Details of the proposed phasings are included in **Appendix I**.

5.5.6.2 *Diversion Route*

Within urban road networks in general and the York Street area in particular multiple diversion routes are available within the local road network for road users affected by the temporary traffic management arrangements. A maximum queue delay has therefore been defined in the QUADRO models to reflect the time that road users are willing to be delayed due to the roadworks before selecting an alternative route.

For the purpose of the assessment of the Proposed Scheme, a maximum queue delay of 5 minutes has been defined in the QUADRO assessment to reflect the likely level of additional delays that road users are likely to experience. This is considered to be a reasonable estimate of average additional journey time based on the number of route options in the area, the advanced notification of the major road works programme which will extend for a period of 3 years and an assessment of peak and off-peak journey times in the area.

5.5.6.3 *Modelled Traffic Conditions*

The QUADRO models are based on the 12-hour traffic flows defined in the COBA assessment using information observed from the May 2012 traffic surveys.

The data collected from the temporary automatic traffic counters installed around York Street as part of the May 2012 data collection survey programme as analysed to define local hourly flow traffic profiles to reflect prevailing conditions.

It should be noted that Transport NI intends to promote a number of traffic reduction initiatives during the construction of the Proposed Scheme. Several measures were implemented during the construction phase of the Westlink upgrade to reduce the volumes of traffic entering the area including signed alternative routes for drivers with destinations outwith the city centre, restricting as far as possible other roadworks on roads in the area throughout the duration of the works and the provisional of additional Variable Message Signs located at the outer approaches to Belfast to allow users to choose alternative routes. It is assumed that similar measures will be implemented during the construction of the Proposed Scheme. Therefore, a 10% reduction in traffic entering the area during the construction of the Proposed Scheme has been assumed and the observed 12-hour flows in the models have been reduced accordingly.

The 24-hour vehicle composition adopted in the QUADRO assessment is consistent with the COBA models. This information is summarised below in **Table 5.5.4**.

Table 5.5.4: QUADRO 24-Hour Vehicle Composition

Year	Cars (%)	LGV (%)	OGV1 (%)	OGV2 (%)	PSV (%)
2012	85.1	8.8	2.8	2.4	1.2

The following traffic adjustment factors are included in the QUADRO models to maintain consistency with the COBA models:

- Local E-Factor: 1.17; and
- Local M-Factor: 346.

The National Road Traffic Forecasts (NRTF) of growth has been adopted to provide a reasonable estimate of long-term future traffic flows within the area over the 60 year economic assessment period. The main QUADRO assessment is based on using NRTF central growth which is consistent with the COBA assessment.

In addition, it should be noted that in the later phases of the three year construction programme, where the network has almost evolved into the Proposed Scheme, the design traffic has been applied to some jobs where the traffic differs significantly from the base traffic and the effects of some traffic management jobs have been excluded from the assessment where temporary traffic management arrangements have been removed.

5.5.7 *Future Conditions*

For the purpose of the economic assessment, it has been assumed that construction of the scheme would be undertaken in 2018, 2019 and 2020, with the scheme opening in 2021. This timeframe has been adopted to provide a reasonable basis for the economic assessment of the Proposed Scheme.

Although significant changes in land use within the Belfast area could occur which would affect traffic conditions within the study area, there is always inherent uncertainty in predicting precisely the nature, scale and implementation programmes for significant developments over such a wide area, particularly given current economic conditions. It should also be noted that in accordance with standard procedures, it is necessary to establish changes in traffic demand over the full economic life of the scheme, which in the case of the Proposed Scheme extends to 60 years from the year of opening.

It is therefore considered that the most likely forecast of long term traffic growth within the study area for the assessment of the Proposed Scheme can best be defined by the application of national forecasts of traffic growth. The National Road Traffic Forecasts (NRTF) (1997) of growth have therefore been adopted to provide a reasonable estimate of long-term future traffic flows within the area over the 60 year economic assessment period.

The traffic growth factors defined in COBA under the NRTF central growth traffic forecasts have been adopted for the purpose of the economic assessment of the Proposed Scheme. The growth factors from the 2012 base year to the 2021 opening year and the 2035 design year are shown in **Table 5.5.5**.

Table 5.5.5: NRTF Growth Factors – Central Growth

Period (Years)	Central Growth
2012 to 2021 Opening Year	1.121
2012 to 2035 Design Year	1.218

In the case of York Street, it should be noted that traffic within the area can be constrained by the capacity of the surrounding road network. It is therefore possible that traffic growth could be constrained to less than the National Road Traffic Forecasts. Given the degree of uncertainty in predicting future traffic flows, the Proposed Scheme has also been tested considering NRTF low and high growth projections from the year 2012 onwards.

In addition to the above low and high traffic forecast sensitivity tests, a further test has been undertaken to consider the potential effects of releasing any suppressed demand when the scheme opens. Therefore, to test the effects of the potential for the release of some suppressed demand on the strategic links in the network when the scheme opens, a ‘High Demand’ scenario sensitivity test has been undertaken based on a high growth scenario with an applied 5% increase in traffic travelling on the strategic routes between Westlink, the M2 motorway and the M3 motorway.

5.6 Operational Assessment of Proposed Scheme

This section of the report provides a general description of the Proposed Scheme in terms of traffic operation and presents an operational assessment of the Proposed Scheme considering traffic flows, journey times and network capacity.

5.6.1 *Description of Proposed Scheme*

5.6.1.1 *Strategic Movements – Westlink / M2 Motorway / M3 Motorway*

The Proposed Scheme would provide an uninterrupted link from Westlink to the M2 motorway (Link No. 1), and from the M2 motorway to Westlink (Link No. 2). This option would also provide an uninterrupted link from Westlink to the M3 motorway (Link No. 3), and from the M3 motorway to Westlink (Link No. 4). The existing link between the M2 and M3 motorways via the Lagan Bridge would be retained.

5.6.1.2 *Local Movements – York Street*

York Street would be realigned to provide a two-way running arrangement, with a single southbound bus lane in operation between the York Street / M2 motorway junction and Great Patrick Street.

On the southern section of York Street, between the junction with Great Patrick Street and the junction with Westlink / Great George's Street, 3 northbound lanes would be provided to accommodate traffic travelling north on York Street and to the M2 motorway, which would flare to provide two 2-lane approaches at the signalised junction.

From the junction with Westlink / Great George's Street, two continuous northbound lanes would be provided to cater for traffic travelling north on York Street towards Dock Street. In addition, two continuous lanes would also be provided for traffic travelling north between the junction with Westlink / Great George's Street and the M2 motorway.

A signalised junction would be provided at the York Street / Westlink / M2 motorway junction.

The existing York Street to York Link / M3 motorway movement would not be directly accommodated within the Proposed Scheme, with traffic diverted via Dock Street and the proposed slip road to the M3 motorway (Link No. 6).

5.6.1.3 *Local Movements – Nelson Street / Corporation Street*

Nelson Street between Dock Street and Great George's Street would be closed to traffic to accommodate the new links to and from the M3 motorway and an access road to the lands between Nelson Street and Corporation Street, where the proposed pumping station would be located.

As a consequence of this closure, traffic on Nelson Street would be displaced on to the surrounding road network.

5.6.1.4 *Local Movements – Duncrue Street*

The Proposed Scheme would provide a new link between Duncrue Street and the Westlink (Link No. 31).

