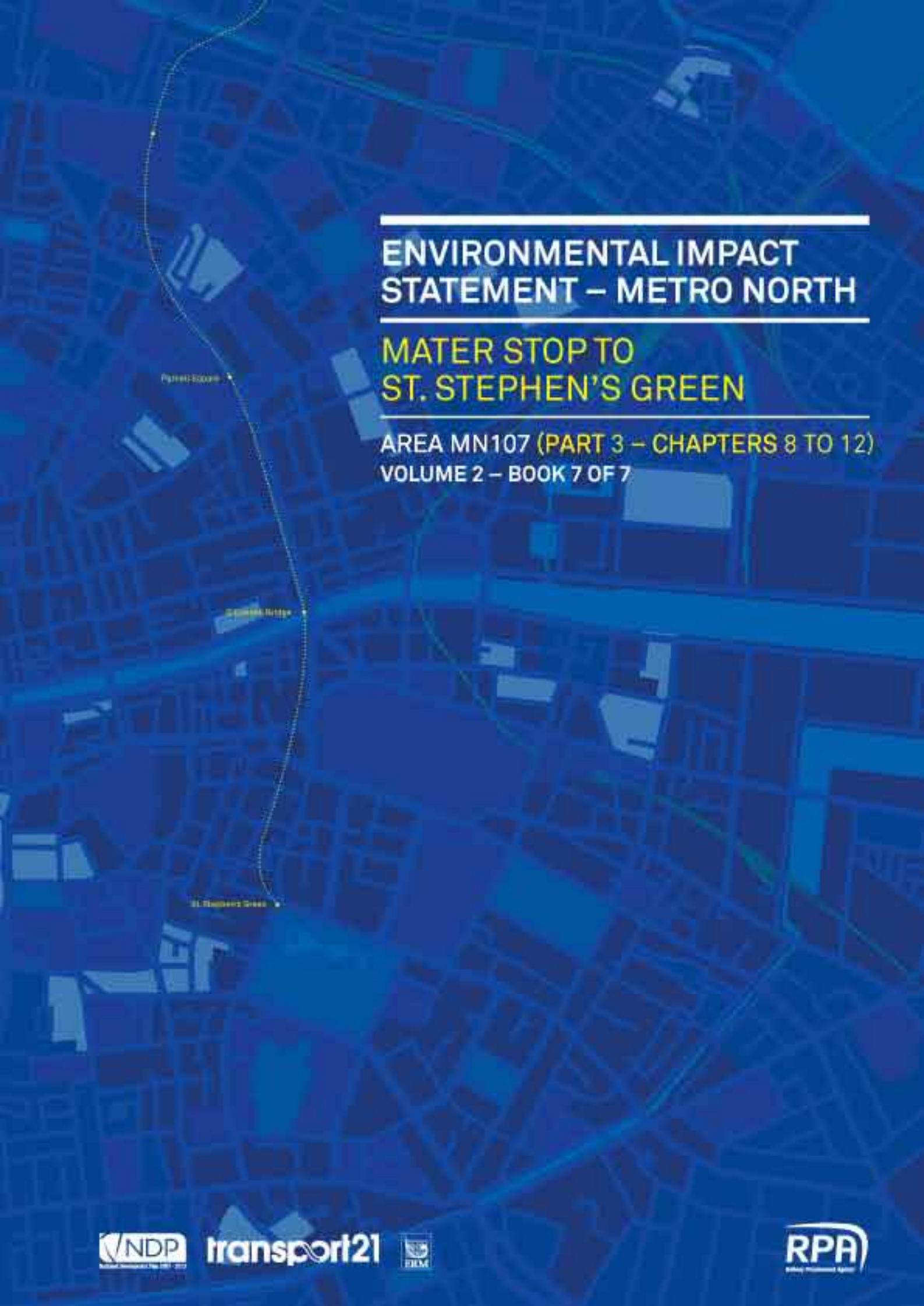


ENVIRONMENTAL IMPACT STATEMENT – METRO NORTH

MATER STOP TO ST. STEPHEN'S GREEN

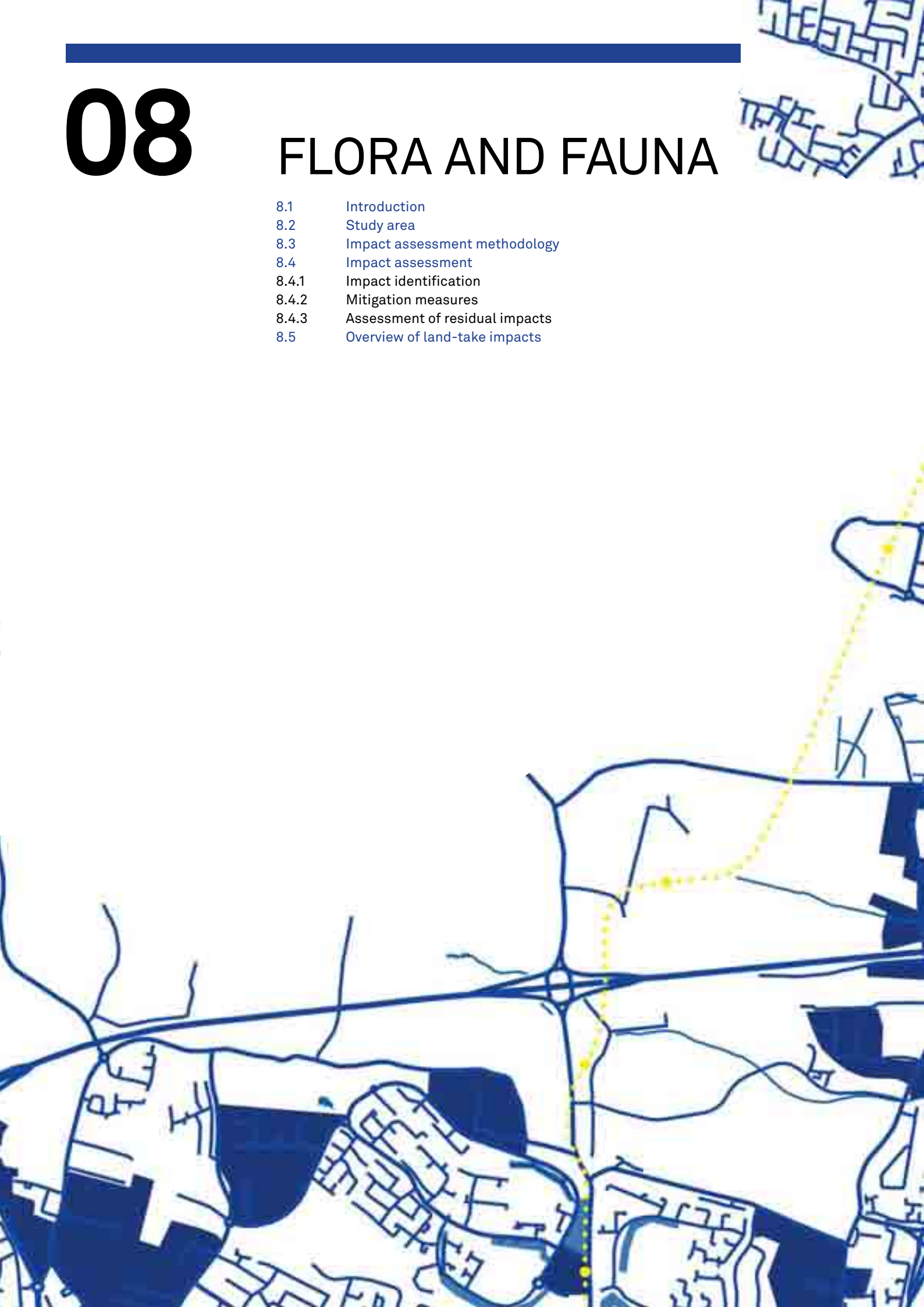
AREA MN107 (PART 3 – CHAPTERS 8 TO 12)

VOLUME 2 – BOOK 7 OF 7

NDP transport21 RPA

08 FLORA AND FAUNA

8.1 Introduction
8.2 Study area
8.3 Impact assessment methodology
8.4 Impact assessment
8.4.1 Impact identification
8.4.2 Mitigation measures
8.4.3 Assessment of residual impacts
8.5 Overview of land-take impacts



This chapter of the EIS describes the potential impacts on flora and fauna, which may arise due to activities associated with the construction and operation of the proposed scheme in Area MN107.

8.1 INTRODUCTION

This chapter describes the potential impacts on flora and fauna, which may arise due to activities associated with the construction and operation of the proposed scheme in Area MN107.

8.2 STUDY AREA

The study area comprises any area within 500m of the centre line of the proposed alignment. This study area extends to up to 1km from the proposed alignment if species or habitats of particular interest are found to occur. The study area for designated sites comprises all areas within 10km of the central line of the proposed alignment. Within this study area, a number of individual detailed faunal surveys have been carried out and the extent of the study area for each of these detailed species surveys is primarily influenced by species mobility. The study area for individual aspects of this environmental topic as set out in Table 8.1.

Table 8.1 Study area

Environmental aspect	Habitats to be surveyed	Width of study area (on both sides of the alignment)
Designated Sites*	Special Areas of Conservation (SAC), Special Protection Areas (SPA), Natural Heritage Areas (NHA), Nature Reserves, Ramsar Sites, National Parks, Refuge for Fauna	10km
Badger	Woodland habitats and hedgerows	500m
Otter	Rivers and streams in the area of above ground sections of the proposed alignment	500m
Bats	Man-made structures (buildings, bridges and culverts) and aquatic habitats including rivers, streams and still water habitats associated with hedgerows, scrub woodlands etc.	500m
Birds	Suitable habitats for birds as identified during the Phase 1 Habitat Survey. Specific survey to record flight heights of wintering birds in the area of the Broad Meadow Swords SPA	500m
Amphibians	Specific aquatic habitats identified during the Phase I Habitat Survey as having a high potential to provide amphibian habitat e.g. lakes, ponds, rivers	500m
Habitats Phase I	All accessible habitats	500m

* Designated sites comprise those designated under national legislation or EU directives and other international conventions.

The majority of the habitat complexes in Area MN107 are of low local value reflecting the fact that this section of the proposed alignment is located within the urban part of Dublin's city centre. The River Liffey and St. Stephen's Green lie within Area MN107 and both are of high local value, especially the River Liffey which supports salmonids and runs into Dublin Bay, an area which supports several European sites designated for their nature conservation importance. St. Stephen's Green is one of the few large areas of green open space in the City of Dublin and is extensively used by the public for recreational and social purposes. It is also of high local value as it supports small numbers of foraging bat species.

8.3 IMPACT ASSESSMENT METHODOLOGY

The impact assessment methodology is described in Section 8.3 and the potential impacts are described in Section 8.4.1. Mitigation measures to be implemented are listed in Section 8.4.2. These measures are designed to reduce the adverse impacts that are deemed to be significant at a given geographical level. The residual impacts are reported in Section 8.4.3.

The potential for ecological and nature conservation impacts has been assessed in the light of the habitats and species that are likely to be affected by the proposed scheme taking into account the latest 'Guidelines for Ecological Impact Assessment in the United Kingdom' published by the Institute of Ecology and Environmental Management (IEEM, 2006), the 'Guidelines for the Assessment of Ecological Impacts of National Road Schemes' (National Roads Authority, 2006) and the relevant EPA guidance with respect to EISs (EPA, 2002, 2003).

As part of the assessment the significance of potential ecological impacts has been evaluated taking into account the following factors:

- The magnitude of both, positive and negative effects, as determined by intensity, frequency and by the effect extent in space and time;
- The vulnerability of the habitat or species to the changes likely to arise from the proposed scheme;
- The ability of the habitat, species or ecosystem to recover, considering both fragility and resilience;
- The viability of component ecological elements and the integrity of ecosystem function, processes and favourable condition;
- Value within a defined geographic frame of reference (national, regional or district);

- The biodiversity value of affected species, populations, communities, habitats and ecosystems, considering aspects such as rarity, distinct sub-populations of a species, habitat diversity and connectivity, species-rich assemblages, and species distribution and extent;
- Designated site and protected species status, and Priority Biodiversity Action Plan (BAP) or Habitat Action Plan (HAP) status.

Significance is determined through consideration of these criteria. The value of the affected feature is used to determine the geographical scale at which the impact is significant (e.g. international, national, regional and local levels). The determination of significance is based on whether the impact will affect the integrity or conservation status of the species, habitat, site or ecosystem within a given geographical frame of reference. Residual impacts are considered to be either significant or insignificant (and negative or positive), after taking into account the zone of influence, mitigation measures and the confidence in predictions associated with the assessment.

8.4 IMPACT ASSESSMENT

8.4.1 Impact identification

Potential sources and types of impact are set out in Table 8.2.

Table 8.2 Sources and types of impact

Impact source	Impact type
Construction	
Temporary land-take - Construction compounds - Working areas along track bed - Cut and cover tunnels	- Permanent loss of habitat or species - Temporary loss of habitats or species - Fragmentation of habitat or severance of wildlife corridors between isolated habitats of ecological importance - Creation of barriers to the movements of animals, especially mammals, amphibians and plants with limited powers of dispersal - Impacts on designated sites.
Construction activities (e.g. runoff and other pollution, increase of suspended solids, alteration of hydraulic conditions, noise and dust emissions, lighting, movement of vehicles, presence of construction personnel)	- Damage or alteration to adjacent habitats - Disturbance to species in the vicinity of the scheme - Impacts on designated sites - Introduction of invasive species
Operation	
Permanent land-take (e.g. stops, track bed, substations, ventilation shafts, ancillary roads, tunnel portals, watercourse crossings (bridges and culverts) , overhead wires, catenary system and supporting structures and elevated structures	- Permanent loss of habitat or species - Permanent alterations to existing habitats - Fragmentation of habitat or severance of wildlife corridors between isolated habitats of ecological importance - Creation of barriers to the movements of animals, especially mammals, amphibians and plants with limited powers of dispersal - Impacts on designated sites - Creation of new habitats as a result of reinstatement works, habitat enhancement proposals and landscaping
Operation of rolling stock and maintenance of the track (e.g. runoff and other pollution, increase of suspended solids, noise and dust emissions, lighting, movement of vehicles, presence of maintenance personnel)	- Disturbance to species in the vicinity of the proposed scheme - Animal collisions - Impacts on designated sites

8.4.2 Mitigation measures

The mitigation measures necessary to avoid or reduce the significance of any adverse impacts on flora and fauna are outlined in this section. Detailed information regarding mitigation measures specific to this area are outlined in this section. These measures are over and above those already incorporated into the scheme design, which has for example sought to avoid sensitive habitats by using existing bridges over watercourses (e.g. across the Broad Meadow River).

- Habitat loss will be limited to the minimum needed for safe implementation of the works. Implementation of best practices will ensure that the risk of disturbance or damage to adjacent habitats is minimised.
    - The 'Guidelines for the Protection and Preservation of Trees, Hedgerows and Scrub prior to, during and post Construction of National Road Schemes' (NRA) will be followed in areas where these habitats will be impacted upon or are in close proximity to the scheme. Where possible, linear habitats such as hedgerows and tree lines will be crossed at right angles, utilising any existing gaps, to reduce the extent of habitat loss.
- Where new access roads are required, they will be situated in a position that utilises existing gaps in hedgerows/trees wherever possible to minimise tree loss and hedgerow removal.
- Where ditches are to be affected by works, measures will be implemented to ensure a regular water flow is maintained.
- Prior to excavation work, topsoil will be stripped and stored separately from subsoil and reinstated in the same order on completion of the works. Topsoil from any habitats of nature conservation value will be stored separately from topsoil removed from other areas.
- Stockpiled sand, gravel and soil will be placed in areas of low conservation value, kept to minimum size, situated well away from all watercourses and covered or seeded where appropriate.
- Sustainable Urban Drainage Solutions (SUDs) are to be incorporated into the design of all storm control areas, using best practice standards as detailed in the Surface Water chapter of this EIS (Volume 2, Chapter 11).
- Best site management practices will be adopted during construction to minimise the risk of secondary impacts on adjacent habitats. Such practices include fencing to clearly mark boundaries and prevent accidental entrance into adjacent habitats, drainage systems designed to prevent water pollution and dust suppression to avoid dust dispersion. Further information is provided in the Surface Water and Air and Climatic Factors chapters of this EIS (Volume 2, Chapters 11 and 12 respectively).
- Measures will be put in place to avoid the pollution of waters during the construction and operation of the scheme, including following CIRIA guidance (Masters et al., 2001) on the control of water pollution from construction sites as detailed in the Surface Water chapter of this EIS (Volume 2, Chapter 11).
- Measures will be taken to avoid the spread of invasive species (including Japanese knotweed (*Fallopia japonica*), and giant hogweed (*Heracleum mantegazzianum*) during construction work (e.g. using appropriate control methods if species are noted), managing plant movement (e.g. wheel washing) and managing the use of imported soil (e.g. not using soil from areas where invasive species known to be present).
- Where habitats are directly lost as a result of the proposed scheme, new alternative habitats will be created where feasible. Temporary works areas will be restored as soon as is reasonably practicable. Progressive restoration will occur along the route. Where areas of land become isolated due to severance and fragmentation, opportunities will be taken to create new habitat as part of the landscape strategy.
- Mitigation planting will be undertaken using predominantly native species typical of the area, obtained from local sources wherever possible and planted in order to emulate the surrounding natural vegetation. The details of tree planting, species mixes and habitat creation will be established by a professional landscape architect with the project ecologist at the detailed design stage of the project, in consultation with NPWS.
- Tree loss during construction and operation of the scheme will be compensated for by tree planting along the alignment as detailed in the Landscape and Visual chapter of this EIS (Volume 2, Chapter 13).
- Where attenuation ponds are created, their restoration upon completion of the construction works will include features to enhance biodiversity in the longer term (e.g. scalloped edges, variation in water depths, marginal habitats and aquatic plant species).
- Mitigation which will be implemented will take account of relevant guidance including for badgers (NRA, 2006), bats (NRA, 2006) and otters (NRA, 2006) and will be agreed with NPWS It will ensure that appropriate pre-construction surveys are undertaken for protected species, that works are undertaken at appropriate times of the year, pathways and foraging routes are maintained including through the sue of tall trees for bats, breeding sites protected and animals are not disturbed or excluded/translocated (unless under licence). Alternative breeding sites (e.g. bat boxes, bird boxes) will be provided in areas where nest and roost sites are lost.

