Forth Replacement Crossing

Sustainability Appraisal & Carbon Management Report

November 2009

FORTH
REPLACEMENT
CROSSING

JACOBS ARUP

A report on behalf of Transport Scotland and in association with Natural Capital

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TRANSPORT SCOTLAND

natural CAPITAL

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1.1 Background to the Forth Replacement Crossing

1.1.1 Introduction

The Forth Replacement Crossing (FRC) is a major infrastructure project proposed by Transport Scotland, an agency of the Scottish Government. The FRC comprises a new cable-stayed bridge across the Firth of Forth and associated new and improved roads infrastructure to both the north and south of the bridge. The project is driven by uncertainty over the future viability of the existing Forth Road Bridge, and is designed to safeguard this vital connection in Scotland's transport network. The proposed scheme will retain the existing Forth Road Bridge as a public transport corridor for use by buses, taxis and other specified users and for continued use by pedestrians and cyclists. The new bridge (referred to as the Main Crossing) will be used by all other traffic including private cars and heavy goods vehicles.

Jacobs Arup was commissioned in January 2008 to assist Transport Scotland to develop the FRC proposals. As part of the proposals, Transport Scotland commissioned Jacobs Arup in association with Natural Capital to carry out a sustainability appraisal and other associated work, including management of carbon in the scheme. Since completion of a sustainability appraisal is not a mandatory requirement, this undertaking represents a commitment by Transport Scotland to aspire to national sustainability criteria, together with the project-specific sustainability objectives that have been developed for the FRC as outlined in this report. The management of this process has been lead by a combined core group comprising all three organisations above.

This sustainability appraisal report is based on the Stage 3 design of the FRC proposals.

1.1.2 Location and Site Description

The proposed scheme can be separated into the following three main sections, with overarching traffic management measures supported through the use of an Intelligent Transport System (ITS) which will operate between Halbeath Junction on the M90 and Newbridge Junction on the M9:

- the Main Crossing (cable-stayed bridge and approach viaducts);
- road connections north of the Main Crossing to Admiralty Junction (M90 Junction 1); and
- road connections south of the Main Crossing to Scotstoun Junction (A90/M9 Spur), together with enhancement to M9 Junction 1A.

The Main Crossing

The Main Crossing will be located upstream of the Forth Road Bridge and will consist of a three-tower, cable-stayed bridge and approach viaducts. The total length of the Main Crossing is approximately 2.7km. It will be a dual two-lane motorway with hard shoulders. There will be adequate clearance (more than 47m) under each of the two main spans of the bridge to maintain access for shipping. The Main Crossing will include wind shields.

The Forth Road Bridge will become a public transport crossing alongside the Main Crossing.

Northern Connecting Roads

North of the Main Crossing, the Ferrytoll Junction will be fully reconstructed to cater for all local and longer distance traffic movements using the main crossing. The junction also provides for pedestrian and cyclist movements and public transport access to the Ferrytoll Park and Ride site and to the existing Forth Road Bridge.

The B981 will be realigned over part of its length and will join Ferry Toll Road, west of the Dunfermline Wastewater Treatment Works. This will maintain access to North Queensferry during the construction period and improve the operation and safety of Ferrytoll Junction. The B980 (Castlandhill Road) will also be realigned to separate local traffic from A90 traffic.

Southern Connecting Roads and M9 Junction 1A

To the south of the Main Crossing a new 3.1km section of dual carriageway will be built around the west and south of South Queensferry, to join with the A90 and M9 Spur at the Scotstoun Junction. A new South Queensferry Junction will link local roads (including the A904) to the new road infrastructure and Main Crossing, whilst maintaining pedestrian and cyclist routes.

From the South Queensferry Junction to the Scotstoun Junction the road will be a dual three-lane carriageway with hardshoulders, constructed to motorway standard. The additional carriageway width means that the existing A8000 overbridge will require to be reconstructed. Dedicated public transport links will be provided from the Forth Road Bridge eastwards in the direction of Edinburgh using the A90, and from the A90 to the A8000 westwards to join a proposed bus priority scheme on that road. There will be no change to the existing A90 from the Scotstoun Junction into Edinburgh.

Junction 1A on the M9 will be redeveloped to provide two general traffic lanes on the existing south-facing slip road and loop, to help traffic flow and make better use of the current junction. New west-facing slip roads will be added to better serve West Lothian traffic. The M9 will be widened to provide four lanes of traffic in the southbound direction to complement the proposed improvements to this junction. An additional lane on the M9 will be added in the northbound direction between the River Almond Bridge and Junction 1A to help diverging traffic.

Managed Motorway Measures

Managed motorway measures will be implemented between Halbeath Junction on the M90 and Newbridge Junction on the M9. Overhead gantries and Intelligent Transport System (ITS) components will provide lane control signals, mandatory (variable) speed limits, ramp metering (to regulate the flow of traffic entering the mainline from a slip road) and other functions to improve the operational efficiency of the road network and reduce congestion.

More details on the proposed scheme can be found in the DMRB Stage 3 Scheme Assessment Report (Jacobs Arup 2009a) and Chapter 4 of the Environmental Statement (ES) (Jacobs Arup 2009b).

1.1.3 Need for the Scheme

The FRC is required because of the uncertainty over the condition and long-term future of the existing Forth Road Bridge. The crossing over the Forth is critical to the east of Scotland economy, providing a vital link between Edinburgh, the Lothians and Fife.

The condition and operational capability of the Forth Road Bridge has deteriorated over time, primarily because of increased traffic and the effects of weather on the bridge. One of the main concerns in recent years has been the condition of the main suspension cables and whether the bridge can continue as the primary crossing for all traffic, as well as other ongoing maintenance issues.

In February 2008, a study by the Forth Estuary Transport Authority (FETA) reported that it would be possible to replace the bridge's cables, however this would not be feasible without a replacement bridge being in place because of the severity of the impact on road users and the wider economy. Studies into the rate of cable deterioration are ongoing and the preliminary findings have been taken into account in the design and programming of the FRC proposals.

The FRC has been identified as a key strategic investment project in Scotland's national transport network in the Strategic Transport Projects Review (STPR) published by Transport Scotland in December 2008, and the National Planning Framework (NPF2) published by the Scottish Government in June 2009.

1.1.4 Scheme Objectives

Eight specific transport planning objectives have been identified for the proposed scheme:

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

1.2 Purpose and Content of the Sustainability Appraisal and Carbon Management Report

The purpose of this Sustainability Appraisal and Carbon Management Report is to:

- summarise the sustainability appraisal process as developed and applied to the proposed scheme throughout its development since January 2008;
- appraise the sustainability performance of the proposed scheme against defined sustainability objectives, including the measurement and management of carbon; and
- identify design measures (ideas and innovations) that could deliver a more sustainable outcome.

The sustainability appraisal process has also been used to increase awareness of sustainability issues within the integrated project development team and wider stakeholder groups. This was undertaken during the design stages through a combination of workshops and meetings, and has provided a framework for moving forward into the construction phase.

The Sustainability Appraisal and Carbon Management Report is structured as follows:

- Section 1: introduction;
- Section 2: policy context for undertaking sustainability appraisal;
- Section 3: approach to sustainability appraisal;
- Section 4: sustainability appraisal: targets, findings and future opportunities;
- Section 5: design implications and sustainability;
- Section 6: future sustainability monitoring;
- Section 7: CEEQUAL; and
- Section 8: conclusions.

1.3 Benefits of the Sustainability Appraisal and Carbon Management

The benefits of undertaking this sustainability appraisal and carbon management process are that it:

- draws together all the information on sustainability and carbon management relevant to the scheme;
- makes sure that the ethos of sustainable design and development is embedded within the project throughout its life-cycle;
- encourages a more efficiently designed and effectively delivered scheme; and

- demonstrates how the scheme contributes towards the delivery of Scottish Government policies on sustainable development and climate change.

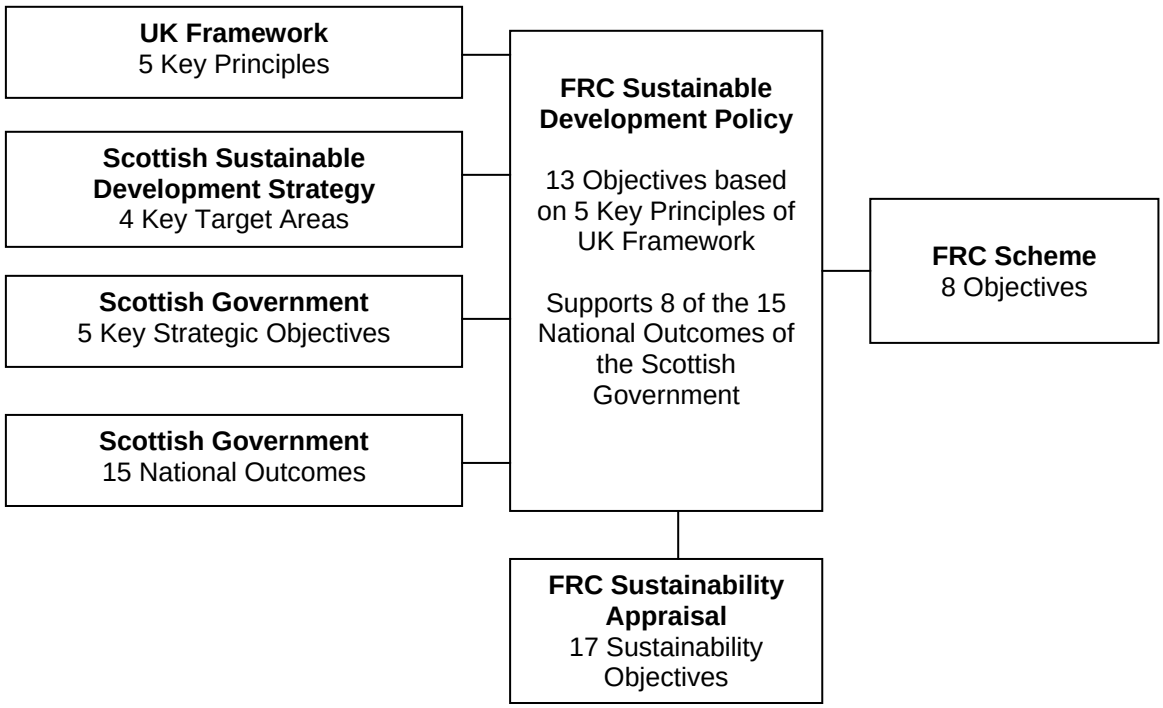
In conjunction with the environmental impact assessment, the sustainability appraisal has also provided a framework for including environmental, social and economic factors in decision-making throughout the life-cycle of the project, thus supporting a sustainable approach. The sustainability appraisal will also support and build on the environmental commitments presented in the ES and Appropriate Assessments.

2 Policy Context for Undertaking Sustainability Appraisal

2.1 Introduction

This section outlines the policy context for the appraisal of sustainability. The relationship between the FRC sustainability policy objectives and UK and National Objectives are shown in Figure 1:

Figure 1: Relationship between UK/ National Objectives and FRC Objectives for Sustainability



2.2 UK Framework for Sustainable Development

In 2005, Scotland signed up to the UK-shared framework for sustainable development, *One future - different paths* (DEFRA 2005a), and this framework set out a common goal for sustainable development across the UK:

"To enable all people throughout the world to satisfy their basic needs and enjoy a better quality of life without compromising the quality of life of future generations".

The framework commits the Scottish Government to promoting a clear understanding of, and commitment to, sustainable development in all that it does so that everyone can contribute to the overall goal.

The UK Framework sets out five key principles for delivering sustainable development:

- living within environmental limits;
- ensuring a strong, healthy and just society;
- achieving a sustainable economy;
- promoting good governance; and
- using sound science responsibly.

2.3 Scottish Sustainable Development Strategy and Objectives

Following the UK Framework, the Scottish Executive (now Scottish Government) published "*Choosing Our Future*" (Scottish Executive 2005) which sets out Scotland's sustainable development strategy based on the five principles of the UK Framework and outlining at a high level what the government, with others, would try to achieve in Scotland. The strategy encompasses four key target areas:

- the well-being of Scotland's people;
- supporting thriving communities;
- Scotland's global contribution; and
- protecting Scotland's natural heritage and resources.

These target areas have helped to shape the more recent Scottish Government Strategic Objectives and associated national outcomes (Scottish Government 2008b) providing the policy framework within which the FRC project should operate. The Scottish Government's five key Strategic Objectives are:

- wealthier and fairer - enable businesses and people to increase their wealth and more people to share fairly in that wealth;
- safer and stronger - help local communities to flourish, becoming stronger, safer place to live, offering improved opportunities and a better quality of life;
- smarter - expand opportunities for Scots to succeed from nurture through to life long learning ensuring higher and more widely shared achievements;
- greener - improve Scotland's natural and built environment and the sustainable use and enjoyment of it; and
- healthier - help people to sustain and improve their health, especially in disadvantaged communities, ensuring better, local and faster access to health care.

2.4 Transport Scotland's Aspirations for Sustainable Development

2.4.1 Sustainable Development

Transport Scotland is committed to promoting sustainability within all its future projects. This will contribute to the achievement of the Scottish Government's overall purpose of achieving sustainable economic growth and the delivery of the five key Strategic Objectives (refer to Section 2.3).

Transport Scotland aims to deliver sustainability throughout all of its operations and is currently undertaking a sustainability review across the whole organisation with a view to building it into the agency's project delivery cycle.

This sustainability appraisal for the FRC will provide a foundation for Transport Scotland to build upon for the future development of sustainability within its scope of work.

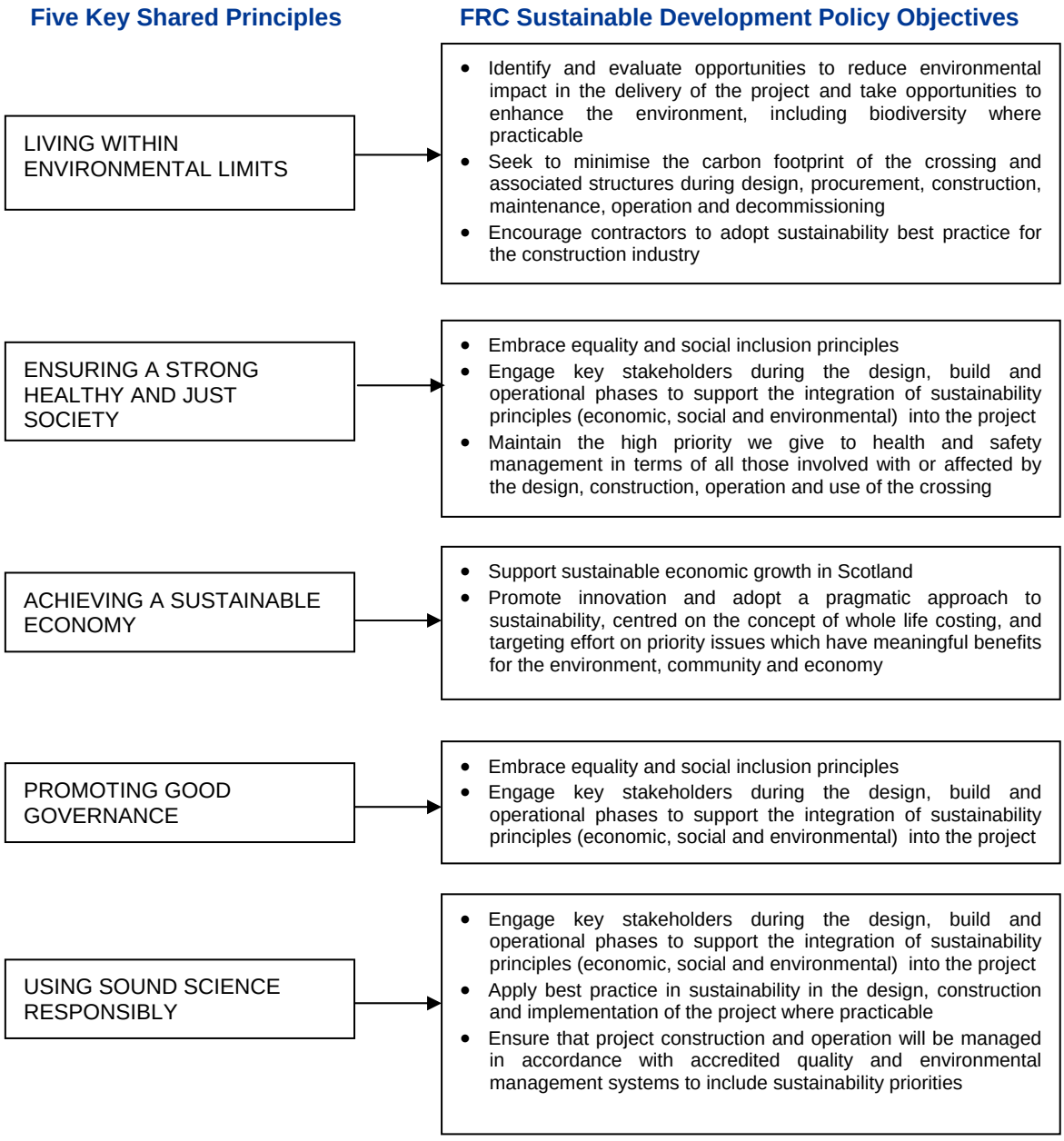
A Sustainable Development Policy was developed for the FRC project (refer to Appendix 1) in an iterative way. The foundations for the policy were developed during a team workshop involving key staff members from Transport Scotland and its consultants Jacobs Arup and Natural Capital.