5.6.1.5 *Junction Arrangements*

The existing traffic signals at the York Street / Great George's Street junction would be retained to manage traffic demand at this junction. The Great George's Street to Westlink movement would no longer pass through the traffic signals.

The existing traffic signals at the York Street / York Link junction would be retained, however traffic progressing to the M2 motorway would no longer pass through these signals. Instead, traffic progressing along York Street to the M2 motorway would pass through a new set of signals which would be provided to manage demand between the York Street to M2 motorway movement and the new southbound bus lane on York Street.

The junction arrangement at York Street / Dock Street would remain unchanged.

The existing traffic signals at the Dock Street / Nelson Street junction would be altered to accommodate a new two-way link on Nelson Street between this junction and a new junction arrangement which would provide access to the lands between Nelson Street and Corporation Street. From this access junction, a new one-way link would be in place to accommodate traffic travelling to the M3 motorway, in place of Nelson Street. A slip from Dock Street to the new two-way link on Nelson Street would also be provided to accommodate traffic turning left from Dock Street to access the lands between Nelson Street and Corporation Street, or progressing to the M3 motorway.

With Nelson Street closed to traffic, the existing traffic signals at York Link and Great George's Street would be removed.

The existing traffic signals at the Nelson Street / Great Patrick Street junction would be retained, with the addition of a right turning lane on Dunbar Link to accommodate traffic turning right on to Nelson Street, which would become two-way between Great George's Street and Great Patrick Street.

The existing traffic signals at the M2 motorway off-slip at Duncrue Street would be altered to accommodate a new one-way link to the Westlink. The left-turn from the M2 motorway off-slip on to Duncrue Street would be reduced from two lanes to a single lane to facilitate traffic turning left onto the single lane on Duncrue Street.

In addition, the Proposed Scheme would also introduce two new junctions. A signalised junction would be introduced on York Street to allow access to and from Galway House and a new priority junction would be introduced on Great George's Street to accommodate traffic turning left from Nelson Street onto Great George's Street.

All other existing junction arrangements within the study area would remain unchanged.

A detailed plan showing the Proposed Scheme is shown in **Figure 5.6.1**.

5.6.2 *Traffic Flows*

5.6.2.1 *Do-Minimum Network*

The Proposed Scheme has been developed to improve the movement of strategic traffic between Westlink, the M2 motorway and the M3 motorway. Through the development of the various computer models and an estimate of the likely changes in travel patterns resulting from the provision of the Proposed Scheme, taking into account the effects of displaced traffic for movements that are not accommodated by the new links, the likely changes in traffic volumes across the network can be estimated.

The 24-hour traffic flows for the Do-Minimum network, which are based on observed traffic flows, in the 2012 base traffic year are shown in **Figure 5.6.2**.

Examination of the 2012 traffic flows indicates that the following traffic volumes, in vehicles per day (vpd), would pass through the York Street gyratory junction:

- some 18,600 vpd would approach the junction on York Street;
- some 40,600 vpd would approach the junction on Westlink;

- some 19,800 vpd would approach the junction on the M2 motorway southbound off-slip;
- some 12,600 vpd would approach the junction on Nelson Street; and
- some 20,200 vpd would approach the junction on the M3 motorway westbound off-slip.

The estimated 24-hour traffic flows for the Do-Minimum network in the 2021 year of opening, under the NRTF central traffic growth scenario, are shown in **Figure 5.6.3**.

Examination of the traffic flows in 2021 under the NRTF central traffic growth scenario indicates the following traffic volumes, in vehicles per day (vpd), would pass through the York Street gyratory junction:

- some 20,800 vpd would approach the junction on York Street;
- some 45,500 vpd would approach the junction on Westlink;
- some 22,100 vpd would approach the junction on the M2 motorway southbound off-slip;
- some 14,200 vpd would approach the junction on Nelson Street; and
- some 22,600 vpd would approach the junction on the M3 motorway westbound off-slip.

5.6.2.2 *Do-Something Network*

The principal operational effect of the Proposed Scheme is to provide improved transport links for strategic traffic movements by providing a grade-separated interchange that avoids the existing signalised junctions on the surface streets with a consequential reduction in delays and congestion for strategic traffic travelling between the Westlink and the M2 and M3 motorways.

The estimated 24-hour traffic flows for the Do-Something network in the 2021 year of opening, under the NRTF central traffic growth scenario, are shown in **Figure 5.6.4**.

A comparison of the daily traffic flows estimated for each of the key approach roads to the junction in the 2021 year of opening under the central traffic growth scenario is shown in **Table 5.6.1**.

Table 5.6.1: Key Approach Road Traffic Flows – 2021 Year of Opening

Approach Road	Do-Minimum Network (vpd)	Do-Something Network (vpd)
York Street	20,800	18,100
Westlink	45,500	44,600
M2 Southbound Off-Slip	22,100	21,000
Nelson Street	14,200	7,700
M3 Westbound Off-Slip	22,600	22,600

Note 1: Where an equivalent link is not available, the nearest comparable link(s) have been used.
Note 2: Traffic flows on York Street under the Do-Something scenario exclude buses.
Note 3: Traffic flows on Nelson Street are not directly comparable across all options due to road closures.
Note 4: Nelson Street approach road link accommodates only Nelson Street to M3 motorway traffic under the Do-Something scenario

In comparing the traffic flows across the various options, the following key issues should be taken into account:

- the absence of a direct link between York Street and the M3 motorway in the Proposed Scheme would result in traffic reassignment over a wide area;
- the closure of Nelson Street to through traffic in the Proposed Scheme would result in traffic reassignment over a wide area; and
- the provision of the new Duncrue Street to Westlink link road would result in increased traffic flows in the Duncrue Street area.

5.6.3 *Journey Times*

5.6.3.1 *Introduction*

Savings in journey times are generally one of the most significant benefits resulting from the provision of a new transport improvement scheme. Although COBA reports link transit times along predefined routes in the modelled network, this information excludes junction delays, which in the case of the Proposed Scheme is an important consideration when comparing the overall changes in journey time.

COBA considers changes in traffic conditions during the day by modelling the 8,760 hours in a year divided into different portions called Flow Groups (FGs). Flow Groups 1-5 represent Weekday Hours, with FG4/5 representing the busiest 522 weekday hours of the year, FG3 representing the next busiest 522 weekday hours, FG2 representing the next busiest 2,088 weekday hours, and FG1 representing the remaining 3,132 weekday hours.

Flow Groups 6-10 represent Weekend Hours, with FG9/10 representing the busiest 208 weekend hours of the year, FG8 representing the next busiest 208 weekend hours, FG7 representing the next busiest 832 weekend hours, and FG6 representing the remaining 1,248 weekend hours.

To provide a direct comparison between journey times on the Do-Minimum and the Do-Something networks in the 2021 year of opening, the average vehicle speeds for each link in the network and the corresponding junction delays along the route were extracted from the COBA models for light vehicles based on Flow Group 2 and Flow Group 4 traffic flow conditions. Flow Group 2 and Flow Group 4 provide a reasonable representation of operating conditions during the inter-peak and peak period respectively.

