Forth Replacement Crossing

DMRB Stage 3 Scheme Assessment Report

Part 2: Engineering, Traffic and Economic Assessment

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APPENDIX A – THE SCHEME

Glossary

Agglomeration Benefits	The productivity benefits that some firms derive from being located close to other firms. This could be through sharing of knowledge, access to more suppliers, or access to larger labour markets
Alluvium	Sediment deposited by a river.
Assessment	An umbrella term for description, analysis and evaluation.
Attenuation	Increase in duration of flow hydrograph with a consequent reduction in peak flow.
Bedrock	Hard rock that lies beneath a superficial cover of soils and sediments.
Benefit to Cost Ratio	An indicator, used in the formal discipline of cost-benefit analysis that attempts to summarize the overall value for money of a project or proposal. A BCR is the ratio of the benefits of a project or proposal, expressed in monetary terms, relative to its costs, also expressed in monetary terms.
Bridge Management (ITS)	The operational management of the Main Crossing and the Forth Road Bridge in its role as a public transport crossing. Where the Forth Road Bridge is closed or operating with restrictions, bus traffic may be diverted to the hard shoulders of the Main Crossing to maintain the public transport corridor.
Combined Kerb Drainage System	A system providing a roadside kerb with integral linear drainage channel. Inlets positioned in the face of the kerb allow surface water to enter the channel, which connects to the main road drainage network, removing the need for gullies.
Corridor Management and Incident Control (ITS)	The ITS system will detect breakdowns in traffic flow and automatically trigger features such as variable message speed limits signs. Where necessary, the system will divert vehicles around an incident (i.e. where a lane is closed). This feature is backed up by CCTV which will stream information to the control room, allowing human intervention where necessary.
Culvert	A metal, wooden, plastic or concrete conduit through which surface water can flow under or across roads.
Cutting	Typically where part of a hill or mountain is cut out to make way for a road or railway line.
Diverge Slip Road	A link road departing the main carriageway to a subsidiary road or junction.
Do-Minimum	Refer to Section 1.6 for definition.
Do-Something	The situation with the proposed scheme in place.
Embankment	A raised bank which is formed to carry a road or railway line over a low-lying or wet area.
Environmental Impact Assessment	The process by which information about the environmental effects of a project are evaluated and mitigation measures are identified.
Environmental Statement	Document provided by the Developer to the Competent Authority, containing environmental information required under Article 5 of Directive 85/337/EEC as amended.
Fill	Material deposited to raise the level of the ground, construct embankments or earth mounds.
Free-Flow Interchange	A form of junction which allows traffic to move unhindered between individual roads without formal traffic control (i.e. traffic signals, stop lines).

Furness Method	The Furness method is used in transport modelling and forecasting to adjust the trip distribution (trips origins and destinations) in a transport model.
Full Corridor Scheme	The improvement considered over the full extent of North Corridor Option 1 and South Corridor Option 1 in the Stage 2 Corridor Report.
General Traffic	General modes of traffic including private light goods vehicles, vans, lorries and buses.
Geomorphology	The branch of geology concerned with the structure, origin and development of topographical features of the earth's crust.
Glacial Till	Glacial till is that part of glacial drift which was deposited directly by the glacier. It may vary from clays to mixtures of clay, sand, gravel and boulders.
Grade Separated Junction	A junction arrangement that is separated by level from the through carriageway.
Grade Separated Gyratory	A form of grade separated junction, which utilises a large roundabout to facilitate traffic movements through the junction area.
Ground Investigation	Exploratory investigation to determine the structure and characteristics of the ground influenced by a development. The collected information is used to establish or predict ground and groundwater behaviour during, and subsequent to, construction.
Groundwater	The term used to describe the presence of water directly beneath the earths surface.
Gyratory	A large roundabout used to facilitate traffic movements between local and strategic roads.
Heavy Goods Vehicle	Vehicles with 3 axles (articulated) or 4 or more axles (rigid and articulated).
Hard Shoulder Running	The controlled use of the emergency lane sited to the nearside of the trafficked carriageway for the running of vehicles.
Hydrogeology	The branch of geology that deals with the occurrence, distribution, and effect of groundwater.
Hydrological Process	The exchange of water between the atmosphere, the land and the oceans.
Impermeable	Material that does not allow fluids to pass through it.
Intelligent Transport Systems	Intelligent Transport Systems are technology systems or a collection of equipment that assists network operators in providing an efficient, reliable and safe transport network by providing a suite of tools to deploy temporary measures at a strategic or local level and complement the fixed route signing. These measures can be used to influence traveller's behaviour, deliver policy objectives or to manage planned or unplanned perturbations on the network.
Interchange Link	A connecting road, within a large junction carrying free flowing traffic between one road and another.
Journey Time Reliability	Journey Time Reliability is the variation of journey times that drivers are unable to predict; the lower this variation is, the higher the reliability.
Journey Time Variability	The daily variation in travel time from the mean at the same time of day.
Landscape	Human perception of the land, conditioned by knowledge and identity with a place.

Land take	Acquired land which is necessary to construct the scheme and associated infrastructure and to undertake the essential environmental mitigation measures.
Local operation model	A traffic assignment model used to represent detailed traffic behaviour in the local area in the vicinity of the proposed scheme.
Local Road	An A, B or C classified road (non Trunk Road) typically operated by a local authority or council.
Loop	A connecting road, utilising a continuous curve in the connection of two roads within a junction.
Made Ground	Material deposited by man i.e. not natural.
Mainline	The principal road being considered, namely the A90/M90 or the road proposed as its replacement.
Main Crossing	The cable-stayed bridge proposed as a replacement to the Forth Road Bridge.
Merge Slip Road	A link road accessing the main carriageway from a subsidiary road or junction.
Micro-simulation model	A transport assignment model which represents the behaviour of individual vehicles and how the vehicles interact in traffic.
Mitigation	Term used to indicate avoidance, remediation or alleviation of adverse impacts.
Net Present Value	The total present value of a time series of cash flows. It is a standard method for using the time value of money to appraise long-term projects.
Normal Operation (ITS)	Steady traffic flow with no congestion, where the ITS system monitors traffic flow but is not required to implement any traffic management tool.
Northern Study Area	The area to the north of the Firth of Forth in which investigations have been undertaken as part of the Forth Replacement Crossing Project.
Ordnance Datum	The mean sea level at Newlyn (UK) used as a base measurement on Ordnance Survey Maps for contours.
PARAMICS	PARAMICS (PARAllel MICroscopic Simulation) is a microscopic traffic simulation package (Micro-simulation model) developed in Scotland. On this project S-Paramics, 2008.02 version of the software has been used.
Pedestrians and others	Pedestrians, cyclists and equestrians.
Present Value	The present value of future year costs or benefits expressed in present terms by means of converting to present year values (currently 2002 equivalent values) and discounting from the year of expenditure to the present year (currently 2002).
Present Value Benefits	The benefits of a Do Something proposal compared with the Do Minimum comparator. Values are expressed as Present Value Benefits.
Present Value Costs	The difference in costs of a Do Something proposal compared with the Do Minimum comparator. Values are expressed as Present Value Costs
Public Transport Corridor	The Forth Road Bridge, adapted for use by public transport, motorcycles with an engine capacity of 50cc or less and non-motorised users.
Public Transport Link / Lane	A trafficked lane which caters for public transport, including, buses and taxis.
Rat Running	Rat running or cut-through driving referring to the use of secondary roads or residential side streets as opposed to the intended main roads, in order to avoid delays.
Rockhead	The surface representing the top of the solid geological strata, i.e. below any drift deposits.

Runoff	Water that flows over the ground surface to the drainage system. This occurs if the ground is impermeable or if permeable ground is saturated.
Screenline	A screenline is an imaginary line across a selection of roads or multi modal transport routes. Screenlines are often used in traffic analyses to determine how much volume is entering or exiting a particular area, using all of the included routes. Natural terrain features such as rivers are often used to define screenlines.
Signal control	The use of traffic signals to control traffic flow at a junction or pedestrian crossing. Signal control can also be implemented on a slip road (commonly referred to as Ramp Metering).
Slip Road	A connector road facilitating access between one road and another.
Southern Study Area	The area to the south of the Firth of Forth in which investigations have been undertaken as part of the Forth Replacement Crossing Project.
Strategic Transport Projects Review	The two year review of the Scottish transport network undertaken by Transport Scotland. The findings, published in December 2008, provide recommendations on a portfolio of land-based strategic transport interventions which will establish the basis for the ongoing development of Scotland's transport infrastructure to meet the demands of the 21st Century.
Superficial Deposits	The youngest geological deposits formed during the most recent period of geological time, the Quaternary, which extends back 1.8 million years from the present.
Sustainable Drainage Systems	A sequence of management practices and control structures designed to drain surface water in a more sustainable fashion than some conventional techniques.
Water Framework Directive	Wide-ranging European environmental legislation (2000/60/EC). Addresses inland surface waters, estuarine and coastal waters and groundwater. The fundamental objective of the Water Framework Directive is to maintain “high status” of waters where it exists, preventing any deterioration in the existing status of waters and achieving at least “good status” in relation to all waters by 2015.

Abbreviations

AADT	Annual Average Daily Traffic
AOD	Above Ordnance Datum
AMI	Advanced Motorway Indicator
BCR	Benefit to Cost Ratio
BCR_{WEB}	Benefit to Cost Ratio Wider Economic Benefits
bgl	Below Ground Level
BRT	Bus Rapid Transit
BS	British Standard
CCTV	Closed-Circuit Television
CIRIA	Construction Industry Research and Information Association
COBA	Cost Benefit Analysis
CO_2	Carbon Dioxide
D&B	Design and Build
DMRB	Design Manual for Roads and Bridges
DfT	Department for Transport
D2M	Dual two lane motorway
D3M	Dual three lane motorway
D3AP	Dual three lane all purpose road
EIA	Environmental Impact Assessment
FETA	Forth Estuary Transport Authority
FRCS	Forth Replacement Crossing Study
GI	Ground Investigation
GL	Ground Level
GROS	General Register Office for Scotland
ha	Hectares
HGV	Heavy Goods Vehicle
ITS	Intelligent Transport System
Km	Kilometres
Kph	Kilometres per hour
Kv	Kilovolt
LATIS	Land-use And Transport Integration in Scotland
LGV	Light Goods Vehicle
LRT	Light Rapid Transit
LS	Lane Signalling
m	Metre
mbgl	Metres Below Ground Level
MCR	Main Cable Replacement
mm	Millimetre
mph	Miles Per Hour
MVSS	Mandatory Variable Speed Signalling
NCR	National Cycle Route

NTS	National Transport Strategy
NPF	National Planning Framework
NPF2	National Planning Framework 2
NPV	Net Present Value
OD	Ordnance Datum
OGV	Other Goods Vehicle
OS	Ordnance Survey
pcu	Passenger Car Unit
PEARS	Programme for Economic Assessment of Road Schemes
PHEM	Passenger car and Heavy-duty Emission Model
P.I.A/MVKm	Personal Injury Accident per Million Vehicle Kilometres
PVB	Present Value of Benefits
PVC	Present Value of Costs
PWS	Private Water Supply
Q4	Quarter 4
RSI	Roads Side Interview survey
RTA	Road Traffic Accident
RTP	Regional Transport Partnership
R720m	A radius applied in the design of the horizontal or vertical geometry of the route corridor. For example R720 corresponds to a radius of 720 metres.
SEPA	Scottish Environment Protection Agency
SEStran	South East Scotland Transport Partnership
STAG	Scottish Transport Appraisal Guidance
STMC	Short Term Mode Choice
STPR	Strategic Transport Projects Review
SUDS	Sustainable Drainage Systems
TD	Technical Document
TEE	Transport Economic Efficiency
TELMoS	Transport and Economic Land Use Model of Scotland
TMfS	Transport Model for Scotland
TUBA	Transport Users Benefit Appraisal
vkt	Vehicle Kilometres Travelled
VMS	Variable Message Sign
WEB	Wider Economic Benefits
WFD	Water Framework Directive

Introduction

Following the completion of the Forth Replacement Crossing Study as part of the Strategic Transport Projects Review (STPR), the Cabinet Secretary for Finance and Sustainable Growth announced to Parliament on 19 December 2007 that the Forth Replacement Crossing would be a new cable-stayed bridge located immediately upstream of the Forth Road Bridge.

The decision to progress with the development of the project was based on the findings of the Forth Replacement Crossing Study, Reports 1 to 5, published in 2007, and addressed ongoing concerns over the continued availability of the Forth Road Bridge as an unrestricted crossing for general road traffic. The policy objective is to provide, in the light of uncertainties about the future availability of the Forth Road Bridge, a continuing and reliable primary road link between Edinburgh, the Lothians, and Fife and beyond in order to safeguard the economy, particularly of the east coast of Scotland.

Following the above announcement, the Jacobs Arup Joint Venture was appointed in January 2008 to work as a development partner with Transport Scotland to take the project forward. With the need, form and location for a replacement crossing having been identified, Jacobs Arup were engaged to carry out the detailed development of all aspects of the Forth Replacement Crossing Project, including the Main Crossing and its connecting roads infrastructure. The findings of the assessment work undertaken during 2008 are published in the following series of reports:

- Forth Replacement Crossing, Route Corridor Options Review.
- Forth Replacement Crossing, DMRB Stage 2 Corridor Report.
- Forth Replacement Crossing, Main Crossing (Bridge) Scheme Assessment Report – Development Report.
- Forth Road Bridge, Feasibility of Multi-Modal Corridor.
- Forth Road Bridge, Audit of feasibility of Future Multi-modal Use Summary Report.
- Forth Replacement Crossing, Main Crossing (Bridge), Scheme Assessment Report, Development of D2M Alternatives.
- Forth Replacement Crossing, Managed Crossing Scheme, Scheme Definition Report.

The reports are available from the Forth Replacement Crossing website (www.transportscotland.gov.uk/projects/forth-replacement-crossing).

The key decisions resulting from this assessment work were announced on 10 December 2008 when the Minister for Transport, Infrastructure and Climate Change announced details of the Forth Replacement Crossing Project to the Parliament as follows:

"Updated findings from the Forth Estuary Transport Authority have allowed us to consider the future of the existing bridge. We have concluded that it can be retained, alongside the new bridge, as a dedicated public-transport crossing as part of a managed crossing strategy. Sustainable public transport will be given priority on a dedicated public transport corridor across the existing bridge, with the option in the future to convert the existing bridge for light rapid transit, trams or guided buses. The existing bridge will continue to provide access for pedestrians and cyclists."

The announcement also included details of:

- The preferred route corridor north and south of the Firth of Forth; and
- The intended design of the new bridge incorporating a dual carriageway for general road traffic and widened hard shoulders.

The new bridge (the Main Crossing) will be a cable-stayed structure with three single column towers, windshielding and a single deck carrying a motorway of two general lanes and hard shoulders in each direction. Windshielding on the Main Crossing will protect the bridge from the effects of wind and provide a more reliable corridor for wind susceptible vehicles. The hard shoulders on the Main Crossing will ensure that breakdowns, incidents and any maintenance works do not cause the congestion which is currently experienced on the Forth Road Bridge, which has no hard shoulders. They also provide the flexibility to carry public transport should it be required in the future, carry traffic during maintenance activities and carry buses relocated from the Forth Road Bridge during the periods of high winds.

South of the Main Crossing, a dual carriageway, designated as motorway southwards to a new junction onto the A904 will be constructed, connecting roads which link to the A90 and thereby to the M9 in the south by making use of the recently completed M9 Spur. An enhancement at M9 Junction 1a will permit full directional access to and from the M9 to the M9 Spur. Providing a west facing slip road will allow greater choices and opportunities to West Lothian, Falkirk and the upper Forth Valley. Eastbound, the revised two lane slip road from the M9 Spur will join the lanes provided on the M9 to form a four lane carriageway with hard shoulder. The westbound approach to M9 Junction 1a from Newbridge will be improved by the addition of an auxiliary exit lane from the River Almond bridge.

North of the Forth, a motorway dual carriageway will be constructed connecting roads to and from the Main Crossing with the A90 / M90, with junction enhancements at Ferrytoll and road widening between this junction and Admiralty Junction as well as a realignment of a local road to North Queensferry. The improved junctions will protect and promote access to the development areas of Fife.

The new route between Queensferry Junction and Admiralty Junction, including the Main Crossing, will be classified as a motorway. To preserve certain use rights attaching to the A90 to the east, the section between Scotstoun and the new Queensferry Junction will be a Special Road to match the requirements of the traffic permitted to use the A90 to the east. It will nevertheless be constructed to a standard suitable for upgrading, if required, at a later date to a motorway. Non-motorway traffic on the A90 travelling westwards will need to divert to the local network at Queensferry Junction.

In preference to increasing the extent of road construction and refurbishment, Intelligent Transport System (ITS) technology will be deployed along the route from the M90 Halbeath Junction over the Main Crossing to the M9 at Newbridge. This will improve traffic flow, reduce congestion and improve road safety. ITS can operate on roads under existing legislation through the application of traffic orders made by the Scottish Ministers and therefore the Parliamentary Bill only seeks to acquire the land and undertake the works necessary to provide the physical apparatus for the system.

The existing Forth Road Bridge will consequently become a dedicated public transport corridor for buses and taxis together with pedestrians, cyclists and motorcycles (with an engine capacity of 50cc or less).

The DMRB Stage 3 Scheme Assessment Report describes the outcomes of the environmental, engineering, traffic and economic work undertaken on the Forth Replacement Crossing Managed Crossing Scheme. The report has been prepared in accordance with the requirements of the Design Manual for Roads and Bridges (DMRB), Volume 5, Section 1, Part 2, TD37/93 and is split into two parts:

- Part 1: The Environmental Statement, which presents the results of the Environmental Impact Assessment on the Stage 3 design for the Managed Crossing Scheme; and
- Part 2: This report, which covers the Stage 3 design for the Managed Crossing Scheme from an engineering, traffic and economic perspective.

A wide range of information has been published by Transport Scotland and is available on the website (www.transportscotland.gov.uk/projects/forth-replacement-crossing).

Report	Summary Content
DMRB Stage 3 Scheme Assessment Report: Part 1 - Environmental Statement	A report on the findings of the Environmental Impact Assessment.
Non Technical Summary of the Environmental Statement	A summary of the Environmental Statement.
Code of Construction Practice	Document setting out the measures to be put in place during construction to reduce impacts on the environment and communities.
Noise & Vibration Policy Statement	Statement of the approach the Scottish Ministers will take in assessing and mitigating noise impacts associated with the operation of the scheme.
Sustainability Appraisal & Carbon Management Report	A report setting out defined objectives and sustainable design measures with the aim of delivering a more sustainable scheme.
Health Impact Assessment	A report presenting an appraisal of the possible health effects of the proposed scheme.
DMRB Stage 3 Scheme Assessment Report: Part 2 - Engineering, Traffic and Economic Assessment	This report, covering the engineering, traffic and economic assessment of the scheme.
Consultation & Engagement Report	A report documenting the consultation and engagement activities which were undertaken during the development of the scheme.

1 Scheme Background

1.1 Forth Replacement Crossing / Strategic Transport Projects Review

1.1.1 In 2006 the Scottish Ministers commissioned the Strategic Transport Projects Review (STPR) to identify nationally strategic interventions to be implemented beyond 2012 and which supported the objectives of the National Transport Strategy. The emergence of the evidence from the first cable inspection on the Forth Road Bridge, undertaken in 2004 and 2005, necessitated an early piece of work for the STPR which was the Forth Replacement Crossing Study (FRCS). This work aimed to identify the form, function and location of any potential replacement to the existing Forth Road Bridge. The study methodology followed closely the Scottish Transport Appraisal Guidance (STAG).

1.1.2 The Forth Replacement Crossing Project is one of twenty nine strategic transport interventions recommended by the STPR to improve Scotland's strategic transport network through more effective operation and maintenance, better use of existing capacity, and / or the implementation of targeted infrastructure enhancements.

1.1.3 The STPR has made recommendations on a portfolio of land-based strategic transport interventions which will establish the basis for the ongoing development of Scotland's transport infrastructure to meet the demands of the 21st Century. Its focus was in the identification of those interventions which would most effectively contribute towards the Government's purpose of increasing sustainable economic growth. Its objective led evidence based approach was designed to allow a wide range of transport issues to be appraised and addressed effectively. This system of assessment had an objective to ensure that the national priorities of a Wealthier and Fairer, Healthier, Safer and Stronger, Smarter and Greener Scotland are met and that investment is targeted on measures which will best assist in the promotion of Scotland's sustainable economic development.

1.1.4 The outcome of the STPR has been based on a tiered system of investment structured around the following priorities:

- Maintaining and safely operating existing assets;
- Promoting a range of measures, including innovative solutions that make better use of existing capacity; and
- Promoting targeted infrastructure improvements where these are necessary, affordable and practicable.

1.1.5 Through the implementation of this approach, best use can be made of the limited resources available, ensuring that new infrastructure is identified only after other interventions have been appraised and considered.

1.1.6 This has been achieved through:

- Looking at what the picture of transport might look like in the future and identifying the issues this creates in terms of achieving the Government's Purpose;
- Allowing a range of interventions, covering a variety of modes across Scotland, judged comparatively on their merits; specifically in terms of their ability to address these issues and support the Government's Purpose; and
- Prioritising investment to meet the Government's Purpose and the complementary objectives of the National Transport Strategy.

1.1.7 Following the completion of the FRCS, it was announced to Parliament on 19 December 2007 that the Forth Replacement Crossing is to be a cable-stayed bridge and that the scheme would be designed to:

- safeguard the capability of future multi-modal use;
- provide for pedestrians and cyclists;
- provide for two lanes in each direction for general traffic;
- incorporate hard shoulders to relieve disruption due to breakdowns and maintenance activity;
- provide an enhanced service to West Lothian; and
- protect and promote the economic development areas in Fife.

1.1.8 The full STPR report was published in December 2008 and defines the strategic investments to be made in Scotland's national transport network from 2012 onwards.

1.2 Previous Studies and Reports

1.2.1 The following studies and reports formed the basis for the decision on the form and location of the Forth Replacement Crossing prior to the decision in December 2007 and for the subsequent development of the project through 2008.

Table 1.1: Forth Replacement Crossing – Studies and Reports

Report Title and Work Period	Report Scope
FRCS, Reports 1 to 5 Work carried out by Jacobs and Faber Maunsell, pre-June 2007.	Reports on work undertaken by Jacobs and Faber Maunsell, to June 2007, to assess the options for a replacement crossing, which recommended that a cable-stayed bridge in 'Corridor D', a crossing point immediately upstream of the Forth Road Bridge, be taken forward as the best overall performing option.
Forth Replacement Crossing, Route Corridor Options Review: Work carried out by Jacobs Arup, January to May 2008.	Report to assess nine mainline connecting road corridors: three in the Northern Study Area and six in the Southern Study Area. It recommended that two of the northern and two of the southern corridor options be taken forward for further assessment.
Forth Replacement Crossing, DMRB Stage 2 Corridor Report: Work carried out by Jacobs Arup, May to August 2008.	Report on the assessment of the shortlisted corridor options and a supplementary assessment of a variant version of a connecting road corridor in the Southern Study Area. The report recommended that work continue to identify in detail the optimum road improvement within North Corridor Option 1 and South Corridor Option 1.
Forth Replacement Crossing, Main Crossing (Bridge) Scheme Assessment Report, Development of Options: Work carried out by Jacobs Arup, January to August 2008.	Report on the assessment of options for the outline design of the replacement crossing.
Forth Road Bridge – Feasibility of Multi-Modal Corridor: Work carried out by Jacobs Arup, August to October 2008.	Report on the feasibility of utilising the existing Forth Road Bridge for non motorised and public transport / light road traffic, including for a potential future guided bus / tram based light rail facility. The report concluded that this would be a feasible option.
Forth Road Bridge - Audit of Feasibility of Future Multi-Modal Use - Summary Report Work carried out by Faber Maunsell to November 2008	Independent summary of review on the Jacobs Arup 'Forth Road Bridge - Feasibility of Multi-Modal Corridor' report, an assessment of the feasibility of utilising the existing Forth Road Bridge for non motorised and public transport / light road traffic, including for a potential future guided bus / tram based light rail facility. The report concluded that the Forth Road Bridge could, in principle, be adapted for future LRT.
Forth Replacement Crossing, Main Crossing (Bridge) Scheme Assessment Report, Development of D2M Alternatives: Work carried out by Jacobs Arup, October to November 2008.	Report on the assessment of options for a narrower replacement crossing to carry a dual carriageway road with hard shoulders.

Report Title and Work Period	Report Scope
Forth Replacement Crossing, Managed Crossing Scheme, Scheme Definition Report. Work carried out by Jacobs Arup, July to November 2008	Report summarising the work undertaken to define the 'Managed Crossing Scheme' Refer to Paragraphs 1.2.3 to 1.2.8 inclusive for a summary description of the Managed Crossing Scheme.

1.2.2 Each of the reports in Table 1.1 has been published, and is available on the Transport Scotland website, (www.transportscotland.gov.uk/projects/forth-replacement-crossing).

The Managed Crossing Scheme

1.2.3 In considering the outcome of the DMRB Stage 2 Corridor Report in tandem with the assessment work undertaken in the potential future use of the Forth Road Bridge, options for optimising the scheme definition were considered. The outcome of this work resulted in the publication of the Scheme Definition Report.

1.2.4 The key considerations in the optimisation of the scheme definition were as follows:

- The DMRB Stage 2 Corridor Report concluded that the Full Corridor Scheme need not be implemented in full and that project planning work should be progressed to give further detailed consideration to the form and function of the junctions required and the extent of the road infrastructure improvements provided within the preferred corridors to achieve the scheme objectives.
- The Forth Road Bridge could be capable of adaptation for multi-modal use, including future tram based light rail use, and it was determined that this would be taken forward as a planning assumption.

1.2.5 The scheme defined to take account of the combined output from these separate exercises is referred to as the Managed Crossing Scheme.

<u>Key Features of the Managed Crossing Scheme</u>

1.2.6 The key features of the Managed Crossing Scheme are as follows:

- Use of the existing Forth Road Bridge for public transport, buses, taxis, motorcycles with an engine capacity of 50cc or less, pedestrians and cyclists with future opportunity to upgrade for use by Light Rapid Transit (LRT) which may take the form of guided bus or a tram based light rail system (refer to Chapter 3);
- A new cabled-stayed bridge with three mono-towers and a single level deck with wind shielding, providing two general lanes of traffic and a hard shoulder in each direction (the hard shoulders being capable of carrying public transport during Forth Road Bridge closures or general traffic in times of maintenance);
- North of the Main Crossing, provision of a new dual carriageway with hard shoulders connecting the Main Crossing to the A90 / M90, incorporating junction enhancements at Ferrytoll and road widening between Ferrytoll and Admiralty;
- South of the Main Crossing, provision of a new dual carriageway with hard shoulders linking the bridge to the A90 and M9, making use of the recently completed M9 Spur with an enhanced M9 Junction 1a providing free-flow, all-ways access;
- Provision of a new junction arrangement providing access to South Queensferry and existing local routes;
- Provision of an Intelligent Transport System (ITS) along the full length of the scheme from the M90 Halbeath Junction over the Main Crossing to the M9;

- Potential for both the development of the park and ride site at Ferrytoll and the introduction of further park and ride / park and choose facilities at Rosyth and Halbeath.

1.2.7 Refinements to the Managed Crossing Scheme were undertaken between November 2008 and April 2009 further developing the scheme from an engineering, environmental and traffic perspective to produce the DMRB Stage 3 design for assessment. These refinements are summarised in Section 3.7 of this report.

1.2.8 The Managed Crossing Scheme as developed for this DMRB Stage 3 assessment hereafter referred to as the 'proposed scheme', is shown in Figure 1.1 in Appendix A.

1.3 Scheme Objectives

1.3.1 The eight specific transport planning objectives developed for the Forth Replacement Crossing and as implemented in the Forth Replacement Crossing Study and Forth Replacement Crossing Project are as follows:

- to maintain cross-Forth transport links for all modes to at least the level of service offered in 2006;
- to connect to the strategic transport network to aid optimisation of the network as a whole;
- to improve the reliability of journey times for all modes;
- to increase travel choices and improve integration across modes to encourage modal shift of people and goods;
- to improve accessibility and social inclusion;
- to minimise the impacts of maintenance on the effective operation of the transport network;
- to support sustainable development and economic growth; and
- to minimise the impact on people, and the natural and cultural heritage of the Forth area.

1.4 Sustainable Development Policy

1.4.1 To support sustainable development and economic growth, the concept of sustainability is at the heart of the Forth Replacement Crossing Project.

1.4.2 Transport Scotland, through its Forth Replacement Crossing, Sustainable Development Policy, published in January 2009, sets out the following vision for the project:

'To deliver an iconic project that respects the environment, contributes to sustainable economic growth at both regional and Scottish levels and facilitates efficient public transport whilst minimising disruption to the community and reducing the use of non-renewable resources during its construction and throughout its life.'

1.4.3 Beneath this vision is a set of sustainable development objectives. Consideration of sustainable development will form a core thread throughout all the activities of the project team and stages in the project life cycle including:

- Project design and appraisal
- Preparation of contract documents;
- Tender evaluation;
- Construction; and

- Maintenance, operation and decommissioning.

1.4.4 The Forth Replacement Crossing, Sustainability Appraisal and Carbon Management Report, published by Transport Scotland in November 2009, reports the measures which aim to deliver a more sustainable project.

1.5 DMRB Stage 3 Scheme Assessment Report Methodology

1.5.1 This DMRB Stage 3 Assessment Report has been prepared in accordance with TD 37/93, Scheme Assessment Reporting, of the Design Manual for Roads and Bridges (DMRB). This report (Part 2) covering the proposed scheme from an engineering, traffic and economic perspective has been broken down into the following sections.

- The Scheme;
- Engineering Assessment; and
- Traffic and Economic Assessment.

1.6 Do-Minimum Definition

1.6.1 For scheme assessment, it is necessary to compare the proposed scheme with a Do-Minimum scheme. The Do-Minimum scheme incorporates the improvements which are foreseeable if the proposed scheme was not to be built. The Managed Crossing Scheme takes account of two associated Do-Minimum scenarios. The first scenario takes into account the main cable replacement works which are likely to be required for the existing Forth Road Bridge, should the Managed Crossing Scheme not be taken forward. The impact of main cable replacement would be spread over several years but would not last for the full duration of the scheme appraisal period. The second scenario, the baseline for the environmental assessment, models the subsequent period when the main cable replacement works would be completed and the Forth Road Bridge would operate as at present.

1.6.2 The two Do-Minimum scenarios are referred to as the restricted Do-Minimum and the unrestricted Do-Minimum.

Restricted Do-Minimum

1.6.3 The restricted Do-Minimum reflects restrictions on the Forth Road Bridge, which allow for extended periods of single lane operation in each direction across the bridge under contra-flow conditions during cable replacement works.

Unrestricted Do-Minimum

1.6.4 The unrestricted Do-Minimum reflects normal operation of the Forth Road Bridge. Both scenarios involve closures and restrictions during periods of high winds, due to other incidents and during other planned maintenance works.

2 Existing Conditions

2.1 Forth Road Bridge

Background

2.1.1 The Forth Road Bridge is a Grade A listed structure. Opened to traffic in 1964, it has a main span of 1006 metres and an overall length of 2500 metres including approach viaducts. On opening, the Forth Road Bridge was the longest suspension bridge outside of the USA and the fourth longest in the world. The bridge is maintained and operated by the Forth Estuary Transport Authority (FETA).

2.1.2 Since opening, traffic using the Forth Road Bridge has increased from 4 million to 24 million vehicles per year. The annual number of heavy goods vehicles (HGVs) has risen commensurately, with the weight of unrestricted HGVs having also increased from 24 tonnes to 44 tonnes. The volume of traffic and intensity of traffic loading is likely to continue to increase in the future.

2.1.3 During normal operation the bridge provides two general traffic lanes in each direction and is the subject of a 50mph speed limit. The northbound and southbound carriageways, which are separated by an air gap, make no provision for hard shoulders or hard strips. The lack of such facilities makes the recovery of vehicles from accidents / breakdowns difficult and can result in significant delays on the bridge, its approaches and on the surrounding road network.

2.1.4 In addition to carrying vehicular traffic, the bridge also caters for pedestrians and cyclists. Combined footway / cycleways are carried on cantilevered sections of the bridge deck. Under normal operating conditions the west footway / cycleway is restricted to Forth Road Bridge personnel and contractors only. The east footway / cycleway is open to the public and connects National Cycle Route 1 (NCR1) north and south of the Firth of Forth.

Maintenance

2.1.5 Major maintenance is an on-going requirement for all large suspension bridges. In the case of the Forth Road Bridge, this requirement has been exacerbated by increases in traffic volume and the increased weight of HGVs. In addition, the Forth Road Bridge is subject to high winds from the west. Combined with the cold waters of the Firth of Forth, this leads to foggy weather during the spring and summer months with high relative humidity. The presence of salt water helps in contributing to highly corrosive conditions.

2.1.6 The most recent focus of concern in relation to the Forth Road Bridge being able to continue to provide an unrestricted crossing has been the condition of the main suspension cables upon which the stability of the bridge depends.

<u>Cable Inspection</u>

2.1.7 In 2004 and 2005, FETA undertook the first internal inspection of the main suspension cables, following draft guidelines as recommended by the American National Co-operative Highway Research Program Report 534 ‘Guidelines for Inspection and Strength Evaluation of Suspension Bridge Parallel Wire Cables’. As there are no UK or European guidelines for such inspections the American guidelines are currently accepted as the industry standard.

2.1.8 FETA found that a significant number of cable wires had broken or were in an advanced state of corrosion. This led to the estimation that the main cables had lost between 8% and 10% of their original strength. In addition, if the rate of cable deterioration was not reduced, it was predicted that restrictions to HGV traffic may be required from 2014 with a closure to all vehicles being required from 2020.

2.1.9 In early 2008, FETA carried out a second internal cable inspection which included some areas of cable which had previously been inspected in 2004 and 2005. In July 2008, FETA reported that the main cables were estimated to have lost 10% of their strength, which can be compared to the lower bound figure of 8% estimated from the 2004 / 2005 work. Whilst the previously predicted timescale for possible traffic restrictions remained valid, cable deterioration appeared to be tending towards the optimistic end of the range. Restrictions to HGV traffic now seem more likely to be required at some point between 2017 and 2021. FETA also reported that these were the predicted dates for restrictions if the cables continued to deteriorate without intervention; if dehumidification is successful then the date for traffic restrictions could be extended.

Cable Dehumidification

2.1.10 FETA has recently completed the installation of dehumidification equipment to the main cables. The dehumification process involves pumping dry air through the voids within each cable, having first applied an air-tight neoprene wrapping around the cable. It is hoped that this process will remove moisture from the cables and prevent or reduce further deterioration. The success of this method can only be determined once the cables have dried out and it will therefore be necessary to wait until 2011 / 2012 when further evaluation can take place.

Cable Replacement or Augmentation

2.1.11 In February 2008, FETA reported on a study undertaken to investigate the feasibility of replacing or augmenting the main cables on the Forth Road Bridge, should this become necessary. Whilst the 'Feasibility Study for the Replacement or Augmentation of the Main Cables' report stated that cable replacement or augmentation was possible, it concluded that this process was not feasible without a replacement bridge, the severity of the impact on road users and the wider economy being too severe.

Future Use

2.1.12 Despite significant ongoing maintenance and operational issues, the improved prognosis for the main cables and the technical feasibility of replacing or augmenting them if necessary, once traffic is diverted to the Main Crossing, has increased the attractiveness of using the Forth Road Bridge as part of the replacement crossing scheme.

2.1.13 An assessment of the capabilities of the existing bridge to carry tram based light rail public transport together with footway loading and reduced highway loadings was reported in the 'Forth Road Bridge – Feasibility of Multi-modal Corridor', published by Transport Scotland (refer to Section 1.2). All of the options assessed were deemed to be geometrically feasible and all but one option reduced the loading on the main cables. With modifications to the movement joints, in particular at the main towers, it was deemed that all of the options had positive potential. The load reduction would mitigate the loss of cable strength that had already occurred and extend the period before cable replacement or augmentation became necessary, with the possibility of deferring such works indefinitely should cable dehumidification be successful.

2.1.14 The work undertaken in the potential future use of the Forth Road Bridge as a multi-modal corridor was the subject of a independent technical audit by Faber Maunsell, reported in the 'Forth Road Bridge Audit of Future Multi-Modal use: Summary Report'. The findings of audit concurred with that of the 'Forth Road Bridge – Feasibility of Multi-modal Corridor' report.

2.1.15 On the basis that the Forth Road Bridge could be capable of adaptation for multi-modal use, including future tram based light rail use, it was determined that the use of the Forth Road Bridge for this function would be taken forward as a planning assumption. These findings led to the development of the Managed Crossing Scheme announced in December 2008.

2.2 Existing Road Network

North of the Firth of Forth

2.2.1 The A90 / M90 forms the strategic link between the Forth Road Bridge and the north, providing access to the population centres of Dunfermline, Perth, Dundee, Aberdeen and Inverness (via the A9). Directly north of the Forth Road Bridge, the strategic route is designated the A90 to Admiralty Junction. In the proximity of the Forth Road Bridge, the route is operated and maintained by FETA. The remainder of the route is operated and maintained by Fife Council. North of Admiralty Junction, the route is designated the M90 and is operated and maintained by BEAR Scotland Ltd as a part of the Scottish Trunk Road Network on behalf of Transport Scotland. Figure 2.1 in Appendix A details the existing road network north of the Firth of Forth, local to the proposed scheme.