The Policy was then formulated in an iterative way with the Project Board and in parallel consultations were held with the Sustainable Development Commission and the Equality and Human Rights Commission.

Once finalised and approved by the Project Board the Policy was published and circulated for information to members of the Environmental Reference Group, including representatives from the Scottish Environment Protection Agency, Scottish Natural Heritage, Historic Scotland, Marine Scotland and the Local Authorities.

Figure 2 demonstrates how the FRC Sustainable Development Policy harmonises with the five key principles that underpin Scotland's sustainable development strategy.

Figure 2: Correlation between FRC Sustainable Development Policy and the Five Shared Principles in the UK's Shared Framework



Fifteen national outcomes have been identified by the Scottish Government that are closely linked with the strategic objectives outlined in Section 2.3. The outcomes describe what the Scottish Government would like to achieve over the next ten years. The FRC policy supports eight of the 15 national outcomes:

- we realise our full economic potential with more and better employment opportunities for our people;
- we live in well-designed, sustainable places where we are able to access the amenities and services we need;
- we have strong, resilient and supportive communities where people take responsibility for their own actions and how they affect others;
- we value and enjoy our built and natural environment and protect it and enhance it for future generations;

- we take pride in a strong, fair and inclusive national identity;
- we reduce the local and global environmental impact of our consumption and production.
- we have tackled the significant inequalities in Scottish society; and
- our public services are high quality, continually improving, efficient and responsive to local people's needs.

2.4.2 Climate Change

The Climate Change (Scotland) Act, 2009 (Scottish Government (2009b) sets targets for the reduction of greenhouse gas emissions and places a climate change related duty on public bodies. The Act also includes provisions for mitigation of and adaptation to climate change. The new climate change duty requires that public bodies must, in exercising their functions, act:

- in a way best calculated to contribute to the delivery of the targets;
- in a way best calculated to deliver any statutory adaptation programme; and
- in a way that it considers most sustainable.

Transport Scotland will exercise its duties in relation to the FRC scheme in a way that it considers is most sustainable, including the requirements of the Climate Change Act.

3 Approach to Sustainability Appraisal

3.1 Introduction

The approach to the sustainability appraisal is structured as follows:

- Project Life-cycle approach (Section 3.2).
- Development of FRC sustainability appraisal framework (Section 3.3 and Appendix 2).
- Consultation on the framework (Section 3.4 and Appendix 3).
- Compatibility of Scheme Objectives with Sustainability Objectives (Section 3.5 and Appendix 4).
- Sustainable Resource Management (Section 3.6 and Appendix 5).
- Energy and Carbon Assessment (Section 3.7 and Appendix 6).

3.2 Project Life Cycle Approach

Sustainability, allied closely to environmental considerations, should form a core thread throughout all the activities of the project team and stages in the project life cycle. The following have been identified as the key stages:

- project design and appraisal;
- preparation of contract documents and tenderers' designs (dependent on procurement method);
- tender evaluation;
- construction;
- operation (including maintenance and decommissioning).

Sustainability appraisal should feature at each of these stages. This sustainability appraisal is based upon the project design and appraisal stage. Design of the proposed scheme commenced in January 2008 and has developed throughout 2008 and 2009. Design development has included:

- consideration of potential route corridors;
- comparative assessments of corridor options (Stage 2);
- selection of a preferred corridor; and
- development of the design to Stage 3 as defined in the Design Manual for Roads and Bridges (DMRB) (Highways Agency 1993 as amended).

The sustainability appraisal has been carried out in parallel with the Environmental Impact Assessment (EIA) and the production of the ES as separate but associated work streams, with emerging results from each informing each of the stages of design development.

The Stage 3 design is the focus of this sustainability appraisal report and the results can be used as benchmarks for any future sustainability considerations in the following stages.

3.3 The FRC Sustainability Appraisal Framework

A framework approach was adopted for evaluating the performance of the FRC proposals against the goals of the Sustainable Development Policy. The sustainability appraisal framework (refer to Appendix 2) was developed through a staged and iterative process involving all relevant stakeholders within the project team. The process was as follows:

- Stage 1: A high-level workshop was held that involved senior staff from Transport Scotland and their consultants Jacobs Arup, in association with Natural Capital. Within this workshop the appraisal framework, consisting of sustainability objectives, targets and associated indicators, was first developed. The objectives were initially arranged under the headings of economic (i.e. those with more of an economic thrust), social

(those with more of a social dimension) and environmental (those with a thrust towards environmental protection or efficient resource management). It was recognised that there could be a range of different targets that could be used to deliver the objectives so targets were selected on the basis that they should be SMART (specific, measurable, achievable, realistic and timebound) wherever possible. The indicators were selected as the most effective measure for indicating delivery of targets and for tracking future performance where this was appropriate.

- Stage 2: Each objective was assigned a 'Sustainability Champion' who would be responsible for seeking to meet their objectives and associated targets. These would be monitored through the use of indicators.
- Stage 3: A sequence of regular sustainability workshops were run over an eighteen month period during which the Sustainability Champions were encouraged to initiate the appropriate actions within their respective teams for delivering the objectives and targets and were invited to report on progress. Workshops enabled opportunities for an exchange of information between 'Champions' and a degree of problem solving with colleagues. From time to time opportunities were taken to refine targets and indicators in line with the deliverability of the sustainability objectives and the progress made.
- Stage 4: At the end of the FRC Project Stage 3 the Champions have reported on the delivery of their objectives and targets through tracking performance via the use of the indicators.

In total, 17 sustainability objectives were developed for the FRC scheme:

1. To design, build and operate a reliable crossing
2. To contribute to the improvement of cross-Forth access to economic opportunities
3. To contribute towards the development of cross-Forth public transport opportunities
4. To minimise the scheme footprint and severance of land
5. To adopt sustainable resource management in design and construction
6. To ensure that community engagement takes place at all the key stages in the FRC project process as set out in 'engaging with communities' (Transport Scotland 2008)
7. To improve local accessibility and reduce community severance
8. To provide a scheme that accommodates the needs of disabled people
9. To contribute to the promotion of healthy lifestyle opportunities and social inclusion
10. To provide a safe design for both vehicle travellers and non-motorised users
11. To reduce, reuse and recycle materials and products where practicable
12. Seek to minimise embodied energy and carbon associated with key materials and their transport to site
13. To minimise carbon emissions once the scheme is open to traffic
14. To protect and enhance the natural heritage including local biodiversity
15. To protect the landscape, historic environment and cultural heritage
16. To reduce noise and air emissions
17. To protect water quality, geomorphology and maximise the use of sustainable drainage systems for environmental and hydrological benefit

A summary of the performance for each objective is given in Section 4 with further detail provided in Appendix 3. The Champions have also provided information on the degree to which it has been possible to come up with design innovations for the Stage 3 design that have addressed key sustainability issues. These are summarised in Section 5 with detail provided in Appendix 7.

The sustainability appraisal framework (Appendix 2) includes a glossary that explains some of the technical terms and assumptions that lie behind the framework.

3.4 Consultation on the Sustainable Development Policy and Framework

It was decided at an early stage that the Sustainable Development Policy should be the focus of specific consultation in order to ensure that its scope was appropriate.

Consultation was held with the Sustainable Development Commission and the Equality and Human Rights Commission.

Further informal consultation has been held on the sustainability appraisal framework with members of the FRC Environmental Reference Group (ERG). The FRC ERG comprises representatives from SEPA, SNH, Historic Scotland, Marine Scotland, Fife Council, City of Edinburgh Council and West Lothian Council. It has regularly convened throughout the past 18 months to provide a forum for discussion and information dissemination on all environmental topics relating to the developing FRC proposals.

A specific consultation with Scottish Government staff in relevant Directorates and Divisions was held in order to ensure that the sustainability approach adopted for the FRC project was aligned with current Government thinking.

3.5 Compatibility of Scheme Objectives with Sustainability Objectives

As a first step within the sustainability appraisal the Scheme Objectives were tested for their compatibility with the Project Sustainability Objectives (refer to Appendix 4). This would demonstrate whether the Scheme Objectives were supportive or in conflict with the Sustainable Development Policy for the project and the sustainability goals of Transport Scotland.

The results as presented in Appendix 4 show that the Scheme Objectives are either neutral, broadly or strongly supportive of the Sustainability Objectives and there are none that have a negative effect. In one case (the development of cross-Forth public transport opportunities) the effect would depend on how any measure was implemented.

The outcome of this assessment is reassuring in that it indicates that the overall Scheme Objectives have been established within a broad sustainable development context.

3.6 Sustainable Resource Management

A Sustainable Resource Management Framework that includes a materials plan has been produced in response to the importance given by the Scottish Government to the concept of a ‘One Planet Economy’ (Greener Scotland 2009). This emphasis is evident at the highest political levels in the rest of the UK with an entire chapter devoted to “One Planet Economy” Sustainable Consumption and Production in the UK’s Sustainable Development Strategy (DEFRA 2005b). This chapter sets out goals and action plans for sustainable consumption and production with a priority on sustainable procurement in the public sector. It highlights the point that the environmental impacts of consumption and production remain severe and inefficient use of resources is a ‘drag on the UK economy and businesses.’

Key themes that form the basis of the Sustainable Resource Management Framework are:

- management of natural resources: which includes the re-use or recycling of materials;
- responsible sourcing: which includes sustainable sourcing, local sourcing, reducing transportation, efficient logistics;
- supply chain management: including waste minimisation, management systems and site stewardship; and
- climate change and energy: including energy efficiency, fossil fuel consumption, renewable sources of energy.

The FRC Sustainable Development Policy has set out two key policy objectives with regard to sustainable resource management these are:

- ‘apply best practice in sustainability in the design, construction and implementation of the project where practicable’; and
- ‘encourage contractors to adopt sustainability best practice for the construction industry’.

The Sustainable Resource Management Framework is contained in Appendix 5. The Framework aims to address the key issues around the supply, management and use of the

resources and materials needed to deliver the proposed scheme. It is seen as leading best practice within Trunk Road project delivery in Scotland.

3.7 Energy and Carbon Assessment

A key principle contained in the FRC Sustainable Development Policy is to seek to minimise the carbon emissions associated with the development of the crossing and the connecting roads to the new bridge throughout the project – during design, procurement, construction, maintenance, operation and decommissioning. Similarly, within the sustainability appraisal framework (refer to Appendix 2) key objectives are 'to seek to minimise embodied energy and carbon associated with the construction of the scheme' and 'to seek to minimise carbon emissions once the scheme is opened to traffic'.

For the proposed scheme, it is simplest to differentiate carbon emissions into:

- carbon emissions from traffic on the road network; and
- embodied energy and carbon associated with key materials to be used in the project along with their transport to site, and consideration of the construction process at the appropriate stage.

3.7.1 Carbon Emissions from Traffic

The traffic and economic assessment of the Main Crossing and connecting road network has primarily 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.

Carbon emissions were initially calculated using the strategic traffic model and standard methodology for calculating carbon dioxide (CO_2) emissions (based on the Department for Transport formulae). This relies on average traffic speed as the basis for calculation. It has the advantage of wide network coverage, so all of the network effects of the proposed scheme will be encompassed by the assessment. However, the CO_2 calculations are based on average speeds and this approach is not capable of assessing the local impact of stop-start traffic conditions.

This assessment using TMfS:05A was supplemented with further assessment using a more detailed local area model which uses Paramics microsimulation modelling software. A new Passenger car and Heavy-duty Emission Model (PHEM[1]) based emissions calculation module has been developed for use with Paramics software. 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 was used to supplement the strategic calculations which are based on the Department for Transport formulae. The PHEM based results are intended to provide a more informed view of the likely locally generated impact of the proposed scheme.

Using the above methods, the effect of the proposed scheme on carbon emissions relating to traffic on the road network is reported in the DMRB Stage 3 Scheme Assessment Report (Jacobs Arup 2009a) and Chapter 15 (Air Quality) of the ES. Chapter 15 of the ES describes the difference between CO_2 emissions that would be likely with the proposed scheme (the 'Do-Something Scenario') and without the proposed scheme (the 'Do-Minimum Scenario') for both the anticipated year of opening (2017) and the design year 15 years after opening (2032).

Objective 13 of the sustainability appraisal draws on the findings of the air quality assessment as presented in the ES and is discussed in more detail in Section 4.15.

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

3.7.2 Embodied Energy and Carbon

The embodied carbon of a construction material (e.g. steel, concrete, etc) refers to the emission of CO_2 over its life cycle. For instance, CO_2 is released during the extraction of raw materials, manufacturing and transportation. Similarly, the embodied energy of material can be taken as the total primary energy consumed over its life cycle.

BSI British Standards, co-sponsored by the Carbon Trust and the Department for Environment, Food and Rural Affairs (Defra) has produced PAS 2050, a publicly available specification for assessing product life cycle greenhouse gas (GHG) emissions (British Standards Institute 2008). This standard sets out five useful stages in carrying out a carbon footprinting exercise which have been adopted for the FRC project:

- building a process map of the construction of the Main Crossing and network connections to include materials, energy and waste flows;
- confirming scope and boundaries of the carbon assessment and performing an initial high-level carbon assessment to help prioritise efforts;
- collecting data on material amounts, activities and emission factors across key life cycle stages;
- calculating the carbon footprint; and
- assessing precision of the footprint analysis.

The energy and carbon assessment is based on estimated material quantities for the main components of the scheme (i.e. the Main Crossing and the road connections including Ferrytoll Junction, Queensferry Junction and M9 Junction). Energy and carbon coefficients were extracted from the Inventory of Carbon and Energy database (University of Bath 2008) and the Highways Agency Carbon Calculator (Highways Agency 2009). The Highways Agency model has been developed with reference to existing carbon accounting methodologies and information from the Environment Agency (EA), Defra, and the International Organisation for Standardisation (ISO), and has drawn upon recognised best practice.

Embodied energy and carbon is the focus of Objective 12 of the sustainability appraisal (refer to Section 4.14) and draws on the findings of the energy and carbon report (Appendix 6).