5.6.3.2 *Journey Time Savings*

The comparison of journey times based on the directional routes between the strategic points, namely Westlink, the M2 motorway and the M3 motorway, for the Proposed Scheme are shown in **Tables 5.6.2(a) and 5.6.2(b) to 5.6.3(a) and 5.6.3(b)**. This includes details for COBA Flow Group 2 and Flow Group 4 and for the 2021 year of opening and 2035 design year.

Table 5.6.2(a): Reductions in Journey Times: Flow Group 2 – 2021 Year of Opening

Route	Do-Minimum Network total Journey Time (mins)	Do-Something Reduction in Journey Time	
		(mins)	(%)
Westlink – M2 Motorway	2.35	0.18	8%
M2 Motorway - Westlink	5.04	2.08	41%
Westlink – M3 Motorway	2.53	0.53	21%
M3 Motorway - Westlink	2.52	1.06	42%
M2 Motorway – M3 Motorway	2.62	0.10	4%
M3 Motorway – M2 Motorway	1.56	-0.05	-3%

Note: Westlink = Node 103 / 109, M2 motorway = Node 285 / 287, M3 motorway = Node 124 / 131

Table 5.6.2(b): Reductions in Journey Times: Flow Group 4 – 2021 Year of Opening

Route	Do-Minimum Network total Journey Time (mins)	Do-Something Reduction in Journey Time	
		(mins)	(%)
Westlink – M2 Motorway	3.19	0.61	19%
M2 Motorway - Westlink	8.04	4.47	56%
Westlink – M3 Motorway	3.51	1.84	53%
M3 Motorway - Westlink	4.44	2.50	56%
M2 Motorway – M3 Motorway	2.85	0.00	0%
M3 Motorway – M2 Motorway	1.81	-0.08	-5%

Note: Westlink = Node 103 / 109, M2 motorway = Node 285 / 287, M3 motorway = Node 124 / 131

Table 5.6.3(a): Reductions in Journey Times: Flow Group 2 – 2035 Design Year

Route	Do-Minimum Network total Journey Time (mins)	Do-Something Reduction in Journey Time	
		(mins)	(%)
Westlink – M2 Motorway	2.42	0.18	7%
M2 Motorway - Westlink	5.30	2.26	43%
Westlink – M3 Motorway	2.63	0.54	21%
M3 Motorway - Westlink	2.67	1.11	42%
M2 Motorway – M3 Motorway	2.65	0.09	3%

Route	Do-Minimum Network total Journey Time (mins)	Do-Something Reduction in Journey Time	
		(mins)	(%)
M3 Motorway – M2 Motorway	1.59	-0.06	-4%

Note: Westlink = Node 103 / 109, M2 motorway = Node 285 / 287, M3 motorway = Node 124 / 131

Table 5.6.3(b): Reductions in Journey Times: Flow Group 4 – 2035 Design Year

Route	Do-Minimum Network total Journey Time (mins)	Do-Something Reduction in Journey Time	
		(mins)	(%)
Westlink – M2 Motorway	3.64	0.91	25%
M2 Motorway - Westlink	10.98	7.36	67%
Westlink – M3 Motorway	5.32	3.02	57%
M3 Motorway - Westlink	6.37	4.41	69%
M2 Motorway – M3 Motorway	2.85	0.00	0%
M3 Motorway – M2 Motorway	1.96	-0.10	-5%

Note: Westlink = Node 103 / 109, M2 motorway = Node 285 / 287, M3 motorway = Node 124 / 131

It should be noted that the information presented in the above Tables assumes that traffic within the general area would increase from the base traffic year to the 2021 year of opening and 2035 design year in line with NRTF central growth forecasts in both the Do-Minimum and Do- Something networks which may not be achievable given the local constraints.

Examination of the above journey time information indicates that journey times from Westlink to the M2 motorway would reduce by 8% in 2021 under Flow Group 2, decreasing slightly to 7% in 2035. Under Flow Group 4 conditions, journey times from the Westlink to the M2 motorway would reduce by 19% in 2021, increasing to 25% in 2035.

In the reverse direction, journey times from the M2 motorway to Westlink would reduce by 41% in 2021 under Flow Group 2, increasing slightly to 43% in 2035. Under flow Group 4 conditions, journey times from the M2 motorway to Westlink would reduce by 56% in 2021, increasing to 67% in 2035.

Journey times from the Westlink to the M3 motorway would reduce by 21% in both 2021 and 2035 under Flow Group 2. Under Flow Group 4 conditions, journey times from the Westlink to the M3 motorway would reduce by 53% in 2021, increasing to 57% in 2035.

In the reverse direction, journey times from the M3 motorway to Westlink would reduce by 42% in both 2021 and 2035 under Flow Group 2. Under Flow Group 4 conditions, journey times from the M3 motorway to Westlink would reduce by 56% in 2021, increasing to 69% in 2035.

Although the proposed improvements do not include specific improvements to the M2 and M3 motorways, the location of merge/diverge points can result in changes in operating conditions along the motorway. Journey times from the M2 motorway to the M3 motorway would reduce by 4% in 2021, reducing slightly to 3% in 2035 under Flow Group 2. Under Flow Group 4 conditions, journey times from the M2 motorway to the M3 motorway would remain the same in both 2021 and 2035.

In the reverse direction journey times from the M3 motorway to M2 motorway would increase by 3% in 2021, increasing slightly to 4% in 2035 under Flow Group 2. Under Flow Group 4 conditions, journey times from the M3 motorway to M2 motorway would increase by 5% in both 2021 and 2035.

5.6.4 *Network Capacity*

5.6.4.1 *Do-Minimum Network*

As part of the overall operational assessment of a proposed road improvement scheme, the COBA model identifies links and junctions where traffic demand exceeds operating capacity. Where demand exceeds capacity, delays and the corresponding costs increase significantly. In urban networks where a number of alternative routes are available, this can lead to an overestimate in transport costs as traffic would be more likely to reassign on to other routes rather than incur high costs on the original route. Nevertheless, the number of over-capacity links and junctions provides a measure of operating conditions on the network.

Based on the information obtained from the COBA models, the links and junctions that are reported as being over-capacity have been identified to provide an indication of the traffic conditions on the various networks. The assessment considers the effects of normal variations in traffic demand that occur during the day, as defined by the various Flow Groups, and the effects of growth in traffic from the 2012 base year to the 2021 year of opening and the 2035 design year.

The number of over-capacity links and junctions in the Do-Minimum network under NRTF central traffic growth is summarised in **Table 5.6.4**.

Table 5.6.4: Number of Over-Capacity Links and Junctions: Do-Minimim Network

Year	Flow Group	Do-Minimum Network	
		Link	Junction
2012	Flow Group 1/2	0	0
	Flow Group 3/4	7	3
	Flow Group 8/9	1	1
2021	Flow Group 1/2	0	0
	Flow Group 3/4	13	6
	Flow Group 8/9	5	2
2035	Flow Group 1/2	1	0
	Flow Group 3/4	18	7
	Flow Group 8/9	7	3

Examination of the above results indicates that traffic demand in 2012 Flow Group 3/4 would exceed capacity on 7 links and 3 junctions. By the 2021 year of opening, these numbers would increase to 13 links and 6 junctions and to 18 links and 7 junctions in 2035.

The locations of the links and junctions that are over-capacity under the central traffic growth forecasts are shown in **Figure 5.6.5**.