<u>A90 – Forth Road Bridge to Ferrytoll Junction</u>

2.2.2 Departing north from the Forth Road Bridge, the A90 takes the form of a dual two lane all purpose carriageway (D2AP), passes to the west of North Queensferry, and descends through the Ferry Hills area towards Ferrytoll Junction. This section of the A90 is kerbed and is drained by gullies along the carriageway edge. The section is lit from the Forth Road Bridge to the south facing slip roads at Ferrytoll Junction, with lighting columns being provided within the carriageway verges.

2.2.3 Further carriageway features through this section include:

- Northbound, a 50mph speed limit from the Forth Road Bridge to the northbound diverge slip road of Ferrytoll Junction, where the national speed limit for a dual carriageway becomes applicable (70mph).
- Southbound, national speed limit restrictions (70mph) apply as far as Welldean Lay-by (Southbound), where the 50mph speed limit associated with the Forth Road Bridge takes effect. An electronic sign board on approach to the Forth Road Bridge enables this limit to be reduced further when necessary.
- Hard shoulder provision northbound over the short distance between Welldean Lay-by (Northbound) and the diverging slip road to Ferrytoll Junction.
- Large parking lay-bys to the northbound and southbound carriageways at Welldean. The southbound lay-by provides a holding area for abnormal loads and a sanctuary for high sided vehicles when high winds necessitate the restricted operation of the Forth Road Bridge.
- A bus stop in both directions located in proximity to the north abutment of the Forth Road Bridge.
- Bus lanes in both directions, the southbound bus lane extending from the Ferrytoll Park and Ride facility to the Forth Road Bridge. Northbound, the bus lane extends from the bus stop to Welldean Lay-by (Northbound). Completed by FETA in 2008, the northbound bus lane aims to ease the difficulties experienced by bus traffic wishing to rejoin the main carriageway from a stationary position.
- Combined footway / cycleways in the verges of both carriageways. The footway / cycleway associated with the northbound carriageway, provides access between the bus stop at the north abutment of the Forth Road Bridge and North Queensferry via an access to the B981, located to the rear of Welldean Lay-by (Northbound). Southbound,

the footway / cycleway, forms a part of NCR 1 and connects the Forth Road Bridge to the B981 (Hope Street) via Ferrytoll Junction.

A90 - Ferrytoll Junction to Admirality Junction

2.2.4 North of Ferrytoll Junction, the A90 climbs to the east of Castlandhill, an area where the road corridor was created by significant rock cuttings. The section has a split carriageway, the northbound carriageway being sited lower on the landscape relative to the southbound carriageway. Cresting in the vicinity of Dunfermline Wynd Overbridge, the route descends toward Admiralty Junction.

2.2.5 The features of this section of carriageway are as follows:

- Northbound, a hard shoulder is provided in addition to the two general traffic lanes. Drainage is provided through a filter drain which is located in the carriageway verge.
- Southbound, and following the completion of improvements by Fife Council in 2006, the A90 provides three traffic lanes between Admiralty and Ferrytoll, the provision of an auxiliary lane complementing the multi-storey expansion of Ferrytoll Park and Ride whilst also improving access to North Queensferry, Inverkeithing, Rosyth and Rosyth Dockyard. The southbound carriageway is kerbed. Drainage is provided through a series of gullies at the edge of the carriageway.

2.2.6 The following points detail existing design issues with the A90 north of the Forth Road Bridge:

- The close proximity of the Ferrytoll and Admiralty junctions means that traffic merging and diverging between the junctions has a very short weaving distance within which to manoeuvre. The auxiliary lane provided to the southbound carriageway provides assistance in the operation of the A90 over this section; however, northbound, no such facility exists, presenting difficulties for merging and diverging traffic between the junctions.
- The section of carriageway between the Ferrytoll and Admiralty junctions contains non standard sections of horizontal and vertical geometry.
- Reduced sight distance is an issue on the immediate approach to the southbound diverge to Ferrytoll Junction and on the northbound carriageway approach to Admiralty Junction.
- At Admiralty Junction, the northbound diverge slip road layout is considered to be non standard as is the southbound merge nose to the A90.

M90 - Admiralty Junction to Halbeath Interchange

2.2.7 At Admiralty Junction, the A90 becomes the M90, a dual two lane motorway (D2M). The M90 continues to Perth, where the A9 and the A90 provide onward travel to Inverness, Dundee and Aberdeen. Local to the proposed scheme, the M90 provides access to the north of Rosyth and the south of Dunfermline via Masterton Junction (M90 Junction 2) and the A823(M). To the north, M90 Junction 2a provides access to the A92 and east Fife. Halbeath Junction (M90 Junction 3) provides access to Dunfermline and Crossgates.

Ferrytoll Junction and connecting Local Roads

Ferrytoll Junction

2.2.8 Located east of Dunfermline Water Treatment Works, Ferrytoll Junction links the A90 and the Forth Road Bridge to the local road network associated with North Queensferry, Inverkeithing and Rosyth. The main gyratory and its subsidiary roundabouts are kerbed and drained via gullies and combined kerb drainage systems. The junction and its approaches are lit, with lighting columns being provided in carriageway verges.

2.2.9 The main operational features of the junction are as follows:

- The main junction as a grade separated gyratory, provides direct south facing connectivity to the A90 and to North Queensferry via the B981, and provides two circulating lanes with nearside lane drops to each of the roundabout exit arms.
- The link roads and subsidiary roundabouts associated with the junction provide connection to Ferry Toll Road, the B980 (Castlandhill Road) and the B981 (Hope Street).
- The subsidiary roundabout located to the east of the main junction provides direct access and egress to Ferrytoll Park and Ride and allows A90 southbound traffic to depart the mainline carriageway via a short 2 lane slip road.
- A bus lane is provided from Ferrytoll Park and Ride, through the junction area, to the A90 southbound merge slip road and the Forth Road Bridge.
- The junction area is the subject of a 40mph speed limit.
- Pedestrian access is provided through the junction. In combination with the B981 (Hope Street) and Ferry Toll Road, the junction also forms part of National Cycle Route 76.

2.2.10 Given the compact nature of the junction and the numerous works undertaken to provide additional functionality, the existing layout of Ferrytoll Junction can be considered to be somewhat sub-standard in nature. The compactness of the main gyratory also impairs visibility, particularly when approaching the bridge structures which carry the A90 over the junction.

Local Roads

2.2.11 The B981, providing access between the main Ferrytoll Junction gyratory and North Queensferry, has been constructed as a distributor road (7.3m carriageway). On approach to the junction, the road operates under national speed limit restrictions (60mph). Whilst being the principal vehicular access to North Queensferry, the B981 also provides access to Dunfermline Waste Water Treatment Works and Deep Sea World's overflow car park, both of which are situated in close proximity to Ferrytoll Junction. The road is kerbed and drained through a series of gullies. A footway is provided within the west verge of the carriageway and provides pedestrian access to North Queensferry. In the east verge, a short section of footway is provided at the foot of the access to Welldean Layby (Northbound). Street lighting is only provided on the immediate approach to Ferrytoll Junction.

2.2.12 The B981 (Hope Street) is a distributor road providing access to Inverkeithing from the subsidiary roundabout located to the east of the main Ferrytoll Junction gyratory. The road provides a single traffic lane in each direction with widening for local road junctions. Footways are provided to each side of the trafficked carriageway from Ferrytoll Park and Ride to the railway viaduct, where the footway associated with the northbound traffic lane terminates. The road is kerbed and is drained by a series of gullies situated along the carriageway edge. Street lighting is provided to the rear of the footways. The speed limit is 30mph.

2.2.13 Ferry Toll Road is a distributor road which provides onward travel to Rosyth and Rosyth Dockyard. In proximity to the subsidiary roundabout located to the west of the main Ferrytoll Junction gyratory, Ferry Toll Road provides two lanes eastbound, accommodating left turning movements to the B980 (Castlandhill Road) and straight on movements to the main gyratory. Further road widening is provided at local road junctions. The road is kerbed and is drained by a series of gullies. Street lighting is provided, lighting columns being situated within the verge of the westbound carriageway when departing Ferrytoll Junction. Beyond the verge of the westbound carriageway, a footway / cycleway is provided. The speed limit is 40mph.

2.2.14 The B980 (Castlandhill Road) provides access between Ferrytoll Junction and Rosyth. Connecting to the subsidiary roundabout situated west of the main gyratory, this distributor road also provides access to the A90 northbound carriageway via an at-grade junction and to Inverkeithing via Dunfermline Wynd Overbridge. A large parking lay-by is also provided, which is situated between Ferrytoll Junction and the junction to the A90 northbound. Whilst the B980 (Castlandhill Road) is lit in proximity to Ferrytoll Junction, no provision is made for pedestrians in this area. The road is kerbed and is drained through a series of gullies. A 40mph speed limit is in operation in proximity to Ferrytoll Junction. Beyond the junction with the A90 northbound slip road, the national speed limit for a single carriageway road applies (60mph).

Admiralty Junction (M90 Junction 1)

2.2.15 Admiralty Junction (M90 Junction 1) takes the form of a grade separated gyratory. The wide circulatory carriageway provides direct connections between the A90 / M90 and the A985 / A921, which provide access to Rosyth and Inverkeithing. The junction is kerbed and is drained by a series of gullies which are situated along the carriageway edge. The junction has a 40mph speed limit.

South of the Firth of Forth

2.2.16 South of the Firth of Forth, the A90 and the M9 Spur form the principal links to Edinburgh and the central Scotland motorway network from the Forth Road Bridge. Figure 2.2 in Appendix A details the existing road network south of the Firth of Forth.

A90 - Forth Road Bridge to Scotstoun Junction

2.2.17 The A90, operated on the immediate approaches to the Forth Road Bridge by FETA and thereafter by the City of Edinburgh Council, provides access to both local and strategic routes. Improvements on the A90, undertaken as part of the M9 Spur Extension contract widened the dual two lane carriageway associated with the Forth Road Bridge, to a dual three lane all purpose (D3AP) carriageway. Taking effect in the proximity of Echline Junction, the D3AP cross section is continued to Scotstoun Junction. The A90 is kerbed from the Forth Road Bridge to Scotstoun Junction and is drained using a combination of gullies and combined kerb drainage systems. The carriageway is lit through this section, with further lighting also being provided on the Scotstoun Junction approaches from the M9 Spur and the A90 (east of the junction).

2.2.18 Further carriageway features include the following:

- A bridge apron on the approach to the Forth Road Bridge;

  The bridge apron provides 2 general traffic lanes in each direction and access to / from Echline Junction, through the provision of a merge slip road northbound, encompassing a single lane for general traffic and a bus lane, and a 2 lane diverge slip road southbound. An abnormal load holding bay is provided northbound on the bridge apron. From the southbound carriageway, access is provided to the FETA compound located to the east.

  Pedestrian and cyclist facilities are also provided on the bridge apron, complementing the footway / cycleways on the Forth Road Bridge. Given that the west footway / cycleway on the Forth Road Bridge is typically used for maintenance access, pedestrians from Echline Junction finding themselves on the west side of the bridge apron are diverted to the east side via the maintenance access road which passes beneath the south abutment. A subway, linking each side of the bridge apron, is also provided. The footway / cycleway on the east side of the bridge apron connects the Forth Road Bridge to the footway on the southbound diverge slip to Echline Junction which in turn provides access to Ferrymuir Gait, which forms a part of National Cycle Route 1.

- Access to / from South Queensferry and West Lothian via Echline Junction;
- A lane gain to the A90 northbound carriageway at Scotstoun Junction, forming the D3AP cross section associated with the route on approach to the Forth Road Bridge;
- A lane drop at Scotstoun Junction from the A90 southbound carriageway (connecting to the M9 Spur) to the A90 and north Edinburgh;
- A 50mph speed restriction from the M9 Spur, south of Scotstoun Junction, to the Forth Road Bridge in both directions, which is also applicable on the A90 approach to Scotstoun Junction from north Edinburgh.

2.2.19 The following points detail existing issues with the design of the A90 south of the Forth Road Bridge:

- Between Echline and Scotstoun, the close proximity of the junctions means that traffic merging and diverging between the junctions has a short weaving distance within which to manoeuvre that is less than that required by current design standards.
- Between the A8000 overbridge and Scotstoun Junction, the A90 also has sections of horizontal geometry and sight distance which do not conform fully to current design standards.
- The merge / diverge layouts at Scotstoun Junction incorporate departures from current design standards.

<u>Echline Junction and connecting Local Roads</u>

Echline Junction

2.2.20 Echline Junction takes the form of a grade separated gyratory. The gyratory, located on bridge structures above the A90, generally provides three circulating lanes (excluding the A90 northbound approach where two lanes are provided), with nearside lane drops to each of the exit arms. The junction facilitates all movements between the A90, the Forth Road Bridge and the A8000 / A904, which provide access to South Queensferry, Kirkliston and West Lothian respectively. A footway is provided across the north of the junction, which facilitates pedestrian movements between the A904, the A8000 and the north facing slip roads of the Forth Road Bridge. The junction is kerbed and is drained by a series of gullies which are situated along the carriageway edge. The junction and its approaches are lit. Traffic flow through the junction is controlled by traffic signals on each of the entry arms and on the gyratory itself.

Local Roads

2.2.21 The A8000 is a distributor road which provides access between Echline Junction, South Queensferry and Kirkliston. Between Echline Junction and Ferrymuir Roundabout, the A8000 (known through this section as Ferrymuir Road) provides two southbound lanes and a single northbound lane. The southbound lanes in conjunction with Ferrymuir Roundabout provide access to South Queensferry, via the B907 (Kirkliston Road), and Ferrymuir Retail Park. South of Ferrymuir Roundabout, the A8000 crosses the A90 via a bridge structure and facilitates onward travel to Kirkliston, passing beneath the M9 Spur at the Humbie Overbridge. The A8000 is kerbed and is drained by a series of gullies which are located along the carriageway edge. North of the A8000 overbridge, a footway is provided on the east side of the carriageway. To the south of the overbridge, a footway is provided to the west side of the carriageway. The speed limit of the road varies along its length. Between the A8000 overbridge and Echline Junction the speed limit is 30mph. South of the A8000 overbridge, the national speed limit (60mph) applies. The road is lit throughout.

2.2.22 The A904 is a distributor road which provides access between Echline Junction and West Lothian. Local road junctions provide access to the B924 (Bo'ness Road) and Builyeon

Road. Between the B924 and Echline Roundabout, a median strip has been introduced along the centre line of the carriageway to provide separation between opposing lanes of traffic. A ghost island junction arrangement is provided to the local services area located north of the A904. The road is kerbed and is drained by a series of gullies which are located along the carriageway edge. A footway is provided to the north of the carriageway which serves a number of properties along the route. The road is lit to the at-grade junction with Headrig Road.

Scotstoun Junction

2.2.23 Scotstoun Junction, constructed as a part of the M9 Spur Extension contract, provides free-flow connectivity to / from the A90 and the M9 Spur to / from the Forth Road Bridge. The M9 Spur forms the principal route through the junction with the westbound slip road from the A90 passing beneath the motorway extension. The eastbound and westbound slip roads to / from the A90 are formed through the use of a lane drop / lane gain arrangement, enabling the cross-section transition between the A90 (D3AP) and the M9 Spur, a dual two lane motorway (D2M). Scotstoun Junction makes no provision for a slip road connection between the M9 Spur northbound and the A90 towards Edinburgh or between the A90 from Edinburgh to the M9 Spur southbound. The junction is kerbed and drained by a series of gullies which are located along the carriageway edge. The junction is lit throughout.

M9 Spur - Scotstoun Junction to M9 Junction 1a

2.2.24 The M9 Spur, encompassing the M9 Spur Extension completed in 2007, provides a dual two lane motorway (D2M) between Scotstoun Junction and M9 Junction 1a. Running parallel to the Falkirk-Fife Railway Line between Scotstoun Junction and Humbie Overbridge, the route has replaced the A8000 as the principal route between the M9 and the Forth Road Bridge. The route has a 70mph speed limit between the Dolphington Burn and M9 Junction 1a. On the new section of carriageway, drainage is provided through filter drains which are located within the carriageway verges. The older section of carriageway between Humbie Railway Bridge and M9 Junction 1a is drained by a series of gullies located at the carriageway edge.

2.2.25 In the provision of the M9 Spur Extension, a number of new structures and culverts have been constructed, crossings being situated at Dolphington Burn, Milton Farm Road and the B800. The construction of this section of the route was funded by FETA with grant assistance from the Scottish Government. It is operated by the City of Edinburgh Council. The original M9 Spur section between M9 Junction 1a and the Humbie Railway Bridge forms a part of the Scottish Trunk Road Network and is maintained by BEAR Scotland Ltd on behalf of Transport Scotland.

M9 Junction 1a

2.2.26 The provision of access between the M9 and the M9 Spur is facilitated through a free-flow interchange arrangement at M9 Junction 1a. Providing only east facing connectivity to / from the M9, a loop connects the M9 westbound to the M9 Spur northbound, a simple slip road arrangement providing connectivity between the M9 Spur southbound and the M9 eastbound.

2.2.27 The loop providing access from the M9 westbound to the M9 Spur northbound provides a single lane to all traffic and is the subject of a 30mph advisory speed limit. The single lane means that slow moving traffic negotiating the loop can have a significant effect on traffic flow. A second lane becomes available for traffic wishing to overtake on the M9 Spur, beyond the M9 overbridge.

2.2.28 On approach to M9 Junction 1a, the D2M cross section associated with the M9 Spur southbound carriageway narrows to a single general traffic lane. The narrowing to a single lane can result in congestion and a bunching of traffic on the slip road, which can in turn lead to interaction difficulties with traffic on the M9 given the short weaving section between M9 Junction 1a and Newbridge Roundabout (M9 Junction 1).

M9 - Newbridge Roundabout (M9 Junction 1) to M9 Junction 1a

2.2.29 The M9 between Newbridge Roundabout and M9 Junction 1a provides three general traffic lanes and a hard shoulder in each direction, the third lane, an auxiliary lane, being generated through the provision of a lane drop / lane gain arrangement between the junctions.

2.2.30 The following points detail existing issues with the design of M9 Junction 1a and the M9 mainline carriageway:

- The close proximity of the slip roads associated with Newbridge Roundabout and M9 Junction 1a means that traffic merging and diverging between the junctions has a short weaving distance within which to manoeuvre.
- The M9, in proximity to M9 Junction 1a, contains sections of horizontal geometry and sight distance that are lower than current desirable design standards.
- The M9 Spur southbound to M9 eastbound slip road and the M9 westbound to M9 Spur northbound slip road / loop have similar features.
- The diverge layout from the M9 westbound to the M9 Spur and the merge layout from the M9 Spur southbound to the M9 eastbound do not conform fully to current design standards.

2.3 Land Based Structures

2.3.1 The structure referencing system used in this DMRB Stage 3 Scheme Assessment Report has been amended from that used in the DMRB Stage 2 Corridor Report. It is a stand alone project based referencing system which does not correlate with any existing system that might be in use by Transport Scotland or BEAR Scotland Ltd. Previous DMRB Stage 2 Corridor Report references used for each structure are given in brackets.

North of the Firth of Forth

2.3.2 Following the finalisation of the scheme definition, the physical road works necessary in the implementation of the proposed scheme requires consideration to be given to existing structures between the Forth Road Bridge and Admiralty Junction. From Admiralty Junction north no existing structures will be affected by the proposed scheme.

2.3.3 The locations of the existing structures which may be affected are shown in Figure 2.1 in Appendix A.

Structure FT06E (previously Structure 177-4)

2.3.4 Structure FT06E carries the existing A90 over the southern leg of the existing Ferrytoll Junction. It is a single span structure with a clear span length of 11.89m between abutments. The bridge is square and consists of an insitu reinforced concrete portal frame of integral construction founded on spread footings.

Structure FT07E (previously Structure 177-5)

2.3.5 Structure FT07E carries the existing A90 over the northern leg of the existing Ferrytoll Junction. It is a single span structure with a clear span length of 11.89m between abutments. The bridge is square and consists of an insitu reinforced concrete portal frame of integral construction founded on spread footings.

Structure FT08E (previously Structure 177-10)

2.3.6 Structure FT08E is the existing Ferrytoll Railway Tunnel and carries the A90 over the Inverkeithing South Junction – Rosyth Dockyard Branch Line Railway at Ferrytoll Junction. It is a single span structure with an overall length of approximately 95m and a clear span of 4.95m at a varying skew. It is a concrete arch structure comprising precast arch beam units supported on mass concrete abutments founded on spread footings.

Structures FT09E and FT10E (previously Structures 177-11 and 177-12)

2.3.7 Structure FT09E is located adjacent to structure FT10E. It is a single span structure with a skew span of 20.5m at a skew of 23°. It comprises a precast beam and slab structure of integral construction founded on spread footings and was built circa 2006. The deck slab of this structure butts onto the parapet wall of Structure FT10E.

2.3.8 Structure FT10E carries the B980 (Castlandhill Road) over the Inverkeithing South Junction – Rosyth Dockyard Branch Line Railway close to the entrance / exit to the tunnel FT08E described above. It is a single span structure with a span of 5.88m at a skew of 23° and comprises a concrete arch of integral construction. The foundation type is unknown.

Structure FT13E – Jamestown Viaduct

2.3.9 Structure FT13E carries the Edinburgh to Aberdeen Railway Line across the B981 (Hope Street) and the Inverkeithing South Junction – Rosyth Dockyard Branch Line Railway. It is a six span viaduct comprising two masonry arch end spans and four main spans. Each main span consists of two braced riveted steel trusses. Stonework abutments and piers support the main spans.

2.3.10 The arched end spans of the structure have a clear square span of 17m and the main spans each have a skew span of 33.5m between the supports, with a skew angle of approximately 70 degrees. Headroom to the underside of the main girders from both the B981 and the branch line is in excess of 12m.

Structure FT14E – Dunfermline Wynd Overbridge

2.3.11 Structure FT14E carries Dunfermline Wynd Road over the existing A90. It is a three span overbridge comprising a 32.156m main span and 19.812m end spans. The superstructure comprises a reinforced concrete deck with propped cantilever end spans and a voided suspended slab centre span. The bridge is square and the superstructure is supported on reinforced concrete piers on spread footings and reinforced concrete piled bankseat abutments.

South of the Firth of Forth

2.3.12 The physical road works necessary in the implementation of the proposed scheme south of the Firth of Forth requires consideration to be given to a number of existing structures in proximity to Scotstoun Junction and M9 Junction 1a.

2.3.13 The locations of the existing structures which may be affected are shown in Figure 2.2 in Appendix A.

Structure ESQ08E (previously Structure 239-3)

2.3.14 Structure ESQ08E carries the A8000 over the A90. It is a two span bridge with an overall length of 29.6m comprising a maximum span of 14.8m at a skew of 20°. It is an insitu slab structure supported on reinforced concrete abutments and pier on spread footings.

Structure ESQ09E

2.3.15 Structure ESQ09E is an existing structure which carries the A90 over the railway lines to the southwest of Dalmeny and consists of a preflex beam and concrete infill type deck slab. Existing parapets are of masonry construction and a service trough is provided in the verges adjacent to the parapets.

Structure ESQ10E

2.3.16 Structure ESQ10E is an existing structure which carries the A90 over Standingstane Road and consists of an insitu reinforced concrete deck slab with deck edge cantilevers which accommodate a number of services.

Structure M905E (previously Structure 167-7)

2.3.17 Structure M905E carries the M9 over Overton Road, west of M9 Junction 1a. It is a two hinged reinforced concrete portal structure with a clear square span of approximately 7.75m at a skew of 18°.

Structure M906E (previously Structure 167-10)

2.3.18 Structure M906E carries the M9 Spur over the M9. It is a three span structure with spans of 20.1m, 43.9m and 20.1m. It is a steel / concrete composite structure with the piers founded on spread footings and abutments supported on piles.

Structure M907E (previously Structure 167-8)

2.3.19 Structure M907E is an insitu reinforced concrete twin barrel culvert carrying the M9 Spur southbound to M9 eastbound slip road over the Swine Burn. It has an overall length of 142m and each barrel has a span of 1.5m and 1.8m headroom.

Structure M908E (previously Structure 167-5)

2.3.20 Structure M908E carries the M9 Spur over the B9080. It is a single span bridge with a clear span of 14.2m with a skew angle of 2°. The northbound and southbound carriageways are each carried on separate decks which comprise of precast pretensioned beams with solid infill. The decks are transversely post tensioned with Macalloy bars. The abutments comprise reinforced concrete counterfort walls supported on bored piles.

Structure M909E – River Almond Bridge

2.3.21 Structure M909E carries the A90 over the River Almond. It is a three span, twin deck continuous structure with each deck comprising 7 no. steel universal beams supporting a 200mm thick reinforced concrete deck slab. Separate decks carry the north and southbound carriageways.

2.3.22 The superstructure is supported on skeletal, spill through full height reinforced concrete abutments, comprising crossheads supporting eight no. vertical tapering columns and spread footings. The intermediate piers consist of reinforced concrete beams supported on 4 no. discrete columns supported on spread foundations on rock.

Structure M910E – Tributary of Swine Burn Culvert

2.3.23 Structure M910E is a precast reinforced concrete box culvert carrying the M9 over the tributary of Swine Burn. It has an overall length of 139m with a span of 2.6m and 1.82m headroom.

Structure M911E – Subsidiary of Niddry Burn Culvert

2.3.24 Structure M911E is a 700mm diameter pipe culvert carrying the M9 over a subsidiary of the Niddry Burn. It has an overall length of 54m.

Structure M912E – Niddry Burn Culvert

2.3.25 Structure M912E is a precast reinforced concrete box culvert carrying the M9 over Niddry Burn. It has an overall length of 82m with a span of 1.8m.

2.4 Existing Traffic Patterns

North of the Firth of Forth

2.4.1 Annual Average Daily Traffic (AADT) volumes for 2005, at selected points along the M90 north of the Firth of Forth are summarised in Figure 2.3 in Appendix A. The traffic volume data was derived from the Transport Model for Scotland (TMfS:05A) (see Section 5.2 for the methodology) and indicates that the most heavily trafficked sections of the M90 north of the Firth of Forth are between Masterton (M90 Junction 2) and Admiralty (M90 Junction 1), and from Admiralty through Ferrytoll Junction to the north bridgehead.

2.4.2 Figure 2.4 in Appendix A indicates the relative proportion of southbound Forth Road Bridge traffic travelling to different destinations.

Congestion

2.4.3 Congestion in the form of southbound queues approaching the Forth Road Bridge is a regular feature, predominantly in the weekday AM peak, and this queue can extend for several kilometres during the busiest part of the peak period. The close spacing of the junctions approaching the Forth Road Bridge contributes to the formation and extension of queues in the morning as traffic attempts to join the southbound carriageway from Masterton, Admiralty and Ferrytoll Junctions.

South of the Firth of Forth

2.4.4 2005 Annual Average Daily Traffic (AADT) volumes were derived from the Transport Model for Scotland (TMfS:05A) for key Forth Road Bridge connections south of the Firth of Forth. These are summarised in Figure 2.3 in Appendix A.

2.4.5 The data presented in Figure 2.3 in Appendix A represents the 2005 modelled network traffic flows, prior to the opening of the M9 Spur Extension between M9 Junction 1a and the A90 at Scotstoun Junction in 2007 and removal of tolls from the Forth Road Bridge in February 2008. The M9 Spur Extension replaced the A8000 as part of the route between the M9 and Echline Junction. As indicated in Tables 2.1 and 2.2, during the weekday morning and evening peaks respectively, traffic on the M9 Spur increased between 2006 and 2008 whilst traffic on the A90 reduced over the same period. This suggests a transfer of some traffic from the A90 to the M9 Spur.

Table 2.1: Effect of the M9 Spur Extension and toll removal on A90 and M9 Spur Traffic Flows (Morning Peak)

Count Year	A90		M9 Spur	
	Northbound	Southbound	Northbound	Southbound
2006	1500	1500	900	1200
2008	1300	1400	1400	1300
Total vehicle change	-200	-100	+500	+100
Percentage change	-13	-7	+56	+8

Note: Morning Peak, 0800-0900 hours. Units are total vehicles, to the nearest 100. Data derived from Transport Scotland Automatic Traffic Counters.

Table 2.2: Effect of the M9 Spur Extension and toll removal on A90 and M9 Spur Traffic Flows (Evening Peak)

Count Year	A90		M9 Spur	
	Northbound	Southbound	Northbound	Southbound
2006	2200	2200	900	1000
2008	1900	1300	1500	1400
Total vehicle change	-300	-900	+600	+400
Percentage change	-14	-41	+67	+40

Note: Evening Peak, 1700-1800 hours. Units are total vehicles, to the nearest 100. Data derived from Transport Scotland Automatic Traffic Counters.

Congestion

2.4.6 Congestion in the form of northbound queues approaching the Forth Road Bridge is a regular feature of the weekday PM peak. These queues are largely as a result of 2 lanes from the A90 merging with 2 lanes from the M9 Spur into 3 lanes and then into 2 lanes as the road passes beneath Echline Junction. At this point, traffic from Echline merges with the bridge traffic, further adding to the congestion effects. Northbound between Newbridge and Scotstoun, via the M9 Spur, the route operates relatively well as congestion at Newbridge tends to constrain the release of Forth Road Bridge bound traffic.

2.4.7 In the AM period, southbound traffic queues on the M9 Spur. Completion of the M9 Spur has encouraged some southbound traffic to re-route to the M9, from the A90 (to Barnton). This increased traffic regularly forms a queue on the M9 Spur as it approaches M9 Junction 1a. The M9 Spur narrows from 2 lanes to 1 lane as it merges with the motorway and this narrowing of the carriageway contributes to queue formation at this location. Weaving traffic on the M9 southeast of Junction 1a causes congestion and, more significantly, traffic queues from high traffic demand entering Newbridge Roundabout, resulting in tail backs on a day to day basis.

2.5 Impacts due to Incidents and Maintenance

2.5.1 Due to the combination of a busy road, closely spaced junctions and a mix of continuous and discontinuous hard shoulders, any incident which results in a blockage during the busy AM or PM periods has an immediate and significant impact on traffic speed and congestion levels on the Forth Road Bridge and its approaches. The lack of hard shoulders on the bridge means that even a relatively minor incident, such as a breakdown, generally results in the loss of one of the available traffic lanes. Therefore, when a lane is blocked in the busy periods large queues and delays quickly build up until the blockage is removed.

2.5.2 Once the blockage has been removed and all traffic lanes are available, the pressure from built up queues and congestion means that the available capacity is not as high, in the available lanes, as it was before the incident occurred. Therefore, the impact of an incident lasts beyond the time taken to recover a vehicle, the road network taking time to recover to normal operation where traffic is able to flow smoothly.

2.5.3 Traffic management, requiring lane closures, is implemented periodically to allow necessary road and bridge maintenance. Works tend to be implemented overnight, to avoid impacting on peak traffic demand and hence avoid significant delays. However, some works require weekend restrictions. The traffic demand across the Forth Road Bridge, during the weekend can be high. Between the hours of 10.00 am and 6.00 pm on Saturdays and Sundays, the traffic volumes across the bridge are similar to interpeak weekday traffic levels. Consequently, the closure of a lane at the weekend can significantly impact the normal traffic demand, resulting in significant delays. Occasionally, maintenance works require closure of one carriageway on the Forth Road Bridge over the weekend. On these occasions, the traffic demand drops in response to the extensive delays which occur at busy periods, during the weekend.

Forth Road Bridge – Unplanned Incidents

2.5.4 Disruption to Forth Road Bridge traffic flow can be caused by a variety of unplanned incidents on or near the crossing. These incidents take a variety of forms, including strong winds, poor visibility and poor road surface conditions resulting from fog, rain, ice and snow, and vehicle breakdowns and accidents. Where weather events have an effect on the operation of the Forth Road Bridge the following measures are typically deployed:

- Strong Winds – combination of speed restrictions and bridge closures to specific classes of vehicle, depending on severity (refer to Strong Wind Procedures).
- Poor visibility – speed limit reduction to 40mph with flexibility for further restrictions in extreme circumstances.
- Poor Road Surface Conditions (Skid Risk) – Speed limit reduction generally to 40mph, with flexibility for further restrictions in extreme circumstances.
- Accidents and Breakdowns – Lane / carriageway closures depending upon the severity of the event (refer to Accidents and Breakdowns).

Strong Wind Procedures

2.5.5 In the operation of the Forth Road Bridge, the most frequent form of unplanned disruption results from strong winds. Table 2.3 details the strong wind procedures implemented by FETA and the frequency of their occurrence between 2006 and 2008.

Table 2.3: Forth Road Bridge Strong Wind Procedures and Wind Event Frequency (2006 - 2008)

Wind Event	Restriction	3 Year Total Duration (hours)	Average Duration (hours)	Percentage Frequency
Winds with gusts exceeding 35mph with a rising wind pattern	• 40mph speed limit on bridge	1841	6	7
Winds with gusts exceeding 45mph with a rising wind pattern	• Closure to double decker buses	549	5	2
Winds with gusts exceeding 50mph with a rising wind pattern	• Closure to high sided vehicles, three wheeled vehicles, motorcycles, pedestrians and cyclists	421	5	2
Winds with gusts exceeding 65mph with a rising wind pattern	• Closure to all vehicles except cars. • 30mph speed limit of bridge.	75	4	0
Winds with gusts exceeding 80mph with a rising wind pattern	• Closure to all traffic.	5 (1 event only)	5	0

Forth Road Bridge – Accident and Breakdown Information

2.5.6 Between 2006 and 2008, a total of 420 vehicle incidents were recorded by FETA on the Forth Road Bridge, encompassing 72 accidents and 348 breakdowns. This equates to an average of 140 incidents per year.

2.5.7 When an incident occurs on the Forth Road Bridge or its immediate approaches, FETA deploys its own recovery vehicles to the scene. It is supported in recovery operations by the Emergency Services and third party operators where required. During unrestricted operation, the average time taken to clear an incident from the Forth Road Bridge is 22 minutes.

Comparison of Accident Rates

Forth Road Bridge

2.5.8 Not being part of the trunk road network, it is not possible to compare the Forth Road Bridge against a particular road type, hence the following comparison between observed annual accident rates and the Scottish annual accident rates is based on the bridge as a non-built up trunk road.

2.5.9 The results of the comparison for accident rates show that observed accidents on the Forth Road Bridge are significantly less than for the Scottish average annual values (0.089 P.I.A/MVKm compared to 0.149 P.I.A/MVKm respectively). The severity of the incidents are comparably much lower (0.063 P.I.A/MVKm compared to 0.259 P.I.A/MVKm for the observed and Scottish values respectively).

Existing Road Network

2.5.10 A comparison of annual accident rates for the period 2003-2007 for the road network in the Forth Road Bridge study area against the Scottish average accident rate for the same time period for the same locations has been undertaken. The following is interpretative of these comparisons for locations on the mainline carriageway within the proposed scheme's study area.

North of the Firth of Forth

2.5.11 Between Admiralty and Masterton along the M90, the observed accident rate is higher than the Scottish average values (0.138 P.I.A/MVKm compared to 00.071 P.I.A/MVKm). The severity however, is much lower in the observed case (0.087 P.I.A/MVKm against the Scottish average value of 0.153 P.I.A/MVKm).

2.5.12 The A90 between the north bridgehead and Admiralty via Ferrytoll shows that the observed accident rate values are less than the Scottish average (0.218 P.I.A/MVKm and 0.228 P.I.A/MVKm respectively). The severity however, is higher in the observed case (0.286 P.I.A/MVKm and 0.259 P.I.A/MVKm respectively).

South of the Firth of Forth

2.5.13 The M9 Spur between M9 Junction 1a and Humbie Overbridge is a section of carriageway which prior to the construction of the M9 Spur Extension connected the M9 to the A8000 via Humbie Roundabout. At this site, the observed annual accident rate is higher than the Scottish average accident rate (0.190 P.I.A/MVKm versus 0.071 P.I.A/MVKm respectively); however, the severity rate of the observed accidents is much lower than those from the Scottish average severity.

2.5.14 The A8000 has been replaced as the principal route between the Forth Road Bridge and the central Scotland Motorway network by the M9 Spur Extension, completed in 2007. At the time of writing this report, no accident data is available for the newly constructed section of carriageway.

3 Description of the Scheme

3.1 Introduction

3.1.1 The following sets out the description of the proposed scheme presented for DMRB Stage 3 assessment and forms the basis for the environmental assessment. The design continues to be developed and refined. It is anticipated that the main elements of the proposed scheme will be procured under a Design and Build (D&B) contract. Under this form of contract the contractor will be required to develop the detailed design in accordance with the Environmental Statement. The design of the project may be refined but will still be deemed to comply with the Environmental Statement provided that such refinements incorporated in the design will be subject to environmental review to ensure that residual impacts will be no worse than those reported.