4 Sustainability Appraisal: Targets, Findings and Future Opportunities

4.1 Introduction

This section provides an overview of the sustainability objectives as detailed in the Sustainability Appraisal Framework Table in Appendix 2.

A summary of the targets and indicators used to measure performance against each of the identified objectives is provided. Appendix 3 (Indicator Results Table) provides more detailed results of the indicators. Future opportunities for each target are also identified where relevant.

4.2 Performance Measurement

Performance against sustainability targets is measured by indicators. The results of the indicators in this appraisal are based upon the Stage 3 design of the FRC proposals. The Stage 3 design may be refined in the development of the detailed design, and the Contractor will be required to use the indicators and results presented here to further measure progress against the objectives. No results can be provided for those indicators that do not apply until the scheme is operational, however the rationale behind target development is outlined.

It is hoped that these targets and indicators may be of use in future Transport Scotland project sustainability appraisals. In some cases the targets and indicators may be of use in Transport Scotland's future KPI regime.

The majority of the indicators are quantitative but in a few cases qualitative indicators are considered to be more relevant.

4.3 Sustainability Objective 1: To Design, Build and Operate a Reliable Crossing

4.3.1 Target 1: To reduce the number of planned daytime lane closures on the FRC (excluding hard shoulders) compared to the existing Forth Road Bridge (FRB)

Target Selection

Lane closures adversely affect journey reliability and therefore as a target for improved reliability, the proposed scheme should aim for fewer planned closures than experienced on the existing crossing.

Indicators

- Predicted number of planned closures.
- Actual number of planned closures.

Appraisal Findings

To obtain this performance figure, data on actual planned closures on the Forth Road Bridge were obtained from bridge log books maintained by FETA covering 2004-2008 (FETA 2008). Works requiring planned closures include inspection, maintenance and resurfacing.

The value for this indicator was quantified in terms of the number of hours where only one lane was open to traffic (expressed as lane-hours). For the years 2004 to 2008, the mean proportion of hours lost due to lane closures was 123 hours (refer to Appendix 3 for calculation). This figure can be used to compare future performance on the FRC scheme. This figure can be used to compare future performance on the FRC scheme and numbers of closures can be monitored during operation.

The Stage 3 design of the proposed scheme should facilitate an improvement on this baseline figure. For example, provision of hard shoulders and the central margin between the carriageways on the Main Crossing should reduce the impact of planned maintenance activities on traffic flow. It is also assumed that maintenance activities on the Main Crossing will be less than currently experienced on the Forth Road Bridge, which is requiring ongoing monitoring and maintenance of the cables.

Future Opportunities

Careful choice and specification of carriageway surfacing on the Main Crossing will reduce the frequency at which resurfacing is required. Surfacing options have been investigated by Jacobs Arup and the Employer's Requirements will specify that the Contractor must choose the most appropriate surfacing for the scheme based on the recommendations provided by Jacobs Arup.

4.3.2 Target 2: To reduce the number of unplanned lane closures on the FRC caused by non-weather events (e.g. vehicle breakdowns) compared to the existing FRB

Target Selection

Lane closures adversely affect journey reliability, and therefore as a target for improved reliability, the proposed scheme should aim for fewer unplanned closures than experienced on the current crossing.

Indicators

- Predicted number of unplanned (non-weather) closures.

- Actual number of unplanned (non-weather) closures.

Appraisal Findings

To measure performance against this target, statistics for breakdowns and accidents for the FRB were obtained for 2001-2008 (FETA 2008). The impact of each vehicle recovery on the operation of the FRB is not known. However, as the FRB carriageways do not have hard shoulders, any vehicle breakdown or accident on the bridge that requires recovery will block one or both traffic lanes on the carriageway concerned. The average number of breakdowns and accidents per year experienced on the FRB is 183 and the average time taken to clear these incidents is 21 minutes. For the purposes of determining this indicator it is assumed that 75% of incidents will affect one lane only of the carriageway concerned and that 25% will affect two lanes. On this basis, the actual number of unplanned closures experienced by FRB is 80 lane-hours/year (refer to Appendix 3 for calculation). This figure can be used to compare future performance on the FRC scheme and numbers of closures can be monitored during operation.

The Stage 3 design of the proposed scheme should facilitate an improvement on this baseline figure through the following measures:

- provision of hard shoulders on the Main Crossing will reduce the disruption impact of accidents and breakdowns on traffic flow;
- windshielding on the replacement crossing will also reduce the occurrence of accidents and incidents due to the "wind shadow" effect; and
- use of an Intelligent Transport System (ITS) that will allow incidents to be managed more efficiently to minimise disruption to traffic.

Future Opportunities

Future development of the managed motorways utilising ITS will be facilitated by the future proofing of the design.

4.3.3 Target 3: To reduce the number of FRC closures due to adverse weather conditions compared to the existing FRB

Target Selection

Significant disruption to traffic on the existing Forth Road Bridge is caused by adverse wind conditions giving rise to closures or restrictions. As a target for improved reliability, the proposed scheme should aim for fewer occurrences of restrictions than are experienced on the current crossing.

Indicators

- Predicted number of closures to any class of vehicle due to adverse weather conditions.
- Actual number of closures to any class of vehicle due to adverse weather conditions.

Appraisal Findings

To measure performance, data were obtained from FETA on occurrences of weather-related emergency warnings on the adjacent highway network from 2002-2008 (FETA 2008).

The average number of hours when restrictions are in place on the Forth Road Bridge due to high winds is 843 hours/year (refer to Appendix 3 for calculation). This figure can be used to compare future performance on the FRC scheme and numbers of closures can be monitored during operation.

The proposed FRC will include windshielding along the full length of the Main Crossing with the objective that all classes of vehicles will be able to cross the bridge in extreme wind conditions if they are able to reach the bridge using the adjacent road network. This would have a major positive impact on the reliability of the crossing during high winds.

Future Opportunities

There are no future opportunities identified for this target at this time.

4.4 Sustainability Objective 2: To Contribute to the Improvement of Cross-Forth Access to Economic Opportunities

4.4.1 Target 1: To contribute towards improved journey time reliability

Target Selection

The more 'reliable' or 'predictable' a journey is, the easier it is to access economic opportunities. Improvements to cross-Forth journey time reliability, and therefore cross-Forth access to economic opportunities, are considered in relation to the existing situation.

Indicators

- Percentage of road journeys that do not take longer than 115% of the average journey time (Traffic Scotland Local Trunk Road Congestion Indicator 4).

Appraisal Findings

The higher the percentage of journeys that do not exceed 115% of the average, the more 'reliable' or 'predictable' a journey is. The performance of the existing road network has been assessed using journey reliability indicators for monitored relevant routes.

Table 1: Percentage of journeys that do not take longer than 115% of the average journey time

Monitored Route	Forth Road Bridge approach from the north	M8 Junction 2 to M9 spur
Existing road network (Traffic Scotland 2006 data)	98.4% northbound 96.7% southbound	89.3% northbound 94.8% southbound

The proposed scheme is expected to improve on these figures through features such as a dedicated public transport corridor, hard shoulders, wind shielding and an ITS throughout the scheme. The ITS will include variable message signage on the gantries which will inform the public of the current conditions on the road network including congestion, road closures, broken down vehicles and adverse weather.

A variety of network performance indicators (e.g. journey time savings, air emissions, etc) are being developed by transport specialists.

Future Opportunities

Once the ITS is in place, the optimum settings for the system and the road network can be achieved through minor adjustments. These settings could contribute to future congestion monitoring by Transport Scotland.

4.4.2 Target 2: To contribute towards increasing the employment catchment areas of major centres of economic activity by public transport

Target Selection

Cross-Forth access to economic opportunities may be enhanced by improving public transport so that the population catchments of major centres of economic activity are increased.

Indicators

- The proposed scheme is designed to not preclude improvements in public transport, but responsibility for their delivery (and therefore monitoring) lies beyond the scope of this project. An indicator for monitoring this target has therefore not been identified.

Appraisal Findings

It is considered that the proposed scheme could contribute to this target by providing the dedicated public transport crossing and access routes.

The structure of public transport service delivery in Scotland is such that much of it is delivered from other private and public sector agencies. The proposed scheme is designed to not preclude any future improvements in public transport, and Transport Scotland is currently investigating possibilities for improvements with partner delivery organisations (see below). It should be noted however that the scope of this is outside of the remit of the FRC project team for delivery or monitoring.

Future Opportunities

Outwith the FRC project, Transport Scotland is currently investigating possibilities for improvement of public transport with partner delivery organisations. These include:

- taking into account future new and improved car/bus interchanges;
- improving reliability for bus services (refer also to Target 1, Section 4.4.1); and
- providing scope for additional services and routes.

The proposed scheme presents an opportunity to assist the above future aspirations by improving cross-Forth infrastructure. There is also an opportunity for the ITS to be linked to the Park and Ride facility at Ferrytoll, informing the public of up-to-the-minute status of parking facilities, promoting the use of public transport.

4.4.3 Target 3: To contribute to the reduction of lost travel time associated with traffic congestion

Target Selection

This target addresses the issue of travel time lost to congestion rather than travel time unreliability associated with congestion which is covered by Target 1 (Section 4.4.1).

Indicators

- Average time lost per vehicle kilometre (veh-km).

Appraisal Findings

As per target 1 (Section 4.4.1), this indicator is taken directly from Traffic Scotland's existing congestion monitoring reporting process, along the same route sections.

Table 2: Average time lost per vehicle kilometre (seconds)

Monitored Route	Forth Road approach from the north	M8 Junction 2 to M9 spur
Existing road network (Traffic Scotland 2006 data)	3.35 secs northbound 7.07 secs southbound	9.48 secs northbound 5.98 secs southbound

As noted for Target 1 (Section 4.4.1) the proposed scheme is expected to improve on these figures through the provision of a dedicated public transport corridor, the addition of hard shoulders, wind shielding and an ITS.

Future Opportunities

Once the ITS is in place, the optimum settings for the system and the road network can be achieved through minor adjustments. These settings could contribute to future network

efficiency improvements utilising ITS in a wider and more strategic context in response to network wide congestion monitoring by Transport Scotland.

4.5 Sustainability Objective 3: To Contribute Towards the Development of Cross-Forth Public Transport Opportunities

4.5.1 Target 1: Maximise the opportunities for multi-modal travel across the Forth Estuary

Target Selection

This target was selected to capture improvements to cross-Forth public transport and thus support moves to reduce the reliance on the car, which in turn would bring a range of social and environmental benefits.

Indicators

- Provision of cross-Forth infrastructure to facilitate multi-modal transport.

Appraisal Findings

The proposed revision to the Ferrytoll park and ride layout will improve access for car/bus interchanges. Bus services using the park and ride will also benefit from direct access onto the dedicated FRB public transport crossing, therefore improving the interchange experience for park and ride users.

Other "Park and Choose" (either car-bus, car-rail, car-car sharing) interchanges are currently being investigated by Fife Council at Rosyth (Pitreavie) and Halbeath. The FRC scheme does not preclude improvements for these other proposed interchanges. The proposed scheme will provide direct access onto a dedicated public transport crossing.

Improved reliability for bus services will be possible through the provision of a dedicated public transport crossing which helps to improve the predictability of bus journey times in peak periods by allowing them to use an uncongested route. Providing scope for additional services and routes would be possible to predict although no evidence is available at this time. Bus services are deregulated and it is left to operators to decide how to specify them based on their commercial objectives. Whilst it is possible to identify where there appear to be gaps in the network and also to identify how the bus network has expanded and changed in recent years, it will only be hindsight that tells how operators actually respond. The commercial objectives of operators are not known since they are in competition and responses to a new opportunity like this cannot be reliably predicted.

The proposed scheme also retains existing cross-Forth walking and cycling infrastructure.

Future Opportunities

Given that the posted speed limit of the new crossing will be 70mph compared to 50mph on the existing Forth Road Bridge, it will be feasible for many existing cross-Forth express services that have no commercial advantage in stopping at South Queensferry to use the new crossing instead, especially during relatively congestion-free off-peak periods.

It may be possible for the scheme ITS to provide improved information to potential Park and Choose users (e.g. no. of spare spaces, services available, etc) to encourage greater use.

4.6 Sustainability Objective 4: To Minimise the Scheme Footprint and Severance of Land

4.6.1 Target 1: Minimise land-take for the scheme

Target Selection

This target recognises the economic importance of current land uses and the importance of avoiding and reducing the amount of land-take by the scheme.

Indicators

- Proportion (%) of land returned to agricultural use.
- Proportion (%) of landholdings, businesses, residential properties and areas of community land significantly affected as a result of land-take.
- Absolute area of agricultural land lost by land type.

Appraisal Findings

The development of the Stage 3 design has reduced impacts on land use and therefore the amount of productive land taken by the project through maximising the use of existing infrastructure, early identification of sensitive land uses and consultation with landowners. The results for the indicators are presented in Table 3.

Table 3: Appraisal Findings for Objective 4 Target 1

Receptor	Residual Impact after Design Mitigation	Land or Land Holding Type
Agricultural, Sporting, and Forestry land	7 agricultural interests impacted by land-take. 100 ha agricultural land lost to scheme (this takes into account 12.5 ha of land which could potentially be returned to agricultural use, equating to 11% of the total)	3 agricultural interests (43%) significantly impacted. Land lost to the scheme includes: • 74 ha prime land • 6.2 ha non-prime land • 12.7 ha woodland • 7.1 ha scrub
Commercial properties	11 properties impacted by land-take	5 properties (45%) significantly impacted (i.e. moderate or above).
Residential properties	2 properties impacted	1 property (50%) significantly impacted.
Community land	7 community land interests directly impacted by land-take	1 land interest (14%) significantly impacted due to high sensitivity.
Development land	Land-take would impact 8 development allocations	1 land interest (13%) significantly impacted where land-take is over 5 ha. Land-take would be very limited for all other affected development land.

Future Opportunities

There may be opportunities to improve on the result of the indicators at the final design and construction stage through minor refinements to the location of the design reducing encroachment onto certain land interests. However any design components will be required to be located within the land acquisition boundary and therefore there may be limited scope for improvement.

4.6.2 Target 2: Minimise the negative impacts of land severance

Target Selection

This target recognises the importance of severance effects that can result from land-take. Severance effects may include disruption to access or the remaining area of severed land being unsuitable for continued use.

Indicators

- Proportion (%) of affected agricultural land holdings where the degree of severance is less than 10% of the total land holding.
- Proportion (%) of land holdings affected by severance where access will be maintained through the provision of new or upgraded overbridges/underpasses as part of the scheme or through accommodation works.

Appraisal Findings

Findings for this target are summarised below in Table 4.

Table 4: Appraisal Findings for Objective 4 Target 2

Indicator	Outcome
Percentage of agricultural land holdings affected by severance where the degree of severance = <10% of total land holdings	86%: 6 out of the 7 land holdings affected by severance would be affected by less than 10%
Percentage of all land holdings affected by severance where access will be maintained	100%: Alternative access will be provided for all agricultural land holdings, residential and commercial properties where existing access arrangements would be affected

The alignment of the proposed scheme reduces severance impacts by making use of existing infrastructure. Although some sensitive uses, including community land, residential and commercial land, and also areas allocated for future development would be affected by land-take, severance of these areas is generally avoided. The main exception is for fields to the west of South Queensferry where the connecting roads to the southern bridgehead pass through an area used for informal recreation which is also allocated for housing development in the Local Plan (CEC 2006).

The potential impact of severance of agricultural land would be mitigated through the provision of appropriate field access.

Further information regarding the potential impacts of the proposed scheme on existing and future land use, as well as mitigation measures to reduce impacts, is reported in the ES.

