Armagh East Link

Stage 2 Scheme Assessment Report

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Background to the Scheme

In 2004 Department for Infrastructure (DFI) formerly Transport NI (TNI) (formerly Roads Service) commissioned Mouchel (now WSP) to investigate options for the proposed Armagh East Link Road.

The Armagh East Link is proposed to the east of the city centre, with termination points on the A28 Markethill Road to the south and the A3 Portadown Road to the north. A junction with the A51 Hamiltonsbawn Road shall also be incorporated into the proposals.

The scheme objectives are to:

- Improve journey times for both strategic and local traffic in and around Armagh City Centre;
- Improve road safety by relieving congestion in Armagh City Centre;
- Improve the road network between the North and South of the Province;
- Develop a scheme offering value for money.

In addition to the above the scheme has the potential to realise some secondary benefits including:

- Facilitate future development to the east of the city and;
- Relieve congestion on associated key routes to improve the environment of the historic city centre.

A joint Public Information Day to explain the principles behind the various options for the East Link and the North-West Link was held on Monday 13th March 2006, at the Armagh City Hotel.

In August 2006 a preferred route corridor was identified in the Stage 1 Scheme Assessment Report from three alternatives;

- An Inner Option that would extend northwards to the west of the Armagh Baptist Church, following the course of the Ballynahone River before crossing the A51 by the Kingston Memorial Playing Fields, then utilising the existing Victoria Road and Drumadd Road corridors to connect to the A3 at an existing mini-roundabout;
- A Central Option which utilised the existing Ardmore Road from its junction with the A28 Markethill Road, which then ran northwards to meet the Ballynahonemore Road, crossing the A51 Hamiltonsbawn Road adjacent to the city's barracks, before continuing northwards alongside the barracks to meet the A3 Portadown Road at Linsey's Heights;
- An Outer Option which would run northwards from an improved junction of the A28 and Edenaveys Road. The existing Edenaveys Road would be widened, forming the southern section of the East Link, and extended via a short section of new road to join the A51 at a new four-way junction. The northern section would be new road from the A51 to join the A3 at an improved five-arm roundabout with Drumman Heights and Killuney Road.

Figure 1 highlighting the location of the three corridors from the SAR 1 report is contained in the Background and Executive Summary Figures at the end of this report before Appendix A.

The Inner Option was found to be the least feasible due to the potential adverse impacts on the Ballynahone River, the extensive retaining structures likely to be required beside it, and the potential for large-scale disruption owing to the construction of the new road on the existing road network. The Outer Option was considered to be less disruptive to construct, with an environmental impact comparable to the Central Option, however it was considered that the additional costs associated with greater distance between the A3 and the A28, higher potential for accommodation structures between severed land parcels and extensive earthworks, made this corridor less feasible.

The Stage 1 Scheme Assessment Report concluded that the Central Option for the proposed scheme was the most feasible of those proposed.

A further Public Exhibition Day for the Armagh East Link scheme was held on the 20th March 2007 to update the public on scheme developments and present the alignment option for the scheme which had been identified as the preferred route.

A Stage 2 Scheme Assessment Report (2007) focused on two main alignment options within the Central Route Corridor:

- The Purple Alignment Option
- The Red Alignment Option

Figure 2 highlighting the location of the two main options from the 2007 SAR2 report is contained in the Executive Summary Figures at the end of the body of this report before Appendix A.

The Stage 2 report recommended that The Purple Route was developed further as the design for the East Link. Whilst the Environmental Assessment slightly favoured the Red Route, the Traffic and Economic and the Engineering Assessments favoured the Purple Route. It was considered that the adverse aspects of the Purple option in environmental terms could be largely mitigated within the land available. The Purple Option became the 2007 Option.

Due to the 2008/2009 economic downturn, progress on a number of DFI schemes, including Armagh East Link, slowed down as public expenditure decreased. In 2014 a decision was taken to update members of the public, elected representatives and other interested parties on the status of the 2007 Option, and gain valuable feedback on the proposals in the intervening period. A Public Information Day was held on the 11th June 2014 where an increased level of public concern relating to integration, accessibility and safety was noted at the southern tie in (A28 Markethill Road) of the scheme. Queries were also raised regarding the development of Edenaveys Industrial Estate between 2007 and 2014, and whether a tie in to the A28 Markethill Road in that vicinity would be a viable alternative.

In light of the information gleaned from the event, given the changes in land use and potential traffic flows and patterns of movement within the study area, the validity of the 2007 Option was reassessed with consideration given to alternative options, ten in total, including options within the Central and Outer corridors identified in the Stage 1 Assessment.

Following on from the Public Information Day and development of alternative route options a workshop was held on Friday 27th February 2015 to review the potential route options to the East of Armagh. The workshop concluded four out of the ten proposed options, including the 2007 Option, should be brought forward for further design and appraisal with recommendations for a number of actions to be completed.

Figure 3 highlighting the four options brought forward is contained in the Executive Summary Figures at the end of the body of this report before Appendix A.

A Route Assessment Report was carried out which reviewed the four potential options and concluded that only three of the options should be brought forward for assessment within the scope of this Stage 2 Scheme Assessment.

Option 50 was not taken forward due to the scheme not meeting the objective of improving safety. The reason for this was identified as being the significant volume of traffic which would utilise Hamiltonsbawn Road as a result of the introduction of the link road in this location. It was identified that Hamiltonsbawn Road in particular has a high density of accidents based on poorer horizontal and vertical alignment when compared with the A3 and A28 corridors and therefore the option was not considered to improve safety in the area.

Report Summary

The report considered the following;

- Engineering Assessment
- Environmental Assessment
- Traffic and Economic Assessment

The intent of this report was to update the previous Stage 2 assessment. The majority of the data acquisition and assessments including traffic, air quality and noise, have all been updated since the 2007 SAR2, with new data acquired when appropriate following the Public Consultation exercise undertaken in June 2014.

The Engineering Assessment has identified that in key areas such as land take, cut/fill earthworks volumes and the requirement for structures the 2007 Option is the more favourable of the options assessed. No significant differences have been highlighted between the routes with regard to hydrology and only a marginally higher impact on utilities for the 2007 Option was identified.

The environmental assessment concludes that there are no significant barriers to the development of the route options proposed. However, it recognises that, with regard to noise and visual amenity, further consideration at detailed design stage is required to identify appropriate mitigation to address any adverse effects, particularly for the 2007 Option which has a higher number of sensitive receptors such as residential properties in the Ardmore Area.

The environmental assessment also recognised that all options have the potential to include elements which could reduce community severance and provide better walking / cycling facilities by providing enhancements which would benefit the local non-motorised user network.

Traffic and Economics Assessment Forecast results show that each of the proposed route options will assist in providing moderate relief to congestion in the city centre and

will provide increased capacity which will improve speed and journey times on the eastern side of the city.

The economic assessment of the proposed routes show that only one of the scheme options, the 2007 Option, provides a Benefit Cost Ratio higher than one i.e. a positive return on investment (value for money). In addition, the 2007 Option has the highest savings from accident reductions and the highest NPV (Net Present Value of benefits).

A breakdown of scheme costs and benefits is provided in Figure 4 of the Executive Summary Figures at the end of the body of this report before Appendix A.

Recommendations

Considering the key areas of assessment outlined above this report recommends that the 2007 Option is taken forward to Stage 3. The proposed route has been identified as having the highest return on investment, is more favourable with regard to engineering constraints and has no significant barriers with regard to environmental impact.

In addition, the 2007 Option addresses the objectives outlined at the outset of this report;

- Improve journey times for both strategic and local traffic in and around Armagh City Centre;
- Improve road safety by relieving congestion in Armagh City Centre;
- Improve the road network between the North and South of the Province;
- Develop a scheme offering value for money.

Within the scope of Stage 3 design development, the junction type and layout at A28 Markethill Road, A51 Hamiltonsbawn Road and A3 Portadown Road shall be finalised.

Design development of the selected preferred route shall be undertaken to allow the Environmental Impact Assessment Report (EIAR), identifying appropriate mitigation, and draft Statutory Orders to be published subject to funding. The EIAR process as outlined in draft DEM 176/18 DEM TITLE: DfI Roads Environmental Impact Assessment will be followed throughout the development of the Stage 3 Scheme Assessment Report.

The quality management system as outlined in DEM 175/18 ‘Environmental communication and quality management strategy for major works schemes’ will also be applied throughout the development of the Stage 3 Scheme Assessment Report.

1. Introduction

1.1. Method of Assessment

1.1.1. The assessment detailed in this report has been carried out in accordance with Roads Service Policy and Procedure Guide (RSPPG) E030 Major Road Improvement Schemes – Inception to Construction, and, TD 37/93, Scheme Assessment Reporting of the Design Manual for Roads and Bridges (DMRB) Volume 5 – Section 1. The purpose of this assessment procedure is to critically evaluate the various corridor options culminating in the selection of a preferred route.

1.1.2. The framework commonly referred to as WebTAG (Web based Transport Analysis Guidance) developed by Department of Transport (DfT), uses four primary assessment criteria - Economy, Environmental, Social and Public Accounts and provides a common appraisal framework for the evaluation of transport related policies, programmes and projects in accordance with HM Treasury Guidance. A WebTAG based appraisal has been undertaken as part of this Stage 2 Preferred Option Assessment and Appraisal Summary Tables are contained within *Appendix B*.

1.1.3. The report has been compiled in accordance with DMRB TD 37/93 Scheme Assessment Reporting, RSPPG E030 and WebTAG as outlined in Section 1.3 above. Following the Introduction, the report is set out as follows:

- Section 2 presents the Existing Conditions
- Section 3 provides a Description of Scheme Options
- Section 4 details the Engineering Assessment
- Section 5 details the Environmental Assessment
- Section 6 details the Traffic and Economic Assessment
- Section 7 presents the scheme Conclusions and Recommendations

1.1.4. During the development of this report Mouchel Limited have become part of WSP, therefore, several of the drawings and tables contained within this report remain labelled as Mouchel documents.

2. Existing Conditions

2.1. Description of the Current Highway Network

2.1.1. Armagh City is the administrative centre of Armagh District, which is an essentially rural district with a population of around 59,340 residents according to the 2011 Northern Ireland census and lies around 35 miles south west of Belfast (see Figure 2.1 below). Armagh City is the commercial and retail hub of the area, and accounts for approximately 30% of the district's population.

2.1.2. The city lies at the intersection of two Link Corridors that form part of the Regional Strategic Transport Network, namely A3 linking Portadown, Armagh and towards Monaghan, and, A28/A29 linking Newry, Armagh, Dungannon, Cookstown and Maghera to Coleraine. Belfast can be reached from the north-east of the city via A3 and M1, while Warrenpoint harbour can be reached from the south of the city via A28 and A2.

2.1.3. The A28 Markethill Road forms part of the trunk road network T15, and A3 Portadown Road forms part of the T5 trunk road.

Figure 2-1 - Armagh Location Plan

2.1.4. The proposed Armagh East Link would commence on A28 Markethill Road, travel due north, crossing the A51 Hamiltonsbawn Road and terminate on A3 Portadown Road. These three primary routes would form the main access points to the scheme. Other roads will be accessed from the proposed link where possible and where an alternative diversion is deemed too long. Some roads may be stopped up or kept open using a structure beneath or over the mainline.

A28 Markethill Road

2.1.5. The existing A28 Markethill Road is a 7.3m wide single carriageway, restricted to 30mph from the City centre, increasing to 40mph where it passes Armagh Baptist

Church building, west of the junction with Ardmore Road, finally increasing to 50mph to the rear of No. 36 Markethill Road heading countrybound. Footways are provided in each direction past the existing junction with Ardmore Road. The northbound footway (citybound) terminates opposite the entrance to a car dealership / garage, however a hard shoulder is provided on the northbound carriageway to facilitate breakdowns and emergencies. The junctions onto A28 in this vicinity are mainly ghost island priority junctions, including the junction with Ardmore Road and Edenaveys Road which can be seen in Figure 2-2 and Figure 2-3 below. In these locations the carriageway is widened locally to approximately 10m to accommodate right turn lanes.

Figure 2-2 - Photograph of the existing A28 Markethill Road at Ardmore Road Junction (looking northwest towards Armagh City)

Figure 2-3 - Photograph of the existing A28 Markethill Road at Edenaveys Industrial Estate Junction (looking northwest towards Armagh City)

A51 Hamiltonsbawn Road

2.1.6. The A51 Hamiltonsbawn Road is a 7.3m wide single carriageway road with simple priority side road junctions, providing a link from Armagh with the towns of Tandragee and Gilford to the east. The A51 Hamiltonsbawn Road has pedestrian facilities in each direction from Armagh City to just east of the junction with Hamiltonsbawn Road Industrial Estate as pictured in Figure 2-4 and Figure 2-5 below. From here, a footway is provided on the eastbound carriageway only to its junction with Tirnascobe Road. The road is restricted to 30mph from the City to approximately 70m to the east of Hamiltonsbawn Road Industrial Estate junction, where it becomes de-restricted heading countrybound.

Figure 2-4 - Photograph of the existing A51 Hamiltonsbawn Road at Hamiltonsbawn Road Industrial Estate Junction (looking west towards Armagh City)

Figure 2-5 - Photograph of the existing A51 Hamiltonsbawn Road approximately 150m east of the junction with Hamiltonsbawn Road Industrial Estate (looking west towards Armagh City)

A3 Portadown Road

2.1.7. From Armagh City Centre A3 Portadown Road is a 7.3m (minimum) single carriageway with footways in both directions to the junction with Linsey's Hill as shown in Figure 2-6 below. A controlled crossing is provided to the west of this junction. The length of carriageway between Linsey's Hill and the roundabout at Drumman Heights (shown in Figure 2-7) contains a mixture of simple junctions and ghost island priority junctions onto the A3 with footways and hard shoulders provided in both directions. West of the junction with Linseys Hill, the Drumadd Road links the A3 Portadown Road to the A51 Hamiltonsbawn Road via a mini roundabout, to the east of the decommissioned army barracks (see Figure 2-8 below). The A3 has a speed limit of 30mph from the City to the junction of Mullinure and A3 Portadown Road, where it increases to 40mph, finally increasing to National Speed Limit at Armagh Elim Church, approximately 200m east of Drumman Heights Roundabout.

Figure 2-6 - Photograph of the existing A3 Portadown Road towards the junction with Linseys Hill (looking west towards Armagh City)

Figure 2-7 - Photograph of the existing roundabout linking the A3 Portadown Road with the housing estates at Killuney Road and Drumman Heights (looking west towards Armagh City)

Figure 2-8 - Photograph of the existing mini roundabout linking the A3 Portadown Road with the A51 Hamiltonsbawn Road (looking west towards Armagh City)

2.2. Existing Public Transport Provision

2.2.1. A park and ride facility exists on A3 Portadown Road, at the junction with Drummanmore Road. It provides seventeen spaces (angled between 45-60° to the direction of traffic).

2.2.2. No rail services are provided to Armagh. The closest train stations are Portadown, approximately 11miles to the north-east and Newry approximately 18miles to the south-east.

2.2.3. A network of national bus routes linking Armagh to most major towns and cities in Northern Ireland, (including Newry, Craigavon, Portadown, Dungannon, Ballygawley, Belfast, Portrush and Londonderry) are provided by Translink. The network also provides cross border services to the Republic of Ireland (ROI) serving Monaghan, Cavan and Dublin (via the airport).

2.2.4. Local services from the city serve the Ardmore Estate via A51 Hamiltonsbawn Road and Ballynahonemore Road. This is presented in Figure 2-9 below.

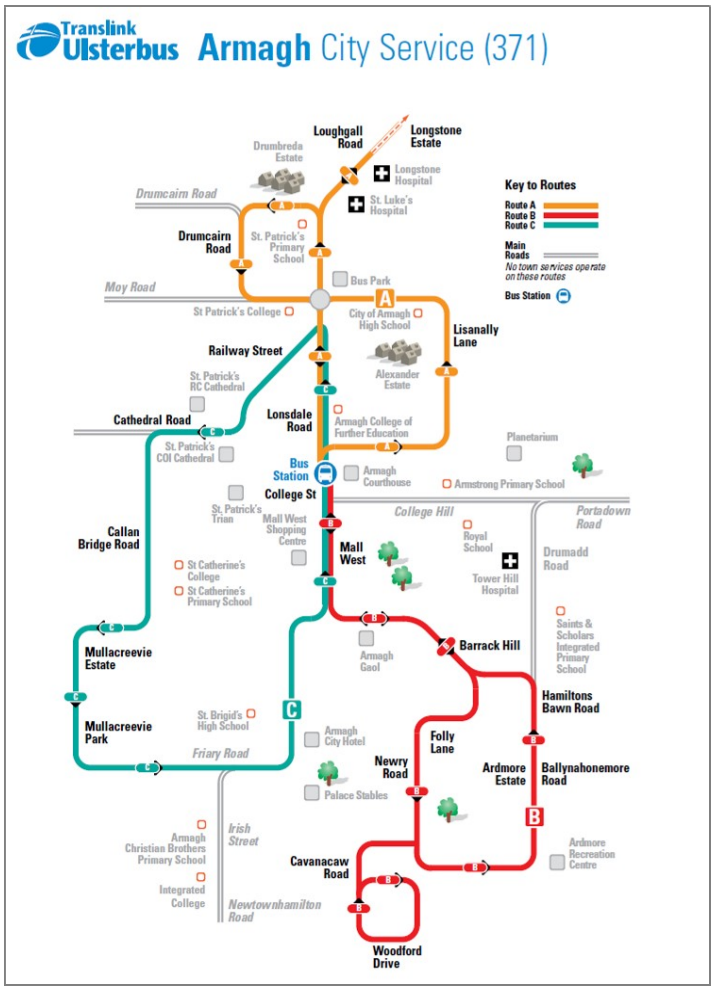

Figure 2-9 - Translink Local Bus Routes for Armagh City

2.3. Existing Traffic Conditions

Traffic Flows

2.3.1. The predominant regional traffic flow through the City occurs along the A28, south east of the city, through the city centre along the A3 (Friary Road and The Mall) to the A3 College Hill and Portadown Road towards Belfast and the north-east of the province. The main north-south route on the eastern periphery of Armagh is currently signed for road users, through the centre of the city, however anecdotal evidence suggests a well-used “rat run” via Ardmore Road (Bannvale Villas), Ballynahonemore Road and Drumadd Road. The routes through the city are constrained by the relatively narrow roads and busy residential and commercial areas through which they pass. Road users experience significant delays due to heavy congestion during the morning and evening peak periods.

2.3.2. Annual Average Daily Traffic (AADT) flows along the A3 Portadown Road to and from Armagh are in the region of 12,000 vehicles per day. Flows along the A28 Markethill Road are in the region of 10,000 vehicles per day with the highest observed flows recorded along Irish Street between Friary Road and A3 Monaghan Road.

2.4. Existing Geotechnical Conditions

Topography

2.4.1. The study area is within the Landscape Character Area (LCA) of the 'Armagh Drumlins', dominated by north-south orientated rolling drumlin topography with low amplitude hills varying from approximately 70-110m above Ordnance Datum (AOD). Land use to the west of the study area is predominantly mixed residential, commercial and amenity / recreational, whilst the area to the east is generally arable and improved grassland.

2.4.2. The ground primarily falls from south to north across the routes and rises from west to east. To the south of the study area the ground levels vary from approximately 78–90m AOD at A28 Markethill Road, rising to a high point of approximately 114m AOD south of Ballynahonemore Road. Further north the ground levels fall to around 65m AOD at Hamiltonsbawn Industrial Estate Road and a low point of 45m AOD in the vicinity of an undesignated minor watercourse a tributary of the Killuney Drain. At the northern extent where the route joins A3 Portadown Road, ground levels are generally around 50m AOD.

Superficial Geology

2.4.3. Superficial deposits have been informed by geological mapping (Drawing 1064968-B-D-6000 in *Appendix A*) and historical investigations, including a Ground Investigation (GI) undertaken in 2006 along the footprint of the Eastlink route alignment.

2.4.4. Superficial (Quaternary) deposits dominate the geology of the area and principally comprise glacial stony clay (till), though deposits of glacial sand and gravel are anticipated. Superficial deposits are extremely variable in their thickness but are indicated to be thinner in the areas of high ground such as the area between Hamiltonsbawn Road and Ballynahonemore Road.

2.4.5. Areas of alluvium (very variable soft clay mixed with loose sand) were proven in the low lying area between Hamiltonsbawn Road and Linsey's Hill Road, associated with existing watercourses namely Killuney Drain and Killuney Drain Tributary. Superficial mapping indicates a potential tract of Alluvium associated with an unnamed watercourse located in the vicinity of the Hamiltonsbawn Road and Stockingmanshill Road junction and a large potential tract associated with Ballynahone River to the south of the area.

2.4.6. Several areas of made / worked ground identified on the geological mapping were proven and encountered in the vicinity of Ardmore Road; at the Hamiltonsbawn Industrial Estate Road and further north in the location of Lindsey Heights.

2.4.7. Geological mapping identifies a pocket of peat in the vicinity of Ardmore Road, this was not however encountered within the ground investigation carried out in 2006.

Bedrock Geology

2.4.8. Solid Geology mapping (Drawing 1064968-B-D-6001 in *Appendix A*) and historical ground investigations indicates the area is predominantly underlain by rocks of the

Leadhills Supergroup, described as wacke and variably coloured mudstone. These rocks are indicated to be folded, dipping in variable directions (however is predominately in a south west direction), and in places the beds are shown to be overturned. The northern extent of the study area is underlain by younger (Carboniferous age) rocks of the Killuney Conglomerate Formation (Tournasian). These are described as purple-red fine grained conglomerates, fine to coarse grained sandstones and banded siltstones.

2.4.9. The Killuney formation outcrop is bounded by a SE-NW trending fault, which is down thrown to the north. The line of the fault is shown to locally coincide with the line of the existing A3 Portadown Road.

2.4.10. North of the fault lies rocks of the Armagh Group described as Limestone (argillaceous rocks with sub ordinate sandstone interbedded); Drumman More Sandstone Formation; Retreat Siltstone Formation (described as argillaceous rocks with subordinate sandstone and limestone) and the Ballynahone Micrite (Limestone) Formation.

2.4.11. The 2006 GI proved bedrock at isolated locations. Limestone was encountered to the south of the study area at 16.3m below ground level (bgl). The underlying bedrock was however generally encountered as strong slightly weathered dark grey mudstone underlain by strong slightly weathered thickly bedded dark grey fine grained sandstone. The weathered zone overlying this was described as fine to coarse grained dark grey gravel with cobbles. Deposits ranged in depth from 4.6m bgl to 12.0m bgl between Hamiltonsbawn Road and the edge of Linsey's Hill.

2.4.12. The published bedrock stratigraphy is illustrated in Drawing 1064968-B-D-6001 (see *Appendix A*). The aquifer class of the underlying geology is Class BI(f) - an intermediate fractured aquifer of limited potential yield.