3.2 Scheme Length and Cross Section Details

3.2.1 The proposed scheme encompassing the Main Crossing and the immediate road infrastructure required in its connection measures approximately 8km. Further enhancements include the upgrade of M9 Junction 1a, the provision of dedicated public transport links to / from the Forth Road Bridge and the implementation of an Intelligent Transport System. For reporting purposes, the proposed scheme has been split into the following sections:

Main Crossing and Forth Road Bridge

3.2.2 The Main Crossing and Forth Road Bridge will provide the following functionality as a part of the proposed scheme:

- The Main Crossing, constructed as a cabled-stayed bridge with three towers and a single level deck with wind shielding, will provide two general traffic lanes and a widened hard shoulder in each direction; and
- The Forth Road Bridge, as a public transport crossing, will cater for buses, taxis, motorcycles with engine capacity of 50cc or less and pedestrians and cyclists, through revised connections to the strategic and local road network north and south of the Firth of Forth.

Road Infrastructure - North of the Firth of Forth

3.2.3 Approximately 2.4km of improvements between the Main Crossing and Admiralty Junction, encompassing:

- 1km of offline road construction linking the Main Crossing to the A90;
- the reconstruction of Ferrytoll Junction;
- 1.4km of online improvements between Ferrytoll Junction and Admiralty Junction;
- associated side road improvements; and
- the provision of public transport links to the Forth Road Bridge.

Road Infrastructure - South of the Firth of Forth

3.2.4 Approximately 3km of improvements between the A90 at Scotstoun Junction and the Main Crossing, encompassing:

- 2.6km of offline road construction;
- the provision of a new junction at South Queensferry;

- associated side road improvements; and
- the provision of public transport links to the Forth Road Bridge.

3.2.5 The improvements to be implemented south of the Firth of Forth include the enhancement of M9 Junction 1a to provide functionality in all directions for traffic between the M9 and the M9 Spur. The works will also include carriageway upgrades to the M9, south of M9 Junction 1a.

Intelligent Transport System (ITS)

3.2.6 Provision of ITS along a 22km corridor extending from the M90 Halbeath Junction over the Main Crossing to the M9 north of Newbridge Roundabout (M9 Junction 1). Overhead signal gantries along the corridor will provide lane control, variable mandatory speed control and incident detection. Strategic and tactical traffic information will be provided to drivers via variable message signs (VMS).

3.2.7 Plan and profile drawings detailing the extent of the road infrastructure works north and south of the Firth of Forth are contained within Appendix A, and are cross referenced throughout this chapter.

3.2.8 The proposed carriageway cross sections for the strategic and local road network within the Stage 3 design are detailed in Table 3.1 and in Figures 3.1 and 3.2 of Appendix A.

Table 3.1: Proposed Cross Sections

D2M (widened hard shoulder)		**D3M**	
Verge:	1.5m	Verge:	1.5m
Hard Shoulder	4.2m	Hard Shoulder:	3.3m
Carriageway:	7.3m	Carriageway:	11.0m
Hard Strip:	0.7m	Hard Strip:	0.7m
Central Reserve:	3.1m	Central Reserve:	3.1m
Hard Strip:	0.7m	Hard Strip:	0.7m
Carriageway:	7.3m	Carriageway:	11.0m
Hard Shoulder	4.2m	Hard Shoulder:	3.3m
Verge:	1.5m	Verge:	1.5m
Total Width	**30.5m**	**Total Width**	**36.1m**
S2 – Rural		**S2 – Urban**	
Verge:	2.5m	Verge:	2m
Hard Strip:	1m	Hard Strip:	N/A
Carriageway:	7.3m	Carriageway:	7.3m
Hard Strip:	1m	Hard Strip:	N/A
Verge:	2.5m	Verge:	2m
Footway / cycleway required in some locations in addition to standard cross section.		*Footways and footway / cycleway required in some locations in addition to standard cross section.*	
Total Width	**14.3m**	**Total Width**	**11.3m**

3.2.9 A more detailed description of the proposed scheme is provided in the Sections 3.3, 3.4 and 3.5.

3.3 Main Crossing and the Forth Road Bridge

Main Crossing

General

3.3.1 Sited upstream of the Forth Road Bridge, the Main Crossing consists of a three tower cable-stayed bridge and a southern approach viaduct. The total length of the Main Crossing is approximately 2.7km.

3.3.2 Figure 3.3 in Appendix A provides an indicative layout of the Main Crossing relative to the Firth of Forth and indicative cross sections of the bridge deck.

3.3.3 Situated on a navigable waterway where approximately 5,500 vessel transits occur per year, the Main Crossing provides a navigational clearance envelope of 47.85m AOD for shipping using the Forth Deep Water Navigation Channel (situated beneath the southern 650m main span and providing access to upstream ports such as Grangemouth) and the Rosyth Navigation Channel (situated beneath the northern 650m main span and serving Rosyth Dockyard).

3.3.4 The Main Crossing has been designed with sufficient capacity to withstand the impact forces from accidental collision by larger ships, appropriate to the risk of such occurrence.

3.3.5 The foundations for the main towers and the marine piers for the Main Crossing are envisaged as prefabricated cellular caissons. The central tower caisson can be placed upon Beamer Rock to provide a spread footing foundation. The flanking towers and marine piers will be supported on large diameter piles socketed into rock. The land based pier foundations will be spread footing foundations.

3.3.6 The deck of the Main Crossing will take the form of either an orthotropic steel box deck or composite steel / concrete box deck. The deck will be assembled into complete structural units from steelwork components. For the composite deck option, the concrete slab will be formed on the unit (in-situ or precast). The length of the units will match the spacing of the cable stays. Parallel strand cable stays are proposed for both options.

3.3.7 Two options are currently being considered for the structural form of the approach viaducts to the Main Crossing; composite box girders or concrete box girders.

3.3.8 The proposed cross section to be implemented on the Main Crossing will be to dual two lane motorway (D2M) standard with widened hard shoulders. The provision of widened hard shoulders shall give flexibility in the use of the Main Crossing. Hard shoulder running may be required during times of maintenance, or where the Forth Road Bridge is unable to fulfil its role as a public transport crossing for wind sensitive vehicles during periods of high winds. The provision of a sufficient width of deck on the Main Crossing would also allow the rearrangement of the bridges functions, with possibilities to adapt the cross section to encompass a multi-modal corridor and dual two lane carriageway, or a footway / cycleway with a dual two lane carriageway.

3.3.9 North of the Firth of Forth, the Main Crossing will land on St Margaret's Hill, east of Admiralty House. The land based approach viaduct provided as a part of the proposed road infrastructure design will connect the Main Crossing to the strategic and local road network (refer to Section 3.4.6).

3.3.10 South of the Firth of Forth, the Main Crossing will connect to an approach viaduct, extending from Echline Field into the Firth of Forth, west of Port Edgar Marina. A new section of offline carriageway, as described in Section 3.4, will connect the Main Crossing to the strategic and local road network.

3.3.11 Sub-stations providing power to the Main Crossing will be sited in proximity to north and south abutments located at St Margaret's Hill and Echline Field respectively. Maintenance access will be provided to these sites as described in Section 3.4.

Forth Road Bridge – Public Transport Crossing

3.3.12 As detailed in Chapter 2, the improved prognosis for the future use of the Forth Road Bridge has led to it being adopted within the scheme proposals as a public transport crossing. The bridge will cater for bus and taxi services, motorcycles with an engine capacity of 50cc or less and pedestrians and cyclists, with possibilities for future adaption to accommodate a Light Rapid Transit (LRT) system in the form of a high quality bus network, guided bus way or tram system.

3.3.13 Figure 3.4 in Appendix A indicates the potential utilisation of the Forth Road Bridge upon opening of the proposed scheme and a possible adaptation for use by LRT in future years.

3.3.14 North of the Firth of Forth, the Forth Road Bridge will be accessed from the reconstructed Ferrytoll Junction upon opening of the Main Crossing. The provision of public transport lanes to the Forth Road Bridge will complement the development of Ferrytoll Park and Ride as a part of the proposed scheme and are described in more detail in Section 3.4 (Ferrytoll Junction and Local Road Connections).

3.3.15 South of the Firth of Forth, it is proposed that access for northbound public transport be provided via a new dedicated slip road between the A90 at Scotstoun Junction and the A8000. The A8000 (Ferrymuir Road) will then carry public transport to the Forth Road Bridge via Echline Junction. Southbound, a dedicated public transport lane is proposed, utilising the existing carriageway departing the Forth Road Bridge and Echline Junction. From Echline Junction, the public transport lane will provide direct access to Edinburgh via the A90, east of Scotstoun Junction. The provision of these public transport links is described in more detail in Section 3.4 (South of the Firth of Forth, Public Transport Links).

3.4 Road Infrastructure

North of the Firth of Forth

3.4.1 North of the Firth of Forth, the Stage 3 design for the proposed scheme consists of an offline section of new carriageway from the Main Crossing to Ferrytoll Junction and upgrades to the existing A90 carriageway as far as Admiralty Junction. The mainline carriageway has been designed in accordance with the Design Manual for Roads and Bridges and has a design speed of 120kph.

3.4.2 Plans and long sections detailing the Stage 3 design are shown on Figures 3.5 to 3.15 contained in Appendix A.

3.4.3 The proposed scheme north of the Firth of Forth has been sub-divided into the following sections:

- Mainline Carriageway - Main Crossing to Ferrytoll Junction
- Mainline Carriageway - Ferrytoll Junction to Admiralty Junction; and
- Ferrytoll Junction and Local Road Connections

<u>Mainline Carriageway - Main Crossing to Ferrytoll Junction</u>

3.4.4 From the abutment of the Main Crossing located at St Margaret's Hill, the mainline carriageway descends on a left hand R720m curve at a gradient of 3.7% towards Ferrytoll Junction, clipping the eastern perimeter of St Margaret's Marsh, south of Dunfermline Water

Treatment Works. Constructed offline, this section complements the cross section of the Main Crossing, providing a carriageway to dual two lane motorway (D2M) standard with widened hard shoulders.

3.4.5 The provision of widened hard shoulders, matching the hard shoulders on the Main Crossing, will provide flexibility in the use of the mainline carriageway through this section.

3.4.6 A 350m viaduct will carry the mainline carriageway from the abutment of the Main Crossing at St Margaret's Hill towards Ferrytoll Junction. A further structure is required for the northbound diverge slip road. Through the junction area, new and existing bridge structures will carry the mainline carriageway. Retaining walls and new rock cuttings will be required at Ferry Hills to facilitate the construction of the proposed scheme given the topographical constraints of the area.

<u>Mainline Carriageway - Ferrytoll Junction to Admiralty Junction</u>

3.4.7 North of Ferrytoll Junction, online improvements to the existing A90 will be undertaken.

3.4.8 Northbound, the proposed scheme will increase the number of traffic lanes available between the Ferrytoll and Admiralty junctions from two to three. The additional lane will operate as an auxiliary lane, assisting weaving traffic movements through this section. The auxiliary lane will be formed through a lane gain arrangement from the Ferrytoll Junction northbound merge slip road and will terminate to the northbound diverge slip road at Admiralty Junction. A hard shoulder will be provided through this section, although it will be discontinuous in proximity to the Dunfermline Wynd Overbridge. The provision of a hard shoulder will require a reconfiguration of the earthworks slopes to the west of the mainline carriageway.

3.4.9 Southbound, the A90 shall continue to operate in its current form with lanes two and three providing access to the Main Crossing. Lane one, an auxiliary lane from Admiralty Junction, will continue to provide dedicated access to Ferrytoll Junction and onward travel to Inverkeithing, North Queensferry, Rosyth, Rosyth Dockyard and Ferrytoll Park and Ride.

<u>Ferrytoll Junction and Local Road Connections</u>

3.4.10 Ferrytoll Junction will be fully reconstructed. Sited north of the existing junction location, the new grade separated gyratory will be larger than its predecessor, requiring a new rock cutting to the northwest. Operationally, the junction will be signalised and will provide strategic and local road connections, including links to the Forth Road Bridge in its role as a public transport crossing.

3.4.11 The northern bridge structure supporting the A90 at the existing junction will be widened and utilised as the southern bridge structure in the new arrangement. A new structure will enable the mainline carriageway to bridge the junction at its northern end. To the west, the existing structures carrying the B980 (Castlandhill Road) over the Rosyth Dockyard Branch Line Railway will be modified to carry the new gyratory. A further structure spanning the Rosyth Dockyard Branch Line Railway to the east side of the existing junction will also be retained as a part of the proposed scheme.

3.4.12 The slip road design provided as a part of the Stage 3 design for Ferrytoll Junction is as follows:

Northbound Diverge

3.4.13 The northbound diverge from the Main Crossing will consist of a single lane with a widened hard shoulder. On approach to the junction, the slip road will merge with the northbound public transport link, which connects to the existing A90 and the Forth Road Bridge, forming a two lane entry to Ferrytoll Junction. During periods where the Forth Road Bridge is unavailable for public transport use, the widened hard shoulder on the Main Crossing slip road will act as a public transport lane, complementing the hard shoulder flexibility offered by the Main Crossing.

Northbound Merge

3.4.14 The northbound merge to the mainline carriageway will consist of a single lane with widened hard shoulder and will be constructed on the line of the existing B980 (Castlandhill Road). This slip road will form the lane gain / lain drop arrangement to be provided between the Ferrytoll and Admiralty junctions, assisting weaving movements through this section. The provision of a widened hard shoulder will enable future road enhancements to be considered north of Ferrytoll Junction in future years.

Southbound Diverge

3.4.15 The southbound diverge from the mainline carriageway to Ferrytoll Junction will consist of a two lane slip road with a widened hard shoulder. The hard shoulder will be allocated for use by bus traffic, providing access to the Ferrytoll Park and Ride facility whilst complementing the other public transport measures being implemented as part of the proposed scheme. The provision of the new slip road as part of the proposed scheme requires a re-profiling of the existing rock cut to the east of the mainline which will encroach on the land occupied by Inverkeithing Cemetery.

Southbound Merge

3.4.16 Departing Ferrytoll Junction, the southbound merge will provide access to the Main Crossing and the Forth Road Bridge. From the junction bellmouth, the slip road will provide two lanes for general traffic and a dedicated public transport lane. The dedicated public transport lane will diverge to the existing A90, retained to provide access to the Forth Road Bridge. The slip road to the Main Crossing will narrow from two lanes to a single lane for general traffic and will provide a widened hard shoulder. The widened hard shoulder will act as a public transport lane to the Main Crossing when the Forth Road Bridge is unavailable for use. The provision of the new slip road will require the existing rock cut to the west of the Edinburgh to Aberdeen Railway Line to be re-profiled. The slip road on approach to the Main Crossing will be ramp metered to assist the flow of traffic during peak periods.

Local Road Connections

3.4.17 The B981, providing access to North Queensferry, will be realigned over part of its length and will be the subject of a 40mph speed restriction. A new offline section of carriageway will be constructed, connecting the existing road at St Margaret’s Hill to Ferry Toll Road via an at-grade junction, west of Dunfermline Waste Water Treatment Works. On approach to the new junction, a bridge structure will be required, carrying the realigned carriageway over the Rosyth Dockyard Branch Line Railway. In the provision of this new section of carriageway, new junctions will be required providing access to Admiralty House and Dunfermline Waste Water Treatment Works. A new access road to Admiralty House will also provide maintenance access to the north abutment of the Main Crossing and to a drainage detention basin located on the southern perimeter of St Margaret’s Marsh. A sub-station providing power to the Main Crossing will also be accessed via a new track from the B981.

3.4.18 The form of at-grade junction to be provided between the B981 and Ferry Toll Road as part of the proposed scheme is the subject of ongoing development. The final junction arrangement may take the form of a roundabout or a traffic signal controlled crossroads. The preferred layout will be determined from further traffic analysis on this section of carriageway. For the purposes of DMRB Stage 3 assessment, the junction is detailed as a roundabout.

3.4.19 The B980 (Castlandhill Road), providing access to Rosyth, will be realigned at its southern end as part of the proposed scheme. Passing through farmland located to the east of Castlandhill Woods, the realigned section of carriageway will require significant cut slopes to implement. A new at-grade signalised junction will be provided to Ferry Toll Road, west of the existing junction location. The realignment of this local route will remove the current interaction between local traffic commuting to / from Rosyth and strategic traffic wishing to access the A90 northbound. The realigned section of carriageway will have a 40mph speed limit.

3.4.20 The junction approaches associated with Ferry Toll Road and the B981 (Hope Street) will be re-profiled to interact with the new gyratory and will have 40mph and 30mph speed limits respectively.

Ferrytoll Park and Ride

3.4.21 The access and egress arrangements to Ferrytoll Park and Ride will be revised. A new signalised entry and exit arrangement on to the B981 (Hope Street) will be provided for bus traffic in proximity to the proposed gyratory. The pick up and set down area utilised by bus traffic within the facility will also be redesigned, improving its functionality and safety for all. A new access to the car park utilised by patrons of the facility will also be provided to the B981 (Hope Street). This will be sited to the northeast of the bus pick up and set down area and will be signalised.

South of the Firth of Forth

3.4.22 South of the Firth of Forth, the proposed scheme consists of the offline construction of new carriageway from Scotstoun Junction to the Main Crossing and the enhancement of M9 Junction 1a. The mainline carriageway has been designed in accordance with the Design Manual for Roads and Bridges to a design speed of 120kph.

3.4.23 The proposed scheme south of the Firth of Forth has been sub-divided into the following sections:

- Mainline Carriageway – Scotstoun Junction to the Main Crossing;
- Queensferry Junction and Local Road Connections;
- Public Transport Links;
- Forth Road Bridge Emergency Link Road; and
- M9 Junction 1a and associated improvements.

Mainline Carriageway – Scotstoun Junction to the Main Crossing

3.4.24 The connection of the existing road network to the Main Crossing is achieved through the provision of a 3km section of carriageway from Scotstoun Junction, of which 2.6km will be constructed offline. The carriageway cross section to be implemented throughout this section will be to motorway standard.

3.4.25 Between Scotstoun Junction and the new Queensferry Junction, the mainline carriageway will be constructed to dual three lane motorway (D3M) standard. Passing through the fields of Dundas Mains and the northern extents of Dundas Estate, this section will be constructed on moderate embankment, accommodating an existing strategic utility and the drainage system to be implemented as a part of the proposed scheme.

3.4.26 At Queensferry Junction, the mainline cross section shall be dual two lane motorway (D2M) standard with widened hard shoulders, complementing the cross section of the Main Crossing. The cross section transition from D3M to D2M is facilitated through a lane drop / lane gain arrangement to the south facing slip roads at the new junction.

3.4.27 On approach to the new junction, the horizontal geometry of the mainline sweeps north towards the Main Crossing on a right hand R720m curve. In order to provide sufficient vertical headroom clearance, the mainline carriageway on approach to the junction transitions from embankment to cutting, the junction being situated at-grade with the A904 above. North of Queensferry Junction, the existing topography of the land tends towards the Firth of Forth. At this point the mainline exits cutting and connects to the Main Crossing approach viaduct on embankment.

<u>Queensferry Junction and Local Road Connections</u>

3.4.28 Queensferry Junction takes the form of a signalised grade separated gyratory. The junction will provide access in all directions between the Main Crossing and the strategic and local road networks. Situated south of the line of the A904, this existing road shall be re-routed to the east and west to form appropriate tie-ins with the new junction. In the provision of the junction, two significant bridge structures will be required, carrying the northern and southern extents of the gyratory over the mainline carriageway. The existing speed limits associated with the A904 will be maintained.

3.4.29 The slip road design provided with Queensferry Junction is as follows:

Northbound Diverge

3.4.30 The northbound diverge from the mainline carriageway will consist of two lanes, a hard shoulder and a wide load transfer lay-by. The slip road will be situated in cutting relative to existing topography and will be formed through the lane drop arrangement on the mainline carriageway from D3M standard to D2M standard on approach to the Main Crossing.

Northbound Merge

3.4.31 The northbound merge to the Main Crossing will consist of a single lane with widened hard shoulder. The widened hard shoulder will be used in tandem with the widened hard shoulder on the Main Crossing, providing a public transport corridor from the A904 when the Forth Road Bridge is unavailable for use. The slip road will be situated in cutting relative to existing topography and will be ramp metered to assist traffic flow on approach to the Main Crossing during peak periods.

Southbound Diverge

3.4.32 The southbound diverge from the Main Crossing will consist of a single lane with widened hard shoulder. The widened hard shoulder will be used in tandem with the widened hardshoulder on the Main Crossing, providing a public transport corridor to the A904 when the Forth Road Bridge is unavailable for use. The slip road will be situated in cutting relative to the existing topography.

Southbound Merge

3.4.33 The southbound merge to the mainline carriageway will provide a single lane, a hard shoulder and a wide load transfer lay-by. The slip road will be situated in cutting relative to existing topography and upon reaching the mainline carriageway will provide the additional lane required in the provision of the D3M cross section between the Queensferry and Scotstoun junctions.

Local Road Connections

3.4.34 In the provision of the new mainline carriageway south of the Firth of Forth, a number of new and improved road connections will be required.

3.4.35 The B924 (Bo'ness Road) providing access to Echline Estate and South Queensferry will be realigned to a new signalised junction with the A904, east of Queensferry Junction, and will be the subject of a 30mph speed limits. In addition, the south abutment and sub-station associated with the Main Crossing, and the drainage detention basins required as a part of the proposed scheme will be accessed via a maintenance track. The new track will connect to a new junction with the B924 and will run parallel to the mainline carriageway through Echline Field.

3.4.36 Builyeon Road will be realigned to a new junction with the A904, west of Queensferry Junction, as the existing road is severed by the mainline carriageway. The realigned section of this local road will be constructed as a single track road with passing places and will provide a safe means of access to the rural properties located south of the A904.

3.4.37 At the A8000, the east to west orientation of the mainline carriageway in combination with the implementation of a D3M cross section will require the existing overbridge to be replaced. A new structure will be sited to the east of the existing bridge, with appropriate carriageway tie-ins being provided to the north and south. In the provision of the new structure, access to Dundas Home Farm and Scotstoun House will be maintained.

Public Transport Links

3.4.38 Dedicated public transport links will be provided to the Forth Road Bridge. Northbound connectivity will be established through the provision of a new slip road from the A90 northbound carriageway at Scotstoun Junction. A new signalised at-grade junction with the A8000, south of the new overbridge, will provide priority to public transport. The existing 30mph speed limit on the A8000 approach to South Queensferry will be extended south to improve junction safety.

3.4.39 The A8000 (Ferrymuir Road) will be reconfigured to accommodate a northbound public transport lane from Ferrymuir Junction to Echline Junction. To further enhance public transport access to the Forth Road Bridge, Ferrymuir Junction will be redesigned becoming a signalised crossroads with public transport priority. General traffic will continue to be accommodated on the A8000 through this section with the provision of a single lane in each direction. The existing 30mph speed limit will be maintained.

3.4.40 Southbound, public transport departing the Forth Road Bridge will be routed through Echline Junction. Facilitating onward travel to the north of Edinburgh, the southbound merge slip road associated with the current junction arrangement will be connected to a new dedicated public transport lane, which will pass beneath the new A8000 overbridge before connecting to the A90, east of Scotstoun Junction.

Forth Road Bridge Emergency Link Road

3.4.41 In the event of a major incident which requires the full closure of the Main Crossing and / or its approaches, an emergency link road to the Forth Road Bridge has been included to further enhance the operational flexibility of the proposed scheme (refer to Figure 3.9). When in use, the emergency link road will be operated under traffic management conditions and a speed limit restriction will apply.

3.4.42 Situated to the west of the A8000 overbridge, the emergency link road will provide a connecting section of dual carriageway between the mainline carriageway and the existing Forth Road Bridge approach. Removable road restraint systems in the central reserve and southbound verge of the mainline carriageway will enable the diversionary route to take effect, providing access for northbound and southbound traffic.

M9 Junction 1a and associated improvements

M9 Junction 1a

3.4.43 M9 Junction 1a comprises a grade separated junction arrangement, which is capable of facilitating all movements between the M9 and the M9 Spur. Located on the site of the existing junction, the new arrangement maintains existing speed restrictions and makes best use of existing infrastructure, minimising the amount of new land take required in its implementation. The east facing functionality provided by the existing junction is enhanced with the provision of two lanes and a hard shoulder to the loop arrangement and the slip road, which connect the M9 westbound to the M9 Spur northbound and the M9 Spur southbound to the M9 eastbound respectively. These revisions will assist traffic flow through the junction area.

3.4.44 To better serve M9 traffic to / from the west, M9 Junction 1a will incorporate west facing slip roads between the M9 and the M9 Spur, a feature not present in the existing junction design. Constructed on embankment, each slip road will provide a single lane and a hard shoulder.

3.4.45 In the implementation of the revised M9 Junction 1a arrangement, a significant structural requirement exists. A new bridge structure will be required to span the M9, carrying the slip road from the M9 westbound to the M9 Spur northbound. The existing M9 structure will be re-utilised to carry the slip road from the M9 Spur southbound to the M9 westbound. The provision of the westbound slip road to the M9 will require a new bridge crossing of Overton Road, west of M9 Junction 1a.

3.4.46 The existing Overton Road structure will be widened to the north, catering for the provision of the M9 eastbound to M9 Spur northbound slip road.

3.4.47 The existing structure carrying the M9 Spur over the B9080 will be widened as a part of the proposed scheme, catering for the new slip road connections to be provided to the M9 Spur. The B9080 will be maintained along its existing line.

3.4.48 As a part of the junction works, the Swine Burn will be realigned to accommodate the M9 eastbound to M9 Spur northbound slip road. Passing beneath the slip road, a new culvert will be constructed to carry the watercourse. The existing culvert carrying the watercourse beneath the M9 Spur will be extended to the west, accommodating the revised M9 westbound to M9 Spur connection.

Associated Improvements

3.4.49 To complement the improvements to M9 Junction 1a, the section of the M9 north of Newbridge Roundabout is to be improved to assist the operation of the road network through this area. Westbound, an auxiliary lane and a hard shoulder is to be added from the River Almond bridge structure to M9 Junction 1a. At the junction, lanes 1 and 2 will diverge towards the M9 Spur via the revised loop arrangement with lanes 3 and 4 continuing on the M9 to form the D2M cross section associated with the existing route. Eastbound, the revised two lane slip road from the M9 Spur will join the two lanes provided on the M9 to form a four lane carriageway with hard shoulder. On approach to Newbridge Roundabout lanes 1 and 2 will diverge to the junction via the existing slip road arrangement with lanes 3 and 4 forming the standard D2M cross section associated with the M9. Within these 4 lane sections weaving movements will only be permitted between lanes 2 and 3.

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Pedestrian and Cyclist Facilities

3.4.50 Pedestrian and cyclist facilities will be provided to maintain and improve existing routes where feasible. In their provision, where the requirement exists to cross a trafficked carriageway, a designated crossing point will be provided.

3.4.51 Details of these facilities are provided in the following paragraphs and they will be designed in accordance with the guidance documents specified in Section 4.2.

North of the Firth of Forth

3.4.52 As detailed previously, the Forth Road Bridge will continue to accommodate pedestrians and cyclists in its role as a public transport crossing. The Forth Road Bridge shall be reconnected to NCR1 and the B981 (Hope Street) with the provision of a new 2.5m wide shared footway / cycleway. This facility shall be constructed in tandem with the southbound public transport lane to the Forth Road Bridge and will connect to the B981 (Hope Street) through the reconstructed Ferrytoll Junction.

3.4.53 The current footway / cycleway located to the west of the A90 in proximity to the Queensferry Hotel will be maintained and connected to a new ramp providing access to the realigned B981. On the B981, a new 2m wide footway will be provided along the length of the realigned carriageway in the west verge, connecting the existing B981 footway at St Margaret's Hill to the new junction at Ferry Toll Road. In the east verge, a cycleway will be provided from the foot of the new ramp to the new junction with Ferry Toll Road.

3.4.54 Ferrytoll Junction will also cater for pedestrians and cyclists, a 3m wide segregated footway / cycleway being provided across the northern extents of the junction. This combined with a new 3m wide segregated footway / cycleway on Ferry Toll Road and the 2.5m wide shared footway / cycleway on the B981 (Hope Street) shall maintain NCR 76.

3.4.55 New 2m wide footways will also be provided on Ferry Toll Road to maintain pedestrian movements. A new 2m wide footway will be provided on the realigned section of the B980 (Castlandhill Road) and will link to the existing footway located to the north, providing pedestrian access between Ferry Toll Road and Rosyth.

3.4.56 The proposed pedestrian and cyclist provision north of the Firth of Forth is detailed in Figure 3.16 in Appendix A.

South of the Firth of Forth

3.4.57 At Queensferry Junction, the existing footway located to the north of the A904 will be realigned over the northern extents of the gyratory with the provision of a 3m wide segregated footway / cycleway. To the east and west of the junction, this facility will be connected to new 2m wide footways, which will in turn connect to the footways associated with the existing A904. A new 3m wide segregated footway / cycleway will also be provided over the southern extents of the gyratory, linking the A904 to the east of the junction with the realigned Builyeon Road to the west.

3.4.58 New 2m wide footways will also be provided on the section of the B924 (Bo'ness Road) affected by the proposed scheme.

3.4.59 On the realigned A8000, a new 2m wide footway will be provided to the west of the trafficked carriageway, terminating at Ferrymuir Junction. The existing footway located to the east of the A8000 between Scotstoun House and Ferrymuir Junction will be reconstructed.

3.4.60 Pedestrian and cycle access to / from the Forth Road Bridge will be maintained via existing routes. A summary of the existing arrangements is provided in Section 2.2.

3.4.61 The proposed pedestrian and cyclist provision south of the Firth of Forth is detailed in Figure 3.17 in Appendix A.

Earthworks

Material Requirements

3.4.62 A summary of the estimated earthworks quantities for the permanent construction of the proposed scheme is provided in Table 3.2. The volumes provided are based on assumptions on acceptability and treatment information available at the time of writing this report. The acceptabilities, and therefore the quantity of material that can be re-used can also be affected by a number of factors such as weather conditions at the time of excavation.

3.4.63 The estimates provided indicate that there is an import requirement at each location. The export quantity is material that is unsuitable to be re-used as engineering fill.

Table 3.2: Estimated Earthworks Quantities

	M9 Junction 1a[1]	Queensferry Junction[2]	Ferrytoll Junction[3]
Estimate Import (m^3)	155,000	105,000	85,000
Estimated Export (m^3)	20,000	55,000	40,000

[1] *Encompassing construction works on M9, M9 Spur and at M9 Junction 1a.*
[2] *Encompassing construction works from Scotstoun Junction to the southern abutment of the Main Crossing.*
[3] *Encompassing construction works from the northern abutment of the Main Crossing to Admiralty Junction.*

Land Acquisition and Land Take

Land Acquisition

3.4.64 No property demolition is necessary.

3.4.65 All construction work will take place within the limit of the land made available to the Contractor as defined within the contract documents. This land will include the land acquired under the Parliamentary Bill together with any land to which the Scottish Ministers already have ownership of or access to, and any other areas the Contractor has acquired by agreement to facilitate construction of the works. The land acquired for the proposed scheme includes land necessary to construct the proposed scheme and associated infrastructure, and to undertake essential environmental mitigation measures.

3.4.66 The Contractor may wish to utilise other areas of land not covered by the Parliamentary Bill. In such an instance, the Contractor will have to secure the use of these areas by agreement.

Land Take

3.4.67 North of the Firth of Forth, between the Main Crossing and Admiralty Junction, the area of land required is approximately 60ha.

3.4.68 South of the Firth of Forth, between the Main Crossing and Scotstoun Junction, the area of land required is approximately 74ha.

3.4.69 At M9 Junction 1a, the area of land required in the construction of the junction and associated improvements is approximately 48ha.

3.4.70 The areas of land quoted are inclusive of the existing road network which is to be upgraded as a part of the proposed scheme.

3.5 Intelligent Transport Systems (ITS)

Overview

3.5.1 ITS is an integral feature of the proposed scheme. It will be provided over a corridor extending from Halbeath Junction on the M90 in the north to the M9 in the south. Additional provision will be made on main road approaches.

3.5.2 The ITS strategy will provide complementary measures to support the operation of the proposed scheme, providing operational signing during normal and abnormal conditions on the network. In the wider context, the implementation of ITS will allow the proposed scheme to be a managed corridor within the Traffic Scotland trunk road network.

3.5.3 The design of the ITS provision takes account of the specific strategic transport planning objectives for the Forth Replacement Crossing Project. The ITS facilities will be provided to support the scheme objectives detailed in Section 1.3.

3.5.4 In addition to the details provided below, further information on the effects of ITS is provided in Section 6.8 of this report.

Operational Regimes

3.5.5 Operational management on the proposed scheme will be developed to deliver optimum capacity within a safe, efficient and reliable environment and provide local and strategic traffic information to road and public transport users during normal and abnormal conditions. The operational management provided by the ITS scheme will assist in the delivery of the scheme objectives. This will be achieved under the Operational Regimes, detailed in Table 3.3, controlled and monitored through the Traffic Scotland Control Centre in Glasgow.

Table 3.3: Operational Regimes

Operational Characteristic	Description
Normal Operation	Under normal operating conditions, the operational regime will provide coverage of the proposed scheme's ITS corridor with Tactical Roadside Communication, Driver and Journey Time Reliability Information and will integrate with the existing Strategic Driver Information System.
Journey Time Reliability	Corridor Mandatory Variable Speed limits to provide consistent flow and corridor journey time.
Corridor Management & Incident Control	Lane Signalling and Message Signing to provide automatic incident management, queue protection and slip road management.
Bridge Management	Forth Road Bridge – Management of bi-directional public transport corridor. Forth Replacement Crossing – Management of Main Crossing and hard shoulder public transport / bus lane running during closures of the Forth Road Bridge.

3.5.6 The operational regimes detailed in Table 3.3 will be designed, where practicable, to permit the future construction and enhancement of the ITS provision with hard shoulder operation.

ITS Components

3.5.7 The ITS components to be provided as a part of the proposed scheme are detailed in Table 3.4.

Table 3.4: ITS Components

Component	Description
Lane Signalling (LS)	Overhead signalling for controlling each lane, displaying road sign aspects and other aspects for managing lane use.
Mandatory Variable Speed Signalling (MVSS)	Used for displaying variable mandatory speed limits incorporating an appropriate enforcement system.
Variable Message Signs (VMS)	For displaying strategic and tactical driver messages and / or multicoloured pictograms to drivers.
Incident Management	Uses real-time detection of traffic to identify incidents / events occurring on the network so that operators can implement strategies to mitigate the effects and manage safety.
CCTV Surveillance	For visual monitoring of the motorway and providing travel information.
Access Control	To regulate traffic entering / exiting the main carriageway to prevent flow breakdown. Also used to close an entry point when a motorway downstream is closed. Sometimes referred to as Ramp Metering.
Traffic Monitoring and Measurement System	For gathering traffic data Journey Time information for real-time application and statistical purposes.
Emergency Telephone System	To provide roadside assistance through direct connection of roadside telephones.
Meteorological Outstation	To inform maintenance and adverse weather.
Communications Network	To collect and disseminate real-time travel information through a variety of medium and applications.

3.5.8 Mandatory Variable Speed Signalling and Lane Management will be provided from Halbeath Junction on the M90 to the M9 at Newbridge in the southbound direction and from the M9 at Newbridge to the M90 at Masterton Junction in the northbound direction. The following sections describe the measures to be implemented within the proposed scheme's ITS corridor.

Halbeath to Admiralty (Southbound)

3.5.9 To manage traffic from Halbeath to Admiralty under recurrent and non-recurrent events it is proposed to provide lane and speed management. Lane signals on the mainline carriageway over each lane will be provided using overhead gantries from just north of the Halbeath Junction to ensure a safe lead-in sequence. Additionally lead-in overhead gantries will be necessary on the A92 approach to the M90.

3.5.10 Speed control will be provided using the same overhead gantries for Lane Management to provide regulatory speed restrictions above each lane throughout the segment. A nominal spacing of 500m to 800m between overhead gantries is allowed for, to satisfy inter-visibility.

3.5.11 Driver messaging will be provided by Variable Message Signs (VMS) mounted on the overhead gantries.

3.5.12 Automatic Incident Management will be provided from Halbeath to Admiralty and in the vicinity of Halbeath Junction that will detect an incident and manage the traffic using lane control and speed control.

Admiralty to Masterton (Northbound)

3.5.13 Lane signals on the mainline carriageway over each lane will be provided using overhead gantries from Admiralty until the merge point of the A823(M). Additionally lead-in overhead gantries will be provided on the A823(M) northbound approach to the M90 to allow speed management and speed equalisation with the mainline carriageway.

3.5.14 The M90 / A823(M) southbound link road will utilise a verge mounted Advanced Motorway Indicator (AMI) to control the merge.

3.5.15 Driver messaging will be provided by VMS mounted on the overhead gantries.

3.5.16 Automatic Incident Management will be provided from Admiralty to just north of Masterton at the merge point with the northbound A823(M).

Admiralty to Scotstoun (Northbound and Southbound)

3.5.17 To manage traffic from Admiralty to M9 Junction 1a under recurrent and non-recurrent events it is proposed to provide overhead gantries that will support the ITS equipment that provide the facilities detailed in Table 3.4. Gantries are generally provided at 500m to 800m spacing. The Main Crossing gantries are located at the tower locations, cantilevered from the structure.

3.5.18 Provision is made within the scheme design and ITS provision for the facility to allow the Main Crossing hard shoulder to be used as a public transport lane if the Forth Road Bridge (public transport corridor) is closed. The Forth Road Bridge is closed infrequently due to high wind. Public transport lane provision extends from Ferrytoll Junction to Queensferry Junction.