Future Opportunities

There may be opportunities to improve on the result of the indicator for the degree of severance at final design and construction stage through minor refinements to the location of the design. However any design components will be required to be located within the land acquisition boundary and therefore there may be limited scope for improvement.

4.7 Sustainability Objective 5: To Adopt Sustainable Resource Management in Design and Construction

4.7.1 Target 1: Develop a Sustainable Resource Management Framework

Target Selection

This target was selected to reflect the importance of managing resources carefully, specific materials planning and responsible sourcing to meet ethical, social and environmental standards.

Indicators

- A sustainable resource management framework in place and in use.

Appraisal Findings

The production of the framework will mean that the target has been delivered at the design stage. Taking this forward via the employer's requirements will ensure that the framework can be used to good effect during construction. This framework has been produced and is provided in Appendix 5.

Future Opportunities

As noted in Section 3.2, the Contractor should consider sustainability throughout the construction of the project, and therefore the vision and objectives of the Sustainable Resource Management Framework, should be followed.

4.7.2 Target 2: Minimise material use through careful design and adopting material reduction measures

Target Selection

This target was selected to focus on materials use and to investigate the methods available for calculating embodied energy and carbon, minimising the generation of waste and the depletion of finite resources.

Indicators

- Development of a specific materials plan.
- Percentage reduction in specific materials as compared with Stage 3 design.

Appraisal Findings

A materials plan is included in the Sustainable Resource Management Framework (Appendix 5). It sets out targets that have been developed based on the Stage 3 design, including materials recovery, re-use and recycling, and the use of locally sourced materials.

Future Opportunities

Design innovations could improve the proportion of use of recycled materials and reuse of materials in the design. The Contractor will ultimately be responsible for sourcing materials although he could commit to using new technologies in his materials for example:

- the use of pre-cast technologies to minimise material use; and
- the use of kerbs formed from recycled materials.

4.8 Sustainability Objective 6: To ensure that community engagement takes place at all the key stages in the FRC project process as set out in 'Engaging with Communities'

4.8.1 Target 1: To make sure that all groups whose interests are affected by the proposed scheme are identified and have access to information and opportunity to engage

Target Selection

This target was selected to make sure that the approach to engagement was fully inclusive and to capture performance against Transport Scotland's FRC commitment to encouraging public interest and involvement as set out in 'Engaging with Communities' published in September 2008 by Transport Scotland for the Forth Replacement Crossing project.

Indicators

- Demonstrate a thorough and inclusive stakeholder identification process.

Appraisal Findings

The outcome shows that all the groups whose interest would be affected by the scheme have been identified. The stakeholder identification process, and list of key stakeholders will be reported in the evolving Consultation & Engagement Report (to be published by Transport Scotland in 2009). The environmental consultation process is described in Chapter 6 of the ES.

This is a defined outcome at Stage 3 Design and indicates that the target has been achieved for this stage.

Future Opportunities

There will be opportunities to maintain the level of engagement and consultation as the project moves through to construction by requiring the Contractor to adopt, where appropriate, equal or improved practices.

4.8.2 Target 2: To select appropriate methods of engagement for target audiences and to make sure information is made available at appropriate stages in the project

Target Selection

This target was selected to ensure the use of appropriate consultation methods to reach target audiences and the provision of information to stakeholders at appropriate stages in the project.

Indicators

- Range of methods of engagement and communication channels.
- Delivery of consultation commitments in 'Engaging with Communities'.

Appraisal Findings

A portfolio of methods (e.g. printed newsletters, ezines, press releases) was used to target as wide an audience as possible, and will be detailed in the Consultation and Engagement Report (Transport Scotland 2009b).

Engagement took place on an ongoing basis but meetings were specifically set up with stakeholders at key junctures in the project as follows:

- Spring 2008 to outline details of the selected crossing, introduce project team members, outline the programme of works and establish working relationships with stakeholder groups;
- early 2009 (to outline details of the revised crossing strategy and road corridor selection and gain feedback on the developing proposals);
- Spring 2009 to consult on proposed amendments to the road layout and junctions; and
- Summer 2009 to consult on landscaping and mitigation, construction approach and construction compounds.

A series of public exhibitions were also held at various locations throughout Edinburgh, Fife and the Lothians for a period of two weeks in January 2009. These were attended by more than 2,200 people. The exhibitions provided the general public with the opportunity to gain more information on the developing scheme proposals, and have their questions answered by representatives from Transport Scotland and Jacobs Arup, who staffed the exhibitions.

To support the exhibitions, information packs were produced containing a summary of the information on display, maps of the proposed scheme and feedback forms. The packs were also made available at information points set up in libraries and community centres.

In August 2009, information display boards were placed at various venues to the north and south of the Forth for a period of two weeks. The display boards provided communities with the latest information about the proposals specific to their area, incorporating feedback from the consultations held in January 2009. The boards also confirmed that further public exhibitions would be held in November 2009 to present the Bill documents to the public.

This is a defined outcome at Stage 3 Design and indicates that the target has been achieved for this stage.

Future Opportunities

There will be opportunities to maintain the level of engagement and consultation as the project moves through to construction by requiring the Contractor to adopt, where appropriate, equal or improved practices.

4.8.3 Target 3: To provide opportunity for two-way dialogue and ensure stakeholder feedback is considered during the design development process

Target Selection

This target was identified to reflect the importance of taking stakeholder views into account during design development. It is important to demonstrate that two-way dialogue has taken place and that there is a feedback mechanism in place.

Indicators

- Facilities for stakeholders to feed into the project development.
- Demonstrate stakeholder comment has been taken into consideration during the project development.

Appraisal Findings

Opportunities for two-way dialogue included:

- stakeholder meeting (including community councils, resident associations, public meetings);
- FRC email enquiry line;
- FRC enquiry telephone line; and

- letter, address details on website.

The public exhibitions in January 2009 and ongoing community liaison provided further opportunity for stakeholders to feedback their views and contribute to the design stage. The results from this are reported in the Public Information Exhibitions: Feedback and Outcomes Report (Transport Scotland, 2009a) and the Consultation and Engagement Report (Transport Scotland 2009b).

This is a defined outcome at Stage 3 Design and indicates that the target has been achieved for this stage.

Future Opportunities

There will be opportunities to maintain the level of engagement and consultation as the project moves through to construction by requiring the Contractor to adopt, where appropriate, equal or improved practices.

4.9 Sustainability Objective 7: To improve local accessibility and reduce community severance

Impacts on communities and local accessibility are addressed within the ES in Chapter 17: Pedestrians, Cyclists, Equestrians and Community Effects.

The assessment on pedestrians, cyclists, equestrians (also referred to as non-motorised users, NMUs) and communities was undertaken in accordance with DMRB (Highways Agency et al., 1993) and focused on the impacts on paths (changes in journey lengths/times and amenity value) and impacts on links between communities and their facilities, resulting from the proposed scheme. Potential impacts on access to the outdoors were also considered using SNH guidance on EIA (SNH, 2006).

Provision for NMUs and local accessibility has been incorporated in the proposed scheme including overbridges, underbridges, and footpaths/cycleways.

Once draft proposals were available, consultation meetings were held with SUSTRANS and the Local Authorities' access officers. A local disability access group was also consulted (refer to Section 4.10). Comments from the consultees informed the development of the scheme design and mitigation proposals incorporated into the environmental assessment.

4.9.1 Target 1: Reduce community severance by reducing traffic on local roads within 400m of the main carriageway centre line

Target Selection

This target was selected in recognition of the potential of the scheme to change local traffic patterns. Existing community severance is considered to be the severance of communities from their facilities, as caused by the existing road network. A reduction in severance can result where traffic flows are reduced by over 30%.

Indicators

- Number of pedestrian/cycle paths which would experience a reduction in traffic flows at non-signalised road crossing points

Appraisal Findings

The most appropriate indicator for identifying any reductions in existing community severance is to report reductions in road traffic flows at path crossing points. However, it should be noted that whilst there may be reductions, there may not be any existing severance at these locations. Existing severance is characterised by roads which separate or divide a community catchment, where Average Annual Daily Traffic (AADT) flows are more than 8,000 and may therefore act as a barrier to NMU movement. Therefore any traffic reductions on roads with less than 8,000 AADT are not considered to be significant and are unlikely to provide any severance relief.

Relief from existing severance would occur at one location, south of South Queensferry, east of the proposed Queensferry Junction, where an approximate 70% decrease in traffic flow is predicted.

Whilst reductions are noted at five other crossing points, traffic flows on these local roads are less than 8,000 AADT, which is considered to be unlikely to provide any significant severance relief in terms of DMRB criteria. Some minor local benefits could however be experienced.

Future Opportunities

No future significant opportunities are identified.

4.9.2 Target 2: Improve walking and cycling provision and integration within the scheme catchment

Target Selection

This target was selected to reflect the importance of walking and cycling as sustainable transport options and the national initiatives of promoting healthy living.

Indicators

- Number of paths/cycleways improved/created/disrupted.

Appraisal Findings

The following improvements have been identified:

- 28 existing paths/ cycleways would be improved as a result of the proposed scheme. The majority of these improvements would be due to slight changes in amenity value;
- realignment of the B981 would include a replacement footpath and a new cycle path (part of NCR 1) to maintain safe access along it. Access from St Margaret's Marsh would also be maintained;
- realignment of the A90 from Ferrytoll to the Forth Road Bridge would include realignment of the combined footpath/ cycleway (part of NCR1); and
- at Ferrytoll and Queensferry Junctions access would be maintained across the proposed scheme by footpaths and cycleways (parts of NCR76 at Ferrytoll) with improved crossing provisions.

New footpaths and cycleways would be created at the Ferrytoll and Queensferry Junctions. New footpaths at B980 (Castlandhill Road) and from the A8000 overbridge would also improve accessibility by increasing the links between existing paths.

The proposed scheme would directly sever and affect access along some existing paths and cycleways. Access would however be maintained in all cases via replacement paths, new paths and diversions.

Future Opportunities

The improvements to the path network as part of the proposed scheme take into consideration the current and future plans of local authorities for improving accessibility within their authority boundaries. Through the proposed core path networks, opportunities exist for local authorities to further improve accessibility in the Forth area, utilising the path and cycle infrastructure implemented as part of the proposed scheme.

4.9.3 Target 3: Contribute to the improvement of access to public transport

Target Selection

This target recognises the general need to improve walk/cycle access to public transport services. This offers a number of positive outcomes including the reduction of social deprivation, and improved general accessibility to work opportunities and essential services etc.

Indicators

- Percentage increase in the number of households within 400m of a high frequency bus service.

Appraisal Findings

Statistics have been compiled on the number of dwellings in the SESTran area within a short (defined as less than 400m) walk of a bus stop providing access to high frequency bus services (defined as an average of 4 buses per hour across a typical weekday daytime).

As shown in Table 5, the results indicate that, based on data for 2007, approximately 29% of dwellings in the SESTran area are within 400m of a high frequency bus service.

Table 5: Access to public transport within the SESTran area (2007)

Indicators	Totals
No. of dwellings in the SESTran area within 400m of a high frequency bus service (2007)	198,495
Total no. of dwellings in SESTran area (2007)*	692,209
Percentage of dwellings in SESTran area within 400m of a high frequency bus service	28.7%

* General Register Office for Scotland (2007)

A number of bus services cross existing junctions of the A90/M90, and in the south are routed along the A904, B9080 and B924. Vehicle access and bus routes along these roads would be maintained with the proposed scheme. As part of the proposed scheme, new bus links would be provided northbound from the A90 to the A8000, and southbound from the Forth Road Bridge to the A90. These would facilitate public transport movements to and from the Forth Road Bridge and improve travel times, benefiting the public transport network and commuting population. It is not anticipated that the position of existing bus stops on the A904 and B924 would be affected by the proposed scheme. The proposed realigned footpaths would provide continued access to the bus stops. The bus stops located at either end of the Forth Road Bridge would also be unaffected by the proposed scheme.

Responsibility for delivery (and therefore monitoring) of public transport services is largely a matter for other private and public sector agencies, outwith the scope of the FRC scheme and Transport Scotland. Therefore future predictions of changes in access to high frequency buses are currently unknown and will be determined by any changes implemented by public service providers.

Future Opportunities

The scheme provides opportunity for further development of public transport and the development of these opportunities could be expected to increase levels of patronage.

4.10 Sustainability Objective 8: To provide a scheme that accommodates the needs of disabled people

Transport Scotland's duty, as a public authority, means that it must comply with the Disability Discrimination Act (2005) (DDA 2005). Transport Scotland has developed an action plan including professional development, promotion and auditing of the existing trunk road network to help the authority meet its duties under the terms of the DDA compliance. Subsequently, Transport Scotland produced the "Disability Discrimination Act Good Practice Guide for Roads" (Transport Scotland 2009c). The Forth Replacement Crossing will be Transport Scotland's first major project where the Guide will be fully incorporated. Consultation has also taken place with local access groups.

4.10.1 Target 1: Ensure all non-motorised user routes impacted by the scheme are designed in accordance with Transport Scotland's *"Disability Discrimination Act Good Practice Guide for Roads"*

Target Selection

This target was selected to underline the importance of meeting the needs of disabled people in the design of routes for pedestrians and cyclists.

Indicators

- The number of pedestrian or cyclist networks retained or amended on their current alignment, or aligned in accordance with Transport Scotland's "Disability Discrimination Act Good Practice Guide for Roads".

Appraisal Findings

NMU routes have been assessed against their compliance with the recommendation made in Transport Scotland's "Disability Discrimination Act Good Practice Guide for Roads" (Transport Scotland 2009c). Consultation has taken place with local disabled groups to discuss compliance with the Stage 3 design and this consultation will continue to the detailed design stage. In line with Transport Scotland's guidance (Transport Scotland 2009b), a Focus Group has been established for the FRC made up of local disabled people and representatives of disability organisations, including The Scottish Disability Equality Forum (SDEF) which acts as an umbrella body for most Access Panels in Scotland. The Group first met in July 2009 and will meet again in early December 2009. This close liaison has allowed for feedback and suggestions to be considered in further optimisation of the design.

All existing pedestrian and cyclist routes will be maintained with the proposed scheme. Where practicable, they will also be improved in accordance with Transport Scotland's "Disability Discrimination Act Good Practice Guide for Roads" (Transport Scotland 2009b). Some routes will retain their current alignment while others will be realigned, however, all will benefit from design measures such as minimum footway widths, tactile paving and best practice at pedestrian crossings while shared routes will be designed in accordance with the Scottish Executive's "Cycling by Design" (Scottish Executive 1999). A new access ramp linking the B981 and the west side of the Forth Road Bridge has also been designed in accordance with Transport Scotland Guidance and will be DDA complaint. This will maintain and improve on the existing access for disabled users to the Forth Road Bridge.

Due to the existing topography longitudinal gradient is the one area of the Guide where the standard will not be achieved. Pedestrian routes in the vicinity of Ferrytoll Junction are currently in excess of the minimum 5% specified in the Guide. Due to the constraints created by topography and the land available to make improvements, the existing gradients will be retained.

Future Opportunities

The design and build contractor will be required to establish regular meetings with the Focus Group over the life of the project and will be expected to appoint an Access Champion to ensure the needs of disabled NMUs are addressed within the scheme.

4.10.2 Target 2: Ensure the needs of disabled people are given due consideration in the design of all aspects of the scheme

Target Selection

This target was selected to underline the importance of meeting the access requirements of disabled people in all aspects of the scheme design.

Indicators

- Consideration of disabled access in the development of the design
- Emergency telephones accessible to disabled people.
- Temporary footpaths/ cycleway diversions during construction in accordance with Transport Scotland's "Disability Discrimination Act Good Practice Guide for Roads" (Transport Scotland 2009c).