Man-made Conditions, Contaminated Sites and Mineral Resources

2.4.13. Constructed slopes are present in the Ardmore Road Cutting (slope gradients of 1:2) and the embankment at A51 Hamiltonsbawn Road Industrial Estate access.

2.4.14. With the exception of industrial or light industrial units within the Hamiltonsbawn Industrial Estate, potentially contaminated land sources are located to the west of the study area and are largely a function of the built environment. There are two disused backfilled quarries recorded north of the A51 Hamiltonsbawn Road – one within the former Drumadd Army Barracks site and one on the industrial estate site (in the vicinity of the Cross Refrigeration building). No areas of contamination were identified during the 2006 investigation.

2.4.15. Approximately 300m north of Ballynahonemore Road there is a scrapyard / storage area containing abandoned non roadworthy cars (identified during a walkover survey) which may pose a possible contamination source. Further appropriate assessment may be required at a later stage.

2.4.16. Given the broadly rural location surrounding Armagh, agricultural processes also provide another source of potential pollution.

2.4.17. A list of sites designated as potentially contaminated by the Land Quality Database is given in

2.4.18. Table 2-1 below. Information is based on historical data which has not been updated for the area since 1972, and these locations should not be considered as an exhaustive list.

Table 2-1 - Potential Historic Sources of Contaminated Land

Location and Area (where known)	Risk Category	Identification Number	Description of Historical Site Activities
Ballynahone More TD	Low	2*	Food Preparation & Processing
Ballynahone TD	Low	3*	Food Preparation & Processing
Portadown Road	Low	4*	Food Preparation & Processing
Drumadd TD – approximately 5000m2	Low	RQ1*	Reclaimed Land
Orangefield Drive	High	5*	Fuel Storage at the Council Depot
Drumadd Road	High	6*	Petrol Station / Fuel Storage
Orangefield Drive	Unknown	7*	Factory – Operations Unknown
Killuney	N/A	RQ2**	Limestone Quarry in 1860
Drumadd TD (East of Ballynahonemore River)	N/A	RQ3**	Quarry in 1860
Drumadd TD (West of Proposed Link Road) – approximately 4992m^2	N/A	RQ4**	Slate Quarry in 1948

RQ – Reclaimed Quarry
* Denotes Land Use in 1972
** Denotes information from Historical Mapping

2.4.19. Four of the ten sites are deemed to be low risk. The quarry referenced as RQ1 is understood to be disused from the information supplied by Geological Survey of Northern Ireland (GSNI) and historical mapping sources. This is located approximately 50 - 100m west of the 2007 Option. By 1945 the overall area had reached nearly 5000m2 and the quarry was reclaimed for agricultural purposes. This is now largely within Drumadd barracks boundary. The possible presence of fly-tipped material cannot be discounted at this location.

2.4.20. The nature, grading and density of materials used as backfill is not known and so the potential for excessive total / differential settlements, gas generation or ground and groundwater contamination cannot be adequately assessed without further investigation.

2.4.21. Three remaining low risk sites were historically used for the purpose of food preparation or processing of flour and corn.

2.4.22. The two sites rated as high risk are fuel storage areas. Two petrol stations are identified, both to the west of the 2007 Option on Orangefield Drive (at the council depot) and Drumadd Road. Their locations should not pose a significant risk to construction.

2.4.23. A factory located on Orangefield Drive near Greenrigg Farm has been registered on the Land Quality Database; however this site has not been assigned a risk level. The

survey indicates it is currently occupied by Shilliday Refrigeration. The 2007 Option is approximately 75m to the east of this location.

2.4.24. Historical mapping identified three further quarries within the study area, which are not included in the Land Quality Database. None of the quarries are evident in the County Armagh Series, Sheet 218, 1967/72 (1:10,000) mapping, indicating that they have been in-filled. Site surveys confirm quarries RQ1 and RQ4 have been in-filled. Drumadd Barracks site extends over the area of RQ1 and fill material is evident in the vicinity of RQ4. As discussed in paragraph 2.4.19, the backfill material and ground conditions are not known at this stage, further ground investigations on the selected preferred route can confirm this.

2.4.25. An area of fly-tipped material was noted on the area of marshland located between the army barracks and the industrial park. The waste materials comprised industrial drums, which may contain waste. This material should be investigated further to establish whether it presents an immediate risk to human health or the environment.

2.5. Existing Hydrological Conditions

Drainage Networks

2.5.1. Where the proposed options meet A3 Portadown Road, A28 Markethill Road and A51 Hamiltonsbawn Road, preliminary investigations at these locations indicate a kerb and gully drainage system currently in operation. Further detailed surveys will be undertaken during design development to determine the extent and capacity of these drainage networks.

2.5.2. A number of existing headwalls, pipes and culverts have been located during site visits at various locations along each route option. However further investigations are likely to be required based on the selected preferred route. Details of the locations and impacts on the existing drainage network have been discussed in paragraph 4.4.35 to 4.4.36 and are shown on Drawing 1064968-B-D-5001 (see *Appendix A*).

Watercourses

2.5.3. Watercourses have been referenced on Drawing 1064968-B-D-5001 (see *Appendix A*) using Rivers Agency designations. It should be noted some watercourses may have additional references based upon WFD designations as referred to in the environmental assessment section 5.13.

2.5.4. The Ballynahone River (WC Ref: U4410) runs from south to north between Markethill Road and Portadown Road, parallel to (and west of) the proposed route options. The river crosses beneath A28 Markethill Road in the vicinity of Armagh Baptist Church, running parallel and to the west of (in an east to west direction) the existing road. The channel width at this location is approximately 3m, with the watercourse entering a 4.8m x 3.2m arch culvert below Markethill Road. It crosses Markethill Road again in the vicinity of the car show room and runs east of the existing road. Upstream of this location the watercourse splits into two branches. Both these branches cross beneath Edenaveys Industrial Estate Road before running south-west and south-east on their respective branches. The northern branch crosses Edenaveys Road via a 2m x 0.8m box culvert (BRC02), and the southern branch crosses via a 4.5m x 1.8m box culvert (BRC01).

2.5.5. Killuney Drain (WC Ref: U4409) runs in a south to north direction from the west of the DVLA Testing centre south of Hamiltonsbawn Road. It crosses beneath Hamiltonsbawn Road, through the former Drummad Army Barracks site and continues

in a north-easterly direction before crossing beneath the existing A3 Portadown Road via a 1.2m diameter circular culvert (KDC01) to the immediate west of Linsey's Hill.

2.5.6. An un-named tributary of Killuney Drain flows from the west of Saints and Scholars Integrated Primary Schools along the southern edge of Linsey's Hill housing development in a 1.6m wide channel , before joining the Killuney Drain to the immediate north of the former Army Barracks.

2.5.7. An unnamed watercourse bounding the housing development of Killuney Manor with an approximate channel width of 1.6m converges to the south-east of the existing Drumman Heights roundabout with a second unnamed watercourse bounding the development with an approximate 3m wide channel, to the rear of Killuney Park Road. The watercourses are culverted beneath A3 Portadown Road via a 2.2m x 1m arch culvert (Killuney Bridge), emerging to the rear of Drumman Heights in a north-westerly direction.

2.5.8. Two field drains have been identified running south to north along the eastern and western boundary of the land parcel immediately to the North of Armagh City Football Club on Ballynahonemore Road. These drains are proposed to be incorporated into the scheme drainage using pre-earthworks drainage (PED) as required.

Flooding

2.5.9. Details of flood mapping are shown on Drawing 1064968-B-D-5002 in *Appendix A*.

2.5.10. Rivers Agency Flood maps show the 1% annual exceedance probability (AEP) flood outline for the Killuney Drain. The flood plain is associated with the culverted section of the watercourse and is restricted to the low lying land located to the east of Hamiltonsbawn Road Industrial Estate and the area surrounding the Driver and Vehicle Testing Centre south of Hamiltonsbawn Road. North of this area the 1% AEP flows are largely retained within the existing channel.

2.5.11. The mapping also shows the 1% AEP for the Ballynahone River where the predicted flood extent is retained to the south of the existing A28 Markethill Road.

2.5.12. The 1% AEP detailed flood map for upstream sections of the Ballynahone River does not extend to the Edenaveys Road where the watercourse is culverted at two separate locations. Upgrade works in this vicinity have been undertaken in 2010, and are assumed to have been sized for the 2% AEP in accordance with the DMRB. The strategic 1% AEP flood maps do not indicate any flood risk to the carriageway at this location, indicating the flood extent is contained within the natural topography below the level of the road.

2.5.13. Flood mapping is not available for the 1% AEP associated with the watercourse which runs from south to north parallel to Killuney Park Road on its eastern side. Instead, 0.5% AEP Surface Water Flood Mapping has been utilised as this is a reliable indicator of flood extent associated with this minor watercourse. This mapping indicates that the floodplain is restricted to the low point in the topography, east of Saints and Scholars Primary School and the river channel itself.

2.5.14. No flood mapping is available for the 1% AEP associated with the watercourse which runs from east to west, south of Killuney Manor and Killuney Crescent. The floodplain associated with the 0.5% AEP Surface Water flood event, indicates this largely remains within the channel of the existing watercourse.

2.6. Existing Environmental Conditions

2.6.1. The existing environmental conditions have been covered in Section 5 of this report under their respective topic area.

2.7. Existing Land Use

2.7.1. Land use has been discussed in detail under Section 4.2.

2.7.2. The built environment surrounding the scheme is mainly residential with lands to the north (Linsey's Hill) and south (Ardmore Road) made up of residential developments, with some light industrial buildings north-east of A51 Hamiltonsbawn Road, and the city's now decommissioned army barracks lies to the north-west.

2.7.3. Lands to the east of the study area are predominantly used for agriculture.

2.8. Changes in the existing condition from Stage 1 Assessment

2.8.1. As referred to in paragraph 1.1.4, the Stage 1 assessment was carried out during August 2006. There have been no significant changes to the existing engineering or environmental conditions. Items of note have been detailed below.

2.8.2. Drumadd Barracks was vacated in July 2007 and handed over to defence estates for disposal. The site of approximately 36Ha was placed on the open market and sold in September 2014 for redevelopment. The existing buildings are currently operating as office buildings.

2.8.3. Changes to the existing highways network from 2006 include:

- Edenaveys Industrial Estate Road improvements (2010), with construction of a footway on the southbound carriageway and associated increased visibility for approximately 700m from the A28 junction. Where the Ballynahone River crosses the carriageway, realignment and improvement works to the channel and replacement of the existing watercourse bridge has been undertaken with associated monitoring equipment, road widening, extension of the existing footway on the northbound carriageway and installation of road restraint systems. Verge widening on the northbound carriageway has been undertaken from the Ballynahone River over approximately 300m.
- Friary Road improvement works, the existing layout at Friary Road improved to allow two lanes of traffic to enter and exit the city including the provision of dedicated right turn lanes.

3. Description of Scheme Options

3.1. "Do-Minimum" Option

3.1.1. The "Do-Minimum" option for the scheme may also be described as "Do-Nothing" option. There are no current plans for minor improvements or traffic calming measures on the road network within the city centre.

3.1.2. It should be noted that the North West Link scheme is still in the planning stage and the impacts of the link have therefore not been included in the Traffic and Economic Assessment to ensure this scheme is assessed on its individual merits.

3.2. Cross Section

3.2.1. Each of the proposed route options have been assessed using a consistent cross section of 14.3m minimum overall carriageway width. This is made up of two running lanes of 3.65m width and an adjacent use footway / cycleway in each direction of 3.0m width. A separation width to the carriageway of 0.5m minimum shall also be provided. This is in line with the minimum widths specified in DMRB TD27/05 'Cross-sections and Headrooms' and TA90/05 'The Geometric Design of Pedestrian, Cycle and Equestrian Routes'.

3.2.2. Separation between the carriageway and the Non-motorised user (NMU) route shall be facilitated by kerbing along the full length of the proposed carriageway. Separation within the NMU route is proposed to be a white line marking between the footway and cycleway.

3.2.3. A schematic cross section is shown in Drawing Figure 2-11064968-B-D-2001 contained within *Appendix A*.

3.2.4. It is recognised that a number of side roads will be impacted by the proposed link road. Some minor roads are planned to be stopped up whilst others will form a priority junction with the mainline. Where priority junctions are created, it is proposed that these shall be in the form of a ghost island junction. The locations of these junctions will be confirmed during design development of the selected Preferred Route and the carriageway cross section amended locally as required.

3.3. 2007 Option Description

3.3.1. This option commences at the junction of A28 Markethill Road and Ardmore Road to the south, extending northwards to the proposed junction with A3 Portadown Road west of Linsey's Hill. This option utilises the existing Ardmore Road, the road through Hamiltonsbawn Road Industrial Estate and part of Linsey's Heights Road. This option provides a junction with A51 Hamiltonsbawn Road and is likely to incorporate a staggered junction to facilitate access to Ballynahonemore Road.

3.3.2. The 2007 Option is shown in detail on Drawings 1064968-B-D-2003 to 1064968-B-D-2005 contained within *Appendix A*.

3.4. Option 12

3.4.1. This option commences in the vicinity of the existing junction of Edenaveys Industrial Estate with A28 Markethill Road and makes use of the relatively recently constructed carriageway through the industrial estate. A proposed roundabout ties the route into A3 Portadown Road in the vicinity of the existing roundabout at Drumman Heights. The

route also proposes to realign part of A51 Hamiltonsbawn Road to facilitate a new junction with the A51 to the east of Hamiltonsbawn Road Industrial Estate. Ballynahonemore Road would remain open underneath the proposed alignment.

3.4.2. Option 12 is shown in detail on Drawings 1064968-B-D-2006 to 1064968-B-D-2010 contained within *Appendix A*.

3.5. Option 16

3.5.1. This option is a combination of the 2007 Option and Option 12. It commences in the vicinity of the existing junction of Edenaveys Industrial Estate with A28 Markethill Road and makes use of the relatively recently constructed carriageway through the industrial estate. The route continues north-west from Ballynahonemore Road to follow the alignment of 2007 Option from Bannvale Villas northwards to the proposed junction with A3 Portadown Road west of Linsey's Hill, again making use of the Road through Hamiltonsbawn Road Industrial Estate and Linsey's Heights Road. This option provides a junction with A51 Hamiltonsbawn Road and Ballynahonemore Road would remain open underneath the proposed alignment.

3.5.2. Option 16 is shown in detail on Drawings 1064968-B-D-2011 to 1064968-B-D-2014 contained within *Appendix A*.

3.6. Cost Estimates

3.6.1. Cost Estimates have been prepared by cost consultants ChandlerKBS. The Option Assessment Report has been included in *Appendix C* for information.

Assumptions and Basis for Estimates

3.6.2. The rates, prices and costs are shown exclusive of VAT with a base date of Q2 2019. No allowance for inflation has been included at this stage.

3.6.3. Cost Estimates have been undertaken by Chandler KBS (CKBS) and are based on preliminary route alignments, their associated assessments and include design elements which could be reasonably foreseen given the level of design development. Table 3-1 below details the assumptions made for each particular cost area.

Table 3-1 – Scheme Cost Estimate Assumptions

Cost Area	Assumptions
Preliminaries and Traffic Management	Preliminaries have been included in line with CKBS cost database and includes traffic management. Additional traffic management has been included for the urban sections on a rate per kilometre, based on historic data. The additional traffic management costs have been applied to the 2007 Option and Option 16.
Land / Compensation	An estimate based on the current earthworks footprint has been used to estimate the overall land required to construct the scheme. The percentage of residential / development and rural / agricultural land has been estimated and considered. Some land is already in DFI ownership which has been factored into the cost assessment. Costs are based on 2016/17 market prices per hectare for land in the vicinity of Armagh and are consistent across each option. At this stage of design, it is not anticipated that dwellings will be required to

Cost Area	Assumptions
	be purchased by DFI. Compensation costs have not been included at this stage.
Construction Costs	
Junctions	Each option has been costed on the basis that a roundabout shall be provided at the junctions with A28 Markethill Road, A51 Hamiltonsbawn Road and A3 Portadown Road on each route. An allowance based on historical cost data for each roundabout has been costed and is consistent across each option.
Earthworks	Earthworks quantities have been produced using MX design software with cut / fill volumes developed into a bill of quantities. A conservative estimate for reuse of excavated material of 25% has been applied across each of the options allowing costs for import and disposal of material to be estimated. The earthwork costs include an allowance for rock, contaminated material and unforeseen ground conditions. This is prudent due to the lack of detailed design information at this stage.
Road Lighting	Road Lighting as a minimum shall be provided at junctions. Where the option, or part thereof, is deemed to be within the urban limits, it shall be lit along the length of the applicable section. At this stage it is not possible to fully quantify the lighting requirements. Historic data has been used to obtain relevant costs per square metre of pavement area for schemes that are lit only at junctions or fully lit. As more design information becomes available this element can be reviewed and the cost assessed in greater detail.
Structures	Major structures including retaining walls, underbridges and watercourse culverts have been considered. In the absence of detailed design, costs per square metre have been used. Deck areas for bridge structures are based on a nominal span and width and foundations have been assumed to be piled.
Existing Side Roads	Preliminary costs for realignment of side roads have been included in the scheme costs, and include new road construction, tying in to the existing road and planing of the existing redundant side road. Each option currently utilises some sections which have already been constructed – namely Ardmore Road and Edenaveys Road. These lengths are not included in the overall pavement areas however an allowance for planing off and resurfacing the existing carriageway has been included.
Preparation Supervision and Design	In accordance with recognised industry standards, costs for preparation and supervision were also allowed for in the cost plans at 9% and 5% respectively.
Statutory Authorities	An approximate value of 1% of the construction works subtotal has been used to provide a costs for diversionary and / or protection works to existing services. This is based on comparable historic data from CKBS database of highway costs in Northern Ireland, the Republic of Ireland and mainland UK.
Optimism	Optimism bias (OB) is included at 44% of all costs (excluding land and compensation), which is the upper limit of the recommended range for

Cost Area	Assumptions
Bias and Risk	standard non-complicated civil engineering schemes, in line with the Green Book guidance and RSPPG E058. It is considered that the optimism bias will reduce at subsequent assessment stages, as and when further details of design requirements and mitigation measures are identified, specified and quantified. Construction risk / contingency has been included at a rate per square metre based on historic data obtained from CKBS database of highway costs in Northern Ireland, the Republic of Ireland and mainland UK.

Costing

3.6.4. Table 3-2 details the high level costs and the ranking given to each of the options where a rank of 1 is shown as the Lowest Cost and 3 as the Highest Cost.

Table 3-2 – Cost Ranking

Option	Rank	Total Cost
2007 Option	1	£ 18.51m
Option 16	2	£ 28.30m
Option 12	3	£ 31.08m

3.6.5. Table 3-3 outlines the Cost Estimates for each of the assessed options.

Table 3-3 - Cost Estimate

Costing Area	2007 Option	Option 12	Option 16
Option Length	2.23km	2.95km	2.86km
Route Constructed	0.55km	0.48km	0.48km
Option Length (net)	1.68km	2.47km	2.38km
Preliminaries / TM	£ 1,717,403	£ 1,792,917	£ 2,021,272
Land / Compensation	£ 2,012,612	£ 818,963	£ 2,119,346
Construction Costs	£ 7,454,430	£ 15,375,197	£ 12,697,614
Sub Total	£ 11,184,446	£ 17,987,077	£ 16,838,231
Preparation, Supervision and Design	£ 1,320,174	£ 2,421,402	£ 2,095,082
Statutory Authorities	£ 125,618	£ 185,430	£ 178,084
Sub Total	£ 12,630,238	£ 20,593,909	£ 19,111,398
Risk & OB (OB at 44%)	£ 5,880,780	£ 10,485,658	£ 9,190,490
Total	**£ 18,511,018**	**£ 31,079,567**	**£ 28,301,888**
Cost per km	**£ 11.04m**	**£ 12.56m**	**£ 11.91m**

4. Engineering Assessment

4.1. Engineering Standards including preliminary Departures from Standard

4.1.1. The appropriate cross-section has been selected in accordance with DMRB TD 27/05 Cross-sections and Headrooms (DMRB 6.1.2), TA 90/05 The Geometric Design of Pedestrian, Cycle and Equestrian Routes (DMRB 6.2.5) and TA 30/82 Choice between Options for Trunk Road Schemes (DMRB 5.1.4).

4.1.2. The standard of road and geometry of the scheme have been designed in accordance with TD 9/93 Highway Link Design (DMRB 6.1.1).

Cross Section

4.1.3. The proposed route options have the following criteria as standard from the DMRB. Table 4-1 below outlines road type, carriageway widths, cycleway / footway widths, hardstrip / hardshoulder provision and street lighting elements of each route option.

Table 4-1 - Cross Section Comparison

Assessment Area	2007 Option	Option 12	Option 16
Road Type	S2*	S2*	S2*
Carriageway Width	7.3m	7.3m	7.3m
Shared Use Cycleway/Footway	3.0m	3.0m	3.0m
Verge Width	1.0m	1.0m	1.0m
Hardshoulder / Hardstrip	None	None	None

*S2 is a 2 lane single carriageway.

4.1.4. Table 4-1 shows proposals to provide both urban and rural environments with shared use cycleways / footways. All route options are 2 lane single carriageway.

Speed Limits / Restrictions

4.1.5. Speed limits vary according to the type of vehicle and the nature of the road. Table 4-2 sets out the environment and associated appropriate speed restrictions for each of the proposed route options.

Table 4-2 - Speed Restriction Comparison

Assessment Area	2007 Option	Option 12	Option 16
Environment	Urban	Rural	Rural / Urban
Speed Restriction	30mph	30mph / 40mph	30mph / 40mph / 30mph

4.1.6. Although previously assessed as a 40mph speed limit, the 2007 Option has now been assessed as a 30mph zone along its length given the urban constraints and residential and commercial properties in close proximity to the alignment.

4.1.7. The current speed limit along the constructed section of Edenaveys Industrial Estate is plated as de-restricted (60mph for a single carriageway road for applicable vehicles). It is proposed this length shall be restricted to 30mph for Option 12 and 16.

4.1.8. Between Edenaveys Industrial Estate and the vicinity of Bannvale Villas where Option 16 follows the 2007 Option alignment, the mainline alignment is proposed to be plated at 40mph due to the constraints on alignment and potential reductions on forward visibility. The speed limit is proposed to reduce to 30mph from Bannvale Villas to the tie-in to A3 Portadown Road in line with its urban environment along this length.

4.1.9. Option 12 is proposed to be restricted to 40mph along the mainline between Edenaveys Industrial Estate (30mph) and the tie-in to A3 Portadown Road.