- Vegetation clearance will take place outside the breeding bird season (1 March to 31 August inclusive) in order to avoid the risk of disturbing breeding birds (which is an offence under the Wildlife Act, 1976 (as amended). If work has to be undertaken within the breeding bird season, buildings and trees, scrub and other vegetation will be checked for nesting birds before removal using methods agreed with NPWS.
- Measures will be taken to ensure that all construction areas are made safe and do not pose a threat to mobile and inquisitive species such as badgers (e.g. planks will be placed across any identified pathways in excavated areas and in trenches to allow escape for any animals which may fall in, and exposed pipe systems will be covered).
- The contractor will develop best practice construction procedures and method statements in consultation with the Eastern Regional Fisheries Board (ERFB) prior to the commencement of in-stream construction activities. In-stream works will be undertaken in accordance with the advice set out in the guidelines of the NRA, ERFB and/or Department of Communications, Marine and Natural Resources. No works will be undertaken in salmonid rivers during the annual closed season of 1st October to 30th April inclusive or where amphibians are present in waterbodies during their breeding season. Any requirements specified by the Office of Public Works (OPW), ERFB or NPWS will be adhered to by the contractor.
- Culverts will be designed to allow the safe passage of wildlife, including fish and otter, in accordance with the NRA and ERFB best practice guidance referenced previously.
- Construction/security/scheme lighting will be kept to a minimum and directed away from sensitive receptors (e.g. badger setts, otter holts, bat foraging habitats). All light will be directed downwards and the height of the light columns will be as low as possible, taking safety and visibility requirements into account. Low pressure sodium lighting will be used where possible as these lights have been shown to attract the lowest numbers of prey insects which attract feeding bats. Construction compounds will not be illuminated at night when working has ceased to avoid impacts to bats.
- Night time lighting at construction compounds will be restricted to the minimum necessary for safety purposes, to reduce the risk of disturbance impacts on bats and otters.
- 'Safe-hop-over' features will be incorporated into the design of new bridges where flight paths of important bird species could potentially be affected. Tall trees will also be included in the landscaping planting to encourage important bird species to fly over the LMVs.
- Works associated with the strengthening of the existing bridges and the construction of new bridges will commence after sunrise and finish before sunset in order to avoid disturbance impacts on otters.
- The methods used for applying herbicides to control plant growth on the tracks will ensure that it does not result in adverse impacts on adjacent habitats. The type of herbicides used will also be ones which do not have adverse effects on wildlife in the surrounding areas. The types and methods of application will be agreed with OPW, NPWS and ERFB.
- Best construction practices will be implemented to ensure that noise and air pollution (such as dust) is kept to a minimum to reduce impacts on adjacent flora and fauna. Further information in this regard is provided in the Noise and Air and Climatic Factors chapters of this EIS (Volume 2, Chapters 4 and 12 respectively).
- Trees that are lost will be replaced where possible using a mixture of native species, of local provenance and typical of the local area and ornamental species.
- Monitoring will be undertaken to confirm the effectiveness of mitigation measures during construction.

8.4.3 Assessment of residual impacts

8.4.3.1 Project scenario: construction phase

Construction impacts on designated sites
The proposed construction works in Area MN107 will not affect any designated sites.

The assessment for MN107 has given particular consideration to the likelihood of significant effects on European sites of nature conservation importance downstream from the construction works in and around the River Liffey in the centre of Dublin. Provided that the mitigation measures to prevent pollution and avoid changes to natural drainage conditions are adopted, successfully implemented and monitored on-the-ground, then the proposed scheme will not adversely affect the integrity of these European sites (see Annex D, Volume 3, Book 2 of 2).

Construction impacts on habitats
The majority of the alignment in Area MN107 is in tunnel and will not affect above ground habitats or the species that they support. There are three construction compounds and stops in this area, at Parnell Square, O'Connell Bridge and in St. Stephen's Green. A temporary Bailey Bridge and construction platform is also to be constructed over the River Liffey to facilitate traffic diversions during the construction phase. This will result in the temporary loss of small areas of river bed habitat.

The following habitat types will be affected by the proposed scheme:

- Freshwater habitats
    - Other artificial lakes and ponds (FL8);
- Scattered trees and parkland (WD5);
- Buildings and artificial surfaces (BL3);
- Tidal rivers (CW2).

Freshwater
The western pond in St. Stephen's Green will be temporarily lost as a result of the creation of the construction compound in this area. Both the ponds are artificial, man-made habitats and contain common aquatic plant species such as common duckweed (*Lemna minor*). The temporary loss of this habitat is not considered to be significant.

Scattered trees and parkland
The creation of Construction Compound 19 (St. Stephen's Green) will result in temporary land-take of an area of 1.9ha in the north west of the park. The construction period is expected to last for approximately four years. A number of trees will be lost including mature and over mature horse chestnut (*Aesculus hippocastanum*), oriental plane (*Platanus orientalis*), willow (*Salix* sp.) and holm oak (*Quercus ilex*). These trees are all either common species or ornamental species. New trees, including semi-mature specimens, will be planted in the affected areas on completion of the works. For further information in this regard, please refer to the Landscape and Visual Chapter of this EIS (Volume 2, Chapter 13). Ornamental species are of little nature conservation value. The loss of these trees will not affect the long-term distribution and abundance of the species nor their favourable conservation status.

The trees in St. Stephen's Green do however provide foraging habitat for bats. Impacts on faunal species in this regard are described later in this section.

There will also be some temporary tree loss for the construction compounds at Parnell Square and O'Connell Street. This results in the loss of 18 semi-mature plane trees (*Platanus* sp.) and mountain ash trees (*Sorbus* sp.) from the central reservation of O'Connell Street, and three mature/over-mature trees comprising ash (*Fraxinus excelsior*) and cherry (*Prunus* sp.) from Parnell Square. Plane trees are non-native ornamental species that are planted for aesthetic reasons and have little wildlife value. Their loss will not result in significant ecological impacts. They will be replaced by new tree species which are appropriate for the urban location. These trees will be replaced with new trees on completion of the works but these trees will take a number of years to mature. Overall the loss of trees at Parnell Square and O'Connell Street will not be significant from an ecological perspective.

Buildings and artificial surfaces
The areas affected at Parnell Square and around the O'Connell Bridge Construction site are within existing road corridors and largely affect areas of existing hardstanding. No significant ecological impacts will occur as a result of such areas.

Tidal rivers
The proposed scheme does involve in-river works for the Bailey Bridge and the construction deck over the River Liffey. The temporary loss of a small area of seedbed habitat is not predicted to be significant. Measures will be implemented to ensure that work at the O'Connell Bridge construction compound does not result in pollution of the River Liffey, which supports salmonid fish and runs into several European designated sites of nature conservation importance as described in the Baseline Flora and Fauna chapter of this EIS (Volume 1, Chapter 16). These measures are described in Section 8.4.2 and set out in in the Surface Water Chapter of this EIS (Volume 2, Chapter 11) and Annex D (Volume 3, Book 2 of 2) which contains information to support the Habitats Regulations Assessment.

Construction impacts on species

Bats
The surveys in St. Stephen's Green between June and August 2008 found, that the habitats in the park support only small numbers of foraging bat species, including common pipistrelle (*Pipistrellus pipistrellus*), soprano pipistrelle (*Pipistrellus pygmaeus*) and Leisler's bat (*Nyctalus leisleri*). Existing levels of disturbance around the margins of St. Stephen's Green are high because of the presence of existing lighting in the area surrounding the Green (but not within it), high levels of recreation within the park during the daytime and high levels of noise in the surrounding area. Much of the construction work will be undertaken during the daylight hours when bats are not active in the park. So whilst the presence of a construction compound is likely to result in an increase in noise levels, significant disturbance impacts on bat species are unlikely. Measures will also be taken to minimise the spillage of construction lighting into adjacent areas of the park. Low sodium lighting will be used where possible to minimise the attraction of insects and thus bats. Significant impacts to bat species using St. Stephen's Green are therefore, not predicted (see also Annex D, Volume 3, Book 2 of 2).

Birds
The construction works will result in disturbance of bird species over a period of approximately four years and nine months. Bird species in the area are dominated by a range of common species. These bird species within St. Stephen's Green are accustomed to a degree of noise and disturbance by people as St. Stephen's Green is regularly used by the public for recreational purposes, and there is considerable lighting in the surrounding area. The parkland habitats (medium functional value) which support them will be recreated once the construction works have been completed, although the trees will take time to mature.

Mitigation measures such as hoarding will be implemented to reduce the risk of additional dust emissions, lighting and disturbance by the construction activities. More information is provided in this regard in the Noise, Air and Climatic Factors and the Landscape and Visual Chapter of this EIS (Volume 2, Chapters 4, 12 and 13). Prior to the removal of the western pond, water will be drawn down outside the period 1st March to 31 August (i.e. outside the breeding bird season). Alternative nesting sites will be provided, if necessary, in the vicinity of the eastern pond which is to remain. Any fish species in the western pond will be collected and released into a suitable waterbody in agreement with NPWS and ERFB. The scheme will not affect the long-term abundance or distribution of these fauna species. Hence the favourable conservation status of these species will not be affected and no significant impacts will result.

Aquatic species

Any fish species in the western pond will be collected and released into an appropriate waterbody. The methods for collection and release, timing of this work, and release location, will be agreed in advance with relevant authorities such as the OPW. The western pond will be re-instated on completion of the works and incorporate features agreed with relevant authorities such as the NPWS to enhance its biodiversity value, for example scalloped edges, marginal and submerged vegetation, islands.The scheme will not affect the long-term abundance or distribution of aquatic species. Hence the favourable conservation status of these species will not be affected and no significant impacts will result. The introduction of the temporary Bailey bridge and the working deck will not have a significant impact on fish species using the River Liffey. The piers are aligned with those of the existing bridge, the loss of habitat will be small and any sediment generated will be dispersed quickly due to the transient nature of the watercourse.

8.4.3.2 Project scenario: operational phase

Operation impacts on designated sites

Once the scheme is operational, there will be no significant impacts on designated sites in this area

Operation impacts on habitats

Once the scheme is operational, there will be no significant impacts on habitats in this area

Operation impacts on species

Once the scheme is operational, there will be no significant impacts on species in this area

8.5 OVERVIEW OF LAND-TAKE IMPACTS

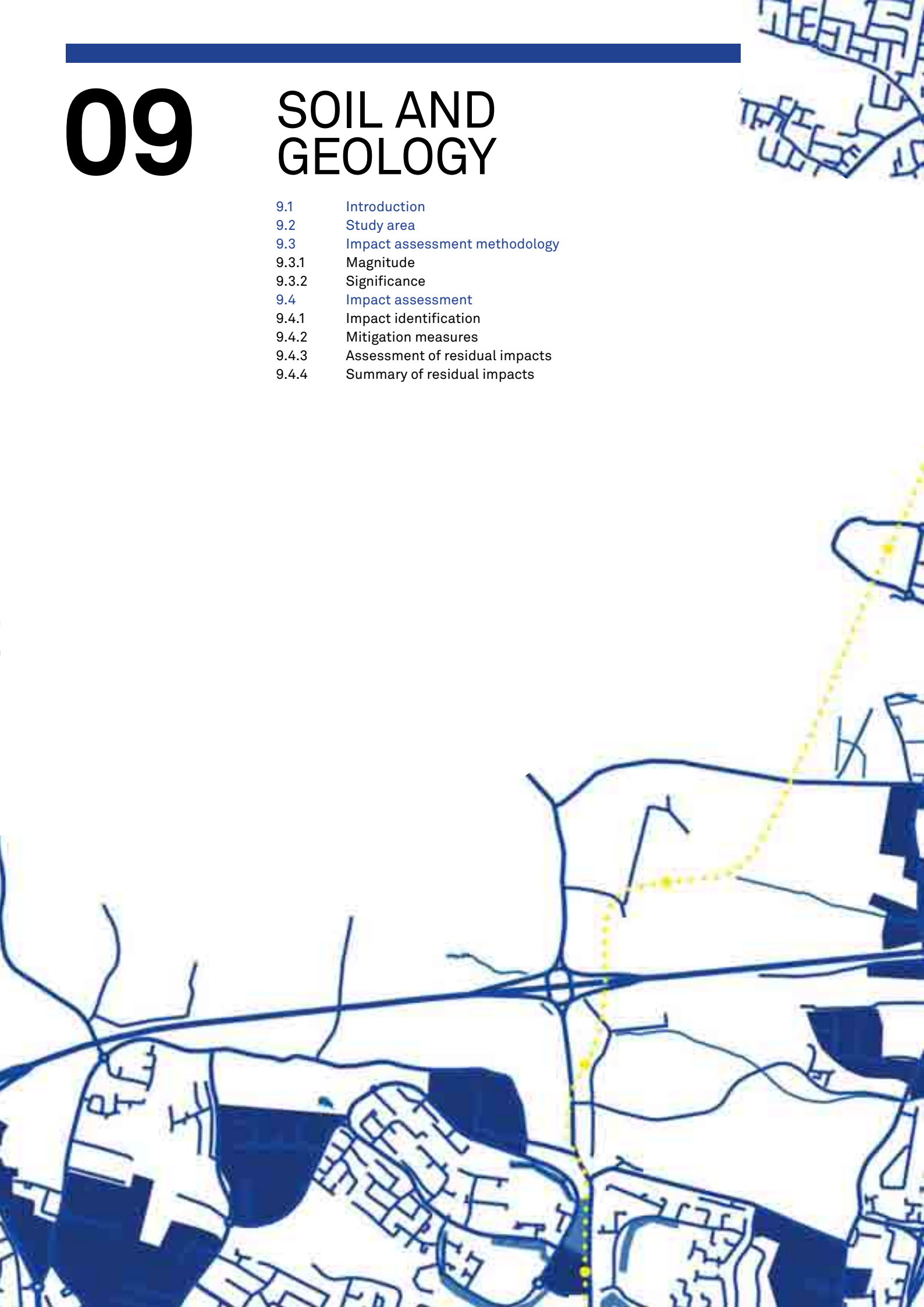
Table 8.3 shows the permanent and temporary land-take within the different habitat types within Area MN107 in comparison to the total area of those habitat types within the study area of the proposed scheme.

Table 8.3 Permanent/temporary habitat loss in area MN107

Habitat Type	Area of habitat lost in Area MN107 [ha]	Total existing area of habitat within Area MN107 [ha]	Total area of habitat in the study area [ha]
Temporary land-take			
WD5	1.95	29.1	63.9
Permanent land-take			
WD5	0.2	29.1	63.9

09 SOIL AND GEOLOGY

9.1 Introduction
9.2 Study area
9.3 Impact assessment methodology
9.3.1 Magnitude
9.3.2 Significance
9.4 Impact assessment
9.4.1 Impact identification
9.4.2 Mitigation measures
9.4.3 Assessment of residual impacts
9.4.4 Summary of residual impacts



This chapter of the EIS describes the potential impacts on soils and geology, which may arise due to activities associated with the construction and operation of the proposed scheme in Area MN107.

9.1 INTRODUCTION

This chapter of the EIS describes the potential impacts on soils and geology, which may arise due to activities associated with the construction and operation of the proposed scheme in Area MN107. In addition this chapter also considers the impact of ground movements generated by the construction of the cut and cover stops (Parnell Square, O'Connell Bridge and St. Stephen's Green), and bored and mined tunnels on adjacent and overlying property.

9.2 STUDY AREA

The study area for this assessment is set out in Table 9.1. The assessment area has been defined with reference to the potential for impact from the scheme and the availability of relevant information.

Table 9.1 Study area

Criteria	Width of study area (on both sides of the alignment)
Geology	50m
Landuse	50m
Subsoils	50m
Ecology	50m
Preliminary Ground Investigation	1km approx.
Construction compounds	All areas within 50m of construction site boundary
Constructed generated ground movements	Tunnels - The greater of 30m horizontal distance from the tunnel centreline or the position of the predicted 2mm settlement contour line. Cut and cover structures - The greater of the distance equating to the depth of the excavation measured from the face of the cut and cover excavation, or the position of the predicted 2mm settlement contour line.

9.3 IMPACT ASSESSMENT METHODOLOGY

The source and type of all potential impacts is described in Section 9.4.1. Mitigation measures to be put in place are defined in Section 9.4.2. Mitigation measures are defined for any adverse impacts that are deemed to be of Medium or greater significance prior to mitigation or are undertaken to manage ground movements generated by cut and cover and tunnel construction. The extent to which mitigation is needed increases as the significance of the impact increases. Mitigation measures are also undertaken to manage ground movements generated by tunnelling and cut and cover construction. The residual impact of each impact is then evaluated in Section 9.4.3 in terms of magnitude and significance.

9.3.1 Magnitude

The criteria used to assess the different impacts associated with this scheme with the exception of those associated with ground movements are shown in Table 9.2.

The method of assessing the impact of ground movements and in particular the response of buildings and infrastructure to excavation induced ground movements is based on a progressive approach, where successive assessment and elimination allows concentration on elements of property considered to be at potential risk. For the proposed scheme a 4 stage assessment process has been adopted, as summarised below. At each stage a review of the proposed construction methods is carried out, and where appropriate the construction methods are amended to reduce the risk of potential damage.

Table 9.2 Criteria for assessment of impact magnitude

Criteria	Impact magnitude
- Creation of impermeable areas that do not allow the percolation of water through soils e.g. paving, construction of impermeable tunnels through areas of soil - Creation of areas with very high levels of contamination	very high
- Permanent substantial impacts to soils including compaction, excavation and contamination - Temporary major impacts to soils during construction e.g. temporary creation of impermeable areas - Creation of areas with high levels of contamination	high
- Temporary moderate impacts to soils including compaction and excavation. - Creation of areas with medium levels of contamination	medium
- Permanent low magnitude impacts such as implementation of drainage schemes, landscaping and maintenance work - Creation of areas with low levels of contamination	low
- Temporary immaterial impacts such as minor ground disturbance or use of unpaved, non-compacted areas for and impacts associated with activities such as track cleaning etc. - Creation of areas with very low levels of contamination	very low

Stage 1 Preliminary 'Greenfield' Settlement Analysis

This stage involves the prediction of ground movements generated by underground excavation and construction of TBM bored tunnels, cut and cover tunnels, retained cuttings, mined tunnels, shafts, stop boxes and portal structures and the identification of property at potential risk of damage.

Settlement predictions take account of likely construction methods, ground conditions and comparable projects (in terms of ground conditions and construction methods). The predictions have been undertaken using empirical, finite element and discrete element computer analysis and validated against case studies.

The settlement predictions are translated into settlement contours that are then used to identify property at potential risk. For the proposed scheme any building where the predicted settlement is less than 10mm and the predicted slope is less than 1/500 shall not be subject to further assessment in accordance with the guidance provided by CIRIA Project Report 30 'Prediction and effects of ground movements caused beneath urban areas'. Settlement and slope less than these values corresponds to a negligible damage classification (superficial damage unlikely). Settlement and slope in excess of these values will be progressed to the next assessment stage.

In addition buildings and structures identified from site inspection that are deemed to be particularly susceptible to ground movements, or are of significant public interest shall also be progressed to the next assessment stage for further study. Typically these include:

- Complex structures;
- High value structures;
- Prestigious property;
- Prominent structures;
- Structures of cultural or historical value;
- Structures in poor condition;
- Structures known or suspected to contain equipment sensitive to ground movements e.g. hospitals, recording studios, aircraft instrumentation.

In addition to buildings there will be items of infrastructure that will be affected by the underground construction of the proposed scheme, including:

- Highways;
- Luas;
- Railways;
- Embankments;
- Bridges;
- Electricity substations;
- Canals;
- Airport infrastructure;
- Monuments;
- Hospitals.

For the Stage 1 assessment any item of infrastructure that falls within the predicted 2mm contour line will be selected for further assessment at Stage 2A.

At this stage consideration is also given to alignment adjustment to minimise the amount of damage, reduce the number of buildings affected, or to avoid particularly sensitive property.

Stage 2A Initial Response Assessment

This stage involves the assessment of the response of buildings and infrastructure (identified during Stage 1) to predicted ground movements, and where appropriate the consideration of possible mitigation measures.

All buildings carried through from the Stage 1 Assessment are individually assessed using a limiting tensile strain approach. Buildings are modelled and assumed to follow the greenfield settlement profile of the ground.

This approach is conservative since it neglects any interaction between the stiffness of the buildings and the ground. The maximum tensile strains resulting from differential settlement and/or rotations of the foundations are calculated and together with the ground surface settlement predictions the corresponding levels of risk are determined in accordance with Table 9.3. The impact of ground movements on piled buildings has been assessed in accordance with methodology proposed by Kaalberg and guidance from Professor John Burland.