3.5.19 Driver messaging will be provided on VMS mounted on each of the overhead gantries.

3.5.20 Signals will be provided at the southbound merge slip at Ferrytoll Junction and northbound merge slip at Queensferry Junction to regulate traffic joining / exiting the mainline carriageway to prevent flow breakdown.

Scotstoun to M9 Junction 1a (Northbound and Southbound)

3.5.21 It is proposed to provide overhead gantries that will support the ITS equipment that provide the facilities detailed in Table 3.4. Gantries are generally provided at 500m to 800m spacing. Currently the approach to Scotstoun has a fixed mandatory speed restriction of 50mph due to the road geometry. The ITS provision on the approach to Scotstoun will be variable speed control with maximum mandatory speed of 50mph.

3.5.22 On the northbound carriageway, ITS provision will commence approximately 150m north of M9 Junction 1a. Variable Mandatory Speed Control will commence at a location approx 500m north of M9 Junction 1a.

3.5.23 The ITS provision will extend to northbound A90 traffic merging with the mainline.

3.5.24 Driver messaging will be provided by VMS mounted on the overhead gantries.

M9 Junction 1a: M9 Eastbound and Westbound approaches

3.5.25 On the eastbound carriageway the ITS provision commences approximately 2500m west of M9 Junction 1a where the variable mandatory speed signalling commences. Overhead gantries are generally provided at 500m to 800m spacings and these will support the ITS equipment that provide the facilities detailed in Table 3.4. ITS provision extends down to the diverge slip of M9 Junction 1 (Newbridge Roundabout). Driver messaging will be provided on VMS mounted on the overhead gantries.

3.5.26 On the westbound carriageway, there is no ITS provision, except the provision of strategic and tactical variable messaging via two verge mounted cantilever signs. The ITS provision commences on the corridor approx 150m north of M9 Junction 1a (refer to paragraph 3.5.22).

3.6 Cost Estimate

Overview

3.6.1 The capital cost estimate at Q4 2006 price base is £1,182m excluding non-recoverable VAT and including an allowance for risk and optimism bias.

3.6.2 A summary breakdown of the cost estimate is included in Table 3.5 below. A detailed breakdown of the cost estimate into the cost headings required by the DMRB, TD37/93 is provided in Appendix B.

Table 3.5: Summary Scheme Cost Estimate Breakdown

Element of the Forth Replacement Crossing Project	Estimated Cost at Q4 2006 Price Base (£m)
North Network Connections	128
South Network Connections	62
Bridge	543
M9 Junction 1a	39
Intelligent Transport Systems (Fife)	11
Employer's Costs	115
Risk Allowance	115
Optimism Bias Allowance	169
Total Estimated Capital Costs (excluding non-recoverable VAT)	**1,182**

Scheme Preparation Costs

3.6.3 The Employer's costs contained within the above cost estimate are made up of the following:

- Professional fees - including all consultants and other advisors appointed in respect of the scheme during both preparation and site supervision stages;
- Survey costs - including ground investigations, aerial surveys and topographical surveys;
- Land purchase and compensation payments;
- District Valuer and legal fees;
- Transport Scotland's direct costs including the purchase of direct issue ITS equipment; and,
- Advanced statutory diversions which will be undertaken by Transport Scotland in advance of the Works Contracts.

Works Costs

3.6.4 The connecting road network has been priced on the basis of quantities and rates. Quantities have been generated from the Stage 3 design and rates have been obtained through comparison with similar contemporary contracts and from standard industry pricing information. Rates have been benchmarked against other current Scottish Design and Build contracts.

3.6.5 The Main Crossing has been costed on a resource basis, in that the principal quantities are used to identify the resources required to provide the temporary works, labour, materials, equipment and subcontracts necessary for the construction. This strategy reflects the greater complexity of this element of the Works. Prices for activities and rates have been obtained from current market prices from industry sources and from similar schemes such as the Stonecutters Bridge in Hong Kong, together with standard industry pricing information.

Risk and Optimism Bias

3.6.6 A comprehensive list of discrete risks and uncertainties in the cost estimates has been generated. These risks and uncertainties have been costed, and a Monte Carlo analysis undertaken to generate a risk allowance to be applied to the cost estimates.

3.6.7 In accordance with HM Treasury Guidance, an assessment of optimism bias has been undertaken for the proposed scheme, taking regard of the risk assessment process and of the current stage of scheme development. Allowances of 8% for the network connections, 22% for the Main Crossing and 15% for the Employer's costs have been included within the estimates.

3.7 Route Refinement History

3.7.1 Further refinements to the proposed scheme were made between November 2008 and April 2009 as more information on physical ground conditions became available. In particular, this work gave consideration to the many comments received from stakeholder consultations and from the feedback received from the Public Information Exhibition events held during January 2009.

3.7.2 The Forth Replacement Crossing, Public Information Exhibitions: Feedback and Outcomes Report, published by Transport Scotland in June 2009, documents the feedback received through the public exhibitions, explains how this was taken into account in the development of the proposed scheme and highlights the changes introduced as a result of the consultation.

3.7.3 The refinements undertaken to the proposed scheme presented to Parliament in December 2008, including those resulting from public exhibition feedback, are detailed in the following paragraphs.

3.7.4 Further refinements to the Stage 3 design will be made as the scheme develops to a detailed design stage to further reduce environmental impacts and to improve value for money.

North of the Firth of Forth

<u>Mainline Carriageway</u>

3.7.5 The mainline carriageway associated with the Managed Crossing Scheme has been broadly consistent throughout the design process. The proposed design is detailed in Section 3.4.

<u>Ferrytoll Junction</u>

3.7.6 As part of the Managed Crossing Scheme, the reconstruction of Ferrytoll Junction forms an important element of the works. The initial Managed Crossing Scheme layout for this junction included the following features:

- A large grade separated gyratory providing connections between strategic and local routes, with direct south facing merge and diverge slip roads to / from the mainline carriageway and a direct diverge slip road from the southbound mainline.

- The realignment of the B980 (Castlandhill Road) at its southern end connecting to the new gyratory, and the continued utilisation of this road to access the northbound mainline carriageway through a new at-grade junction.
- The realignment of Ferry Toll Road on approach to the new gyratory.
- Minor improvements to the B981 (Hope St) and Ferrytoll Park and Ride to allow connection to the new gyratory.
- The realignment of the B981 to North Queensferry, connecting the existing local road at St Margaret's Hill to the new gyratory via a subsidiary roundabout which also provided public transport access to the main junction from the Forth Road Bridge.
- Southbound access to the Forth Road Bridge via a public transport lane from the southbound merge slip road to the Main Crossing.

3.7.7 The feedback received from the exhibition events held in January 2009 helped to inform the development of the junction design. The feedback highlighted some public concern about the complexity of the proposed junction and the provision of local access during construction.

3.7.8 Taking into consideration the comments received, Ferrytoll Junction was refined further as a part of the proposed scheme for Stage 3 assessment. The key changes are as follows:

- The main gyratory and slip road geometry has been reconfigured to provide direct all movements access to and from the mainline carriageway.
- Local road connections have been developed to provide simpler and more reliable access for local traffic.
- The B980 (Castlandhill Road) has been realigned at is southern end to a new signalised junction with Ferry Toll Road. The provision of a northbound merge slip road to the gyratory enables the B980 (Castlandhill Road) to operate independently from the strategic carriageway.
- The B981 is realigned to the west of Dunfermline Waste Water Treatment Works and to a new at-grade junction with Ferry Toll Road. The realignment of this road allows access to be maintained to North Queensferry during the construction period and will assist in the operation of Ferrytoll Junction once complete.
- Revised public transport links to the Forth Road Bridge are provided, and facilitate direct access to the new gyratory through a partial utilisation of the Main Crossing slip roads.
- The B981 (Hope St) is realigned and widened on approach to Ferrytoll gyratory.
- Improved access / egress is provided to the Ferrytoll Park and Ride facility from the B981 (Hope St). The internal layout of the facility is also refined to provide improved operation.

South of the Firth of Forth

<u>Mainline Carriageway and Queensferry Junction</u>

3.7.9 The initial layout of the mainline carriageway and Queensferry Junction included the following features:

- A dual three lane carriageway between Scotstoun Junction and the proposed grade separated Queensferry Junction located immediately south of South Queensferry, encompassing lane drop / lane gain arrangements to the new junction arrangement.
- A dual two lane motorway with widened hard shoulders from Queensferry Junction to the Main Crossing passing beneath the A904 at Echline Corner.
- Provision of a link road from Queensferry Junction to the A904 where a subsidiary roundabout would provide access to existing local routes.

- Public transport access to / from the Forth Road Bridge via Queensferry Junction, the A904 and Echline Junction.
- Provision of new structures maintaining existing local routes including the A8000, A904 and Builyeon Road.

3.7.10 The ongoing development of the design led to an updated Queensferry Junction and mainline carriageway layout being presented at the exhibition events held in January 2009.

3.7.11 The feedback received from the exhibition events held in January 2009 helped to inform the further development undertaken on the Queensferry Junction arrangement and the mainline carriageway. This also considered operational performance (particularly for public transport), environmental impact, traffic, economics and cost factors. Feedback from the exhibitions included comments on the noise and visual impacts of the route to the south of South Queensferry relating to the height of the junction and associated road embankments and the configuration of the junction arrangements proposed. Concerns were also raised over potential delays that public transport might experience when negotiating Queensferry Junction to access the Forth Road Bridge or the A90.

3.7.12 The key changes to the design considered for Stage 3 assessment are as follows:

- Provision of dedicated public transport links to the Forth Road Bridge from the A90 at Scotstoun Junction as detailed in Section 3.4.
- The relocation of the Queensferry Junction to the west, made possible by the new provision for public transport links. The new junction location is situated at grade with the A904 and is capable of providing direct connections between the Main Crossing, the mainline carriageway and existing local routes.
- A substantial reduction in the height of the embankments associated with the mainline carriageway to the south of South Queensferry as a result of the relocation of Queensferry Junction, thus reducing the visual impact of the route.
- A reconfiguration of the junction arrangements on the A904 at the B924 and Builyeon Road to improve local access and to allow interaction with Queensferry Junction.

<u>M9 Junction 1a and associated improvements</u>

3.7.13 The initial conceptual design considered for the reconstruction of M9 Junction 1a within the Managed Crossing Scheme took the form of a free-flow interchange providing full functionality between the M9 and the M9 Spur. Further development work led to a revised layout being presented at the exhibition events in January 2009 which maximises the use of existing infrastructure. The revised layout provides the same level of functionality as that previously considered, whilst reducing the amount of land required in the junction's implementation.

3.7.14 Improvements to the M9 south of M9 Junction 1a continue to be a feature of the proposed scheme, improving the operation of the trunk road network through this section. A full description of the junction and associated improvements are provided in Section 3.4.

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4 Engineering Assessment

4.1 Introduction

4.1.1 The following sets out the engineering description of the proposed scheme presented for DMRB Stage 3 assessment, encompassing the Main Crossing, its connecting road infrastructure and associated features. It describes some further design development and also provides indicative programme and phasing information for the construction of the proposed scheme between 2011 and 2016.

4.2 Design Standards

Road Alignment Design

4.2.1 The following documents are considered to be particularly relevant to the alignment design element of the proposed scheme:

Design Manual for Roads and Bridges (DMRB), Volume 6:

- TD 9/93 Highway Link Design
- TD 27/05 Cross-Sections and Headroom
- TD 22/06 Layout of Grade Separated Junctions
- TD 16/07 Geometric Design of Roundabouts
- TD 42/95 Geometric Design of Major/Minor Priority Junctions
- TD 41/95 Vehicular Access to All Purpose Trunk Roads
- TD 40/94 Layout of Compact Grade Separated Junctions
- TD 39/94 Design of Major Interchanges
- TD 50/04 The Geometric Layout of Signal - Controlled Junctions and Signalised Roundabouts;
- TA 69/96 The Location and Layout of lay-bys;
- TD 19/06 Requirement for Road Safety Restraint Systems.
- City of Edinburgh Development Guidelines
- Fife Council Transportation Development Guidelines

Pedestrian and Cyclist Provision

4.2.2 All cycling facilities will be designed in accordance with the requirements of the relevant local authority and Transport Scotland, utilising the Scottish Government's 'Cycling by Design' guidance document, published in 2000.

4.2.3 New pedestrian and cyclist facilities will be designed in accordance with Transport Scotland's 'Disability Discrimination Act, Good Practice Guide for Roads' published in January 2009.

Main Crossing and Land Based Structures

4.2.4 The design of the Main Crossing and Land Based Structures will be undertaken using Eurocodes BS EN 1990 – BS EN 1999 and their accompanying UK National Annexes where available.

4.2.5 It is intended that Structural Eurocodes be formally implemented in March 2010 for highway schemes in the UK to coincide with the withdrawal of all UK National Standards by this date.

4.2.6 In the absence of a Highways Agency implementation standard for the use of Eurocodes, a consistent approach to structural design of the Main Crossing and the Land Based Structures has been agreed with Transport Scotland. This includes the preparation of the Structural Design Basis requirements to specify the design requirements of the Main Crossing and Land Based Structures, utilising the Eurocodes and non-contradictory complementary guidance in the DMRB.

4.2.7 The Structural Design Basis shall form the design specification and be incorporated into the contract documents for tendering purposes. In addition, BD 100/09, 'The use of Structural Eurocodes for Design and Construction of Highway Structures' is currently available in draft. The requirements of this document have been incorporated into the Structural Design Basis.

4.3 Departures from Standard

General: DMRB Volume 6 - Road Geometry

4.3.1 In order to avoid incurring high construction, social or environmental costs it is occasionally necessary to adopt geometric elements of design below the desirable minimum standards recommended by the DMRB. These geometric elements include gradient, visibility as well as horizontal and vertical curvature. A procedure exists whereby such departures from DMRB Standards are applied for by the designer to the road authority and the application is independently scrutinised and due diligence is applied in approving or rejecting the application.

4.3.2 On the Forth Replacement Crossing Project, Transport Scotland is responsible for approving or rejecting departures from standard applications on the mainline carriageway and junctions, and the existing trunk roads. Transport Scotland also takes responsibility for approving or rejecting departure from standard applications on the side roads it is to provide. In this latter case these are also subject to acceptance of the design by the relevant local road authority.

4.3.3 Appropriate departures from standard have been identified within the proposed scheme at a number of locations where environmental or cost constraints have merited their inclusion. These departures are discussed below under the following general headings:

- Mainline Carriageway departures, which relate to the alignment of the proposed scheme;
- Junction departures, which relate to the connection of the local road network to the mainline;
- Side Road departures, which relate to roads which lie within the responsibility of Fife Council and the City of Edinburgh Council; and
- Existing Trunk Road departures, which relate to locations where the section of road concerned is not re-routed as a consequence of the scheme but where other changes, for example through the introduction of a junction or change to an existing junction layout, result in departures from standard being identified.

North of the Firth of Forth

Mainline Carriageway Departures

4.3.4 The departures from standard associated with the mainline north of the Firth of Forth include:

- 4 departures on the northbound / southbound carriageway relating to the provision of either a wide hard shoulder (4.2m: 3.6m shoulder + 0.6m hard strip) or locations where a hard shoulder discontinuity or no hard shoulder is proposed. Wide hard shoulders are to be provided on the mainline from the Main Crossing to the back of the Ferrytoll north facing slip road noses.

- 10 departures on the northbound / southbound carriageway relating to a combination of sight distance, horizontal and vertical geometry issues.
- 5 departures that relate to the horizontal curve required to accommodate the fixity of the Main Crossing alignment and also provide the optimum horizontal line within a constrained corridor to facilitate the construction of the proposed Ferrytoll junction.

Other departures relate to the adoption of the horizontal and vertical geometry of the existing mainline between Ferrytoll Junction and Admiralty Junction, where the proposed scheme utilises as much of the existing pavement and highway infrastructure as possible. These are:

- 1 departure on the southbound mainline carriageway relating to sight distance on the immediate approach to the southbound diverge slip road to Ferrytoll Junction.
- 2 departures on the northbound / southbound carriageway relating to weaving lengths between Ferrytoll Junction and Admiralty Junction.
- 1 departure on the northbound / southbound carriageway relating to a combination of horizontal and vertical geometry issues.
- 2 departures on the northbound / southbound carriageway relating to horizontal geometry. These departures occur online. The design aims to re-use as much of the existing pavement as possible, limiting disruption to road users. As such, the design of the online section aims to follow the crossfall of the existing carriageway.
- 2 departures on the northbound / southbound carriageway relating to vertical geometry. These departures are online where the design follows the vertical alignment of the existing carriageway. The vertical geometry of the existing road will be retained in order to utilise as much of the existing road pavement and highway infrastructure as possible.
- 1 departure on the northbound diverge slip road to Admiralty Junction relating to the diverge layout. The existing diverge arrangement is adopted in order to minimise the works required to the existing slip road arrangement.

<u>Junction Departures</u>

4.3.5 The departures from standard associated with the Ferrytoll Junction include:

- 4 departures on the northbound and southbound merge / diverge slip roads relating to the provision of a wide hard shoulder (4.2m: 3.6m shoulder + 0.6m hard strip).
- 2 departures on the northbound diverge slip road and the southbound diverge slip road relating to sight distance.
- 1 departure on the northbound merge slip road relating to horizontal geometry.
- 4 departures on the northbound and southbound merge / diverge slip roads relating to the layout of the merge / diverge arrangements.
- 1 departure on the Ferrytoll gyratory relating to circulatory visibility.
- 1 departure on the weaving distance on approach to a junction. This is where the northbound diverge and the public transport link from the Forth Road Bridge merge on approach to the Ferrytoll gyratory.

<u>Side Road Departures</u>

4.3.6 The departures associated with the side road arrangements proposed for the scheme which fall within the responsibility of Fife Council include:

- 3 departures on the B981: These departures relate to relaxations in horizontal curvature and superelevation. Lower radius curves are incorporated as they allow a tighter alignment around the edge of St. Margaret's Marsh.
- 3 departures on the B980 (Castlandhill Road): These departures relate to relaxations in horizontal curvature including transitions. Low radius curves with short transitions are incorporated to allow the alignment to follow the topography of the land reducing land take and earthworks.

4.3.7 A further side road departure may be required subject to the form of junction provided between the B981 and Ferry Toll Road. The provision of an at-grade roundabout requires the removal of transition curves from the realigned Ferry Toll Road alignment, east of the junction. The provision of an at-grade signalised cross road at this location would not require such a departure. The preferred layout for the junction will be determined from further traffic analysis on this section of carriageway and through ongoing consultations with Fife Council as the adopting roads authority.

<u>Existing Trunk Road Departures Incorporated Within Scheme</u>

4.3.8 The departures from standard associated with the tie in to the M90 at Admiralty Junction include:

- 1 departure on the northbound mainline relating to sight distance.

  The safety barrier in central reserve obstructs visibility. The existing horizontal radius would require substantial central reserve widening to eliminate this departure resulting in impacts to the current junction configuration and the existing underbridge provision through Admiralty Junction.
- 1 departure on the northbound mainline relating to superelevation.
- 1 departure on the southbound mainline relating to superelevation.
- 1 departure on the southbound mainline relating to the nose length at the southbound merge from Admiralty Junction.

South of the Firth of Forth

<u>Mainline Carriageway Departures</u>

4.3.9 The departures from standard associated with the mainline carriageway between Scotstoun Junction and the Main Crossing include:

- 5 departures on the northbound / southbound carriageway relating to horizontal geometry on the online section of carriageway between Scotstoun Junction and the A8000.
- 2 departures on the northbound / southbound carriageway relating to weaving lengths between Scotstoun Junction and Queensferry Junction.
- 5 departures on the northbound / southbound mainline carriageway relating to sight distance. 2 of these departures are associated with the online section of carriageway between Scotstoun Junction and the A8000. The remaining 3 stopping sight distance departures are a result of the right hand curve on the mainline through the Queensferry Junction.
- 2 departures on the northbound / southbound carriageway relating to the provision of either a wide hard shoulder or locations where a hard shoulder discontinuity or no hard shoulder is proposed.

Junction Departures

4.3.10 The departures from standard associated with the Queensferry Junction and Scotstoun Junction include:

- 2 departures on the northbound merge slip road from the A904 to the Main Crossing and the southbound diverge slip road from the Main Crossing to the A904, relating to lane provision and the addition of a wide hard shoulder.
- 3 departures on the northbound slip road from the A904 to the Main Crossing, the southbound diverge slip road from the Main Crossing to the A904 and the southbound merge slip road from the A904 to the mainline carriageway, relating to the layout of the merge / diverge arrangements.
- 2 departures on the Scotstoun Junction southbound diverge interchange link and the Scotstoun Junction northbound merge interchange link, relating to the layout of the merge / diverge arrangements. The existing merge / diverge nose position is maintained, thus minimising the impact on Scotstoun Junction. Providing the full merge / diverge layout would reduce the weaving length between the Scotstoun Junction and Queensferry Junction.

Side Road Departures

4.3.11 The departures associated with the side roads provided as a part of the proposed scheme. fall within the responsibility of the City of Edinburgh Council and include:

- 11 departures on the A8000 relating to stopping sight distance, horizontal and vertical geometry or a combination of both, and the cross section of the proposed road.

  A speed limit of 30mph exists to the south of the existing A8000 overbridge. It is proposed to adopt and extend this speed limit to the extent of the re-alignment thereby reducing the design speed required. However, for the purposes of Stage 3 assessment, the alignment has been assessed with the view that the existing speed limit remains in its current position. Consequently the alignment has been assessed to a higher design speed and thus introduces a number of departures that theoretically will not be required. To improve the design to eliminate these departures would have significant impacts on the local environment, involving additional earthworks and land acquisition.

  Taking the above into account, 2 departures will still be required for the cross section of the road. The cross section between the southern extent of the works and the Ferrymuir Junction has reduced verge widths and no hard strips. However with the extended speed limit, the proposal meets the DMRB requirements for an urban all-purpose mainline.

  Between Ferrymuir and Echline the existing road has one northbound lane and two southbound lanes. To avoid unnecessary widening of the existing carriageway, the cross section will be re-configured to incorporate a single southbound lane, a single northbound lane and a northbound delineated bus lane. The bus lane provided meets the City of Edinburgh Council standards with regards to width (4m).

- 1 departure on Builyeon Road relating to the proposed cross section of the road.

  The existing road is a non standard country road. As a relatively short stretch of Builyeon Road is to be realigned, the cross-section is designed to match the existing; a single lane at 4.2m wide. Passing places have been added to increase safety.

- 1 departure on the B924 relating to the proposed cross section of the road.

  The existing carriageway is a wide two lane 8.8m carriageway. As only a short section of the B924 is to be realigned, the proposed cross section is designed to match the existing. This is an over provision from the standard 7.3m carriageway.

M9 Junction 1a

Mainline Carriageway Departures

4.3.12 The departures from standard associated with the M9 mainline include:

- 2 departures on the northbound / southbound carriageway relating to weaving lengths between the M9 Junction 1a and Newbridge Roundabout.
- 4 departures on the M9 eastbound / westbound carriageway relating to a combination of horizontal geometry and sight distance.

  These departures are proposed in order to retain as much of the existing road pavement and central reserve infrastructure as possible, minimising the amount of disruption to the road user during construction. Providing the full verge and central reserve widening would have structural (demolition of the existing M9 overbridge), geotechnical (additional earthworks cuts) and environmental impacts (ancient woodland south of M9 Junction 1a).

Junction Departures

4.3.13 The departures from standard associated with the enhancement of M9 Junction 1a include:

- 1 departure on the M9 Spur southbound to M9 eastbound interchange link relating to the cross section.

  To maintain the existing B9080 underbridge parapets and kerb upstands on the eastern side, the cross section of the link is required to have a narrow verge width.
- 3 departures on the M9 Spur southbound to M9 westbound link and M9 Spur southbound to M9 eastbound interchange link relating to sight distance.

  In relation to the M9 Spur southbound to M9 eastbound interchange link, the existing B9080 underbridge parapets and kerb upstands are maintained, restricting the visibility. To remove this departure would involve the demolition of the existing structure and this would result in acquisition of residential properties to the south of the B9080 underbridge.
- 2 departures on the M9 westbound to M9 Spur northbound interchange link and the M9 Spur southbound to M9 eastbound interchange link relating to a combination of horizontal geometry and sight distance.

  The M9 westbound to M9 Spur northbound interchange link aims to re-use the existing loop carriageway. As such the existing pier arrangement for the M9 Spur overbridge does not allow full sight distance to the back of the nose which is similar to the existing situation.

  Reduced sight distance on the M9 Spur southbound to M9 eastbound interchange link results from the maintaining of the existing verge and earthwork slope, which minimises the impacts on the residential area at the foot of the embankment.
- 3 departures on the M9 westbound to M9 Spur northbound interchange link and M9 Spur southbound to M9 eastbound interchange link relating to the layout of the diverge / merge arrangements.

  The M9 westbound to M9 Spur northbound interchange link aims to re-use the existing loop carriageway. As such the available pavement width between the existing overbridge pier and central reserve dictates the location of the diverge nose. In providing the standard diverge layout and near straight at back of the nose, a larger loop would need to be incorporated. This larger loop would encroach upon Newliston Estate to the south. Furthermore, it would not make best use of existing infrastructure.

  In the case of the M9 Spur southbound to M9 eastbound interchange link, the proposed layout aims to re-use the existing M9 Spur southbound to M9 eastbound slip road. The lack of near straight and reduced nose length at this location are existing approved departures. This departure has been retained to keep as much of the existing pavement as possible, thereby minimising the amount of disruption to the road user during construction. Applying a standard ghost island merge with an appropriate near straight and nose length would reduce the existing weaving length.

- 1 departure on the M9 Spur southbound to M9 eastbound interchange link relating to horizontal geometry.

  To maintain the existing B9080 underbridge parapets and kerb upstands on the eastern side, the link is required to have a non standard cross section.

Existing Trunk Road Departures Incorporated Within Scheme

4.3.14 There are 4 departures from standard associated with the M9.

- 1 departure on the M9 eastbound carriageway, west of the M9 Spur overbridge, relating to sight distance.
- 1 departure on the existing M9 at the scheme extent. This is located on the M9 eastbound to Newbridge Roundabout diverge link and relates to sight distance. Sight distance is reduced due to the River Almond bridge parapet and the adjacent safety barriers, which obstruct forward visibility.
- 2 departures on the M9 westbound carriageway relating to horizontal geometry.

Main Crossing and Land Based Structures

4.3.15 Other than the use of Structural Eurocodes for design, the only structures departure proposed is for the combination of road and rail traffic loading to be adopted for the design of the replacement A8000 overbridge, ESQ04, to allow for a possible tram based LRT extension to the Forth Road Bridge.

4.4 Topography and Land Use

North of the Firth of Forth

4.4.1 To the north of the Firth of Forth, the proposed scheme utilises the existing A90 / M90 route corridor.

4.4.2 The towns of Rosyth and Inverkeithing lie to the northwest and northeast of the proposed scheme. Castlandhill, a prominent coastal hill, lies to the west. St. Margaret's Marsh is a flat marshy area, and a distinctive feature on the northern shore of the Firth of Forth. To the east of St. Margaret's Marsh lies St. Margaret's Hope, a wooded hill which slopes steeply to the shoreline. The town of North Queensferry is situated upon a coastal hill to the east of the proposed scheme.

4.4.3 The main concentration of commercial land use to the north of the Firth of Forth is located around Rosyth, Dunfermline and Inverkeithing. This includes Belleknowes Industrial Estate located just to the east of the A90 / M90, Masterton Business Park to the north of the A823(M) and Dunfermline Business Park in Dunfermline. Industrial uses include scrap metal processing operations and also a freight carrier and haulage centre located at Inverkeithing Bay. In addition, the former HM Naval Base at Rosyth, located on the north shore of the Firth of Forth, functions as a commercial port and industrial park.

4.4.4 Rosyth Dockyard, part of the former Naval Base, now operated by Babcock International, has been selected for the final assembly of the Royal Navy's new Queen Elizabeth Class Aircraft Carriers. The two-ship class will consist of the HMS Queen Elizabeth, which is expected to enter service between 2014 and 2016 and HMS Prince of Wales, between 2016 and 2018.

4.4.5 The Main Crossing will cross the Firth of Forth to the west of the existing Forth Road Bridge. There is a lighthouse (Beamer Beacon) located on Beamer Rock which lies within the northern section of the channel.

4.4.6 There are two main navigation channels in the Firth of Forth that are used for shipping activities. The Forth Deep Water Navigation Channel passes under the centre of the Forth Road Bridge and has the highest frequency of shipping traffic. The Rosyth Navigation Channel passes below the Forth Road Bridge further north but has a much lower volume of shipping traffic. In terms of commercial fishing, there are three static gear vessels which fish in and around the Forth Road and Rail Bridges. The main creel fishery areas are located around Beamer Rock and to a lesser extent the Forth Rail Bridge.

4.4.7 The Firth of Forth is utilised as a recreational resource by a number of marinas and sailing clubs both north and south of the Firth of Forth. There are a number of ports, harbours and marinas used by cruise ships as well as smaller private vessels.

South of the Firth of Forth

4.4.8 South of the Firth of Forth, the area surrounding the proposed scheme encompasses a mixture of residential areas and agricultural land. The land rises sharply from the Firth of Forth with a steep change in gradient experienced between Port Edgar and Inchgarvie House. To the south of the A904, the land gently slopes downwards from north to south.

4.4.9 The town of South Queensferry lies on the southern shore of the Firth of Forth, close to the Forth Road Bridge and the Forth Rail Bridge. South Queensferry is a popular tourist destination and commuter town for Edinburgh. Further south, Dundas Estate is a large estate encompassing extensive wooded areas, Dundas Castle and Dundas Loch. The A904 runs east to west from South Queensferry through Newton, serving small communities along the coast, and links to the M9 at Phillipstoun via the B8046. The M9 Spur runs to the southeast of Dundas Estate, connecting the M9 with the A90. The town of Kirkliston lies to the east of M9 Junction 1a.

4.4.10 Port Edgar Marina to the immediate west of South Queensferry comprises several small units which include the Marina Office, Port Edgar Yacht Club, HM Coastguard, various sailing and marine based businesses, a cafe and metal works.

4.4.11 Industrial activity to the south of the Firth of Forth is located at Newbridge (Newbridge Business Park / Newbridge North Business Park), Eastmains Industrial Estate (south of Winchburgh) and Ferrymuir Business Park in South Queensferry.

4.4.12 Edinburgh Airport is sited in close proximity to the M9, M9 Spur and Kirkliston. Given the orientation of the airfield relative to the proposed scheme, consultations with BAA Airports Ltd and the Civil Aviation Authority will continue to inform the design of the proposed scheme.

4.5 Roads Infrastructure - Ground Conditions, Geology and Geomorphology

Summary of Ground Conditions

4.5.1 The ground conditions for the mainline carriageway and associated network connections have been determined from a review of published information and historical ground investigation information followed by staged project-specific ground investigations: Preliminary in 2007; Detailed in 2008; and Additional in 2009. These ground investigation works were carried out by BAM Ritchies and Norwest Holst. The findings of all the studies and investigations have been collated into the Ground Investigation Report.

Superficial Deposits

North of the Firth of Forth

4.5.2 The nature and extent of the superficial deposits to the north of the Firth of Forth vary significantly along the proposed alignment. Superficial deposits present in the north include made ground, alluvial deposits, peat, reclaimed estuarine deposits, marine beach deposits and weathered and fresh glacial till.

4.5.3 Made ground is present at several locations along the proposed scheme and comprises a variety of material including quarry backfill containing large cobbles and boulders, reworked glacial till, landfill material, and fill associated with the existing embankments on the A90 and side roads. To the south of the existing Ferrytoll Junction, made ground up to 18m thick associated with quarry backfill is present beneath the existing A90 and surrounding areas. Landfill material is present within St. Margaret's Marsh and additional made ground, associated with former land uses, is present around the peripheral area of the marsh. To the north of Ferrytoll Junction, made ground predominantly comprises reworked glacial till and has been encountered in the vicinity of the B980 (Castlandhill Road) and within cuttings along the existing A90.

4.5.4 Made ground within the St. Margaret's Marsh landfill contains elevated levels of soil contamination including hydrocarbons and metals. Made ground elsewhere along the alignment contains localised elevated hydrocarbons and metals.

4.5.5 Alluvial deposits, described on the published geological plan as 'undifferentiated deposits', comprising soft, often laminated clays, silts and sand were encountered within the topographical low area corresponding to the current location of the B980 (Castlandhill Road). Horizons of peat and organic clays have been recorded locally within this area to depths of 9.7m.

4.5.6 Reclaimed estuarine deposits are present in the area of land that forms St. Margaret's Marsh. These generally comprise a thick sequence of very soft clays and silts, which are underlain by marine beach deposits of sand and gravel.

4.5.7 Glacial till is present across most areas of the site and is predominantly found to the north of Ferrytoll Junction. Weathered till, generally described as firm to stiff slightly gravelly sandy clay with occasional cobbles and boulders, is present either side of the A90 corridor north of Ferrytoll Junction. This generally overlies fresh till, which is similar in composition to the weathered till, but generally stiffer. Glacial till has also been recorded at depth across other areas of the site, beneath areas of made ground, alluvial and estuarine deposits.

South of the Firth of Forth

4.5.8 The superficial deposits present beneath the majority of the proposed road network connections comprise a succession of weathered overlying fresh glacial till. The weathered glacial till is generally approximately 2m thick, and is described as 'Soft to firm, or firm brown mottled orange slightly sandy slightly gravelly clay'. The fresh till is generally cohesive in nature, described as 'Stiff to very stiff grey slightly gravelly sandy clay', although deposits of sand and / or gravel are also recorded in localised areas. Granular raised beach deposits are also recorded in the north of the Echline Field, in the vicinity of the Main Crossing approach viaduct.

4.5.9 Published geological information (Ref Geo S3) records the presence of lacustrine deposits, comprising 'laminated and locally organic-rich clay, silt and fine sand' to the west of the A8000. Also, localised areas of made ground were recorded during the 2008 GI; these primarily relate to the barracks area on the shore, although further deposits may be present in the vicinity of abandoned oil shale workings around Scotstoun Junction. In addition, the existing road network including the A8000 and the A90 lie on man-made embankments; these generally comprise burnt oil shale.

M9 Junction 1a

4.5.10 The superficial deposits present in the vicinity of M9 Junction 1a generally comprise a succession of weathered over fresh glacial till. However, it is noted that deposits of residual soil comprising completely weathered sedimentary rock are also recorded and the fresh till is absent in places. The weathered glacial till is generally approximately 2.5m thick, and is described as 'Soft, or soft to firm mottled slightly sandy slightly gravelly clay'. The fresh till is generally cohesive in nature, described as 'Stiff to very stiff grey slightly gravelly sandy clay'.

4.5.11 Alongside the M9, deposits of alluvium are recorded in the vicinity of the Swine Burn and the River Almond, in addition to 'moundy sand and gravel' close to the River Almond (Ref Geo S3).

Solid Geology

North of the Firth of Forth

4.5.12 Rockhead varies across the site from ground level (outcrop) to 36m depth beneath the A90 to the east of St. Margaret's Marsh. Outcrops are present at several locations immediately to the east of the proposed mainline alignment, including at Ferry Hills and Little Hill, and to the west of the proposed alignment at Whinny Hill. Rock outcrops are also situated at St. Margaret's Hope near the Main Crossing landfall location and also to the northwest and northeast of the Dunfermline Waste Water Treatment Works.

4.5.13 Published geological maps and recent ground investigation information indicate that the solid geology of the site generally comprises quartz dolerite of carboniferous age and sandstones, mudstones, siltstones, limestones and thin coal seams of the Carboniferous Sandy Craig and Anstruther Formations. A small area of bedded basaltic volcaniclastic rocks is indicated to be at rockhead to the northwest of the waste water treatment works.

4.5.14 The underlying solid geology of the area east of the proposed mainline is predominantly quartz dolerite. The quartz dolerite sill extends west of the proposed alignment at St. Margaret's Hope and at Whinny Hill, including locally at the access to Castlandhill House on Ferry Toll Road. The remainder of the site is underlain by sedimentary strata of the Sandy Craig and Anstruther Formations. The Sandy Craig Formation is present beneath the superficial deposits of St. Margaret's Marsh; borehole information indicates that this generally consists of sandstone and siltstone. Strata of the Anstruther Formation are present at rockhead at the northern end of Castlandhill and predominantly comprise mudstone.

4.5.15 Minor coal seams are present within the sedimentary strata, however, there is no evidence of workings within these seams in the immediate vicinity of the proposed alignment.

4.5.16 Five faults are indicated to be present across the site. The two most significant faults trend ESE-WNW, cutting across the proposed alignment immediately to the north of St. Margaret's Hope and immediately to the north of Inverkeithing Cemetery.

South of the Firth of Forth

4.5.17 Rockhead levels vary along the alignment, from within 1.0m of existing ground level to in excess of 30.0m depth close to the A8000. The rock is mainly sedimentary in nature, comprising sandstones, siltstones and mudstones of the Calders and Hopetoun Members of the Lower Carboniferous (Ref Geo S4). A teschenite intrusion (sill intrusion) is also recorded to the west of South Queensferry, close to the proposed scheme.

4.5.18 The Broxburn and Fells Shales, and the Houston Coal of the Hopetoun Member subcrop beneath the proposed scheme to the south and southeast of South Queensferry; workings are recorded in the oil shales beneath the route to the east of the A8000. These workings are discussed in more detail in paragraph 4.5.41.