Examination of the over-capacity links and junctions under the 2012, 2021 and 2035 demand scenarios for the Do-Minimum network indicates that traffic flows on sections of the Westlink northbound carriageway, sections of the Westlink southbound carriageway, and the M2 motorway southbound off-slip at Nelson Street would all exceed capacity in 2012.

Demand in 2012 at the York Street / Great George's Street junction, the Nelson Street / York link junction and the York Street / M2 motorway northbound on-slip priority junction would also exceed capacity.

By the 2021 year of opening, traffic flows on sections of the Westlink southbound carriageway, sections of North Queen Street and on Great George's Street, between the York Street / Great George's Street junction and the Nelson Street / Great George's Street junction, would all exceed capacity.

Demand in 2021 at the Westlink / York Street junction and the York Street / Frederick Street priority junction would also exceed capacity.

By the year 2035, traffic flows on sections of North Queen Street and the section of the M2 motorway southbound carriageway between the southbound off-slip at Nelson Street and the southbound on-slip at Nelson Street would all exceed capacity.

Demand in 2035 at the Nelson Street / Great George's Street junction would also exceed capacity.

5.6.4.2 *Do-Something Network*

The number of over-capacity links and junctions in the Do-Something network under NRTF central traffic growth is summarised in **Table 5.6.5**.

Although the Proposed Scheme would not be completed until 2021, details of over-capacity links and junctions have been extracted from the 2012 model to assist in comparing the performance of the Do-Minimum and Do-Something scenarios in the base year.

Table 5.6.5: Number of Over-Capacity Links and Junctions: Do-Something Network

Year	Flow Group	Do-Minimum Network	
		Link	Junction
2012	Flow Group 1/2	0	0
	Flow Group 3/4	9	1
	Flow Group 8/9	0	0
2021	Flow Group 1/2	0	0
	Flow Group 3/4	12	3
	Flow Group 8/9	6	1
2035	Flow Group 1/2	0	0
	Flow Group 3/4	18	4
	Flow Group 8/9	9	1

Examination of the above results indicates that traffic demand in 2012 Flow Group 3/4 would exceed capacity on 9 links and 1 junction. By the 2021 year of opening, these numbers would increase to 12 links and 3 junctions and to 18 links and 4 junctions in 2035.

The locations of the links and junctions that are over capacity under the central traffic growth forecasts are shown in Figure 6.6.

Examination of the over-capacity links and junctions under the 2012, 2021 and 2035 demand scenarios for the Do-Something network indicates that traffic flows on sections of the Westlink northbound carriageway, sections of the Westlink southbound carriageway and sections of North Queen Street would all exceed capacity in 2012.

Demand in 2012 at the Clifton Street / Frederick Street junction would also exceed capacity.

By the 2021 year of opening, traffic flows on sections of the Westlink southbound carriageway and the new single-lane Westlink to M3 motorway link (Link No. 3) would all exceed capacity.

Demand in 2021 at the Clifton Street / Westlink northbound off-slip priority junction and the Clifton Street / Westlink southbound off-slip priority junction would also exceed capacity.

By the year 2035, traffic flows on the new single-lane M3 motorway to Westlink link (Link No. 4), the two-lane section of York Street between the Westlink / York Street junction and the York Street / Cityside Retail Park junction, the section of the M2 motorway southbound carriageway between the new M2 motorway to Westlink link (Link No. 2) and the southbound on-slip at Nelson Street and the short single-lane section at the new access road to the lands adjacent to the Dock Street to M3 motorway on-slip would all exceed capacity.

Demand in 2035 at the M2 motorway southbound off-slip / Duncrue Street junction would also exceed capacity.

5.7 Road Safety

5.7.1 *Road Safety*

Given the inherent uncertainties in predicting future accident rates and casualty severities over the 60-year economic assessment period, the COBA assessment has been based on the application of default accident rates and costs. These have been applied to both the Do-Minimum and Do-Something networks to provide a reasonable measure of the relative change in road traffic accident characteristics associated with the two networks.

The changes in the number of personal injury accidents and the corresponding casualty severities over the 60-year assessment period under NRTF central traffic growth due to the provision of the Proposed Scheme at the York Street Interchange are shown in Tables 7.1(a) and 7.1(b). The associated Present Values of Benefit are also shown in this Table.

It should be noted that due to the characteristics of some of the new links relative to the existing urban links, the COBA model indicates that the various improvement options would lead to road safety disbenefits. For example, whereas the northbound approach to York Street on the existing Westlink currently has a 50 mph speed limit with a default accident rate of 0.174 Personal Injury Accidents / Million Vehicle Kilometres (PIAs / mvkm), the Do-Something option reduces the speed limit on this section of the road network to 40 mph with a default accident rate of 1.004 PIAs / mvkm which results in a corresponding increase in accident numbers and associated disbenefits. This characteristic of the model should be taken into account when considering the road safety effects of the Proposed Scheme.

5.7.1.1 *Do-Something Network*

The changes in the number of personal injury accidents and the corresponding casualty severities over the 60-year assessment period due to the provision of the Proposed Scheme are shown in **Tables 5.7.1(a)** and **5.7.1(b)**.

Table 5.7.1(a): Accident Numbers and Costs

Network	Number of Accidents			Accidents Total Cost (£m's)
	2021 Opening Year	2035 Design Year	60-Year Total	
Do-Minimum	49.5	51.3	3,068.4	174.343
Do-Something	64.7	67.3	4,023.4	223.720
Benefits	-15.2	-16.0	-955.0	-49.377

Table 5.7.1(b): Casulties by Severity

Network	Accident Severity			Total Accidents
	Fatal	Serious	Slight	
Do-Minimum	32.4	321.8	4,167.1	3,068.4
Do-Something	36.7	390.6	5,502.3	4,023.4
Benefits	-4.3	-68.7	-1,335.2	-955.0

From the above information, the Proposed Scheme would lead to an additional 955 personal injury accidents over the 60-year period, which equates to an economic disbenefit of -£49.4m.

The results of the COBA analysis, based on the application of default accident rates, indicate that the provision of the Proposed Scheme would lead to an increase in road safety costs over the 60-year economic life of the scheme.

5.8 Economic Assessment of Scheme

5.8.1 *COBA Appraisal*

The economic results from the COBA model for the Proposed Scheme, based on the scheme costs defined previously including optimism bias and the application of the National Road Traffic Forecasts (NRTF) central traffic growth projection, are summarised in **Table 5.8.1**.

Table 5.8.1: COBA Proposed Scheme Appraisal Summary

Item	Do-Something Network Proposed Scheme
Present Value of Benefits (PVB) (£m's)	£212.981
Present Value of Costs (PVC) (£m's)	£74.942
Net Present Value (NPV) (£m's)	£138.039
Benefit to Cost Ratio (BCR)	2.842

Note: Assessment is based on NRTF central growth with results expressed in 2010 prices.

In accordance with current government guidelines on the reporting of transport economic efficiency, the results of the economic appraisal are presented in the market prices unit of account that was introduced in COBA11.

A more detailed presentation of the COBA results is shown in **Table 5.8.2** and indicates the transport economic efficiency, public accounts and monetised costs and benefits as defined in COBA11 Tables 15A to 15C.