Buildings identified as being in the negligible, very slight or slight damage risk category will not be assessed further. Where buildings or structures are classified as being at moderate damage or above risk levels, then a review of the construction methods proposed is undertaken and if appropriate amended and the building(s) reanalysed. Where ground movements still generate an unacceptable level of risk to buildings they are passed to Stage 3 for detailed assessment. In addition buildings that are deemed to be complex structures in terms of their response to ground movements, or where the application of the Stage 2A building response assessment methodology is considered inappropriate are also progressed to the Stage 3 detailed assessment.

As noted earlier the above approach for deriving categories of damage is likely to be conservative in its estimation. In the majority of cases the likely actual damage will be less than the assessed category. Since the calculation of tensile strain assumes that the building in question has no inherent stiffness, and that it deforms to the greenfield settlement profile. In reality the stiffness of the building will interact with the supporting ground, and therefore tend to reduce the deflection ratio and horizontal strains. More robust buildings such as framed buildings will offer greater restraint and therefore ground slope may overestimate likely damage.

The Stage 2A assessment of infrastructure involves an assessment of the impact of predicted ground movements against specified limiting criteria set down by standards or infrastructure owner's guidance documents. In the absence of documents defining limiting criteria, assessments are undertaken to demonstrate the predicted ground movements do not cause unacceptable damage. Where infrastructure is adjudged to be at potential risk, then the assessment is progressed in a manner similar to that described for buildings above.

The impact of long term consolidation settlements resulting from groundwater drawdown is also considered at Stage 2A.

Stage 2B Review of 2A Initial Response Assessment

Stage 2B provides for a review and update of the Stage 1 and 2A assessments taking account of the detailed design and actual construction methods to be used.

Stage 3 Detailed Response Assessment

This stage involves a detailed assessment of all buildings, utilities and infrastructure carried over from Stage 2B, and the design and implementation of protection measures as appropriate. All buildings that fall into the moderate, severe and very severe categories will be assessed in detail taking account of information collected from detailed structure and sub-structure surveys. The method, extent and detail of the analysis will be determined on a case by case basis, however factors that would be taken account of include, three dimensional effects, construction and excavation methods and sequencing, structural continuity of the building, foundation and structural details, building condition, orientation of the building, soil / structure interaction, settlement predictions at depth and previous movements.

Reflecting the conservative assumptions of the previous assessments, the detailed evaluation will usually result in a reduction in the possible degree of damage. If any buildings fall into the 'at risk' category after the Stage 3 Assessment then further amendments to construction proposals will be considered as will possible protective works. The assessment is then repeated to ensure that the measures taken remove the property from the 'at risk' category.

Prior to the Railway Order Planning Application, Stages 1 and 2A have been undertaken by RPA. The remaining stages of the process shall be undertaken by the Contractor taking account of its detailed design and construction proposals.

The criteria used to assess the impact of construction generated ground movements on overlying and adjacent buildings for the Railway Order Application is undertaken are in accordance with the building damage classification system set out by the Building Research Establishment 251 (1990) using a limiting tensile strain approach (see Table 9.3).

Table 9.3 Building Damage Classification System

Category of damage	Normal degree of severity	Limiting Tensile Strain (%)	Description of typical damage
0	Negligible	0 – 0.05	Hairline cracks less than about 0.1mm
1	Very Slight	0.05 – 0.075	Fine cracks not greater than 1mm which are easily treated during normal decoration.
2	Slight	0.075 – 0.15	Cracks less than 5mm. Cracks filled. Re-decoration probably required. Recurrent cracks can be masked by suitable linings.
3	Moderate	0.15 – 0.30	Cracks 5-15mm, or number of cracks >3mm. The cracks require some opening up and can be patched by a mason. Repointing of external brickwork and possibly a small amount of brickwork to be replaced.
4	Severe	>0.3	Cracks 15-25mm. Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows.
5	Very Severe	>0.3	Cracks >25mm. This requires a major repair job involving partial or complete rebuilding.

The calculated damage category forms the basis for determining the need for ground movement mitigation measures for each of the buildings assessed. It is generally considered that where the degree of damage predicted is 'negligible', 'very slight' or 'slight' that these categories fall under the aesthetic damage category and that protective measures are not required.

The basis for not providing protective measures for the slight damage category or below is that small deformations that cause cracking with a very low risk of structural damage may generally be more easily and cost effectively repaired than the measures required to prevent them. Any potential protective measures are likely to result in considerable disruption to the function and occupiers of the buildings, and may themselves cause some degree of cracking or damage during their installation. Therefore it is preferable to monitor the buildings, with final crack repairs, re-plastering and finishing being carried out after the cessation of ground movements.

For buildings where the degree of severity of ground movement damage is 'moderate' or above, protective measures will be considered with the aim to restrict damage to the 'slight' category or below. However it is recognised that the degree of importance attached to cracks less than 5mm can be subjective, and there may be situations where such damage would be unacceptable. For example where a building has been identified as having historical or other significance and the development of such cracking may be unacceptable, then the limit before mitigation or protection measures are considered is reduced to 'very slight'.

9.3.2 Significance

The significance of all impacts is assessed in consideration of the magnitude of the impact and the functional value of the area upon which the impact has an effect.

9.4 IMPACT ASSESSMENT

9.4.1 Impact identification

The following components of the proposed development may cause impacts on soils and geology.

- All areas where elements of the scheme intersect soils or geology e.g. stops, track, substations, ventilation shafts, landscaping bunds, ancillary roads and access ways and tunnel portals;
- Earthworks, cuttings and embankments;
- Spoil storage areas and disposal sites;
- Construction compounds;
- Track maintenance and drainage operations which may lead to contamination of soil.

In addition ground movements generated by the excavation and construction of the following has the potential to impact on property overlying or adjacent to sites where such works are being undertaken:

- TBM bored tunnels;
- Cut and cover tunnels;
- Retained cuttings;
- Mined tunnels;
- Shafts;
- Stop boxes;
- Portal structures

Two types of impact are recognised to occur: temporary and permanent.

9.4.1.1 Temporary impacts

Temporary impacts are typically associated with the construction phase of the scheme. These impacts are typically short-term in nature and are required to facilitate the construction of the scheme. The impacts will not continue after the construction phase has been completed. Impacts of this type include those associated with activities such as excavation and disposal of soils, contaminated materials and bedrock, temporary paving or compaction of soils, temporary construction of roads, traffic management procedures and dewatering works.

In some cases, only minor disturbance of soils occurs. An example of this is areas on construction compounds used for temporary administration structures or ground disturbed during construction but not subject to compaction.

9.4.1.2 Permanent impacts

Permanent impacts are longer term impacts which are expected to persist for the lifetime of the scheme and its operation. Permanent structural impacts occur where the soil or geology has been permanently altered to allow for the construction of the parts of the scheme e.g. sealing of surfaces by paving and also impacts associated with the installation of the railway, new traffic systems or roadways, drainage and conduit channels, car park facilities, ancillary buildings and ground movement and/or settlement.

Permanent operational impacts occur where the general day to day operation of the scheme impacts on soil and geology. Potential impacts of this type arise due to activities such as maintenance works (including track cleaning) and activities which could potentially lead to contamination.

To assess the impact of ground movements on Area MN107, a Stage 1 Preliminary Ground Movement Assessment and a Stage 2A Preliminary Building Response Assessment have been undertaken. From these assessments the following impacts have been determined:

Highways
The assessment of highways has been undertaken in two stages:

1. An assessment of the impact of ground movements on serviceability criteria, measured in terms of poor performance due to excessive change in gradient, cross fall and / or road drainage inefficiency. These criteria are more critical and onerous in determining the performance of a highway than risk of structural damage.
2. For highways identified as exceeding serviceability limiting criteria, or highways deemed to be particularly sensitive to ground movements, a risk based approach has then been adopted to consider particular features of the highway such as surfacing material, condition and traffic levels / usage. The risk assessment has been completed considering likelihood of 'ponding' occurring, and requirement for temporary and permanent repair. An assessment of the temporary and permanent situations has also been undertaken for walkways.

From St. Joseph's Parade to just north of the Dublin Spire, ground movements are predicted to be in the region of 40mm, increasing to 45mm above the cross passage locations. Predicted ground slopes are in the range of 1:200 to 1:800. At the interface of the running tunnels with the Parnell Square Stop box, settlements are expected to increase in excess of 60mm due to the cumulative effects of tunnelling and cut and cover box construction, and the transition from bored tunnel construction to cut and cover construction. These predicted settlements reflect the ground conditions (glacial sands and gravels). For all these aforementioned roads corresponding ground slopes are greater than 1/500. Based on experience of highway maintenance, settlements of up to 50mm are considered permissible for carriageways and can be managed for temporary situations provided ground slope is not greater than 1:500. It is therefore possible that during construction provision may need to be made for planned road maintenance along this section of the proposed scheme in Area MN107.

Approximately at the location of the Spire the tunnels pass into the limestone bedrock, and predicted settlements reduce to less than 5mm. At O'Connell Bridge Stop settlement is predicted to peak at around 30mm along the Bachelors Walk / Eden Quay, while within Westmoreland Street due to the south box construction settlements are estimated to be in the region of 10-15mm. Therefore some resurfacing of the highway and paths may be necessary on the cessation of ground movements.

Beyond O'Connell Bridge Stop until just north of St. Stephen's Green the running tunnels are predicted to generate settlement of less than 5mm, with the exception of College Green where settlement of up to 10mm is predicted to be generated by construction of the mined emergency crossover. Based on these predictions remedial work to highways is generally not envisaged with the exception of a localised area in the vicinity of the emergency crossover.

At St. Stephen's Green the settlements are expected to be in the region of 60mm at the north end of Grafton Street where the caverns will be constructed to accommodate the crossing of the Eastbound Interconnector railway tunnel beneath the Metro North running tunnels and therefore localised reinstatement may be required. Along St. Stephen's Green West and North, settlements from box construction within the park may result in the need for some resurfacing of the roads and pathways.

Buildings
From St. Joseph's Parade, building use continues to change from residential to a mix of residential, commercial and offices. The tunnel passes along Frederick Street North that has major buildings on both sides. There are a large number of medium sized hotels, and Findlaters Church, a prominent and prestigious structure. The tunnel drive between St Joseph's Parade and Parnell Square Stop will traverse ground that has a complex mix of glacial till with sands and gravels resulting in predicted settlements in the region of up to 45mm. None of the buildings assessed along this section of the alignment are predicted to exceed Damage category 2 in accordance with Table 9.3, however surveys have identified 12 buildings in poor condition, the Telecom Eireann Building that is a piled structure, and Findlaters Church, a prestigious structure. All will be assessed further as part of the Stage 3 Detailed Assessment.

Immediately to the east side of the proposed Parnell Square Stop there is a prestigious Georgian style terrace. The combination of being located immediately adjacent to the stop cut and cover box, and construction being undertaken in the glacial sands and gravels means all these buildings will be the subject of a detailed Stage 3 Assessment. Likewise the same applies to the Gate Theatre and Ambassador Cinema which are subject to predicted settlements in the region of 45mm due to the tunnel rising into Parnell Square Stop and being located in the glacial sands and gravels. These structures are also considered sensitive structures taking account of their use.

From south of Parnell Square Stop the tunnel is situated in glacial sands and gravels before descending in to limestone bedrock at approximately the location of the Dublin Spire. The running tunnels run directly beneath O'Connell Street, with adjacent structures to the running tunnels including The Gresham Hotel, Cleary's Department Store and the General Post Office.

From south of Parnell Square Stop to Bachelors Walk / Eden Quay no buildings are predicted to exceed damage category 2 as a result of predicted building settlements not exceeding 20mm with corresponding gentle settlement slopes. However 11 buildings have been identified to be taken forward to the Stage 3 Detailed Assessment Stage either due to their surveyed condition, identified as a piled structure (No. 9 Cavendish Row), or significant historical interest (The General Post Office).

From O'Connell Bridge the tunnel will be constructed completely in the limestone bedrock. Overlying structures are mainly commercial, but also include, O'Connell Bridge, Trinity College Gate House, The Bank of Ireland Building, Brown Thomas Department Store, St. Teresa's Church, Gaiety Theatre and the Westbury Hotel.

The settlements generated by construction of O'Connell Bridge Stop on the north side of the River Liffey are less than 20mm, while along Westmoreland Street they are expected to be of a magnitude of 15 to 20mm. Three buildings on the north side of O'Connell Street Lower are to be the subject of a detailed Stage 3 Assessment due to their existing condition suggesting they may be susceptible to ground movements. Along Westmoreland Street no buildings are predicted to exceed the damage category 2 in accordance with Table 9.3, but due to being founded on piles (No.'s 18-19, 20-21, 23-25, 35-39, 40-41) they will be moved forward to Stage 3 for a detailed assessment.

From College Green to St. Stephen's Green the settlements are small as a result of the tunnels being constructed in limestone bedrock. Settlements are predicted to be in the region of 5mm or less with exception of a localised area at the emergency crossover located between College Green and Suffolk Street where buildings within the zone of influence are predicted to settle up to 18mm. As a result only prominent structures such as Bank of Ireland, Regent House, St Teresa's Church and the Gaiety Theatre on King Street South (understood to be founded on piles) have been identified as requiring further detailed assessment at Stage 3.

In addition buildings that fall within the zone of influence of the cavern structures that will accommodate the crossing of the Interconnector Eastbound tunnel beneath the Metro North running tunnels will be considered for a detailed Stage 3 Assessment.

Many of the buildings selected for a Stage 3 Detailed Assessment are a result of surveys that have identified these buildings may be susceptible to damage from ground movements due to their condition. It is therefore possible that future surveys may identify further buildings whose condition might make them susceptible to movement and therefore the response of these buildings to ground movements would also be investigated further at the Detailed Stage 3 Assessment Stage.

River Liffey

From preliminary inspection the masonry quay walls to the River Liffey at O'Connell Bridge are in good condition and are predicted to be subject to 30mm settlement over a 30m length, with a maximum predicted settlement slope of 1/1000. This corresponds to a 'slight' damage category (superficial damage unlikely). However given the significance of these walls as supporting structures to Bachelors Walk, Eden Quay, Aston Quay, Burgh Quay and O'Connell Bridge they will be the subject of a detailed Stage 3 Assessment based on information collected from structural and condition surveys, and detailed design and construction proposals for O'Connell Bridge Stop.

O'Connell Bridge platform and concourse tunnels will be constructed beneath the River Liffey. Settlement of the river bed is predicted to be in the region of 30mm and is not expected to detrimentally affect the river bed.

O'Connell Bridge

O'Connell Bridge is predicted to be subject to settlement in the region of 30mm. The response of O'Connell Bridge to ground movements generated by tunnelling and cut and cover construction will be assessed taking account of the results of a Principal Bridge Inspection. This assessment shall also determine what mitigation and/or protection measures should be implemented to prevent this prominent structure from suffering unacceptable damage.

Monuments

A total of 14 monuments have been identified along this section of the alignment that could potentially be affected by construction generated ground movements. All the monuments have been categorised as being within the negligible damage category (superficial damage unlikely) with the exception of the fountain and water trough on Cavendish Row, and the Charles Stewart Parnell monument that may be subject to some superficial damage. The monuments in this area close to Parnell Square will be given particular attention due to the ground conditions and resulting predicted settlements. The Sir John Gray, William Smith O'Brien, and Daniel O'Connell monuments will be temporarily removed to facilitate the construction of O'Connell Bridge Stop. Similarly the Fusiliers Arch in St. Stephen's Green will be temporarily relocated to allow construction of St. Stephen's Green Stop.

The 120m tall steel Spire is located on O'Connell Street at the junction with Henry Street and North Earl Street. Taking account of the General Post Office (GPO) Building canopy structure in the close vicinity of the Spire, a track separation of 23.4m with the Spire located centrally between the tracks results in a predicted settlement of the Spire of 3.9mm, and the GPO canopy of 2mm. This magnitude of settlement is not expected to place these structures at risk of damage from tunnelling.

9.4.2 Mitigation measures

Paving
Paving of areas will be avoided where possible. Paved areas that are not required after the construction of the project will be removed and reinstated with landscaping to compliment the surrounding landuse. The areas that are to be reinstated are illustrated on the Landscape Insertion Plans included in the Landscape and Visual chapter of this EIS (Volume 2, Chapter 13).

Compaction
Compaction of areas will be avoided where possible. Hoarding and signposting will be used in this regard to clearly demarcate haulage routes and other areas being used during construction. Landscaping and restoration will be undertaken with areas reinstated to their original condition, where possible. The areas that are to be reinstated are illustrated on the Landscape Insertion Plans included in the Landscape and Visual chapter of this EIS (Volume 2, Chapter 13).

Excavation
Excavation of areas will be avoided where possible. Areas of potential contamination may be encountered during the construction phase. Uncontaminated spoil will be reused where possible within the scheme to construct areas such as the depot, embankments, bunds and landscaping structures. Uncontaminated spoil will be loaded directly onto trucks so that intermediate storage will not usually be required. Any contaminated spoil will be treated in accordance with all relevant legislation and best practice guidelines at the point of origin or at an alternative suitable site prior to disposal. Spoil will be dewatered, as part of treatment, if required, in order to reduce the volume of spoil generated. Once the spoil has been loaded onto the trucks, the trucks will then travel directly to the area in which the spoil is to be reused, recycled or disposed. All trucks will be covered during transport. Spoil that cannot be reused or recycled will be disposed of in a manner that is in accordance with all relevant legislation and best practice guidelines.

Any mitigation measures associated with potential human health impacts are addressed in the Human Health chapter of this EIS (Volume 1, Chapter 8). Measures taken to reduce the potential for environmental pollution and dispersion of contaminated soil comprise capping of contaminated areas and dust suppression if necessary. The disturbance of contaminated soils will be minimised and an appropriate risk assessment will be undertaken to mitigate against environmental risks.

Waste, spoil and contamination
A waste management plan is to be developed in accordance with the Best Practice Guidelines on the Preparation of Waste Management Plans for Construction and Demolition Projects (DoEHLG, 2006) as part of the construction environmental management plan to ensure that all construction waste is managed, stored and disposed of in an appropriate manner by appropriate contractors in accordance with all relevant waste legislation. A spoil strategy is to be developed as part of the detailed project design to ensure that spoil and any potential contamination is dealt with in an appropriate manner in accordance with all relevant legislation.

Maintenance of the rolling stock will only occur in hardstanding areas of the depot. All maintenance/ repair work of rolling stock or track will be undertaken using non-polluting substances where possible. Any hazardous materials required for scheme maintenance will be stored in bunded areas.

Ground gases including radon
It is noted the RPII assessment does not take into consideration exposure pathways that may be created due to any underground works such as the construction of tunnels or underpasses. In recognition of this fact, an occupational monitoring programme will be implemented to ensure that no adverse impacts occur as a result of the tunnel construction process due to the migration of ground gases (including carbon dioxide, methane and radon) which may be mobilised due to the tunnel construction technique or associated dewatering activities. The RPII has issued separate guidance in respect underground working entitled 'Radon in Underground Workplaces - Guidance Notes for Employers' (2007) and in this guidance an occupational exposure standard of 400 Bq/m^3 has been set. If radon levels in the underground sections of the scheme exceed this threshold during construction, appropriate remedial measures (as prescribed by the RPII) will be undertaken to ensure that no negative impact on the surrounding environmental occurs.

A programme of monitoring is to be put in place to monitor potential ground settlement. If adverse impacts are detected appropriate mitigation measures are to be put in place.