4.5.19 The solid strata are intersected by the Ochiltree Fault which runs approximately east to west and crosses the route to the south of the Queensferry Junction.

M9 Junction 1a

4.5.20 Rockhead levels are generally within 5m of existing ground level around M9 Junction 1a, extending to between 5m and 10m below ground level to the south of the existing M9 and towards Newbridge Roundabout. Shallow bedrock will result in rock cuttings in the realigned Swine Burn channel, and adjacent to the M9 near Kirkliston. The rock is anticipated to be mainly sedimentary in nature, comprising sandstones, mudstones, siltstones and occasional limestones, although dolerite intrusions are also present in the vicinity of the M9 at Lindsay Craigs, and therefore may outcrop in places in the M9 cutting faces (Ref Geo S4).

4.5.21 Various oil-shale seams are recorded to occur in the vicinity, in addition to the Burdiehouse Limestone. Limited surface extraction of the limestone is recorded, and no historical extraction of the oil-shales is evident from the available records. These mineral sources are discussed in more detail in paragraph 4.5.44.

Groundwater and Ground Gas

4.5.22 North of the Firth of Forth, groundwater is present across the site within the made ground, natural superficial deposits and bedrock. Monitored groundwater levels vary across the site from 0.3m below ground level on the periphery of St. Margaret's Marsh to >25.0m at the northern end of the alignment. Elevated hydrogen sulphide concentrations were recorded within St. Margaret's Marsh during the drilling operations. In addition to this, there is the potential for areas of ground gas to be associated with the made ground, particularly in St. Margaret's Marsh.

4.5.23 South of the Firth of Forth, groundwater conditions across the site are shallow, with monthly monitoring indicating levels generally within 1m to 2m of existing ground level. In localised areas, small artesian heads have been recorded. Monitoring installations along the route have recorded localised elevated levels of ground gas, including methane, carbon dioxide and, on occasion, carbon monoxide. Correspondingly low oxygen levels have been recorded in some locations. These results are generally encountered where the installations have pathways to the permeable sedimentary bedrock, and the elevated levels may be due to migration of gas from the oil-shales beneath the site. Elevated levels will require to be taken into consideration during detailed design and construction of this part of the proposed scheme.

4.5.24 At M9 Junction 1a, groundwater conditions across the site are variable, with monthly monitoring indicating levels from within 1m to 8m of existing ground level.

General Earthworks Design Issues

Slope angles

4.5.25 Soil cutting slopes are generally proposed at gradients between 26.6˚ (1:2) and 18˚ (1:3). However, slope drainage and stabilisation measures are required in places to provide stability given the shallow groundwater conditions. Where reinforcement of slopes through soil nails is required, proposed slope angles can be steeper.

4.5.26 Rock cutting slopes are generally proposed at gradients between 30° and 70° depending on the lithology and orientation of the strata. The slopes are currently designed with a rock trap at the toe of the slope to catch rock fall and reduce the risk of falling rock reaching the road. Higher rock slopes incorporate benches to provide additional stability and permit maintenance access. A berm will be required at the soil/rock contact for slope stability and drainage. Standard rock slope stabilisation measures may be necessary locally to stabilise blocks or friable areas of the exposed rock face.

4.5.27 Proposed embankment slopes are mainly 26.6˚ (1:2), although dig-out and replacement of soft spots may be necessary to ensure stability and control settlement in some locations. Embankments over areas of recorded alluvium, for example close to the Swine Burn and the River Almond are proposed at 21.8° (1:2.5) side slopes, to allow for treatment or removal of thicker soft deposits beneath the new embankment footprint.

4.5.28 Techniques such as soil nailing, in-slope drainage, rock dowelling, scaling and meshing may be required to stabilise the proposed cutting slope angles. Specification of reinforcement or high grade embankment fill could be used to steepen the proposed embankments from the proposed gradients, thus reducing the footprint widths and the quantity of material required. This technique is also applicable to areas where culverts pass beneath the existing embankments. Localised steepening could be achieved to minimise the extent of culvert extension required.

<u>Groundwater</u>

4.5.29 Where groundwater is encountered within cuttings, drainage measures will be required to deal with the flow of water in the cutting and to aid ongoing slope stability. Temporary drainage measures will also be required during excavation works. Design groundwater levels have reflected maximum levels recorded during ground investigations and subsequent monitoring of installations, with an allowance for changes in level not detected by monitoring.

4.5.30 Proposed methods for the control and removal of groundwater from the slope face include lined crest channels, toe channels, stepped channels and counterfort drainage. Where groundwater is high, in-slope drainage in the form of raking drains will be required for both soil and rock slopes. Rock slopes may require specific rock slope drainage measures.

4.5.31 At M9 Junction 1a, slope protection measures will be required within the proposed Swine Burn channel realignment to prevent scour and degradation of the exposed cutting slopes. This may take the form of a geotextile protective matting covering the insitu materials with the appropriate rock armour.

<u>Geotechnical Summary - Tabulated data</u>

4.5.32 Tables 4.1, 4.2 and 4.3, present a summary of the earthworks features and anticipated ground conditions for each feature for the proposed mainline and associated road network connections. Locations of individual earthworks are shown on Figures 4.1, 4.2 and 4.3 in Appendix C.

Table 4.1: Geotechnical Summary - North

Earthworks Reference	Road and Chainage (m)	Critical Section	Height at Critical Section and Earthwork Type	Design Angle	Ground Conditions at Critical Section	Groundwater at Critical Section (mbgl)	Remarks
NC2b	A90 NB Diverge Ch 0 to Ch 220	Ch 140	19.5m cut	70°	Dolerite (existing outcrop). Topsoil cover <0.3m thick encountered.	6.45mbgl (monitored)	Benched with rock traps
NC5	A90 NB Diverge Ch 760 to Ch 900	Ch 820	1.4m cut	1V:2H	Made ground (reworked till) to 2.0mbgl Made ground (boulders) to 7.0mbgl Fresh cohesive glacial till to 10.35mbgl Dolerite >10.35mbgl	None encountered	In the vicinity of Chainage 760, cutting is within dolerite
NC6	A90 NB Diverge Ch 570 to Ch 900	Ch 680	5.6m cut	1V:2.5H	Made ground to 13.5m Fresh cohesive glacial till to >34.5mbgl	11.1mbgl	In the vicinity of Chainage 760, cutting is within dolerite
NC7	A90 SB Merge Ch 7500 to Ch 7855 (Mainline Chainage)	Ch7620	29m cut	70°	Dolerite (existing outcrop). Topsoil cover <0.2m thick encountered.	None encountered	Benched with rock traps
NC9	B980 (Castlandhill Road) Ch 60 to Ch 320	Ch 200	4.5m cut	1V:3H	Made ground to 3.3mbgl Weathered cohesive glacial till to 5.5mbgl fresh cohesive glacial till to 10.7mbgl Mudstone >10.7mbgl	2.0mbgl	Alluvium present locally, additional ground investigation to confirm presence or absence of alluvium within slope
NC10a & b	FRC NB Merge Ch 0 to Ch 270	Ch 170	7m cut	NC10a - 55° NC10b - 60°	Dolerite (existing outcrop). Superficial deposits cover to be determined during current ground investigation.	None observed within outcrop	Rock trap, no benching
NC11a	Ferrytoll Gyratory Ch 0 to Ch 35; Ch 385 to Ch 420	Ch 405	15m cut	60°	Made ground to 1.3mbgl Sand (weathered dolerite) to 1.65mbgl Dolerite >1.65mbgl	None encountered	Rock traps, no benching
NC11b	Ferrytoll Gyratory Ch 0 to Ch 80; Ch 350 to Ch 420	Ch40	7.5m cut	50°	Weathered cohesive glacial till to 1.4mbgl Dolerite >1.45mbgl	None encountered	Rock traps, no benching
NC12a	FRC SB Diverge Ch 40 to Ch 260	Ch 220	2.0m cut	1V:2.5H	Weathered cohesive glacial till to 3.0mbgl Fresh cohesive glacial till to 4.0mbgl Dolerite >4.0mbgl	4.15mbgl	Dolerite likely to be at shallow level within areas of cutting.

Earthworks Reference	Road and Chainage (m)	Critical Section	Height at Critical Section and Earthwork Type	Design Angle	Ground Conditions at Critical Section	Groundwater at Critical Section (mbgl)	Remarks
NC12b	FRC Mainline Ch 8160 to Ch 8320	Ch 8220	21m cut	70° (locally 75°)	Dolerite (existing outcrop). Soil cover noted between Ch 8305 to Ch 8320 to be confirmed during current ground investigation.	4.7mbgl	Retaining wall <2m high required between Ch 8305 and Ch 8320 to support existing cemetery wall. Benched with rock traps. 75° slope proposed between Ch 8235 and Ch 8250.
NC12c	FRC Mainline Ch 8320 to Ch 8380	Ch 8380	28m cut	60°	Dolerite (existing outcrop)	None encountered	Benched with rock traps
NC13	FRC Mainline Ch 8610 to Ch 8790	Ch 8780	9.0m cut	35°	Weathered cohesive glacial till to 2.5mbgl Fresh cohesive glacial till >2.5mbgl	8.0 mbgl	Soil nailed solution proposed, with raking drains
NC14	FRC Mainline Ch 8845 to Ch 9195	Ch 8940	17.7m cut	1V:1H to 1V:4.5H	Made ground to 1.2mbgl Weathered cohesive glacial till to 4.2mbgl Fresh cohesive glacial till to 25.1mbgl Mudstone >25.1mbgl	1.7 mbgl	Soil nailed solution proposed, with raking drains Ch 8845 to Ch 8940 – Lower 7m – 1V:1H, mid slope – 1V:4,5H, upper slope 1V:4.5H. Bench between lower and mid slope. Ch8940 to Ch 8970 – transition zone, bench tapers out. Ch 8970 to Ch 9200 – lower slope 1:4, upper slope 1V:4.5H
NC15	FRC NB Merge Ch320 to Ch 380	Ch 340	2.5m cut	1V:2.5H	Made ground to 4.5mbgl Alluvial deposits (incl. peat) to 14.3mbgl Fresh cohesive glacial till to 22.0mbgl Mudstone with minor coal seam >22.0mbgl	4.3mbgl	Peat may be locally encountered, requiring removal
NC17	FRC Mainline Ch 6995 to Ch7100	Ch 85	8.2m cut	60° West 45° East	Topsoil 0.5m Dolerite >0.5m	None encountered	Rock trap required
NE1	B981 Realignment Ch0 – Ch 1080	Ch640	9.0m (maximum height – not at critical section)	1V:2H	Made ground to 1.0mbgl Reclaimed estuarine deposits to 8.0mbgl Marine beach deposits to 16.0mbgl Mudstone >16.0mbgl	1.1mbgl	Piled embankment required

Earthworks Reference	Road and Chainage (m)	Critical Section	Height at Critical Section and Earthwork Type	Design Angle	Ground Conditions at Critical Section	Groundwater at Critical Section (mbgl)	Remarks
NE2	A90 NB Diverge Ch 240 to Ch 610	Ch 500	11.8m embankment	1V:2H	Made ground to 3.2mbgl Boulders and gravel to 5.5mbgl Soft clay to 13.5mbgl Glacial till to 21.0mbgl Mudstone >21.0mbgl	2.2mbgl	Piled embankment required
NE3	A90 SB Merge Ch 35 to Ch 140	Ch 90	1m embankment	1V:2.5H	Made ground to 18.0mbgl Soft to stiff clay to 36.05mbgl Mudstone >36.05mbgl	13.2mbgl	
NE7	FRC Mainline Ch 410 to Ch 730	Ch 610	6.0m embankment	1V:2H to 39° (with rockfill)	Weathered cohesive glacial till to 3.2mbgl Fresh cohesive glacial till to 28.9mbgl Mudstone to >28.9mbgl	2.8mbgl	Local alluvial deposits may be present.
NE8	Ferrytoll Road Ch 0 to CH 280	Ch 260	11.3m embankment	1V:2H	Made ground to 2.8m Sand to 5.5m Alluvial Clay to 8.8m Sand to 15.6m Glacial till to 17.0m (rockhead)	3.2mbgl	Reinforcement may be required due to anticipated settlement
NE10	B980 (Castlandhill Road) Ch 330 to Ch 400	Ch 340	1.1m embankment	1V:2.5H	Made ground to 1.8mbgl Alluvial deposits (including peat) to 14.3m Fresh cohesive glacial till to >20.2mbgl	2.8mbgl	Band drains, surcharging and geogrid placement may be required
NE11	FRC NB Merge Ch 270 to Ch 340	Ch 320	0.8m embankment	1V:2.5H	Made ground to 1.8mbgl Alluvial deposits (including peat) to 14.3m Fresh cohesive glacial till to >20.2mbgl	2.8mbgl	Band drains, surcharging and geogrid placement may be required

Table 4.2: Geotechnical Summary - South

Earthworks Reference	Critical Section	Height at Critical Section and Earthwork Type	Design Angle	Ground Conditions at Critical Section		Groundwater encountered (mbgl)	Remarks
Ch 1490m to Ch 1560m	N/A	At Grade	N/A	GL – 2.0m 2.0 – 19.5m 19.5m	Weathered cohesive and Granular Glacial Till Fresh cohesive Glacial Till Bedrock (Sandstone)	21m (strike), shallowest thereafter 7.4m	
SE1	2180m	9.9m, Embankment (including height of landscape bunds)	1V:2H	GL – 2.5m 2.5 – 3.0m 3.0 – 11.5m ~11.5m	Granular Glacial Till Weathered cohesive Glacial Till Fresh cohesive Glacial Till Bedrock (Sandstone / Mudstone)	2.2m (seepage)	Granular Glacial Till present in localised areas, elsewhere weathered cohesive till overlies fresh cohesive till
SC1	3340m 3880m	4.1m, Cutting 7.3m, Cutting	1V:2H to 1V:3H (Soil) 30° to 45° (Rock)	Ch. 3340m GL – 5.0m ~5.0m Ch. 3880m GL – 2.0m 2.0 – 8.5m 8.5m	Granular Glacial Till Bedrock (Sandstone) Weathered cohesive Glacial Till Fresh cohesive Glacial Till Bedrock (Dolerite)	Ch. 3340m 1.5m, 2.5m (strikes) Shallowest thereafter 1.35m Ch. 3880m 10.5m (strike) Shallowest thereafter 1m	Slope stabilisation measures may be required.
SE13	4334m	7.5m, Embankment	1V:2H	GL – 1.2m 1.2 – 2.8m 2.8 – 4.5m 4.5m	Granular Glacial Till Weathered Glacial Till Granular Glacial Till Bedrock (Sandstone)	2.5m (seepage), 3.5m (strike) Shallowest thereafter 1.79m	

Table 4.3: Geotechnical Summary - M9 Junction 1a

Earthworks Reference	Critical Section	Height at Critical Section and Earthwork Type	Design Angle	Ground Conditions at Critical Section		Groundwater encountered (mbgl)	Remarks
M9 Mainline							
SE12	640m	7m, Embankment	1V:2.5H	GL – 3m 3 – 5.3m 5.3m	Soft sandy clay with gravel Sand and gravel Bedrock (shale)	No strikes recorded	
SE11	1040m	7.5m, Embankment	1V:2H	GL – 2.7m 2.7 – 4.6m 4.6 – 7.6m	Soft to firm sandy clay with gravel Loose clayey sand and gravel Compact gravel	1.22m	
SC4	1360m (E) 1400m (W)	14.5m, Cutting	1V;2H (Soil) 30^{o} (Rock)	GL – 2.2m 2.2 – 4.6m 4.6m	Weathered cohesive Glacial Till fresh cohesive Glacial Till Bedrock (Mudstone)	1.8m	
M9 Spur							
SE9	240m	5m, Embankment	1V:2H	GL – 2m 2m – 4m 4m	Firm weathered cohesive Glacial Till fresh cohesive Glacial Till or Residual Soil Bedrock (Mudstone)	3.9m, 8m (strikes) Shallowest thereafter 2m	
SE10	160m	15m, Embankment	1V:2H				

Earthworks Reference	Critical Section	Height at Critical Section and Earthwork Type	Design Angle	Ground Conditions at Critical Section		Groundwater encountered (mbgl)	Remarks
M9 Junction 1a Interlinks							
SE7	550m	5m, Embankment	1V:2H	GL – 2.2m 2.2 – 4.2m 4.2m	Weathered cohesive Glacial Till fresh cohesive Glacial Till Bedrock (Weathered mudstone)	1.7m (seepage)	
SE6	330m	14.5m, Embankment	1V:2.5H	GL – 1.9m 1.9 – 3.9m 3.9m	Weathered cohesive Glacial Till fresh cohesive Glacial Till Bedrock (Mudstone)	8m (seepage)	
Swine Burn Realignment							
SC5	310m	9.5m, Cutting	1V:2.5H (Soil) 30^{o} (Rock)	GL – 2.7m 2.7 – 4.5m 4.5m	Weathered cohesive Glacial Till Fresh cohesive Glacial Till Bedrock (Mudstone)	1.7m	

Specific Earthworks Design Issues

Excavation of Rock

North of the Firth of Forth

4.5.33 Standard mechanical excavation techniques alone are unlikely to be sufficient to excavate bedrock from proposed cuttings within dolerite. Due to the strength of the dolerite, excavation for the cuttings will require the use of blasting or chemical splitting techniques. For Cutting NC7, which is located adjacent to the Edinburgh to Aberdeen Railway Line and the existing A90, blasting will require specific measures to ensure there is no risk to users of the transport connections. This is likely to require possessions of the road and rail networks during nights and weekends, installation of catch fences to protect the railway line during operation, protection measures and traffic management for the road network. Similar issues are likely to be experienced for Cuttings NC2b, NC10, NC11, NC12b and NC12c, which are situated adjacent to the road network.

4.5.34 Cutting NC12b is situated adjacent to Inverkeithing Cemetery but it is considered unlikely that the proposed cutting will impact on burial sites. Subject to further design refinement, a retaining wall may be required at the topographical low point of the cemetery cutting.

South of the Firth of Forth and M9 Junction 1a

4.5.35 The ground investigation information obtained through the areas of proposed cutting suggests that excavation of the rock would be achievable through ripping, although some blasting may be required if dolerite (M9 Junction 1a) is encountered within the cutting excavation.

Soft Ground and Ground Improvement Techniques

North of the Firth of Forth

4.5.36 The slope angles for cuttings NC13 and NC14 adjacent to the mainline at the northern end of the scheme are constrained by the B980 (Castlandhill Road), which passes close to the crest of existing cuttings at these locations. Soil nailing would be required to permit the proposed steeper slopes at these locations. In light of very shallow groundwater in these locations, raking drains are required in the soil cuttings to reduce water levels.

4.5.37 The proposed B981 realignment across St. Margaret's Marsh (Embankment NE1) traverses an area underlain by a relatively thick sequence of soft clays and silts. Current thinking is that the design may require a piled solution for this embankment. Information from the current ground investigation will be used to determine the feasibility of adopting pre-consolidation of the soft clays and silts through staged construction and possibly band drains, and to assess the impact of this upon the salt marsh. Embankment NE2 may also require piling.

4.5.38 The proposed Ferrytoll Junction northbound merge requires the widening of an existing embankment. The B980 (Castlandhill Road) situated at the toe of the embankment requires slopes of up to 39°. In order to ensure a stable side slope, it is proposed to use rock fill to widen the embankment.

4.5.39 Alluvial and occasionally peat deposits are noted beneath Embankments NE8, NE10 and NE11, which may require band drains, staged construction or geogrids to prevent excessive settlement.

South of the Firth of Forth and M9 Junction 1a

4.5.40 In places where high embankments are proposed over significant deposits of weathered glacial till, ground improvement techniques may be required to control the settlement, including differential effects between the existing and new construction, or adjacent to structures. These techniques may include use of lightweight fill, installation of band drains, coupled with staged construction, excavation of the upper 1 to 2 metres of unsuitable materials or lime stabilisation. Investigation of the strength and extent of soft weathered till and alluvial deposits is ongoing at the time of preparation of this report. It is likely that dig-out and replacement may be sufficient if only localised softer deposits are found to be present beneath the proposed footprints, or in areas of lower height embankment. If soft spots are left in place, problems such as stability, extrusion and settlement may affect the design of any embankment.

Mineworkings

South of the Firth of Forth

4.5.41 Abandoned oil-shale workings associated with the Dalmeny No. 3 Pit are recorded to lie beneath the proposed public transport links to the east of the A8000. Based on the mine abandonment plans, up to 3 oil shale seams are recorded to have been worked by the stoop and room method, although extensive stooping (removal of the stoops) has been recorded. The total thickness of the worked seams and the intervening strata is approximately 10 to 12 metres, and they dip to the north and northwest at between 16° and 27°.

4.5.42 Investigation of the depth and condition of the workings has confirmed the presence of workings in two of the seams. Pavement depths of approximately 70 to 135 metres below ground level are anticipated below the proposed public transport links to the Forth Road Bridge.

4.5.43 The depth of competent rock cover has been initially assessed in relation to the thickness and condition of the workings to determine the most appropriate approach to this risk. As the risk is currently assessed as low, it is not anticipated that stabilisation by drilling and grouting, will be required although geogrid reinforcement to the embankment may be considered.

M9 Junction 1a

4.5.44 No abandoned mineworkings are recorded in the vicinity of the M9 Junction 1a improvements. A number of oil-shale seams are recorded in the area, however a review of the available information suggests that these may be poorly developed, and it is not considered likely that they have been worked. A number of abandoned quarries along the outcrop of the Burdiehouse Limestone are recorded on the historical OS plans of this area. Where these coincide with the proposed locations for construction or extension of embankments, further investigation is ongoing to determine the depth and nature of any quarry backfill. Appropriate techniques to improve the strength of the backfill material shall be determined if necessary on conclusion of these investigations.

4.6 Main Crossing Geotechnical Summary

4.6.1 The following summary of the ground conditions, geology and geomorphology has been developed with reference to factual ground investigation information and other published literature including geological maps and memoirs. The factual ground investigation information referred to in the production of this summary includes historical investigations and project specific investigations, as follows:

Historic Investigations

- Land and marine investigations undertaken in 1993 by Soil Mechanics in relation to the Setting Forth Study.

Project Specific Investigations

- Marine geophysical (bathymetry and side-scan sonar) investigations undertaken by Ritchies (Osiris) in 2007;
- Preliminary land based investigations undertaken in 2007 by Ritchies in relation to the FRCS;
- A detailed marine based investigation undertaken by Glovers in 2008; and
- Additional marine based investigation undertaken by Glovers in 2009.

The findings of all the studies and investigations have been collated into the Preliminary Sources Study Report and Ground Investigation Report.

4.6.2 In addition, the land based ground investigations, described in Section 4.5.1, have also been used in the development of the geology for the approach viaducts to the north and south.

Superficial Deposits

Litho-Stratigraphic Succession

4.6.3 The superficial deposits generally comprise a downward succession of Raised Beach Deposits, Alluvium, granular Fluvio-Glacial Deposits over cohesive Till and basal granular Fluvio-Glacial Deposits.

4.6.4 Made Ground is also encountered sporadically, largely in the southern land area of Port Edgar Barracks, with minor quantities recorded in the northern land area of St. Margaret's Hope around Admiralty House.

Made Ground

4.6.5 Made ground encountered in the southern land area generally comprises gravel with minor proportions of clay and sand and is less than 2m thick. Made ground encountered in the northern land area generally comprises thin (<0.5m thick) topsoil deposits and variable granular and cohesive deposits (mainly related to landscaping), directly underlain by bedrock of dolerite.

Alluvium

4.6.6 Alluvium is encountered within the southern and northern marine areas generally comprising unconsolidated sandy clay and silt, grading to granular deposits comprising silty sand and sandy gravel. This deposit increases in thickness with distance from the northern and southern shorelines to a maximum thickness of 14m. Near shore this deposit generally comprises granular beach deposits directly underlain by bedrock.

Raised Beach Deposits

4.6.7 Raised beach deposits are tentatively identified in the southern land area at two levels, capping the Till located to the east of Inchgarvie House at approximately +25mOD and on the low lying area of Port Edgar Barracks at approximately +10mOD, respectively known as the 100ft and 30ft deposits in published information. These are granular deposits, generally less than 2m in thickness.

Till

4.6.8 Till is encountered in the southern land area and throughout the southern and northern marine areas, with variable distribution and thickness (up to 12.9m) and was not encountered in the northern land area or the central marine area. The deposit is generally less than 6m thick and is indicated to comprise a sandy and gravelly cohesive deposit with granular lenses and occasional cobbles and boulders and displays a weathered mantle, up to 2m in thickness.

Fluvio-Glacial Deposits

4.6.9 Granular fluvio-glacial deposits are encountered in the southern land area and throughout the southern and northern marine areas (not encountered within the central marine area or the northern land area), with variable distribution and thickness (up to 16.66m, but commonly circa 5m) and is laterally discontinuous. Within the southern land area, these deposits are generally encountered as the filling material to meltwater channels incised into the Till. Within the southern and northern marine areas these deposits are recorded at two distinct levels of variable extent, an upper deposit resting on Till and a lower deposit, below the Till, resting directly on bedrock. These deposits generally comprise coarse granular material of medium dense to very dense silty sands and gravels with occasional cobbles and boulders and subordinate thin lenses of cohesive material.

Main Crossing Stratigraphy - Solid Geology

Litho-Stratigraphic Succession

4.6.10 Solid geology encountered on the proposed alignment of the Main Crossing comprise strata of three main sedimentary formations; namely the Hopetoun Member over the Calders Member, in the southern land and southern marine areas, and the Sandy Craig Formation in the central marine and northern marine areas. Further to this, these formations are commonly intruded by igneous sills which in the case of the northern land area make up the entirety of the proven solid geology. Similarly to a depth of approximately -50mOD, Beamer Rock consists entirely of an igneous sill below which the Sandy Craig Formation was encountered. These geological units have been subject to regional folding and extensional faulting with faults generally striking east-west.

Hopetoun and Calders Members

4.6.11 The Hopetoun and Calders Members are found below the southern land and marine areas. These rocks generally comprise mudstone, sandstone, siltstone, oil shale, limestone and subordinate units of non-marine limestone, volcanic tuffs and thin coal seams. These members are separated by the Burdiehouse Limestone.

4.6.12 The volcanic tuffs encountered occasionally form more significant, thicker layers and are specifically named, such as the Port Edgar Ash.

Sandy Craig Formation

4.6.13 The Sandy Craig Formation is encountered within the central marine and northern marine areas and generally comprises sandstone, siltstone, mudstone, non-marine limestone, thin coal seams, and volcanic tuffs.

4.6.14 The volcanic tuffs are encountered as a thicker unit identified to the north of the north tower and south of the northern shore. The base of this material was not penetrated, but it is thought to be underlain by sedimentary strata, described above.

Dolerite

4.6.15 The above named formations encountered beneath the proposed alignment of the Main Crossing are commonly intruded by igneous sills of varying thickness from 0.1m to 60m. In the case of the northern land area an igneous sill makes up the entirety of the proven solid geology. In the central marine area the same igneous sill makes up the upper 25m of the solid geology forming Beamer Rock, while another sill with an approximate thickness of 22m is found to underlie the southern land area forming the cliffs towards the north of the Inchgarvie House area. This sill is also found to underlie the southern marine area as a succession of much thinner sills within the sedimentary rocks and is possibly related to the sill encountered beneath the north tower location.

4.6.16 These doleritic intrusions were found to be altered to varying degrees predominantly around their edges with thinner sills being altered to a greater extent.

Groundwater and Ground Gas

4.6.17 Perched groundwater is expected to exist in granular layers within the glacial till and within the granular fluvio glacial and raised beach deposits located in the Echline Field and Inchgarvie House areas.

4.6.18 Shallow groundwater has been encountered within the permeable sandstone units which overlie the less permeable doleritic sill encountered to the south of the cliffs formed by the same sill located towards the north of the Inchgarvie House area. To the north of these cliffs within the southern land area and within the northern land area the groundwater is confined to flow along the fracture of the impermeable doleritic bedrock. Where encountered the groundwater was found to be significantly deeper and in hydrostatic continuity with the Forth.

4.6.19 The groundwater beneath Port Edgar Barracks was found to be in hydrostatic continuity with the Forth. No groundwater monitoring was undertaken as part of the marine investigations as all positions were located below sea level. However, groundwater within the marine areas is expected to be in hydrostatic continuity with the Forth.

4.6.20 The ground investigations generally did not encounter any ground gas producing strata with the exception of the beach deposits / made ground beneath Port Edgar Barracks, which was found to produce low levels of ground gas.

Foundations

4.6.21 The foundations to the Main Crossing structure have been developed as spread pad footings and piled foundations, with structure loads being taken down to bedrock. Foundations to the south and north towers are in deep water over deep soft soils, with the depth between sea level and rockhead being up to 40m. The difficultly in forming foundations at this depth led to the development of piled foundations at the flanking towers and also approach piers S1, S2, S3, S4 and N1 (refer to Figure 3.3 in Appendix A). Beamer Rock and the remaining approach viaduct piers will be constructed on pad foundations.

4.6.22 The top level of all foundations associated with the Main Crossing (pile caps and caissons), are positioned to be below -5mOD or below mud line where this is higher. This ensures that the foundations are both visually unobtrusive and provide limited clearance at low water level for small craft that may inadvertently pass close to the piers and towers.

4.6.23 Limited dredging and rock blasting will be required where the pile caps and caissons are located below sea bed level. Further blasting operations will be necessary for the preparation of Beamer Rock to receive the precast cellular caisson foundations for the central tower.

4.6.24 The land based foundations are all spread footing foundations and will be built in-situ. The construction issues for these largely relate to the excavations on steep slopes required both to create access for construction and to construct the foundations themselves. This is particularly the case on the steeply sloping inaccessible north shore.

4.7 Drainage, Hydrology and Hydrogeology

General

4.7.1 The drainage design for the proposed scheme incorporates a number of Sustainable Drainage Systems (SUDS) to achieve the required level of treatment for road runoff. These systems include carriageway drainage systems, swales and detention basins.

4.7.2 The drainage works associated with the proposed scheme consist of:

- Pre-earthworks drainage systems, which intercept surface and sub-surface drainage at the top of cuttings or the base of embankments, and directs this to a suitable outfall location or incorporates it within the carriageway drainage system. Pre-earthworks drains will comprise a filter drain system. The water carried in these systems is considered to be free from pollutants arising from the proposed scheme and is isolated from the carriageway drainage systems where possible.
- Carriageway drainage systems collect surface water runoff from the main carriageway together with surface water runoff from cut slopes and any sub-surface drainage present in areas of cutting. These systems typically comprise pipes placed at the base of free draining stone material, through which the surface water filters to enter the pipe. This filtration process provides a first stage in removing pollutants arising from the surface water runoff.
- Flood flow routes – flood flows over and above that which can be carried by the carriageway drainage system, in areas sensitive to flood risks, have been identified and catered for when required.
- Swales can also be used to collect surface water runoff from the main carriageway. Swales usually comprise a grassed ditch and occasionally incorporate a standard filter drain below the grassed ditch. This system provides a level of treatment as it removes pollutants arising from the proposed scheme from the surface water runoff. Swales can be incorporated into a treatment train along with a detention basin.
- An outfall detention basin, which receives water from drainage systems immediately prior to its discharge into the receiving watercourse. This feature has two principal functions. Firstly, it is designed to reduce the rate at which water outfalls into the receiving watercourse to a pre-development flow rate from the rate at which it enters the detention basin. The basins are designed to attenuate the 1:200 year run-off rate with the proposed scheme to the 1:2 year pre-development run-off rate that would have occurred without the proposed scheme in place. In addition, the basins provide capacity for the 1:1000 year storm within the basin freeboard. This enables the hydrological performance of the receiving watercourse to be maintained at the levels occurring prior to the introduction of the proposed scheme, avoiding downstream flooding events. The second

principal function is to enable the removal of pollutants in the 'first flush' of carriageway runoff through settlement such that the cleanliness of the water discharged is at an acceptable level in terms of the receiving watercourse.

- The final element of the drainage system, which is not physically linked to the elements previously described, is the provision of suitably sized structures to accommodate watercourses crossed by the proposed scheme. There are no watercourse crossings in proximity to the Ferrytoll or Admiralty junctions. South of the Firth of Forth, these structures are in the form of extensions to existing culverts or new culverts which are sized in relation to the catchment area of the watercourse and the specified flood flow event that must be accommodated.

4.7.3 Where the proposed scheme encroaches on the floodplain of watercourses, adequate compensatory storage will be provided.

4.7.4 All proposed detention basins and swales will be designed with an impermeable liner to reduce risk of pollution to groundwater. In addition, proposed drainage systems along areas of groundwater sensitivity will be contained or lined.

4.7.5 The Scottish Environment Protection Agency (SEPA) is the body responsible for the regulation of activities which may effect Scotland's water environment. Under the Water Environment (Controlled Activities) (Scotland) Regulations 2005, licenses will be required for the following activities:

- Engineering works within existing watercourses.
- The discharge of water from the drainage system into existing watercourses.

Drainage Networks – North of the Firth of Forth

4.7.6 The drainage systems employed within the Stage 3 design for the proposed scheme north of the Firth of Forth are summarised below:

<u>Firth of Forth Drainage System</u>

4.7.7 This drainage system proposes a direct outfall to the Firth of Forth and caters for a section of the Main Crossing, chainage 6850m to chainage 8870m of the mainline carriageway (as detailed in Figures 3.12, 3.13 and 3.14 in Appendix A), the proposed Ferrytoll Junction and the connections to the Forth Road Bridge.

<u>Existing Drainage Systems</u>

4.7.8 Existing drainage systems shall be utilised to drain the following sections:

- The southern section of the realigned B980 (Castlandhill Road) and the realigned Ferry Toll Road;
- The realigned section of the B981 (Hope Street) to Inverkeithing;
- Chainage 8870m to chainage 9110m (as detailed in Figure 3.15 in Appendix A) of the mainline carriageway where the existing A90 is enhanced as a part of the proposed scheme.

<u>Attenuation and Treatment</u>

4.7.9 The outfall of the proposed Firth of Forth drainage system uses a detention basin to attenuate the 'first flush' of surface water runoff. The runoff will then be discharged into the Firth of Forth. An additional level of treatment is proposed through the provision of a swale at the outlet from the detention basin.

4.7.10 Any overflow of surface water collected by the detention basin will be directed through a grassed overflow channel and then discharged into the Firth of Forth.

Additional Constraints

4.7.11 Mitigation is required to reduce the impact to the hydrology and flood risk of St. Margaret's Marsh as a result of the operation of the SUDS basin and the realigned B981 through the northern portion of the marsh. To mitigate against catchment severance following the completion of the realigned B981, cross drainage will be provided beneath this road to hydrologically link the upstream and downstream portions of the marsh area.

Drainage Networks – South of the Firth of Forth

4.7.12 The drainage systems employed within the Stage 3 design for the proposed scheme south of the Firth of Forth are summarised below:

Queensferry Junction

- Ferry Burn outfall, servicing the carriageway drainage network extending from chainage 1810m to chainage 2800m (refer to Figure 3.9 in Appendix A)
- Mouth of Forth Estuary / Linn Mill Burn outfall, servicing the carriageway drainage network extending from chainage 2980m to chainage 4360m (refer to Figure 3.10 in Appendix A).
- Mouth of Forth Estuary / Linn Mill Burn outfall, servicing the carriageway drainage network of the Main Crossing approach viaduct.

4.7.13 There are six drainage systems which connect directly into the drainage networks associated with existing infrastructure.

4.7.14 The following sections connect to the drainage system associated with Scotstoun Junction:

- The carriageway drainage network extending from chainage 1490m to chainage 1930m (refer to Figure 3.9 in Appendix A) including the widened A90, public transport links and a section of the realigned A8000 south of the mainline overbridge; and
- The carriageway drainage network on the eastbound public transport link.

4.7.15 The carriageway drainage network on the realigned A8000 north of the mainline overbridge connects to the drainage network associated with the existing road.

4.7.16 Further connections to existing drainage systems occur in proximity to the A904 / B924 junction at Echline Corner, and include:

- The carriageway drainage network on the minor realignment of the A904 east of Queensferry Junction;
- The carriageway drainage network on the minor realignment of the B924 Bo'ness Road; and
- The carriageway drainage network on the minor realignment of the A904 west of Queensferry Junction.

M9 Junction 1a

- Swine Burn outfall, servicing the drainage network on the southbound carriageway extending from chainage 2200m to chainage 2500m (refer to Figure 3.6 in Appendix A).

- Tributary of Swine Burn outfall, servicing the drainage network on the northbound carriageway extending from chainage 2180m to chainage 2500m (refer to Figure 3.6 in Appendix A).
- Niddry Burn outfall, servicing the carriageway drainage network extending from chainage 1300m to chainage 2200m (refer to Figures 3.5 and 3.6 in Appendix A) and including the M9 eastbound to M9 Spur northbound link, the M9 Spur southbound to M9 westbound link and the M9 Spur southbound to M9 eastbound link.
- River Almond outfall, servicing the carriageway drainage network extending from chainage 700m to chainage 1300m (refer to Figure 3.5 in Appendix A).
- Swine Burn outfall, servicing the carriageway drainage network on the M9 Spur extending from chainage 0m to chainage 770m (plus an additional 460m of existing drainage to the north) and the M9 eastbound to M9 Spur northbound link (refer to Figure 3.7 in Appendix A).