Departure from Standard

4.1.10. Departures and relaxations from standard will be subject to formal acceptance from DFI Technical Approval Authority (TAA) and divisions. At this stage only departures and relaxations along the mainline have been considered. Departures for side roads and private / field access have not been assessed at this stage. This will be assessed during the development of the Preferred Route. Table 4-3 compares the departures and relaxations across each of the route options and gives further details of preliminary relaxations. It should be noted that the design is at a preliminary stage and further detailed design may remove or increase the number applicable to the selected preferred route.

Table 4-3 – Departures and Relaxation from Standard Comparison

Assessment Area	2007 Option	Option 12	Option 16
Departures from Standard	0	0	0
Relaxations of Standard	1	4	5

4.1.11. There are no identified departures for 2007 Option, Option 12 or Option 16.

4.1.12. Option 16 has five relaxations from standard, Option 12 contains four and the 2007 Option contains one.

4.1.13. The 2007 Option has made use of a sub-standard horizontal curve (127m radius) on the approach to the A3 Portadown Roundabout in order to make best use of Linsey's Heights road. This relaxation also applies to Option 16.

4.1.14. The existing alignment through Edenaveys industrial Estate contains two relaxations relating to horizontal radii used. This will apply to Option 12 and 16.

4.1.15. Relaxations in vertical gradient have been used in a number of locations to tie into existing ground levels at Bannvale Villas and Edenaveys Industrial Estate road for example, to ensure minimal disruption to side roads and their tie-in.

Table 4-4 - Details of Relaxations of Standard

Option	Description of Relaxations from Standard
2007 Option	Ch2190m - 2 step horizontal relaxation on approach to roundabout at the A3 Portadown Road
Option 12	Ch35m - 3 step horizontal relaxation Ch105m - 2 step horizontal relaxation Ch445m - 1 step relaxation in vertical gradient Ch2200m - 1 step relaxation in vertical gradient
Option 16	Ch35m - 3 step horizontal relaxation Ch105m - 2 step horizontal relaxation Ch445m - 1 step relaxation in vertical gradient Ch1400m - 1 step relaxation in vertical gradient CH2820m - 2 step horizontal relaxation on approach to roundabout at the A3 Portadown Road

Junction Type and Road Lighting

4.1.16. Roundabouts have been proposed to tie into A28 Markethill Road, A51 Hamiltonsbawn Road and A3 Portadown Road on each of the proposed options. The junction strategy for the selected Preferred Route shall be developed and confirmed during the Stage 3 assessment. For the purposes of this assessment major junction type is not a key consideration or deciding factor.

4.1.17. As a minimum, junctions along each of the routes shall be lit. The 2007 Option is deemed to be located within an urban environment which would typically be lit along it's full length. In contrast a rural link road such as Option 12 will only be lit on the approach to and at junctions. Option 16 is a mixture of the two environments, and for the purposes of this assessment will be lit at junctions only to the point where it merges with the 2007 Option, where road lighting will be provided along its full length through the urban environment section.

Proposed Junctions and Roads to be Stopped Up

4.1.18. The general strategy to reduce disruption and impacts on the existing road infrastructure is to maintain accessibility where it is feasible and safe to do so, thereby reducing severance and disruption to existing movement patterns. Roads may be stopped up where flows are considered to be significantly low and provision of direct access to the link road or a structure is not considered feasible. Alternative access will be provided in these cases.

4.1.19. There are a number of private accesses which may need to be stopped up under the 'Stopping Up of Private Accesses Order'. Alternative access will be provided in these cases.

4.1.20. Priority junctions are proposed where access onto the link road is required. The exact location and type will be confirmed during design development of the selected preferred route. For the purposes of this report priority junction type is not a key consideration or deciding factor.

4.1.21. The 2007 Option does not currently require any existing roads to be stopped up. The proposed priority junctions are at the following approximate chainages (Ch) along the mainline alignment:

- Ch300m East Side (Ardmore Drive);
- Ch320m West Side (Thornleigh);
- Ch450m (Greenfield Close);
- Ch640m (Ballynahonemore Road / Bannvale Villas East);
- Ch760m (Ballynahonemore Road / Bannvale Villas West);
- Ch1000m (Road off Cul-De-Sac off Bannvale Villas East);
- Ch1050m (Road off Cul-De-Sac off Bannvale Villas West);
- Ch1550m (Industrial Estate); and,
- Ch2170m (Linsey's Hill/Heights).

4.1.22. Option 16 does require a section of Linsey Heights to be stopped up. The proposed priority junctions are at the following approximate chainages along the mainline alignment:

- Ch0m to 160m (Edenaveys Industrial Accesses);
- Ch280m (Private Access);
- Ch510m (Edenaveys Road);
- Ch1620m (Access road off Cul-De-Sac off Bannvale Villas);
- Ch1670m (Access road off Cul-De-Sac off Bannvale Villas);
- Ch2110 (Industrial Access);
- Ch2180 (Hamiltonsbawn Road Industrial Estate Access);
- Ch2800m (Linsey's Hill/Heights).

4.1.23. Option 12 would require significant realignment of the A51 Hamiltonsbawn Road to incorporate a safe roundabout junction. Access to dwellings on the existing road would be provided onto the realigned section, with the existing road being stopped up where the alignment intersects the road close to the junction with Stockingmans Hill Road either side of the mainline. The proposed priority junctions are situated at the following approximate chainages:

- Ch0m to 160m (Edenaveys Industrial Accesses);
- Ch280m (Private Access);
- Ch510m (Edenaveys Road);
- Ch2050m (Private Access).
- Ch2860m (Private Access).

4.1.24. Table 5-5 summarises the number of junctions proposed and roads to be stopped up. The 2007 Option proposes nine priority junctions onto the link road. Option 12 proposes five and Option 16 proposes eight junctions.

Table 4-5 - Impacts and Proposed Mitigation for Side Roads

Side Road / Chainage	2007 Option	Option 12	Option 16
Number of Priority Junctions	9	5	8
Number of Roads Stopped Up	0	2	1

Side Roads to be Realigned

4.1.25. A number of side roads which will be bisected by the proposed options will require realignment in order to provide safe junctions with the link road. The proposed 2007 Option will require approximately 445m of realignment, Option 12 will require approximately 1120m of realignment and Option 16 will require approximately 325m of realignment. Table 4-6 below summarises the details of road re-alignment.

4.1.26. 2007 Option will require the following roads to be realigned:

- Ch650 and 750m Ballynahonemore Road south of Bannvale Villas (east and west of the proposed route)
- Ch1000 and 1050m Ballynahonemore Road north of Bannvale Villas (east and west of the proposed route)
- Ch2150m Linseys Hill

4.1.27. Option 12 will require the following roads to be realigned:

- Ch500m Edenaveys Road
- Ch950m A51 Hamiltonsbawn Road

4.1.28. Option 16 will require the following roads to be realigned:

- Ch500m Edenaveys Road
- Ch1000 and 1050m Ballynahonemore Road north of Bannvale Villas (east and west of the proposed route)
- Ch2920m Killuney Road

Table 4-6 - Impacts and Proposed Side Road Realignment

Side Road / Chainage	2007 Option	Option 12	Option 16
Number of Side Roads Realigned	3	2	3
Total Approximate Length of Realignment	443m	1121m	323m

4.2. Climate and Land Use

Climate

4.2.1. The climate is typical of that to be expected in Northern Ireland with no significant aberrations or conditions of special interest.

Land Use and Landtake Requirements

4.2.2. Table 4-7 outlines the land take required for each option and the approximate split, where applicable, in relation to residential, agricultural, industrial and commercial.

Table 4-7 - Approximate Landtake Requirements

Assessment Area	2007 Option	Option 12	Option 16
Landtake (hectares)	6.17	10.19	8.63
Urban / Residential	100%	0%	42%
Rural / Agricultural	0%	100%	58%
Land owned by DFI (hectares)	2.791	0.730	1.249
Land owned by DFI (%)	45%	7%	15%*

*Split into 8% Urban / Residential and 7% Rural / Agricultural

4.3. Geology, Geomorphology and Ground Conditions

Geotechnical Investigations

4.3.1. The Department of Finance and Personnel (DfP) Central Procurement Directorate (CPD) have undertaken several localised ground investigations within the study area. The location of the ground investigations (see Drawing 1003235-AEL-A605 in *Appendix A*).

4.3.2. A further ground investigation was undertaken by Soil Mechanics Limited between 29th August 2006 and 14th November 2006 (along the alignment at the time selected as the preferred route option). The findings of the GI proved the geology of the site to be generally in agreement with the published geology and historical investigations, comprising a succession of topsoil, isolated areas of made ground and Glacial Till containing lenses of glacial sand and gravel. Bedrock was encountered during the investigation at certain isolated locations.

Geological Constraints

4.3.3. Each of the scheme options are broadly similar in terms of the amount of interaction with the existing highway infrastructure at the A28 Markethill Road; A51 Hamiltonsbawn Road and A3 Portadown Road tie-ins with respect to the form of earthworks. The 2007 Option and the northern section of Option 16 utilises the existing road infrastructure and earthworks through the residential developments along Ardmore Road, Lindsey Heights and the Hamiltonsbawn Industrial Estate. The 2007

Option may require retaining structures or reinforced earth embankments due to the land take constraints along discrete sections of the scheme.

4.3.4. Option 16 and 12 use the existing road infrastructure and earthworks along Edenaveys Industrial Estate for approximately 480m. Option 16 will necessitate new earthworks between this point and its tie-in with the 2007 Option as detailed above. Option 12 will require new earthworks from the existing road along Edenaveys Industrial Estate to its terminal point on the A3 Portadown Road.

Glacial Till

4.3.5. The glacial soils are of variable thickness relating to the topography of the area. All route options are likely to encounter till with the thickest deposits expected within the drumlins or within infilled stream valleys as reflected from investigations with deposits varying from 0.2m–16m bgl.

4.3.6. The till is anticipated to consist mainly of variable cohesive deposits predominantly described as firm brown sandy gravelly clay. Lenses of glacial sand and gravel described as orange brown sandy clayey gravel may occur up to a thickness of 1.7m.

4.3.7. It is estimated that around 75% of the glacial clay arisings will be too wet for re-use as structural fill in the works unless treated or stabilised, the balance is however expected to be largely suitable for use as landscape material. Where encountered within the sub-formation, glacial soils are unlikely to be suitable without placement of a capping layer or other methods of ground improvement.

4.3.8. Excavations which encounter the underlying sand and gravel are likely to be suitable for re-use as engineering fill. However, due to the discontinuous nature, the quantity of suitable material is likely to be relatively small, and potentially water bearing, which may have a negative impact on stability of cuttings.

Alluvium

4.3.9. Tracts of Alluvium associated with watercourses throughout the area, including the Ballynahone River to the North; Killuney Drain to the south and other minor undesignated watercourses, are likely to consist of very soft to firm orange brown and black sandy gravelly clay deposits similar to those encountered in the vicinity of Drumadd and Killuney during the 2006 GI. A starter layer comprising a geotextile separator and Class 6A granular material may be required due to the variable nature of the material, in order to prevent mixing of the subgrade and embankment fill, and assist in drainage at the base of the embankment.

Peat

4.3.10. Although identified on geological mapping, peat was not proven in the GI. Despite this, localised areas of peat cannot be discounted and if encountered are likely to be highly compressible, with low strength and high moisture content and as such would be unsuitable for re-use within the works except as landscaping material.

Bedrock

4.3.11. Bedrock is not expected to be encountered with the exception of the cuttings between Hamiltonsbawn Road and Ballynahonemore Road. Rock may be encountered in the bed of these cuttings, impacting on excavatability and drainage installation. Evidence suggests rock is more likely to be encountered further east of the study area, with Option 12 most likely to be impacted.

Contaminated Land

4.3.12. There is little evidence of contaminated ground, beyond some fly tipped material near the Drumadd site and a scrapyard/storage area containing non-roadworthy cars approximately 300m north of Ballynahonemore Road. Some further analysis in this location may be required during design development of the selected preferred route. The presence of unrecorded tipping activities has not been identified, but cannot be entirely dismissed.

4.3.13. Given the broadly rural location surrounding Armagh, agricultural processes also provide another source of potential pollution.

Geotechnical Engineering Solutions

Cuttings

4.3.14. In cohesive glacial soils, permanent 1v:3h cutting slopes should be designed at this stage due to the possible presence of high groundwater. Slopes of 1v:2.5h cutting slopes in predominantly granular soils is achievable. It may be necessary to incorporate groundwater control methods due to the presence of bands of sand within till material which have the potential to be water bearing. These bands can lead to running sand conditions and instability of both temporary and permanent slopes. Short term slope stability for temporary slopes will be governed by the presence of groundwater; where there is little or no groundwater encountered, 1v:2.5h slopes are likely to be acceptable.

4.3.15. Orientated fabrics may be encountered through drumlin excavation. These fabrics can induce decreased soil strength and friction characteristics in certain directions requiring a reduction in safe slope angles in these locations.

4.3.16. Asymmetric cuttings may require meticulous observation during construction for planes of weakness and instability within drumlins.

4.3.17. Given the high groundwater levels (generally 0.5-2.5m below ground level) design and installation of slope drainage should be considered to ensure slope stability. Groundwater discharged longitudinally from cuttings can also lead to softening of the formation of adjoining embankments and at grade sections. Consideration of provision of formation drainage at the transition between cutting and at grade or embankment sections shall be given.

4.3.18. The findings from the 2006 GI indicate that without improvement, approximately 25% of arisings from cuttings would be suitable as engineering fill as class 2A or 2C (wet cohesive fill), with the balance as landscape (Class 4) fill.

Embankments

4.3.19. Embankments formed from site won Glacial Till are likely to be stable with 1v:2.5h side slopes or 1v:2h side slopes if utilising underlying sand/gravel or imported fill. Surface water and formation drainage measures to prevent ingress into the slope would be necessary to maintain these slopes in the long-term. At this stage of design embankments should be designed to a 1v:3h ratio, particularly for Route Option Alignment 12 and 16. A granular, free draining starter layer with geotextile separation is likely to be required under all embankment constructions.

4.3.20. Where embankments cross low-lying ground between drumlins and river valleys, considerable settlement should be anticipated due to the presence of compressible soils. There are a number of potential solutions which could be utilised in order to minimise consolidation times, including the use of load transfer platforms, ground

improvement with band drains and staged construction to avoid failure of soft and compressible ground.

4.3.21. Sub-formation treatment may be required if embankments cross areas of Peat or Made Ground. This may involve excavation and replacement (with granular fill material) if these materials are encountered to depths not greater than 2.5m. Excavations within Peat or Alluvium may encounter significant groundwater ingress which is likely to compromise slope stability.

Subgrade

4.3.22. Where the formation is constructed on rock, then a CBR value in excess of 15% is expected. However it is likely the majority of the works will be constructed over in-situ Glacial Till or supported on embankments constructed from re-worked Glacial Till fill. The condition of in-situ material is likely to be relatively poor given the anticipated upper weathered horizons, and a CBR value of 2% should be assumed at this stage. Embankment fill material can be specified such that a minimum CBR value is achieved, values in the range 5% to 10% should be assumed at this stage. Very soft spots may be encountered, and these areas should be excavated as required and replaced with acceptable fill material.

4.3.23. If at grade sections are constructed across low-lying marshy ground, very low CBR values of less than 2% may be expected. These sections may require the use of geogrid reinforcement to the capping layer in order to minimise differential settlement although ground improvement using lime or cement may be considered as alternative solutions. The formation in these sections is also likely to be frost susceptible.

Foundations

4.3.24. Potential retaining structures are likely to be required for areas where land take is constrained such as the cutting along Ardmore Road; Jubilee Gardens and Hamiltonsbawn Industrial Estate Road. Each route option will require watercourses to be culverted. Where shallow bedrock is encountered, it is likely that structures could be founded using spread foundations on the underlying limestone bedrock, with either excavation and replacement or surcharging the overlying soft, compressible strata.

4.3.25. Excavations for spread foundations through Glacial Till and Alluvium can expect to encounter moderate to significant groundwater ingress. In such circumstances, as well as water control, issues with stability of temporary works excavation side slopes can be expected unless battered back to a shallow angle, or artificially supported.

4.3.26. The use of piled foundations where significant thicknesses of soft and compressible soils are encountered cannot be discounted at this stage.

4.3.27. Consideration should be given to the effects of chemically aggressive ground and groundwater on buried concrete. The solid and the majority of the drift deposits within the study area are not considered to be problematic in this respect, as they are not expected to contain particularly high levels of sulphides and sulphates although this is subject to confirmation through further investigation. Alluvium may have higher sulphate levels, and Peat deposits generally have a lower pH (acidic). Foundations will be designed based on results of laboratory testing on site specific samples.

Earthworks Quantities

4.3.28. Construction and landscaping will have an impact on soil quality within the urban environment. Use of techniques that maintain soil quality and function help ensure that soils can continue to maintain drainage characteristics and support vegetation, while minimising the risk of causing flooding or erosion. Table 4-8 outlines the

approximate earthwork quantities for each option considering unsuitable material, surplus and shortfall of materials.

Table 4-8 - Preliminary Earthworks Quantities

Assessment Area	2007 Option	Option 12	Option 16
Cut Volume (m^3) and percentage of overall earthworks	69281 (82%)	167680 (59%)	117039 (53%)
Fill Volume (m^3) and percentage of overall earthworks	14965 (18%)	116863 (41%)	102454 (47%)
Percentage of Re-useable Material *	25%	25%	25%
Deposition of Acceptable Material (m^3)	17320	41920	29260
Disposal of Un-acceptable Material (m^3)	54316 (includes 2355 surplus)	125760	87779
Imported Material Volume (m^3)	0	74943	73194

*See section 4.3.7 for further details.

4.3.29. With the percentage of material able to be reused (without undergoing treatment) expected to be low, this has a significant impact on both the volumes of material which are required to be disposed of and required imported material.

4.3.30. Whilst Options 12 and 16 have a moderate balance between cut and fill volumes, the 2007 Option (with the lowest cut and fill earthworks volumes) requires approximately 80% of the overall earthworks activity to be excavated. This is the only option which has a surplus of material and therefore no additional import material is required.

4.3.31. Option 12 and 16 require imported material of approximately 75,000m^3 and 73,200m^3 respectively, however Option 12 requires a significantly higher volume of material to be disposed of (approximately 125,800m^3 compared to 87,800m^3).

4.3.32. The above analysis of earthworks are, as appropriate for this stage of design development, high level. The figures above are for the purpose of this report and do not include quantities relating to the following:

- Capping Layers;
- Earthworks improvements;
- Box cuts.

Summary

4.3.33. The key geotechnical issues are summarised in Table 4-9 below. The issues largely affect all of the routes to a similar degree, based on the extent of soft ground, earthworks balance and avoidance of significant man-made features and interaction with structures.

4.3.34. Option 12 is least favourable with the largest earthworks volume and traversing areas of potentially soft marshy ground within inter drumlin areas. The fill re-usability for this

route option may be marginally lower than the 2007 Option and Option 16. All routes have the potential to encounter potentially contaminated soils, however 2007 Option and Option 16 have a slightly increased likelihood over other route options where it traverses through the Hamiltonsbawn Industrial Estate. The risk is, to some extent, mitigated with works being undertaken within the footprint of the existing road.

Table 4-9 - Summary of Geotechnical Assessment

Assessment Area	2007 Option	Option 12	Option 16
Earthworks Volume	×	××	××
Reuse of Excavated Material	-	×	-
Rock Excavation Volume	-	×	-
Peat / Soft ground	×	×××	××
Contaminated Sites	×××	×	×××
Structural Foundation Issues	×	×	×
Overall Rating	×	××	×

Key:
✓✓✓ / ✓✓ / ✓ / - / × / ×× / ×××
(Positive – neutral - negative)

4.4. Hydrology, Hydrogeology and Drainage

Proposed Drainage Strategy

4.4.1. At this stage in the assessment process, in order to undertake the hydrology and drainage assessment on a consistent basis, several engineering assumptions are required. These assumptions and the proposed strategy for watercourse crossings, river engineering, flood risk and road drainage are briefly outlined below. It should be noted that that following selection of a preferred route, a review of the drainage and flooding strategy will be undertaken to ensure that the most appropriate approach for the collection and discharge of surface runoff is adopted during the development of the design proposals.

Drainage Engineering Requirements

4.4.2. In assessing drainage engineering requirements, the key consideration is the vertical alignment of the proposed road relative to potential discharge locations to the existing watercourses. The drainage engineering issues will be assessed and solutions employed accordingly following selection of the preferred route.

4.4.3. Another key consideration of drainage design will be the environmental requirements associated with drainage discharges; more specifically, the treatment required at each outfall location. Mitigation measures may include the use of sustainable urban drainage (SUDs) such as filter drains, grassed channels, vortex separators, oil interceptors or ponds (dry/detention or wet/retention). These can be utilised individually or through a combination of these systems and incorporated into a positive gravity based drainage system.

4.4.4. Initial consultations with relevant Statutory Authorities (Rivers Agency in particular), have highlighted specific requirements for proposed drainage along the length of the Armagh East Link Road scheme as follows:

- Under Schedule 6 of the Drainage (Northern Ireland) Order 1973, approval is required for any discharge to a watercourse. The proposed rate of storm runoff should be no greater than the existing rate – which is equivalent to Greenfield runoff where no existing development is in place). Rivers Agency use 10 litres/sec/hectare for Greenfield run-off. If this is exceeded then a Drainage Impact Assessment (DIA) is required to demonstrate no negative downstream impact as a result of an increase in discharge.
- Under the terms of Schedule 6, any works (either temporary or permanent) which might affect a watercourse (e.g. culverting, diversions, bridging and discharges) require written consent from Rivers Agency. Details of proposed structures, including culverts, watercourse bridges, and diversions shall be provided during design development of the selected preferred route.
- Rivers Agency have advised that multi-barrelled structures should be avoided in order to minimise the likelihood of debris build-up.

4.4.5. The minimum recommended standard for the design of drainage infrastructure is detailed as follows:

- 1200mm minimum diameter for culverts (including box culverts) over 12m long
- 600mm minimum diameter for culverts less than 12m long
- Design return period for main trunk roads is 1 in 100 year
- Design return period for all other roads is 1 in 50 year
- Design return period for farm lane is 1 in 25 year
- Design return period for field crossings where farm buildings may be affected is 1 in 25 year
- Design return period for field crossings where farm buildings are not affected is 1 in 10 year
- Manhole / inspection chambers should be constructed at intervals no greater than 60m or at any change of direction or gradient or at any junction with existing pipelines
- Any proposed bridges should have soffit levels set at an appropriate freeboard (usually nominally 300mm for culverts 1500mm diameter or less, and 600mm for culverts greater than 1500mm diameter) above the 100 year flood levels contained in the Flood Risk Assessment. The structure should be designed to avoid an increase in upstream water levels in times of high flows and provide a free flow of water at all times. Therefore intermediate supports in the river channel and solid approaches, if located in the floodplain, may not be acceptable.