Settlement
The mitigation and protection measures for Area MN107 have, or are expected to take the form of the following:

(a) Ground Investigation

To enable the adequate design of ground support measures to control and manage ground movements resulting from cut and cover stop construction and tunnelling, and the accurate prediction of ground movements. For the proposed scheme this has been achieved by undertaking a review of historical site investigation data available from Geological Survey Ireland, the Metro North Preliminary Ground Investigation, the Metro North Main Ground Investigation and a desk study review of historical maps. Further ground investigation shall be carried out as required for the detail design and construction phase of the proposed scheme.

(b) Sub-structure surveys and building records

The collection of sub-structure survey data, property condition data and as-constructed records to enable the impact of ground movements to be accurately determined and appropriate mitigation and / or protection measures to be designed where required.

(c) Alignment design

The tunnel horizontal alignment has been set with a tunnel separation of two tunnel diameters to minimise settlement effects and impacts. In addition the tunnel separation has been further increased at the Spire to minimise settlement impacts on the Spire and GPO. This separation may however be reduced during detailed design but only should there be the assurance that the anticipated settlement effects and impacts are substantially unchanged.

Cross passages will be located wherever possible beneath greenfield sites and highways to minimise settlement impact on overlying property. Relocation of cross passages depending on location of geological discontinuities encountered during running tunnel construction may also be undertaken if required.

(d) Internal measures

The running tunnels will be constructed using a TBM with the capability to pressurise and support the tunnel face to minimise ground losses. Particular care will be taken to select the right machine to be able to cope with the contrasting ground conditions of the glacial sands and gravels and the limestone bedrock, as well as the potential for high water inflows during tunnelling in the limestone bedrock. Probing ahead of the tunnel face to determine problematic ground conditions in advance, such as water bearing sand lenses in the glacial till, rockhead profile uncertainty, and mixed face conditions will also be undertaken as necessary.

The installation of a segmental tunnel lining with the annulus (the void between the back of the tunnel lining and the excavated profile of the ground) grouted immediately after erection and installation of the tunnel lining will further reduce the opportunity for the ground to relax and generate surface settlement.

At the interface of the tunnel with the stop boxes, the ground immediately outside the box may be treated to prevent excessive ground movements at the surface being generated. Ground treatment may also be undertaken in the glacial sands and gravels, particulalrly between Parnell Square and Mater Stops to mitigate ground movements generated by tunnelling.

The cross passages, O'Connell Bridge Stop platform tunnels, the emergency crossover south of O'Connell Bridge Stop and the caverns to accommodate the crossing of the Interconnector eastbound tunnel beneath the Metro North running tunnels will be constructed using sequential excavation measures (SEM). Excavation in parts, sequencing of excavation, reducing excavation lengths and installing pre-support as required will be employed to maintain tunnel stability and manage ground movements at the surface. Where cross passages are constructed in the glacial till, and in particular glacial sands and gravels ground treatment is likely to be undertaken to stabilise sand and gravel lenses. While fissure grouting of the limestone to facilitate construction of the cross passages, O'Connell Bridge Stop platform tunnels, the mined emergency crossover south of O'Connell Bridge Stop and the caverns to accommodate the crossing of the Interconnector eastbound tunnel beneath the Metro North running tunnels may also be necessary to prevent lowering of the groundwater leading to settlement.

For the stop boxes at Parnell Square, O'Connnell Bridge and St Stephen's Green, structural measures comprising stiffness of the vertical support, propping arrangements and excavation phasing will be employed to maintain ground movements within manageable limits. Ground treatment may also be employed to manage ground water inflows at the interface between rock and the softer overlying ground at O'Connell Bridge and St Stephen's Green.

In the permanent condition the bored and mined tunnels and stops are designed as undrained structures thereby preventing ground water drawdown and the potential for long-term consolidation settlement. For the SEM tunnels this will be achieved by placing an in situ concrete lining with a waterproof membrane, while the TBM constructed tunnel will have a 'one pass' segmental tunnel lining that will be watertight.

(e) Instrumentation and monitoring

A comprehensive instrumentation and monitoring regime will be implemented to monitor ground displacements and the deformation of structures. Measurements can be taken at the surface or indirectly from sub-surface installations. Instrumentation that may be employed includes:

- Optical/electronic surveying methods;
- Portable displacement gauges;
- Single point monuments;
- Vertical pipe settlement gauges;
- Remote settlement gauges;
- Heave gauges;
- Inclinometers and electrolevels;
- Borehole extensometers;
- Soil strain gauges;
- Piezometers;
- Load cells and strain gauges.

Instrumentation will be installed to enable baseline monitoring to be undertaken 6 to 12 months prior to construction to identify ambient background levels, operator variations, reading errors, instrument error, survey and seasonal variations.

During construction, verification of the predicted settlement and building damage assessment results will be carried out using actual monitoring data measured on site. The results of the verification re-analysis will be communicated back to the design and site teams so that modifications to the construction methods and/or the protection and mitigation measures can be made if appropriate.

(f) Action and contingency plans

Pre-determined plans of action in response to recorded readings to ensure that action is taken before damage is incurred to buildings, structures, utilities and infrastructure or the stability of the works are placed at risk. The action and contingency plans shall be integrated with monitoring and construction plans.

(g) Particular mitigation and protection measures

(i) Highways

Resurfacing of highways and walkways to restore them to their original condition prior to Metro North construction may be required. In addition, during construction, planned maintenance (re-surfacing) of highways between St. Joseph's Parade to just north of the Spire may be required as a result of tunnelling through the glacial sands and gravels, and at the north end of Grafton Street where the caverns will be constructed to accommodate the crossing of the Eastbound Interconnector railway tunnel beneath the Metro North running tunnels.

(ii) Buildings

Buildings have been identified along Section MN107 which due to their condition could potentially be susceptible to movement and therefore may require mitigation or protective measures to be employed. The extent to which mitigation measures would need to be employed would be the subject of detailed assessment taking account of detail design and construction proposals. Depending on the conclusions of this detailed assessment, bearing in mind that refinement of the assessment process often results in a reduction of the predicted potential risk, structural mitigation measures that might be considered include:

- Increase the ability of foundations to resist movement by underpinning.
- Strengthening of the building through shoring and bracing walls, internal propping of walls to prevent distortion and stiffening of the structure using tension elements such as straps, tie bars, and ring beams.
- Mitigate progressively the effects of movements through instigation of a planned maintenance regime, for example measures such as propping or repair to be implemented on basis of observed performance.

In addition the ground conditions (glacial sands and gravels) between St. Joseph's Parade to Parnell Square Stop and beyond to include the Gate Theatre and Ambassador Cinema may require ground treatment prior to tunnelling beneath certain buildings. This would involve treating blocks of ground from shafts or the Parnell Square stop box to grout beneath structures to provide a stiffened raft to mitigate settlement effects. Further ground treatment would be expected to be undertaken at the interface between the running tunnels and Parnell Square cut and cover stop structure to reduce the increased settlements that would be expected as a result of the tunnel boring machine entering and leaving the stop box.

In addition to the above structural measures sensitive elements of structures can be temporarily moved or relocated, for example chimneys of buildings.

(iii) O'Connell Bridge

A Principal Bridge inspection will be undertaken to gather details of general condition of the structure including joint widths, stone condition, evidence of cracking and the presence of longitudinal joints between the old and new bridge construction (O'Connell Bridge was widened in the 18th Century). This information will be used to determine the strength capacity of the bridge taking account of the settlement predictions, including the transient progression of settlements during construction.

If the structural capacity of the bridge is determined to be adequate then possible recommendations may include the temporarily dismantling of existing parapets and their reinstatement on the cessation of ground movements, or cutting additional joints to allow articulation of the structure followed by re-pointing of these joints on the cessation of ground movements.

In the event that predicted ground movements from construction are determined to place the bridge at an unacceptable risk of damage, then ground treatment to stiffen the ground beneath the abutments to mitigate the effects of settlement will be investigated.

(iv) Monuments

Many of the monuments are prominent features with historical importance. Monitoring and inspection of monuments will be undertaken during construction to ensure their integrity is preserved. Consideration will be given to emptying water retaining monuments to allow ease of inspection.

(h) Property Protection Scheme

A Property Protection Scheme will be implemented covering properties within 30m of the tunnel centreline or the face of a cut and cover structure. If damage occurs as a result of the underground works below a ceiling of €30,000, as certified by an independent firm of building surveyors, arrangements will be made for prompt rectification involving as little disruption to the property owner as possible. The Property Protection Scheme is in addition to and does not impede people's normal legal rights.

9.4.3 Assessment of residual impacts

9.4.3.1 Project scenario: construction phase

Paving
Area MN107 consists of tunnelled sections and stops in existing hardstanding paved areas. Some paved areas will also be created for construction compounds and access points to stops. The magnitude of the impact associated with paving of any area is considered to be very high because the soil cannot continue to perform its natural functions. The paved areas will be constructed predominantly in areas that are already paved and which are therefore of Low to very low functional value so the impacts are of low to Very low significance.

A cut and cover stop is to be developed in St. Stephen's Green. This area encompasses part of the existing pond, pathways and green areas as illustrated on maps (Baseline Soil and Geology) included in Volume 3, Book 1 of 2. St. Stephen's Green is of low functional value with respect to soil so the impact on this area will be of Low significance.

The cut and cover areas will be reinstated in that soil will be replaced on top of the underground structure and vegetation will develop on this soil. As such, the soil in this area will recover some of its current functionality but not all of it because the soil depth will be limited (2m approx.) and groundwater movement will be restricted by the existence of the underground structure. The impact on these areas is therefore deemed to be of Low significance.

The locations of paved areas are illustrated on the Landscape Insertion Plans included in the Landscape and Visual chapter of this EIS (Volume 2, Chapter 13) and in Table 9.4.

Compaction
Compacted areas will occur at the construction compounds. The magnitude of the impact associated with the compacting of an area during construction is high as the soil is compressed and disturbed. The compacted areas are to be constructed in areas of low to very low functional value so the impacts will be Low to Very low. When the mitigation measures are taken into consideration, the magnitude and significance of this impact remains the same but the footprint of the area impacted upon decreases.

The locations of paved areas are illustrated on the Landscape Insertion Plans included in the Landscape and Visual chapter of this EIS (Volume 2, Chapter 13) and in Table 9.4.

Excavation
Excavation of soil will occur at the constructi on compounds and stops. The magnitude of the impact associated with this activity (i.e. excavating an area during construction) is high as soil disturbance has a High impact on soil function. The excavated area will be constructed in an area of low to very low functional value so the impacts will be Medium to Low.

The locations of paved areas are illustrated on the Landscape Insertion Plans included in the Landscape and Visual chapter of this EIS (Volume 2, Chapter 13) and in Table 9.4.

Waste, spoil and contamination
Soil from a number of sampling locations along the route has been sampled and tested for contamination. In all cases, the current information indicates that there will not be any impact on commercial landuses in which the samples all occur because contamination levels are all below the screening criteria for a commercial end landuse. However, soil sampling was undertaken at discrete representative locations only based on historical activities and an assessment of the potential for contamination to be encountered. Areas of soil contamination could potentially be encountered in other areas outside the areas where analysis was undertaken.

If contamination is encountered in other areas during construction, the magnitude of this impact will range from low to high depending on the type and amount of contamination encountered. Areas of contamination may be encountered in Area MN107 in areas of medium functional value so the impacts would be of moderate significance if mitigation measures were not put in place. The mitigation measures to be put in place are specified in Section 9.4.2. When these mitigation measures are taken into consideration, the magnitude of the impact will be reduced to Low or Very low.

A total of approximately 2.9 million cubic metres of spoil is to be generated across the entire scheme. Approximately 2.0 million cubic metres of this spoil is to be reused in the scheme for a number of purposes such as construction of embankments, levelling of topography, landscaping and other mitigation measures. Where reuse is not possible, spoil will be recycled if possible and where this is not possible, disposed of in a manner that is in accordance with all relevant legislation. Impacts associated with the transport of spoil are addressed in the Traffic chapter of this EIS (Volume 2, Chapter 7). A waste management plan is to be developed as part of the construction environmental management plan to ensure that all construction waste is managed, stored and disposed of in an appropriate manner by appropriate contractors in accordance with all relevant waste legislation.

Ground gases including radon

Radon gas comes from the radioactive decay of minute quantities of uranium present in all rocks and soils. The Radiological Protection Institute of Ireland (RPII) has produced a 'Radon Map of County Dublin' which was compiled based on monitoring results from a number of sample houses within the county. The map illustrates 10km grid squares within the county and provides an estimate of the percentage of dwellings within each 10km area which are predicted to exceed the domestic radon standard of 200 Bq/m³ of radiation.

The geology of the study area is described in the Baseline Soil and Geology chapter of this EIS (Volume 1, Chapter 17). As detailed in this chapter, the study area is dominated by limestones and shales which would allow the transmission of radon to occur if a significant source of radon existed. However, the RPII database indicates that within the study area, the percentage of dwellings predicted to exceed the domestic radon standard is low (1- 5%) and the area is not defined as a 'high radon area'. This provides an indication that the area as a whole is not likely to be associated with a significant radon problem.

It is noted that the RPII assessment does not take into consideration exposure pathways that may be created due to any underground works such as the construction of tunnels or underpasses. In recognition of this fact, the mitigation measures detailed in Section 9.4.2 are to be put in place to ensure that no significant adverse impact occurs.

Settlement

Between St. Joseph's Parade and the Spire settlements of up to 45mm are predicted as a result of construction being undertaken in the glacial sands and gravels. These settlement predictions may increase further slightly immediately adjacent to Parnell Square Stop. At approximately the Spire the TBM constructed running tunnels enter the limestone bedrock and predicted settlement reduces to less than 5mm generally between here and St. Stephen's Green Stop with the exception of those areas identified below.

At O'Connell Bridge Stop, ground movements generated by cut and cover construction of the vertical access boxes in O'Connell and Westmoreland Streets, and mining of the platform tunnels using SEM techniques is predicted to generate 30mm settlement.

The mined emergency crossover is predicted to generate peak settlements over a localised area between College Green and Suffolk Street of less than 20mm, while the caverns at the north end of Grafton Street to accommodate the crossing of the eastbound Interconnector tunnel beneath the Metro North running tunnels is expected to generate peak settlement in the region of 60mm.

Peak settlements in St. Stephen's Green Park resulting from the construction of the stop box, and loop arrangement immediately south of the box are expected to be approximately 40mm.

During the operational phase Metro North infrastructure will not generate further ground movement. The underground structures are designed as undrained (watertight) and therefore long-term ground movements beyond the construction phase are not expected to occur.

9.4.3.2 Project scenario: operational phase

Scheme maintenance

Maintenance work is unlikely to be undertaken along the track. However, there is the potential for contaminating materials (such as oils, lubricants, weed killer and cleaning materials) to impact on the soil outside of paved areas. The magnitude of impact associated with a spill of hazardous materials during maintenance/repair work is high because of the potential for soil contamination to occur. However, when the mitigation measures set out in Section 9.4.2 are taken into account and the track is within tunnelled areas, the significance of an impact is Very low.

During the operational phase Metro North infrastructure will not generate further ground movement. The underground structures are designed as undrained (watertight) and therefore long-term ground movements beyond the construction phase are not expected to occur.

9.4.4. Summary of residual impacts

A summary of the residual impacts associated with the scheme and affecting this area is provided in Table 9.4.

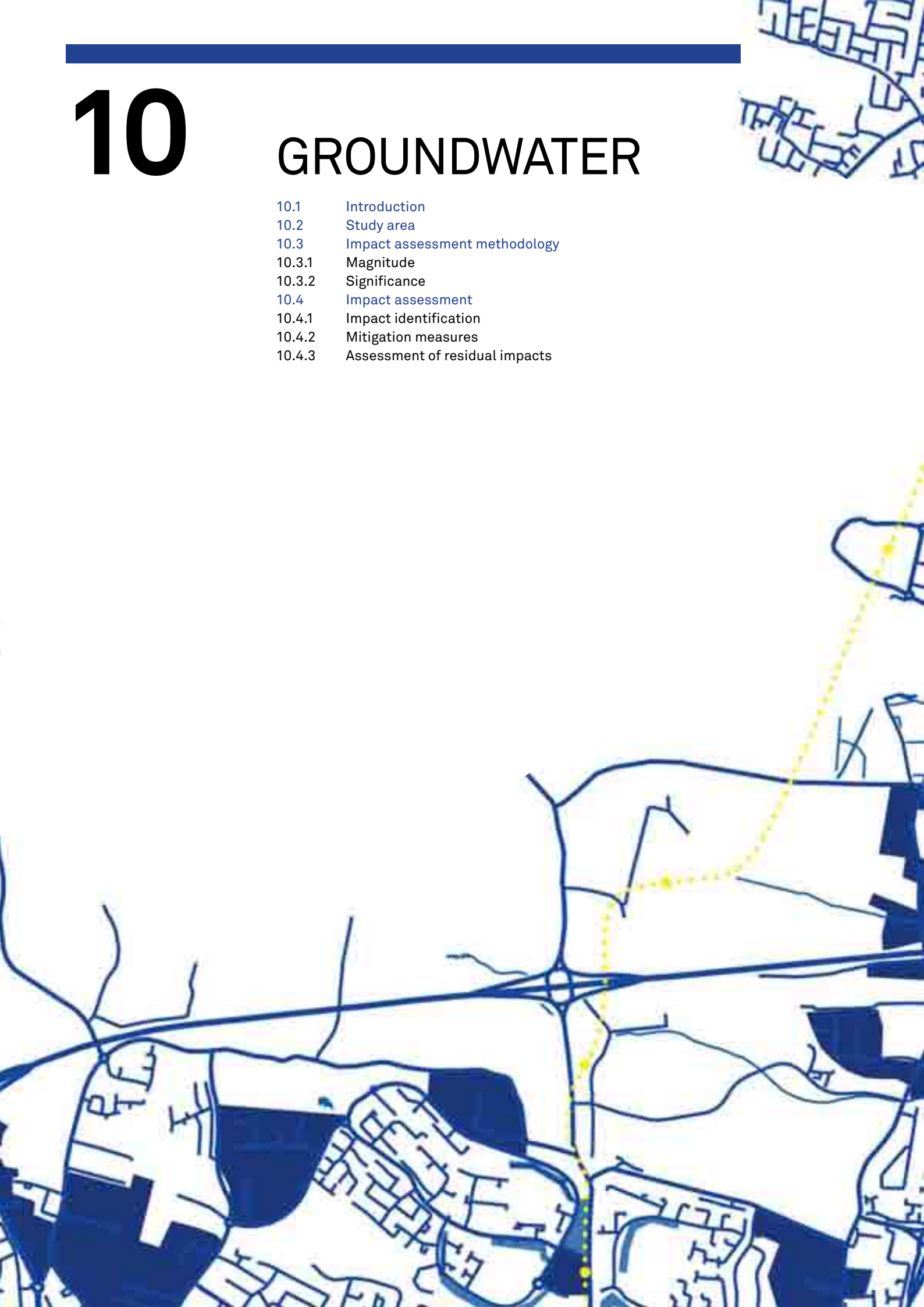
Table 9.4 Summary of residual impacts

Location	Area of land-take (hectares)	Type of impact	Significance of Impact
MN107	0.2	Paved	Medium to Very low
MN107	19.5	Potentially Disturbed Ground	Medium to Very low

O'Connell Bridge Stop (ticket hall)

10 GROUNDWATER

10.1 Introduction
10.2 Study area
10.3 Impact assessment methodology
10.3.1 Magnitude
10.3.2 Significance
10.4 Impact assessment
10.4.1 Impact identification
10.4.2 Mitigation measures
10.4.3 Assessment of residual impacts



This chapter of the EIS describes the potential impacts on groundwater, which may arise due to activities associated with the construction and operation of the proposed scheme in Area MN107.