Appraisal Findings

Emergency telephones, accessible to disabled people, will be provided. Attempts will be made to co-locate emergency telephones with signalised gantry hard standing areas and where this is not possible, stand alone sites will be adopted. In any case the principles of the Guide will be applied to ensure the needs of disabled people are incorporated into the design.

Construction work will not act as a barrier to disabled people. The contract will specify that any temporary NMU routes be designed in accordance with the Guide.

Future Opportunities

DDA good practice could be extended to full bus routes around the Forth area, thereby ensuring the needs of disabled people are fully accommodated throughout their journey.

4.11 Sustainability Objective 9: To contribute to the promotion of healthy lifestyle opportunities and social inclusion

4.11.1 Target 1: Maintain the quality and accessibility of open or green space

Target Selection

This target was selected to capture effects on healthy lifestyle opportunities.

Indicators

- The number of open/green spaces in the vicinity of the scheme experiencing significant positive/negative effects, measured according to direct loss, effects on amenity, views and accessibility.

Appraisal Findings

Chapter 17 (Pedestrians, Cyclists, Equestrians and Community Effects) of the ES has identified potential impacts on access to the outdoors. The assessment takes account of journey lengths along footpaths leading to outdoor areas, and direct amenity effects such as noise levels and views. In addition Chapter 7 (Land Use) of the ES assesses direct potential impacts arising from land-take of the outdoor areas. The outdoor areas include playing fields, parks, woodlands, greenspaces and areas identified as open space within Local Plans.

In the vicinity of the proposed scheme the only outdoor area identified as potentially experiencing significant adverse affects is the informal recreation area at the Echline fields, west of South Queensferry. The recreational value of the Echline fields would be reduced by the proposed scheme as a result of the loss of local paths and an approximate 57% loss of land. Reduced access from South Queensferry to the west of the proposed scheme would result in residual impacts of moderate significance. The proposed scheme will however maintain access routes to the recreational area to the west of the mainline via paths and cycleways on the Queensferry Junction and routes via Society Road.

Residual beneficial impacts are predicted on the Echline and Ferry Glen community woodlands, associated local paths and Inchcolm Park in South Queensferry. Users of these areas are likely to experience a more pleasant environment as a result of the proposed scheme due to decreased noise levels and improved air quality.

Future Opportunities

Through the proposed core path networks, opportunities exist for local authorities to further improve accessibility to open and green spaces in the Forth area, utilising the path and cycle infrastructure implemented as part of the proposed scheme.

4.11.2 Target 2: Seek to create training and employment opportunities

Target Selection

This target was selected to capture social inclusion issues.

Indicators

- Training places provided that are recognised and accredited by the CITB-Construction Skills and which lead to a qualification of at least Scottish Vocational Qualification (SVQ) Level 2 or higher.

- Training places provided that are recognised and accredited by Professional Bodies (such as the Institution of Civil Engineers) leading to membership of the Professional Body.
- The number of employment opportunities for those who are currently long-term unemployed.
- Proportion of training and employment opportunities taken by local people, and for residents of deprived areas.

Appraisal Findings

There is currently no data available at Stage 3 design to report against the identified indicators.

Future Opportunities

This target can be monitored by the Contractor during the construction stage using employee post-code data and SIMD data.

4.11.3 Target 3: Contribute to the improvement in public transport access to economic opportunities for communities where this is a factor in deprivation

Target Selection

This target was selected in recognition of the important role that public transport plays towards alleviating social deprivation though improved access to economic opportunities.

Indicators

- Public Transport journey times to key economic centres in the region for communities where geographic access is a factor in high levels of deprivation.

Appraisal Findings

This target is complementary to objective 2, target 2 (refer to Section 4.4.2). Of the immediately adjacent Community Health Partnership (CHP) areas to the scheme, Edinburgh is significantly better off than Scotland as a whole in terms of the majority of health and wellbeing indicators. West Lothian, Dunfermline and West Fife are largely rural, although both contain significant urban settlements. These CHP areas are also significantly better than average compared to the rest of Scotland, but not to the extent of Edinburgh.

As with all locations, smaller pockets of relatively more deprived areas will be found within the overall area. Instead of addressing major economic centre catchments for the population as a whole, focus should be given to those smaller population centres where transport-related social exclusion is a more significant element of social deprivation.

Journey time information will be used to enable this indicator to be monitored.

Future Opportunities

There could be opportunities for local public transport providers working with public authorities to encourage an improvement in bus services. Changes in accessibility and journey times between these areas where transport-related social exclusion is a more significant element of social deprivation and economic centres can be monitored.

4.11.4 Target 4: Avoid increasing health inequalities during the construction process

Target Selection

This target was selected to test whether the construction of the proposed scheme would disproportionately affect health along its length.

Indicators

- The proportion of the population in deprived communities directly affected by construction impacts.
- The proportion of the population in non-deprived communities directly affected by construction impacts.

Appraisal Findings

The proximity of deprived and non-deprived communities to the proposed scheme was assessed.

The Scottish Index of Multiple Deprivation (SIMD) (Scottish Government 2009c) ranks 6,505 data zones across Scotland according to deprivation indicators, 1 being the most deprived and 6,505 the least deprived. The overall SIMD rankings provide a picture of relative deprivation, and areas can be divided into 10-percentile brackets, with the areas ranked 0 to 646 identified as the most deprived 10% (1) and the areas ranked 5855 to 6505 identified as the least deprived 10% (10). A plan of SIMD rankings in the vicinity of the proposed scheme is provided in the Health Impact Assessment (HIA) (Jacobs Arup 2009h).

An analysis was undertaken of the proportion of SIMD rankings, by % area, within 200m of the proposed scheme as a whole (refer to Table 6).

Table 6: Summary (by % area) of SIMD rankings across the whole study area compared with areas affected by construction

SIMD Percentile (1 to 10, 1 = most deprived	% of study area within each SIMD percentile
	Areas within 200m of the proposed scheme
1	0%
2	0%
3	0%
4	0%
5	11%
6	18%
7	35%
8	0%
9	31%
10	3%

The results show that the areas directly affected by the proposed scheme are all within SIMD percentile groups 5 to 10, or the 60% least deprived areas within Scotland. The most deprived areas located along the proposed scheme route are in SIMD percentile 5, and these comprise 11% of the total area. The proposed scheme does not appear therefore to disproportionately affect more deprived communities.

Future Opportunities

There will be opportunities for the successful contractor to work with local training and skills providers to develop relevant construction skills. This will potentially enable local people to benefit from job opportunities during construction.

The contractor should undertake monitoring and corrective action to ensure that adverse construction impacts do not disproportionately affect more deprived communities.

4.12 Sustainability Objective 10: To provide a safe design for both vehicle travellers and non-motorised users

4.12.1 Target 1: To reduce the risk / likelihood of accidents as compared to the existing FRB

Target Selection

This target was selected to illustrate safety issues relating to the proposals.

Indicators

- Predicted accident rates.
- Actual accident rates.

Appraisal Findings

The proposed scheme complies with the DMRB with appropriate departures from standard identified at a number of locations where environmental or cost constraints have merited their inclusion.

As the Main Crossing is a new bridge, default accident rates have been applied for the purpose of calculating forecast accident costs (using Cost Benefit Analysis (COBA) software). The Forth Road Bridge has a relatively good safety record. It is anticipated that the provision of widened hard shoulders, wind shielding, the introduction of controlled crossing points for pedestrians and others, and ITS management will maintain a suitable level of safety on the Main Crossing.

The ITS system will assist in managing safety on the road network through lane signalling, mandatory variable speed signalling, variable message signs, incident management and information on adverse weather conditions. It is predicted that the ITS will assist in reducing accidents on the FRC scheme by approximately 26% (calculated using COBA software in line with the transport analysis guidance (Department for Transport 2009).

An initial road safety audit (unpublished) has been completed which has assisted in informing the development of the scheme design. This audit will be provided to the contractor and the contractor will be responsible for undertaking further road safety audits based on the detailed design.

Future Opportunities

Accident statistics will be monitored in the future.

4.13 Sustainability Objective 11: To Reduce, Reuse and Recycle Materials and Products Where Practicable

Objective 11 has been prepared with the aim of achieving sustainable construction of earthworks for the proposed scheme.

4.13.1 Target 1: Minimise absolute volumes and difference between cut and fill earthworks quantities

Target Selection

This target was selected to capture resource use issues relating to scheme earthworks.

Indicators

- Predicted (Stage 3 and tender design) and actual (as built) cut and fill design volumes
- Predicted and actual proportions by volume of cut material that is used on site as part of the works.
- Predicted and actual proportions by volume of fill material that is site won (including modified material).
- Actual quantities of recycled materials used during construction.

Appraisal Findings

An earthworks strategy has been developed for the proposed scheme which reviews the earthworks material available on site, potential sources of imported material, the earthworks balance, options available for improving the earthworks balance and the impact that the proposed construction programme will have on the earthworks balance. Attention is paid to earthworks geometry (flat slopes to allow lower grade material to be used in fill or steepened slopes with reinforcement, soil nails or reinforced embankments) in an attempt to reduce cut and fill quantities and to minimise the need to import fill to site (or export fill from site).

The earthworks strategy has allowed the development of the Stage 3 design and will be further developed to aid the final design within the constraints of the EIA and ES, minimising both the volume of imported material required and the surplus destined for disposal.

Table 7 presents the estimated cut and fill volumes for the proposed scheme, divided into three sections: North of the Firth of Forth, South of the Firth of Forth and M9 Junction 1A.

Table 7: Summary of Estimated Cut and Fill Volumes for Proposed Scheme (Stage 3)

Summary of Performance	Reference	Comments
Assessment of cut and fill volumes (1000m3): **North Cut / Fill:** 295 / 340(45 deficit) **South Cut / Fill:** 535 / 585 (50 deficit) **Jct 1A: Cut / Fill:** 165 / 300 (135 deficit)	Stage 3 Scheme Assessment Report	Vertical and horizontal alignment requirements to be considered in appraisal

NB. 1. bulking of material has not been used above in keeping with other cut and fill volumes presented in the ES and Stage 3 report. Figures are rounded to the nearest 5,000$m^{3.}$ Potential reduction in import volumes due to bulking will further reduce the apparent deficits in Table 7 for North, South and Jct 1A areas. The deficits (in this case, other solutions may have surplus) assumes full use of all cut material for use as fill. This is clearly an idealised situation as there will likely be some additional out of balance due to material being not viable for use in earthworks as apparent from the table below. 2. Volumes related to structures are not included in these calculations.

Table 8 presents the estimated successful incorporation or use of site won material in the scheme, where 100% is all cut material being used in the scheme (i.e. zero export).

Quantities are divided into three sections: North of the Firth of Forth, South of the Firth of Forth and M9 Junction 1A.

Table 8: Summary of the Estimated Successful Incorporation of Site Won Material in the Scheme (where 100% is all cut material being used in the scheme) (Stage 3)

Summary of Performance	Reference	Comments
Assessment of cut and fill volumes (1000m3). Maximising use of site won materials (minimising export): **North Cut used / Total Cut:** 255 / 295 (86%) (40,000m^3 exported) **South Cut used / Total Cut:** 480 / 535 (89%) (55,000m^3 exported) **Jct 1A: Cut used / Total Cut**: 145 / 165 (87%) (20,000m^3 exported)	Stage 3 Scheme Assessment Report	Consideration of north, south and Junction 1A as individual entities reduces possible economies of scale. The assessment assumes the following volumes of unsuitable material have been processed to allow incorporation in the works thereby reducing import (and export) volumes: North 38,000m^3, South 167,000m^3 and Junction 1A 66,000m^3.

NB. 1. bulking of material has not been used above in keeping with other cut and fill volumes in the ES and Stage 3 report. Figures are rounded to the nearest 5,000m^3 2. Volumes related to structures are not included in these calculations.

Table 9 presents the estimated volume of imported fill compared to required fill. The imported fill should consist, where possible, of recycled material. The lower the percentage value the more sustainable the solution. Clearly this indicator also impacts on Objective 11, Target 2 where haulage distances are addressed. Quantities are divided into three sections: North of the Firth of Forth, South of the Firth of Forth and M9 Junction 1A.

Table 9: Summary of the Estimated Import of Earthworks Materials to the Site (where 0% is no imported fill to the site) (Stage 3)

Summary of Performance	Reference	Comments
Assessment of cut and fill volumes (1000m3). Minimising imported volumes: **North: Imported fill / Fill used**: 85 / 340 (25%) **South: Imported fill / Fill used**: 105 / 585 (18%) **Jct 1A: Imported fill / Fill used**: 155 / 300 (51%)	Stage 3 Scheme Assessment Report	Consideration of north, south and junction 1A as individual entities reduces possible economies of scale. The assessment assumes the following volumes of unsuitable material have been processed to allow incorporation in the works thereby reducing import (and export) volumes: North 38,000m^3, South 167,000m^3 and Junction 1A 66,000m^3.

NB. 1. bulking of material has not been used above in keeping with other cut and fill volumes in the ES and Stage 3 report. Figures are rounded to the nearest 5,000m^3 2. Volumes related to structures are not included in these calculations.

Future Opportunities

The Stage 3 assessment results will be compared with the participating contractor's final design allowing a qualitative comparison to be made. The results throughout the construction period and on completion will be gathered to inform future projects.

4.13.2 Target 2: Maximise Percentage of earthworks materials sourced locally

Target Selection

This target was selected to ensure earthworks materials are sourced locally where appropriate.

Indicators

- Predicted % materials by type sourced locally – within 10km.
- Predicted % materials by type sourced locally – within 80km.
- Actual % materials by type sourced locally– within 10km.
- Actual % materials by type sourced locally – within 80km.

Appraisal Findings

The indicators identified for this target quantify percentage of materials sourced within 10km and 80km of the FRC Scheme split into North, South and M9 Junction 1A areas each with its own focal point.

The availability of earthworks material for import to the site has been assessed. The Contractor will be required to work with National Industrial Symbiosis Programme (NISP) and consider possible opportunities for beneficial local solutions.

Table 10 presents the results of this assessment split into earthworks fill materials which are sourced at a distance of less than 10km from the site, between 10 and 80km from the site and greater than 80km from the site. Optimum performance is linked to the results in Table 8 above where the primary aim is to eliminate the need to import fill, thereafter the aim, as herein, is the reduction of haulage distance for imported fill. The choice of distances ranges (less than 10km. between 10 and 80km and greater than 80km) are illustrative, it is also possible to assess the indicator in terms of m^3.km or even tonne.km.

Table 10: Summary of distance travelled of imported fill

Summary of Performance	Reference	Comments
Assessment of local sourcing of earthworks materials (%): **North distance travelled**: <10km: 0% >10, <80km: 100% >80km: 0% **South distance travelled**: <10km: 100% >10, <80km: 0% >80km: 0% **Jct 1A distance travelled**: <10km: 100% >10, <80km: 0% >80km: 0%	Stage 3 Report	Consideration of north, south and junction 1A as individual entities reduces possible economies of scale.

A similar assessment can also be made for imported products (types as per Target 3 below) to show local manufacture / sourcing for the entire road form and not just earthworks materials.

In addition the haulage distance for exported material can also be considered. For initial purposes, this is provided below assuming all materials are sent to Lochhead Landfill located some 14km from the site (average distance for North, South and M9 Junction 1A). The results are shown in Table 11. Alternative locations should be considered to limit the quantity of material transported over the Forth Road Bridge. Material will need to be classified and landfill requirements incorporated in any disposal strategy.

Table 11: Summary of distance travelled for exported cut material (assumed non-hazardous).

Summary of Performance	Reference	Comments
Assessment of local landfill or excess earthworks materials (%): **North distance travelled**: <10km: 0% >10, <80km: 100% >80km: 0% **South distance travelled**: <10km: 0% >10, <80km: 100% >80km: 0% **Jct 1A distance travelled**: <10km: 0% >10, <80km: 100% >80km: 0%	Stage 3 Report	Split landfill sites between area North and areas South and Jct 1A thereby changing haulage distances for South and Jct 1A compared to those shown.