Watercourse Crossings

4.4.6. Each of the proposed options will cross a number of designated and undesignated watercourses which will require culverting and / or watercourse diversions / realignments. At this stage it is deemed unlikely that any of the watercourses present would require a bridge structure.

4.4.7. The watercourses which are impacted by the options are illustrated below in Table 4-10 and shown on Drawing 1064968-B-D-5001 in *Appendix A*.

Table 4-10 – Summary of Watercourse Crossings

Watercourse Name	Designation ID	2007 Option	Option 12	Option 16
Ballynahone River	U4410	0	2	2
Killuney Drain	U4409	1	0	1
Killuney Drain Tributary	N/A	1	0	1
Un-named WC 1	N/A	0	1	0
Un-named WC 2	N/A	0	1	0
	Total	2	4	4

4.4.8. Option 12 and 16 cross the Ballynahone River at two locations on Edenaveys Road. It is anticipated that the existing culverts (BRC01 & BRC02) will be retained.

4.4.9. Option 16 and 2007 Option cross a tributary of the Killuney Drain which will require a culvert beneath the alignment. A diversion of approximately 78m to the east of the proposed alignments is proposed to reduce the length of culverting required.

4.4.10. At the proposed tie-in with A3 Portadown Road, Option 16 and 2007 Option cross the Killuney Drain to the south-west of where it is culverted beneath the existing road (KDC01). Proposals for the crossing may include extension of or connection to the existing culvert.

4.4.11. The alignment of Option 12 affects two un-named watercourses where they converge south of the proposed junction with A3 Portadown Road. There is an existing culvert (Killuney Bridge) beneath the A3 at this location and further investigation would be required to finalise details, though it is anticipated that the proposed scheme can link with the existing culvert. Re-alignment of the watercourse and culverting will be required at this location to convey flows beneath Option 12 and connect to the existing downstream culvert which crosses the existing A3 Portadown Road.

River Engineering Requirements

4.4.12. Preliminary culvert sizing and assessment has been undertaken for the watercourses crossings discussed above using CIRIA C689 – Culvert Design and Operation Guide and the Design Manual for Roads and Bridges (DMRB): Volume 4, Section 2, Part 7, HA107/04 – Design of Outfall and Culvert Details. Watercourse cross-sectional surveys and flow estimation calculations (using Flood Estimation Handbook techniques) have been undertaken to assist with this assessment. Indicative culvert sizes are shown in Table 4-11 to Table 4-13. Culvert sizing will be confirmed during the design development stage of the selected Preferred Route and shall be designed to accommodate the 1% annual exceedance probability (AEP) flows.

4.4.13. Once the Preferred Route is determined, the structures associated with the Ballynahone River, Killuney Drain and other watercourse floodplains will be hydraulically modelled to assess if there is an increase in flood risk, and propose mitigation measures if required.

4.4.14. It may be necessary to locally alter the alignment of watercourses in order to avoid excessive culverting. Potential watercourse re-alignments / diversions are summarised in Table 4-11 to Table 4-13, and shown on Drawing 1064968-B-D-5001 in *Appendix A*.

Table 4-11 - 2007 Option Preliminary Culvert and Diversion Assessment

Chainage (m)	Watercourse Name	Culvert Type	Culvert Size (m)	Culvert Length (m)	Diversion Length (m)
1844	Killuney Drain Tributary	Pipe	1.2 ∅	26.9	78
2230	Killuney Drain	Pipe	1.2 ∅	28.3	-

Table 4-12 - Option 12 Preliminary Culvert and Diversion Assessment

Chainage (m)	Watercourse Name	Culvert Type	Culvert Size (m)	Culvert Length (m)	Diversion Length (m)
70	Ballynahone River [1]	Box	4.5 x 1.8	31.3	-
300	Ballynahone River [1]	Box	2.0 x 0.8	22.5	-
2900	Unnamed WC 1	Pipe	2.1 ∅	21.1	26
2930	Unnamed WC 2	Box	2.4 x 1.8	14.8	-

Note 1: Existing culverts proposed to be retained with the scheme.

Table 4-13 - Option 16 Preliminary Culvert and Diversion Assessment

Chainage (m)	Watercourse Name	Culvert Type	Culvert Size (m)	Culvert Length (m)	Diversion Length (m)
70	Ballynahone River [1]	Box	4.5 x 1.8	31.3	-
300	Ballynahone River [1]	Box	2.0 x 0.8	22.5	-
2474	Killuney Drain Tributary	Pipe	1.2	26.9	78
2980	Killuney Drain	Pipe	1.2	28.3	-

Note 1: Existing culverts proposed to be retained with the scheme.

4.4.15. The 2007 Option and Option 16 require a diversion of approximately 78m for Killuney Drain Tributary. Option 12 requires a diversion of approximately 26m for Unnamed Watercourse 1.

4.4.16. The 2007 Option and Option 16 would require culverts for the Killuney Drain and Killuney Drain Tributary, ranging in length from 26.9m to 28.3m. Option 12 would require two culverts for the two unnamed watercourses it crosses south of the junction with the A3 Portadown Road.

Flood Defences

4.4.17. No flood defences have been identified within the study area for the watercourses adjacent to the proposed scheme.

Impact on Floodplains

4.4.18. The proposed scheme will be subjected to a Flood Risk Assessment (FRA) in accordance with DMRB: Volume 11, Section 3, Part10 HD45/09 – Road Drainage and the Water Environment and Planning Policy Statement (PPS) 15 (Revised) – Planning and Flood Risk. This will be conducted during development of the selected preferred route.

4.4.19. The Route Options have not been individually modelled within a hydraulic model and the assessment of floodplains has been based on available data as discussed in paragraph 2.5. Further detailed assessments will be required to ensure that the selected preferred route road levels are above predicted flood water levels and assess the alignments potential impacts on the floodplain. The FRA will summarise this assessment as well as reporting any potential mitigation requirements. The FRA is subject to Rivers Agency approval.

4.4.20. Drawing 1064968-B-D-5002 in *Appendix A* presents extents of potential floodplain interaction for each Option. In summary an existing floodplain has been identified along the Killuney Drain and un-named watercourses to the east of Killuney Park Road. It is noted at all locations, the proposed routes lie outwith the potential floodplain.

4.4.21. Consultation with Rivers Agency confirms there are no records of previous flood issues along the proposed routes.

Road Drainage Design

4.4.22. The general principle is where practicable, road related runoff will be discharged to the existing network of watercourses, however, the vertical alignment of the selected preferred route will be reviewed to ascertain if this is viable and some road related runoff may need to be discharged to existing drainage networks.

4.4.23. As discussed in section 2.5 Rivers Agency have provided guidelines in relation to the discharge of road related runoff. To achieve greenfield runoff at outfalls of 10litres/second/hectare, it is proposed to incorporate elements of Sustainable Urban Drainage Systems (SUDS). A Drainage Impact Assessment (DIA) will be undertaken during the preferred route development to determine the impacts of drainage discharges in relation to the receiving watercourses, and the associated mitigation; incorporating attenuation where necessary.

4.4.24. It is proposed that kerb and gullies with carrier sewers will be utilised as the highways drainage strategy. This is in accordance with DMRB: Volume 4, Section 2, Part 3 HA 33/06 – Surface and Subsurface Drainage Systems for Highways.

4.4.25. Based on required water quality requirements discussed in Section 5.13 the drainage strategy for the scheme is likely to include provision of water treatment mitigation (such as grassed surface water channels). This will increase the verge width required either side of the carriageway and the impacts would be similar for each option.

4.4.26. Water quality treatment requirements will be assessed once the preferred option has been determined.

4.4.27. Surface water drainage systems are designed to accommodate a 1 year storm in-bore without surcharging and are checked against a 5 year storm intensity to ensure that surcharge conditions are satisfied (DMRB HD33/06).

4.4.28. It is best practice to keep existing land drainage separate from road drainage wherever possible. At this stage, it is proposed to utilise filter drains and Pre-Earthwork Drainage (PED) ditches to intercept flows arising from natural catchments surrounding each option.

Preliminary Discharges

4.4.29. The increase in area of impermeable surface arising from new highway developments within a catchment has the potential to increase flows to watercourses and increasing the rate and volume of runoff from surface water drainage has the potential to increase flood risk. Although the impact of a single drainage outfall on a watercourse may not be significant, the cumulative effect of several outfalls could potentially affect flood risk within the catchment area. Drawing 1064968-B-D-5000 indicates the proposed discharge locations for each Option under consideration.

4.4.30. As outlined previously, for the purposes of the current assessment, it is assumed that discharges would be restricted to greenfield runoff rates prior to discharge. To meet these requirements, a form of attenuation will be required at each outfall. This assessment assumes that ponds are utilised for the purposes of comparison.

4.4.31. Some outfalls have limited potential to utilise standard attenuation methods such as ponds, due to land limitations, or are located within a flood plain. In these circumstances it may be appropriate to use alternative methods for restricting or attenuating flow, such as on-line storage within large diameter pipes or off-line storage tanks in conjunction with flow control devices. It is noted however that such engineering approaches provide limited benefit in terms of water quality.

4.4.32. The appropriate form of flow attenuation, combined with treatment requirements, will be assessed further following selection of a preferred route.

4.4.33. Table 4-14 to Table 4-16 below identify proposed outfall locations, alongside the calculated area of contributing highway, and the potential attenuation requirements at each of the outfalls.

Table 4-14 - 2007 Option Preliminary Discharge Data and Indicative Attenuation Requirements

Chainage (m)	Outfall ID	Contributing Area of Highway (Ha)	Un-attenuated Design Discharge (l/s)	Greenfield Runoff Volume for Highway Area (l/s)	Proposed Attenuation
0	2007 OPT: Outfall 1	0.8787	135	8.8	Pond – 365m^3
400	2007 OPT: Outfall 2	2.059	316	20.1	Pond – 856m^3
750	2007 OPT: Outfall 3	0.5952	91	6.0	Pond – 247m^3

Table 4-15 - Option 12 Preliminary Discharge Data and Indicative Attenuation Requirements

Chainage (m)	Outfall ID	Contributing Area of Highway (Ha)	Un-attenuated Design Discharge (l/s)	Greenfield Runoff Volume for Highway Area (l/s)	Proposed Attenuation
270	OPT 12: Outfall 1	1.299	200	13.0	Pond – 540m^3
2875	OPT 12: Outfall 2	3.381	520	33.8	Pond – 1405m^3

Table 4-16 - Option 16 Preliminary Discharge Data and Indicative Attenuation Requirements

Chainage (m)	Outfall ID	Contributing Area of Highway (Ha)	Un-attenuated Design Discharge (l/s)	Greenfield Runoff Volume for Highway Area (l/s)	Proposed Attenuation
270	OPT 16: Outfall 1	1.382	212	13.8	Pond – 574m^3
2480	OPT 16: Outfall 2	2.505	385	25.1	Pond – 1041m^3
2850	OPT 16: Outfall 3	0.5952	91	6.0	Pond – 247m^3

4.4.34. The 2007 Option outfalls to three watercourses. The vertical alignment of Option 12 permits two outfalls discharging to two watercourses. Option 16 as a combination of two options, has three outfalls to three watercourses. Attenuation is proposed upstream of each outfall in the form of a dry/detention pond that is sized according to the contributing area of highway. 2007 Option has the smallest total contributing area at approximately 3.53Ha, Option 16 has approximately 4.48Ha and Option 12 has the largest total contributing area at almost 4.68Ha.

Interaction with Existing Drainage Infrastructure

4.4.35. As discussed in paragraph 2.5, there is potential for connections to the existing drainage infrastructure on A28 Markethill Road, A51 Hamiltonsbawn Road and A3 Portadown Road on each option. The feasibility of connecting to these networks will be considered during design development of the selected preferred route.

4.4.36. Field drains have been identified during site surveys which would be impacted by Option 16 at approximate Ch1050m and Ch1150m. It is proposed that flows to these ditches are incorporated into the Pre-Earthworks Drainage (PED) ditches / filter drains. If Option 16 is progressed as the preferred route, the volumes discharging to these field drains will be identified and flows incorporated within the scheme drainage design.

Summary

4.4.37. The key drainage and flooding issues are summarised in Table 4-17 below.

4.4.38. Option 12 and 16 utilise the existing culverts on Edenaveys Industrial Estate Road and therefore the number of watercourse crossings and lengths of culverts required are broadly similar and not a deciding factor in selecting a preferred route. None of the routes are expected to have a significant impact on flood plains and the number of outfalls required / available are also similar.

4.4.39. Option 12 currently requires the shortest watercourse realignment and has the lowest overall length of new culverts required. However, with only two available outfalls, and the largest overall contributing area, the attenuation pond volumes are most onerous of the options. 2007 Option with the lowest overall contributing area may still pose some difficulties with attenuation at Outfall 1 where land availability is restricted due to existing development.

Table 4-17 - Summary of Hydrological Assessment

Assessment Area	2007 Option	Option 12	Option 16
Number of Watercourse Crossings	2	4 (2No existing crossings [1])	4 (2No existing crossings [1])
Rating	-	-	-
Watercourse Diversions	78m	26m	78m
Rating	×	×	×
Approximate Length of Culverts Required	1) 27m Pipe 2) 28m Pipe	1) 31m Box [1] 2) 23m Box [1] 3) 21m Pipe 4) 15m Box	1) 31m Box [1] 2) 23m Box [1] 3) 27m Pipe 4) 28m Box
Rating	-	-	-
Floodplain Displacement	None	None	None
Rating	-	-	-
Number of Outfalls and Contributing Area	3 Outfalls area: 35,329m2	2 Outfalls area: 46,800m2	3 Outfalls area: 44,822m2
Rating	×	××	×
Outfall Restrictions	Runoff attenuation: ponds viable option for Outfall 2 and 3 Outfall 1 requires alternative solution.	Runoff attenuation: ponds viable option	Runoff attenuation: ponds viable option
Rating	×	-	-
Overall Rating	×	×	×

Note 1: Existing culverts proposed to be retained with the scheme.
Key:
✓✓✓ / ✓✓ / ✓ / - / × / ×× / ×××
(Positive – neutral - negative)

4.5. Public Utilities

4.5.1. The key public utilities issues are summarised in Table 4-18 below. The impacts of the routes are similar, with the majority of underground utilities located on the main arterial routes (A28 Markethill Road, A51 Hamiltonsbawn Road and A3 Portadown Road). Overhead utilities such as NIE where present, tend to be located across fields, and may require some diversionary works (raising poles or diversion beneath the proposed route for example).

Northern Ireland Electricity (NIE)

4.5.2. Underground MV cables are present along A28 Markethill Road in the vicinity of the 2007 Option tie-in would require protection or diversion. At the junction with Edenaveys Industrial Estate Road, an 11kV overhead line is present. This is likely to require protection or diversion works if Options 12 or 16 are selected as the proposed route. A 33kV overhead line runs in close proximity to the junction with A28 and Edenaveys Industrial Estate Road. Depending on the junction arrangement, this may require some diversionary works, however design development would aim to avoid impact on the services if practicable.

4.5.3. NIE underground services along Ardmore Road are limited to two 11kV crossings and four MV cable crossings which may require protection or diversion works. From Ardmore road to Ballynahonemore Road, where the 2007 Option traverses fields, there are three 11kV overhead crossings and a MV underground cable on Ballynahonemore Road which may require diversion works. These are impacted by 2007 Option only.

4.5.4. A further three 11kV overhead crossings may by impacted on between Ballynahonemore Road and the tie-in to A3 Portadown Road. It is also likely some protection or diversionary works will be required at Hamiltonsbawn Industrial Estate Road at the bellmouth junction to the existing buildings. These are applicable to both 2007 Option and Option 16.

4.5.5. Underground MV and 11kV cables are present along Edenaveys Industrial Estate Road. Option 12 and 16 may require protection or diversion works where the alignment of the routes are proposed. Two 33kV overhead lines cross the existing road and may require diversionary works with regards to the proposed alignments.

4.5.6. From Edenaveys Industrial Estate Road to Ballynahonemore Road, there is a further 11kV overhead line which may be impacted on by Options 12 and 16.

4.5.7. Option 16 between Ballynahonemore Road and Bannvale Villas has the potential to impact on three 11kV overhead lines which converge to a central point, currently within the footprint of the option, where diversionary works are likely.

4.5.8. Option 12 between Ballynahonemore Road and A3 Portadown Road crosses four 11kV overhead lines which may require diversionary works.

4.5.9. Underground MV cables are present along A51 Hamiltonsbawn Road which would require protection or diversion at the tie-in locations for each option.

4.5.10. Underground MV cables are present along A3 Portadown Road which would require protection or diversion at the tie-in locations for 2007 Option, Option 12 and 16.

Telecommunications

4.5.11. BT underground apparatus is present along A28 Markethill Road at the junction with Ardmore Road and along Ardmore Road which would require protection or diversion with the 2007 Option. A number of lengths of underground apparatus along Ballynahonemore Road in the vicinity of Bannvale Villas would also be impacted by 2007 Option and would require protection or diversion.

4.5.12. 2007 Option and Option 16 would impact on BT apparatus located along the existing A51 Hamiltonsbawn Road and Hamiltonsbawn Industrial Estate Road. Underground apparatus is also present at Linsey's Heights and A3 Portadown Road which may require protection or diversion at the tie-in locations for each option.

4.5.13. BT underground apparatus is present along A28 Markethill Road at the junction with Edenavays Road and along Edenavays Industrial Estate Road for approximately 200m which would require protection or diversion with the Option 12 and 16.

4.5.14. Where Option 16 crosses an existing road to the east of Bannvale Villas, a length of underground BT equipment would require protection or diversion.

4.5.15. Where Option 12 crosses A51 Hamiltonsbawn Road (and the west tie-in to the same) protection or diversionary works may be required for BT apparatus. BT apparatus along the A3 Portadown Road

4.5.16. Vodaphone have confirmed they have cables along the A3 Portadown Road which may require protection or diversion at the tie-in locations for each option.

4.5.17. Eircom have also confirmed they have cables along the A28 Markethill Road and A3 Portadown Road which may require protection or diversion at the tie-in locations for each option.

4.5.18. O2 and Vodaphone have telecommunications equipment on one mast located south of Ballynahonemore Road. Option 16 passes to the west of this mast, and design development would aim to ensure this is not impacted upon.

Northern Ireland Water (NIW)

4.5.19. Nil Response.

Gas Networks

4.5.20. Firmus Energy have confirmed they have medium pressure distribution mains in the vicinity of Ballynahonemore Road to the north of Ardmore Road, A51 Hamiltonsbawn Road and Hamiltonsbawn Industrial Estate Road which would be impacted on by the 2007 Option and would require protection or diversionary works. They also have a medium pressure distribution mains on A3 Portadown Road which would require protection or diversion at the tie-in locations for each option.

Road Lighting

4.5.21. Existing road lighting (including control pillars and bollards) is present on A28 Markethill Road at the junction with Ardmore Road as well as along Ardmore Road which would be impacted by the 2007 Option.

4.5.22. The 2007 Option and Option 16 have an impact on existing road lighting on A51 Hamiltonsbawn Road (in the vicinity of and into the Industrial Estate) and A3 Portadown Road.

4.5.23. Existing road lighting is present on Edenaveys Industrial Estate Road impacted by Options 12 and 16. Option 12 also has an impact on road lighting present on A3 Portadown Road.

Traffic Lights

4.5.24. A controlled crossing is located on the Portadown Road approximately 25m from the Linsey's Hill junction. This is likely to be impacted by the proposed junction of 2007 Option and Option 16. Confirmation of the junction type will determine if this will be replaced with uncontrolled crossings within the standard layout of a roundabout or incorporated into a signalised junction layout.

Private Utilities

4.5.25. Private Utilities have not been covered in this document. Once the preferred route has been selected, the design development will take into account information gathered from affected landowners along the scheme which shall include locations of any private utilities. It is expected these will not be extensive.

Table 4-18 - Summary of Utilities Assessment

Assessment Area and Rating	2007 Option	Option 12	Option 16
Number of crossings required – NIE Rating	14 ××	12 ××	16 ××
Number of crossings required - BT / Telecommunications Rating	9[*1] ××	8 ×	7 ×
Number of crossings required – NIW Rating	Nil Response	Nil Response	Nil Response
Number of crossings required – Gas Rating	3 ××	1 ×	1 ×
Number of crossings required – Road Lighting Rating	4 ×	2 ×	3 ×
Impact on Traffic Lights Rating	Yes ×	No -	Yes ×
Impact on Private Utilities Rating	N/A -	N/A -	N/A -
Overall Rating	××	×	×

Key:
✓✓✓ / ✓✓ / ✓ / - / × / ×× / ×××
(Positive – neutral - negative)
Notes:
[*1] Includes lengths of parallel crossings as a single crossing

4.6. Existing and Proposed Structures

4.6.1. The key impacts are to existing road structures such as watercourse culverts. There are no planned property demolitions or impacts on industrial heritage sites.

Existing Structures

4.6.2. The 2007 Option and Option 16 cross the Killuney Drain in the vicinity of the proposed roundabout tie-in to A3 Portadown Road. This section of watercourse is currently culverted as discussed in section 2.5 and it is anticipated that extension or replacement of the existing culvert may be required.

4.6.3. Options 12 and 16 utilise the existing Edenaveys Road through the industrial estate crossing the Ballynahone River in two locations. At this stage it has been assumed that there will be no impact on the relatively recently completed upgrade works on the Ballynahone River and the existing culverts will be retained.

4.6.4. Option 12 where it ties into A3 Portadown Road crosses an existing culvert (as discussed in paragraph 4.4.11). At this stage it is anticipated that extension or replacement of the existing culvert may be required.

Proposed Structures

4.6.5. The 2007 Option passes through existing embankments along Ardmore Road. Widening of the existing road may be required which will impact on the existing footprint of the road. To mitigate impact on the existing property owners retaining structures are proposed. The extents and height of material to be retained shall be confirmed during design development of the selected preferred route.

4.6.6. Where route options cross an existing open channel watercourse, we have assumed a culvert structure will be required. Sizing of any required watercourse culvert will be confirmed during development of the selected preferred route. As discussed in paragraph 4.4.14, 2007 Option / Option 16 will require a watercourse culvert at approximate Ch1925/Ch2550m respectively. Option 12 is likely to require a culvert at approximate Ch2900m and Ch2950m just south of the proposed tie-in at A3 Portadown Road.

4.6.7. Option 12 and 16 require an underbridge to continue use of Ballynahonemore Road. Currently no overbridges are required. This does not include potential accommodation structures to mitigate severance of lands. The requirements for of accommodation structures will be confirmed during development of the selected preferred route.