10.1 INTRODUCTION

This chapter of the EIS describes the potential impacts on groundwater, which may arise due to activities associated with the construction and operation of the proposed scheme in Area MN107.

10.2 STUDY AREA

The study area for this assessment is set out in Table 10.1.

Table 10.1 Study area

Criteria	Width of study area (on both sides of the alignment)
Groundwater	500m

10.3 IMPACT ASSESSMENT METHODOLOGY

The source and type of all potential impacts is described in Section 10.4.1. Mitigation measures to be put in place are defined in Section 10.4.2. Mitigation measures are defined for any adverse impacts that are deemed to be of Medium or greater significance prior to mitigation. The extent to which mitigation is needed increases as the significance of the impact increases. The residual effect of each impact is then evaluated in Section 10.4.3 in terms of magnitude and significance.

10.3.1 Magnitude

The criteria used to assess the different impacts associated with this scheme are shown in Table 10.2. The criteria have been defined in consideration of the 'Guidelines on Information to be Contained in Environmental Impact Statements' (EPA, 2002).

Table 10.2 Criteria for assessment of impact magnitude

Criteria	Impact magnitude
- Permanent impact relating to the alteration of the direction of groundwater flow - Long-term impact relating to the depletion of groundwater sources due to dewatering activities - Long-term impact relating to the deterioration of groundwater quality (if left untreated) - Permanent impact relating to the recharge of the underlying groundwater sources	very high
- Long-term impact relating to the alteration of the direction of groundwater flow - Medium-term impact relating to the depletion of groundwater sources due to dewatering activities - Medium-term impact relating to the deterioration of groundwater quality (if left untreated) - Long-term impact relating to the recharge of the underlying groundwater sources	high
- Medium-term impact relating to the alteration of the direction of groundwater flow - Medium-term impact relating to the depletion of groundwater sources due to dewatering activities - Medium-term impact relating to the deterioration of groundwater quality (if left untreated) - Medium-term impact relating to the recharge of the underlying groundwater sources	medium
- Short-term impact relating to the alteration of the direction of groundwater flow - Short-term impact relating to the depletion of groundwater sources due to dewatering activities - Short-term impact relating to the deterioration of groundwater quality (if left untreated) - Short-term impact relating to the recharge of the underlying groundwater sources	low
- Temporary impact relating to the alteration of the direction of groundwater flow - Temporary impact relating to the depletion of groundwater sources due to dewatering activities - Temporary impact relating to the deterioration of groundwater quality (if left untreated) - Temporary impact relating to the recharge of the underlying groundwater sources	very low

The duration of impacts (as detailed in Table 10.2) are defined as shown in Table 10.3 as per EPA Guidance (EPA, 2002).

Table 10.3 Definition of duration criteria

Impact Description	Definition
Permanent impact	Impact lasting over sixty years
Long-term impact	Impact lasting fifteen to sixty years
Medium-term impact	Impact lasting seven to fifteen years
Short-term impact	Impact lasting one to seven years
Temporary impact	Impact lasting for one year or less

10.3.2 Significance

The significance of all impacts is assessed in consideration of the magnitude of the impact and the functional value of the area upon which the impact has an effect. The functional value of all groundwater resources is set out in the Baseline Groundwater chapter of this EIS (Volume 1, Chapter 18).

10.4 IMPACT ASSESSMENT

10.4.1 Impact identification

Various elements of both the construction and operational phases have the potential to impact on the groundwater environment.

10.4.1.1 Construction phase impacts

During the construction phase, certain activities have the potential to impact on the hydrogeological environment within the study area. Potential impacts can include localised alteration of the direction of groundwater flow due to tunneling operations. Developments that extend into underlying aquifers, for example during tunneling, can potentially cause temporary lowering of the water table. This can result in the depletion of groundwater in supply wells (where present) in the surrounding area.

There is the potential that the underlying groundwater quality may be impacted during the construction phase due to leakage of fuel from construction vehicles, oil spillages during refueling or vehicle maintenance operations, leakage from chemical storage areas and inappropriate disposal of chemicals (paints, oils, glues etc.). Surface contaminants can migrate towards underlying groundwater sources. Contaminants arising from similar activities during subsurface operations can be released directly into the surrounding aquifer. It should be noted that the construction of the proposed development may result in a localised improvement in groundwater quality along some sections of the route due to the removal of overlying contaminated material.

10.4.1.2 Operational phase impacts

Potential impacts on the groundwater environment during the operational phase would be expected to include localised alteration of the groundwater flow along sections of the proposed route where tunnels exist. The replacement of greenfield areas along sections of the route with areas of hardstanding areas (stops, rail depots, in addition to Park & Ride facilities) can reduce to some extent the recharge rate into the underlying aquifer. The construction of a tunnel within an aquifer can result in a localised depression of the water table due to the construction of sumps within the tunnel.

During the operational phase of the project, there is the potential for the migration of surface contaminants (arising from the chemical storage areas at depots, wastewater discharge and runoff from car parks, for example) towards the underlying groundwater sources. Due to the fact that the tunneled sections of the route will comprise sealed structures and all underground pipework will include appropriate containment measures, the potential for contamination from underground sections of the route is considered to be low.

10.4.2 Mitigation measures

10.4.2.1 Construction phase

All of the impacts identified for the construction phase of the scheme for this section of the route were found to be of Low significance. Therefore, mitigation measures are not considered compulsory. Nevertheless, the following good housekeeping practices will be implemented in order to ensure protection of the surrounding groundwater sources.

Where possible groundwater will be recharged to the groundwater aquifer. Potentially contaminated groundwater generated by dewatering activities and firewater (in the event of a fire in the tunnel) will be removed from the tunnel by a sump and pump arrangement to a foul water sewer at the surface in accordance with the conditions set in the Trade Effluent Discharge License from the relevant Local Authority. Where required by the Local Authority, the treatment of groundwater will be carried out prior to discharge to the foul sewer in order to comply with the requirements of the discharge licence, which may contain limits for such parameters as, inter alia, pH, heavy metals, hydrocarbons, suspended solids and Biochemical Oxygen Demand (BOD. In the event that sufficient capacity is not available in the local foul sewer, the groundwater will be treated in accordance with the conditions in the Effluent Discharge License from the relevant Local Authority prior to discharge to a nearby surface water body. The treatment of groundwater will include as a minimum the use of silt/sediment traps and oil interceptors prior to the release to surface water bodies, surface water drains or foul sewers. The discharge of firewater to surface water bodies or surface water drains will not take place.

Groundwater, which is generated during the construction phase, will be collected on-site and tested prior to discharge to the surface water drain or foul sewer, in order to ensure any related adverse impacts are minimised. The treatment of surface water runoff and groundwater will include as a minimum the use of silt/sediment traps and oil interceptors prior to the release to surface water bodies, surface water drains or foul sewers.

Foul water generated by the welfare facilities at the construction compounds will collected in portaloo facilities. At the larger compounds semi-permanent welfare facilities may be provided and the foul water generated will be treated at a local package treatment plant and the effluent will be discharged to local foul sewers.

Groundwater pollution will be minimised by the implementation of good construction practices as contained in the publication by the Construction Industry Research and Information Association (CIRIA) 'Control of Water Pollution from Construction-sites, Guidance from Consultants and Contractors' (Master et al. 2001). An emergency response protocol for pollution incidents will be established by the contractor and regularly updated. This protocol will include containment measures, a list of appropriate clean-up materials and equipment, details on staff responsibilities and trained personnel and contact details for pollution clean-up companies.

In order to minimise any impact on the underlying subsurface strata and groundwater, all oils, solvents and paints used during construction will be stored within labelled, sealed containers in specially constructed dedicated, temporary, bunded areas or suitable bunded lockable storage containers within buildings or enclosures (hardstanding) in the construction compounds or TBM launch site. The storage of small quantities of oils, lubricants and conditioning agents for the TBM in the tunnel will follow similar containment procedures. A strict protocol will be followed for the movement of any oils, chemical substances or other potentially hazardous construction materials from the TBM launch site or stop box compounds down into the tunnel.

Taking into account the 'Guidance Note for the Control of Pollution (Oil Storage) (England) Regulation 2001' (Department of Environment, Food and Rural Affairs in the UK (DEFRA), 2001), oil and fuel storage tanks shall be stored in designated bunded areas within the surface construction compounds and TBM launch site. These areas shall be either double skinned or shall be bunded to a volume of 110% of the capacity of the largest tank/container present or 25% of the total tank capacity within the bund (plus an allowance of 30mm for rainwater ingress). Filling and draw-off points will be located entirely within the bunded area(s). Drainage from the bunded area(s) shall be diverted for collection and safe disposal off site by an appropriately licensed contractor. All storage tanks will have primary, secondary and tertiary containment. Their integrity will be regularly checked and maintained. Tank level gauges will be checked regularly in order to detect leakage at an early stage.

Refuelling of construction vehicles and the addition of hydraulic oils or lubricants to vehicles, will take place in a designated area of the surface stop box compound or TBM launch site. The refuelling area will not be situated close to any surface water body or surface water drain. If it is not possible to bring a machine to the refuelling point, fuel will be delivered in a double skinned mobile fuel bowser. A drip tray will be used beneath the fill point during refuelling operations in order to contain any spillages that may occur. Spill-kits and hydrocarbon absorbent packs will be stored in this area and operators will be fully trained in the use of this equipment. Spill-kits and drip trays will be used to contain any spillages, which may occur.

Where concrete mixing is required this will only take place at a designated area at the construction compound, which will not be located next to a surface water drain or stream. The washing of concrete mixing vehicles will take place in a hardstanding bunded designated area. An emergency response protocol will be implemented in the event of concrete spillages during pouring operations.

All associated hazardous waste residuals, such as oil, solvent, material used in oil spill clean-ups, glue and solvent based paint containers will be stored within appropriately covered skips at the TBM launch site or stop box compounds prior to removal by a suitable Local Authority or EPA licensed waste management contractor for off-site treatment/ recycling/disposal. Any other construction waste will be disposed of to on-site skips for removal by a duly approved waste management contractor.

Stockpiles of spoil from tunnelling operations will be covered (to minimise the generation of runoff) and temporarily stored at the TBM site in a bunded area of hardstanding prior to collection by a suitably licensed waste contractor on a regular basis for off-site disposal.

10.4.2.2 Operational phase

All of the impacts identified for the operational phase of the scheme for this section of the route were found to be of Low significance. Therefore, mitigation measures are not considered compulsory. Nevertheless, the following good housekeeping practices will be implemented in order to ensure protection of the surrounding groundwater sources.

Substations located at each stop will be regularly checked and maintained to minimise the potential for leakage of oil from them. The substations will be located on areas of hardstanding and bunded.

In accordance with the Waste Management Act 1996 (as amended) and associated regulations, waste material generated at the stops along this section of the route should be stored in a suitably designed waste storage area and transferred to the surface for collection on a regular basis by a suitably licensed waste collection contractor for disposal at an appropriately licensed waste facility. The waste storage area should be regularly and appropriately maintained.

Foul effluent generated at the stops along this section of the route will be discharged to the foul water sewer at the surface by means of a sump, pump and rising main arrangement under the approval of the relevant Local Authority. This will ensure that untreated foul water is not released into the surrounding groundmass, thus towards the underlying groundwater sources. A similar arrangement will apply for the discharge of firewater from the tunnel in the event of a fire.

Runoff that enters the cut and cover sections of the route will be collected in sumps located at low points along the track alignment. The water from the sumps will be pumped to a nearby surface water drain.

The integrity of surface and foul sewers will be regularly checked and they will be appropriately maintained.

10.4.3 Assessment of residual impacts

10.4.3.1 Project scenario: construction phase

During the construction phase of this section of the route, there is the minor potential for localised alteration of groundwater flow around the tunnel. Provided that the mitigation measures detailed in Section 10.4.2 are put in place, the magnitude of this impact is low and the impact affects an area of low functional value. Therefore, the impact is considered to be of Low significance.

The Groundwater Baseline Assessment indicates that the levels of a range of contaminants in groundwater are either non-detectable or present at low concentrations along this section of the route with the exception of Total Petroleum Hydrocarbons (TPH), which exceeded the criteria contained in Table 3.1 Interim Guideline Values for Characterisation of List of Parameters (IGV) in the document. 'Towards Setting Guideline Values for the Protection of Groundwater in Ireland, Interim Report by the EPA' (EPA, 2003). In general, the concentration of the contaminants in the groundwater along this section of the route is below the surface water quality criteria in the EPA publication 'Parameters of Water Quality, Interpretation and Standards' (EPA, 2001).

Therefore, there is the possibility that groundwater generated from construction along this section of the route can be discharged into a surface water body/drain but this would be subject to approval by the relevant Local Authority and the use of oil interceptors due to the presence of TPH in the groundwater. It is understood that the construction of the bored sections of the tunnel will not require continuous significant dewatering operations but will require the removal of groundwater seepage into the tunnel by means of a sump, pump and rising main arrangement. Dewatering is likely to be required at the cut and cover stop at Parnell Square.

There is the potential that the groundwater quality may be impacted during tunnelling operations due to the leakage of fuel/lubricants/conditioning agents from the TBM and associated equipment underground. Waste spoil generated by boring operations and waste construction materials will be transported to the TBM launch site for removal and disposal off-site. Water may be generated in the tunnel in the event of a fire and could impact the surrounding groundwater quality if not appropriately contained and managed. The hydrostatic pressure at the depth of the tunnel would be expected to minimise the potential for the release of contaminants from the tunnel into the surrounding aquifer. Provided that the mitigation measures detailed in Section 10.4.2 are put in place, the magnitude of this impact is low and the impact affects an area of low functional value. Therefore, the impact is considered to be of Low significance.

The construction phase for this section of the route will also involve activities at the surface stop box compounds with the potential to adversely impact the underlying groundwater quality as follows:

- leakage of fuel/lubricants from the construction vehicles and associated equipment;
- oil spillages during refuelling or vehicle maintenance operations;
- leakage from chemical storage areas (including storage tanks) at the compounds and inappropriate disposal of chemicals (paints, oils, glues etc.);
- the generation of leachate/runoff from inappropriately managed waste storage areas at the construction compound;
- Spillage and/or inappropriate disposal of raw or uncured concrete or grout;
- The generation of potentially contaminated leachate from storage areas for construction materials at the construction compounds;
- Inappropriate disposal of domestic effluent from welfare facilities at the construction compound;
- Spillage and/or leakage of bitumen or sealants for waterproofing surfaces.

Surface contaminants can migrate towards underlying groundwater sources. Provided that the mitigation measures detailed in Section 10.4.2 are put in place, the magnitude of this impact is low and the impact affects an area of low functional value. Therefore, the impact is considered to be of Low significance.

Tunnel boring operations will result in the generation of spoil that has the potential to be contaminated with oil, lubricants or conditioning agents. The storage of stockpiles of potentially contaminated spoil from boring operations could result in the generation of contaminated leachate, if suitable mitigation measures (such as the immediate removal of spoil) are not implemented. Provided that the mitigation measures detailed in Section 10.4.2 are put in place, the magnitude of this impact is low and the impact affects an area of low functional value. Therefore, the impact is considered to be of Low significance.

According to the Groundwater Baseline Assessment, groundwater has been encountered within 1.0m below ground level along this section of the route and would be largely expected to be hydraulically connected to the River Liffey. Therefore, the tunnel, which extends to depths in the range of 26m bgl will be located within the underlying aquifer and well below the River Liffey. The tunnelling operations are not expected to result in dewatering of significant volumes of groundwater. However, dewatering operations are likely to be required for the cut and cover sections of the route. Unless they are suitably controlled, dewatering activities have the potential to temporarily lower the water table to the extent that the water supply in nearby wells is affected. No significant long-term lowering of the water is expected as a consequence of building the scheme. Lowering of the water table will be limited to 1m. Provided that the mitigation measures detailed in Section 10.4.2 are put in place, the magnitude of this impact is low and the impact affects an area of low functional value. Therefore, the impact is considered to be of Low significance.

It should be noted that the application of the above mitigation measures will ensure that the magnitude of the impact on groundwater quality and its regime in the St. Stephen's Green area will be low during the construction of the proposed scheme. Due to the long history of urban development in the St. Stephen's Green area and the fact that the groundwater would not be considered suitable (due to contamination and the potential for saline intrusion due to the proximity to the coast) for abstraction for water supply purposes, the area has a low functional value. Therefore, the impact of the construction of the proposed scheme on groundwater in the St. Stephen's Green area is considered to be of Low significance.

10.4.3.2 Project scenario: operational phase

During the operational phase of this section of the route, there is a slight potential for localised alteration of groundwater flow around the tunnel. Provided that the mitigation measures detailed in Section 10.4.2 are put in place, the magnitude of this impact is low and the impact affects an area of low functional value. Therefore, the impact is considered to be of Low significance.

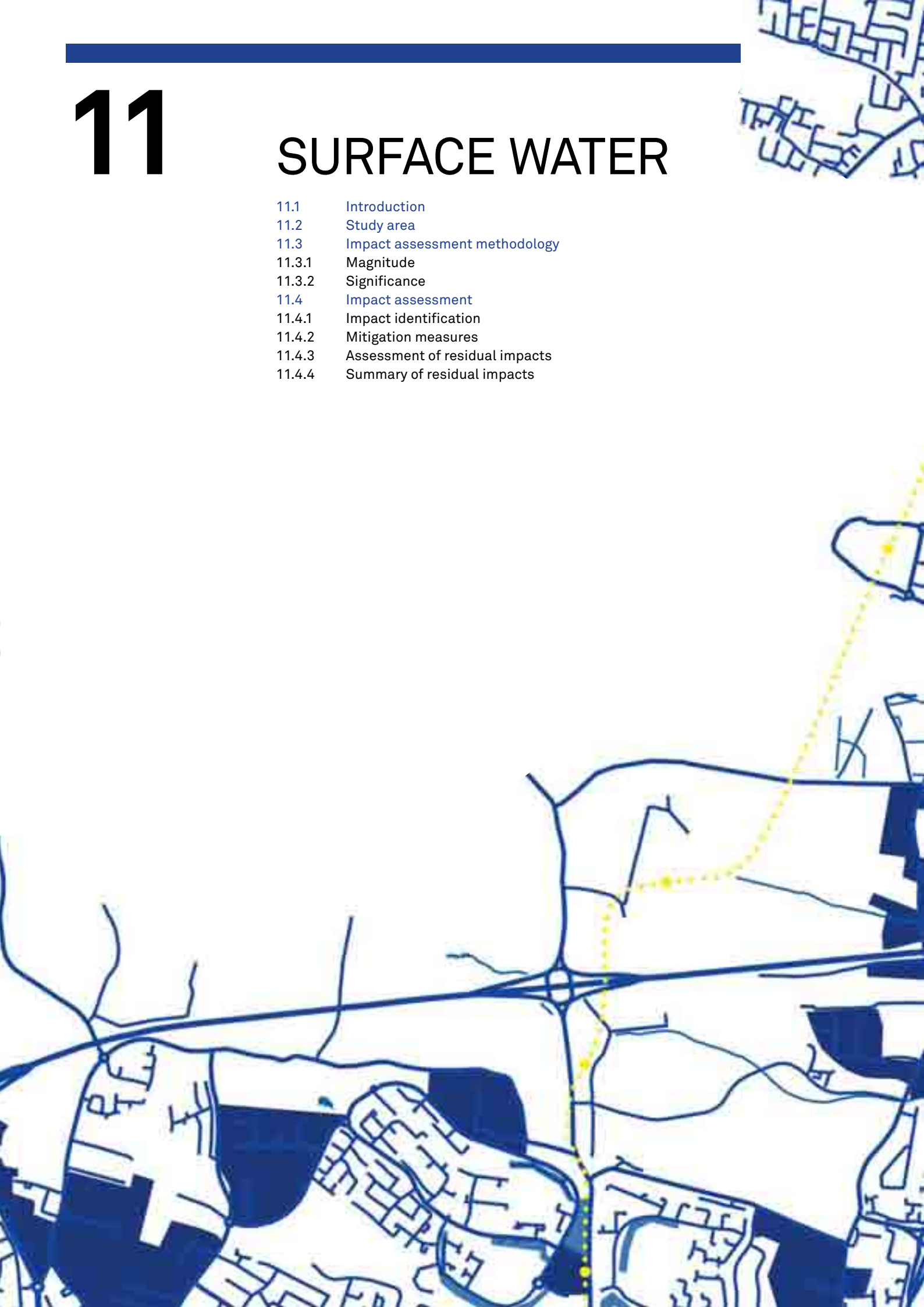
Infiltration into the bored tunnel sections of the route will be collected at the stops, filtered and where possible recharged into the water table during the operational phase. If the quality of this drainage water is not controlled, it can impact the quality of the surrounding aquifer. Provided that the mitigation measures detailed in Section 10.4.2 are put in place, the magnitude of this impact is low and the impact affects an area of low functional value. Therefore, the impact is considered to be of Low significance.