Table 5.8.2: COBA Proposed Scheme Appraisal

Item	Do-Something Network Proposed Scheme (£m's)
Consumers (User Benefits)	
Travel Time	£153.867
Approx. Link Transit Time	£23.112
Approx. Junction Delay	£130.755
Vehicle Operating Costs	-£1.138
Travel Time and VOC during Construction (QUADRO)	£0.000
Travel Time and VOC during Maintenance (QUADRO)	£0.000
Net Non-Business User Benefits	**£152.729**
Business User (User Benefits)	
Travel Time	£110.113
Approx. Link Transit Time	£16.540
Approx. Junction Delay	£93.573
Vehicle Operating Costs	-£0.494
Travel Time and VOC during Construction (QUADRO)	£0.000
Travel Time and VOC during Maintenance (QUADRO)	£0.000
Subtotal	£109.620
Private Sector Provider Impacts (Operating Costs)	-£0.050
Net Business Impact	**£109.570**
Total Present Value of TEE Benefits	**£262.299**
Public Accounts	
Government Funding	
Operating Costs	£0.195

Item	Do-Something Network Proposed Scheme (£m's)
Investment Costs	£74.747
Present Value of Costs	**£74.942**
Analysis of Monetised Costs and Benefits	
TEE Benefits	
Consumer User Benefits	£152.729
Business Benefits	£109.620
Private Sector Provider Impacts	-£0.050
Accident Benefits	-£49.377
Indirect Tax Revenues	£0.085
Emissions Benefits	-£0.026
Present Value of Benefits (PVB)	**£212.981**
Present Value of Costs (PVC)	**£74.942**
Overall Impact	
Net Present Value (NPV)	**£138.039**
Benefit to Cost Ratio (BCR)	**2.842**

Source: COBA11 Release 15 Tables 15A – 15C.
Note: Costs in 2010 prices in £m's discounted to 2010 at 3.5% for the first 30 years, 3% thereafter for 46 years and thereafter 2.5%.

Examination of the above information indicates that the principal benefits of the Proposed Scheme result from savings in transit time, which equates to £263.980m. However, due to the characteristics of the new links relative to the existing urban links, this option would also lead to road safety disbenefits of -£49.377m.

5.8.2 *QUADRO Appraisal*

The economic results from the QUADRO model for the Proposed Scheme, based on the application of the NRTF central traffic growth projection, are summarised in **Table 5.8.3**.

Table 5.8.3: QUADRO Proposed Scheme Appraisal Summary

Item	Do-Something Network Proposed Scheme (£m's)
Present Value of Benefits (PVB)	-£34.918
Present Value of Costs (PVC)	-£0.136
Net Present Value (NPV)	-£34.781

Note: Assessment is based on NRTF central growth with results expressed in 2010 prices.

In accordance with current government guidelines on the reporting of transport economic efficiency, the results of the economic appraisal are presented in the market prices unit of account that was introduced in QUADRO4.

The QUADRO models are based on local traffic flow profiles, a maximum queue delay of 5 minutes and 24-hour working on the existing network on Monday to Sunday between 00:00 hours and 24:00 hours. Overnight and weekend closures have been modelled although these are likely to be less significant in economic terms due to the reduced volumes of traffic. It has also been assumed that temporary speed limits of between 30 mph and 50 mph would be in place over the network throughout the duration of the works.

As noted in this report, a number of traffic management and other initiatives will be promoted during construction and therefore a 10% reduction in traffic volumes during the construction of the scheme is considered reasonable, based on past experience of similar projects in the Belfast area.

A more detailed presentation of the QUADRO appraisal of the Proposed Scheme is shown in **Table 5.8.4**.

The information is presented in a similar format to the COBA appraisals, allowing the results to be readily combined to determine the overall economic benefits of the Proposed Scheme.

Table 5.8.4: QUADRO Proposed Scheme Appraisal

Item	Do-Something Network Proposed Scheme (£m's)
Do-Minimum Model	
Consumers – Net Consumer Impact	£0.000
Business Users – User Costs	£0.000
Private Sector Provider Impacts – Operating Costs	£0.000
Accidents Costs	£0.000
Carbon Emission Costs	£0.000

Item	Do-Something Network Proposed Scheme (£m's)
Government Funding	£0.000
Overall Impact	**£0.000**
During Construction	
Consumers – Net Consumer Impact	£18.811
Business Users – User Costs	£14.665
Private Sector Provider Impacts – Operating Costs	£0.160
Accidents Costs	£1.078
Carbon Emission Costs	£0.204
Government Funding	-£0.136
Overall Impact	**£34.781**
Proposed Scheme	
Consumers – Net Consumer Impact	£0.000
Business Users – User Costs	£0.000
Private Sector Provider Impacts – Operating Costs	£0.000
Accidents Costs	£0.000
Carbon Emission Costs	£0.000
Government Funding	£0.000
Overall Impact	**£0.000**
Overall Assessment (Net Present Value)	
Consumer User Benefits	-£18.811
Business User Benefits	-£14.665
Private Sector Provider Benefits	-£0.160
Accidents Benefits	-£1.078
Carbon Emission Benefits	-£0.204

Item	Do-Something Network Proposed Scheme (£m's)
Government Funding	£0.136
Overall Impact	**-£34.781**
Present Value of Benefits During Construction	-£34.918
Present Value of Benefits During Maintenance	£0.000
Present Value of Benefits (PVB)	**-£34.918**
Present Value of Costs (PVC)	**-£0.136**
Net Present Value (NPV)	**-£34.781**

Source: COBA11 Release 15 Tables 15A – 15C.
Note: Costs in 2010 prices in £m's discounted to 2010 at 3.5% for the first 30 years, 3% thereafter for 46 years and thereafter 2.5%.

As there is a tendency for project appraisers to be overly optimistic, optimism bias has been included in the QUADRO appraisal to increase the projected duration of the works by 10%.

The results of the QUADRO appraisal including 10% optimism bias are shown in **Table 5.8.5**.

Table 5.8.5: QUADRO Proposed Scheme Appraisal Summary, including 10% Optimism Bias

Item	Do-Something Network Proposed Scheme (£m's)
Present Value of Benefits (PVB)	-£38.410
Present Value of Costs (PVC)	-£0.150
Net Present Value (NPV)	-£38.259

Note: Assessment is based on NRTF central growth with results expressed in 2010 prices.

5.8.3 *COBA / QUADRO Appraisal*

The economic results based on the combined COBA and QUADRO appraisals including the effects of optimism bias, the application of the NRTF central traffic growth projection and default accident characteristics, are summarised in **Table 5.8.6**.

Table 5.8.6: COBA QUADRO Proposed Scheme Appraisal Summary

Item	Do-Something Network Proposed Scheme
Present Value of Benefits (PVB) (£m's)	£174.571
Present Value of Costs (PVC) (£m's)	£74.792
Net Present Value (NPV) (£m's)	£99.780
Benefit to Cost Ratio (BCR)	2.334

Note: Assessment is based on NRTF central growth with results expressed in 2010 prices.

In accordance with current government guidelines on the reporting of transport economic efficiency, the results of the economic appraisal are presented in the market prices unit of account that was introduced in COBA11 and QUADRO4.

The results from the combined COBA and QUADRO appraisal indicate that the Proposed Scheme would deliver a positive Net Present Value of £99.780m and Benefit to Cost Ratio of 2.334 and therefore represents good value for money.