Table 4-19 - Summary of Structures Assessment

Assessment Area	2007 Option	Option 12	Option 16
Impact on Existing Structures	×	××	××
Proposed Retaining Structures	1	0	0
Proposed Bridge Structures	0	1	1
Proposed Watercourse Structures	2	2	2
Overall Rating	×	××	××

Key:
✓✓✓ / ✓✓ / ✓ / - / × / ×× / ×××
(Positive – neutral - negative)

4.7. Summary of Engineering Assessment

4.7.1. There are no identified departures from standard for 2007 Option, Option 12 or Option 16. Option 16 has five relaxations from standard, Option 12 contains four and the 2007 Option contains one. None of these relaxations would pose a significant barrier to the development of any of the proposed schemes.

4.7.2. The 2007 Option is considered to be the most suitable with regard to its land take with 45% of the land along this route already being owned by DFI, compared to Option 12 with 7% and Option 16 with 15%. It is estimated that the preferred route will also not require a significant volume of imported materials.

4.7.3. Geotechnical issues largely affect all of the routes to a similar degree, based on the extent of soft ground, earthworks balance and avoidance of significant man-made features and interaction with structures. Option 12 is least favourable with the largest earthworks volume and traversing areas of potentially soft marshy ground within inter drumlin areas. The fill re-usability for this route option may therefore be marginally lower than 2007 Option and Option 16.

4.7.4. All routes have the potential to encounter potentially contaminated soils, however 2007 Option and Option 16 have a slightly increased likelihood over other route options where they traverse through the Hamiltonsbawn Industrial Estate. The risk is, to some extent, mitigated with works being undertaken within the footprint of the existing road.

4.7.5. Option 12 and 16 utilise the existing culverts on Edenaveys Industrial Estate Road and therefore the number of watercourse crossings and lengths of culverts required are broadly similar and not a deciding factor in selecting a preferred route. None of the routes are expected to have a significant impact on flood plains and the number of outfalls required / available are also similar.

4.7.6. All potential routes will impact on utilities with the 2007 Option having a marginally greater impact resulting from its proximity to the urban environment.

4.7.7. The 2007 Option will require a retaining structure while Options 12 and 16 will each require an underbridge to continue use of Ballynahonemore Road.

4.7.8. The Engineering Assessment has identified that in key areas such as land take, cut/fill earthworks volumes and the requirement for structures the 2007 Option is the more favourable of the options assessed. No significant differences have been highlighted between the routes with regard to hydrology and only a marginally higher impact on utilities for the 2007 Option was identified.

5. Environmental Assessment

5.1. General

5.1.1. The aim of the environmental assessment has been to gain an understanding of the environmental sensitivities, within defined study areas, of the options being considered. The assessment provides a comparison of the options and indicates if any of the options could result in likely significant effects on the environment.

5.1.2. The options have, accordingly, been subject to a process of screening and scoping in accordance with DMRB Interim Advice Note (IAN 125/15), mainly to determine those impacts which should be addressed and the form that the assessments should take.

5.1.3. This assessment provides a comparison of impacts for each option at the end of each section. Each environmental aspect has used an appropriate level and methodology based on the amount and quality of information available, to provide a meaningful and robust assessment and comparison.

5.1.4. Article 3 of the EIA Directive (Directive 2014/52/EU) requires the consideration of the cumulative effects of a project and the interaction between the factors described therein (human, flora and fauna, soil, water, air, climate and the landscape). The Directive also requires consideration of cumulative effects of the project with other projects that may impact on the same receptor and resources. The need for this assessment has been transposed to the planning (EIA) Regulations (Northern Ireland) 2017 and incorporated in the DMRB, Volume 11, Section 1 and 2. A cumulative effects assessment has therefore been undertaken to assess whether the options could give rise to significant cumulative effects.

5.2. Potential Impacts and Effects

5.2.1. Activities that may give rise to impacts and effects were identified and considered initially through the scoping exercise. The impacts and effects of the options have been assessed as taking place in two principal phases:

- Construction phase – impacts within this phase are usually short term and reversible
- Operational phase – impacts within this phase are long term and caused by the physical nature and footprint of the options alongside it's every day operation

5.2.2. During the construction phase impacts may arise from:

- Temporary offices, compounds, storage areas and worksites
- Demolition of structures, including removal of some existing infrastructure (i.e. signs, safety barriers etc.)
- Vegetation clearance and soil removal
- Ground and excavation works
- Material import / export and other contractor vehicle movements along the construction corridor and adjacent road network
- Airborne dust, noise, vibration and drainage runoff
- Pollution events from construction processes
- Temporary diversion for vehicles and Non-Motorised Users (NMUs)

- Potential killing or injury and temporary severance of protected species habitats
- Temporary visual impacts to relevant sensitive receptors

5.2.3. During the operational phase of the options consideration has been given to:

- Change in traffic flow and speeds
- Locations of infrastructure associated with junction upgrades that have potential physical impacts and locational, visual setting impacts on nearby receptors and setting of cultural heritage assets as a result of an increase in vertical alignment
- Permanent physical impacts to protected species (killing or injury), cultural heritage assets or land use where the road is widened outside of the existing roads
- Increased impermeable area and potential impacts to the flood plain and other environmental receptors through increased run-off
- Maintenance of the options as a result of the works which will require a change to the existing environment which could be re-instated or compensated

5.2.4. During the operational phase of the selected option, the duration of the effect will be assessed on the following basis:

- Short term – Opening year (2020)
- Long term – Design year (15 years - 2035)

5.2.5. Assessment of cumulative effects (Section 5.14) will be determined as the net result of the environmental impact from a number of activities (where these are known and can be determined), and as the result of the incremental (combined) effect of several individual environmental effects.

5.2.6. The options have been developed in parallel with the environmental assessment. However, no specific design mitigation has been incorporated into the options at the time of assessment. Therefore, the assessment has, in some cases, determined potential impacts pre and post mitigation. However, where environmental aspects require further survey or assessment work to determine the potential effects of the specific options, mitigation has not been recommended and this will be resolved during further design development and in preparation of the Stage 3 Environmental Impact Assessment.

5.3. Scoping Process

5.3.1. The main purpose of the environmental scoping exercise at this stage is to:

- Refine the environmental impact assessment of the options
- Describe the existing and baseline knowledge
- Where possible define the value of the environmental resources and receptors
- Describe the potential impacts and likely significant effects
- Propose a methodology for assessment of effects including significance

5.3.2. To ensure that the scoping exercise identified relevant potential environmental receptors and / or issues, an initial maximum area of construction (without the benefit of understanding requirements for drainage mitigation or flood compensation) was determined.

5.3.3. The maximum area of construction and operation influence was developed to provide a study area for DMRB Stage 2 assessment, see Drawing 1064968-B-D-3000, Appendix A. The information included in the Armagh East Link DMRB Stage 1 and 2 Options Report and associated constraint plans / drawings (from RPS Planning and Environment, Mouchel Parkman and Mouchel in 2006–2007, 2009 and 2015), where applicable, provided a substantial amount of existing and baseline knowledge for the scoping exercise.

5.3.4. Table 5-1 provides a summary of the result of the screening and scoping exercise undertaken in accordance with IAN 125/15. The screening and scoping table should be read in conjunction with the associated environmental topics drawings (see *Appendix A*), as these include the baseline conditions identified through the scoping exercise and the baseline for the impact assessment sections. The table provides:

- an indication of the type of anticipated impacts – direct (D) or indirect (I), temporary (T) or permanent (P)
- the results of the rapid screening assessment (see *Appendix D*)
- the level of assessment required to identify the likelihood of significant effects on each environmental aspect
- the options and scope of assessment

5.3.5. Details of further works required to inform the selection process in relation to each environmental aspect in order has also been provided.

5.3.6. The Environmental Assessment Process is provided in *Appendix D*.

Table 5-1 - Summary of Screening Scoping Exercise

Potential Impacts	Topics	Likely significant Effects screened out(Y/N/U)	Level of Assessment Required		Study Area	Scope of Assessment at Stage 2
			Simple*	Detailed*		
D / T / P	Air Quality	N		✓	The study area was defined by the location of the options – consisting of both existing and new carriageway – and the location of any affected roads.	For the assessment of local air quality impacts, the defined study area meets the DMRB Volume 11, Section 3, Part 1 screening criteria: • Road alignment will change by 5m or more; or • Daily traffic flows will change by 1,000 annual average daily traffic (AADT) flow or more; or • Heavy duty vehicles (HDV) flows will change by 200 AADT or more; or • Daily average speeds will change by 10km/hr or more; or • Peak hour speed will change by 20km/hr or more. The assessment identified the number of relevant sensitive receptors within 200m of the affected roads from the options, where the influence of changes to vehicle emissions on pollutant concentrations is likely to be highest. Receptors considered sensitive to changes in local air quality have been selected according to the selection criteria within the DMRB from the Pointer address data set published by NI Direct Government Services. Each property has a Unique Property Reference Number (UPRN), representative of a specific residence or business. The air quality assessment study area facilitated the development of a detailed atmospheric dispersion modelling exercise, which was undertaken using the Atmospheric Dispersion Modelling System (ADMS) Roads v5.1. The ADMA was used to predict the potential changes in NO_2, $PM_{2.5}$ and PM_{10}

Potential Impacts	Topics	Likely significant Effects screened out(Y/N/U)	Level of Assessment Required		Study Area	Scope of Assessment at Stage 2
			Simple*	Detailed*		
						concentrations at the identified sensitive receptor locations. The ADMS was also used to predict the magnitude of potential local air quality impacts associated with the options.
D / T / P	Cultural heritage	U	✓		The nature and extent of any known or potential cultural heritage assets, including statutorily designated assets, such as listed buildings, has been examined to determine the potential impact of the options within study areas comprising the option alignments and a 500m buffer around their boundaries.	Cultural heritage has been examined in accordance with the Chartered Institute for Archaeologist's Standards and Guidance for Historic Environment Desk-Based Assessments (2014); with respect to the guidance provided by Volume 11, Section 3, Part 2, Appendix 8 and Annexes 5, 6 and 7 of the DMRB; HA208/07; and supplementary advice provided in IAN125/15. A walkover survey of the options was undertaken by a suitably qualified archaeologist in August 2016. The assessment of the value of cultural heritage assets involved consideration of how far the asset(s) contribute to an understanding of the past, through their individual or group qualities, either directly or potentially. These are professional judgements, but they are also guided by legislation, national policies, acknowledged standards, designations, criteria and priorities.
D / T / P	Landscape	Y		✓	The study area has been limited to a 1km buffer extending either side of the outer extents of options. Within the study area an Indicative Zone of Theoretical Visibility (ZTV) area was drafted.	The scope of the assessment has included a review of available and relevant documents relating to the study area. A site based review of baseline information was carried out to identify constraints associated with landscape character and visual receptors. The site visit was undertaken was undertaken in May 2016. The landscape and visual assessment will follow guidance on stages of the assessment contained in the DMRB, Volume 11, Section 5, Part 3 (1993) and

Potential Impacts	Topics	Likely significant Effects screened out(Y/N/U)	Level of Assessment Required		Study Area	Scope of Assessment at Stage 2
			Simple*	Detailed*		
						Highways Agency IAN 135/10 – Landscape and Visual Effects Assessment (HA, 2010). At this stage of the assessment, landscape character and visual amenity will be focussed on: • Recording and analysis of existing landscape character and visual context of the receiving environment through desk based and field based appraisals; • Identification of the key sensitivities associated with the study area and an appreciation of the design and mitigation measures appropriate to the options; • An assessment of the impacts and effects likely to result from the options and the sensitivity of the existing landscape and identified visual receptors to change; and • A comparison of the options and their potential to give rise to a significant effect on landscape character or visual amenity.
D / T / P	Nature conservation	U		✓	The study area comprised an area extending to 1km from each of the options. The following study areas for the assessment will be as follows: • International statutory designations – 2km, 30km for sites with bats as a qualifying feature;	Assessment of the effects of the proposals on ecological features was carried out in accordance with the recommendations of the Chartered Institute of Ecology and Environmental Management (CIEEM 2016), methods outlined in the DMRB Volume 11, Section 3, Part 4 Ecology and Nature Conservation and in line with Interim Advice Note 130/10 Ecology and Nature Conservation: Criteria for Impact Assessment and IAN 125/15 Environmental Assessment Update. The following sources were consulted to collate historical ecological records within the study area. Records were limited to statutory and non-statutory ecological designations and species records within the

Potential Impacts	Topics	Likely significant Effects screened out(Y/N/U)	Level of Assessment Required		Study Area	Scope of Assessment at Stage 2
			Simple*	Detailed*		
					• Nationally designated sites – 1km; • Non-statutory sites – 250m; and • Habitats – within and adjacent to the options.	study area. • Northern Ireland Environment Agency (NIEA); • Centre for Environmental Data and Recording (CEDaR); the Local Records Centre for Northern Ireland. A walkover survey, undertaken broadly in accordance with standard Phase 1 habitat survey methodology (JNCC, 2007), was carried out on 6th and 7th June 2016. Habitat types were identified and mapped, with target notes made of features of interest. The suitability of habitats within the site to support legally protected, valuable or controlled species was assessed with incidental field signs or sightings of species recorded as seen.
D / T / P	Geology and Soils	N / U		✓	The study area comprised an area extending to 1km from the options.	The assessment has been restricted to the extent to which the options could have physical interactions with known geological and soil environment. Therefore, the study area includes geology, soils or contaminated sites under or directly adjacent to the options. Information relating to geology and soils and the assessment relating to contaminated land and sites has been sourced and undertaken with reference to the following guidance provided in the DMRB - Volume 11, Section 3, Part 11 Geology and Soils (1993) and DMRB – Volume 11, IAN 125/15 (2015) Further studies will involve a review of current data to verify the status of sites which have been previously considered. Reference were made to the following data sources:

Potential Impacts	Topics	Likely significant Effects screened out(Y/N/U)	Level of Assessment Required		Study Area	Scope of Assessment at Stage 2
			Simple*	Detailed*		
						• The information included in the Armagh East Link DMRB Stage 2 Options Report (Mouchel Parkman and RPS Planning and Environment 2006 – 2007) and Mouchel (2015) Armagh East Link Route Assessment Report. <u>Assessment of Contamination Risk</u> Where contaminated / potentially contaminated sites could be disturbed during construction, the risk of contaminants (a source; e.g. a historic landfill) finding a linkage (pathway) to a receptor (e.g. construction workers) has been assessed. Where the assessment has identified such a potential source – pathway – receptor linkage, mitigation measures have been identified with the objective of breaking or modifying the linkage and avoiding or reducing the potential impact.
D / T	Materials and Waste	N	✓		Materials required / waste produced - within the footprints of the options. Capacity of waste sites – not considered at this stage	The assessment has been undertaken with reference to IAN 153/11. The assessment has focussed on the construction phase. Guidance on the environmental assessment of material resources and the amounts of materials required to construct the options. During scoping, the potential to generate hazardous waste was identified as being of environmental concern. Potential sources of hazardous waste have been identified from experience and knowledge of the types of waste typically generated throughout construction on large infrastructure projects. Section 7.6: Geology and Soils provides information / identified the potential for contamination to be encountered during construction, which are classed as

Potential Impacts	Topics	Likely significant Effects screened out(Y/N/U)	Level of Assessment Required		Study Area	Scope of Assessment at Stage 2
			Simple*	Detailed*		
						hazardous waste. • Impacts have been identified from the storing and disposal of such hazardous wastes and the potential for the waste to impact sensitive receptors. • The assessment provides broad assumptions regarding the difference between the options. • Waste strategy documents relating to the management of waste within Armagh City, Banbridge and Craigavon Borough (ABCB) Council have been identified in order to understand the available capacity for the treatment of Construction Demolition and Excavation Waste (CD&E) Waste in proximity to the options.
D / T / P	Noise and Vibration	U		✓	The study area is defined as 600m from the options edge (including proposed, or improved routes), 600m from any other affected route within 1km of the options, and 50m from any affected routes beyond 1km.	Both operational and construction related assessments have been undertaken with reference to the guidance provided in the DMRB Volume 11, Section 3, Part 7, HD 213/11 – Revision 1 Noise and Vibration. Reference will also be made to guidance within BS5228 Code of practice for noise and vibration control on construction and open sites (2009). A count of dwellings and relevant sensitive receptors within 600m of the options was undertaken. Noisemap Server Edition noise mapping software was used to predict propagation and noise levels within the study area. This commercially available 3D modelling software applies the calculation procedures as detailed in HD213/11. Traffic related noise levels have been predicted with the options in place, Do-Something, and without the scheme in place, Do-Minimum. The assessment

Potential Impacts	Topics	Likely significant Effects screened out(Y/N/U)	Level of Assessment Required		Study Area	Scope of Assessment at Stage 2
			Simple*	Detailed*		
						considers the Short-term, on scheme opening, and the Long-term, plus 15 years. For the options the following comparisons are made: • Do-Something verses Do-Minimum scenario in Opening Year (2020); and • Do-Something verses Do-Minimum scenario in Design Year (2035).
D / T / P	People and Communities	U		✓	<u>Non-Motorised Users (NMUs) and Users of Local Road</u> The study area for the assessment of journey length and amenity value is considered to be the network of NMUs routes in the vicinity of the options and where options link into or cross the routes. The NMUs routes that were included for identification through the desk study, site visits and consultation include: • Public Rights of Way (PRoW); and • Footways. <u>Vehicle Travellers</u> The study area for the	The assessments have been undertaken with reference to the following guidance: • DMRB – Volume 11, IAN 125/15 (HA 2015). <u>NMUs and Users of Local Roads</u> The method of assessment related to impacts on journeys undertaken by NMUs and users of local roads; in relation to changes in journey length and time, as an indicator of new severance; and relief of severance on the amenity value of PRoW has been undertaken based on the guidance provided in the DMRB, Volume 11, Section 3, Part 8, Pedestrians, Cyclists, Equestrians and Community Effects. <u>Vehicle Travellers</u> The methods of assessment related to driver stress and views from the road have been based on the guidance provided in the DMRB Volume 11, Section 3, Part 9 (Vehicle Travellers). <u>Land Use</u> The methods of assessment have been informed by the guidance detailed in the DMRB Volume 11, Section 3, Part 6 Land Use (Incorporating Amendment No.1 dated August 2001). The baseline environment has

Potential Impacts	Topics	Likely significant Effects screened out(Y/N/U)	Level of Assessment Required		Study Area	Scope of Assessment at Stage 2
			Simple*	Detailed*		
					assessment of changes to views from the road is limited to the connecting road within the options and is based on the ZTV outlined in Section 7.4 - Landscape. <u>Land Use</u> The study area allows for the identification of impacts to present or future land use that could be permanently precluded due to land take or a change in amenity as a result of the options.	been established through a desk-based assessment.
D / T / P	Road Drainage and the Water Environment	U		✓	The study area defined for the road drainage and the water environment assessment refers to a 1km buffer surrounding the extent of all the options, on the eastern fringe of the city of Armagh. Downstream surface water receptors have also been considered within 5km downstream of the	The assessment has been carried out in accordance with the guidance contained in the DMRB, Volume 11, Section 3, Part 10 Road Drainage and the Water Environment (HD 45/09). An explanation of the methods used is provided below. Other DMRB guidance documents used to inform this assessment: • DMRB Volume 11, Section 4, Part 1 HD 44/09 – Assessment of Implications (of Highways and/or Road Projects) on European Sites (Including Appropriate Assessment); • DMRB Part 7 HA 107/04 Design of Outfall and Culvert Details; and • DMRB Volume 4, Section 2, Part 3 HD 33/16

Potential Impacts	Topics	Likely significant Effects screened out(Y/N/U)	Level of Assessment Required		Study Area	Scope of Assessment at Stage 2
			Simple*	Detailed*		
					options.	Design of Highway Drainage Systems. A hydrological/hydromorphological walkover survey was undertaken on the 6th and 7th July 2016. This included review of existing water-related infrastructure, characterising local water features and identifying potential scheme interactions, in order to establish the sensitivity of receptors and to identify any potential water quality monitoring locations in advance of DMRB Stage 3. Assessment of surface water focused on the characteristics and subsequent potential impacts to surface water hydrological catchments with reference to water bodies characterised by the Northern Ireland Environmental Agency (NIEA) under the Water Framework Directive (WFD). This hydrological catchment-based approach enables due consideration to be given to both individual locations and the wider cumulative impacts within larger surface water body areas. Assessment of groundwater focussed on the potential for pollution of groundwaters/aquifers is greatest where cuttings are proposed and locations where there are permeable drift deposits. The length of cutting has been quantified for the options. The sensitivity of the groundwater has been evaluated based on the groundwater vulnerability classification, the magnitude of impact has been evaluated qualitatively.

Table 5-1 and 5-4 Notes:

1. Y/N/U: Y=Yes, N=No, U=Uncertain
2. Potential for direct (D), temporary (T), permanent (P) impacts
3. *Simple or detailed level assessment as defined in DMRB Volume 11

5.4. Methodology

5.4.1. Given the stage of design development and as a result of the scoping section as detailed above, it is appropriate to consider all technical environmental disciplines considered in DMRB Volume 11 and IAN 125/15 as follows:

- Air Quality
- Cultural Heritage
- Landscape
- Nature Conservation
- Geology & Soils
- Materials and Waste
- Noise and Vibration
- People and Community
- Road Drainage and the Water Environment
- Assessment of Cumulative Effects

Baseline Conditions

5.4.2. Baseline conditions were identified with identification and review of information relating to known or likely presence of environmental receptors and resources within defined study areas in order to determine their relative value / importance and / or sensitivity towards change. The desk based data sources have comprised:

- literature relating to the study area and databases
- records relating to environmental designations
- national policy documents
- historic and current mapping
- aerial photography
- data from previous environmental studies

Impact Identification and Assessment

5.4.3. Impact identification involves comparison of the existing environmental conditions or those predicted to exist immediately prior to introduction of the options, against the conditions that would occur, or be likely to occur, as a consequence of its implementation. Impacts comprise identifiable changes to the environment which may be direct or indirect; short-term / temporary, medium-term, or long-term / permanent; secondary, cumulative and either beneficial or adverse. These are defined in accordance with accepted terminology and standardised methodologies contained in DMRB to predict the magnitude of impact (change) resulting from implementation of the options.

5.4.4. Where enough information can be gathered from desk study or initial site visits the magnitude and significance of impacts / effects has been provided in the separate discipline assessment below. Where preliminary assessments have been undertaken the language used to compare the impacts of the options has been limited to negative or positive impacts.

5.4.5. Some environmental topics such as landscape effects require further assessment beyond the Long term – Design year (15 years – 2035), to take account of factors such as traffic growth and establishment / maturity of mitigation.

5.4.6. As an introduction to the comparison of the potential impacts the following sections generally describe the impacts associated with the option and provide clarity on the differences between the receptors potentially impacted by the options.

5.4.7. Significance criteria as provided in DMRB Volume 11 and supporting IANs will be used for the environmental assessment. Where quantitative measures may not be applied, criteria derived from DMRB will be utilised and a qualitative comment regarding the remaining likely significant effects is provided.