Attenuation and Treatment

4.7.17 The proposed outfalls described utilise detention basins to attenuate surface water runoff prior to discharge into the receiving watercourse, with the exception of the drainage run to the southbound carriageway at M9 Junction 1a, which outfalls directly to Swine Burn.

4.7.18 The following drainage runs have additional treatment.

- River Almond Outfall - one swale prior to the detention basin.
- Ferry Burn Outfall – one swale prior to the detention basin.

Watercourse Structures

4.7.19 The requirement for watercourse structures as part of the proposed scheme south of the Firth of Forth is as follows:

- Extension of the existing culvert at the tributary of Niddry Burn (M911E).
- Extension of the existing culvert at Niddry Burn (M912E).
- Extension of the existing culvert at Swine Burn (M907E).
- Provision of a new culvert at the Swine Burn realignment (M904).
- Extension of the existing culvert at the tributary of Swine Burn (M910E).

Drainage Network – Main Crossing

4.7.20 For drainage, the Main Crossing has been split into 3 separate sections:

- The southern area over land and the intertidal foreshore, drained to south;
- The central section, directly over the estuary with direct drainage to the Firth of Forth; and
- The northern area over intertidal foreshore and land, drained to north.

4.7.21 The section directly over the estuary drains by collecting the surface runoff from the carriageway and directing it into an asphalt surface water channel which runs longitudinally on the outside edge of the bridge deck. The surface runoff at the central zone between the two carriageways will be collected by kerb channel next to the asphalt surfacing. The surface water drains to gullies, located along both outside edge and central zone, at regular spacings to ensure the surface water does not overtop the channel and flood the bridge deck. The outlets from the gullies are connected to pipes which run vertically down through the bridge deck and outfall directly to the Firth of Forth. This process is similar to the design on the current Forth Road Bridge.

4.7.22 The sections of the Main Crossing that sit over the intertidal foreshore and land on the north and south side of the estuary make use of a similar surface runoff collection design to that detailed above. However, to avoid the occurrence of erosion of the intertidal foreshore or land from pipes outfalling directly, the outlets from the gullies connect to carrier pipes which run longitudinally within the bridge deck. These pipes drain back to the north and south abutments, where they are connected to the land based drainage systems and then on to the SUDS detention basins before outfalling into the Firth of Forth.

4.8 Land Based Structures

Structural Description and Location

4.8.1 The structure referencing system used in this DMRB Stage 3 report has been amended from that used previously in the DMRB Stage 2 Corridor Report. It is a stand alone project based referencing system which does not correlate with any existing system that might be in use by Transport Scotland or BEAR Scotland Ltd. Previous DMRB Stage 2 Corridor Report references used for each structure are given in brackets.

North of the Firth of Forth

4.8.2 A summary of the proposed Stage 3 Design for the structures which are required within the proposed scheme north of the Firth of Forth is provided in the following paragraphs. The location of each structure is shown in Figure 4.4 in Appendix C.

<u>Structure FT01 (previously Structure 177/1)</u>

4.8.3 Structure FT01 consists of a pair of new multi span composite steel / concrete multi-cell box girder structures which carry the new mainline from north of the Main Crossing towards the relocated Ferrytoll Junction. Span lengths vary and the structure supports are located on a skew alignment to accommodate the location of side roads below the structure. The overall length of the structure is approximately 350m with the deck supported on reinforced concrete abutments and piers founded on reinforced concrete piled foundations.

<u>Structure FT02 (previously Structure 177/2)</u>

4.8.4 Structure FT02 is of similar construction to Structure FT01 above and provides a northbound connection from the mainline to Ferrytoll Junction. It is approximately 250m long and supported on substructure similar in construction to Structure FT01.

<u>Structure FT03</u>

4.8.5 Structure FT03 is a new structure located approximately 100m north of the existing Ferrytoll Junction which will carry the A90 over the northern leg of the reconstructed Ferrytoll Junction. It consists of a single 27.4m clear square span deck on a skew of approximately 17°. The deck comprises a composite steel beam and slab type deck integral with reinforced concrete cantilever abutment walls supported on spread footings.

<u>Structure FT05</u>

4.8.6 Structure FT05 is a new structure to carry the realigned B981 over the Inverkeithing South Junction – Rosyth Dockyard Branch Line Railway. It consists of a single 14.5m clear span precast pre tensioned beam and slab type deck integral with reinforced concrete abutments. The wingwalls are also of reinforced concrete construction. The abutments and wingwalls will be supported on reinforced concrete spread footings. In selecting the span of the structure, provision has been made to accommodate a future second track to the south of the existing track. Very high containment level (H4a) parapets will be provided over the structure in accordance with Network Rail requirements for new bridges over the railway.

Structure FT06E (previously Structure 177-4)

4.8.7 Structure FT06E which carries the existing A90 over the southern leg of the existing Ferrytoll Junction will be demolished due to the relocation of Ferrytoll Junction to the north.

Structure FT07E (previously Structure 177-5)

4.8.8 Structure FT07E which carries the existing A90 over the northern leg of the existing Ferrytoll Junction will in future span over the proposed southern leg of the relocated Ferrytoll Junction. The existing structure will be widened on each side to accommodate the new wider mainline carriageway. The form of the widening will be similar to the existing bridge, i.e. a single span structure with a clear span length of 11.89 metres between abutments consisting of an insitu reinforced concrete portal frame of integral construction founded on spread footings.

Structure FT08E (previously Structure 177-10)

4.8.9 Structure FT08E which is an existing railway tunnel located beneath the A90 at Ferrytoll Junction will be retained without modification.

Structures FT09E and FT10E (previously Structures 177-11 and 177-12)

4.8.10 Structures FT09E and FT10E carry the B980 (Castlandhill Road) over the Inverkeithing South Junction – Rosyth Dockyard Branch Line Railway and will be retained. The existing western masonry parapet to the arch structure FT10E located in the centre reserve of the B980 (Castlandhill Road), which is a dual carriageway at this location, will be demolished and the existing deck slab of Structure FT09E extended over the arch fill to tie in with the eastern masonry parapet of the arch bridge. This slab extension will act as a load transfer structure to the arch thus reducing load effects on the arch whilst allowing a single carriageway without longitudinal joints to be provided over both structures to form the western leg of the relocated Ferrytoll Junction.

Structure FT11

4.8.11 Structure FT11 is a new retaining wall structure located between the new southbound mainline and the new southbound merge from Ferrytoll Junction. It consists of a reinforced concrete cantilever wall structure featuring rock anchors. It is approximately 190m long and retains a maximum height of 10.6m. The exposed concrete finish of the wall will match that of Structures FT03 and FT07E.

Structure FT12

4.8.12 Structure FT12 is a new retaining wall structure located between the new southbound mainline and the new southbound diverge to Ferrytoll Junction. It consists of a reinforced concrete cantilever wall structure featuring rock anchors. It is approximately 225m long and retains a maximum height of 7.6m. The exposed concrete finish of the wall will match that of Structures FT03 and FT07E.

Structure FT13E

4.8.13 Structure FT13E carries the Edinburgh to Aberdeen Railway Line across the B981 (Hope Street) and the Inverkeithing South Junction – Rosyth Dockyard Branch Line Railway. It will be retained without modification.

Structure FT14E

4.8.14 Structure FT14E carries Dunfermline Wynd Road over the existing A90 and will be retained. The existing southbound A90 carriageway arrangement will be retained without modification; however, the northbound will be modified to accommodate three carriageway lanes and a hard shoulder which reduces to 1000mm wide through the structure.

4.8.15 The existing masonry facing to the lower section of the western reinforced concrete pier will be removed and a reinforced concrete collar will be constructed around the lower section of pier to connect a double rail open box beam safety barrier to the pier both on approach to and departure from the structure.

South of the Firth of Forth

4.8.16 A summary of the proposed Stage 3 design for the structures which are required within the proposed scheme south of the Firth of Forth, including in proximity to M9 Junction 1a, is provided in the following paragraphs. The location of each structure is shown in Figure 4.5 in Appendix C.

Structure ESQ02

4.8.17 ESQ02 is a new junction structure which is required to carry the northern leg of the Queensferry Junction gyratory over the new mainline. It consists of three square spans of 27.9m, 47m and 17.7m. It will comprise a steel / concrete composite deck supported on reinforced concrete piers and bankpad abutments supported on spread foundations. A 3m wide footway / cycleway is provided in the north verge with the south verge sized to accommodate sightlines around the gyratory carriageway.

Structure ESQ03

4.8.18 ESQ03 is a new junction structure to carry the southern leg of the Queensferry Junction gyratory over the new mainline. It consists of three square spans of 18.4m, 47.9m and 14.5m. It will comprise a steel / concrete composite deck supported on reinforced concrete piers and bankpad abutments supported on spread foundations. A 3m wide footway / cycleway is provided in the south verge with the north verge sized to accommodate sightlines around the gyratory carriageway.

Structure ESQ04

4.8.19 New Structure ESQ04 will replace existing Structure ESQ08E which is to be demolished and will carry the realigned A8000 over the new mainline and proposed public transport lane. It consists of three spans of 31.25m, 40.3m and 32.75m at a skew of approximately 11°. It will comprise a steel / concrete composite deck supported on reinforced concrete piers and bankpad abutments. ESQ04 will also be designed to accommodate future provision of an LRT / BRT system with one track located in each verge. In this case, a new footbridge will be constructed alongside to accommodate pedestrian traffic.

Structure ESQ05 (previously Structure 239/5)

4.8.20 Structure ESQ05 is required to protect an existing strategic utility and is of similar construction to a culvert. The utility crosses below the proposed location of the new mainline. It comprises a single span structure having an approximate length of 160m. It is an insitu reinforced concrete portal structure founded on spread footings.

Structure ESQ06 (previously Structure 239/9)

4.8.21 Structure ESQ06 is a structure similar to Structure ESQ05. It comprises a single span structure having an approximate length of 78m.

Structure ESQ07 (previously Structure 239/8)

4.8.22 Structure ESQ07 is a structure similar to Structure ESQ05. It comprises a single span structure having an approximate length of 225m.

Structure ESQ08E (previously Structure 239-3)

4.8.23 Structure ESQ08E carries the A8000 over the A90. This structure will be demolished and replaced with Structure ESQ04 above on an adjacent alignment.

Structure ESQ09E

4.8.24 Structure ESQ09E is an existing structure which carries the A90 over the railway line to the southwest of Dalmeny and consists of a preflex beam and concrete infill type deck slab. Existing parapets are of masonry construction and a service trough is provided in the verges adjacent to the parapets. Due to the proposal to provide a dedicated public transport lane eastbound along the A90, it will be necessary to widen the existing carriageway and upgrade the parapet containment on the existing bridge. It is proposed to provide a precast concrete very high (H4a) containment parapet over the structure, the parapet being anchored to the existing deck slab inbound of the existing services trough. The services trough and existing masonry parapet will therefore be retained without need for modification.

Structure ESQ10E

4.8.25 Structure ESQ10E is an existing structure which carries the A90 over Standingstane Road and consists of an insitu reinforced concrete deck slab with deck edge cantilevers which accommodate a number of services. Due to the proposal to provide a dedicated public transport lane eastbound along the A90, it will be necessary to widen the existing carriageway. The widened carriageway can be carried by the existing deck slab and it is not proposed to carry out any further works on this structure with the exception of reconstructing the verge to a new crossfall.

Structure M901

4.8.26 Structure M901 is a new structure provided at M9 Junction 1a to carry the new M9 westbound to M9 Spur northbound slip road over the existing M9. It is located immediately to the west of the existing Structure M906E and consists of three spans of 14.3m, 42.2m and 14.8m with a steel concrete composite deck on reinforced concrete piers and abutments. The form of the structure has been chosen to be similar to the existing adjacent Structure M908E.

Structure M903

4.8.27 Structure M903 is a new structure provided at M9 Junction 1a to carry a new link from the M9 Spur to the M9 westbound carriageway. It crosses Overton Road and comprises a single 8.6m square span reinforced concrete portal type structure supported on spread foundations. It is located adjacent to the existing Structure M905E.

Structure M904 (previously Structure 167-2)

4.8.28 Structure M904 is a new culvert which will carry the Swine Burn below the M9 eastbound to the M9 Spur northbound link. The structure comprises a single span box type structure with a clear span of 6m and overall length of approximately 70m. A low flow channel is also provided through the structure.

Structure M905E (previously Structure 167-7)

4.8.29 Structure M905E carries the M9 over Overton Road to the west of M9 Junction 1a. It is a two hinged reinforced concrete portal structure with a clear square span of approximately 7.75m at a skew of 18°. This structure will be retained and widened on the northern side to accommodate a new link from the M9 eastbound to the M9 Spur northbound.

Structure M906E (previously Structure 167-10)

4.8.30 Structure M906E carries the existing link from the M9 westbound to the M9 Spur northbound over the M9. It is a three span structure with spans of 20.1ms, 43.9m and 20.1m. It is a steel / concrete composite structure with the piers founded on spread footings and abutments supported on piles. The existing structure will be retained and following construction of Structure M901, Structure M906E will carry the M9 Spur southbound over the M9, forming the new westbound slip road to the M9.

Structure M907E (previously Structure 167-8)

4.8.31 Structure M907E is an insitu reinforced concrete twin barrel culvert carrying the M9 Spur southbound to M9 eastbound slip road over the Swine Burn. It has an overall length of 142m and each barrel has a span of 1.5m and 1.8m headroom. The existing structure will be extended on the west side to accommodate the new connection between the M9 westbound and the M9 Spur northbound over Structure M901.

Structure M908E (previously Structure 167-5)

4.8.32 Structure M908E carries the M9 Spur over the B9080. It is a single span bridge with a clear span of 14.2m with a skew angle of 20°. The northbound and southbound carriageways are each carried on separate decks which comprise of precast pretensioned beams with solid infill. The decks are transversely post tensioned with Macalloy bars. The abutments comprise reinforced concrete counterfort walls supported on bored piles. The existing western deck will be removed and the existing abutments extended westwards to support a new widened deck to carry the northbound and southbound carriageways of the M9 Spur over the B9080. In addition, new inspection galleries will be provided to the existing abutment walls to improve maintenance and inspectability of both the new and existing bridge decks.

Structure M909E

4.8.33 Structure M909E carries the A90 over the River Almond and will be retained without modification.

Structure M910E

4.8.34 Structure M910E is a precast reinforced concrete box culvert carrying the M9 over the tributary of Swine Burn. It has an overall length of 139m with a span of 2.6m and 1.82m headroom. The existing structure will be extended to the north and south to accommodate the widened M9 eastbound and westbound carriageways.

Structure M911E

4.8.35 Structure M911E is a 700mm diameter pipe culvert carrying the M9 over a subsidiary of the Niddry Burn. It has an overall length of 54m. The existing structure will be extended to the east and west to accommodate the widened M9 northbound and southbound carriageways.

Structure M912E

4.8.36 Structure M912E is a precast reinforced concrete box culvert carrying the M9 over Niddry Burn. It has an overall length of 82m with a span of 1.8m. The existing structure will be extended to the east and west to accommodate the widened M9 eastbound and westbound carriageways.

4.9 Fencing and Environmental Barriers

Fencing

4.9.1 Temporary fencing will be erected prior to the commencement of construction where appropriate. Whilst much of the agricultural land bounding the proposed scheme is arable in nature, stock proofing may be required in some areas.

4.9.2 Upon completion of the works, the proposed scheme boundary will typically take the form of a permanent fence, with a timber post and rail fence commonly being used to indicate a motorway boundary and a post and wire fence being used in other instances. Alternative methods of signifying property boundaries may include the planting of hedgerows or the construction of walls.

Environmental Barriers

4.9.3 Environmental barriers may be required to reduce the impact of the proposed scheme in specific locations. The requirement for such measures including the provision of visual screening or mammal mitigation, including badger fencing and otter fencing, will be provided in accordance with the requirements of the Environmental Statement.

4.9.4 To counteract the noise effects associated with the proposed scheme, suitable noise mitigation measures will be provided. Noise mitigation will also be provided in accordance with the requirements of the Environmental Statement.

4.10 Traffic Signs and Lighting

Traffic Signs

4.10.1 The traffic signs required in the provision of the proposed scheme will be designed to the relevant design standards. The detailed design of this element of the works will be the responsibility of the Contractor, and will be subject to compliance with the contract documents. As a part of the design process, the Contractor will consult with Transport Scotland and local roads authorities with regards to the provision of all signage.

Lighting

4.10.2 For the purposes of the Environmental Impact Assessment (EIA), it has been assumed that the whole of the proposed scheme would be lit at night, which is a conservative “worst-case” scenario in terms of potential environmental impacts. Design development indicates that road lighting will be required as a minimum on the mainline between the Scotstoun Junction and the Main Crossing in the south and between the Main Crossing and Admiralty Junction in the north. In addition, it is considered that Ferrytoll and Queensferry junctions and the side roads in their vicinity will require to be lit. The functionality of the installed lighting will allow for dimming and remote control for future energy reduction to support government objectives to reduce carbon emissions, pollution of the night sky and to reduce impacts on the rural landscape where this can be achieved safely and effectively.

4.11 Road Restraint Systems

4.11.1 The road restraint systems required in the implementation of the proposed scheme will be designed in accordance with the relevant design standards. The detailed design of this element of the works will be the responsibility of the Contractor, and will be subject to compliance with the contract documents. As a part of the design process, the Contractor will be required to consult with Transport Scotland, local roads authorities and third parties where particular requirements for road restraint systems exist.

4.12 Public Utilities

General

4.12.1 All public utility companies were contacted in accordance with the New Roads and Street Works Act 1991 (NRSWA) to identify locations of existing plant and details of preliminary proposals for diversions and budget costs. There are numerous locations where public utility apparatus conflicts with the proposed scheme, requiring diversionary and / or protection measures to be provided prior to and during construction.

Specific Requirements

<u>North of the Firth of Forth</u>

4.12.2 To the south of Ferrytoll junction, Scottish Power, Cable and Wireless, Scotia Gas Networks (medium pressure) and BT apparatus are currently located beneath the B981 and A90. These services will require diversion. Careful programming will be required in this area due to the narrow construction corridor which has been dictated by existing constraints.

4.12.3 A survey has been undertaken to establish the line and level of sewers in the vicinity of Ferrytoll Junction. Large diameter pipes feed in and out of the adjacent Dunfermline Waste Water Treatment Works and depending on the final design of the viaduct and approach roads associated with the reconstructed Ferrytoll Junction it is likely that sections of the sewer will require protection or diversion.

4.12.4 A large diameter Scottish Water pipe from Dunfermline Waste Water Treatment Works outfalls into the Firth of Forth at a point to the east of the Forth Road Bridge, outwith the proposed scheme. An overflow outfall does cross St Margaret's Marsh however, which will require diversion to the south side of the proposed detention basin. Any diversion to the north of the detention basin would adversely impact the marsh area.

4.12.5 The proposed Ferrytoll gyratory, Ferry Toll Road, the B981 (Hope Street) and the proposed slip roads and public transport links will impact on Scottish Power, Scottish Water (clean water), Cable and Wireless, Scotia Gas Networks (medium pressure) and BT apparatus. It is expected that much of the apparatus on the B981 (Hope Street) and on the Ferrytoll gyratory can be protected during construction.

4.12.6 A medium pressure gas main and Cable and Wireless apparatus may need to be diverted from the east verge to the west verge of the B980 (Castlandhill Road). This requirement will be dictated by the earthworks design for both the B980 (Castlandhill Road) and the mainline carriageway.

4.12.7 A 33kv overhead Scottish Power line crosses the A90 south of Dunfermline Wynd Overbridge. It is anticipated that the proposed scheme will not impact upon this apparatus although it should be considered as an electrocution risk during construction.

4.12.8 North of Dunfermline Wynd Overbridge, Scottish Power apparatus runs beneath the verge of the mainline carriageway southbound, before crossing the mainline to the verge of the diverging slip road to Admiralty Junction northbound. It is proposed that this apparatus is retained in the proposed verges of the mainline carriageway.

4.12.9 Public utilities apparatus is known to exist at numerous locations on the M90. The provision of ITS equipment, including gantries and road side VMS, may have an impact on existing apparatus which will require diversions or protection measures to be implemented.

<u>South of the Firth of Forth</u>

4.12.10 A Scottish Water long sea outfall for treated effluent is likely to be compromised if left in its current position due to Main Crossing construction activities. It is therefore proposed that this diversion be undertaken in advance of the main construction contract thus avoiding any delays to the Main Crossing construction programme.

4.12.11 Two further diversions would also be proposed as advanced works. In Echline Field, a twin Scottish Water rising main and gravity sewer plus a Scottish Power 11kv overhead power line clash with the Main Crossing south abutment and launching area. Further diversions including a Scottish Power overhead line and Scottish Water (clean water) apparatus will be required to allow the construction of the proposed mainline, although not necessarily as advanced works.

4.12.12 During any upgrade of Society Road, which may be required to accommodate the passage of construction vehicles to the site of the proposed south approach viaduct, the protection of Scottish Water (clean water), BT and Scotia Gas Networks (Low Pressure) apparatus will be required.

4.12.13 A diversion of Scottish Water (clean water), BT and Scotia Gas Networks (Medium Pressure) apparatus will required from the existing A904 to the realigned section of this route. This apparatus will be need to be accommodated within one of the two Queensferry Junction overbridges. At the western tie in of the A904, a twin Scottish Water rising main and gravity sewer will require protection or diversion.

4.12.14 To the south of Queensferry Junction, BT and Scottish Water (clean water) apparatus will require diversion from the existing Builyeon Road, which is severed by the proposed scheme, to the realigned section of this route. Under the proposed scheme, the structures at Queensferry Junction would also be required to carry this apparatus.

4.12.15 A Scottish Power 33kv overhead line will require diversion under the proposed mainline.

4.12.16 Immediately west of the A8000 overbridge, a Scottish Water (clean water) pipe and a Scottish Power underground main run parallel to the existing A90. Construction programming in this area will be dictated by the diversionary works required to utilities apparatus. These works are required before any construction of the proposed road network can commence.

4.12.17 The existing A8000 acts as a corridor for public utility apparatus. Due to the volume of apparatus, the possibility of a future LRT scheme and general availability of space within the proposed A8000 overbridge, it is proposed that larger utility apparatus, such as that required by Scottish Water, Scottish Power and Scotia Gas Networks, be located under the adjacent mainline carriageway. Other apparatus would be diverted into ducts which would be built into the structure. Careful programming will be required with regards to utilities diversions in advance of the construction of the new A8000 overbridge and the subsequent demolition of the existing structure. In the provision of the new structure, the diversion of an existing Scottish Water (clean water) pipe which crosses beneath the A90 may also be required.

4.12.18 Several public utilities have apparatus in the A8000 north of the existing overbridge. This apparatus will require protection during any upgrade works on this road.

4.12.19 East of the A8000 overbridge, Scottish Water, Scottish Power and BT apparatus are all impacted by the proposed mainline carriageway and public transport links. Diversions and protection measures will be required.

M9 Junction 1a

4.12.20 At M9 Junction 1a, a high pressure gas main will require protection as it crosses beneath the M9 Spur north of the junction. Only minimal earthworks will impact upon the pipe at this location. An additional crossing point to the west of M9 Junction 1a will have a greater impact due to the introduction of the proposed M9 Spur southbound to M9 westbound slip road. A diversion may be required at this location should protection works be deemed insufficient.

4.12.21 The extension of the underbridges at the B9080 and west of M9 Junction 1a will have an impact on Scottish Water and BT apparatus. Protection or diversion works will be required depending on the foundation design of each structure. BT apparatus will also be impacted by embankment widening adjacent to the M9 Spur southbound. This apparatus will require to be diverted to the toe of proposed embankment slope.

4.12.22 The widening of the M9 between M9 Junction 1a and Newbridge will impact upon a BT underground crossing, which will require a small diversion and some protection works. A Scottish Power overhead line may also require a diversion. BT underground apparatus in the B800 will also require protection during the construction of the access road to the proposed drainage detention basin located west of the River Almond.

4.13 Design Development

4.13.1 Further development work has been undertaken on the main elements of the Stage 3 design to seek to further reduce environmental impact and improve value for money. These design developments may be incorporated into the final detailed design.

4.13.2 The possible design refinements include minor amendments to local access roads and tracks including the realignment of the B924 (Bo'ness Road) to position it further from existing properties. There have also been localised changes to the position and shape of detention basins and minor amendments to engineering side slopes as a result of further ground investigation information becoming available.

4.13.3 A further refinement relates to the ITS design and the positioning of gantries and associated maintenance bays.

4.13.4 A notable area of design development is in proximity to Ferrytoll Junction where elements of the Stage 3 design have been refined to reduce the effects of the proposed scheme on existing features. It is possible to reduce the requirement for significant new rock cuts in proximity to Ferrytoll Junction at Ferry Hills and Inverkeithing Cemetery by implementing a western shift of up to 15m in the geometry of the mainline carriageway. This enables the existing rock cuts in these areas to be broadly maintained. Overall, it is assessed that there will be environmental benefits associated with the removal of the rock cuttings.

4.13.5 The western shift in the mainline geometry requires some refinements to the connecting road infrastructure associated with Ferrytoll Junction. These refinements are considered to have a positive effect on the operation of the proposed junction and the strategic / local road network to which it connects.

4.13.6 An environmental review has been undertaken on all refinements to the Stage 3 design, identified at the time of writing this report, to ensure that residual impacts are no worse than those reported in the Environmental Statement should they be incorporated into the detailed design. A similar process will be adopted for any further design developments considered in the development of the final design.

4.14 Proposed Construction Sequence

General

4.14.1 Three contracts are proposed:

- the principal contract for the new crossing and approach roads north and south of the Firth, along with the ITS to be installed over these sections;
- a concurrent contract to improve Junction 1a on the M9 and the installation of ITS from Newbridge to South Queensferry; and
- a contract to install ITS between Halbeath and Admiralty Junctions on the M90 in Fife.

4.14.2 The following sections summarise possible construction sequences for both the principal and concurrent contracts. The contractors are able, within the constraints of the contracts, to adopt a construction sequence of his choosing and, therefore, the construction sequencing described within this report is illustrative only and not prescriptive.

Site Compounds

4.14.3 Site compounds are required on both sides of the Firth of Forth to service the land based construction. One of these compounds is required to house the site management team and also to service the marine fed construction out in the Firth of Forth. A piled temporary access jetty is needed to construct the south approach viaduct to the Main Crossing. This was a consideration in the decision to locate the primary site compound on the south side of the Firth of Forth, in or in proximity to Echline Field, as the access jetty can provide a berth at its end for labour, plant and materials to be delivered to the main tower work sites.

4.14.4 The Environmental Statement describes two options for the primary compound sites; Echline Field (i.e. east of the works) and a site to the west of the works off the A904. The site to the west is the proposed location. This main compound will provide site offices, parking for personnel, workshops, a site laboratory, plant depot, material store, stockyard and messing facilities.

4.14.5 Similar functions will be required to the north of the Firth of Forth but to a much more limited extent as this compound will only serve the construction of the land based works in this area.

4.14.6 A further construction compound will be required for the proposed works at M9 Junction 1a. This compound will provide a similar function to that located north of the Firth of Forth.

Main Crossing

4.14.7 The Environmental Statement for the proposed scheme will ensure that the construction impacts on the Firth of Forth will be minimised and mitigated, whilst allowing the contractor flexibility to develop appropriate construction methods. A scheme construction report is included within the Environmental Statement describing indicative construction methods that have informed the Environmental Impact Assessment (EIA) process.

4.14.8 The design of the Main Crossing reflects the need to minimise construction impacts including:

- Limited foundation footprints;

- The span arrangement of the approach viaducts, with relatively long spans, to avoid environmentally sensitive sites on the land and to minimise the foundation footprint in the intertidal foreshore;
- The requirement for focused dredging activities and designed blasting;
- Consideration of methods to minimise work at the exposed location through the use of prefabrication;

4.14.9 Planning for the site activities for the project has been developed in accordance with the Code of Construction Practice. Certain marine construction activities require longer working hours because of the constraints of weather, tide and, critically, production time.

4.14.10 Weather records have been assessed to determine loss of productivity from the above working week. For marine construction activities 30% weather loss is assumed for programme estimation. Elsewhere, 17.5% weather loss has been assumed.

4.14.11 The total construction duration from site mobilisation to completion of finishes is assumed to be of the order 5 to 5.5 years.

4.14.12 The typical critical path in simplified form for the Main Crossing is as follows (with estimated durations in brackets):

- Main tower foundation construction within dry dock (12 months)
- Float out and positioning of caisson in rock pocket excavated on Beamer Rock (1 month)
- Construction of Central Tower (17 months)
- Construction of deck fan associated with Central Tower (10 months)
- Siting of deck erection equipment to North Flanking Tower (2 months)
- Construction of deck fan associated with North Flanking Tower (10 months)
- Erection of deck closure sections (2 months)
- Completion of deck finishes (7 months)

4.14.13 The approach viaduct construction is not on the critical path.

Primary Drivers Affecting Main Crossing Construction

4.14.14 The primary drivers that differentiate the options available in the construction of the Main Crossing are as follows:

<u>Erection Cycle and Unit Length</u>

4.14.15 The orthotropic deck option has been based upon 25m unit lengths and an 11 - day erection cycle. The composite box option is based upon 16m unit lengths and an 8 - day erection cycle. There is little time differential between the options resulting from this.

<u>Tower Complexity</u>

4.14.16 Jump forming of the mono-towers can be undertaken unhindered through angular changes in the legs or through the introduction of tie beams at deck level.

Heavy Lift of Tower Deck Units

4.14.17 The larger the unit that can be erected at the tower by strand jacks or floating crane, the eariler the main span deck erection can commence. A longitudinal splice in the deck is required at the towers to allow erection.

4.14.18 At the next stage of design more detailed programmes will be developed. The assumed loss of productivity due to weather will require a quantitative assessment based on wind and weather records for the site.

Construction Access

4.14.19 Access for construction has many constraints. The nature of the Main Crossing with three towers and associated deck erection fronts only accessible from water and constrained topography of the shores are drivers to a marine construction operation wherever possible. Conversely the long south approach over the intertidal flats and barracks drives land fed construction methods. These two drivers lead to the provision of primary access for construction and marine access from the south side of the Firth of Forth.

4.14.20 On the north shore, access is very difficult with steeply sloping outcropping which would require construction both at the top of the scarp and on the foreshore. As a result, land fed construction activities are kept to a minimum on this side of the Firth of Forth.

Construction Access – North Shore

4.14.21 The founding level of the Main Crossings north abutment and Pier N1 (refer to Figure 3.3 in Appendix A) would generate a haul road with a gradient of over 20% if it were to follow the route alignment. This is clearly not practical and hence two options exist for construction of the north shore structures. The first involves the generation of two access roads: one access road to construct the structures at the top of the scarp and the other road on top of rock fill land reclamation along the foreshore from St. Margaret's Marsh to the bridge alignment. The second option is to provide road access to the top of the scarp and create a transfer platform at the top of the scarp to allow plant and material to be lifted down to the foreshore to construct the piers and temporary works. The second option is considered more economic as well as having a less adverse environmental impact.

Construction Access – South Shore

4.14.22 An access dedicated to construction traffic has to be constructed down to the shore and out along the south approach viaduct. The A904 offers good access to Echline Field located above Society Road.

4.14.23 Two of the required piers, S5 and S6 (refer to Figure 3.3 in Appendix A), do not have an adequate depth of water at high tide to allow marine based plant to construct the foundations. The scheme envisaged at present has construction of these foundations within a temporary bund. The top of the bund will also form the access road to these foundations and the other piers.

4.14.24 A piled access jetty can provide access for construction of Piers S4 to S1 and will allow labour and materials to be delivered to the main towers. The access jetty would also service the construction of the south approach viaduct.

Interfaces with Road Infrastructure Network Works

4.14.25 The principal issues associated with the construction of the road infrastructure network interfaces are as follows:

- The constraints on space for the construction works on the north side will require either early completion of the Main Crossing approach spans or shared resource and planning in this area.
- The tie-in to the mainline carriageway has to be completed after the completion of the Main Crossing.

4.14.26 The interfaces on the south side are not particularly constrained as the Main Crossing works are relatively self contained on this side.

Road Infrastructure Network

4.14.27 To aid the process of assessing a possible construction sequence for the road network, the proposed scheme has been considered in the following sections, namely:

- Northern Bridge Approach and Ferrytoll Junction;
- Southern Bridge Approach and Queensferry Junction; and
- M9 Junction 1a.

4.14.28 These sections have been considered in respect of the necessary phasing of the works and the maintenance of existing traffic movements during construction. Each phase of the work will include one or more of the following activities:

- Site clearance;
- Temporary and permanent fencing;
- Service diversions;
- Top soil strip;
- Pre-Earthworks drainage;
- Earthworks;
- Drainage and service ducting;
- Top soiling and landscaping;
- Pavement construction;
- Road Restraint Systems;
- Signing and road marking;
- Structures;
- Accommodation works; and
- Communications and ITS.

4.14.29 An outline of the possible timing for the construction of the road network associated with the proposed scheme is provided in Table 4.4.

Table 4.4: Works Timescales

Network Connections North	Timescale
Advanced Works	July 2011 – March 2013
Ferrytoll Junction & Mainline North	April 2012 – July 2016
Network Connections South	
Queensferry Junction and Mainline South	April 2013 – July 2016
M9 Junction 1a	July 2011 – October 2014

Northern Bridge Approach and Ferrytoll Junction

Phase 1 – Mainline viaduct approach

4.14.30 The B981 will be diverted to facilitate construction of the approach viaduct and the A90 northbound diverge slip road. The B980 (Castlandhill Road) will also be diverted to the west and Ferry Toll Road realigned. Further north the A90 northbound carriageway will be widened. The west side of the Ferrytoll Roundabout underbridges and the existing A90 immediately north of the junction will be widened to permit commencement of the new gyratory underbridge in the next phase. Excavation of rock for the new southbound merge slip road will begin and a temporary southbound diverge slip road will be constructed.

Phase 2 – Gyratory East Underbridge

4.14.31 With traffic diverted onto the temporarily widened A90 the eastern half of the gyratory underbridge would be constructed. On the west side of the A90 the northbound merge slip road would be completed. Construction of the new southbound diverge slip road, including excavation of rock adjacent to the A90 southbound carriageway, would be carried out in this phase. Construction of the approach viaduct would also continue.

Phase 3 – Gyratory West Underbridge

4.14.32 In Phase 3 the western half of the gyratory underbridge will be completed and the A90 northbound diverge slip road will be completed up to the new gyratory. The gyratory would also be completed including the new access to Ferrytoll Park and Ride. Following completion of rock excavation, the new southbound merge slip road would be partially constructed with a temporary connection to the southbound A90.

Phase 4 – Mainline tie-in west side

4.14.33 With the gyratory and the new A90 northbound diverge slip road open, the west side of the tie-in of the new and old carriageways can be completed. A temporary ramp would then be constructed between the existing A90 and the newly constructed carriageway areas to allow traffic to be diverted in the next phase.

Phase 5 – Mainline tie-in east side

4.14.34 With traffic diverted onto a contra-flow on the completed northbound carriageway, the southbound tie-in and new southbound merge slip road can be completed and the Main Crossing opened. The A90 southbound merge and northbound diverge slips to the Forth Road Bridge would be completed after the Main Crossing is opened together with the remaining finishing works.

Southern Bridge Approach and Queensferry Junction

Phase 1 – Main offline earthworks, drainage and structures

4.14.35 This would involve the construction of the mainline and junction earthworks, and the junction structures. The A8000 overbridge, A904 / B924 junction and new northbound public transport link would also be completed in this phase.

Phase 2 – Completion of main offline road works and widening of A90 southbound carriageway

4.14.36 This would involve completing all road works on the mainline except for the tie-in to the existing A90 south of the Echline Junction. A temporary diversion at the A8000 would be constructed during this phase in order to allow completion of the tie-in at Phase 3. The existing A90 southbound carriageway, east of the A8000, will be widened to D3M standard through the addition of a hard shoulder. Construction of the new southbound public transport link would also commence in this phase.

Phase 3 – Main line tie-in and widening of A90 northbound carriageway

4.14.37 The A90 northbound carriageway east of the A8000 would be widened to D3M standard through the addition of a hard shoulder. Completion of the tie-in works would be coordinated with the opening of the Main Crossing. Completion of the southbound public transport link would take place after opening.

<u>M9 Junction 1a</u>

Phase 1 – Widening of the M9 westbound carriageway and all off line construction work

4.14.38 This work would involve construction of the M9 eastbound to M9 Spur northbound and M9 Spur southbound to M9 westbound links together with the widening of the existing M9 westbound to M9 Spur northbound loop. This would involve the construction of a new bridge over the M9 and the widening of existing bridges over the B9080 and Overton Road. The M9 westbound carriageway between the River Almond overbridge and M9 Junction 1a will be widened to 4 lanes with hard shoulder.

Phase 2 – Widening of the M9 eastbound carriageway and completion of all tie-ins at M9 Junction 1a

4.14.39 This would involve widening the M9 eastbound carriageway to 4 lanes with hard shoulder between M9 Junction 1a and the diverging slip road to Newbridge Roundabout, and the completion of all tie-in works at M9 Junction 1a, including finishing works.