Future Opportunities

The Stage 3 assessment results will be compared with the participating contractor's final design allowing a qualitative comparison to be made. The results throughout the construction period and on completion will be gathered to inform future projects.

4.13.3 Target 3: Maximise use of reused/recycled products

Target Selection

This target was selected to ensure recycled materials, other than earthworks fill, are incorporated into the design where appropriate. The Scottish Government currently sets a target of at least 10% material by value to be recycled or re-used in publicly procured construction projects over £1 million (Scottish Executive 2006).

Indicators

- Predicted % of materials used that are from recycled sources.
- Actual % of materials used that are from recycled sources.

Appraisal Findings

There are a number of products used in the construction of a road that could be derived from recycled materials such as kerbing, fencing and plastic pipes. The use of any recycled materials should comply with the Manual of Contract Documents for Highway Works (MCHW) (Highways Agency 1992) and British Standards.

Future Opportunities

The Stage 3 assessment results will be compared with the participating contractor's final design allowing a qualitative comparison to be made. The results throughout the construction period and on completion will be gathered to inform future projects.

4.13.4 Target 4: Promote the restoration and development of brownfield/contaminated sites within areas affected by the scheme

Target Selection

This target addresses the issue of brownfield and/or contaminated areas of land in the scheme area and aims to promote the improvement of sites where this would be appropriate.

Indicators

- Area of brownfield/contaminated land brought back into beneficial use, according to environmental risk.

Appraisal Findings

The beneficial use identified in this indicator is determined in relation to environmental risk and includes use such as industrial land, housing, business, and agriculture. Road infrastructure could also be considered to be of benefit since it would provide access to the future development of brownfield sites.

The proposed scheme passes through and adjacent to areas of development land, some of which are allocated for residential use in the future. The scheme would therefore improve accessibility to these development sites providing benefit to the area.

Future Opportunities

Where appropriate, the detailed design will seek to facilitate the restoration and development of brownfield/contaminated land by providing improved access to these sites.

4.14 Sustainability Objective 12: Seek to minimise embodied energy and carbon associated with key materials and their transport to site

4.14.1 Target 1: Seek to minimise the embodied energy and carbon associated with key materials and their transport to site.

Target Selection

This target acknowledges the importance of greenhouse gases and hence carbon emissions and their contribution to climate change, and addresses the embodied carbon associated with materials used in the scheme.

Indicators

- Estimated embodied energy and carbon.
- Actual embodied energy and carbon in materials, transportation and waste.

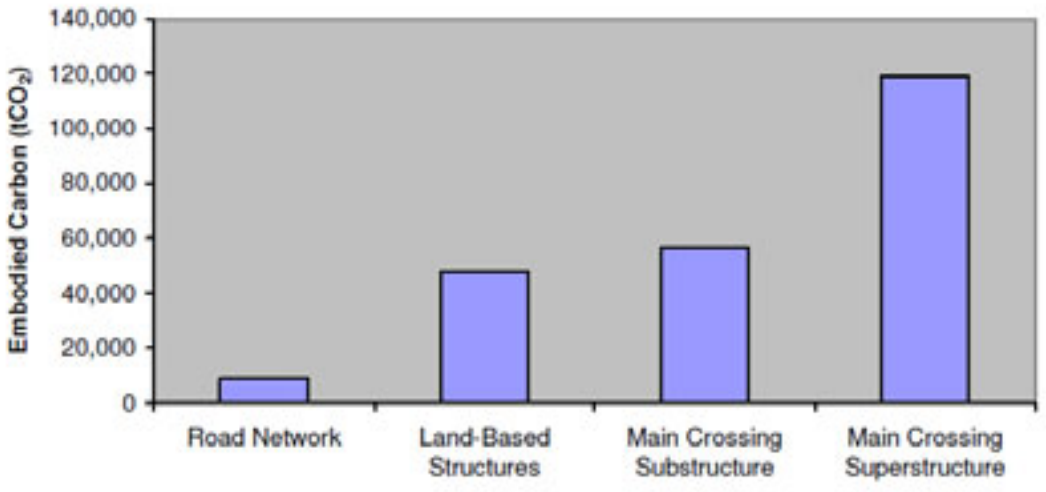
Appraisal Findings

Appendix 6 comprises an Energy and Carbon Report which provides detailed findings of the embodied energy and carbon assessment for the FRC.

The assessment of embodied energy and carbon was based on estimated material quantities (based on Stage 3 design) for key components of the scheme and their associated energy and carbon coefficients.

The total material (for transport calculations see below) embodied energy for the scheme is estimated to be 3,129,574 GJ and the total embodied carbon would be 232,074 tCO_2 (This is based on the assumption that Option 1 would be used for the Main Crossing superstructure (i.e. orthotropic single deck box girder for the cable-stayed bridge and twin composite box girder for the approach viaduct). Figure 3 below provides a summary of total embodied carbon for each component of the scheme.

Figure 3: Summary of total embodied carbon for each component of the scheme



Steel is estimated to account for approximately 75% of total embodied carbon. Quarry sourced materials (soil/earth, aggregates, stone, etc) make up around 14% of total embodied carbon, while cement and concrete account for around 11%.

The energy and carbon report also contains an initial examination of carbon emissions associated with the transport of materials to site. Emissions from transport will depend on:

- the quantity of material to be transported;
- where the material is sourced from (i.e. distance to site); and

- the predominant mode of transport used.

By way of illustrative example, four possible sourcing scenarios for steel were considered. These options are presented in Table 12.

Table 12: Sourcing Options for Steel

Option 1	All steel sourced a distance of **400 km** (approximate distance Edinburgh to Sheffield) from site and transported by **rail** to site
Option 2	All steel sourced a distance of **400 km** from site and transported by **road** to site
Option 3	All steel sourced from **Rotterdam**, the Netherlands, (approximately 730km) and transported by **sea** to site
Option 4	All steel sourced from **China** (approximately 17,000 km), being the furthest producers from site, and transported by **sea** to site

The results are summarised below in Table 13. These calculations are for emissions associated with transport only. Of the three options, Option 3 would result in the lowest amount of CO_2 being emitted, while Option 4 would result in the highest. Choosing option 3 over option 4 would result in a carbon saving of 10,397 tCO_2.

Table 13: Carbon emissions associated with the different sourcing options for steel

Material	Total Mass of Steel Material (tonnes)	Carbon Emissions associated with Transport (tCO_2)			
		Option 1	Option 2	Option 3	Option 4
Steel	90,000	1,148	3,096	466	10,863

Future Opportunities

A number of potential measures have been identified with the aim of reducing embodied energy and carbon associated with construction materials to be used in the scheme. Examples of such measures include:

- using recycled aggregate instead of quarried aggregate – it is estimated that the embodied carbon of recycled aggregate is 54% lower compared to quarried aggregate;
- using an increased proportion of recycled steel – the embodied energy and carbon of steel from secondary sources is significantly lower than that from primary sources. The potential for use of recycled steel is dependent on the required steel specification;
- steel could be sourced from a number of locations and transported to site using different transport options; and
- other sustainability factors also need to be considered in the scheme design and materials planning, such as durability and the life span of products, performance, ability to reuse materials after decommissioning. These issues are addressed within the Sustainable Resource Management Framework (Appendix 5). Section 5 of this report also provides a further discussion of how sustainability has influenced and informed scheme design.

The Contractor will be provided with the relevant data to calculate embodied energy and carbon in their final design. This can then be compared to the calculations presented in Appendix 6 and this should preferably improve on the baseline condition.

4.14.2 Target 2: Minimise energy use and all carbon emissions during construction.

Target Selection

This target was selected to promote the minimisation of energy use and carbon emissions during construction.

Indicators

- Predicted energy requirement and CO_2 emissions.
- Actual energy used and CO_2 emissions.

Appraisal Findings

Predicted energy use and CO_2 emissions during construction have not been estimated for Stage 3 design, since detailed methods of construction are not known at this stage. Once the Contractor develops the detailed design and construction methodology, meaningful figures can be calculated. Actual energy use and CO_2 emissions will be monitored during construction.

Future Opportunities

A number of measures are being considered for incorporation into the design of the scheme aimed at reducing energy consumption and/or carbon emissions during construction. Examples of such measures include:

- installing energy-efficient lighting systems;
- sourcing electricity from renewable/sustainable sources;
- programming of earthworks to minimise 'double-handling' of materials; and
- a 'Green Travel Plan' to be developed by the Contractor for site workers. This will promote sustainable forms of travel (car sharing, public transport etc) for employees travelling to and from site, where practicable.

The Contractor will be required to implement a site energy management plan, demonstrating measures to reduce energy consumption and/or carbon emissions during construction.

4.15 Sustainability Objective 13: To Minimise Carbon Emissions Once the Scheme is Open to Traffic

4.15.1 Target 1: Seek to reduce CO_2 emissions from vehicles crossing the Forth at Queensferry compared with existing FRB

Target Selection

This target recognises the impact of CO_2 emissions from vehicles crossing the Forth and seeks to identify design measures to reduce emissions.

Indicators

- Predicted CO_2 emissions per veh-km.

Appraisal Findings

In terms of emissions of greenhouse gases such as CO_2 associated with the operation of the scheme, the ES (Chapter 15: Air Quality) reports a predicted increase in CO_2 with the proposed scheme in place, due to more vehicle kilometres being travelled. The scheme will increase the length of the majority of cross-Forth journeys by about 1km because the new crossing is slightly further west than the Forth Road Bridge.

The increase in CO_2 emissions produced by the proposed scheme in 2017 is 14,952 tonnes. This figure is derived from strategic modelled traffic data covering the national road network using established Department for Transport methodology. Although small in an overall Scottish context, this increase does not contribute to the requirement in the Climate Change (Scotland) Act 2009 to reduce emissions by 42% by 2020 (interim target) and 80% by 2050. Therefore, the increase in CO_2 as a result of the proposed scheme will require to be offset by greater reductions elsewhere within Scotland.

Further assessment was carried out to more fully capture the localised effect of “stop-start” motoring conditions on the congested approaches to the Forth Road Bridge and the localised benefits to be derived from relieving these conditions (refer to Appendix 6). The assessment involved modelling a local network in the vicinity of the Forth Replacement Crossing using an alternative approach that better takes into account the emissions from such “stop-start” traffic conditions. Initial findings indicate that during the congested morning peak period, increased CO_2 emissions from the additional distance travelled may be mitigated by reduced congestion that the proposed scheme will deliver relative to the situation without the scheme. There is less congestion relief in the evening peak and therefore the mitigating effect referred to above is less evident during this period.

As noted in Appendix 6, the scheme includes a number of features aimed at reducing CO_2 emissions. These include:

- use of Intelligent Transport Systems to improve network efficiency and decrease congestion;
- infrastructure to facilitate modal shift, particularly through the provision of a dedicated public transport corridor on the FRB and associated public transport public transport lanes and public transport links; and
- encouraging and facilitating active modes of transport (e.g. cycling) by minimising impacts on paths and cycle routes and improving these where feasible.

Future Opportunities

There are no future opportunities identified for this target at this time.

4.15.2 Target 2: Minimise the energy requirements of the scheme (once it is open to traffic) to the minimum necessary for safe operation

Target Selection

This target was selected to ensure energy is used efficiently and sustainably during operation of the scheme.

Indicators

- Predicted energy requirements.
- Actual energy requirement.

Appraisal Findings

Energy requirements have been an important factor in the design of the proposed scheme and a number of design measures aimed at reducing energy use have been discussed within the project team. These included the use of energy efficient lighting and ITS equipment.

The predicted operational energy use for the following scheme components in the Stage 3 design is:

- Main Crossing dehumidification system (deck cells, southern approach viaduct and towers): 1,067,625 kWh per year;
- lighting (for road infrastructure including provision for Main Crossing, excluding any saving through dimming): 1,000,196 kWh per year; and
- ITS (based on 65 fully equipped gantries): 1,959,922 kWh per year.

These estimates are based on worst-case assumptions, and therefore present maximum KWh likely to be required. During development and refinement of the detailed design these energy requirements may be reduced.

Actual energy use will be assessed during operation.

Future Opportunities

ITS will be implemented throughout the scheme to improve operational efficiency, reduce vehicle emissions and improve air quality and noise levels through the use of traffic control measures.

The lighting to be installed along the scheme 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.

4.15.3 Target 3: Maximise the percentage of required energy for the scheme (once opened to traffic) acquired from renewable sources

Target Selection

This target reflects the importance of sourcing energy for the scheme in a sustainable way. Using renewable energy has a variety of sustainability benefits, especially in terms of reducing dependence on fossil fuels and lowering overall carbon emissions.

Indicators

- Predicted energy sources.
- Actual energy sources.

Appraisal Findings

The potential for incorporating renewable energy technology into the scheme or sourcing energy from renewables was discussed within the project team and it was agreed to continue to review the potential for renewables during the tender stage.

Future Opportunities

The relevance of the targets in respect of construction are uncertain but will be reviewed during the tender stage to consider any potential, associated with the operation of the scheme.

4.16 Sustainability Objective 14: To protect and enhance the natural heritage including local biodiversity

This objective is achieved through careful alignment and design based on constraints identified in baseline surveys as well as complying with the DMRB (Highways Agency 1993), and following IEEM 2006 EIA guidance. In addition the mitigation design has been agreed with Scottish Natural Heritage (SNH).

There are two targets associated with achieving this objective and performance on each is summarised below.

4.16.1 Target 1: To minimise number of sites designated for natural heritage conservation and protected species affected and significance of any adverse impacts

Target Selection

This target reflects the importance of achieving a design that minimises impacts on natural heritage.

Indicators

- Number and type of sites (e.g. international and local) and protected species impacted and significance of predicted impacts.
- Actual impacts on sites and protected species during construction.

Appraisal Findings

The proposed scheme crosses over land that is of high ecological value, including the Firth of Forth SPA, St. Margaret's Marsh SSSI, and Ferry Hills SSSI. The scheme's design was informed by ecological constraints identified from data collection that included consultation, desk based searches and field surveys. This enabled impacts to natural heritage including woodland, other semi-natural habitats and protected species to be minimised.

The direct and indirect effects of the scheme on sites of European importance have been considered in Reports to Inform Appropriate Assessments for the Firth of Forth SPA, Forth Islands and Imperial Dock Lock, Leith SPAs and the River Teith SAC (Jacobs Arup 2009c, 2009d, 2009e). The conclusions of the reports are that the integrity of the sites would not be affected. The conclusions of the relevant EIA chapters of the ES were also that provided the committed mitigation is robustly implemented there would be no significant effects on local nature conservation and that the scheme provided some opportunities to enhance local biodiversity in the longer term.

There are no predicted residual impacts on the following protected species during construction or operation: badgers; terrestrial wintering and breeding birds; amphibians, reptiles and terrestrial invertebrates.

Table 14 provides a brief summary of residual impacts on protected species and habitats as a result of the proposed scheme. More detailed appraisal findings are available in the ES Chapters 10 (Terrestrial and Freshwater Ecology) and Chapter 11 (Estuarine Ecology).