Mitigation

5.4.8. As the Options are under currently under development, the level of mitigation included is limited. This will be included during design development of the preferred option with continued assessments undertaken in parallel with the design. Therefore, where possible and appropriate, recommendations have been made for the implementation of mitigation to inform the selected preferred route design.

Consultation

5.4.9. The strategy for consultation partly depends on the consent method to be utilised for the options. The appropriate option for public consultation is a multi-phase approach as the scheme will require consultation with interested parties, statutory consultees and those impacted by landtake from the scheme.

5.4.10. A multi-phase consultation involves two (or more) phases of consultation where one of these is statutorily required. The first (informal) stage of consultation would include communication channels such as website updates, leaflet drops and public consultation exhibitions to gain feedback from stakeholders and interested parties. The statutory stage of consultation would include similar communication channels and additional notices to prescribed and statutory consultees and persons with an interest in land to be affected by the options. There is a statutory requirement to take account of consultation responses received.

5.4.11. Given the stage of options definition no consultation has been undertaken with statutory organisations on the scope of this assessment or to seek opinions on the options.

Regulatory and Policy Framework

5.4.12. In the UK, development is guided and regulated through national, regional and local planning policy. *Appendix E* contains a list of documents including policies considered applicable to the environmental aspects and to the wider scheme.

5.5. Air Quality

5.5.1. This section provides a review of existing air quality conditions within and in proximity to the defined study area. It details the outcomes of the assessment in relation to potential local and regional air quality impacts associated with the operation of the options. The assessment was undertaken in accordance with technical guidance published by Highways Agency, the Department of Environment Food and Rural Affairs (DEFRA) and other relevant guidance published by the Institute of Air Quality Management (IAQM).

5.5.2. The air quality impact assessment focussed on vehicle exhaust emissions and specifically changes in concentrations of those pollutants of principal health concern – Nitrogen dioxide (NO_2) and fine particulates (PM_{10} and $PM_{2.5}$).

5.5.3. The results of the assessment for the options were used to determine the likelihood of significant air quality effects, in accordance with the criteria provided in Highways Agency et al. guidance IAN 125/15 Environmental Assessment.

Study Area

5.5.4. For the assessment of local air quality impacts, the study area was defined by the location of the options – consisting of both existing and new carriageway – and the location of any affected roads meeting the DMRB Volume 11, Section 3, Part 1 screening criteria as follows:

- Road alignment will change by 5m or more
- Daily traffic flows will change by 1,000 Annual Average Daily Traffic (AADT) flow or more
- Heavy duty vehicle (HDV) flows will change by 200 AADT or more
- Daily average speeds will change by 10km/hr or more, or
- Peak hour speed will change by 20km/hr or more

5.5.5. The options include new carriageway and therefore the DMRB criteria would be met due to the change in road alignment. The presence of affected links as part of the affected road network requires a detailed DMRB assessment for impacts to local air quality to be undertaken.

5.5.6. Identifying the air quality assessment study area facilitated the development of a detailed atmospheric dispersion model to predict the magnitude of potential local air quality impacts associated with the options.

Methodology

5.5.7. The following guidance documents were referenced in completing the air quality impact assessment:

- Section 3, Part 1 – HA207/07 Air Quality of Volume 11 of the DMRB
- DEFRA Local Air Quality Management Technical Guidance (LAQM.TG(16))
- IAN 170/12 - Updated air quality advice on the assessment of future NOx and NO2 projections for users of HA207/07. The IAN provides updated advice on long term trends (LTT) for NO2
- IAN 125/15 - Environmental Assessment
- Institute of Air Quality Management Guidance on the Assessment of Dust from Demolition and Construction
- The Air Quality Strategy for England, Scotland, Wales and Northern Ireland
- The Air Quality Standards Regulations (Northern Ireland 2010)

Construction Phase

5.5.8. As the final option has not yet been selected and therefore detailed design is not yet available, information relating to the construction area, site entrance and traffic data is not available.

5.5.9. Best practice mitigation measures to minimise potential air quality impacts from construction activities are recommended, which should be included in the Construction Environment Management Plan (CEMP).

Local Air Quality Impacts

5.5.10. The following methodology was executed to enable potential local air quality impacts associated with the options to be identified, incorporating:

- Establishment of the local air quality study area through traffic data screening
- Identification of relevant sensitive receptors within the study area
- Review of baseline conditions in relation to designated Air Quality Management Areas (AQMAs) situated within the modelled study area based upon the affected road network, local monitoring data, and DEFRA mapped background levels for the assessed pollutant species
- Calculation of predicted concentrations of NO_2, PM_{10} and $PM_{2.5}$ for the base year and the Do-Minimum (DM) and Do-Something (DS) scenarios in the proposed opening year
- Evaluation of the results against Air Quality Standards (AQS) to determine the significance of changes in concentrations of the pollutants
- Significance criteria applied relating to likely significant effects in accordance with the criteria provided in IAN 125/15

5.5.11. The following scenarios with associated traffic data were assessed using detailed dispersion modelling as part of the local air quality assessment:

- **Base Year / Model Verification (2014)** – assessment of current air quality conditions within study area;
- **DM Opening Year (2020)** – future baseline air quality predictions based on future traffic flows without the options in operation
- **DS Opening Year (2020)** – future air quality predictions based on future traffic flows with the options in operation.

Identified Sensitive Receptor Locations

5.5.12. The local air quality impacts assessment is focussed on relevant sensitive receptors within 200m of the affected road links, where the influence of changes to vehicle emissions on pollutant concentrations is likely to be highest.

5.5.13. Receptors considered sensitive to changes in local air quality have been selected according to the selection criteria within the DMRB from the Pointer address data set published by NI Direct Government Services. Each property has a Unique Property Reference Number (UPRN), representative of a specific residence or business.

5.5.14. The following locations represent sensitive receptors where there may be people whose health is vulnerable to changes in air quality:

- Schools and nurseries
- Care homes and hospitals
- Residential properties

Detailed Atmospheric Dispersion Modelling

5.5.15. Operation of each of the options will generate additional vehicle exhaust emissions on the local road network relative to the existing baseline. An atmospheric dispersion modelling exercise was undertaken using Atmospheric Dispersion Modelling System (ADMS) Roads v5.1 to predict the potential changes in NO_2, $PM_{2.5}$ and PM_{10} concentrations at the identified sensitive receptor locations.

5.5.16. Annual Average Daily Traffic (24-hour AADT) flows and Heavy Duty Vehicle (HDV) percentages were input into the air quality assessment. Vehicle emissions factors were applied using DEFRA's Emission Factor Toolkit v7 to calculate emissions of NOx, PM_{10} and $PM_{2.5}$ for each road link, accounting for road type, vehicle flow, fleet composition, and traffic speeds per affected road link.

5.5.17. Meteorological data providing hourly sequential data including wind direction, wind speed, temperature, precipitation and the extent of cloud cover for each hour of a given year from the Belfast Aldergrove weather station (54.656, -6.214, 50km north east of the scheme) for 2014 was input to the ADMS Roads model. A modelled surface roughness on 0.5m was used, the surface roughness reflects the land use of open land and suburban areas.

5.5.18. A profile of time-varying emissions factors was derived based on automatic traffic counts to represent the changes in traffic flow throughout typical weekday and weekend 24-hour periods. The traffic count data related to the following roads within the study area:

- A3
- A29
- Barrack Hill
- Keady Road
- Moy Road
- A28

5.5.19. The relevant time-varying emissions factors used within ADMS Roads Model are presented in Table 5-2 below.

Table 5-2 - Time-Varying Emissions Factors Applied to Road Links within ADMS-Roads Model

Hour	Weekday Factors	Weekend Factors
00:00 - 01:00	0.10	0.26
01:00 - 02:00	0.06	0.20
02:00 - 03:00	0.03	0.14
03:00 - 04:00	0.04	0.09
04:00 - 05:00	0.06	0.07
05:00 - 06:00	0.19	0.13
06:00 - 07:00	0.49	0.29

Hour	Weekday Factors	Weekend Factors
07:00 - 08:00	1.12	0.62
08:00 - 09:00	1.86	1.13
09:00 - 10:00	1.59	1.34
10:00 - 11:00	1.39	1.47
11:00 - 12:00	1.45	1.61
12:00 - 13:00	1.56	1.82
13:00 - 14:00	1.65	1.90
14:00 - 15:00	1.68	1.87
15:00 - 16:00	1.76	1.80
16:00 - 17:00	1.86	1.85
17:00 - 18:00	1.95	1.87
18:00 - 19:00	1.61	1.65
19:00 - 20:00	1.27	1.32
20:00 - 21:00	0.89	0.99
21:00 - 22:00	0.68	0.72
22:00 - 23:00	0.47	0.53
23:00 - 24:00	0.24	0.34

Regional Emissions Assessment

5.5.20. The regional emissions assessment focusses on changes in total annual mass emissions of oxides of nitrogen (NOx), PM_{10} and $PM_{2.5}$, and carbon dioxide (CO_2) across the study area. Vehicle emissions of each species were predicted for the following scenarios:

- Base Year (2014)
- Do-Minimum Opening Year (2020)
- Do-Something Opening Year (2020)
- Do-Minimum Design Year (2035)
- Do-Something Design Year (2035)

5.5.21. Traffic data for each scenario were input to the DEFRA emission factor toolkit (EFT v.7), which enabled total emissions to be derived based on vehicle flow volumes, composition, speed, and vehicle kilometres travelled on each affected link.

5.5.22. For the study area focussed on regional impacts, the following DMRB screening criteria were applied to identify road links that exhibit:

- A change of more than 10% in AADT; or
- A change of more than 10% to the number of heavy duty vehicles; or
- A change in daily average speed of more than 20 km/hr.

Existing Environment

Local Air Quality Management

5.5.23. Within Northern Ireland, Local Air Quality Management is provided for under the Environment Order (Northern Ireland) 2002, by which air quality is managed by district councils. Councils are required to declare an Air Quality Management Area (AQMA), and in conjunction with other relevant authorities, develop an Action Plan to address the problem.

5.5.24. Two AQMAs have been designated in Armagh:

- Armagh AQMA – An area encompassing the A29 and A3 in Armagh, running from Railway Street in the north, along Lonsdale Road, Mall West and along Barrack Street in the south. Declared for exceedances of the annual mean NO_2 objective (40µg.m-3)
- Greenpark Terrace Armagh AQMA – Incorporating properties 1 – 4 Greenpark Terrace and 74 – 94 Irish Street. Declared for exceedances of the annual mean NO2 objective

5.5.25. The route options are not situated within an AQMA; however the affected road network modelled for the local air quality assessment does include road links within the Armagh AQMA designated by Armagh, Banbridge and Craigavon Borough Council (ABCB) Council. As such, the potential impacts of the proposed scheme on air quality at sensitive receptors located within this AQMA were considered in the assessment. Table 5-3 outlines the distances between each of the options and the AQMAs.

Table 5-3 - Distance between designated Armagh AQMA and Options

AQMA	2007 Option	Option 12	Option 16
Armagh	1.2km	1.3km	1.2km
Greenpark Terrace Armagh	1.7km	2.1km	1.7km

Local Air Quality Monitoring

5.5.26. DEFRA operates a roadside continuous NO_2 monitor in Armagh at Lonsdale Road. Measured annual mean concentrations from this site are presented in Table 5-4. The monitor is situated in a residential area and thus is representative of sensitive exposure.

Table 5-4 - NO_2 Concentrations from the Armagh Lonsdale Road Continuous Monitor

Continuous Monitor Site Name	Site XY Coordinates	Year	Annual Mean NO_2 ($\mu g.m^{-3}$)*
Armagh Lonsdale Road	287517, 345826	2015	27.6
		2014	28.4
		2013	26.5

* Based on daily average data.

5.5.27. Passive diffusion tube NO_2 monitoring is carried out by ABCB Council at one location within 1km of the options at Greenfield Way. Published data for Greenfield Way (X 288780; Y 344238) from 2014 (11µg.m-3) was below the NO_2 annual mean objective of 40 µg.m-3.

5.5.28. A scheme specific air quality monitoring programme was implemented from April 2016 to October 2016, to provide an indication of the baseline NO_2 levels in the vicinity to the options and existing roads considered likely to be affected by the options. Monitoring was conducted using diffusion tubes supplied and analysed by a UKAS certified laboratory (ESG). The monitoring results are given in Table 5-5.

Table 5-5 - Annualised Mean Bias Adjusted Summary of NO2 Concentrations from Scheme Specific Monitoring within 1km of the Options

Concentration	Site Name	X	Y	NO_2 annualised bias adjusted concentration 2016 (µg.m^{-3})	Data Capture (%)
Maximum	Newry Road	287894	344990	**59.4**	100
Minimum	Drumbeemore Road	291082	343698	5.9	100
Average[+]	-	-	-	19	-
Main Road	Portadown Road	289233	346334	35.2	83.3
Main Road	Hamiltonsbawn Road	289298	345215	10.3	100
Main Road	Stockingmans Hills Road	290008	345095	14.5	100
Main Road	Canavancaw Road	288637	343876	23.6	100

[*] For all sites within 1km of scheme. Bold indicates monitored exceedance.

5.5.29. The scheme specific monitoring results listed in Table F-1 (*Appendix F*) show that there were three locations in exceedance of the annual mean NO_2 objective at Irish Street within the Greenpark Terrace AQMA, Newry Road just to the South of the Armagh AQMA and at the Armagh DEFRA operated continuous monitor colocation on Lonsdale Road in the town centre.

Relevant Sensitive Receptors

5.5.30. A total of 2,552 sensitive receptors were identified within 200m of the affected roads from the options, a breakdown of which is presented in Table 5-6. Religious premises and sports facilities have been included as they may have associated residential dwellings. Any properties for which the use was not defined in the Pointer address data set have been assumed to be sensitive locations for the purpose of the assessment.

Table 5-6 - Identified Sensitive Receptor within 200m of Affected Roads

Receptor type	Do Minimum	Do Something
Education	3	3
Leisure and Tourism	0	0
Health	18	18

Receptor type	Do Minimum	Do Something
Hospitality	4	4
Residential	2174	2174
Religious	11	11
Sports Facilities	5	5
Use not defined in dataset	337	337
Total	**2552**	**2552**

Ecological Designations

5.5.31. Further to the above, the locations of ecologically designated sites including Area of Special Scientific Interest (ASSI), Special Area of Conservation (SAC), Ramsar, and Special Protection Area (SPA) sites should be considered in the assessment of local air quality (refer to Section 5.8 – Nature Conservation and 5.9– Geology and Soils). The closest designated site to the scheme is the Drumarg ASSI situated 1.9km from the closest alignment of the options and 840m from the nearest affected link. As the Drumarg ASSI is situated beyond 200m from any affected link, it was not considered further in this assessment.

Background Concentrations

5.5.32. A summary of background concentrations of NOx, NO_2, PM_{10} and $PM_{2.5}$ obtained from the DEFRA air pollutant concentration maps, and based on a reference year of 2013, are presented in Table 5-7. The full dataset is listed in Table F-2 (*Appendix F*).

Table 5-7 - Summary of Background Pollutant Concentrations Obtained for 1km2 Grids Covering the Options and Surrounding Road Network

Concentration	1 km^2 grid (X,Y)	Pollutant	2014 (Base Year) ($\mu g.m^{-3}$)	2016 ($\mu g.m^{-3}$)	2020 (Opening Year) ($\mu g.m^{-3}$)
Maximum	288500; 345500	NO_x	9.8	8.8	6.7
	288500; 345500	NO_2	7.4	6.7	5.2
	288500; 345500	PM_{10}	14	13.7	13.2
	288500; 345500	$PM_{2.5}$	10.4	10.2	9.7
Minimum	290500; 343500	NO_x	6	5.5	4.3
	290500; 343500	NO_2	4.7	4.2	3.4
	290500; 343500	PM_{10}	11	10.7	10.3
	290500; 343500	$PM_{2.5}$	7.4	7.2	6.8
Average (for all grid squares covering the scheme options)	-	NO_x	7.6	6.9	5.3
	-	NO_2	5.9	5.3	4.1
	-	PM_{10}	12	11.7	11.3
	-	$PM_{2.5}$	8.3	8.1	7.7

5.5.33. Local NO_2, $PM_{2.5}$ and PM_{10} background concentrations are below the respective annual mean objectives within the DEFRA grid squares encompassing the options and the surrounding road network.

5.5.34. For the model results processing, adjustment of the background concentrations was undertaken to remove motorway, primary and trunk A-Road NO_X, PM_{10} and $PM_{2.5}$ sources to avoid double counting of vehicle emissions from the modelled road links.

Local Air Quality Impacts

Atmospheric Dispersion Modelling

5.5.35. Annual mean NO_2, $PM_{2.5}$ and PM_{10} concentrations were predicted at the identified sensitive receptors using ADMS Roads Model in the Base Year (2014) and the proposed Opening Year (2020) DM and DS scenarios. Model predictions from the Base Year were verified against scheme specific WSP (Mouchel) monitoring data. The changes in pollutant concentrations between the DM and DS scenarios were calculated at each identified sensitive receptor.

5.5.36. The results of the modelling assessment are presented in Table 6-8 for the options. Exceedances of the relevant air quality objectives are highlighted in bold.

Base Year (2014)

5.5.37. The results of the base year assessment predicted 78 exceedances of the NO_2 annual mean objective (40µg.m-3) at identified sensitive receptors. The exceedances were predicted within central Armagh and at receptors near to the junction of the A3 Portadown Road with Drumadd Road and Mullinore Road to the west of the proposed scheme. The annual mean NO_2 concentrations were predicted to be below the objective at all other identified sensitive receptors in the Base Year (2014) scenario.

5.5.38. Annual mean concentrations of PM_{10} and $PM_{2.5}$ were predicted to be below the respective air quality objectives in the base year at all locations within the study area.

5.5.39. In accordance with DEFRA TG(16) guidance, exceedances of the one-hour mean objective for NO_2 are unlikely as the predicted annual mean concentrations at all receptors are less than 60µg.m-3. The short-term air quality objective for PM_{10} is not expected to be exceeded at any of the modelled locations as there are no predicted exceedances of the daily mean objective of 50µg.m-3.

Table 5-8 - Predicted Annual Mean NO_2, PM_{10} and $PM_{2.5}$ Results Summary for Base Year (BY) (2014) and Opening Year (2020) Do-Minimum (DM) versus Do-Something (DS) for the Options

2007 Option				
Pollutant		**NO_2**	**PM_{10}**	**$PM_{2.5}$**
Annual Mean Objective (µg.m^{-3})		**40**	**40**	**40**
Number of Properties	BY Exceedances	**78**	0	0
	DM Exceedances	**9**	0	0
	DS Exceedances	**9**	0	0
	New Exceedances	0	0	0
	Removal of Exceedances	0	0	0
Total Number of Properties	Improvement in Concentration	1,266	654	402
	No Change in Concentration	689	1,543	1,921
	Deterioration in Concentration	597	355	229
DS-DM Annual Mean Change (µg/m^3)	Maximum Worsening	5.3	1.2	0,7
	Maximum Benefit	-11.9	-1.6	-0.9
Option 12				
Pollutant		**NO_2**	**PM_{10}**	**$PM_{2.5}$**
Annual Mean Objective (µg.m^{-3})		**40**	**40**	**40**
Number of Properties	BY Exceedances	**78**	0	0
	DM Exceedances	**9**	0	0
	DS Exceedances	**9**	0	0
	New Exceedances	0	0	0
	Removal of Exceedances	0	0	0
Total Number of Properties	Improvement in Concentration	2,039	943	581
	No Change in Concentration	355	1,586	1,927
	Deterioration in Concentration	158	23	44
DS-DM Annual Mean Change (µg/m^3)	Maximum Worsening	2	0.4	0.2
	Maximum Benefit	-12.2	-1.6	-1
Option 16				
Pollutant		**NO_2**	**PM_{10}**	**$PM_{2.5}$**
Annual Mean Objective (µg.m^{-3})		**40**	**40**	**40**
Number of Properties	BY Exceedances	**78**	0	0
	DM Exceedances	**9**	0	0
	DS Exceedances	**9**	0	0
	New Exceedances	0	0	0
	Removal of Exceedances	0	0	0
Total Number of Properties	Improvement in Concentration	1,648	720	492
	No Change in Concentration	474	1,574	1,871
	Deterioration in Concentration	430	258	189
DS-DM Annual Mean Change (µg/m^3)	Maximum Worsening	2.3	0.4	0.2
	Maximum Benefit	-12	-1.6	-0.9

Opening Year (2020)

5.5.40. The predicted annual mean concentrations of NO_2 at 99.6% of the modelled sensitive receptors are below the air quality objective in the opening year of the proposed development in both the Do-Minimum (DM) and Do-Something (DS) scenarios for the options (see figures 1064968-B-D-3001 to 1064968-B-D-3021). There are nine receptors that exceed in both the opening year DM and DS scenarios and the base year (see Table 5-9).

5.5.41. The receptors in exceedance of the NO_2 objective are located on Newry Road, approximately 35m to the south of the Armagh AQMA. The predicted NO_2 annual mean concentration is predicted to reduce at each property with the options in operation.

5.5.42. The options are not predicted to result in the introduction of new exceedances of the NO_2 objective in 2020.

5.5.43. There are no predicted exceedances of the annual mean PM_{10} and $PM_{2.5}$ objectives at any of the modelled receptor locations, in both the DM and DS scenarios for the options. All predicted annual mean PM_{10} and $PM_{2.5}$ concentrations are below 50% of the respective objective concentrations, with the maximum predicted values at 17.9µg.m-3 (PM_{10}) and 12.3µg.m-3 ($PM_{2.5}$) in the DS scenario.

5.5.44. The daily mean PM10 objective of 50µg.m-3 (not to be exceeded more than 35 times a year), is predicted to be met at all identified receptor locations in all scenarios. Predicted NO2 concentrations are below 60µg.m-3 and therefore the hourly mean objective of 200µg.m-3 is unlikely to be exceeded.