Potential sources of groundwater contamination within the tunnel during the operational phase would be expected to include inappropriate disposal of domestic effluent from stops along the route and fire water from the tunnel. In addition, there is the potential for leakage from oils used in substations at each stop, in addition to storage areas for waste, cleaning agents and chemicals (oils, lubricants and solvents for example) required for stop equipment. The tunnel will be a sealed structure and the potential for the release of contaminants into the surrounding groundwater is low. The hydrostatic pressure at the depth of the tunnel would be expected to minimise the potential for the release of contaminants from the tunnel into the surrounding aquifer. Provided that the mitigation measures detailed in Section 10.4.2 are put in place, the magnitude of this impact is low and the impact affects an area of low functional value. Therefore, the impact is considered to be of Low significance.

It should be noted that the application of the above mitigation measures will ensure that the magnitude of the impact on groundwater quality and its regime in the St. Stephen's Green area will be low during the operational phase of the proposed scheme. Due to the long history of urban development in the St. Stephen's Green area and the fact that the groundwater would not be considered suitable (due to contamination and the potential for saline intrusion due to the proximity to the coast) for abstraction for water supply purposes, the area has a low functional value. Therefore, the impact of the operation of the proposed scheme on groundwater in the St. Stephen's Green area is considered to be of Low significance.

11 SURFACE WATER

11.1 Introduction
11.2 Study area
11.3 Impact assessment methodology
11.3.1 Magnitude
11.3.2 Significance
11.4 Impact assessment
11.4.1 Impact identification
11.4.2 Mitigation measures
11.4.3 Assessment of residual impacts
11.4.4 Summary of residual impacts



This chapter of the EIS evaluates the potential impacts on surface water, which may arise due to activities associated with the construction and operation of the proposed scheme scheme in Area MN107.

11.1 INTRODUCTION

This chapter of the EIS evaluates the potential impacts on surface water, which may arise due to activities associated with the construction and operation of the proposed scheme in Area MN107.

11.2 STUDY AREA

The study area for this assessment is set out in Table 11.1. As shown in the table, this assessment focuses on all watercourses within 500m of the proposed alignment. Impacts that may affect the catchment of any watercourse within this study area are considered.

Table 11.1 Study area

Criteria	Width of study area (on both sides of the alignment)
Surface water quality and hydrodynamics (including flooding)	500m

11.3 IMPACT ASSESSMENT METHODOLOGY

The source and type of all potential impacts is described in Section 11.4.1. Mitigation measures to be put in place are defined in Section 11.4.2. Mitigation measures are defined for any adverse impacts that are deemed to be of Medium or greater significance prior to mitigation. The extent to which mitigation is needed increases as the significance of the impact increases. The residual impact of each impact is then evaluated in Section 11.4.3 in terms of magnitude and significance.

11.3.1 Magnitude

The criteria used to assess the different impacts associated with this scheme are shown in Table 11.2. The criteria have been defined in consideration the 'Guidelines on Information to be Contained in Environmental Impact Statements' (EPA, 2002).

Table 11.2 Criteria for assessment of impact magnitude

Criteria	Impact magnitude
- Long-term to permanent change to a designated conservation site or designated salmonid river - Medium-term to permanent contamination of surface water over entire surface water catchment - Medium-term to permanent potential changes in drainage patterns over entire catchment	very high
- Medium term change to a designated conservation site or a designated salmonid river - Temporary to short-term contamination of surface water over entire surface water catchment - Temporary to short-term potential changes in drainage patterns over entire catchment	high
- Temporary to short-term change to a designated conservation site or a designated salmonid river - Medium to long-term contamination of local surface water - Medium to long-term potential changes in local drainage patterns	medium
- Short-term contamination of local surface water - Short term potential changes in local drainage patterns	low
- Temporary contamination of local surface water - Temporary potential changes in local drainage patterns	very low

The duration of impacts (as detailed in Table 11.2) are defined as shown in Table 11.3 as per EPA Guidance (EPA, 2002).

Table 11.3 Definition of duration criteria

Impact Description	Definition
Permanent impact	Impact lasting over sixty years
Long-term impact	Impact lasting fifteen to sixty years
Medium-term impact	Impact lasting seven to fifteen years
Short-term impact	Impact lasting one to seven years
Temporary impact	Impact lasting for one year or less

11.3.2 Significance

The significance of all impacts is determined in consideration of the magnitude of the impact and the functional value of the surface water resource.

11.4 IMPACT ASSESSMENT

11.4.1 Impact Identification

11.4.1.1 Construction impacts

Potential impacts on hydrodynamics and flooding
During the construction phase, various activities have the potential to result in increased surface water runoff which could potentially impact local drainage, patterns and flooding. Other construction activities have the potential to alter the hydraulic flow regimes within watercourses and to lead to flooding.

These include:

- The discharge of dewatering liquids from tunnel excavations, construction of watercourse crossing points;
- Construction and installation of a Bailey bridge and working deck at the Liffey;
- The installation of drainage discharge points to watercourses and surface water or foul drains;
- The installation of hard standing for temporary construction compounds and access roads and construction of surface structures. During the operation phase, surface water runoff will arise from drainage of the surface structures. Dewatering of groundwater from tunnelled sections may also be necessary during the operation phase which may require to be discharged to surface water bodies.

Works involving the installation of decking to facilitate construction works, a bridge (including piling works in the river bed) and also sealing of the river bed has the potential to impact flow regimes in existing watercourses and to lead to flooding of adjacent lands. If significant this may have the following impacts:

- Increased flood levels upstream of the culvert due to the creation of a restriction in the watercourse;
- Erosion of the watercourse and/or floodplain being initiated or accelerated due to the restriction increasing flow velocities and turbulence;
- Deposition of material in the watercourse or on the flood plain due to a change in flow velocities and turbulence;
- Interference with the passage or movement of fish.

Potential impacts on water quality
During construction, potentially contaminated runoff may arise in parking and turning areas, fuel off-load and distribution areas, materials storage areas, skip and waste compactor areas and from on-site trade effluent. During the operation phase any contaminated runoff has the potential to pollute receiving water bodies.

There is the potential for surface water run-off (rainfall directly falling on open surfaces in excavation and rainfall migrating by overland flow to the excavation) to infiltrate open sections of the route along this area. In areas where soil may be compacted due to construction works, or where impermeable soils are encountered, it will be necessary to collect this run-off in sumps at low points along the track alignment.

From the sumps it will be pumped into the nearby storm water drainage system or treated and discharged to surface water bodies (if available). All waters collected in this manner will be treated in silt traps and hydrocarbon interceptors prior to discharge. These measures are subject to agreement with Dublin City Council and if necessary to obtaining an appropriate discharge licence.

Furthermore, dewatering of groundwater from tunnels and structures that are below the local groundwater table level has the potential to pollute surface water bodies if subsequently discharged to them untreated.

11.4.1.2 Operation impacts

Potential impacts on hydrodynamics and flooding
During the operational phase, increased surface water runoff will arise from drainage of the surface structures. The operation of features associated with drainage of the proposed scheme (including drainage discharge points to surface water bodies and surface water or foul drains) has the potential to impact flow regimes in existing watercourses and to lead to flooding of adjacent lands. These potential impacts are detailed in Section 11.4.1.1 (Construction impacts).

Potential impacts on water quality
Dewatering of groundwater from tunnelled sections may be necessary during the operational phase which may require to be discharged to surface water bodies. This has the potential to pollute surface water bodies if contaminated dewatered groundwater is discharged to them untreated.

During operation, potentially contaminated runoff may arise in parking and turning areas, fuel off-load and distribution areas and from on-site trade effluent. Contaminated runoff has the potential to pollute receiving water bodies.

11.4.2 Mitigation measures

11.4.2.1 Construction

Measures to mitigate potential impacts on hydrodynamics and flooding
Detailed measures to mitigate potential impacts associated with works on the River Liffey are subject to the outcome of further hydraulic modelling. The proposed piles which will be used to support the Bailey bridge and the working deck across the River Liffey are to be located in line with the existing supports for O'Connell Bridge, which will mean that no additional cross sectional river channel area is affected by the piles.

During the detailed design phase of the temporary structures hydraulic modelling will be carried out to determine the most appropriate and effective mitigation measures to minimise potential flooding effects on the River Liffey.

Such mitigation measures would include shaping the piles to minimise the surface area presented to the direction of the river flow, putting in place temporary protective measures on the river walls and using angled deflector plates on the upstream face of the piles to minimise turbulence around the piles.

The bridge design will be in accordance with the requirements of the Office of Public Works (OPW) and Section 50 of the Arterial Drainage Act, 1945. As such, approval will be sought from the OPW for construction of the bridge, and the OPW's hydraulic design standards will be adhered to. In addition, cognisance will be taken of the National Roads Authority (NRA) Guidelines for the Crossing of Watercourses during the Construction of National Road Schemes.

Measures to mitigate potential impacts on water quality

Any discharges arising from the construction phase of this area entering foul/storm sewer network will be in accordance with the requirements of a discharge licence granted by Dublin City Council. Similarly, any water discharged to surface water bodies will be treated in advance and also in accordance with the requirements of a discharge licence granted by Dublin City Council.

All waters collected in sumps in open excavations during the construction phase will be treated in silt traps and hydrocarbon interceptors prior to discharge. These measures are subject to agreement with Dublin City Council and if necessary to obtaining an appropriate discharge licence.

All discharge points will be fitted with oil separators which will comply with current European Standard EN 858. The oil separators will have silt chambers for the removal of silts and other settleable solids. Each separator will be fitted with an automatic alarm system which will relay information to a control unit to indicate the state of the separator. The alarm probes will be set to coincide with the maximum oil storage volume for each separator. All full retention separators will be fitted with automatic closure devices which will be set to operate when the separated light liquid storage capacity reaches a volume equal to ten times the nominal size of the separator. By-pass separators will not be fitted with automatic closure devices.

The connection between the Grand Canal and the ponds in St. Stephen's Green is gravity fed and therefore the risk of any water migrating from St. Stephen's Green to the Canal is considered insignificant.

Treatment of water produced during the construction phase will involve silt removal using a silt trap and hydrocarbon removal using a hydrocarbon interceptor. Contaminated groundwater, if encountered, may require treatment using more specialised treatment equipment including chemical treatment, activated carbon or other absorbent systems.

During construction, regular monitoring of water will be conducted prior to discharge to ensure all relevant water quality parameters are within criteria specified by the Dublin City Council.

Re-fuelling of construction equipment and the addition of hydraulic oil or lubricants to vehicles/ equipment will take place in designated bunded areas within the construction compounds, away from surface water gullies or drains. The vehicles and equipment will not be left unattended during refuelling. Spill kits and hydrocarbon adsorbent packs will be stored in this area and operators will be fully trained in the use of this equipment. As a precaution, a spill kit will also be stored in cab of each vehicle in case of localised hydrocarbon loss of containment incidents, such as a machine 'blowing' a hydraulic hose.

Any hazardous waste residuals or potentially contaminated sludge from spill clean-up will be stored within appropriate metal or plastic containers in temporary bunded storage areas in the construction compounds prior to removal by an appropriate Local Authority or EPA approved waste management contractor for off-site treatment/ recycling/disposal.

The guidelines provided by the Department of the Marine and Natural Resources and guidelines provided by CIRIA (2001) on the prevention of water pollution from construction sites will be adhered to, in order to ensure that the impact on the water environment during the construction phase of the proposed development is minimised.

The guidelines provided by the Department of the Marine and Natural Resources (1997) and guidelines provided by CIRIA (2001) and the Eastern Regional Fisheries Board (2006) on the prevention of water pollution from construction sites will be adhered to, in order to ensure that the impact on the water environment during the construction phase of the proposed development is minimised.

Measures to mitigate potential impacts on the passage of salmon

In relation to construction works in the River Liffey, if necessary, a foreshore licence will be obtained from the Department of the Marine. Works will be scheduled in order to avoid interference with the passage of salmon in the River Liffey.

11.4.2.2 Operation

Measures to mitigate potential impacts on water quality

Any discharges arising from the operational phase of this area entering foul/storm sewer network will be in accordance with the requirements of a discharge licence granted by Dublin City Council. Similarly, any water discharged to surface water bodies will be treated in advance and also in accordance with the requirements of a discharge licence granted by Dublin City Council.

During operation, all discharge points will be fitted with oil separators which will comply with current European Standard EN 858. Mitigation measures will be as described in Section 11.4.2.1 (Construction).

Herbicides used during operation will be applied sparingly and in compliance with suppliers' guidance, and will be suitable for use in an environment in which receiving watercourses are present.

11.4.3 Assessment of residual impacts

11.4.3.1 Project scenario: construction phase

This area extends from St. Joseph's Parade south of the Mater Hospital to the terminus at St. Stephen's Green. It is proposed to construct the entire length of the scheme in this area by means of tunnel boring machines, with excavated stops at Parnell Square, O'Connell Bridge and St. Stephen's Green. The route will pass underneath the River Liffey at O'Connell Bridge.

River Liffey
At the River Liffey, it will be necessary to temporarily deck over a 30m length downstream of O'Connell Bridge to provide working space for construction of the stop. This will involve temporary piling through the river bed into the bedrock. In addition, a temporary bridge, a Bailey bridge, will be constructed over the River Liffey from Burgh Quay to Eden Quay, which will also involve piling works through the river bed into the bedrock. This bridge will act as a mitigation measure to alleviate traffic impacts within the city centre.

During the detailed design phase of the temporary structures hydraulic modelling will be carried out to determine the most appropriate and effective mitigation measures to minimise potential flooding effects on the River Liffey.

Other works that have the potential to impact on surface waters in this area include sealing of the bed of the River Liffey at the O'Connell Bridge Stop location, tunnel construction and construction of the stops.

St. Stephen's Green Ponds
At St. Stephen's Green, construction works will involve temporarily draining the pond in the northwest corner of the Green. The pond will be re-instated on completion of construction works. The water supply from the canal to the other pond will be maintained during the construction phase.

The connection between the Grand Canal and the ponds in St. Stephen's Green is fed by gravity in the direction of the Green and therefore the risk of any water migrating from St. Stephen's Green to the Canal during the construction phase is insignificant.

Water from the pond will be discharged to storm or foul water sewers, subject to agreement with Dublin City Council and obtaining an appropriate discharge licence.

The duration of construction works at St. Stephen's Green is expected to be approximately four years. The magnitude of the impact on the ponds at St. Stephen's Green is assessed as low. Although the ponds are of high amenity value, the baseline surface water assessment indicated that the ponds at St. Stephen's Green are artificial or highly modified habitats with low species diversity, low wildlife value and no current or significant potential fisheries value. They are of low ecological sensitivity and therefore the surface water impact on the pond at St. Stephen's Green is assessed as not significant.

De-watering of groundwater
During the construction phase, it may be necessary to de-water groundwater entering the tunnel in this area. Where possible groundwater will be recharged to the groundwater aquifer. If this is not feasible, groundwater will be discharged to foul or storm water sewers. If insufficient capacity is available, it will be discharged to a receiving surface water body. Discharges to surface water bodies will receive prior treatment. All measures are subject to agreement with Dublin City Council and to obtaining an appropriate discharge licence, if required.

The impacts associated with recharging groundwater entering the tunnels to the underlying groundwater aquifer are addressed in the Groundwater chapter of this EIS (Volume 2, Chapter 10).

Other residual impacts on water quality
Construction compounds will be located at each of the stop locations. The compounds will provide welfare facilities for construction workers. Temporary portaloo facilities will be used and foul water generated will be removed and treated off-site by an appropriately licensed contractor or discharged to the existing local foul sewer network.

Discharge of water being drained from the pond at St. Stephen's Green and of de-watered groundwater (due to construction activities) to storm or foul sewers could potentially impact receiving water bodies if contamination is present. Discharge directly to a receiving water body has the potential to contaminate the receiving water body if water does not receive adequate treatment in advance. The degree of contamination of the receiving water body depends on the volume and composition of the discharge. A serious pollution incident could potentially contaminate a receiving surface water body for a duration of up to 1 year.

There is the potential for surface water run-off (rainfall directly falling on open surfaces in excavation and rainfall migrating by overland flow to the excavation) to infiltrate open sections of the route along this area. In areas where soil may be compacted due to construction works, or where impermeable soils are encountered, it will be necessary to collect this run-off in sumps at low points along the track alignment. From the sumps it will be pumped into the nearby storm water drainage system or treated and discharged to surface water bodies (if available).

All waters collected in this manner would be treated in silt traps and hydrocarbon interceptors prior to discharge. These measures are subject to agreement with Dublin City Council and if necessary to obtaining an appropriate discharge licence.

Discharge of surface water runoff to storm water sewers or receiving surface water bodies could potentially impact the quality of receiving water bodies if the runoff does not receive adequate treatment in advance. The degree of contamination of the receiving water body depends on the volume and composition of the discharge. A pollution incident (for example a fuel spill) could potentially contaminate a receiving water body for a duration of up to 1 year.

Provided that the mitigation measures specified in Section 11.4.2 are implemented for the construction phase, the magnitude of all impacts on surface water quality are considered to be low. The significance of impacts depends on the impact magnitude and the sensitivity of receiving water bodies. Surface water courses within this area were identified as having a medium functional value in the baseline study. Therefore the significance of this impact is assessed as Low.

Residual impacts on the passage of salmon
Provided that construction works in the River Liffey are appropriately scheduled, there will be no interference with the passage of salmon in the river.

11.4.3.2 Project scenario: operational phase

The pond at St. Stephen's Green will be re-instated at the end of the construction phase. Impacts on the pond are assessed in Section 11.4.3.1. This re-instatement will be conducted using water fed from the Grand Canal by the existing gravity feed system.