5.9 Sensitivity Tests

A series of sensitivity tests has been undertaken to examine the extent to which the results from the COBA and QUADRO economic appraisals vary under various scenarios. The results of these sensitivity tests are shown below.

5.9.1 *Traffic Forecast Sensitivity Tests*

5.9.1.1 *COBA Appraisal Traffic Forecast Sensitivity Tests*

As there is an inherent degree of uncertainty in predicting long-term future traffic flows over the 60-year period of the economic assessment, the Proposed Scheme has been tested considering NRTF low, central and high growth projections from the year 2012 onwards.

The results of the COBA sensitivity tests based on low and high growth projections are shown in **Table 5.9.1**. The results of the main COBA run, which is based on NRTF central growth, are also included for comparison.

Table 5.9.1: COBA Proposed Scheme Appraisal Summary – Traffic Forecast Sensitivity Tests

Item	Do-Something Network Proposed Scheme		
	NRTF Growth Projection		
	Low Growth	Central Growth	High Growth
Present Value of Benefits (PVB) (£m's)	£148.319	£212.981	£308.896
Present Value of Costs (PVC) (£m's)	£74.942	£74.942	£74.942
Net Present Value (NPV) (£m's)	£73.377	£138.039	£233.954
Benefit to Cost Ratio (BCR)	1.979	2.842	4.122

Note: Assessment is based on NRTF low / central / high growth with results expressed in 2010 prices.

The results of the COBA traffic forecast sensitivity tests indicate that the Net Present Value of the Proposed Scheme improves as the level of future traffic growth increases and that the Proposed Scheme provides a good economic return under a range of future traffic growth forecasts.

In addition to the above low and high traffic forecast sensitivity tests, a further test has been undertaken to consider the potential effects of releasing any suppressed demand when the scheme opens.

Therefore, to test the effects of the potential for the release of some suppressed demand on the strategic links in the network when the scheme opens, a 'High Demand' scenario sensitivity test has been undertaken based on a high growth scenario with an applied 5% increase in traffic travelling on the strategic routes between Westlink, the M2 motorway and the M3 motorway.

The results of this sensitivity test are shown in **Table 5.9.2**. The results of the main COBA assessment, which is based on NRTF central growth, are also included for comparison.

Table 5.9.2: COBA Proposed Scheme Appraisal Summary – Potential Supressed Demand Traffic Sensitivity Test

Item	Do-Something Network Proposed Scheme	
	NRTF Growth Projection	
	Central Growth	High Demand
Present Value of Benefits (PVB) (£m's)	£212.981	£215.079
Present Value of Costs (PVC) (£m's)	£74.942	£74.942
Net Present Value (NPV) (£m's)	£138.039	£140.138
Benefit to Cost Ratio (BCR)	2.842	2.870

Note: Assessment is based on NRTF central / high growth with results expressed in 2010 prices.

The results of the above sensitivity test indicate that the Net Present Value of the Proposed Scheme is similar to that of the main COBA assessment, which is based on NRTF central growth projections.

5.9.1.2 *QUADRO Appraisal Traffic Forecast Sensitivity Tests*

The QUADRO models are based on local hourly traffic flow profiles, a maximum queue delay of 5 minutes and a 10% reduction in traffic during construction.

To test the sensitivity of the QUADRO assessment to changes in traffic growth, the Proposed Scheme has been tested considering NRTF low, central and high growth projections from the year 2012 onwards.

The results of these sensitivity tests are summarised in **Table 5.9.3**. The results of the main QUADRO assessment, which is based on NRTF central growth projections, a maximum queue delay of 5 minutes and a 10% reduction in traffic during construction, is also included for comparison.

Table 5.9.3: QUADRO Proposed Scheme Appraisal Summary – Traffic Forecast Sensitivity Tests

Item	Do-Something Network Proposed Scheme (£m's)		
	NRTF Growth Projection		
	Low Growth	Central Growth	High Growth
Present Value of Benefits (PVB)	-£28.518	-£34.918	-£39.919
Present Value of Costs (PVC)	-£0.107	-£0.136	-£0.160
Net Present Value (NPV)	-£28.412	-£34.781	-£39.759

Note: Assessment is based on NRTF low / central / high growth with results expressed in 2010 prices.

As there is a tendency for project appraisers to be overly optimistic, optimism bias has been included in the QUADRO appraisal to increase the projected duration of the works by 10%.

The results of the QUADRO appraisal including 10% optimism bias are shown in **Table 5.9.4**.

Table 5.9.4: QUADRO Proposed Scheme Appraisal Summary – Traffic Forecast Sensitivity Tests, including 10% Optimism Bias

Item	Do-Something Network Proposed Scheme (£m's)		
	NRTF Growth Projection		
	Low Growth	Central Growth	High Growth
Traffic Reductions During Construction	10%	10%	10%
Maximum Queue Delay	5 mins	5 mins	5 mins
Present Value of Benefits (PVB)	-£31.370	-£38.410	-£43.911
Present Value of Costs (PVC)	-£0.117	-£0.150	-£0.176
Net Present Value (NPV)	-£31.253	-£38.259	-£43.735

Note: Assessment is based on NRTF low / central / high growth with results expressed in 2010 prices.

The results of the QUADRO Traffic Forecast sensitivity test indicate that as traffic growth increases, the Net Present Value of the Proposed Scheme decreases.

5.9.1.3 *COBA / QUADRO Appraisal Traffic Forecast Sensitivity Tests*

The combined COBA and QUADRO results based on the above traffic forecast sensitivity tests, including the effects of optimism bias, the application of the NRTF traffic growth projections and default accident characteristics, are summarised in **Table 5.9.5**.

It should be noted that the 'High Demand' scenario is based on the NRTF high growth QUADRO assessment.

Table 5.9.5: COBA / QUADRO Proposed Scheme Appraisal Summary – Traffic Forecast Sensitivity Tests

Item	Do-Something Network Proposed Scheme			
	Growth Projection			
	Low Growth	Central Growth	High Growth	High Demand
Present Value of Benefits (PVB) (£m's)	£116.949	£174.571	£264.985	£171.168
Present Value of Costs (PVC) (£m's)	£74.825	£74.792	£74.766	£74.766
Net Present Value (NPV) (£m's)	£42.124	£99.780	£190.219	£96.403
Benefit to Cost Ratio (BCR)	1.563	2.334	3.544	2.289

Note: Assessment is based on NRTF low / central / high growth with results expressed in 2010 prices.

The results of the combined COBA / QUADRO Traffic Forecast sensitivity test indicate that as traffic growth increases, the Net Present Value of the Proposed Scheme increases.

The results from the combined COBA and QUADRO Traffic Forecast sensitivity test indicate that the Proposed Scheme would deliver a combined positive Net Present Value range of £42.124m to £190.219m, and a Benefit to Cost ratio range of 1.563 to 3.544.

5.9.2 *Maximum Queue Delay Sensitivity Tests*

5.9.2.1 *QUADRO Appraisal Maximum Queue Delay Sensitivity Tests*

The QUADRO models are based on local hourly traffic flow profiles, a maximum queue delay of 5 minutes and a 10% reduction in traffic during construction.