Table 14: Summary of Residual Impacts on Protected Species and Habitats

Terrestrial Habitats	Significant positive residual impact at Swine Burn Significant positive residual impact at St. Margaret's Marsh (pending further consultation and agreement).
Bats	During construction some significant negative residual impacts of negligible magnitude at Port Edgar Barracks and West of South Queensferry. Significant positive residual impacts of high magnitude are predicted at North and South Queensferry during operation, due to the provision of a third crossing over the Firth of Forth which would facilitate further bat movements between Fife and the Lothians.
Otters	During construction, there would be some significant negative residual impacts of low magnitude at the Swine Burn, Niddry Burn and River Almond. In the long- term these impacts are not considered to be significant.
Freshwater Ecology	Significant positive residual impacts of medium magnitude during operation for all receptors through the inclusion of meanders and bends as part of the Swine Burn realignment, in addition to the provision of riparian planting. Significant positive impact of low magnitude for freshwater fish would remain due to increased cover provided by the new culvert on the Swine Burn and extensions to existing culverts on Swine Burn and Niddry Burn.
Estuarine Ecology	During construction, residual impacts from noise and vibration on estuarine ecology have been assessed as extremely unlikely to occur. IN the event impacts do result they would be of low magnitude. During construction, residual impacts of temporary and permanent benthic habitat loss are certain to occur resulting in a residual impact of low magnitude. During construction, mitigation would reduce the likelihood of a chemical spill during the construction phase and an impact is extremely unlikely to occur. Should a spill occur it may result in a significant residual impact of low magnitude. During operation, the impact of a spillage from a road traffic accident on the Main Crossing on all receptors is extremely unlikely to occur. Should a spill occur it may result in a significant residual impact of low magnitude.

Future Opportunities

A significant positive residual impact of medium magnitude could be achieved through the management of wetland habitats at St. Margaret's Marsh SSSI during operation, pending further consultation and development/agreement of between Transport Scotland and SNH.

4.16.2 Target 2: To protect and enhance biodiversity

Target Selection

This target reflects the importance of achieving a design that conserves and enhances local biodiversity.

Indicators

- Number of watercourses impacted and significance of predicted impacts.
- Actual number of watercourses impacted and significance of impacts.
- Actual impacts on water quality.
- Number of reported roadkills of protected species.
- Percentage area of new habitats compared with areas lost.
- Number of new records of species and habitats of nature conservation value.

Appraisal Findings

A number of design features have been incorporated into the design to protect and enhance biodiversity including semi-natural habitats and protected species. Where possible, the proposed scheme has been designed to avoid important habitats for plants, birds and animals.

There are 10 waterbodies within the study area that would be potentially impacted by the proposed scheme. With mitigation, during both construction and operation, residual impacts on all of these waterbodies would however be reduced to slight or negligible significance. Impacts on water quality would be reduced to negligible for all 10 waterbodies.

The number of roadkills will be monitored during operation.

Some of the land-take for the proposed scheme will encroach upon ecological habitat. Wherever possible, replanting has been incorporated into the scheme design as mitigation to offset habitat lost to the scheme. As a result of the scheme there is predicted to be net gain of 35ha of semi-improved grassland, 19.2ha of plantation mixed woodland, 5.8ha of dense/continuous scrub and less than 1ha of swamp. Habitats which are predicted to experience a net loss are poor semi-improved grassland (4.9ha), plantation broadleaved woodland (3.2ha), semi-natural broadleaved woodland (1.2ha) and scattered scrub (1.1ha).

In addition to planting to reduce and offset potential adverse impacts on ecology, the following mitigation measures are described in the ES:

- translocation of important species;
- provision of replacement badger setts; otter holts and bat boxes;
- use of mammal underpasses and fencing to guide animals to the tunnels;
- integration of mammal ledges in new culverts;
- ensuring that culverts and watercourse realignments are constructed in accordance with best practice guidelines;
- employing an Ecological Clerk of Works to supervise the works;
- sensitive timing of construction activities; and
- the use of acoustic deterrents during key construction periods to deter sensitive marine species from entering the area.

Future Opportunities

A significant positive residual impact of medium magnitude could be achieved through the management of wetland habitats at St. Margaret's Marsh SSSI during operation, pending further consultation and development/agreement between Transport Scotland and SNH.

4.17 Sustainability Objective 15: To protect the landscape, historic environment and cultural heritage

4.17.1 Target 1: develop alignment and design to avoid or minimise impacts on the landscape resource and character, and setting of cultural heritage features

Target Selection

This target was selected in order to promote the minimisation of impacts on landscape and cultural heritage in the scheme design.

Indicators

- Reported significance of residual landscape effects
- Number of and significance of direct and indirect residual effects on cultural heritage sites
- Actual number of and significance of direct and indirect residual effects on archaeological sites and monuments

Appraisal Findings

This objective is achieved through careful alignment design as well as complying with the DMRB and following the relevant landscape and historic environment legislation.

A summary of the appraisal findings of ES Chapter 12 (Landscape) indicate the following:

- north of the Firth of Forth: the Main Crossing and northern route would have significant adverse impacts for the landscape of Ferry Hills and the area of reclaimed coastal flat, which features St. Margaret's Marsh, west of North Queensferry; and
- south of the Firth of Forth: the landscapes of South Queensferry and the farmland of Duddingston, to the west of South Queensferry, would be adversely affected by the Main Crossing and southern connecting roads. Main Crossing impacts are considered adverse in this location owing to the presence of the bridge abutment and approach road structures. The designed wooded landscape of Dundas would also be adversely affected by significant impacts from the proposed scheme. Elsewhere, impacts upon the surrounding landscape would not be significant.

In terms of cultural heritage, there are two sites which are predicted to experience residual direct impacts of moderate significance: Beamer Rock Beacon and Dundas Castle Designed Landscape. Significant residual impacts on setting are predicted for five sites: substantial at St. Margaret's Hope, St. Margaret's Hope Relict Country Estate and Port Edgar Harbour Barrack Complex; and moderate at Ferry Craig, South Queensferry, Inchgarvie House and Inchgarvie House Lodge. All other residual impacts would be of slight or neutral significance, with slight positive impact on the setting of the Forth Road Bridge.

In order to reduce impacts on cultural heritage features and landscape resource and character the following mitigation measures will be put in place:

- building recording prior to construction;
- vibration monitoring of buildings during construction;
- integration of the alignment and earthworks with the surrounding landform;
- formation of new rock cuttings to achieve a natural appearance;
- provision of false cuttings;
- replacement stone walls and noise barriers; and
- planting mixed or scrub woodland, hedges and standard trees to reflect existing boundaries and/or provide screening.

Future Opportunities

It is considered that through careful alignment design development and the mitigation measures described above this target has been met. No future opportunities are identified at this stage.

4.18 Sustainability Objective 16: To reduce noise and air emissions

4.18.1 Target 1: Manage effectively construction noise impacts and reduce and mitigate significant operational noise impacts where practicable

Target Selection

This target was selected in order to promote the reduction and mitigation of impacts associated with construction and operational noise where practicable.

Indicators

- Noise level changes and associated changes in nuisance levels at quantified numbers of dwellings/groups of dwellings within 600m in accordance with DMRB methodology.
- Number of legitimate complaints about noise nuisance.

Appraisal Findings

Construction noise has been assessed as part of the environmental assessment process, with some temporary adverse impacts potentially occurring within the vicinity of the construction compounds. Mitigation has been suggested (where appropriate) to reduce the level of impact from construction activity and a Code of Construction Practice (Jacobs Arup 2009f) has been developed to assist the Contractor in ensuring that disruption during construction is kept to a minimum.

Where operational impacts are likely to result in significant adverse effects, noise barriers have been proposed and noise insulation requirements have been highlighted at qualifying properties in the ES. At some properties, particularly close to the Forth Road Bridge, the proposed scheme will have beneficial changes in noise level.

A noise nuisance analysis was undertaken as part of the noise assessment in Chapter 16 (Noise and Vibration) of the ES. In summary, noise level increases of less than 3dB(A) would affect 2180 fewer dwellings than without the proposed scheme and 990 more dwellings would be subject to increases of greater than 3dB (A). Noise level decreases of less than 3dB(A) would affect 560 more dwellings than without the proposed scheme and 630 more dwellings would be subject to decreases of greater than 3dB (A).

Complaints concerning noise nuisance will be monitored throughout construction and operation.

Future Opportunities

The Code of Construction Practice (Jacobs Arup 2009f) and Employer's Requirements will assist in ensuring that noise and air emission impacts are properly managed.

4.18.2 Target 2: Air quality limit values (absolute concentrations) not to be exceeded (40µg/m^3 for NO_2; 18µg/m^3 for PM_{10}) at selected residential properties and other sensitive receptors

Target Selection

This target aims to minimise the opportunities for air quality limits to be exceeded as a result of the proposed scheme at residential properties and other sensitive receptors for both 2017 and 2032.

Indicators

- Absolute concentrations (µg/m^3) for NO_2 and PM_{10} at selected residential properties and other sensitive receptors.

Appraisal Findings

Sensitive receptors are all located within the local air quality study area, together with representative residential properties within 200m of road links affected by the proposed scheme outside the local study area.

At all residential properties and sensitive receptors, the concentrations of NO_2 and PM_{10},as a result of the proposed scheme, are not predicted to exceed 40µg/m^3 and 18µg/m^3 respectively. The highest values predicted for the receptors assessed within the study area in 2032 (do-something) are 29µg/m^3 for NO_2 and 14.4µg/m^3 for PM_{10}.

The predicted impacts on local air quality as a result of the proposed scheme are generally very small, therefore no mitigation measures are proposed with respect to operational traffic. During construction the Contractor will implement a Dust and Air Quality Management Plan to limit the air pollution from transportation and storage of materials and from construction plant and vehicles.

More detailed appraisal findings are available in the ES Chapter 15 (Air Quality).

Future Opportunities

A dust and air quality monitoring programme for construction activities will be agreed with the local authorities and it will be the Contractor's responsibility to monitor air quality throughout the construction period.

4.18.3 Target 3: Dust deposition to be contained within rate limit values

Target Selection

This target was selected to ensure that dust deposition rates do not exceed limit values at sensitive receptors as a result of the construction of the scheme.

Indicators

- Dust deposition rates during construction that exceed 200mg/m^2/day.
- Dust deposition rates for biological SSSIs that exceed 1000mg/m^2/day.

Appraisal Findings

Dust nuisance is the result of the perception of the soiling of surfaces by excessive rates of dust deposition and is defined as a statutory nuisance by the Environmental Protection Act (1990). Potential nuisance arising from dust is likely to occur at sensitive receptors where deposition rates exceed 200mg/m^2/day and for sensitive plant species at rates of greater than 1000mg/m^2/day (Highways Agency 2007).

As reported in the ES, without mitigation the risk of dust nuisance occurring on receptors up to 200m from the construction of the proposed scheme would be high. This would be due to the location of sensitive receptors in close proximity to the site boundary, and the duration of the works, rather than the level of dust generated from the works. The amount of dust generated from the construction of the proposed scheme is not predicted to exceed 200mg/m^2/day at the construction sites or sensitive receptors.

The Contractor has an obligation under the Environmental Protection Act 1990 to use best practicable means to prevent or counteract the effects of any dust nuisance. The Contractor will prepare and implement a Dust and Air Pollution Management Plan to set out the controls to be implemented to limit dust and air pollution due to the works. Dust mitigation measures as set out in the Code of Construction Practice, ES and Employers Requirements will aid the minimisation of dust nuisance at sensitive receptors. This will generally reduce this risk to medium to low and would occur on a short to medium term basis only for all properties other

than Inchgarvie House where, due to the close proximity to the construction works for the Main Crossing, it is anticipated that the risk of dust nuisance may be higher during certain activities.

Future Opportunities

Site layout of construction compounds (not yet established) can further help to reduce dust arisings at residential receptors.

Dust monitoring results would indicate whether dust mitigation measures are effective and deposition is below the specified rates or whether additional measures are required.

4.19 Sustainability Objective 17: To protect water quality, geomorphology and maximise the use of sustainable drainage systems for environmental and hydrological benefit

4.19.1 Target 1: Limit impacts and significance of residual effects on water quality and pass majority of runoff through SUDS

Target Selection

This target was selected to ensure water quality is not significantly affected as a result of the proposed scheme. This will be achieved by passing the road surface runoff through a series of Sustainable Drainage Systems (SUDS).

Indicators

- Percentage of mainline drainage passing through SUDS.

Appraisal Findings

The different SUDS systems filter out contaminants from the runoff before the runoff enters the nearest watercourse. SEPA generally requires 2-3 levels of SUDs be achieved for new sections of road.

In addition, any increase in pavement area requires the runoff to be controlled so that no additional flooding occurs. This requires detention basins to be designed and constructed which hold the road runoff and then empty over approximately 24hours to control the rate of flow going in the watercourse. Agreement on flooding control is required with the Local Authorities

After consultation with SEPA and subsequent alignment changes to help with the road drainage the vast majority of surface runoff for the trunk roads including motorways passes through SUDs. The only exception to this is the Main Crossing over the Forth. The sections of the crossing that are over land and the intertidal zones will drain back to a SUDs basin on either side of the crossing. The centre section of the crossing will drain directly into the Forth.

The design will result in approximately 80-85% of the drainage from the Trunk Roads including motorways passing through SUDs.

The residual impact significance for all assessed watercourses would be reduced to negligible in terms of water quality.

Future Opportunities

The maintenance contractor will be expected to ensure the efficient operation of the SUDS network.

4.19.2 Target 2: Limit watercourse re-alignments and limit number of watercourse crossings

Target Selection

This target was selected to avoid and reduce impacts on watercourses as a result of the scheme infrastructure where practicable.

Indicators

- Attainment of Controlled Activities Regulation (CAR) Licence.

Appraisal Findings

The new scheme makes use of existing infrastructure where possible, with the result that watercourse crossings and re-alignments have been kept to a minimum.

The southern section of the new scheme is the only part that has any direct effect on watercourse alignments. Initially the alignment of the new northbound slip from the M9 to the M9 Spur required a number of new culverts on the Swine Burn. After discussions between the FRC team, SNH and SEPA the alignment of the slip was altered and a realignment of Swine Burn was proposed to reduce the number of crossings of the Swine Burn. The realignment has resulted in only one new crossing of the Swine Burn and the new culvert has been reduced to approximately 65 metres in length. The realignment has the added benefit of providing a more natural channel for Swine Burn as the current channel (designed to previous standards) is straight and has the appearance of being heavily engineered.

The indicator for target 2 is the attainment of the CAR licence. The licence will require a report to be submitted outlining in detailing the five watercourse crossings, realignments and culvert extensions that are being proposed. In addition plans showing the drainage outfall details will be prepared.

Consultations have been held with SEPA regarding the CAR licence and it is the intention to pursue a CAR licence from the agreement in principle.

Future Opportunities

The base case will be the Stage 3 design. The participating contractor will be expected to meet or improve on this during detailed design.

5 Design Implications and Sustainability

5.1 Introduction

This section summarises the key design ideas and innovations that have been generated by the team during the design stage in order to improve the sustainability of the various structures and earthworks used in the FRC scheme. It addresses these under the headings of:

- Main Crossing; and
- Road Connections (roads, earthworks and land-based structures).

Each are summarised in tabular form and include the design idea, its sustainability benefits and how it is to been taken forward within the project. Ideas that are now standard best practice are left out of these tables but included in Appendix 7. This latter provides an overall summary of the various ideas and innovations and indicates where these generate different benefits within the overall 'sustainability mix'.

In addressing the sustainability objectives, targets and indicators as reviewed in Section 4, there have been a number of sustainability design ideas and innovations brought forward. These have either been incorporated into the Stage 3 design or will be considered at the tender design stage.