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5 Modelling and Forecasting

5.1 Introduction

5.1.1 The traffic and economic assessment of the Main Crossing and connecting road network has been undertaken using the Transport Model for Scotland (TMfS:05A). This is a strategic, four stage, multi-modal forecasting model with a 2005 base year that translates output from the Transport and Economic Land Use Model of Scotland (TELMoS) into forecasts of travel demand on both the road and public transport networks. The assessment using TMfS:05A was supplemented with further assessment using a more detailed local area model using Paramics microsimulation modelling software.

5.1.2 This chapter of the report describes the operation of the transport model, future year forecasting and the derivation of the Do-Minimum scenarios. It also introduces the local area Paramics model: developed for detailed operational testing of the proposed scheme, including traffic management proposals and various Intelligent Transport System (ITS) measures. Chapter 6 (Operational Effects of the Managed Crossing Scheme) summarises the forecast traffic flows on the road network following construction of the proposed scheme and the benefits of the proposed scheme. The economic performance of the scheme is presented in Chapter 7 (Economic Performance of the Scheme).

5.2 Transport Model for Scotland

5.2.1 The Transport Model for Scotland (TMfS:05A) is an enhanced version of TMfS:05, as used in the Forth Replacement Crossing Study (FRCS) as part of the Strategic Transport Projects Review (STPR). Both models have a base year of 2005, and cover a geographical area that encompasses 95 per cent of the population of Scotland. They also include all of the principal urban centres (except Inverness), all Trunk Roads and a large proportion of non-Trunk principal roads. MVA Consultancy (MVA) maintains the model for Transport Scotland, for use as a planning and forecasting tool on major projects.

5.2.2 The main difference between these two versions of the transport model was the inclusion of modelled zones and public transport networks across the Highlands and Islands, alongside the incorporation of additional Origin – Destination travel data obtained through Roadside Interview (RSI) data in Ayrshire and around Dundee, into the model calibration and validation process. Full details of TMfS:05A model development and operation are available from the modelling portal on Transport Scotland's Land-use And Transport Integration in Scotland (LATIS) website (www.latis.org.uk).

5.2.3 Road based travel demand is assigned to the highway network using a volume averaged all-or-nothing assignment, in passenger car units (pcu) for each of the following four vehicle classes:

- Cars (travelling in work time);
- Cars (travelling in non-work time);
- Light Goods Vehicles (LGV); and
- Other Goods Vehicles (OGV).

5.2.4 In addition, scheduled bus and coach services are coded to follow predefined routes based on operator timetables.

5.2.5 Model vehicle speeds are derived from speed-flow curves for each link type in the TMfS:05A model. Junction delays are calculated for each movement, at each modelled junction. Figures showing the extent of junctions modelled are provided in the model calibration and validation reports available from the modelling portal on Transport Scotland's Land-use And Transport Integration in Scotland (LATIS) website (www.latis.org.uk).

5.2.6 Three distinct one hour time periods are modelled. These are:

- 08:00 – 09:00 (AM);
- A one hour average of the 10:00 – 16:00 (inter-peak); and
- 17:00 – 18:00 (PM).

5.2.7 Across the network as a whole, the 08:00 – 09:00 (AM) modelled hour is considered broadly representative of the morning 'peak' hour, while the 17:00 – 18:00 (PM) modelled hour is considered broadly representative of the evening 'peak' hour.

5.2.8 The modelled traffic volumes were converted to equivalent 18 hour weekday and Average Annual Daily (24 hour) Traffic volumes by applying a factor to each modelled hour. These conversion factors were derived from analysis of Scottish Household Survey data. Factors were derived for both Scotland as a whole and disaggregated by Regional Transport Partnership (RTP) area.

5.2.9 The following factors were applied to derive 18 hour and Annual Average Daily Traffic (AADT) volumes. These factors represent traffic in the SEStran Regional Transport Partnership area:

- 18 hour weekday flow = 2.21 x AM flow + 8.61 x inter-peak flow + 2.58 x PM flow
- AADT flow = (560 x AM flow + 3419 x inter-peak flow + 651 x PM flow) / 365

5.3 TMfS:05A Representation of Baseline Conditions

5.3.1 TMfS:05A is designed to replicate 2005 flows across the modelled area as closely as possible. The accuracy of the model nationwide is addressed in the model calibration and validation reports available from the modelling portal on Transport Scotland's Land-use And Transport Integration in Scotland (LATIS) website (www.latis.org.uk).

5.3.2 Two highway only model tests were undertaken to review the sensitivity of the model response to the opening of the M9 Spur Extension in September 2007 and the removal of bridge tolls in February 2008. These sensitivity tests assumed no change in travel demand from the calibrated base model and allowed only for change in route choice arising from these interventions. This approach best represents the short term route choice effects of the changes modelled, without the influence of longer term travel behaviour choices, which are represented in the full demand model.

5.3.3 These sensitivity tests indicate that construction of the M9 Spur Extension would lead to a decrease in traffic using the A90 between Scotstoun and Barnton with a corresponding increase in traffic on the M9 Spur south of the former Humbie Roundabout. This route switch is broadly consistent with observed changes in traffic demand in this area (as presented in paragraph 2.4.5).

5.3.4 These sensitivity tests also indicate that removal of the tolls from the Forth Road Bridge would lead to an increase in northbound flows across the Forth, particularly in the morning and evening modelled hours, but would result in little change to southbound flows. The additional northbound traffic forecast to use the Forth Road Bridge is consistent with a modest increase in traffic using the extended M9 Spur in the northbound direction and increased traffic flows on the A90 between Barnton and Scotstoun; to a level similar to that which existed prior to the opening of the M9 Spur Extension.

5.3.5 Taken together, these tests provide confidence that the model adequately represents baseline conditions across the study area and in its suitability for the testing and appraisal of the proposed scheme. The TMfS based modelling and appraisal work undertaken has been audited by the Traffic and Transport Auditor and Adviser appointed by Transport Scotland.

5.4 Population and Employment Forecasting

5.4.1 TELMoS is a land use model that forecasts future changes in population and employment, based on data from the 2001 census and more recent population forecasts made by the General Register Office for Scotland (GROS), forecast planning allocations provided by the local authorities, and relative travel costs obtained from TMfS:05A, taking account of committed future transport interventions. Population and employment changes, in turn, generate changes in travel demand, with increased travel demand generated by additional households and attracted by additional jobs.

5.4.2 TELMoS produces four future year forecasts of population, number of households and employment: 2012, 2017, 2022 and 2027. These forecasts are then used within TMfS:05A to generate travel demand forecasts in these years.

5.5 Growth between 2005 and 2017

5.5.1 Figures 5.1, 5.2 and 5.3 in Appendix D, indicate the forecast distribution of growth (and decline) of population, households and jobs, at a zone level between 2005 and 2017. Shaded areas show significant forecast changes, defined in the context of this chapter as an increase or decrease of more than 1,500 people, households or jobs compared to the 2005 base. Darker colours indicate the areas with the most significant changes.

5.5.2 Figure 5.1 in Appendix D indicates the principal areas where TELMoS forecasts a significant change in population between 2005 and 2017. Within the City of Edinburgh, the population is forecast to increase in a number of parts of the city, with forecast growth being strongest in the Leith area.

5.5.3 Within West Lothian, the population is forecast to grow in several areas, primarily to the north and west of Livingston.

5.5.4 North of the Firth of Forth, population growth is forecast in the Halbeath / Dulloch Park areas of Dunfermline and around Cardenden. However, a reduction in population is forecast in adjacent areas including central Dunfermline, the Templehall area of Kirkcaldy and the south of Glenrothes.

5.5.5 Figure 5.2 in Appendix D indicates the areas where TELMoS forecasts a significant change in the number of households. The distribution of growth in the number of households mirrors the growth in population.

5.5.6 Figure 5.3 in Appendix D indicates the areas where TELMoS forecasts a significant change in employment between 2005 and 2017. To the south of the Firth of Forth, employment growth is forecast to be strongest in southeast Edinburgh. The growth in jobs is forecast to be strongest in Edmonstone: the area surrounding the Edinburgh Royal Infirmary; and in the Millerhill area of Midlothian.

5.5.7 Substantial growth in employment is also forecast for West Lothian in the Bathgate area and to a lesser extent across the south of the West Lothian area encompassing Fauldhouse / Whitburn, Blackburn, Kirknewton, Harburn and Almondvale.

5.5.8 No significant changes in permanent long term employment are forecast to the north of the Firth of Forth between 2005 and 2017.

5.5.9 Traffic is likely to increase most within and between areas where a significant increase in population is forecast and areas where a significant increase in employment is forecast. Traffic growth will generally be lowest between areas where population and employment opportunities are both forecast to decline

5.5.10 Growth in traffic movements within south Fife is likely to be lower as a result of a small decline in population in parts of south Fife and the lower employment growth than forecast in West Lothian. Some growth in cross-Forth traffic would be expected as Fife residents take up employment opportunities in growth areas south of the Firth of Forth.

5.6 Growth between 2017 and 2032

5.6.1 Figures 5.4, 5.5 and 5.6 in Appendix D indicate the forecast distribution of growth (and decline) over the period 2017 to 2027, which is the most distant forecast year, at a zone level. These figures forecast demographic changes and assume unrestricted operation of the existing Forth Road Bridge over the period to 2027.

5.6.2 The pattern of development over the period 2017 to 2027 indicates development occurring at more outlying locations, as the supply of available development land becomes increasingly restricted.

5.6.3 Within the City of Edinburgh, TELMoS forecasts further growth in the population of the Leith area. No significant reductions in population are forecast in Edinburgh over the period 2017 to 2027.

5.6.4 Within West Lothian, the population is forecast to continue to grow, with growth being strongest to the north and west of Livingston. Further growth to the south of Livingston and around Winchburgh is forecast. As with the period prior to 2017, no areas of West Lothian are forecast to see a significant reduction in population over the ten year period beyond 2017.

5.6.5 North of the Firth of Forth, no significant growth in population is forecast, but the downward trend in the population of Glenrothes South and the Templehall area of Kirkcaldy is forecast to continue.

5.6.6 Figure 5.5 in Appendix D indicates the areas where TELMoS forecasts a significant change in the number of households. The distribution of growth in the number of households mirrors the forecast growth in population.

5.6.7 Figure 5.6 in Appendix D indicates the principal areas where TELMoS forecasts a significant increase in employment over the period 2017 to 2027. With most of the commercial land allocation in Edinburgh and the 'South East Wedge' area of Midlothian taken up by 2017, growth in employment between 2017 and 2027 is forecast to be strongest in West Lothian and the parts of Midlothian further from Edinburgh, particularly in the Roslin and Bilston area. In West Lothian, significant employment growth is forecast across much of the local authority area, with employment opportunities increasing to the south, east, north and west of Livingston.

5.6.8 Within Midlothian and southeast Edinburgh, further growth in employment opportunities is forecast in the area surrounding the Edinburgh Royal Infirmary. Within the City of Edinburgh itself, there is little additional employment growth forecast between 2017 and 2027, although a significant reduction in employment opportunities is forecast in parts of central Edinburgh. In southern Fife, employment is forecast to decline in central Dunfermline, but this is offset by forecast increases in employment in the Cowdenbeath area and the Sinclairtown area of Kirkcaldy.

5.6.9 These changes in demographics translate into changes in trip generation and attraction within the transport model in future years.

5.7 Future Year Trip Matrices

5.7.1 As highlighted in the previous section, the Transport Model for Scotland (TMfS:05A) has four future forecast years: 2012, 2017, 2022 and 2027. Full demand model runs create the future year matrices for each of these years. However, as the design year (15 years after scheme opening) is not a modelled year, it was necessary to adopt a methodology to create forecast 2032 traffic flows for design and environmental appraisal purposes.

5.7.2 The proposed scheme coding was used in demand model runs in each of the years 2017 (first year of operation), 2022 and 2027. 2022-27 difference matrices were then derived by subtracting each of the 2022 matrices from the corresponding 2027 matrices. These difference matrices were then added to the 2027 matrices to create 2032 assignment matrices, hence, effectively extrapolating 2022 to 2027 changes, from 2027 to 2032. Any resultant zone-to-zone movements with a negative value were set to zero, with negligible impact.

5.7.3 The resultant 2032 matrices were then assigned in TMfS:05A by undertaking a 'highway only' assignment using 2027 generalised cost equations and other parameters. The principal reasons for adopting this extrapolation methodology were:

- It is based on TELMoS / TMfS:05A forecast trends;
- It can be applied to both highway and public transport assignments;
- It takes account of differing rates of growth in the three modelled time periods;
- It takes account of differing rates of growth for the assigned vehicle types; and
- It takes account of differing rates of growth between different origins and destinations.

5.7.4 This means that all forecast trends are projected forward and higher rates of traffic growth will result over the period 2027 to 2032 between areas forecast to develop the most between 2022 and 2027. Lower or negative growth will however occur between areas forecast by TELMoS to be already fully developed, or likely to suffer from forecast economic decline due to growth elsewhere. Consequently, this methodology broadly correlates with the forecast changes in the land use model between 2005 and 2027 and forecast capacity constraints on the existing network in 2027. The principal drawback is that there are a few origin destination movements where the number of trips between 2022 and 2027 declines and it may be considered unrealistic for this trend to continue between 2027 and 2032 without Government intervention. In such circumstances, the methodology could underestimate some traffic movements.

5.7.5 The 2032 forecasts were excluded from the economic assessment of the scheme to ensure that the assessment was both robust and conservative. No traffic growth was applied and hence, no additional benefits were incorporated beyond 2027. The 2032 forecasts derived by this extrapolation methodology were however used for highway design and environmental appraisal where use of the 2027 rather than 2032 forecasts could underestimate the highest flows within the first fifteen years following scheme opening.

5.8 Do-Minimum Definition

5.8.1 The TMfS:05A model is intended to assess the impact of large scale strategic interventions by comparing the intervention scenario with a Do-Minimum scenario, such that the difference between the two identifies the impacts.

5.8.2 It is therefore necessary to define the committed and most likely changes that will be made to the transport network between 2005 and each of the appraisal years (2012, 2017, 2022 and 2027) to obtain the most representative appraisal results. These committed and likely interventions form the TMfS:05A Do-Minimum and Reference Case scenarios respectively and were defined by Transport Scotland in August 2007 and subsequently incorporated into TMfS:05A by MVA.

5.8.3 The Do-Minimum interventions included within TMfS:05A (source: www.latis.org.uk), are listed in Table 5.1.

Table 5.1: Interventions in TMfS:05A Do-Minimum scenario

Appraisal Years	Interventions incorporated in TMfS:05A Do-Minimum
2017, 2022 & 2027	**As 2005 Base Scenario plus:** • M74 Completion; • M9 Spur Extension; • Finnieston Bridge; • A68 Dalkeith Northern Bypass; • Ferrytoll Link Road; • Second Upper Forth Crossing at Kincardine; • Alloa - Stirling - Glasgow Rail Service; • Airdrie - Bathgate Rail Reopening; • Edinburgh Tram Project (Phase 1a); • Glasgow Airport Rail Link; • Borders Rail Service; • M80 Upgrade; • Aberdeen Western Peripheral Route; • M8 Baillieston to Newhouse Upgrade (including Raith Interchange and Associated Network Improvements); • Larkhall to Milngavie rail project; • Edinburgh Waverley station upgrade; • A830 Arisaig to Loch Nan Uahm; • A96 Fochabers to Mostodloch Bypass; • A90 Balmeddie to Tipperty Dualling; • Removal of Forth Road Bridge tolls; • Removal of Tay Road Bridge tolls; • Heartlands development; • Pollock development; • A68 Roundabout at Newton St Boswells; • A90 New Interchange at Portlethan; and • A82 Strathleven Roundabout. Cross-Forth rail scenarios: • Larbert – Stirling re-signalling; • Forth Rail Bridge re-signalling; • Additional park and ride capacity at Kirkcaldy, Markinch, Rosyth and Perth; • Edinburgh - Aberdeen express services; • Edinburgh - Dundee services stopping at Fife stations; • Hourly Edinburgh - Perth service; • Newcraighall services extended to Fife (instead of Bathgate / Dunblane); and Scotland's Railway short-term Infrastructure: • Laurencekirk station (2 hourly service); • Bishopbriggs platform extension (6-car services between Glasgow - Dunblane); • Elgin & Insch platform extensions (6-car services between Aberdeen – Inverness); • Lugton to Stewarton Loop – ½ hour Kilmarnock to Glasgow service; • Haymarket station (no model impact); and • Gourock Transport Interchange (no model impact).

5.8.4 In addition to the TMfS:05A Do-Minimum interventions, a number of non-contentious interventions are considered likely to progress, but are not yet committed. These interventions form the TMfS:05A Reference Case and are listed in Table 5.2.

Table 5.2: Interventions in TMfS:05A Reference Case scenario

Appraisal years	Interventions incorporated in TMfS:05A Reference Case
2012	As TMfS:05A Do-Minimum plus: M8 Bishopton Junction; Glasgow East End Regeneration Route; A77 South of Whitlett Dualling; and Cross-Forth rail scenarios: • Additional park and ride capacity at Cupar, Dunfermline Town, Leuchars, Markinch and Dunfermline Queen Margaret.
2017	As 2012 Reference Case plus: Cross-Forth rail scenarios: • Hourly Edinburgh - Inverness service; • Remove Dalmeny / North Queensferry stops from Fife Circle; and • Borders rail service to Inverkeithing stopping all stations.
2022 & 2027	As 2017 Reference Case plus: Cross-Forth rail scenarios: • All Edinburgh - Dundee services operated as 6-car sets.

5.8.5 For appraisal of the proposed scheme, the TMfS:05A Reference Case was adopted as the basis of a Do-Minimum definition for the project, representing unrestricted operation. The only addition to the interventions highlighted in Tables 5.1 and 5.2, was the inclusion of a full diamond grade separated gyratory junction on the M9 at Duntarvie, between Junction 1a and Junction 2, to serve the proposed Winchburgh development nearby.

5.8.6 Details of the form of this junction and its connections are not committed, so for appraisal purposes the new motorway junction assumed was a full diamond layout with a gyratory, linking directly into the proposed development at Winchburgh, with no direct connection to the B8020. It is assumed that this new junction is constructed in advance of the Forth Replacement Crossing opening. This is the Do-Minimum definition in the context of the main part of the Environmental Statement and assumes that the Forth Road Bridge remains open, without restriction, to all traffic.

5.8.7 The latest structural information provided by the Forth Estuary Transport Authority (FETA), whilst not as pessimistic as the earlier 2004 / 2005 survey, still suggests that the Forth Road Bridge will not be able to maintain its role as the sole road-based crossing at Queensferry.

5.8.8 Whilst earlier studies assumed a Do-Minimum scenario representing complete closure of the Forth Road Bridge to all traffic, this has evolved into a hybrid definition of two states of operation, representing unrestricted normal operation and restricted operation. These are discussed in Sections 5.9 and 5.10 respectively.

5.9 Unrestricted normal operation Do-Minimum Forecasts

5.9.1 A Do-Minimum traffic forecast is required in order to compare the proposed scheme's performance with traffic conditions which would otherwise prevail. The Do-Minimum comparator for this particular scheme needs to reflect the impact of traffic restrictions associated with repairing the existing Forth Road Bridge and in particular the impact of Main Cable Replacement (MCR) works. However, the traffic restrictions required for MCR work would not be in place all the time and for most of the scheme appraisal period, the Forth Road Bridge would operate normally. Therefore, two Do-Minimum scenarios need to be modelled as follows:

- a restricted operation Do-Minimum, representing periods with MCR traffic restrictions; and
- an unrestricted Do-Minimum, where the Forth Road Bridge operates normally.

5.9.2 Figure 2.3 in Appendix A indicates AADT flows on the wider road network in 2005, while Figures 5.7 and 5.8 in Appendix D indicate forecast AADT flows over the same area in 2017 and 2032 respectively. These are the flow forecasts used in the Environmental Statement and represent forecast flows during periods of normal unrestricted operation.

5.9.3 Daily traffic crossing the Forth Road Bridge is forecast to increase by around 44% between 2005 and 2017. The rate of traffic growth is forecast to drop significantly beyond 2017, with a further predicted increase of 6% between 2017 and 2032. A similar pattern of high early years growth followed by slower growth beyond 2017 is exhibited on the M90 north of Admiralty. South of the Forth, the growth in traffic is generally high between 2005 and 2017, with reduced, but still significant levels of traffic growth between 2017 and 2032. Some notable exceptions are the A90 east of South Queensferry, where growth between 2005 and 2017 is forecast at 19% and growth from 2017 to 2032 is forecast at 5%. The traffic on this road is influenced by the completed M9 Spur Extension, between 2005 and 2017. Count evidence since the opening of the M9 Spur Extension suggests that some of the A90 traffic has diverted on to the M9 Spur. This is supported by the forecast traffic on the M9 Spur and A8000 combined, compared with the A8000, 2005 traffic volumes.

5.9.4 Traffic growth is driven by forecast demographic changes to the population, number of households and number of jobs. As discussed in Section 5.5, high growth in southeast Scotland and in particular West Lothian, drives high growth in travel demand in this area.

5.10 Restricted operation Do-Minimum Forecasts

5.10.1 Under normal operation, the TMfS:05A demand model includes choice modelling: destination choice, mode choice and trip frequency choice. Therefore the model would normally react to contra-flow restrictions on the Forth Road Bridge with significant changes to the destination of trips, along with mode and trip frequency changes, in response to the significant changes in travel costs, which result from the constraint and associated delays.

5.10.2 TMfS:05A was developed to model these effects as long-term effects of changing travel conditions, for example, people moving home or changing jobs. However, whilst the MCR works would be undertaken over several years, the traffic management required would be implemented for several weeks at a time, with normal un-constrained operation in the intervening periods. Therefore, the long-term effects associated with destination choice for many of the trip purposes is unlikely to be affected by a series of short-term works.

5.10.3 In order to overcome this feature within the standard version of TMfS:05A, a different version of TMfS:05A was developed, which restricted the destination choice part of the choice model. In this variant, trips to work and employer's business trips were not subject to destination choice. However, discretionary trips such as shopping or personal business were still subject to destination choice. This version of TMfS:05A was called the Short Term Mode Choice (STMC) model.

5.10.4 Within TMfS:05A, it is difficult to model the impacts of specific traffic management measures, such as speed restrictions, with any precision. Consequently, restricted operation testing in TMfS:05A was limited to the modelling of contra-flow operations. All tests assumed that one lane was operational in each direction, which entailed halving the link capacities and adding capacity constraining nodes to represent the entries to the contra-flow to invoke delay in each direction. The capacity of a traffic management scenario involving contra-flow will depend on a number of factors such as the angle of taper and the length of the median gap. Consequently, testing was undertaken with a range of capacities, to determine the model's sensitivity to the capacity assumed.

5.10.5 Figure 5.9 in Appendix D indicates forecast AADT flows on the wider road network in 2017 during periods of restricted operation of the Forth Road Bridge (assuming a capacity restriction of 1400 passenger car units per direction). Comparing the forecasts with Figure 5.7 in Appendix D indicates the likely diversionary, mode change and frequency change impacts arising during periods of restricted operation.

5.10.6 Relative to 2017 Do-Minimum traffic volumes 2017 forecast traffic volumes on the Forth Road Bridge, traffic is forecast to reduce by 41%, during periods of contra-flow restriction on the bridge. This restriction across the Forth Road Bridge also impacts other traffic volumes. Traffic on the M9 west of Junction 1a is forecast to increase by 8% during contra-flow works, reflecting diverted traffic, which uses alternative routes across the Forth. On the M9 south of Junction 1a, traffic is forecast to reduce by 18%, reflecting the reduced volume of Forth Road Bridge traffic on this section. On the M8, east and west of Claylands (M8 Junction 2) traffic is forecast to reduce by around 7% and 9% respectively.

5.11 Local Operational Model

5.11.1 In order to best reflect the local routing and congestion on the road network around the proposed scheme, a local micro simulation traffic model was developed. This model was used to test scheme performance at the local level and to test the impact of construction of the Managed Crossing Scheme and the impact of maintenance works on the Forth Road Bridge. Output from the local operational model was also used to calculate emissions in the local area.

5.11.2 By using a micro simulation model, the behaviour of individual vehicles can be simulated. This feature, in turn, provides a good indication of likely levels of queuing and delays which could be experienced in the future under Do-Minimum and Do-Something scenarios. The local operational model provides a good visual representation of traffic behaviour around the scheme in the base (existing) network in the present day and both the base and proposed scheme networks, in future years. As the local operational model represents traffic performance and interaction in high detail, this model is used to model the application of Intelligent Transport System (ITS) measures. The model simulates congestion features such as stop-start traffic volumes and queue pulses propagating along arterial routes. ITS measures, including variable speed limits and access control (ramp metering) are designed to reduce these unstable flow conditions and improve steady and reliable traffic conditions. The local operational model is important for this component of scheme assessment.

5.11.3 The local operational model requires the application of traffic growth from a third party source and, for this study, TMfS was used to provide the traffic growth forecast. The base and forecast modelled traffic volumes on the routes which cross the boundary of the local operational model and to and from zones within the local operational model area were extracted and compared. The relative growth was applied to the local operational model base demand matrices in terms of row and column (origin and destination) growth factors. The target growth factors were Furnessed to equalise row and column growth and hence produce forecast traffic demand matrices for each forecast year.

5.11.4 The local operational model was developed and calibrated using local traffic count data and on site behavioural observation. Model validation was undertaken using journey time data collected on the principal routes through the modelled area.

5.11.5 The extent of the modelled network includes the principal roads in Dunfermline, Inverkeithing and Rosyth, to the north and principal roads around South Queensferry, including the M9 and A904, to the south. The modelled network is indicated in Figure 5.10 in Appendix D.

5.11.6 The level of model calibration and validation is such that it is suitable for use as a tool for testing scheme performance. Further model calibration and validation is being progressed in parallel with Stage 3 modelling and evaluation in order to support further optimisation of the scheme design.

6 Operational Effects of the Managed Crossing Scheme

6.1 Introduction

6.1.1 The proposed scheme maintains free-flow connections for general traffic between the M90 in the north and the M9 and A90 in the south. The Main Crossing will have a wider deck than the Forth Road Bridge, with a higher speed limit and hard shoulders. These features are likely to improve speed and capacity over the Main Crossing as well as improving journey time reliability. The connecting road from the southern bridgehead will take the form of a new section of carriageway, connecting to a new junction at South Queensferry. The route will cross beneath the A904 (the new junction bridging the main carriageway) and continue to the existing Scotstoun Junction where it will connect to the A90 and M9 Spur. The new section of road will benefit from the provision of hard shoulders, a motorway standard design and speed limit, and associated journey time, capacity and reliability benefits. The distance between Scotstoun and the new Queensferry Junction will be greater than the distance between Scotstoun and Echline junctions at present. This increased separation is expected to improve weaving performance on this section of road and hence improve capacity and reduce journey time variability.

6.1.2 The journey for general traffic utilising the Main Crossing will involve a slightly longer journey distance than that experienced when using the Forth Road Bridge. However, the improved speed and moderate capacity improvement will generate journey time benefits which mean that despite the additional distance travelled, journey times are reduced by comparison to the Do-Minimum scenarios.

6.2 Key benefits

6.2.1 Some of the key benefits of the scheme are highlighted below and should be read with reference to the scheme objectives detailed in Section 1.3. These benefits are more fully explored later in this chapter and in Chapter 7.

- The Managed Crossing Scheme is better able to cater for forecast travel demand growth through a combination of improved design, the operation of ITS and the provision of public transport priority through the utilisation of the existing Forth Road Bridge.
- The project represents good value for money. The monetised benefits of the scheme exceed the forecast costs.
- The Scottish economy will benefit through improved productivity associated with improved accessibility.
- Congestion due to future road works will be less than under the Do-Minimum scenarios.
- Improved journey times to and from Fife will promote access to development areas.
- Local trips will continue to be able to access the mainline more efficiently with the Managed Crossing Scheme.
- Levels of congestion on the local network will reduce.
- The network will operate more efficiently with the Main Crossing in place. Variability of journey times will be reduced and speeds will increase on the mainline.
- The ITS strategy will reduce accidents and improve the management of incidents.

6.3 Review of Strategic Traffic Forecasts

6.3.1 Figures 6.1 and 6.2 in Appendix D present details of AADT flows on key links in the network in the area of the Firth of Forth in both the opening year of operation (2017) and the subsequent design year (2032). These traffic flows were derived from the TMfS model as described in Chapter 5.

6.3.2 Traffic flows over the Firth of Forth are forecast to increase by 11% due to the improved journey times with the Managed Crossing Scheme in place.

6.3.3 A comparison of traffic has been carried out across two screenlines, each of which is a collection of road links or bridges which identify all of the points that traffic would have to pass to travel from one side of the screenline to the other. The first of these, the Forth Screenline, cuts the road links crossing the Forth from the M9 near Stirling to the Main Crossing / Forth Road Bridge. Changes in traffic on the links forming this screenline are presented in Table 6.1 below.

Table 6.1: Forth Screenline traffic flows from TMfS 2017, 2 way AADT volumes

Link description	Do-Minimum traffic	Managed Crossing traffic	% Difference
Cross Forth traffic on the Main Crossing &/ or Forth Road Bridge	83,000	92,000	11%
Kincardine crossings	35,000	32,500	-7%
A91 east of A9	22,500	22,500	0%
A9	15,000	15,000	0%
M9	38,500	38,000	-1%
Total	**194,000**	**200,000**	**3%**

6.3.4 A reduction in traffic is forecast on the Kincardine crossings and on the M9. This indicates that some of the additional traffic on the Main Crossing is traffic which re-routes from the upstream crossings. The remainder of the traffic growth is primarily driven by changes in trip destination.

6.3.5 The second screenline analysed is a north to south oriented screenline to the west of Edinburgh. This screenline helps us to gauge the change in traffic to and from Edinburgh, from the Managed Crossing and from the high growth area of West Lothian. The west Edinburgh screenline comparison results are presented in Table 6.2.

Table 6.2: West Edinburgh Screenline traffic flows from TMfS 2017, 2 way AADT volumes

Link description	Do-Minimum traffic	Do-Something traffic	% Difference
A90 west of Barnton	41,000	41,500	1%
A8 west of Gogar	53,000	53,500	1%
M8 west of Hermiston	82,000	82,000	0%
A71 west of City bypass	31,000	30,500	-2%
A70 west of City bypass	18,500	18,500	0%
Total	**225,500**	**226,000**	**0%**

6.3.6 The screenline flows indicate a modest increase in traffic on the A90 and A8, both of which carry traffic to and from the Main Crossing. Overall, there is little change in traffic crossing the screenline, which suggests that most of the increased traffic on the proposed scheme will be associated with changes to route choice and travel destinations for trips to and from locations to the west of Edinburgh. This corresponds well with the pattern of growth suggested by forecast changes to population and households in West Lothian, outlined in Chapter 5.

6.4 Review of Local Traffic Forecasts

6.4.1 The forecast traffic growth derived from TMfS was applied to the local micro simulation model to produce future year Do-Minimum and Do-Something forecasts. These were used as the basis for testing scheme traffic performance and interaction with the connecting network. The micro simulation modelling takes the scheme and its interaction with surrounding infrastructure into account, ensuring that the assessment takes a balanced view of the scheme and surrounding infrastructure.

6.4.2 The modelled operation of the Managed Crossing Scheme indicates that in 2017 the traffic using the proposed scheme does not exhibit the same level of congestion and stop-start motoring that is prevalent during the peak periods in present day conditions and which will be further exacerbated in the future Do-Minimum scenarios. It is likely that much of the travel demand growth beyond this date will need to be accommodated by public transport to retain the modelled 2017 level of service.

6.5 Improved Local Access

6.5.1 The introduction of Intelligent Transport System (ITS) measures will allow queues to be managed on the busiest slip roads thus improving access to the mainline, whilst maintaining smoother flow conditions for traffic already on the mainline. ITS measures are discussed further in Sections 3.5 and 6.8.

6.5.2 Junction improvements at each side of the Firth of Forth will greatly improve the access for trips to the mainline. Improvements at Ferrytoll will result in an increased capacity and therefore a reduction in delay at the junction for trips across the A90 as well as facilitating improved conditions for traffic joining the A90 northbound and southbound.

6.5.3 Traffic to and from North Queensferry will benefit from the new junction arrangement which separates the B981 from direct entry to Ferrytoll gyratory and offers the choice of travelling via Ferrytoll gyratory or via the B980 (Castlandhill Road) or Ferry Toll Road. The entry capacity of all arms into Ferrytoll Junction will increase by approximately 65% under the proposed scheme, thereby providing benefits for all movements through the junction and maintaining access to the local development areas identified in Rosyth, Dunfermline and Dalgety Bay identified in the Fife Structure Plan.

6.5.4 Junction capacity improvements together with the introduction of ITS measures will allow queues to be managed at the critical locations and on the busiest slip roads, thereby improving access to the mainline. For example, currently at the Ferrytoll junction traffic queues back onto the B981 (Hope Street) through Inverkeithing. These queues also block access from Ferrytoll Park and Ride and key economic areas, such as Rosyth Port. Without improvements to the junction, the queues are forecast to increase significantly.

6.5.5 Under the proposed scheme, signal control and priority measures at Ferrytoll Junction will reduce queuing and allow bus priority between Ferrytoll Park and Ride and the Forth Road Bridge. Ramp Metering on the southbound merge slip road, from Ferrytoll Junction, will assist in balancing operation levels on the mainline and slip road, however queuing will be controlled within the slip road. This will better manage traffic levels and operation and not impact east to west journeys through the junction.

6.5.6 Signal control at the Queensferry Junction and greater capacity, when compared with the existing Echline Junction, will provide improved operation. Control on the northbound merge slip road, through ramp metering, will also assist in balancing operation between the mainline and side road. The signals at the junction and the ramp meter will also deter use of the A904 from Newton, helping to re-direct traffic via the new west facing slip roads at M9 Junction 1a.

6.5.7 The improved junction arrangement at South Queensferry in the proposed scheme, will result in a reduction on the levels of congestion experienced in the Do-Minimum scenario. Consequently, delays expected in the Do-Minimum for traffic joining the A90 will be significantly reduced or removed in the Do-Something.

6.5.8 The following table indicates traffic flow volumes in the AM peak period (4 hours) on several approaches to the A90 corridor from the local Dunfermline / Rosyth, Inverkeithing and South Queensferry areas. These routes are commonly thought to contain ‘rat running’ traffic which may be better accommodated by routing more directly to the mainline. The locations in bold will experience a significant reduction in traffic flows under the Managed Crossing Scheme.

Table 6.3: AM period comparison of Do-Minimum and Do-Something forecast traffic volumes

AM (0600-1000hrs)	Direction	Do Min	Scheme	Change
B981 Hope Street, Inverkeithing	S/B	1110	1260	150
Ferrytoll S/B Merge	**S/B**	**3790**	**2370**	**-1420**
B980 (Castlandhill Road) South	**S/B**	**1590**	**370**	**-1220**
B980 (Castlandhill Road) North	**S/B**	**1580**	**1030**	**-550**
Admiralty S/B Merge	S/B	3360	3620	260
Admiralty S/B Diverge	**S/B**	**1580**	**1170**	**-410**
Masterton S/B Merge	S/B	810	880	70
Kings Road	S/B	1780	1610	-170
Queensferry Road	S/B	1090	1040	-50
B981 North Road	**S/B**	**2260**	**1750**	**-510**
A823(M)	S/B	2610	2720	110
B981 at Inverkeithing	S/B	2170	1830	-340
A90 Admiralty to Ferrytoll	S/B	10580	13240	2660
A904 East of Newton	E/B	2740	2800	60
	W/B	**2590**	**2090**	**-500**
A904 West of Echline	**E/B**	**2660**	**1410**	**-1250**
	W/B	**2730**	**1450**	**-1280**
Ferry Muir Road East of Echline	**E/B**	**2110**	**1400**	**-710**
	W/B	1760	1480	-280
A8000 South of A90	N/B	650	590	-60
	S/B	1110	1260	150

6.5.9 The following table indicates traffic flow volumes in the PM peak period on several approaches from the A90 corridor to the local Dunfermline / Rosyth and Inverkeithing areas. The locations in bold will experience a significant reduction in traffic flows under the Managed Crossing Scheme.

Table 6.4: PM period comparison of Do-Minimum and Do-Something forecast traffic volumes

PM (1500-1900 hrs)	Direction	Do Min	Scheme	Change
B981 Hope Street, Inverkeithing	N/B	990	880	-110
Ferrytoll N/B Diverge	N/B	2530	2200	-330
B980 (Castlandhill Road) South	N/B	1230	990	-240
B980 (Castlandhill Road) North	N/B	700	610	-90
Admiralty N/B Diverge	N/B	3440	3790	350
Admiralty N/B Merge	N/B	1540	1500	-40
Masterton N/B Diverge	N/B	1640	1820	180
Kings Road	N/B	1600	1500	-100
Queensferry Road	N/B	600	730	130
B981 North Road	N/B	1270	1320	50
A823(M)	W/B	3080	3340	260
A90 between Admiralty and Ferrytoll	N/B	13270	14110	840
A904 East of Newton	E/B	2280	2980	700
	W/B	2600	2980	380
A904 West of Echline Junction	**E/B**	**2460**	**1430**	**-1030**
	W/B	**2770**	**1650**	**-1120**
Ferrymuir Road east of Echline Junction	E/B	1470	1420	-50
	W/B	**2220**	**1740**	**-480**
A8000 South of A90	N/B	1070	940	-130
	S/B	960	860	-100

6.5.10 From the figures presented in Tables 6.3 and 6.4, it is observed that there is a trend for those roads where 'rat running' was thought to occur to see a drop in forecast traffic, with a complementary increase on the mainline links where we would expect the 'rat running' traffic to re-route.