To test the sensitivity of the QUADRO assessment to changes in maximum queue delay, the Proposed Scheme has been tested considering a 10 minute maximum queue delay under NRTF low, central and high growth projections from the year 2012 onwards.

The results of these sensitivity tests are summarised in **Table 5.9.6**. The results of the main QUADRO assessment, which is based on NRTF central growth projections, a 5 minute maximum queue delay and a 10% reduction in traffic during construction, is also included for comparison.

Table 5.9.6: QUADRO Proposed Scheme Appraisal Summary – 10 Minute Maximum Queue Delay Sensitivity Tests

Item	Do-Something Network Proposed Scheme (£m's)		
	Growth Projection		
	Low Growth	Central Growth	High Growth
Traffic Reductions During Construction	10%	10%	10%
Maximum Queue Delay	10 mins	5 mins	10 mins
Present Value of Benefits (PVB)	-£36.490	-£34.918	-£46.127
Present Value of Costs (PVC)	-£0.133	-£0.136	-£0.176
Net Present Value (NPV)	-£36.357	-£34.781	-£45.951

Note: Assessment is based on NRTF low / central / high growth with results expressed in 2010 prices.

As there is a tendency for project appraisers to be overly optimistic, optimism bias has been included in the QUADRO appraisal to increase the projected duration of the works by 10%.

The results of the QUADRO appraisal including 10% optimism bias are shown in **Table 5.9.7**.

Table 5.9.7: QUADRO Proposed Scheme Appraisal Summary – 10 Minute Maximum Queue Delay Sensitivity Tests, including 10% Optimism Bias

Item	Do-Something Network Proposed Scheme (£m's)			
	Growth Projection			
	Low Growth	Central Growth		High Growth
Traffic Reductions During Construction	10%	10%	10%	10%
Maximum Queue Delay	10 mins	5 mins	10 mins	10 mins
Present Value of Benefits (PVB)	-£40.139	-£38.410	-£50.740	-£62.308
Present Value of Costs (PVC)	-£0.146	-£0.150	-£0.193	-£0.248
Net Present Value (NPV)	-£39.993	-£38.259	-£50.546	-£62.060

Note: Assessment is based on NRTF low / central / high growth with results expressed in 2010 prices.

The results of the QUADRO maximum queue delay sensitivity tests indicate that increasing the maximum queue delay results in a decrease in the Net Present Value.

5.9.2.2 *COBA / QUADRO Appraisal Maximum Queue Delay Sensitivity Tests*

The combined COBA and QUADRO results based on the above maximum queue delay sensitivity tests, including the effects of optimism bias, the application of the NRTF traffic growth projections and default accident characteristics, are summarised in **Table 5.9.7**. As before, the results of the main COBA and QUADRO assessment, which is based on NRTF central growth projections, a maximum queue delay of 5 minutes and a 10% reduction in traffic during construction, is also included for comparison.

It should be noted that the 'High Demand' scenario is based on the NRTF high growth QUADRO assessment.

Table 5.9.7: QUADRO Proposed Scheme Appraisal Summary – 10 Minute Maximum Queue Delay Sensitivity Tests, including 10% Optimism Bias

Item	Do-Something Network Proposed Scheme (£m's)				
	Growth Projection				
	Low Growth	Central Growth		High Growth	High Demand
Traffic Reductions During Construction	10%	10%	10%	10%	10%
Maximum Queue Delay	10 mins	5 mins	10 mins	10 mins	10 mins
Present Value of Benefits (PVB) (£m's)	£108.180	£174.571	£162.241	£246.588	£152.771
Present Value of Costs (PVC) (£m's)	£74.796	£74.792	£74.749	£74.694	£74.694
Net Present Value (NPV) (£m's)	£33.384	£99.780	£87.493	£171.894	£78.078
Benefit to Cost Ratio (BCR)	1.446	2.334	2.170	3.301	2.045

Note: Assessment is based on NRTF low / central / high growth with results expressed in 2010 prices.

The results of the combined COBA / QUADRO maximum queue delay sensitivity tests indicate that increasing the maximum queue delay from 5 minutes to 10 minutes results in a decrease in the Net Present Value.

The results from the combined COBA and QUADRO maximum queue delay sensitivity test indicate that the Proposed Scheme would deliver a positive Net Present Value range of £33.384m to £171.894m, and a Benefit to Cost ratio range of 1.446 to 3.301.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

URS was commissioned by Transport NI to undertake a Stage 3 Scheme Assessment to the requirements of the DMRB for the proposed York Street Interchange Strategic Road Improvement Scheme. The Proposed Scheme seeks to improve links on the Westlink, M2 and M3 that form part of the Regional Strategic Transport Network by introducing grade separation at the existing signalised York Street junction in Belfast.

6.2 Scheme Objectives

The objectives for the scheme were identified at the onset of the URS commission to be the Government's five main objectives for transport, i.e.:

- Environment - to protect the built and natural environment
- Safety - to improve safety
- Economy - to support sustainable economic activity and get good value for money
- Accessibility - to improve access to facilities for people with disabilities and those without a car and to reduce severance
- Integration - to ensure that all decisions are taken in the context of the Government's integrated transport policy.

In addition, the following scheme specific objectives have been identified:

- to remove a bottleneck on the strategic road network
- to deliver an affordable solution to reduce congestion on the strategic road network
- to improve reliability of strategic journey times for the travelling public
- to improve access to the regional gateways from the Eastern Seaboard Key Transport Corridor
- to maintain access to existing properties, community facilities and commercial interests
- to maintain access for pedestrians and cyclists
- to improve separation between strategic and local traffic.

6.3 Previous Scheme Assessments

The previous Stage 1 Scheme Assessment completed in March 2009 identified that the introduction of grade separation at the existing signalised junction would deliver positive benefit to cost ratios. In the published Preliminary Options Report, six identified Preliminary Options were reported to deliver positive benefit to cost ratios, across a range of projected traffic growth scenarios. It should be noted that the economic assessment did not take account of the economic impact of queues and delays during construction.

The Stage 1 Scheme Assessment concluded that the scheme had sufficient merit to be taken forward, with four of the six Preliminary Options recommended for further development and assessment. Transport NI accepted the recommendations made by URS, with the scheme attaining its Transport NI Gateway 0 approval in March 2009.

Further to the recommendations arising from the Stage 1 Scheme Assessment, four of the six Preliminary Options were shortlisted for a further Stage 2 Scheme Assessment in line with the recommendations of the Preliminary Options Report. The engineering designs of the options were developed in more detail through consultations with various statutory and non-statutory bodies, with a formal public consultation period held in June 2011 to allow members of the public to view and comment upon the proposals.

The developed four options proposed the introduction of grade separation at the existing junction using various alignments. Following their identification and refinement, the options were subject to separate Stage 2 engineering, environmental, traffic and economic assessments in accordance with the requirements of the DMRB. The findings from these assessments were reported in the Preferred Options Report of October 2012.

Taking into consideration its overall performance across the scheme objectives and the views raised in response to the public consultation, a Preferred Option was identified. It was recommended that the Preferred Option be further developed in line with the engineering standards set out in the DMRB to a level sufficient for a Stage 3 Scheme Assessment.

The recommendations of the report were endorsed by the Transport NI Board at its meeting of 26 October 2012. The Minister for Regional Development subsequently made the public announcement of the Preferred Option for the scheme on 6 December 2012.