5.2 Main Crossing

Table 15: Key Design Ideas and Innovations for the Main Crossing

Design Proposal	Sustainability Objectives contributed to*	Outcome and State of Progress
Wind shielding on Main Crossing will improve reliability	To design, build and operate a reliable crossing (1)	Taken forward through Stage 3 Design / Employer's Requirements
Both carriageways on the Main Crossing will have widened hard shoulders	To design, build and operate a reliable crossing (1)	Taken forward through Stage 3 Design / Employer's Requirements
Dedicated public transport corridor helps public transport services run more reliably	To design, build and operate a reliable crossing (1) To contribute to the improvement of cross-Forth access to economic opportunities (2) To contribute towards the development of cross-Forth public transport opportunities (3) To improve local accessibility and reduce community severance (7) To contribute to the promotion of healthy lifestyle opportunities and social inclusion (9) To minimise carbon emissions once the scheme is opened to traffic (13)	Taken forward through Stage 3 Design / Employer's Requirements
Intelligent Transport Systems (ITS) will help to regulate the flow of traffic	To design, build and operate a reliable crossing (1) To provide a safe design for both vehicle travellers and non-motorised users (10) To minimise carbon emissions once the scheme is open to traffic (13)	Taken forward through Stage 3 Design / Employer's Requirements
Specification of carriageway surfacing to the cable-stayed bridge to reduce the frequency at which resurfacing is required	To design, build and operate a reliable crossing (1) To adopt sustainable resource management in design and construction (5) To reduce, reuse and recycle materials and products where practicable (11)	Options considered at Stage 3 Design. Contractor to choose most practicable option.
Energy-efficient ITS and lighting systems	To minimise carbon emissions once the scheme is opened to traffic (13)	To be considered at Tender Design Stage
Sustainable sourcing of steel	To adopt sustainable resource management in design and construction (5) To reduce, reuse and recycle materials and products where practicable (11) To minimise embodied energy and carbon associated with the construction of the scheme (12)	To be considered at Tender Design Stage

* Sustainability Objective no. in brackets

5.3 Road Connections

5.3.1 Roads and Earthworks

Table 16: Key Design Ideas and Innovations for Roads and Earthworks

Design Proposal	Sustainability Objectives contributed to*	Outcome and State of Progress
Hard shoulder provision on the scheme. The proposed scheme will incorporate hard shoulders on the majority of the scheme	To design, build and operate a reliable crossing (1) To contribute to the improvement of cross-Forth access to economic opportunities (2) To provide a safe design for both vehicle travellers and non-motorised users (10)	Taken forward through Stage 3 Design / Employer's Requirements
New and improved car/bus interchanges to facilitate use of public transport	To design, build and operate a reliable crossing (1) To contribute to the improvement of cross-Forth access to economic opportunities (2) To contribute towards the development of cross-Forth public transport opportunities (3) To improve local accessibility and reduce community severance (7) To contribute to the promotion of healthy lifestyle opportunities and social inclusion (9) To minimise carbon emissions once the scheme is open to traffic (13)	Taken forward through Stage 3 Design / Employer's Requirements
Provision for non-motorised users (NMU paths and crossings at Queensferry Junction and Ferrytoll Junction)	To improve local accessibility (7) To contribute to the promotion of healthy lifestyle opportunities and social inclusion (9)	Taken forward through Stage 3 Design / Employer's Requirements
Ensuring the scheme accommodates the needs of disabled people (DDA 2005)	To contribute to the improvement of cross-Forth access to economic opportunities (2) To provide a scheme that accommodates the needs of disabled people (8)	Taken forward through Stage 3 Design / Employer's Requirements
Optimisation of cut and fill balance to minimise the need to import, or export, fill from site	To adopt sustainable resource management in design and construction (5) To reduce, reuse and recycle materials and products where practicable (11) To minimise embodied energy and carbon associated with key materials and their transport to site (12)	Taken forward through Stage 3 Design / Employer's Requirements

Design Proposal	Sustainability Objectives contributed to*	Outcome and State of Progress
Pass majority of runoff through SUDS	To protect water quality, geomorphology and maximise the use of sustainable drainage systems for environmental and hydrological benefit (17)	Taken forward through Stage 3 Design / Employer's Requirements
Limit number of watercourse crossing and re-alignments by making use of existing infrastructure	To protect water quality, geomorphology and maximise the use of sustainable drainage systems for environmental and hydrological benefit (17)	Taken forward through Stage 3 Design / Employer's Requirements
Sourcing timber products from certified sustainable sources (e.g. FSC)	To adopt sustainable resource management in design and construction (5) To reduce, reuse and recycle materials and products where practicable (11) To minimise embodied energy and carbon associated with key materials and their transport to site (12) To protect and enhance the natural heritage including local biodiversity (14)	To be considered at Tender Design Stage
Use of recycled materials in highway design (including, recycled aggregate, kerbs, plastic pipes)	To adopt sustainable resource management in design and construction (5) To reduce, reuse and recycle materials and products where practicable (11) To minimise embodied energy and carbon associated with key materials and their transport to site (12) To protect and enhance the natural heritage including local biodiversity (14)	To be considered at Tender Design Stage

* Sustainability Objective no. in brackets

5.3.2 Land-based Structures

Table 17: Key Design Ideas and Innovations for Land-Based Structures

Design Proposal	Sustainability Objectives contributed to*	Outcome and State of Progress
Retain and re-use existing structures where possible	To reduce, reuse and recycle materials and products where practicable (11) To provide a safe design for both vehicle travellers and non-motorised users (10) To minimise embodied energy and carbon associated with key materials and their transport to site (12) To reduce noise and air emissions (16)	Taken forward to Stage 3 Design and to be utilised at: M9 Junction 1A Overton Road Bridge Newmains Road Bridge Existing Ferrytoll railway bridges

Design Proposal	Sustainability Objectives contributed to*	Outcome and State of Progress
To accept non-toxic products for concrete impregnation	To adopt sustainable resource management in design and construction (5) To protect and enhance the natural heritage including local biodiversity (14) To protect water quality, geomorphology and maximise the use of sustainable drainage systems for environmental and hydrological benefit (17)	This is not a mandatory contract requirement. The Contractor could consider this design proposal for the detailed design.
Lightweight fills for abutments / wingwalls etc	To adopt sustainable resource management in design and construction (5) To reduce, reuse and recycle materials and products where practicable (11) To minimise embodied energy and carbon associated with key materials and their transport to site (12)	This could not be included at Stage 3 design. The Contractor could consider this design proposal for the detailed design.
Stainless steel reinforcement in areas of high exposure (piers / parapet edge beams) to reduce future maintenance	To adopt sustainable resource management in design and construction (5) To reduce, reuse and recycle materials and products where practicable (11)	This could not be included at Stage 3 design. The Contractor could consider this design proposal for the detailed design.
Greater use of voided concrete construction to reduce materials (Cobiaxdeck, voided abutments)	To adopt sustainable resource management in design and construction (5) To reduce, reuse and recycle materials and products where practicable (11) To minimise embodied energy and carbon associated with key materials and their transport to site (12)	This could not be included at Stage 3 design. The Contractor could consider this design proposal for the detailed design.
Precast Technologies – Precast foundations, columns crossheads, beams and deck	To adopt sustainable resource management in design and construction (5) To reduce, reuse and recycle materials and products where practicable (11) To minimise embodied energy and carbon associated with key materials and their transport to site (12)	This could not be included at Stage 3 design. The Contractor could consider this design proposal for the detailed design.
Compressive membrane action to reduce reinforcement in deck slabs	To adopt sustainable resource management in design and construction (5) To reduce, reuse and recycle materials and products where practicable (11) To minimise embodied energy and carbon associated with key materials and their transport to site (12)	This could not be included at Stage 3 design. The Contractor could consider this design proposal for the detailed design.

Design Proposal	Sustainability Objectives contributed to*	Outcome and State of Progress
Use of non-chemical de-icing or non-salt de-icing products	To adopt sustainable resource management in design and construction (5) To protect and enhance the natural heritage including local biodiversity (14) To protect water quality, geomorphology and ecology (17)	This is not a mandatory contract requirement. The maintaining authority could consider this proposal.
Flexi-arch for culverts and/or pipeline structures	To adopt sustainable resource management in design and construction (5) To provide a safe design for both vehicle travellers and non-motorised users (10)	Not taken forward on major utility structures due to cover requirements from crown of structure. Flexi arch was not applied to a new culvert (Swine Burn) due to flood water flow conditions and also the need to form a low flow channel through the culvert.
Self compacting concrete	To minimise embodied energy and carbon associated with key materials and their transport to site (12)	Not to be taken forward
Over widening bridges for future lane provision	To contribute towards the development of cross-Forth public transport opportunities (3)	Incorporated for A8000 overbridge and for hard shoulders on the main crossing, in both cases to facilitate future public transport opportunities.
T-headed reinforcement – Reduce anchorage length of rebar (Departure required)	To adopt sustainable resource management in design and construction (5) To reduce, reuse and recycle materials and products where practicable (11) To minimise embodied energy and carbon associated with key materials and their transport to site (12)	Not covered by current British Standards or included in future Eurocodes. Design has not been implemented on highway bridges and therefore no evidence of its structural performance.
Lightweight concrete to reduce loading and member sizes	To adopt sustainable resource management in design and construction (5) To reduce, reuse and recycle materials and products where practicable (11) To minimise embodied energy and carbon associated with key materials and their transport to site (12)	The Client has specific concrete mix requirements to achieve the necessary strength as well as provide durable concrete structures and lightweight concrete would not comply.
Intelligent monitoring for structures	To provide a safe design for both vehicle travellers and non-motorised users (10)	Not taken forward due to cost and uncertainty of effectiveness. Current bridge maintenance regime is considered sufficient for monitoring the condition of structures.

* Sustainability Objective no. in brackets

5.4 Moving Forward to Construction

A number of the ideas and innovations that relate to the sustainability objectives with an 'environmental' focus have been generated during the EIA process and feature as identified mitigation measures. These will be contract requirements.

Other design ideas and innovations have already been incorporated into the Stage 3 design particularly those that have been identified as 'best practice'.

A key output from the carbon footprinting work has been the development of a carbon calculator and baseline footprint for the Stage 3 design. This will be made available to the successful contractor who will be expected to deliver 'no worse' and preferably an improvement on the baseline carbon footprint.

The targets and requirements set out in the Sustainable Resource Management Framework and its associated Materials Plan will be included in the Contract.

It is intended that the ethos of sustainability will be a requirement of the Contract and the tenderers and the successful Contractor will be expected to join with the FRC team and work as a team to delivery sustainable benefit of the project.

6 Future Sustainability Monitoring

6.1 Introduction

Targets and indicators have been identified (refer to Appendix 2) to enable monitoring of the performance of the project and its ability to meet the sustainability objectives.

6.2 Construction Monitoring

6.2.1 Design Monitoring

Monitoring during the Contractor's design development is likely to include the following:

- design for energy efficiency;
- design for on-site renewables (if any) and for carbon reduction;
- design for transportation and accessibility;
- water efficiency during construction; and
- low environmental impact materials.

The above measures would support the Sustainable Development Policy for the Project, the sustainability objectives and sustainability in general. Further information is presented in the Sustainable Resource Management Framework and the Materials Plan in Appendix 5. This plan, as translated into the Employers Requirements will be used by Transport Scotland's FRC Sustainability Team to monitor the progress towards achieving the project sustainability objectives. It will also form part of the basis for evidence gathering for CEEQUAL (refer to Section 7) and also for both the construction and operational monitoring, and should be used by the Contractor during development of the Environmental Management Plan (EMP).

6.2.2 Procurement Stage and Construction Monitoring

The following monitoring of procurement and construction activities is likely to be considered:

- the selection of the tenderers based on criteria which will include a review of their sustainability and carbon management credentials;
- the construction Contractor will develop an EMP, for the construction phase of the project, as suggested above. By incorporating the information within this Sustainability Appraisal and Carbon Management Report (including the Energy and Carbon Report (Appendix 6) and the Sustainable Resource Management Framework, see Appendix 5), the EMP should aim to minimise and manage potential environmental and sustainability effects of the scheme; and
- the construction Contractor's activities on-site will be monitored by Transport Scotland to ensure the environmental and sustainability requirements of the EMP are delivered appropriately on-site.

The above measures would support the Sustainable Development Policy, sustainability framework objectives and sustainability best practice in general.

6.3 Operational Monitoring

The following monitoring of the operation of the FRC Scheme may be considered in order to check performance against the sustainability objectives and ultimately the delivery of the FRC Sustainable Development Policy.

Scheme reliability:

- actual number of planned closures;
- actual number of unplanned (non-weather) closures; and
- actual number of closures to any class of vehicle due to adverse weather conditions.

Journey time reliability:
- average time lost per vehicle kilometre.

Improved Public Transport:
- provision of cross-Forth infrastructure to facilitate multi-modal transport.

Safety:
- actual accident rates.

Carbon emissions:
- actual energy requirement;
- actual energy used and CO_2 emissions; and
- actual sources of energy for the scheme.

Biodiversity:
- number of reported roadkills of protected species; and
- number of new records of species and habitats of nature conservation value.

Landscape:
- reported significance of residual landscape effects.

Historic Environment:
- actual number of and significance of direct and indirect residual effects on archaeological sites and monuments.

Air Quality:
- absolute concentrations ($\mu g/m^3$) for NO_2 and PM_{10} at selected residential properties and other sensitive receptors.

Water
- actual number of watercourses impacted and significance of impacts;
- actual impacts on water quality; and
- percentage of mainline drainage passing through SUDS.

7 Sustainability and the Civil Engineering Environmental Quality Assessment and Awards Scheme (CEEQUAL)

CEEQUAL is an assessment and award scheme that measures and seeks to improve the environmental performance of civil engineering projects through a series of questions and evidence gathering. It can apply across the life-cycle of the project to cover design as well as construction and delivery. Recent updates of the CEEQUAL scheme have increasingly embraced the sustainable development agenda and there are detailed sections that now cover resource and materials use, carbon management, stakeholder engagement and relations with local communities.

Transport Scotland has decided that the CEEQUAL would provide a useful tool for assessing the environmental and sustainability performance of the FRC Project as it is based on a management systems approach that includes:

- evidence gathering;
- auditing; and
- certification.

The undertaking of a CEEQUAL audit is expected help to provide a systematic and coherent approach to tracking the management activities and associated sustainability effects of the FRC Project, within the overall framework of best sustainability practice. It will also help to cover areas not routinely covered by the EIA process such as energy and carbon assessment.

A CEEQUAL award publicly recognises the achievement of high environmental and sustainability performance. Awards are made to projects in which the clients, designers and contractors go beyond the legal and environmental minima to achieve distinctive environmental and sustainability standards of performance.

Undertaking a CEEQUAL assessment will evaluate the benefit of the environmental and sustainability assessments that have been undertaken since the start of the project.

The successful contractor will be expected to join with the FRC team to build on the initial results achieved during the design and preparation stages.

8 Conclusions

A framework approach has been adopted for evaluating the performance of the FRC proposals against the goals of the Sustainable Development Policy. Under the three headings of economic, social and environmental issues, 17 sustainability objectives were identified in the Sustainability Appraisal Framework (refer to Appendix 2) for the FRC. This report has presented the progress achieved against the FRC sustainability objectives for the Stage 3 design (refer to Appendix 3).

Opportunities for future design innovations and measurement have also been identified for future progress to be made against the targets within the suite of sustainability objectives (refer to Section 5, Tables 15 to 17).

A framework for delivering sustainable resource management has been produced (refer to Appendix 5) together with a materials plan and these have been developed in order to ensure that the scheme:

- uses materials wisely (through recovery, reuse and recycling);
- sources materials responsibly; and
- reduces its carbon footprint where practicable.

An approach to carbon management has been developed and a carbon footprint at Stage 3 design has been calculated (refer to Appendix 6). This will be used as a basis for measuring and monitoring the footprint as the scheme progresses and will act as a guide to adopting design strategies for reducing carbon emissions where practicable.

Through the use of indicators and monitoring targets (refer to Section 6), the sustainability and carbon management objectives for the FRC can be progressed throughout the life cycle of the scheme.

It is anticipated that the work undertaken to develop and achieve this Sustainability Appraisal and Carbon Management Report will aid the wider Transport Scotland project assessment process in the future.