Discharge of surface water runoff can potentially impact the quality of receiving water bodies however, the likelihood of contamination from surface water run off from the proposed scheme is considered low as the system is electrically powered, and while it uses hydrocarbon lubricants within the LMVs, the lubricants are contained within sealed units, and the risk of leaks is therefore low. Herbicides may be used occasionally to control weed growth, but the quantities involved will be small and the herbicides used will comply with all applicable environmental codes.

During the operational phase, it will be necessary to maintain some water collection capability within the tunnel to collect water which may seep into the tunnel. Where possible groundwater will be recharged to the groundwater aquifer. If this is not feasible, groundwater will be discharged to foul or storm water sewers. If insufficient capacity is available, it will be discharged to a receiving surface water body. Discharges to surface water bodies will receive prior treatment. All measures are subject to agreement with Dublin City Council and to obtaining an appropriate discharge licence, if required.

The impacts associated with recharging groundwater from the tunnels to the underlying groundwater aquifer are addressed in the Groundwater chapter of this EIS (Volume 2, Chapter 10).

Other residual impacts on water quality
Construction compounds will be located at each of the stop locations. The compounds will provide welfare facilities for construction workers. Temporary portaloo facilities will be used and foul water generated will be removed and treated off-site by an appropriately licensed contractor or discharged to the existing local foul sewer network.

As described under potential construction impacts in Section 11.4.3.1, discharge of de-watered groundwater to a foul/storm water sewer and/or to a receiving water body during the operational phase has the potential to contaminate the receiving waters if it does is not receive adequate treatment in advance. The degree of contamination depends on the volume and composition of the discharge and a serious pollution incident could potentially result in contamination for a duration of up to 1 year.

Provided that the mitigation measures specified in Section 11.4.2 are implemented for the operational phase, the magnitude of all impacts on surface water are considered to be low. The significance of impacts depends on the impact magnitude and the sensitivity of receiving water bodies. Surface water courses within this area were identified as having a medium functional value in the baseline study. Therefore the significance of this impact is assessed as Low.

11.4.4 Summary of residual impacts

The main surface water features present in this area of the proposed scheme are the River Liffey and the ponds at St. Stephen's Green (which are fed by the Grand Canal). The River Liffey has a medium baseline functional value. The ponds at St. Stephen's Green have been identified in the baseline assessment as artificial or highly modified habitats with low species diversity, low wildlife value and no current or significant potential fisheries value. They are of low ecological sensitivity.

During the detailed design phase of the temporary structures hydraulic modelling will be carried out to determine the most appropriate and effective mitigation measures to minimise potential flooding effects on the River Liffey.

Residual impacts on the water quality of the River Liffey are of low magnitude, therefore the significance is assessed as Low.

Impacts on the ponds at St. Stephen's Green have been assessed as not significant.

12 AIR AND CLIMATIC FACTORS

12.1 Introduction
12.2 Study area
12.3 Impact assessment methodology
12.3.1 Introduction
12.3.2 Assessment methodology for dust
12.3.3 Assessment methodology for vehicle emissions
12.3.4 Assessment methodology for micro climate
12.3.5 Assessment methodology for climate change
12.3.6 Assessment criteria
12.4 Impact assessment
12.4.1 Impact identification
12.4.2 Mitigation measures
12.4.3 Assessment of residual impacts

This chapter of the EIS evaluates the potential air and climatic impacts arising from the construction and operation of the proposed scheme in Area MN107.

12.1 INTRODUCTION

This chapter of the EIS evaluates the potential air quality and climatic impacts arising from the construction and operation of the proposed scheme in Area MN107.

12.2 STUDY AREA

The study area for this assessment comprises all areas within 175m of the central alignment or construction compounds and areas within 200m of road links where changes in air quality are predicted to occur.

12.3 IMPACT ASSESSMENT METHODOLOGY

12.3.1 Introduction

The source and type of all potential impacts is described in Section 12.4.1. Mitigation measures to be put in place are defined in Section 12.4.2. Mitigation measures are defined for any adverse impacts that are deemed to be of Medium or greater significance prior to mitigation. The extent to which mitigation is needed increases as the significance of the impact increases. The residual effect of each impact is then evaluated in Section 12.4.3 in terms of magnitude and significance.

The impact that the scheme will have on air quality is assessed after the first year of construction 2011. The impact that the scheme will have on air quality during operation is assessed for 2029. Predicted changes in traffic flows for the do minimum and do metro years of 2011 and 2029 are described in the Baseline Traffic chapter (Volume 1, Chapter 15) and the Traffic Impact chapters (Volume 2, Chapter 7) of this EIS.

12.3.2 Assessment methodology for dust

For the purposes of this study, dust is taken to mean the particles released that have the capacity to cause annoyance to neighbours, through soiling of surfaces, such as windows and cars. There are no legal standards relating to acceptable levels of deposited dust, although monthly mean deposition rates in excess of 200 mg m^{-2} day^{-1} are considered likely to cause a nuisance (Schofield and Shillito, 1990). A risk-based approach has been developed for the purpose of the EIS to identify significant potential impacts. This risk evaluation matrix has been devised and is presented in Table 12.1.

The criteria detailed in the table have been devised in consideration of studies by the Building Research Establishment (BRE) which suggests that nuisance is unlikely to occur at distances greater than 50m from a construction site boundary (BRE, 2003). One particular study (Baughan, 1980) has also shown that at least half the people living within 50m of the site boundary of a road construction scheme were 'seriously bothered' by construction nuisance due to dust, but that beyond 100m less than 20% of the people were 'seriously bothered'. Construction sites are also temporary in nature and some degree of nuisance is normally tolerable if the activity lasts for no more than a few months.

Table 12.1 Evaluation of Potential Significant Effects of Dust Deposition, with control measures in place

Duration of on-site dust raising activity	Distance from Site Boundary to Sensitive [(a)] Receptors (m)		
	< 50 m	50 – 100 m	> 100 m
> 12 months	Significant	Significant	Potentially Significant
6 – 12 months	Significant	Potentially Significant	Not Significant
< 6 months	Potentially Significant	Not Significant	Not Significant

(a) Sensitive receptors defined as: residential, commercial office, hospital, surgery etc

12.3.3 Assessment methodology for vehicle emissions

The Transport Analysis Guidance (TAG) of the UK's Department for Transport (2004) and the Design Manual for Roads and Bridges (DMRB) Air Quality Assessment (Highways Agency, 2003) have been used to assess the scheme with respect to the pollutants that relate to road traffic i.e. nitrogen dioxide (NO_2) and particulate matter (PM_{10} or $PM_{2.5}$), and the greenhouse gas, carbon dioxide (CO_2). These tools have been selected because they are the best tools available in terms of allowing the user to assess impacts across many roads in a network, rather than simply considering individual roads in isolation.

In order to protect our health, vegetation and ecosystems, the EU has set down air quality standards in member states for a wide variety of pollutants. On the 14th April 2008 the European Commission adopted the Directive on Ambient Air Quality and Cleaner Air for Europe 2008. This directive merges four earlier directives and one Council decision into a single directive on air quality, all of which have been transposed into Irish law through the Environmental Protection Agency Act 1992 (Ambient Air Quality Assessment and Management) Regulations (S.I. No. 33 of 1999).

The new directive has not yet been transposed into Irish law, but does not introduce any new air quality limit values, except for the approach to particulate matter. Whereas the previous directive, and Irish law, have a limit value for PM_{10} to be achieved in 2010, the new directive calls for a limit value for $PM_{2.5}$ of 20 µg m^{-3} to be achieved by 2020, with an interim target value of 25 µg m^{-3} by 2015. This limit value will, at some point, be transposed into Irish law and has therefore been adopted as a criterion for this assessment.

A summary of the air quality standards relevant to the Dublin area is shown in Table 12.2.

Table 12.2 Irish Air Quality Standards

Pollutant	Limit Value Objective	Averaging Period	Limit Value (μg m^{-3})	Basis of Application of the Limit Value	Limit Value Attainment Date
NO_2	Protection of Human Health	Calendar year	40	Annual mean	1st January 2010
		1 hour	200	Not to be exceeded more than 18 times in a calendar year	1st January 2010
PM_{10} Stage 1[(a)]	Protection of Human Health	Calendar year	40	Annual mean	1st January 2005
		24 hours	50	Not to be exceeded more than 35 times in a calendar year	1st January 2005
PM_{10} Stage 2[(b)]	Protection of Human Health	Calendar year	(20)	Annual mean	1 January 2010
		24 hours	(50)	(Not to be exceeded more than 7 times in a calendar year)	1 January 2010

(a) Stage 1: 1 January 2005 to 1 January 2010

(b) Stage 2: From 1 January 2010 (no longer part of EU legislation)

12.3.4 Assessment methodology for microclimate

The significance of impacts associated with conversion of vegetated to unvegetated surfaces is assessed through consideration of the area of the land experiencing such a change and the area of vegetated land that continues to remain. If the area of land affected is marginal, then the effect on air temperature and microclimate is insignificant. The areas of land-take associated with the proposed scheme have been calculated on the basis of the following assumptions:

- Temporary land-take inside the CPO-line and in the construction is assumed to be reinstated back to its original state after construction operation;
- Permanent land-take associated with the proposed scheme is converted to permanent hardstanding concreted areas during operation. This is a worst-case scenario assumption because the some of this land may remain vegetated, depending on the limits of deviation associated with the scheme design.
- Cut and cover areas and embankments are assumed to reinstated to their original status after construction.
- For the purpose of the calculations, all construction works are assumed to occur in tandem. The actual planned duration of individual construction work tasks is discussed in Section 12.4.3.1.
- Calculated figures are approximate figures with an estimated margin of error of approximately 10%.

All other potential microclimatic impacts are assessed on a case-by-case basis in consideration of the nature of the area affected and the specific design proposed in the area.

12.3.5 Assessment methodology for climate change

The impact of the scheme with respect to climate change is assessed through consideration of the change in CO_2 emissions that will occur due to traffic changes in response to the proposed scheme.

12.3.6 Assessment criteria

The criteria used to assess the different magnitudes of impact associated with this scheme are shown in Table 12.3. In the case of air quality, five classes of impact magnitude are used. In the case of microclimate and climate change, only four classes of magnitude are used because the precision of the assessment is such that only four classes are required.

Table 12.3 Criteria for assessment of impact magnitude

Criteria	Impact magnitude
Air quality - Change of > 35 µg m^{-3} in ambient NO_2 concentration - Change of > 17.5 µg m^{-3} in ambient PM_{10} concentration - Change of > 17.5 µg m^{-3} in ambient $PM_{2.5}$ concentration - Any change with regards to compliance with any regulatory air quality limit specified in relevant legislation - A substantial change in the area of green areas exerting an influence on the surface energy balance.	very high
Air quality - Change of between 25 and 35 µg m^{-3} in ambient NO_2 concentration - Change of between 12.5 and 17.5 µg m^{-3} in ambient PM_{10} concentration - Change of between 12.5 and 17.5 µg m^{-3} in ambient $PM_{2.5}$ concentration - Any change with regards to compliance with any regulatory air quality limit specified in relevant legislation **Microclimate** - A substantial change in the area of green areas exerting an influence on the surface energy balance. **Climate Change** - More than 25% change in CO_2 emissions	high
Air quality - Change of between 5 and 25 µg m^{-3} in ambient NO_2 concentration - Change of between 2.5 and 12.5 µg m^{-3} in ambient PM_{10} concentration - Change of between 2.5 and 12.5 µg m^{-3} in ambient $PM_{2.5}$ concentration **Microclimate** - Permanent structural impacts such as bridges, roadways, embankments, car park facilities and buildings where cold air 'ponding' and shading may take place. - A moderate change in the area of green areas exerting an influence on the surface energy balance **Climate Change** - 15- 25% change in CO_2 emissions	medium
Air quality - Change of between 1 and 5 µg m^{-3} in ambient NO_2 concentration - Change of between 0.5 and 2.5 µg m^{-3} in ambient PM_{10} concentration - Change of between 0.5 and 2.5 µg m^{-3} in ambient $PM_{2.5}$ concentration **Microclimate** - A minor change in the area of green areas exerting an influence on the surface energy balance - Temporary stockpiling of soils during construction that may cause cold air ponding and shading to take place. **Climate Change** - 5- 15% change in CO_2 emissions	low

Criteria	Impact magnitude
Air quality	very low
- Change of between -1 and 1 µg m^{-3} in ambient NO_2 concentration	
- Change of between -0.5 and 0.5 µg m^{-3} in ambient PM_{10} concentration	
Microclimate	
- Permanent non-structural impacts such as minor landscaping and minor drainage.	
- Air movement generated through movement of the light metro vehicles (LMVs)	
- Immaterial temporary impacts such as minor ground disturbance or non-compacted areas of construction compounds.	
- A very minor change in the area of green exerting an influence on the surface energy balance	
Climate Change	
- 0-5% change in CO_2 emissions	

The significance of impacts is assessed in consideration of the magnitude of the impact and the functional value of the receptor or nature of the receiving environment in which the impact has an effect.

12.4 IMPACT ASSESSMENT

12.4.1 Impact identification

12.4.1.1 Dust

For the purposes of this study, construction dust is taken to mean dust particles that have the capacity to cause annoyance to neighbours, through soiling of surfaces, such as windows and cars.

Sources of such dust include material stockpiles and other dusty surfaces, which may be disturbed by wind action. Dust of this type may also be thrown up by mechanical action, due to activities such as the movement of tyres on a dusty road, drilling or demolition. General construction works may cause occasional rather than continuous emissions of dust, as only certain activities (such as grinding and cutting) will result in dust emissions. Black smoke particles may also occur where hot bitumen is used to carry out tarmac laying. Ventilation shafts can also act as a minor source of dust above ground. Dust is generated underground through the action of train braking and friction wear on the tracks, together with a small biological component from the passengers themselves. Ventilation shafts transfer dust particles from underground tunnels and emit them to the open atmosphere.

The quantity of dust released during construction depends on a number of factors, including:

- the type of construction activities occurring (e.g. crushing and grinding);
- the volume of material being moved;
- the moisture and silt content of the materials;
- the distance travelled on unpaved roads;
- the area of exposed materials;
- the mitigation measures employed.

The effect of dust also depends on the wind direction and the distance between the dust source and receptor. Dust emissions arising from construction activities have the potential to cause nuisance both within the construction site and outside the site boundary. Accumulation and settling of particles on surfaces close to the point of release may occur leading to soiling of property, windows, cars or laundry. Such dust affects amenity, as the particles are mostly of sufficient size that they are visible. In industrial and commercial premises dust can cause soiling of goods, abrasion of moving parts in the plant and clogging of filters, if present in sufficient quantity. The generation of dust can also lead to increases in levels of particulate matter; this will have impacts on human health. It is also important to consider whether the dust has been generated through the disturbance of contaminated ground.

12.4.1.2 Vehicle emissions

Local emissions of NO_2, PM_{10} and $PM_{2.5}$ are typically emitted from vehicle exhausts and therefore are directly associated with the number of vehicles travelling on local road networks. The change in vehicles numbers as a result of the proposed scheme will therefore have an impact on the concentrations of these pollutants in areas where traffic levels change in response to the scheme. The changes in traffic that will occur are described in the Traffic chapter of this EIS (Volume 2, Chapter 7). NO_2, PM_{10} and $PM_{2.5}$ emission can have a potential impact on human health as described in the Human Health chapter of this EIS (Volume 1, Chapter 8).

12.4.1.3 Microclimate

The principal change to microclimate would occur through the replacement of a previously vegetated surface with paved surfaces. If this change occurred over a sufficiently large area, a change in the surface energy balance would occur, as moisture evaporation from the soil beneath the paved surfaces is eliminated and more of the available solar radiation is used to heat air rather than to evaporate water transpired by plants and trees. This could potentially have a discernible effect on air temperature, especially as a cooling effect in summer, and exacerbate the Urban Heat Island (UHI) effect, as described in the baseline Air and Climatic Factors chapter of this EIS (Volume 1, Chapter 20).

During the construction phase, vegetated surfaces may be replaced with compacted or paved surfaces that are not vegetated. Examples include construction compounds, embankments, stockpiles and other temporary features that may lead to the disruption or destruction of existing vegetation. Vegetated surfaces may also be replaced permanently due to the above ground operational structures of the scheme (e.g. track form, Park & Ride facilities, stops)

Alterations of the direction and speed of air flow may occur, due to large structures associated with the proposed scheme. The movement of LMVs on the track can potentially generate localised wind turbulence if the vehicles are moving at significant speeds. The construction of new elevated pedestrian crossings can expose pedestrians to wind turbulence and compromise pedestrian safety.

Similarly, large structures can also lead to changes in lighting and shade. This can impact on visibility. This impact is usually only significant if the barriers are solid and if sensitive areas are located in close proximity. Cold air can also accumulate behind physical barriers, such as buildings and embankments, thereby blocking nocturnal drainage flows and increasing the potential for incidence of 'frost hollows' and ice.

These frost hollows and ice can impact on crops in an agricultural setting or create slip hazards on thoroughfares. These artificial frost hollows only typically occur if relatively solid barriers are created across valleys, where cold surface air would otherwise drain away during the night.

12.4.1.4 Climate change

Greenhouse gases are gases that exist in the earth's atmosphere and that contribute to global temperatures by reducing the loss of heat into space. This 'greenhouse effect' is a natural essential phenomenon in that without it, the planet would be cold and uninhabitable. However, the creation of excess greenhouse gases can lead to adverse impacts associated with excessive increases in global temperature. The major greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases. Significant sources of methane, nitrous oxide or fluorinated gases cannot be associated with the proposed scheme. Traffic emissions are considered to be a significant source of carbon dioxide and this source of impact is considered in the EIS.

12.4.2 Mitigation measures

12.4.2.1 Dust

It is not possible to eliminate completely emissions of dust from construction sites. However, there are a number of good site practices that will be implemented to reduce the risk of dust effects arising during construction:

- All materials with the potential to cause dust will be covered during transport;
- Wheel washing facilities will be installed in all relevant construction sites and will be used by vehicles leaving the site;
- All material stockpiles with the potential to generate dust will be covered or dampened as necessary to minimise the potential for creation of dust. Particular precautionary measures will be undertaken if stockpiles comprise hazardous materials. Such measures will be agreed with the relevant authorities prior to commencement of the activity such that no adverse impact on the environment or human health is allowed to occur at any stage.
- Water suppression or dust extraction will be fitted where possible to construction equipment that has the potential to generate dust e.g. drilling, cutting and grinding equipment;
- On-site vehicle speeds on unhardened roads and surfaces will be limited to less than 20 mph;
- Drop heights for material transfer activities such as unloading materials will be minimised;

- Surfaces that are to be excavated or cleared will be dampened prior to clearing or excavation where there is potential for excessive dust to be created;
- Bowsers or similar equipment will be available for use in construction compounds to wash down surfaces and roads, particularly in periods of dry weather.

Tarmac laying and the associated use of hot bitumen can generate significant amounts of black smoke particles. This will be minimised by the application of the following measures suggested by the Building Research Establishment (BRE, 2000):

- bitumen will not be overheated and where possible, bitumen will not be heated with open flame burners;
- pots and tanks containing hot bitumen will be covered to minimise fume production;
- spillages will be minimised.

12.4.2.2 Vehicle emissions

The measures to be taken to minimise the potential for traffic generation and congestion, and associated emissions of PM_{10} and NO_2, are described in the Traffic chapter of this EIS (Volume 2, Chapter 7).