Table 5-9 - Predicted Annual Mean NO_2 Concentrations at the Receptor Locations in Exceedance of the Objective in the Opening Year 2020 for the Options

2007 Option			
Location	**DM NO_2 (µg.m^{-3})**	**DS NO_2 (µg.m^{-3})**	**Change NO_2 (µg.m^{-3})**
20 Newry Rd	41.9	41.3	-0.6
14 Newry Rd	48.1	47.5	-0.6
16 Newry Rd	47.7	47	-0.7
18 Newry Rd	46.9	46.3	-0.6
12 Newry Rd	49.0	48.3	-0.7
10 Newry Rd	48.6	48	-0.6
6 Newry Rd	46.8	46.1	-0.7
8 Newry Rd	48.2	47.6	-0.6
4 Newry Rd	44.6	44.0	-0.6
Option 12			
Location (Armagh)	**DM NO_2 (µg.m^{-3})**	**DS NO_2 (µg.m^{-3})**	**Change NO_2 (µg.m^{-3})**
20 Newry Rd	41.9	41.0	-0.9
14 Newry Rd	48.1	47.4	-0.7
16 Newry Rd	47.7	46.9	-0.8
18 Newry Rd	46.9	46.1	-0.8
12 Newry Rd	49.0	48.3	-0.7

2007 Option			
Location	**DM NO_2 ($\mu g.m^{-3}$)**	**DS NO_2 ($\mu g.m^{-3}$)**	**Change NO_2 ($\mu g.m^{-3}$)**
20 Newry Rd	41.9	41.3	-0.6
14 Newry Rd	48.1	47.5	-0.6
16 Newry Rd	47.7	47	-0.7
18 Newry Rd	46.9	46.3	-0.6
12 Newry Rd	49.0	48.3	-0.7
10 Newry Rd	48.6	48	-0.6
6 Newry Rd	46.8	46.1	-0.7
8 Newry Rd	48.2	47.6	-0.6
4 Newry Rd	44.6	44.0	-0.6
Option 12			
Location (Armagh)	**DM NO_2 ($\mu g.m^{-3}$)**	**DS NO_2 ($\mu g.m^{-3}$)**	**Change NO_2 ($\mu g.m^{-3}$)**
10 Newry Rd	48.6	47.9	-0.7
6 Newry Rd	46.8	46.1	-0.7
8 Newry Rd	48.2	47.5	-0.7
4 Newry Rd	44.6	44.0	-0.6
Option 16			
Location	**DM NO_2 ($\mu g.m^{-3}$)**	**DS NO_2 ($\mu g.m^{-3}$)**	**Change NO_2 ($\mu g.m^{-3}$)**
20 Newry Rd	41.9	41.7	-0.2
14 Newry Rd	48.1	47.8	-0.3
16 Newry Rd	47.7	47.4	-0.3
18 Newry Rd	46.9	46.6	-0.3
12 Newry Rd	49	48.7	-0.3
10 Newry Rd	48.6	48.3	-0.3
6 Newry Rd	46.8	46.4	-0.4
8 Newry Rd	48.2	47.9	-0.3
4 Newry Rd	44.6	44.3	-0.3

Regional Emissions

5.5.45. The results of the DMRB regional assessment are presented in Table 5-10 below. There is predicted to be an overall decrease in annual mass emissions of each vehicle exhaust species assessed from the Base Year (2014) to the Opening Year (2020) and Design Year (2035), with the exception of CO_2, which increases marginally for Options 12 and Option 16.

5.5.46. A comparison of the DM and DS scenarios for the Opening Year indicates a predicted increase in CO_2 emissions associated with the operation of Option 12 and Option 16 in the Opening Year. For the 2007 Option, the CO_2 emissions are lower for the DS scenario than for the DM scenario in the Opening Year.

5.5.47. The emissions of $PM_{2.5}$ and NOx marginally decrease and PM_{10} emissions do not change in the Opening Year with Option 12 in operation. With Option 16 in operation,

the emissions of NOx and PM_{10} do not change and emissions of $PM_{2.5}$ are marginally reduced. Operation of the 2007 Option is predicted to lead to a reduction in emissions of CO_2, NO_X, $PM_{2.5}$ and PM_{10}.

5.5.48. A comparison of the DM and DS scenarios for the Design Year 2035 indicates that there is predicted to be an increase in CO_2 emissions associated with the operation of Option 12 and Option 16. There is a decrease in CO_2 emissions with the operation of the 2007 Option.

5.5.49. Emissions of $PM_{2.5}$, NO_X and PM_{10} are predicted to reduce with the operation of Option 12 in the Design Year. With Option 16 in operation, the emissions of $PM_{2.5}$ are predicted to fall slightly; however emissions of NO_X are predicted to increase marginally, with no change in PM10 emissions. Emissions of CO_2, NO_X, PM_{10} and $PM_{2.5}$ are predicted to be lower in 2035 with the 2007 Option in operation.

Table 5-10 - Summary of Regional Emissions for the Options

2007 Option				
Pollutant	**$PM_{2.5}$***	**NO_X***	**PM_{10}***	**CO_2***
	tonnes/yr	**tonnes/yr**	**tonnes/yr**	**tonnes/yr**
Base Year (2014)	1.2	27.6	1.8	8031.6
Opening Year DM (2020)	0.9	11.8	1.6	7854.1
Opening Year DS (2020)	0.8	11.7	1.6	7204.9
Change from DM to DS (2020)	-0.1	-0.1	0.0	-649.2
Percentage Change DS-DM (2020)	-11.0%	-1.1%	-0.6%	-8.3%
Design Year DM (2035)	1.0	7.4	1.8	8527.5
Design Year DS (2035)	0.9	7.3	1.8	7850.3
Change from DM to DS (2035)	-0.1	0.0	0.0	-677.2
Percentage Change DS-DM (2035)	-10.3%	-0.3%	-1.1%	-7.9%
Option 12				
Pollutant	**$PM_{2.5}$***	**NO_X***	**PM_{10}***	**CO_2***
	tonnes/yr	**tonnes/yr**	**tonnes/yr**	**tonnes/yr**
Base Year (2014)	1.2	27.6	1.8	8031.6
Opening Year DM (2020)	0.9	11.8	1.6	7918.9
Opening Year DS (2020)	0.8	11.5	1.6	8317.3
Change from DM to DS (2020)	-0.1	-0.3	0.0	398.4
Percentage Change DS-DM (2020)	-11.0%	-2.4%	-1.2%	5.0%
Design Year DM (2035)	1.0	7.4	1.8	8527.5
Design Year DS (2035)	0.9	7.3	1.8	9043.9
Change from DM to DS (2035)	-0.1	-0.1	0.0	516.4
Percentage Change DS-DM (2035)	-11.3%	-0.8%	-1.1%	6.1%
Option 16				
Pollutant	**$PM_{2.5}$***	**NO_X***	**PM_{10}***	**CO_2***
	tonnes/yr	**tonnes/yr**	**tonnes/yr**	**tonnes/yr**
Base Year (2014)	1.2	27.6	1.8	8031.6
Opening Year DM (2020)	0.9	11.8	1.6	7854.1
Opening Year DS (2020)	0.7	11.8	1.6	8410.0

Change from DM to DS (2020)	-0.2	0.0	0.0	555.9
Percentage Change DS-DM (2020)	-20.9%	0.3%	0.0%	7.1%
Design Year DM (2035)	1.0	7.4	1.8	8527.5
Design Year DS (2035)	0.8	7.4	1.8	9139.0
Change from DM to DS (2035)	-0.2	0.1	0.0	611.5
Percentage Change DS-DM (2035)	-19.6%	0.8%	0.0%	7.2%

*Calculated with EFT version 7.0. Values given in Table 7.2.9 are rounded to 1 decimal place.

Significant Effects

Local Air Quality

5.5.50. The significance of local air quality effects associated with the options was evaluated in accordance with IAN 174/13. This includes analysing the results of the local air quality assessment, with respect to the number of properties predicted to experience:

- Worsening of air quality objective already above objective or creation of a new exceedance
- Improvement of an air quality objective already above objective or the removal of an existing exceedance

5.5.51. The results are presented in Table 5-11.

Table 5-11 - Significance of Impacts upon Local Air Quality in the Opening Year 2020

Magnitude of Change in Annual Average NO_2 or PM_{10} ($\mu g.m^{-3}$)	Total Number of Receptors with:	
	Worsening of air quality objective already above objective or creation of a new exceedance	Improvement of an air quality objective already above objective or the removal of an existing exceedance
2007 Option		
Large (>4)	0	0
Medium (>2)	0	0
Small (>0.4)	0	9
Option 12		
Large (>4)	0	0
Medium (>2)	0	0
Small (>0.4)	0	9
Option 16		
Large (>4)	0	0
Medium (>2)	0	0
Small (>0.4)	0	0

5.5.52. The options are not predicted to result in any new exceedances of an air quality objective or contribute to a worsening of air quality where an objective is already exceeded (e.g. within an existing AQMA).

5.5.53. Of the nine receptors predicted to exceed the NO_2 annual mean objective in the base year and Opening Year DM scenarios, all are predicted to experience a small improvement in the DS scenarios for each of the options. For Option 16, the predicted improvements are below 0.4µg.m-3, thus are considered imperceptible.

5.5.54. All of the options have an overall beneficial impact on local air quality, with predominantly marginal improvements to pollutant concentrations in the DS scenario. The option which has the greatest potential improvement to local air quality is Option 12, which is predicted to result in the largest magnitude of reduction in NO_2 concentrations (see Table 5-9).

5.5.55. Given the relatively small magnitude of changes across the study area, the options are not predicted to result in a significant environmental effect with respect to local air quality.

Regional Emissions

5.5.56. Guidance document DMRB HA207/07 acknowledges that regional emissions associated with the options are expected to be small in relation to the national emissions.

5.5.57. The 2007 Option is predicted to be most beneficial in terms of regional emissions, with predicted reductions in NOx, PM_{10}, and $PM_{2.5}$ emissions in each DS scenario for the Opening Year and Design Year compared to DM. Option 12 and Option 16 are predicted to result in marginal increases in CO_2 emissions, with a decrease predicted for the 2007 Option.

5.5.58. Given the size and scale of the options, significant effects with respect to regional emissions are unlikely in the context of national emissions and the predicted magnitude of changes relative to the DM scenario.

Recommended Mitigation Measures

Local Air Quality: Construction Phase

5.5.59. To mitigate potential adverse effects upon air quality during the construction of the selected option, the IAQM Guidance 19 identifies appropriate site-specific mitigation. These measures are related to whether the site is classed as ‘low risk’, ‘medium risk’ or ‘high risk’. Without information on the extent of the construction area, duration of works, locations of site entrances or construction traffic flows, at this stage it has not been possible to fully assess the likely construction impacts.

5.5.60. A CEMP should be developed as good practice to prevent or minimise the release of dust entering the atmosphere and/or being deposited on nearby receptors. Particular attention should be paid to operations which unavoidably take place in the immediate vicinity of sensitive receptors. The following recommendations should be included in the CEMP:

- Plant used on site should be fitted with particulate filters to reduce emissions of particulate matter (PM_{10} and $PM_{2.5}$)
- Implementation of a Dust Management Plan (DMP), incorporating protocols for recording all complaints, identifying cause(s), and taking appropriate measures to reduce emissions in a timely manner
- Removal of materials that have a potential to produce dust from site as soon as possible, unless being re-used on site. If they are being re-used on-site carry out

covering, compacting, seeding or fencing stockpiles to prevent wind whippin as appropriate

- Provision of an adequate water supply on the site for effective dust/particulate matter suppression
- Using enclosed chutes and conveyors and covered skips
- Minimisation of drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate
- Ensuring equipment is readily available on site to clean any dry spillages, and clean up spillages as soon as reasonably practicable after the event using wet cleaning methods

Local Air Quality: Operation Phase

5.5.61. Operation of each of the options are predicted to result in predominantly beneficial changes to local air quality, with a greater number of receptors experiencing an improvement in the Opening Year (2020) DS scenarios relative to the DM scenario. The option which predicts the greatest potential improvement to local air quality is Option 12, which results in the greatest magnitude of improvements.

5.5.62. As such, beyond the inherent predicted benefits of the options, no further mitigation measures specific to local air quality are considered necessary at this stage.

Summary of Likely Significant Effects

5.5.63. The local and regional air quality impacts of implementing either of the options are predicted to be predominantly beneficial. However, the magnitude of changes of these improvements are relatively small. As such, the options are not predicted to result in a significant environmental effect with respect to local and regional air quality.

5.5.64. Table 5-12 summarises the likelihood of the options to generate significant effects on air quality.

Table 5-12 – Summary of Likelihood of Significant Effects on Air Quality in Accordance with IAN 125/15

	2007 Option	Option 12	Option 16
Local Air Quality – Operation Phase	Low Likelihood	Low Likelihood	Low Likelihood
Regional Emissions	No Likelihood	No Likelihood	No Likelihood

Limitations of Assessment

5.5.65. The assessment is based on preliminary traffic data.

5.5.66. The relevant sensitive receptors have been selected based upon the affected road network, which is based upon the preliminary traffic data.

5.5.67. Potentially relevant sensitive receptors within proximity to the options were identified using the latest Ordnance Survey address base layer data, thus the property counts were limited by the completeness of this data set. No site based investigations were undertaken for this stage of the assessment.

5.5.68. The assessment of potential air quality impacts associated with the construction and operation phases of the proposed options were based on the preliminary drawings provided, which at this stage of development, only partially provide a detailed representation of an operational scheme.

Recommendations for Further Works

5.5.69. The ABCB Council Environmental Health Department will be consulted to agree the adopted methodology pertinent to the Stage 3 assessment for the preferred option.

5.5.70. Further assessment will be undertaken to review and consider relevant sensitive receptors that are within 200m of the affected road network, based upon any updated traffic data to ascertain the magnitude and significance of any air quality impacts to local air quality, either adverse or beneficial. This will be determined through further detailed air quality assessment.

5.5.71. A DMRB assessment of the contribution of the options to regional emissions could be undertaken applying the regional assessment calculation identifying traffic characteristics and road length for each link in the traffic network area.

5.5.72. Further traffic data should be provided with reference to Highways Agency et al. IAN 185/15 to further understand potential impacts to air quality. Traffic data provided should include a detailed description of traffic model performance on links within the air quality study area. The extent of the roads modelled for changes in flows and speeds should be developed in collaboration with air quality and traffic consultants and in consultation with DFI and ABCB Council.

5.5.73. The detailed air quality assessments during the next stage will involve consultation with Environmental Health Department at ABCB Council to agree the appropriate level of further assessment and to obtain the following elements for inclusion within the assessment:

- Local Authority air quality monitoring data
- Latest LAQM Review and Assessment reporting

5.5.74. An assessment of the potential air quality impacts within the context of the existing Armagh and Greenpark Terrace Armagh AQMA and emerging ABCB air quality policies may be required.

5.6. Cultural Heritage

5.6.1. The screening and scoping exercises indicated that there is uncertainty regarding likely significant effects on cultural heritage resources relating to the construction and operation of the options. Through the screening and scoping exercises the requirement for a detailed assessment of potential impacts to cultural heritage resources was identified.

5.6.2. The scoping exercise identified potential impact on three specific areas of cultural heritage interest, as defined in the DMRB; archaeological remains, the built heritage and historic landscapes.

5.6.3. Archaeological assets consider those materials created or modified by past human activities, which includes a wide range of visible and buried artefacts, field monuments, structures and landscape features. Built and Industrial heritage considers architectural, designed or other structures with a significant historical value, such as listed buildings. The historic landscape concerns perceptions that emphasise evidence of the past and its significance in shaping the present landscape.

5.6.4. Within the context of the DMRB a cultural heritage asset is considered an individual archaeological site or building, a monument or group of monuments, an historic building or group of buildings, and/or a historic landscape.

5.6.5. Under the scoping terminology used by DMRB and IAN 125/15 this is a simple assessment using readily available desk-based resources, supplemented by the results of walkover survey, to determine the likelihood of significant effects.

Study Area

5.6.6. The nature and extent of any known or potential cultural heritage assets, including statutorily designated assets, such as listed buildings, has been examined to determine the potential impact of the options within study areas comprising the option alignments and a 500m buffer around their boundaries. The extents of the options study areas are shown on Drawing No 1064968-B-D-3022 (see *Appendix A*).

Methodology

5.6.7. Cultural heritage has been examined in accordance with the Chartered Institute for Archaeologist's Standards and Guidance for Historic Environment Desk-Based Assessments (2014); with respect to the guidance provided by Volume 11, Section 3, Part 2, Appendix 8 and Annexes 5, 6 and 7 of the DMRB; HA208/07; and supplementary advice provided in IAN 125/15.

5.6.8. In summary, the assessment has involved consultation of the following sources:

- The Northern Ireland Sites and Monuments Record (NISMR)
- The Industrial Archaeology Record (IAR)
- The Northern Ireland Monuments and Buildings Record (MBR)
- The Register of Historic Parks, Gardens and Demesnes
- The Heritage Gardens Inventory
- The Northern Ireland Buildings at Risk Register
- Aerial photographs

- Historic cartographic sources
- Archaeological and historical literature

Walkover Survey

5.6.9. A walkover survey of the options was undertaken by a suitably qualified archaeologist in August 2016. Conditions during the walkover survey were overcast with intermittent rain, but visibility remained good throughout. A single field at the north, and two fields at the south of Option 12 were not accessible at the time of the walkover, although all were visually examined. All other areas were systematically walked and assessed in terms of landscape, land use, vegetation cover, presence or lack of archaeological sites and potential for undetected archaeological sites / features.

Assessment

5.6.10. The assessment of the value of cultural heritage assets has involved consideration of how far the asset(s) contribute to an understanding of the past, through their individual or group qualities, either directly or potentially. These are professional judgements, but they are also guided by legislation, national policies, acknowledged standards, designations, criteria and priorities.

5.6.11. The assessment has referenced Annexes 5, 6, and 7 of the DMRB, HA 208/07 (Cultural Heritage) which recommends the adoption of six ratings for value in relation to archaeology, built heritage and historic landscapes: very high, high, medium, low, negligible and unknown. The assigned value of heritage assets is set out in the gazetteer (see *Appendix G*).

5.6.12. Definitions for each rating are outlined in Table 6-13 to 6-15.

Table 5-13 - Factors for Assessing the Value of Archaeological Assets

Value	Status and Definition
Very High	World Heritage Sites (including nominated sites) Assets of acknowledges international importance Assets that can contribute significantly to acknowledged international research objectives
High	Scheduled Monuments (including proposed sites) Undesignated assets of scheduled quality and importance Assets that can contribute significantly to acknowledged national research objectives
Medium	Designated or Undesignated assets that can contribute to regional research objectives
Low	Designated or undesignated assets of local importance Assets compromised by poor preservation and / or poor survival of contextual associations Assets of limited value, but with potential to contribute to local research objectives
Negligible	Assets with very little or no surviving archaeological interest
Unknown	The importance of the resource has not been ascertained

Table 5-14 - Criteria for Establishing the Value of Built Heritage Assets

Value	Status and Definition
Very High	International Importance i.e. World Heritage Sites
High	National Importance i.e. listed buildings at Grade I and II*, Scheduled Monuments with standing remains, conservation areas containing very important buildings and undesignated structures of clear national importance
Medium	Regional Importance i.e. listed buildings at Grade II, conservation areas containing buildings that contribute significantly to its historic character, historic townscape with important integrity in their buildings, or built settings and undesignated structures of clear regional importance
Low	Local Importance i.e. undesignated assets of modest quality in their fabric or historical association and historic townscape of limited historic integrity (including buildings and structures included in local list prepared by local authority)
Negligible	Assets of no archaeological or historical note
Unknown	Assets with some hidden i.e. inaccessible potential for historic or architectural significance.

Table 5-15 - Criteria for Establishing the Value of Historic Landscapes

Value	Status and Definition
Very High	World Heritage Sites inscribed for their historic landscape qualities Historic Landscapes of international value, whether designated or not Extremely well preserved historic landscapes with exceptional coherence, time-depth, or other critical factor(s)
High	Designated historic landscapes of outstanding interest Undesignated landscapes of outstanding interest Undesignated landscapes of high quality and importance, and of demonstrable national value Well preserved historic landscapes, exhibiting considerable coherence, time-depth or other critical factor(s)
Medium	Designated special historic landscapes Undesignated historic landscapes that would justify special historic landscape designated, landscapes of regional value Averagely well-preserved historic landscapes with reasonable coherence, time-depth or other critical factor(s)
Low	Robust undesignated historic landscapes Historic landscapes with importance to local interest groups Historic landscapes whose value is limited by poor preservation and/or poor survival of contextual associations
Negligible	Landscapes with little or no significant historical interest

Magnitude of Impact

5.6.13. The magnitude of impact has been assessed using the guidance contained in DMRB Volume 11, Section 3, Part 2: Cultural Heritage. Table 5-16 below is an amalgamation of the three tables which can be found in the annexes in the above volume.

Table 5-16 - Assessing the Magnitude of Impacts

Magnitude	Criteria
Major	Changes to most or all key archaeological materials or key historic building elements such that the resource is totally altered Change to most or all key historic landscape elements, parcels or components: extreme visual effects: gross change of noise or change to sound quality: fundamental changes to use or access: resulting in total change to historic landscape character unit Comprehensive changes to setting
Moderate	Changes to many key archaeological materials or key historic building elements, such that the resource is clearly modified Changes too many key historic landscape elements, parcels or components, visual change to many key aspects of the historic landscape, noticeable differences in noise or sound quality, considerable changes to use or access: resulting in moderate changes to historic landscape character Considerable changes to setting that affect the character of the asset
Minor	Changes to key archaeological materials or key historic building elements, such that the asset is slightly altered Changes to few key historic landscape elements, parcels or components, slight visual changes to few key aspects of historic landscape, limited changes to noise levels or sound quality; slight changes to use or access: resulting in limited changes to historical landscape character Slight changes to setting
Negligible	Very minor changes to archaeological materials, historic buildings elements, or setting Very minor changes to key historic landscape elements, parcels or compounds, virtually unchanged visual effects, very slight changes in noise levels or sound quality; very slight changes to use or access; resulting in very small change to historic landscape character
No Change	No change to fabric or setting No change to elements, parcels or components; no visual or audible changes; no changes arising from in amenity or community factors

Existing Environment

5.6.14. Designated and un-designated cultural heritage assets recorded by the NISMR, IAR and MBR within 500m of the options (hereafter the study areas within this section) are tabulated in a Gazetteer (*Appendix G*) and their location is shown on Drawing No 1064968-B-D-3022 (see *Appendix A*). The asset numbers assigned in the gazetteer, shown on the drawing and referenced in brackets in the following text (e.g. 1) have been added for the purposes of this report only.

5.6.15. A total of 20 designated and undesignated cultural heritage assets are recorded in the study area. One additional asset, in the form of the historic agricultural landscape, has been added to the gazetteer, but the assigned asset number (21) is not shown on Drawing No 1064968-B-D-3022 (see *Appendix A*).

Designated Cultural Heritage Assets

5.6.16. There are no World Heritage Sites, Scheduled Monuments, State Care Monuments, or Registered Battlefields within the study areas.

5.6.17. The nearest Conservation Area encompasses the historic core of Armagh; its closest boundary is located approximately 850m to the west of the 2007 Option and Option 16. As a consequence of local topography and the existing built environment there is little intervisibility between the options and the Conservation Area.

5.6.18. Two Registered Parks, Gardens or Demesnes (14 and 15) are present at the west of the 2007 Option study area, one of these assets (15) also lies within the Option 16 study area. No Registered Parks, Gardens or Demesnes are present in the Option 12 study area. Assets 14 and 15 do not have any intervisibility with the 2007 Option as a consequence of local topography and the existing built environment.