Following the announcement of the Preferred Option, the layout of the scheme has been further refined ahead of a Stage 3 Scheme Assessment in accordance with the requirements of the DMRB and the recommendations of the Preliminary Options Report. The resultant layout presented for Stage 3 Scheme Assessment has been termed the Proposed Scheme.

6.4 Summary of Stage 3 Scheme Assessment

Section 1 of this Proposed Scheme Report reaffirms the scheme objectives as those developed at the onset of the assessment process. The findings from a review of the strategic context of the scheme, particularly in light of the recently published revised Regional Development Strategy (RDS), the revised Regional Transportation Strategy (RTS) and the New Approach to Regional Transportation are also reported. This review confirms that the proposed scheme clearly complements the Regional Strategies by improving connectivity within the region and removing a bottleneck on the Regional Strategic Transport Network and importantly, the North-Sea Mediterranean Trans-European Transport Network Corridor.

Section 2 presents a summary of the conditions at the existing junction, considering both engineering and traffic conditions. These baseline conditions are used to determine the subsequent impact of the Proposed Scheme and make informed comparisons.

Section 3 provides a detailed description of the scheme in its revised form and its proposed Estimate Range of **£125-165m**.

Section 4 presents the findings from the engineering assessment of the Proposed Scheme in accordance with the DMRB. Various engineering aspects of the layout are assessed, including:

- road geometry;
- earthworks;

- structures;
- geotechnics;
- drainage, hydrology and hydrogeology;
- public utilites;
- motorway communications;
- health and safety; and
- Departures from Standard.

The findings from each of these assessments collectively confirm that although the scheme is feasible, there are significant engineering challenges to be overcome due to the number and nature of existing constraints, primarily the poor ground conditions and the proximity of existing built infrastructure.

In overcoming these challenges, the scope of engineering works associated with the scheme has increased, with the associated additional costs reflected in the identified Estimate Range. Whilst the design of the layout has sought to meet the relevant road geometry Standards of the DMRB, it has not been possible to meet their associated requirements within the identified constraints. As a result, a significant number of unavoidable road geometry related Departures from Standard have been identified for the Proposed Scheme with associated mitigation measures proposed to mitigate their impact on the safety and efficiency of the junction.

Importantly, the engineering assessment considers the construction of the scheme within the confines of the existing heavily congested junction. Through consultations with the industry and an appointed buildability advisor, a potential construction sequence has been identified that demonstrates how the scheme can be built whilst maintaining connections for strategic traffic flows. This construction sequence is likely to present a starting point for the actual construction sequence developed by the appointed contractor. Whilst the construction sequence has been developed on the basis of identified requirements for lane availability, major traffic disruption during the construction phase is to be expected. Transport NI will identify potential measures to mitigate the disruption created by the works as part of future scheme development.

A key component of the Proposed Scheme at this time is the separation of stormwater discharge in lieu of connection to the existing storm sewer network at Corporation Street. It is proposed that stormwater from the underpass pumping station will discharge to the existing disused Gamble Street combined sewer overflow. This proposal has been developed through consultations with NI Water and is expected to alleviate demand on the existing sewerage system, providing benefit to NI Water. The proposal is being progressed on a cost-sharing basis with NI Water and discussions between the parties will continue until a formal agreement is reached.

In a similar manner, the development of the Proposed Scheme in consultation with Translink has identified the opportunity for foundation strengthening works to be carried out to the Dargan Bridge during construction of the scheme. The purpose of the strengthening works would be to “future-proof” the existing Dargan Bridge substructure for a longer-term scheme to dual it between Dock Street and Donegall Quay. Works to the superstructure are not envisaged to form part of the construction contract of the Proposed Scheme. The additional works involved in incorporating these strengthening works into the construction contract for the Proposed Scheme would be subject to confirmed funding contribution from Translink.

A traffic and economic assessment of the Proposed Scheme was carried using the Department for Transport Cost Benefit Analysis (COBA) computer model in accordance with the procedures set out in Volume 13 of the DMRB. The development of the models for the Proposed Scheme under various traffic growth scenarios was based on a programme of traffic surveys that encompassed not just the existing junction, but junctions and links in the surrounding area. These models were developed and validated to provide a reasonable represenatiation of observed conditions within the study area under existing traffic patterns. In line with COBA, the costs associated with queues and delays at roadworks during construction were also identified using the Department for Transport QUADRO computer model. A summary of the expected improvements in strategic journey times and an overall Benefit to Cost Ratio (BCR) is presented in **Section 5** of this report.

To summarise the performance of the Proposed Scheme against the Government's five objectives for transport, an Assessment Summary Table has been prepared and included in **Volume 3** of this report.

6.5 Conclusions

The economic results based on the combined COBA and QUADRO appraisals including the effects of optimism bias, the application of the NRTF central traffic growth projection and default accident characteristics, are summarised in **Table 6.5.1**.

Table 6.5.1: COBA QUADRO Proposed Scheme Appraisal Summary

Item	Do-Something Network Proposed Scheme
Present Value of Benefits (PVB) (£m's)	£174.571
Present Value of Costs (PVC) (£m's)	£74.792
Net Present Value (NPV) (£m's)	£99.780
Benefit to Cost Ratio (BCR)	2.334

Note: Assessment is based on NRTF central growth with results expressed in 2010 prices

In accordance with current government guidelines on the reporting of transport economic efficiency, the results of the economic appraisal are presented in the market prices unit of account that was introduced in COBA11 and QUADRO4.

The results from the combined COBA and QUADRO appraisal indicate that the Proposed Scheme would deliver a positive Net Present Value of £99.780m and Benefit to Cost Ratio of 2.334. The Proposed Scheme therefore represents good value for money, despite the significant challenges presented by the constraints at the existing junction.

6.6 Recommendations

On the basis of its positive economic potential, it is recommended that the Proposed Scheme is progressed through the various statutory procedures, including the publication of the Notice of Intention to Make a Designation Order (NIMDO), the Notice of Intention to Make a Vesting Order (NIMVO) and the publication of the Environmental Statement.

Following completion of the engineering assessments, the following engineering and operational issues should be given further consideration during the continued development of the Proposed Scheme ahead of the competition process:

- the completion of the approval process for identified Departures from Standard and incorporation of agreed mitigation measures;
- value engineering opportunities in relation to the use of alternative embedded retaining wall forms away from underpass “pinch-points”;
- works required at identified bases of the Dargan Bridge to provide sufficient strengthening for a future long-term scheme to widen the superstructure of the bridge;
- the proposed drainage outfall arrangement to Gamble Street CSO, subject to confirmed contributions from NI Water;
- progression of the NIRAUC process for the proposed diversion of existing utilities, through consultation with the various utility providers;
- additional monitoring and modelling of the potential impacts on groundwater regime and development of associated mitigation measures;
- options to minimise, or remove the requirement for, the diversion of existing 110kV NIE cables at Whitla Street subway;
- the development of temporary works to maintain motorway communications links for Transport NI during the construction phase;
- the development of a traffic management strategy for the construction phase to consider specific minor improvement works or broader initiatives to encourage modal change to minimise the disruption during construction;
- consultations with the associated DBFO Co maintenance agent further to the provisions of its DBFO Contract with the Department; and
- options to improve user appreciation through enhancements to design quality.