12.4.2.3 Microclimate

A powerful method of off-setting the loss of vegetated surfaces is to plant trees, which have a large leaf area and transpire large quantities of water and thereby exert a significant cooling effect in summer. A summary of the key planting measures to be implemented at numerous locations across the entire scheme is provided in this section. For detail regarding where exactly these measures are to be implemented, please refer to the Landscape and Visual chapter (and Landscape Insertion Plans) of this EIS (Volume 2, Chapter 13).

- As much existing vegetation as possible is to be retained within and adjacent to the scheme. Trees that are to be retained will be protected in accordance with BS5837;
- Planting and/or hedgerow is to be introduced to compensate for vegetation loss;
- Planting is to be introduced on earthwork embankments and construction compounds to facilitate the reinstatement of these areas.

All bridges have been designed in accordance with appropriate safety design standards.

12.4.2.4 Climate change

The measures to be taken to minimise the potential for traffic generation and congestion, and associated emissions of CO_2, are described in the Traffic chapter of this EIS (Volume 2, Chapter 7).

12.4.3 Assessment of residual impacts

12.4.3.1 Project scenario: construction phase

Dust

Sources

Area MN107 contains 3 construction compounds. Compound 17 and 18 are Stop Box compounds. These are compounds set up at the location of the proposed underground stops and will facilitate the construction of the stop boxes. The compounds will contain;

- Project offices and staff welfare facilities;
- A stabling area for piling rigs including maintenance facilities;
- An assembly area for steel cage fabrication / piles and storage;
- Provision for reception of 'ready mix' concrete wagons.

Compound 19 is a TBM Extraction compound. These are compounds set up to enable the TBMs to be dismantled and extracted for transfer to a new launch site or removal from the site having completed tunnelling operations.

The route within Area MN107 is in bored tunnels and, therefore, the tunnel construction will cause no potential dust formation, except possibly at either end of the bored tunnel. The stop box compounds, however, will have some potential for dust generation and over a period of greater than 12 months. At St. Stephen's Green, a loop tunnel will be constructed from the south end of the stop. Traditional drill and blast methods will be used to construct the loop tunnel, which will generate dust.

Sensitive Receptors

Maps (Air and Climatic Factors Baseline and Impact) included in Volume 3, Book 1 of 2 shows the boundaries of Area MN107 with dust buffers around construction compounds at 50m, 100m and 150m intervals. The alignment and construction compound boundaries have been used as the point from which to measure the distance contours because it is not possible at this stage to pinpoint the actual locations of potential dust generating activities within specific construction compounds. In reality, the actual project worksites are likely to be much more limited in their spatial extent than the project boundary would indicate.

Table 12.4 summarises the potential (non residential) receptors that are within 150m of the alignment and construction compounds. However, as the proposed scheme in Area MN107 will be constructed in bored tunnels a number of these receptors will not experience any impact, as there will be no resulting emissions of dust to ambient air.

Table 12.4 Summary of Potential Receptors to Construction Dust

Distance from site boundary (m)	Receptors
< 50m	- Rotunda Hospital[a] - Trinity College - Church of Ireland converted Tourist information office, shops and restaurants - Royal College of Surgeons[a]
50 –100m	- DIT College Food and tourism department[a] - School of music
100 – 150m	- Belvedere School, Swimming Pool and Community Uses[a] - Trinity College[a]

Note: (a) receptors close to construction compounds

Sensitive receptors in Area MN107 include schools, hospitals (shown in Table 12.4) and residential properties located close to the 3 construction compounds. Patients at Rotunda hospital, located within 50m of the construction compound, may experience impacts on health from dust, which may be significant. The only sensitive residential receptors in Area MN107 are located close to Compound 16 where the Parnell Square Stop will be located. As these sensitive receptors are located in such close proximity to construction compounds, it is expected that they will be subject to fugitive dust emissions. There will be activity in the compounds over a period of more than 12 months and therefore the impacts are assessed as being significant. The residential properties to the north are located more than 100m away from the compound and are, therefore, less likely to experience dust deposition.

Vehicle emissions

Changes in NO_2 and $PM_{2.5}$ across the entire scheme in comparison to regulatory limits

Many of the changes described in the previous section do not lead to breaches of any regulatory limits. As described in the Baseline Air and Climatic Factors chapter of this EIS (Volume 1, Chapter 20), air quality along 3 road links of the traffic network of the scheme is predicted to breach the NO_2 limit value of 40 µg m^{-3} in 2011 if the scheme is not implemented. If the scheme is implemented during construction, air quality at these 3 road links does not improve and breaches of the limit value persist. The breaches are not attributable to the scheme and therefore are not discussed any further.

The net result of the construction of the proposed scheme in 2011 is that the NO_2 concentration alongside a further 1 road link is predicted to exceed the NO_2 limit value of 40 µg m_{-3}. Table 12.5 shows the street link where a new marginal breach of the NO_2 limit value is predicted to occur in 2011, as a result of the construction phase of the alignment. This street link occurs within Area MN101.

Table 12.5 Street links where a new breach of the NO_2 limit value (40 µg m^{-3}) is predicted to occur in 2011

Road link	Street name	Magnitude of Change (µg m^{-3})	New Concentration (µg m^{-3})	Distance from Alignment
NO_2				
3562_3560	Link road from M1 Northbound to R127 north of Lissenhall	13.53	40.7	Between 500m and 1km

Source: Road names provided by MVA traffic consultants

The magnitude of change in NO_2 concentrations is 13.53 µg m^{-3}. This adverse impact would therefore normally be considered to be of medium magnitude because a change of between 5 and 25 µg m^{-3} in ambient NO_2 concentration occurs. However, this change leads to a breach of the 40 µg m^{-3} NO_2 limit value and therefore the impact is considered to be of high magnitude. As set out in the baseline Air and Climatic Factors chapter of this EIS (Volume 1, Chapter 20), any areas where a potential breach of any regulatory limit may occur are considered to be of very high functional value. This impact is therefore considered to be of High significance.

The scheme does not have any impact in terms of changes in compliance or non-compliance with the limit values for PM_{10} or $PM_{2.5}$ in any area.

Changes in NO_2 and $PM_{2.5}$ across the entire scheme

Changes in NO_2 and PM_{10}/$PM_{2.5}$ concentration (µg m^{-3}) for 2011 (the first year of construction) are presented in Table 12.6 for two scenarios: if the scheme is not implemented and if it is implemented. The table shows the number of road links that will experience air quality improvements and degradations. The extent of change that will occur has been evaluated using the criteria detailed in Table 12.3 and the links on which changes will occur have been categorised into the relevant magnitude classes. It is assumed that vehicle exhaust is essentially all in the form of $PM_{2.5}$ and therefore may be thought of as contributing to PM_{10} or $PM_{2.5}$ concentrations equally.

Table 12.6 Road links with changes in NO_2 and PM_{10}/$PM_{2.5}$ Concentration (µg m^{-3}) from 2011 Do Minimum to 2011 With Metro

	Number of links with			
Impact Magnitude	Degradation in Air Quality with respect to NO_2 Concentration (µg m^{-3})	Improvement in Air Quality with respect to NO_2 Concentration (µg m^{-3})	Degradation in Air Quality with respect to PM_{10}/$PM_{2.5}$ Concentration (µg m^{-3}) [a]	Improvement in Air Quality with respect to PM_{10}/$PM_{2.5}$ Concentration (µg m^{-3}) [a]
high	0	0	0/0	0/0
medium	5	7	0/3	0/8
low	108	46	34/77	23/44
very low	12,318 [b]		12,427/12,352 [b]	

(a) Although the magnitude of the $PM_{2.5}$ and PM_{10} concentration changes are equal, the assessment criteria are not and so the impacts are distributed differently across the categories.

(b) This is the total number of changes as defined by a very low impact magnitude for both Degradation and Improvement combined

All of the changes in NO_2 and PM_{10}/$PM_{2.5}$ concentrations are of medium to very low magnitude. These changes are of Low significance.

Microclimate

During the construction phase, existing vegetated areas within Area MN107 will be temporarily converted to unvegetated areas due to the development of construction compounds, embankments and localised movement of plant and construction vehicles. The main sources of land-take are outlined in Table 12.6.

Table 12.7 Significant sources of temporary land-take within Area MN107

Land-take	Approximate area	Duration of land-take
Compound 17 – Parnell Square	3,500m²	4 years approx
Compound 18 – O'Connell Bridge	11,500m²	4 years approx
Compound 19 – St. Stephen's Green	19.000m²	4 years approx
Total	34,000m²	

Area MN107 is dominated by hardstanding areas. Compound 18 is to be located in an existing hardstanding area. Compound 18 is located primarily in existing hardstanding areas but a deck over the River Liffey is also to be used. Compound 19 occupies and important inner city urban park. The microclimatic impact of the total land-take is therefore considered to be of medium magnitude and Medium significance.

Climate change

Predicted CO_2 emissions in the do minimum year of 2011 are detailed in the Baseline Air and Climatic Factors chapter of this EIS (Volume 1, Chapter 20). The annual CO_2 emissions from vehicles during construction that will be produced in 2011 if the scheme is implemented are detailed in Table 12.8 along with the percentage change relative to baseline emissions.

Table 12.8 CO_2 Emissions from Network in 2011 (tonnes annum^{-1})

Do Metro 2011 (tonnes annum^{-1})	Change relative to baseline (%)
2, 671,268 [a]	+0.6 %

(a) Estimated using DMRB methodology

The magnitude of change in CO_2 emissions in 2011 during construction if the scheme goes ahead is very low and is, therefore, of no significance. The slight increase arises through a slight reduction in overall vehicle speeds on parts of the network and the additional traffic associated with construction activity.

12.4.3.2 Project scenario: operational phase

Modelling results for 2014, the first operational year of the scheme, showed less of an influence on air quality than for 2029; therefore, these results have not been discussed in detail in this section. They are however presented in the technical report included as Annex I (Volume 3, Book 2 of 2). The 2029 results reflect the worst case scenario and are detailed in the following sections.

Dust

The ventilation shafts located at the stops within this area represent a very minor source of particulate matter emissions. Measurements carried out elsewhere, e.g. on the London Underground, have shown that quantities of PM_{10} emitted underground are not large when compared with road traffic. This is not a significant problem for passengers, as their typical exposure times are small and concentrations are acceptable by reference to occupational exposure levels for workers.

The shaft does not represent a significant source of environmental PM_{10} emissions because it merely transfers PM_{10} at the concentrations found underground and emits them to the open atmosphere, where they immediately become diluted by a factor of a hundred or more, even quite close to the shaft. Ventilation shafts have been the subject of some anxiety by residents in London when the Jubilee line was constructed and during the recent Crossrail application. Monitoring conducted at a shaft on the Jubilee Line and reported as part of the Crossrail application showed conclusively that it did not contribute to local PM_{10} concentrations.

Vehicle emissions

Changes in NO_2 and $PM_{10}/PM_{2.5}$ across the entire scheme in comparison to regulatory limits

As described in the Baseline Air and Climatic Factors chapter of this EIS (Volume 1,Chapter 20), air quality along six road links of the scheme within the 50m band alongside the road are predicted to breach the NO_2 limit value in 2029 if the scheme is not implemented. If the scheme is implemented, air quality at these six road links improves such that breaches of the limit value no longer occur. The six relevant links are shown in Figure 12.1.

The magnitude of improvement in NO_2 concentrations for the majority of the six links shown in Figure 12.1 is between -10 and -20 µg m^{-3}. This positive impact would normally therefore be considered to be of medium magnitude. However, the changes are such that breaches of relevant legislative limits no longer occur. The impacts are therefore considered to be of high magnitude and Medium significance.

Table 12.9 Street links where improvements in NO_2 concentrations result in compliance with the NO_2 limit value (40 µg m^{-3}) in 2029

Road link	Street name	Magnitude of Change (µg m^{-3})	New Concentration (µg m^{-3})	Distance from Alignment
NO_2				
5165_5144 (b)	Taney Road	-18.11	26.28	More than 5km
5014_5011 (b)	N11	-18.47	25.95	Between 3km and 4km
4250_4210 (b)	N7 Eastbound	-12.01	29.19	More than 5km
1833_1832	Oscar Traynor Road	-26.10	27.24	Between 2km and 3km
1415_1408	Berkeley Road	-17.51	24.99	Between 250m and 500m
2013_2012	Junction between College Green, Westmoreland Street and College Street.	-11.32	32.65	Less than 250m

(a) North of the alignment

(b) South of the alignment

Source: Road names provided by MVA traffic consultants

The result of the implementation of Metro North in 2029 is that there will only be one road link where NO_2 concentrations are predicted to exceed the NO_2 limit value. This is part of the Red Cow Roundabout. The link is shown in Figure 12.1 and Table 12.10.

The magnitude of increase in the annual average NO_2 concentration for this link is approximately 13 µg m^{-3} and causes a marginal breach of the regulatory limit. This negative impact is therefore considered to be of high magnitude and of Medium significance.

Table 12.10 Street link where a new breach of the NO_2 limit value (of 40 µg m^{-3}) is predicted to occur in 2029

Road link	Street name	Magnitude of Change (µg m^{-3})	New Concentration (µg m^{-3})	Distance from Alignment
NO_2				
4221_4220 (b)	Part of the Red Cow Roundabout, going from the East to the West (4221 to 4220), roundabout linking Western Parkway, R110 and Naas Road	12.98	41.41	More than 5km

(b) All links are South of the alignment

Source: Road names provided by MVA traffic consultants

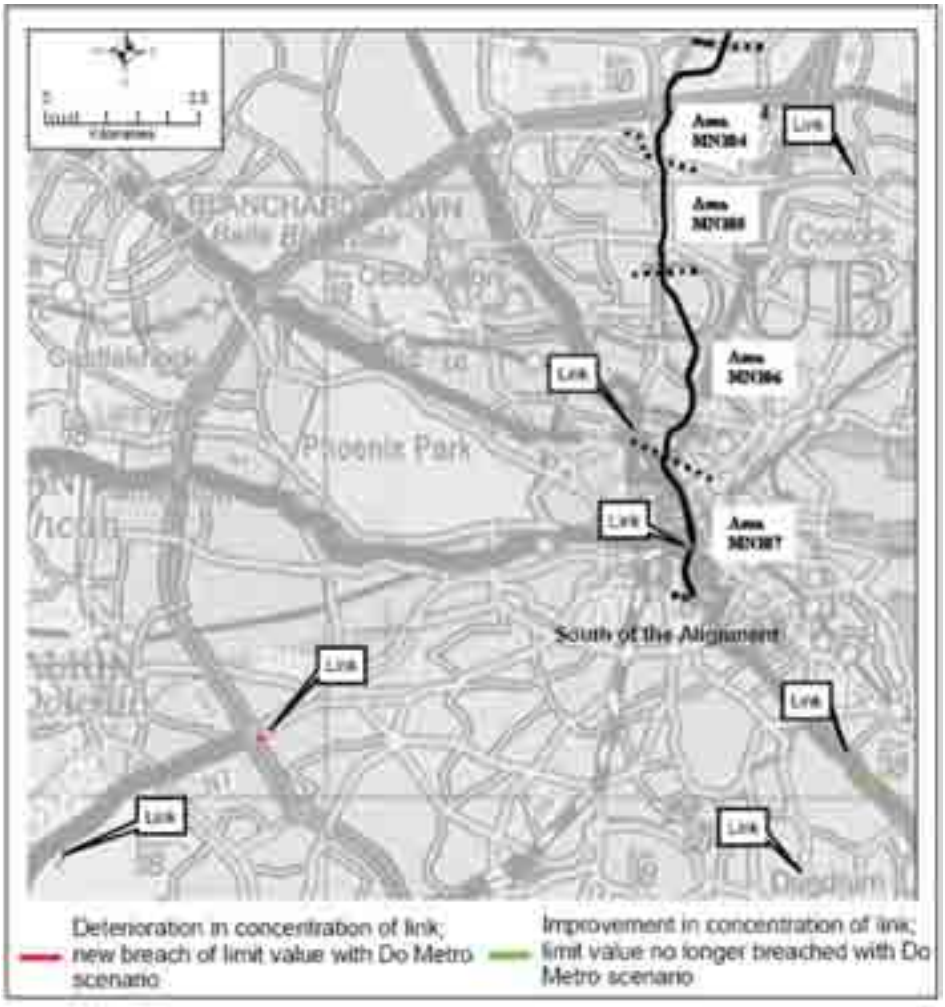


Figure 12.1 Road links where changes in compliance with regulatory NO_2 levels occur

If the proposed scheme is implemented, PM_{10}/$PM_{2.5}$ concentrations will decrease substantially alongside several road links. The scheme does not have any implications in terms of compliance with PM_{10}/$PM_{2.5}$ limit values.

Changes in NO_2 and PM_{10}/$PM_{2.5}$ across the entire scheme

Changes in NO_2 and PM_{10}/$PM_{2.5}$ concentration (µg m^{-3}) for 2029 are presented in Table 12.11 for two scenarios: if the scheme is not implemented and if it is implemented. The table shows the number of road links with air quality improvements or degradation related to the magnitude of concentration changes for both NO_2 and PM_{10}/$PM_{2.5}$.

Table 12.11 Road Links with changes in NO_2 and PM_{10}/$PM_{2.5}$ Concentration (µg m^{-3}) from 2029 Do Minimum to 2029 With Metro

	Change in NO_2 Concentration (µg m^{-3})		Change in PM_{10}/$PM_{2.5}$ Concentration (µg m^{-3})	
Impact Magnitude	Number of links with Degradation in Air Quality	Number of links with Improvement in Air Quality	Number of links with Degradation in Air Quality	Number of links with Improvement in Air Quality
high	0	1	0/0	0/0
medium	47	45	0/7	3/14
low	595	536	68/184	63/198
very low	11,404 [(a)]		12,225 [(a)]	

(a) This is the total number of insignificant positive and negative changes as defined by a very low impact magnitude

All of the changes in NO_2 and $PM_{10}/PM_{2.5}$ concentrations are of medium to very low magnitude. These changes are of Low significance.

Microclimate

Permanent land-take in this area occurs to facilitate structures such as the above ground structures associated with Parnell Square Stop, O'Connell Bridge Stop and St. Stephen's Green Stop. All of these areas of permanent land-take are relatively small and the alignment is located in a bored tunnel throughout this section so the total area of permanent land-take is considered to be of low magnitude and Low significance.

The alignment is underground in this area so significant microclimatic impacts due to LMV movement, cold air pooling, shading, or wind pattern disruption are not expected to occur.

Climate change

Predicted CO_2 emissions in the do minimum year of 2029 are detailed in the Baseline Air and Climatic Factors chapter of this EIS (Volume 1, Chapter 20). The annual CO_2 emissions from vehicle emissions that will be produced in 2029 if the scheme is implemented are shown in Table 12.12, along with the percentage change relative to baseline emissions.

Table 12.12 CO_2 Emissions from Network in 2029 (tonnes per annum)

Do Metro 2029 (tonnes annum^{-1})	Change relative to baseline (%)
3,096,110 [(a)]	- 0.6 %

(a) Estimated using DMRB methodology

The magnitude of change in CO_2 emissions in 2029 if the scheme goes ahead is low and is, therefore, insignificant. The decrease is a result of a combination of traffic re-routing associated with the direct impacts of the proposed scheme on road capacity and the modal shift from car to the rail system. Emission factors are used to predict future emissions; these depend on fuel consumption and the carbon content of fuel. Emission factors decrease in the future as fuel consumption changes with improvements in vehicle efficiency and carbon content from 2008 to 2020 will reflect the introduction of bio-fuels.

O'Connell Bridge Stop