6.6 Measures to Encourage Public Transport

6.6.1 The project has objectives to increase travel choices and improve integration across modes to encourage modal shift of people and goods and to improve accessibility and social inclusion.

6.6.2 Direct dedicated road links for public transport will be provided between the Forth Road Bridge and the upgraded Ferrytoll Junction. South of the Forth Road Bridge the existing slip roads and Echline Junction will be retained for public transport. A new dedicated busway will link the southbound slip road south of the Echline Junction to the existing bus lane eastbound on the A90. For A90 traffic from Edinburgh, a busway off slip will connect to the A8000 by way of a bus priority signal installation. Buses will then approach the Forth Road Bridge by way of the A8000, upgraded to ensure that the buses are not delayed by congestion, and the Echline Junction. The busways will be constructed under powers granted by the Parliamentary Bill.

6.6.3 Improvements will be made to the existing Park and Ride at Ferrytoll as part of the junction upgrading. The capacity for car parking has already been increased to 1000 spaces; however, the facility is also becoming a significant interchange point between local bus services and longer distance routes. As a result of the impact of the work to improve the capacity and operation of the Ferrytoll Junction gyratory system the access arrangements at the park and ride site will need to be altered. Bus and car access will be segregated, and at the same time the bus circulation system will be improved and extended to facilitate bus loading and waiting, and passengers moving between services.

6.6.4 These provisions and opportunities within the proposed scheme will support and form part of further improvements to rail services, park and ride proposed schemes and a light rapid transport proposed scheme between Fife and Edinburgh. These schemes stand to be developed within the implementation of the STPR decisions which were announced to the Parliament by the Minister for Transport, Infrastructure and Climate Change on 10 December 2008.

6.6.5 Given this context, the Managed Crossing Scheme provides the infrastructure to enable others to take forward: a light rapid transit system in the form of high quality bus network, guided bus way or a tram based system. The creation of a new public transport corridor will support the further development of the public transport interchange park and ride facility at Ferrytoll and the development of new facilities as planned by Fife Council. There is also the further potential to create a new park and ride facility at South Queensferry for West Lothian and local residents.

6.7 CO_2 Emissions

6.7.1 Results for the Do-Something forecast scenario, compared with Do-Minimum, from conventional emissions modelling based on the TMfS strategic model results, show overall modest increases in CO_2[1]. This approach uses standard Department for Transport methodology (DMRB emission factors) to calculate CO_2 emissions based on model output speeds and volumes. This approach forecasts modest increases in CO_2 emissions, associated with the introduction of the proposed scheme. Standard emissions forecasts are discussed in greater detail in the Environmental Statement, Chapter 15, Air Quality.

6.7.2 Use of the strategic traffic model has the advantage of wide network coverage, so all of the network effects of the proposed scheme will be encompassed by the assessment. The methodology used to calculate emissions is consistent with many other road projects assessed in Scotland in recent years and it is recognised as the current best practice. However, the CO_2 calculations are based on average speeds calculated on the network, which, in the vicinity of the scheme in the Do-Minimum scenario, reflects a range of emissions conditions from traffic which is variously accelerating, braking, idling and cruising, rather than travelling steadily at that average speed. The approach is not capable of assessing the local impact of stop-start traffic conditions.

6.7.3 A new Passenger car and Heavy-duty Emission Model (PHEM[2]) based emissions calculation module has been developed. This can be used with microsimulation models such as S-Paramics (referred to generically as Paramics)[3]. The emissions evaluation using Paramics with PHEM relationships is a technique being developed on behalf of Transport Scotland, but not yet generally deployed for use in scheme appraisal. The information obtained from this evaluation tool has been used to supplement the strategic calculations which are based on the Department for Transport methodology. The PHEM based results are intended to provide a more informed view of the likely locally generated emissions of the proposed scheme.

[1] CO_2 is used to refer to both CO_2 and CO_2(e) (CO_2 Equivalent) values. The conventional emissions calculations which are detailed in the Environmental Statement refer to CO_2, whilst the results from PHEM evaluation refer to CO_2(e) values.

[2] PHEM was developed by TUG (TU Graz – Institute for Internal Combustion Engines and Thermodynamics)

[3] Paramics and S-Paramics references relate to the use of S-Paramics version 2008.2 software

6.7.4 The PHEM model output is a series of emission factors, based on vehicle type, vehicle speed, vehicle loading and vehicle acceleration. This method calculates the rate of emission for each vehicle at each simulated timestep. The use of PHEM emissions relationships with the Paramics Local Operation model offers the ability to take into account emissions from stop-start motoring. The local PHEM based assessment therefore examines the localised effect of motoring conditions on the congested approaches to the Forth Road Bridge during peak periods and the localised benefits to be derived from relieving these conditions. In comparison to the Do-Minimum, the proposed scheme will result in smoother traffic flows and improved journey time reliability. One of the features of the Managed Crossing Scheme is that traffic will be controlled to improve flow conditions and hence, reduce emission rates, compared with the current conditions. The local assessment does not quantify wider impacts outwith the Paramics model area.

6.7.5 Tests were undertaken using the Paramics / PHEM module to compare Do-Something traffic emissions with normal operation Do-Minimum emissions in the AM and PM modelled periods for 2017 forecasts. The proposed scheme design in conjunction with ITS operation will result in improved fuel efficiency and lower emissions per kilometre. However, the Do-Something scheme involves additional travel distance for cross Forth traffic and additional traffic demand which results in increased CO_2 emissions.

6.7.6 The additional daily CO_2 emissions are forecast to be 3.7 tonnes in the AM period and 14.7 tonnes in the PM period. These forecasts relate to AM and PM periods during average week day traffic. The proposed scheme involves some additional travel distance to cross the Forth and attracts more traffic to this part of the network.

6.7.7 Results of the test are presented in Tables 6.5 and 6.6.

Table 6.5: Total CO_2 Emissions within the Paramics Network in 2017 (tonnes)

Pollutant	Daily Emissions 2017 Do-Minimum	Daily Emissions 2017 Do-Something	Difference 2017 Do-Minimum/2017 Do-Something	% Change 2017 Do-Something versus 2017 Do-Minimum
CO_2 (Tonnes) AM	253.1	256.8	3.7	1.5%
CO_2 (Tonnes) PM	268.4	283.1	14.7	5.5%

Table 6.6: Total vehicle Kilometres within the Paramics Network in 2017

	Daily Vehicle Kilometres 2017 Do-Minimum	Daily Vehicle Kilometres 2017 Do-Something	Difference 2017 Do-Minimum/2017 Do-Something	% Change 2017 Do-Something versus 2017 Do-Minimum
AM	932,669	995,484	62,815	6.7%
PM	1,129,048	1,191,004	61,956	5.5%

6.7.8 When the increases in CO_2 in Table 6.5 are compared with the increases in vehicle kilometres in Table 6.6, we can see that the percentage increase in CO_2 in the PM peak is similar to the percentage increase in travel in the PM peak. However, in the AM peak the percentage increase in CO_2 is significantly lower than the increase in travel distance and hence, less than might otherwise be expected. The test indicates that during the congested morning peak period, the forecast increase in CO_2 emissions from the additional traffic and distance travelled is reduced by the improved scheme design and operation of ITS, which reduces congestion.

6.7.9 There is less congestion relief forecast in the evening peak and therefore the increase in CO_2 emissions is more closely related to the proportionate increase in travel distance.

6.7.10 The proposed scheme will also reduce or delay the need for MCR and other maintenance works that are likely to be necessary to retain the Forth Road Bridge in use in the absence of a replacement crossing. The MCR works on the Forth Road Bridge, extending over an anticipated eight year period, would have a significant impact on traffic congestion and routing and hence emissions. Further work is under way to establish the impact the MCR works would have on CO_2 emissions. Illustrative results are presented in the Environmental Statement, Appendix A 5.1. The data in that Appendix illustrates that total emissions during the congested peak periods for the proposed scheme are likely to be less than the Do-Minimum (including MCR) over the period 2012 to 2025. That assessment excludes the additional benefits that may result from avoiding delays and increased emissions within the interpeak periods due to MCR works.

6.8 Intelligent Transport Systems (ITS)

6.8.1 As detailed in 3.5, ITS is an integral feature of the proposed scheme. It will be provided over a corridor extending from Halbeath Junction on the M90 in the north to the M9 in the south. Additional provision will be made on main road approaches.

6.8.2 The proposed ITS strategy for the Forth Replacement Crossing corridor will further build on the existing strategic ITS network and should help reduce accident rates when compared with the scheme without ITS measures by an anticipated 26% and increase travel reliability by reducing delay due to incidents by up to 4%.

6.8.3 The key benefits from the operation of ITS are expected in the following operational components:

- **Journey time reliability benefits** – The application of measures including Variable Message Signs, Lane Signalling, Variable Speed Limits and Access Control will aid management of traffic conditions. Whilst these measures are aimed at maintaining controlled and steady traffic conditions, the impact on average journey times for all users will be limited but reliability will be improved.
- **Journey time improvement** – Modest journey time improvements are anticipated. The scope for benefits are limited owing to the need to use variable (lower) speed limits and access control measures to control traffic and maintain controlled conditions during busy periods.
- **Accident reduction** – The application of control measures and advanced messaging and information is anticipated to reduce accident rates by up to 26%. In addition to the obvious safety benefits experienced by drivers, there are further benefits to journey time reliability through reducing the frequency of incidents, which would disrupt traffic flow.
- **Reduced incident duration** – Improved incident detection and response times through the application of ITS will reduce the duration of any impact related to an accident or breakdown on the carriageway. An overall reduction of 2% in average incident duration is anticipated.

6.8.4 The variability in journey times during the peak hours will be reduced with the proposed scheme in place. In addition to reducing average journey times, the incorporation of ITS measures will also improve the reliability of journey times.

6.8.5 ITS components such as advanced incident management system and variable speed limit control with strong enforcement will lead to a reduction in the accident rate by an average of 26%. Much of this benefit is a result of preventing rear-end collisions through warning about queues, through smoother flow and the enforcement of sensible driving behaviour in busy periods. Additionally, on controlled motorways, through the use of CCTV, incident duration can be reduced by enabling a quicker response to incidents, including ensuring that the appropriate personnel and equipment are sent to the incident, as well as a faster provision of information to drivers, reducing secondary accidents. These improvements are in line with Highways Agency guidance (Interim Advice Note 111/08 on Managed Motorways and the emerging Interim Advice Note on Appraisal of Technology Schemes) and based on an extensive database of empirical data collected on English roads. This data relates to the frequency of incident occurrence, their build-up duration and their severity expressed in number of lanes affected.

- At least 6000 vehicle hours of delay caused by incidents could be saved each year;
- Journey time reliability on the corridor should increase with ITS measures aimed at reducing the number and impact of incidents by 4%; and
- At least 25 lane blocking incidents might be avoided each year due to the ITS.

6.9 Safety and Incident Management

Managed Crossing Scheme

6.9.1 Several improvements to the network layout and design are discussed below. These improvements are designed to both improve capacity and reduce accidents which are associated with congested conditions and short weaving manoeuvres.

6.9.2 Several improvements to weaving sections are proposed under the proposed scheme.

- The M9 eastbound between M9 Junction 1a and Newbridge Roundabout (M9 Junction 1) will be widened to 4 lanes and a hard shoulder. Westbound 4 lanes and a hard shoulder will be provided from the River Almond bridge structure to M9 Junction 1a. These measures will provide higher capacity and more room for merging and weaving.
- The weaving section between Scotstoun and Echline will be replaced with a longer weaving section between Scotstoun and the proposed junction at South Queensferry. This will provide improved access to the main carriageway at Scotstoun Junction and allow vehicles more time to get into the correct lane before approaching the new Queensferry Junction.

6.9.3 Improvements between Ferrytoll and Admiralty include a lane gain in the northbound direction. This will relieve some of the issues relating to the short weaving section on the existing network.

6.9.4 The Main Crossing has been designed to motorway standards and will provide a widened hard shoulder in each direction. Although the Forth Road Bridge does not incur a large number of accidents as illustrated in paragraph 2.5.9, the introduction of hard shoulders on the Main Crossing will allow vehicles involved in accidents or breakdowns to be removed from the trafficked carriageway and will help to keep traffic flowing. The presence of hard shoulders will ensure greater network resilience during maintenance activities and in relation to incident management.

6.9.5 The proposed scheme area will be managed by ITS which should help to control congestion and speeds throughout, reducing the overall accident rate and generally reducing accident potential on the route.

6.9.6 COBA assessment has been used to compare proposed changes to the network in the scheme. This process uses UK national rates and default road standard values to provide the worst case economic impact due to accident benefits or dis-benefits associated with the scheme implementation.

Bridge (Existing and Replacement Crossing)

6.9.7 As the Main Crossing is a new bridge, default accident rates have been applied for the purpose of calculating forecast accident costs. The Forth Road Bridge has a relatively good safety record and it is anticipated that the provision of hard shoulders and ITS management will maintain a suitable level of safety on the Main Crossing.

North of the Bridge

6.9.8 Between Admiralty and Masterton along the M90, accident rates are higher than the national average for this route type.

6.9.9 The M90 north of Admiralty will benefit by the application of ITS control, which will reduce accident rates and incident duration and frequency. This is likely to result in improved safety on this section of road.

6.9.10 Observed accident rates on the A90 between the northern bridgehead and Admiralty are slightly lower than Scottish average accident rate values. In the Do-Something accident evaluation, default rates are applied as this section of road will be altered. The higher default accident rate when combined with increased traffic results in a forecast increase in accidents, without the implementation of ITS. With the implementation of ITS, it is expected that the safety of this stretch of road will be improved when compared with the present road.

6.9.11 In the proposed scheme, the complex gyratory at Ferrytoll will be rationalised to become a single gyratory junction with improved sight lines and weaving characteristics. This will reduce potential conflicts at the junction through reduced driver confusion.

South of the Bridge

6.9.12 The M9 Spur between M9 Junction 1a and Scotstoun will benefit from the operation of ITS which will tend to reduce safety impact and result in a safer section of road. In addition, alterations to M9 Junction 1a will eliminate the weaving issues on the M9 eastbound from the M9 Spur, reducing conflict and improving safety. The widening of the M9 westbound to M9 Spur northbound link at M9 Junction 1a will also serve to reduce conflict and enhance safety.

7 Economic Performance of the scheme

7.1 Introduction

7.1.1 The economic evaluation of the proposed scheme has been undertaken using TMfS model outputs processed using a program developed by the Department for Transport (DfT), called Transport User Benefits Appraisal (TUBA). This software was used for the appraisal of steady state operation of the Do-Minimum scenario and the proposed scheme. The appraisal of construction impact of the proposed scheme and maintenance impact of the Do-Minimum scenario were undertaken using the Paramics model and its associated PEARS software.

7.2 Method of Appraisal

7.2.1 Inputs to TUBA include zone-to-zone trips, time and distance for the Do-Minimum and Do-Something scenarios. These data were obtained from TMfS:05A. The scheme benefits are calculated by comparing, for each pair of zones, the total costs of travel (including travel time and vehicle operating costs). Inputs to PEARS software for the network in the vicinity of the scheme was obtained from the Paramics model forecasts.

7.2.2 In accordance with Her Majesty's Treasury 'Green Book' guidance and DMRB guidance, a 60-year period following the year of opening, is used to calculate the benefit stream. Because the Do-Minimum works would commence prior to this date, the FRC appraisal required a 65-year period, commencing in 2012 through to 2076 inclusive. This is necessary to capture the negative impacts associated with the Do-Minimum works. The summed monetised units of benefit are expressed in 2002 prices and values, discounted to 2002. A 3.5% per annum discount rate applies to costs and benefits accruing in the first 30 years from 2009 and 3.0% per annum for the remainder of the appraisal period. Appraisal of accident costs and benefits, using COBA and maintenance impact of the Forth Road Bridge were undertaken over the 60 year period following scheme opening. Appraisal of scheme construction impact was undertaken over the duration of construction works prior to opening of the scheme.

7.2.3 The summed benefits and costs are denoted by PVB (Present Value of Benefits) and PVC (Present Value of Costs); from these are calculated the NPV (Net Present Value = PVB - PVC) and the BCR (Benefit to Cost Ratio = PVB / PVC). A positive NPV indicates a future stream of forecast benefits in excess of scheme costs and a BCR>1.

7.3 Scheme Specific Data

7.3.1 TMfS:05A was run for the AM, PM and Inter-peak periods. Modelled runs were undertaken for the appraisal years 2017, 2022 and 2027. For intermediate years, benefits were obtained by interpolation. No traffic growth is assumed after 2027, as agreed with Transport Scotland. Consequently, travel costs and, hence, route corridor choices will remain unchanged. However, economic parameters, and therefore scheme benefits, are assumed to continue to change beyond 2027, as set out in WebTAG (www.webtag.org.uk). These parameters include;

- Value of Time.
- Cost of Fuel.
- Proportion of transport fleet using diesel or petrol.

7.3.2 This approach offers a conservative valuation of scheme benefits and a suitable basis for comparison.

7.3.3 The following factors were used to factor road traffic demand outputs from the three modelled time periods to annual benefits as output by TUBA. The factors were derived from the analysis of Scottish Household Survey data as discussed in paragraph 5.2.7. The annualisation factors relate to the whole of Scotland.

- AM 559
- Inter peak 3596
- PM 650

7.4 Removal of Model "Noise"

7.4.1 TMfS operates in a series of iterations of cost calculation based on assigned travel costs. Results from the prior iterations are used to calculate costs in each subsequent iteration. This process can result in some changes which are due more to the iterative nature of the model, rather than primarily based on changes due to the coded scheme. We refer to these background changes due to iterations, as model "noise". In areas remote from the proposed scheme, where traffic is unlikely to be significantly influenced, there is a degree of background 'noise' in the modelled calculations of flows and delays. To reduce errors in the benefit calculations, areas considered likely to be unaffected by the proposed scheme, but with high traffic volumes and so possible sources of error, were identified. All changes to costs within and between those areas were then removed. The areas were:

- South Lanarkshire;
- East Ayrshire;
- South Ayrshire;
- North Ayrshire;
- East Renfrewshire;
- Glasgow City;
- North Lanarkshire;
- East Dunbartonshire;
- Renfrewshire;
- Inverclyde; and
- West Dunbartonshire.

7.4.2 The majority of TUBA benefits quoted therefore come from the areas that would be directly affected by the tested scenarios; i.e. within or between the four council areas: City of Edinburgh, West Lothian, Fife and Perth & Kinross.

7.5 Basic Transport Economic Efficiency benefits of the Scheme

7.5.1 The Transport Economic Efficiency (TEE) benefits of the proposed scheme compared with the unrestricted Do-Minimum were calculated using TMfS and TUBA. The benefits calculated will be £498,545,000 (presented in Table 7.1) over the appraisal period. This figure includes a monetised carbon dis-benefit of £15,134,000.

7.5.2 Journey time savings are in part due to capacity enhancements at key locations along the main corridors surrounding the Forth. Improvements to the Ferrytoll gyratory, improvements of standards through the use of the Main Crossing including the potential for hard shoulder use when necessary, enhancements to M9 Junction 1a and the M9 between Junction 1a and

Newbridge Roundabout (M9 Junction 1) would all help contribute to capacity improvements for journeys made along the mainline to and from the bridge.

7.5.3 Better operational benefits of public transport may also contribute to improvements in journey times. One of the key factors in this will be the use of the Forth Road Bridge for public transport.

7.5.4 The implementation of the Managed Crossing Scheme will also help to reduce the variability in journey times during the peak hours.

7.6 Benefits to be derived by avoiding the impact of Main Cable Replacement on the Forth Road Bridge

7.6.1 Based on the FETA Cable Augmentation Study report, the traffic management arrangements required for MCR works would be closure of one of the Forth Road Bridge carriageways for several weeks at a time several times each year for several years. The proposals were reviewed and adjustments made to the cost and works duration to account for appropriate risk and optimism bias adjustments.

7.6.2 It is anticipated that the contra-flow required to allow MCR works to be processed, would operate for 268 weeks over 8 years between 2012 and 2019 inclusive. The proportion of time that a contra-flow would be in operation equates to 64.4% of the duration of the works. Therefore, the relative dis-benefit of the impact of traffic management for MCR works will be 64.4% of the impact of full time contra-flow.

7.6.3 In order to calculate the benefits of avoiding the impact of extensive road works associated with MCR works, by building the proposed scheme, two scheme comparisons are undertaken in TUBA. The first comparison is to compare the Do-Something with the unrestricted operation reference case Do-Minimum over the initial 8 years plus the remainder of the appraisal period.

7.6.4 The second comparison is to compare the Do-Something with the restricted operation (contra-flow) reference case Do-Minimum over eight years and the unrestricted reference case for the remainder of the appraisal period.

7.6.5 The additional benefit associated with avoiding the impact of MCR works, over and above those benefits associated with the scheme versus unrestricted Do-Minimum would be £367,547,000, if the MCR works were in place continuously over the eight years.

7.6.6 As the MCR works will be in place for only 64.4% of the time over the eight year works period, we add 64.4% of the additional benefits related to avoiding the impact of MCR works to the benefits of the scheme compared with unrestricted Do-Minimum. Hence, the benefits related to MCR works are 64.4% x £367,547,000 = £236,681,000 (presented in Table 7.1). This value includes a monetised carbon dis-benefit of £2,609,000.

7.7 Accident benefits

7.7.1 The proposed scheme involves construction of new bridge and high quality roads. The forecast accidents are based on observed accident rates where available and default accident rates, based on road type, where no local accident data is available. Observed local accident data was collected and used for the roads in the vicinity of the proposed scheme.

7.7.2 The COBA (Cost Benefit Analysis) software was used to calculate forecast accidents for the Do-Something and Do-Minimum. Where new roads are to be provided, the observed accident rates were replaced with default rates appropriate to the standard of road being provided.

7.7.3 Base and forecast daily traffic volumes for the Do-Something and Do-Minimum schemes were input into COBA. The COBA programme applied the traffic to the accident rates for each road link in the defined network, to calculate the forecast number of accidents on each link, based on the product of traffic volumes and accident rates (accidents per million vehicle kilometres). The accidents per link are then aggregated to the total number across the whole network. A user dis-benefit cost is associated with each accident. The cost varies by type of accident, with the cost increasing with accident severity.

7.7.4 The total cost of accidents in each year was calculated and discounted to the base assessment year of 2002. The aggregate cost for all of the assessment period was calculated for the Do-Something and the Do-Minimum. Where the accident cost in the Do-Something is less than in the Do-Minimum, there is a calculated accident cost benefit.

7.7.5 The comparison of the Do-Something with the Do-Minimum accident costs revealed an accident dis-benefit of £59,613,000 (presented in Table 7.1). Much of this increase in accident cost is due to an increase in traffic volumes associated with the scheme, as it attracts users from alternative journeys and also because the distance involved to use the Main Crossing, will be slightly greater for most users, compared with the use of the Forth Road Bridge.

7.8 Basic scheme costs

7.8.1 In accordance with HM Treasury 'Green Book' guidance, the scheme costs reflect the difference in costs between the Do-Something and the Do-Minimum. The costs were adjusted to 2002 prices and values and discounted to 2002, as discussed in section 7.2. Using this approach the scheme cost excluding ITS costs will be £504,688,000.

7.9 Summary of basic benefits and costs

Table 7.1: Basic Benefits and Costs

Component appraised	Net Present Value (NPV)	Do-Something benefits relative to Do-Minimum (PVB)	Scheme cost difference relative to Do-Minimum (PVC)
Scheme benefits compared with un-restricted Do-Minimum	N/A	£498,545,000	
Additional benefits through avoiding the impact of MCR works	N/A	£236,681,000	£504,688,000
Accident Benefits	N/A	£-59,613,000	
Total	£170,925,000	£675,613,000	£504,688,000
Benefit to cost ratio (BCR)	**1.34**		

Note: All figures are 2002 prices and values discounted to 2002 in accordance with HM Treasury 'Green Book' guidance. The BCR presented is BCR to Government.

7.9.2 The benefit to cost ratio (BCR) of the basic scheme benefits relative to scheme cost will be 1.34.

7.10 Construction impact

7.10.1 Construction of the proposed scheme, whilst largely undertaken offline and outside the bounds of the existing road system, will require some works phasing which interferes with the normal operation of the road system associated with the Forth Road Bridge. The phasing of the construction traffic management is represented by road works at 4 locations.

7.10.2 The delays incurred by traffic travelling through the construction road works were modelled using the Paramics local simulation model. The cost of the delays was calculated using PEARS. The user costs of the delays caused by the road works were £18,890,000(presented in Table 7.2).

7.11 Whole life maintenance impact

7.11.1 One of the advantages of the proposed scheme is that it will reduce both the requirement for maintenance on the Forth Road Bridge and the impact that maintenance works would have on traffic.

7.11.2 In the future, the impact of undertaking on-going maintenance works on the Forth Road Bridge would be far greater than for on the Main Crossing. The proposed scheme includes hard shoulders which can be used during maintenance works to maintain 2 lane traffic flows in each direction during peak periods throughout any maintenance works.

7.11.3 Under the Do-Minimum scenario, the Forth Road Bridge would require significant maintenance works, over and above main cable replacement, for the remainder of the appraisal period. The Do-Minimum depicts that further closures with higher traffic levels will be necessary and therefore the impact of the road works would be expected to be greater. Increased traffic levels are also likely to result in more accidents during road works which would be less manageable under the Do-Minimum case. Furthermore, to undertake maintenance would require regular weekend lane closures resulting in increased average journey times over the Forth of around 40 minutes based on the potential changes in routes or modes under maintenance periods.

7.11.4 The whole life maintenance impact has assessed the impact on traffic of maintenance work throughout the life of the Forth Road Bridge. This appraisal excludes the impact of MCR works and only assesses the impact of maintenance works following completion of the MCR works.

7.11.5 The roadworks required to support the whole life maintenance of the Forth Road Bridge would have greatest impact if they occur during daytime periods of traffic activity, especially during traditional weekday morning and evening peaks. Single lane working and a reduction in speed limit from 50mph to 30mph in both directions will need to be imposed for a number of continuous weekend periods (from Friday 2100 to Monday 0600) to support the following maintenance activities:

- Resurfacing of main and side spans.
- Resurfacing viaducts.
- Resurfacing north approaches.
- Main cable acoustic monitoring.
- Parapet replacement.
- Viaduct barrier replacement.
- Tower impact strengthening.
- Wind barriers.

7.11.6 Single lane working will also be required during extended weekends (from Thursday 2100 to Tuesday 0600) for the replacement of expansion joints. These will affect traditional weekday peak periods of operation (i.e. Friday mornings, Monday mornings and Monday evenings). Single lane working will be in place for up to 40 weekends for some activities (parapet replacement). If another 60 years operation of the existing crossing is required, single lane working of up to 350 weekends for all activities would be likely.

7.11.7 Maintenance works on the Main Crossing will also be required but can be undertaken with two lanes remaining open during peak traffic with a speed limit reduction to 40mph. These road works will support the maintenance of:

- Stay cables.
- Movement joints.
- Vehicle road restraint.
- Parapet – windshield and outer pedestrian barrier.
- Lighting renewals.
- Drainage system.
- Resurfacing.

7.11.8 Many of the maintenance operations on the Managed Crossing Scheme will be undertaken at night. As with maintenance on the Forth Road Bridge, the traffic volumes at night are so much lower, that even single lane operation in each direction would still provide more than adequate capacity for traffic volumes. Therefore, night time restrictions were assumed to have negligible impact for either Do-Minimum or Do-Something assessments.

7.11.9 The Paramics model was used to model the impact of traffic management required for the maintenance works. The impact of the restrictions was calculated over the appraisal period using PEARS software. The impact of whole life maintenance would be £199,560,000 (presented in Table 7.2). The avoidance of this impact is recorded as a scheme benefit.

7.12 Additional benefits

7.12.1 In addition to the basic benefits calculated, additional benefits and dis-benefits are likely to arise due to delays to traffic during construction of the proposed scheme and delays to traffic during periodic maintenance of the existing bridge. The benefits from these additional factors were calculated and added to the basic benefits as an indication of the likely additional benefits of the proposed scheme, over and above the basic benefits of day to day operation. The indicative BCR, taking the additional benefits and costs into account, rises to 1.70. This BCR is presented as an additional sensitivity to the Traffic Economic Efficiency results in line with the STAG guidance (Part 2, Section 9, Para 9.3.6).

Table 7.2: Additional Benefits from Construction Impact and Whole Life Maintenance Impact

Component appraised	Net Present Value (NPV)	Do-Something benefits relative to Do-Minimum (PVB)	Scheme cost difference relative to Do-Minimum (PVC)
Basic benefits (from Table 7.1)	N/A	£675,613,000	£504,688,000
Construction Impact	N/A	£-18,890,000	
Whole Life Maintenance Impact	N/A	£199,560,000	
Total	£351,595,000	£856,283,000	£504,688,000
Benefit to cost ratio (BCR)	**1.70**		

Note: All figures are 2002 prices and values discounted to 2002 in accordance with HM Treasury 'Green Book' guidance. The BCR presented is BCR to Government.

7.12.2 The benefit to cost ratio (BCR) will be 1.70.

7.13 Additional ITS benefits

7.13.1 The basic scheme benefits calculated using TMfS and TUBA relate to the proposed scheme as it would operate without the ITS measures, including lane control, variable speed limits and access control. The TMfS model is not able to model the benefits of ITS operation. Therefore, additional modelling of ITS operation was undertaken using the Paramics model and the benefits relative to a Paramics model of the proposed scheme without ITS were calculated.

7.13.2 The benefits of ITS derive from several factors including reduced accidents, improved incident management and improved network performance and journey time savings. However, coupled with these benefits there is an additional cost for the additional equipment and maintenance costs, over and above the cost associated with the basic ITS equipment, which would be required as part of any new road scheme. The additional costs in 2002 prices and values and discounted to 2002 will be £55,973,000 (presented in Table 7.3). The benefits of operating the ITS system would be £80,800,000 (presented in Table 7.3). The indicative BCR, taking the additional benefits and costs into account, rises to 1.67. This BCR is presented as an additional sensitivity to the Traffic Economic Efficiency results in line with the STAG guidance (Part 2, Section 9, Para 9.3.6).

Table 7.3: Benefits and Costs including ITS

Component appraised	Net Present Value (NPV)	Do-Something benefits relative to Do-Minimum (PVB)	Scheme cost difference relative to Do-Minimum (PVC)
Basic scheme benefits & Construction Impact & Whole Life Maintenance Impact (from Table 7.2)	£351,595,000	£856,283,000	£504,688,000
Additional ITS benefits & Costs	£24,827,000	£80,800,000	£55,973,000
Total Benefit	£376,422,000	£937,083,000	£560,661,000
Benefit to cost ratio (BCR)	**1.67**		

Note: All figures are 2002 prices and values discounted to 2002 in accordance with HM Treasury 'Green Book' guidance. The BCR presented is BCR to Government.

7.13.3 The benefit to cost ratio (BCR) will be 1.67.

7.14 Summary of additional WEB benefits

7.14.1 In addition to the basic scheme benefits, there are further benefits associated with Wider Economic Benefits (WEB), which are associated with agglomeration benefits. In line with STAG guidance, the results from the Wider Economic Benefits calculations are presented as an additional sensitivity to the Traffic Economic Efficiency results.

7.14.2 There are currently four types of wider economic benefits that can be included in a transport appraisal as additional to the TEE results. These are:

- Agglomeration economies;
- Increased competition as a result of better transport;
- Increased output in imperfectly-competitive markets; and
- Improved labour supply.

7.14.3 Increased competition as a result of better transport is generally only considered to be an issue in remote communities with an extremely low level of existing transport infrastructure. It is therefore not considered as part of this appraisal.

7.14.4 A description of what comprises agglomeration economies and how agglomeration benefits may be realized is presented as follows: "*Economies of agglomeration"* describe the productivity benefits that some firms derive from being located close to other firms. This could be because proximity to other firms facilitates more sharing of knowledge or because locating close to other firms means access to more suppliers and larger labour markets.[4] The TMfS model calculates the travel cost between model zones. Agglomeration benefits are calculated using changes in travel costs forecast by TMfS.

7.14.5 For calculation of increased output in imperfectly-competitive markets, the accepted approach is to make an allowance for business cost savings based on 10% of business cost savings from the TEE analysis.

7.14.6 The wider economic benefits associated with improved labour supply were related to more people choosing to work due to lower commute costs. The calculation of the benefits associated with lower commuter costs is elasticity based and makes use of average Scottish data. The change in commuting cost, taken from TMfS, is used as the basis for determining the benefits associated with improved labour supply.

7.14.7 The WEB central estimate of benefits over the appraisal period is £200,000,000 (presented in Table 7.4) but may range up to £235,000,000. The majority of these benefits are related to agglomeration economies with £50,000,000 associated to increased output and £5,000,000 associated with labour supply impacts. This scale of benefits calculated is considered reasonable in comparison with benefits calculated for other schemes. When the central WEB benefits and costs are added to the scheme benefits and costs summarised earlier, the BCR_{WEB} will be 2.03 as illustrated below. As with earlier accounting for additional benefits, this BCR is presented as an additional sensitivity to the Traffic Economic Efficiency results in line with the STAG guidance (Part 2, Section 9, Para 9.3.6).

[4] Transport, Wider Economic Benefits and Impacts on GDP, Department for Transport (2006)

Table 7.4: Benefits and Costs including WEB

Component appraised	Net Present Value (NPV)	Do-Something benefits relative to Do-Minimum (PVB)	Scheme cost difference relative to Do-Minimum (PVC)
Basic scheme benefits & Construction Impact & Whole Life Maintenance Impact & ITS benefits and costs (Table 7.3).	N/A	£937,083,000	£560,661,000
Additional WEB benefits	N/A	£200,000,000	
Total Benefit	£576,422,000	£1,137,083,000	£560,661,000
Benefit to cost ratio $(BCR)_{WEB}$	**2.03**		

Note: All figures are 2002 prices and values discounted to 2002 in accordance with HM Treasury 'Green Book' guidance. The BCR presented is BCR to Government.

7.14.8 The benefit to cost ratio $(BCR)_{WEB}$ will be 2.03.

7.15 Summary of all benefits

7.15.1 The benefits and costs associated with the basic scheme elements and sensitivity illustrations are summarised in the following table. This illustrates that there are quantifiable benefits over and above the basic user benefits associated with the scheme, illustrating that the project offers good value for money and opportunities to increase economic activity.

Table 7.5: Summary of Benefits and Costs

Component appraised	Net Present Value (NPV)	Present Value Benefit (PVB)	Present Value Cost (PVC)	BCR
Basic scheme benefits & costs (Table 7.1).	£170,925,000	**£675,613,000**	**£504,688,000**	**1.34**
Basic scheme benefits & Construction Impact & Whole Life Maintenance Impact & costs (Table 7.2).	£351,595,000	**£856,283,000**	**£504,688,000**	**1.70**
Basic scheme benefits & Construction Impact & Whole Life Maintenance Impact & ITS benefits and costs (Table 7.3).	£376,422,000	**£937,083,000**	**£560,661,000**	**1.67**
Basic scheme benefits & Construction Impact & Whole Life Maintenance Impact & ITS benefits & WEB benefits and costs (Table 7.4).	£576,422,000	**£1,137,083,000**	**£560,661,000**	**2.03**

Note: All figures are 2002 prices and values discounted to 2002 in accordance with HM Treasury 'Green Book' guidance. The BCR presented is BCR to Government.

7.15.2 The proportion that each element of the scheme appraisal contributes to the overall BCR including WEB is presented in the following table.

Table 7.6: Benefit proportions

Scheme benefit element	Present Value Benefit	Percentage of all scheme benefits
Scheme compared with unrestricted Do-Minimum	£498,545,000	43.8%
Avoidance of Main Cable Replacement Impact	£236,681,000	20.8%
Accident benefits	-£59,613,000	-5.2%
Construction Impact	-£18,890,000	-1.7%
Avoidance of Whole Life Maintenance Impact for the Forth Road Bridge	£199,560,000	17.5%
ITS benefits	£80,800,000	7.1%
WEB benefits	£200,000,000	17.6%
Total benefits	£1,137,164,000	100.0%

Note: All figures are 2002 prices and values discounted to 2002 in accordance with HM Treasury 'Green Book' guidance.

7.16 Conclusions

7.16.1 The project provides good value for money and is enhanced by the introduction of ITS components. The benefits associated with the scheme are derived from several different sources and hence calculated using a variety of methods. For the calculation of benefits associated with each element, a conservative and robust approach was adopted.

7.16.2 The total wider economic benefits for the scheme have been calculated at being in the range of £200 million to £235 million (as illustrated in paragraph 7.14.7). The majority of these benefits relate to agglomeration economies, with £50 million associated with increased output, and only £5 million associated with labour supply impacts. The scale of the calculated benefits is considered reasonable in comparison with those for other schemes.

Part C - References

The City of Edinburgh Council, East Lothian Council, Midlothian Council, West Lothian Council. Edinburgh and Lothians Structure Plan 2015

Fife Council. Fife Structure Plan 2006 - 2026

APPENDIX A – THE SCHEME

APPENDIX B – COST ESTIMATE

APPENDIX C – ENGINEERING ASSESSMENT

APPENDIX D – TRAFFIC ASSESSMENT