5.6.19. Four listed buildings (16, 17, 18 and 20) are situated within the 2007 Option study area. Three of these listed buildings (17, 18 and 20) are also located within the Option 16 study area. A single listed building (19) is situated within the Option 12 study area.

Previous Archaeological Investigation

5.6.20. An area of high ground known as Linsey's Heights, is located on the southern side of A3 Portadown Road at land situated between the northern terminal points of the options. This area is situated slightly to the north of a possible ecclesiastical and reputed famine burial site (3) and has been subject to three archaeological investigations (not as part of this scheme development):

- A small number of negative test trench evaluation was completed prior to resedentialdevelopment at the south west of Linsey's Heights in 1994 (Archaeology Data Service (ADS 1994))
- Monitoring and subsequent excavation was completed before development at the south of the Linsey's Heights in the Killuney Park Road area in 2009 (ADS 2009: Licence AE/09/65). Evidence of multi period occupation was discovered, including Neolithic pits and post holes at the east, extensive parallel early medieval ditches interpreted as defining the northern part of a possible; ecclesiastical enclosure, an early medieval rath at the centre, three early medieval ring ditches at the west, and widespread quarry pits of similar date
- A geophysical survey was completed in 2014 (Centre for Archaeological Fieldwork 2014) over 1.2 hectares of land located to the north east of the 2009 resedential development area. The survey results were interpreted as suggesting the presence of widespread pits, a possible ring ditch, two parallel ditches with a sub circular termini that could enclose an avenue extending out of the survey area to the north east. The character of the potential archaeology led to the conclusion that part of a prehistoric ritual landscape may have been discovered

5.6.21. In addition, monitoring of topsoil stripping was completed in 2000 prior to construction of the Edenaveys Industrial Estate, which is located at the southern end of options 12 and 16. A single undated pit with a charcoal rich fill was present (ADS 2000).

5.6.22. The 2007 Option was subject to desk-based assessment, including a walkover survey, in 2009 (Mouchel Parkman 2009). Map regression showed a potential tree ring may have been located to the west of the 2007 Option study area near Ballinahone House. Potential early prehistoric (Mesolithic/Neolithic) flint artefacts were observed on the

surface of a ploughed field situated adjacent to the 2007 Option during the walkover, although the exact location of the flint artefacts was not specified.

Archaeological Assets

5.6.23. Heritage assets located within the options study areas are described in the context of a timeline of archaeological periods from prehistoric through to modern. The time periods can be broadly divided as follows:

- Mesolithic 8,000 – 4,000 BC
- Neolithic 4,500 – 2,500 BC
- Bronze Age 2,500 – 600 BC
- Iron Age 600 BC – AD 400
- Early Medieval AD 400 – 1160
- Late Medieval AD 1160 – 1600
- Post-Medieval AD 1600 – 1900
- Modern AD 1900 – present

5.6.24. The Ballynahone River, which runs to the west and subsequently through the south of the study areas; the Killeen Water, which joins the Ballynahone River at the south of the Option 12 and 16 study areas; a network of unnamed burns; and the drumlin and inter-drumlin landscape, will have provided varied natural resources suitable for exploitation by mobile Mesolithic hunter – fisher – gatherers. As referred to previously, a scatter of possible flint debitage of potential Mesolithic / Neolithic date was noted on the surface of a ploughed field situated adjacent to the 2007 Option during an earlier walkover survey (Mouchel Parkman 2009), but no other evidence of this period is recorded at the study areas.

5.6.25. The Neolithic period saw the beginning of stock rearing and cereal cultivation. Pottery began to be made and megalithic communal funerary monuments were constructed. The only evidence for this period within the study areas are pits, post holes and stake holes discovered during archaeological investigations at Linsey's Heights (3).

5.6.26. The Bronze Age saw the beginning of metalworking and individual burial in cairns, barrows and stone cists. Significant sites of this period, such as Haughey's Fort, the King's Stables and Navan Fort, are located to the west of Armagh City and form part of an important prehistoric ritual landscape. Unequivocal evidence of the period has not been recorded at the study areas, although the interpretation of results of a geophysical survey carried out at Linsey's Heights (3) has suggested the presence of sub-surface remnants of parallel ditches, perhaps bounding an avenue with similarities to a late Bronze Age example located near Haughey's Fort.

5.6.27. Iron Age evidence in the wider environs of Armagh City includes continuity of use of Navan Fort, but evidence of this period is not recorded at the study areas.

5.6.28. Armagh City is closely connected to the development and spread of Christianity in early medieval Ireland, it became the ecclesiastical capital of the island after Saint Patrick established his church at Armagh in the 5th century. The early church was reputedly founded at the site of St Patrick's Church of Ireland Cathedral. Ecclesiastical sites recorded within the wider environs of the city include churches, graveyards, ecclesiastical settlements and holy wells. The presence of a church and graveyard (3) has long been suspected at Linsey's Heights and archaeological investigations (ADS

2009) have revealed two widely spaced parallel ditches which were interpreted as defining an ecclesiastical enclosure.

5.6.29. The early medieval period saw the development of ringforts (raths), souterrains and enclosures. Souterrains or enclosures are not recorded within the study areas, but three possible raths are known: an example (1) is located approximately 150m east of Option 12; a tree ring (possible re-used rath; 2) is situated approximately 280m east of Options 12 and Option 16; and the surrounding ditch of another example (3) was discovered during archaeological investigations at Linsey's Heights (ADS 2009). Other early medieval evidence discovered at Linsey's Heights included three ring ditches and numerous quarry pits, which were interpreted as being associated with pottery production.

5.6.30. There are no late medieval heritage assets recorded within the study areas, although heritage assets of this period are preserved slightly to the west within the historic core of Armagh City. The city was a hub of religion, learning and economic activity throughout the medieval period and it was granted a weekly market by royal charter as early as 1587.

5.6.31. The graveyard at Linsey's Heights (3) is said to have seen reuse in the 1840s as a burial ground for famine victims.

5.6.32. The study areas retained an agricultural character throughout the medieval, post medieval and the majority of the modern periods. It is only since the late 20th century that Armagh City has seen significant expansion and the gradual incorporation of much of the 2007 Option and Option 16 study areas into the eastern urban fringe of the city.

5.6.33. No additional archaeological assets were noted at the study area during the walkover survey.

The Built and Industrial Heritage

5.6.34. The prosperity of Armagh grew during the post medieval period as the linen trade saw increased success from the 18th century. Many grand buildings, including a Royal School, an astronomical observatory, a public library and many other substantial Georgian buildings were built in the city at this time. The late 19th century saw the construction of the St Patrick's Roman Catholic Cathedral in the city centre and Armagh is now one of very few cities with two cathedrals of the same name.

5.6.35. The built and industrial heritage assets located within the study area were constructed during the latter part of the post medieval period.

5.6.36. Undesignated industrial heritage assets situated within the 2007 Option and Option 16 study area comprise two road bridges (9 and 10) spanning the Ballynahone River. The sites of four demolished mills (7, 11, 12 and 13) are also present within the 2007 Option study area and three of the mill sites (11, 12 and 13) are also within the Option 16 study area. A further road bridge (8) crosses the Ballynahone River at the south and three rail bridges (4, 5 and 6) are present at the north of the Option 12 study area.

5.6.37. Four listed buildings (16, 17, 18 and 20) are situated within the 2007 Option study area. Three of the listed buildings (17, 18 and 20) are also located within the Option 16 study area. The listed buildings comprise:

- (16): Woodford House, Markethill Road (House, Gate Piers, Bridge and Garden Features: B1 Listing)

- (17): Avon Lodge, Dean's Bridge, Portadown Rd. (House: B Listing)
- (18): Sunnymeade, Portadown (House: B Listing)
- (20): Ballinahone House, Hamilton's Bawn Rd. (House: B1 Listing)

5.6.38. A single listed building is situated within the Option 12 study area:

- (19): Little Castle Dillon, Portadown Rd. (House: B Listing).

5.6.39. Listed buildings 17, 18 and 20 do not have any intervisibility with the options as a consequence of local topography and the existing built environment. Listed buildings 16 and 19 are currently screened from the options by mature stands of trees, hedgerows and other physical boundaries.

5.6.40. No additional built or industrial heritage assets were noted at the study areas during the walkover survey.

The Historic Landscape

5.6.41. In general the options cross an undulating drumlin and inter-drumlin landscape situated to the east of the town of Armagh. However, each option has slightly different landscape characteristics, which influence the value of the landscape, the setting of known heritage assets and the potential for presence of unknown sub-surface archaeological assets.

5.6.42. The broad character of the agricultural areas crossed by the options was established during planned enclosure during the late 18th and first half of the 19th centuries. Piecemeal enclosure hedgerows were established to subdivide the planned enclosures during the second half of the 19th century and the first half of the 20th century. The latter part of the 20th century has seen rationalisation of the field layout at the south of Option 12 and Option 16 through removal of hedgerows. At the time of the walkover survey all of the agricultural land traversed by the options was in use as pasture.

5.6.43. The following descriptions result from examination of topographic surveys and observations made during the walkover survey.

Potential Impacts

5.6.44. The number of recorded archaeological heritage assets within the study areas is relatively low, but this is probably a consequence of the agricultural character of sections of the options and a paucity of archaeological work. The distribution and density of known archaeological heritage assets is unlikely to accurately reflect the density of sub-surface archaeological heritage assets present.

5.6.45. The potential impacts during construction and operational phases of the options are detailed below.

2007 Option

5.6.46. The potential impact on archaeological assets where the 2007 Option passes through developed areas, i.e. the Hamiltonsbawn Road Industrial Estate and the Ardmore Road Housing Estate, could be **major adverse** impact although the probability of survival of sub-surface archaeology at these areas is **negligible**.

5.6.47. Neolithic settlement and early medieval evidence has been discovered approximately 50m east of the northern part of the option at Linsey's Heights (3). A possible

prehistoric ritual landscape has been tentatively identified from results of geophysical survey and a 1840s famine burial site is suspected to be located in this area. The northern end of the option has potential to have a **major adverse** impact on sub-surface archaeological assets associated with this known archaeology.

5.6.48. The 2007 Option may have a **major adverse** impact upon unknown sub-surface archaeological assets of the prehistoric and later periods, particularly at areas of agricultural land with high potential, such as elevated ground and south facing slopes.

5.6.49. The 2007 Option junction at the existing Ardmore Road and Markethill Road (A28) junction has the potential to impact the setting of Woodford House (16), its gate piers, a bridge and garden features, which are all Grade B1 listed. If a signalised junction was used then no change is envisaged, however a roundabout could encroach into the grounds of Woodford House, which would have a **moderate adverse** impact. No change is predicted to the setting of three other listed buildings (17, 18 and 20).

5.6.50. The 2007 Option would have **no change** on two designated parks and gardens (14 and 15).

5.6.51. The 2007 Option would have **no change** upon designated or industrial heritage assets, comprising two road bridges (9 and 10) and the sites of four demolished mills (7, 11, 12 and 13).

5.6.52. Truncation of field layout at the centre of the 2007 Option would have a **minor adverse** impact upon the historic agricultural landscape, which has already been compromised by its proximity to relatively recent development.

Option 12

5.6.53. The potential impact on archaeological assets where Option 12 passes through previously developed areas, i.e. along the Edenaveys Road and through the Edenaveys Industrial Estate, could be **major adverse** impact although the probability of survival of sub-surface archaeology at these areas is **negligible**.

5.6.54. Neolithic settlement and early medieval evidence has been discovered approximately 50m west of the northern part of the option at Linsey's Heights (3). A possible prehistoric ritual landscape has been tentatively identified from results of geophysical survey and a 1840s famine burial site is suspected to be located in this area. The northern end of Option 12 has potential to have a **major adverse** impact on sub-surface archaeological assets associated with the known archaeology.

5.6.55. Option 12 may have a **major adverse** impact upon unknown sub-surface archaeological assets of the prehistoric and later periods, particularly at areas of agricultural land with high potential, such as elevated ground and south facing slopes.

5.6.56. Two possible raths (1 and 2) are respectively situated approximately 150m and approximately 280m east of the option, both are screened from the option by mature trees. The potential impact is **negligible**.

5.6.57. Option 12 junction with A3 Portadown Road may have a **minor adverse** impact on the setting of Little Castle Dillon (19), which is Grade B listed.

5.6.58. Option 12 will have **no change** upon industrial assets, comprising three rail bridges (4, 5, and 6) and one road bridge (8).

5.6.59. Truncation of field layout at the agricultural sections of Option 12 would have a **moderate adverse** impact upon the historic landscape.

Option 16

5.6.60. The potential impact on archaeological assets where Option 16 passes through developed areas, i.e. the Hamiltonsbawn Industrial Estate, along the Edenaveys Road and through the Edenaveys Industrial Estate could be **major adverse** impact although the probability of survival of sub-surface archaeology at these areas is **negligible**.

5.6.61. Neolithic settlement and early medieval evidence has been discovered approximately 50m east of the northern part of Option 16 at Linsey's Heights (3). A possible prehistoric ritual landscape has been tentatively identified from results of geophysical survey and a 1840s famine burial site is suspected to be located in this area. The northern end of Option 16 has potential to have a **major adverse** impact on sub-surface archaeological assets associated with the known archaeology.

5.6.62. Option 16 may have a **major adverse** impact upon unknown sub-surface archaeological assets of the prehistoric and later periods, particularly at areas of agricultural land with high potential, such as elevated ground and south facing slopes.

5.6.63. A possible rath (2) is situated approximately 280m east of the Edenaveys Road at the southern end of Option 16. It is screened from the Edenaveys Road by mature trees. The potential impact is **negligible**.

5.6.64. **No change** is predicted to the setting of three listed buildings (17, 18 and 20) and no change is predicted to one designated park and garden (15).

5.6.65. Option 16 would have **no change** upon industrial assets, comprising three road bridges (8, 9 and 10) and the sites of three demolished mills (11, 12 and 13).

5.6.66. Truncation of field layout at the centre of Option 16 would have a **moderate adverse** impact upon the historic agricultural landscape.

Recommended Mitigation Measures

5.6.67. A signalised junction at the 2007 Option junction of Ardmore Road and Markethill Road (A28), would preserve the setting of Woodford House (16), its gate piers, a bridge and garden features, which are B1 Listed. The listed structures are currently screened from the Markethill Road by a low wall and a dense stand of mature trees and this screening should be maintained. An alternative junction design which encroached into the grounds of Woodford House would necessitate agreement of appropriate and adequate mitigation with Historic Environment Division and any impact to the listed structures would require listed building consent.

5.6.68. The Option 12 junction with Portadown Road, should be designed to minimise its impact on Little Castledillon (19), which is Grade B listed. The house is currently bounded by substantial walls and dense stands of mature trees, which screen it from nearby roads. It would be necessary to re-establish appropriate screening of the listed building from the road network if the new junction encroached into the grounds of the house.

5.6.69. A rapid landscape and hedgerow survey would record the character of the historic landscape prior to development.

5.6.70. Appropriate mitigation of the impact of the options on unknown archaeological assets cannot be defined without further study. Further studies would comprise testing of land within the scheme footprint by a suitably qualified archaeologist under licence from the Historic Environment Division of the Department of Communities (Northern Ireland) through:

- Magnetometer survey; to provide a rapid and relatively inexpensive initial assessment of the potential for presence of unknown sub-surface archaeological heritage assets
- Test trenching at, but not limited to, areas of high archaeological potential, such as land in close proximity to Linsey's Heights, areas of high ground and any south facing slopes. Completed after review of results of the magnetometer survey and in advance of commencement of construction

5.6.71. The results of the magnetometer survey and trenching would enable identification of areas where mitigation of impact on significant archaeological assets would be necessary. The mitigation could be achieved by option redesign, or through excavation and recording under licence from the Historic Environment Division of the Department of Communities (Northern Ireland).

5.6.72. The excavation and recording of significant archaeological assets would be completed in advance of development, and would be followed by a staged programme of post excavation assessment, analysis, dissemination of results through reporting, archive preparation and deposition.

Summary of Likely Significant Effects

5.6.73. Most of the impacts to archaeological assets would arise from construction, which while temporary in duration would have a permanent impact through removal of assets during ground breaking. Impacts to historic buildings and landscape would occur during construction and operation. The overall impacts of the options on cultural heritage resources, after taking into account proposed mitigation strategies are assessed as:

- 2007 Option: **Minor adverse**
- Option 12: **Moderate adverse**
- Option 16: **Minor adverse**

Table 5-17 summarises the likelihood of the options to generate significant effects on each of the identified cultural heritage assets.

Table 5-17 - Summary of Likelihood of Significant Effects on Cultural Heritage Assets in Accordance with IAN 125/15

Assets	2007 Option	Option 12	Option 16
Unknown Sub-Surface Archaeological	Uncertain	Uncertain	Uncertain
Known Archaeology	Uncertain	No Likelihood (rath and a tree ring)	No Likelihood (a tree ring)

Built Heritage	No Likelihood (**4** listed buildings)	No Likelihood (**1** listed building)	No Likelihood (**3** listed buildings)
Registered Parks, Gardens or Demesnes	No Likelihood	N/A	No Likelihood
Industrial Heritage	No Likelihood (**2** road bridges and **4** demolished mills)	No Likelihood (**3** rail bridges and **1** road bridge	No Likelihood (**3** road bridges and **3** demolished mills)
Historic Agricultural Landscape	Low Likelihood	High Likelihood	High Likelihood

Limitations of Assessment

5.6.74. Limitations on the assessment of the cultural heritage is restricted to the completeness of records held by the consulted sources and uncertainty regarding the presence of unknown sub-surface archaeological assets at areas of undeveloped and agricultural land.

5.6.75. The assessment scores are based on a review of readily available information for the study areas and assume that appropriate and adequate mitigation of impact on the known and potential heritage resource can be achieved.

5.6.76. The baseline for archaeological assets in the vicinity of the options is currently poorly understood as a consequence of a paucity of recent investigations. Evaluation, perhaps comprising geophysical survey and test trenching, should be agreed with Historic Environment Division, Department of Communities (Northern Ireland) to determine the archaeological baseline prior to development and to enable refinement of the assessment scores. However, the timing of this work may be restricted by various constraints including those imposed by access, project programme and project funding.

Recommendations for Further Works

5.6.77. A detailed desk based assessment and further walk over survey is proposed once the preferred option has been selected. This assessment will be carried out in accordance with DMRB guidance for a detailed assessment and will include a staged methodology for identifying impacts of the selected option and measures required to mitigate likely significant adverse effects.

5.7. Landscape and Visual Effects

5.7.1. The screening and scoping exercise identified the existing landscape and visual constraints and addresses the likelihood of significant landscape and visual effects for each of the options. As the options introduce new infrastructure and into a generally drumlins landscape and in close proximity to visual receptors, the initial assessment indicate that a detailed assessment will be required to understand and address potential impacts.

5.7.2. The comparison of the options relative to assets and resources associated with landscape character and visual effect has been focused on:

- Impacts on the composition and quality of the existing landscape associated with the study area based on an analysis of distinctive local landscape character areas
- Evaluation of the visual receptors which would be subject to potentially significant visual effects as a result of the introduction of the options into the existing landscape

Study Area

5.7.3. The study area has been limited to a 1km buffer extending either side of the outer extents of options. For the purpose of this assessment it has been considered that views beyond 1km would not represent a high likelihood of significant effects occurring. Within this study area an indicative Zone of Theoretical Visibility (ZTV) has been drafted which covers all options and shown on Drawing No.1064968-B-D-3023 and 1064968-B-D-3024 (see *Appendix A*). This would be refined as part of the detailed assessment at Stage 3.

Methodology

5.7.4. The scope of the assessment has included a review of available and relevant documents relating to the study area following a site based review of baseline information to identify constraints associated with landscape character and visual receptors. A site visit was undertaken was undertaken in May 2016.

5.7.5. The landscape and visual assessment has followed guidance on stages of the assessment contained in the DMRB - Volume 11, Section 3, Part 3 Landscape Effects (1993) and IAN 135/10 – Landscape and Visual Effects Assessment (HA, 2010).

5.7.6. Reference has also been made to the following published guidance and assessment criteria:

- Guidelines for Landscape and Visual Impact Assessment (GLVIA) (Third Edition), published by the Landscape Institute and the Institute of Environmental Management and Assessment (2013)
- Landscape Character Assessment: Guidance for England and Scotland, published by Scottish Natural Heritage and the Countryside Agency (2002)

5.7.7. At this stage the assessment of landscape character and visual amenity has focussed on:

- Recording and analysis of existing landscape character and visual context of the receiving environment through desk based and field based appraisals
- Identification of the key sensitivities associated with the study area and an appreciation of the design and mitigation measures appropriate to the options

- An assessment of the impacts and effects likely to result from the options and the sensitivity of the existing landscape and identified visual receptors to change
- A comparison of the options and their potential to give rise to a significant effect on landscape character or visual amenity

5.7.8. For the purposes of this assessment and to aid the comparison of the options a significant effect has been considered to be:

- where there is at least a partial loss or noticeable damage to existing landscape character or distinctive features and elements that contribute to a sense of place; or
- where the project would cause, as a minimum, a noticeable deterioration in an existing view.

5.7.9. The assessment provides details regarding the certainty or uncertainty relating to likely significant effects in accordance with the criteria provided in IAN 125/15.

5.7.10. Construction effects have been scoped out of this assessment as works undertaken within the corridor of all options would be likely to have similar effects and would not significantly contribute to the differentiation of options.

5.7.11. Construction effects would be relatively short duration and are therefore not considered likely to give rise to potentially significant effects on the perception of the wider landscape character.

Existing Environment

5.7.12. This section describes the baseline environment for landscape character and visual amenity of the study area for the options. Please refer to Drawing No.1064968-B-D-3023 and 1064968-B-D-3024 (see *Appendix A*).

Landscape Character

Regional Character Areas

5.7.13. The study area lies within Character Area 13 ‘Southern Drumlins and Orchards’ of the Northern Ireland Regional Landscape Character Assessment (NIRLCA), of which the key characteristics and land cover elements that are relevant to the study area have been abstracted below:

- Landscape of drumlins of varying scales;
- An intensely rural landscape, dominated by pastoral farmland, with several key settlements and a more dispersed wider pattern of farms and individual homes
- An enclosed feeling is maintained throughout much of the landscape by dense and in places overgrown hedgerows and hedge trees which restrict views from the back roads in most places other than the highest elevations on the taller drumlins
- The local pink-yellow limestone known as ‘Armagh Marble’ is widely used
- The field pattern in this area is dictated by the drumlin landforms. There are intact areas of small fields with mature hedges and field boundary trees, mixed with other areas where fields have been rationalised or enlarged, and hedges are more closely clipped

- Views are restricted at many parts of the RLCA away from more elevated areas due to the deeply undulating nature of the landscape with development on ridges around settlements such as Armagh highly visible because of this character;
- The restrictiveness of views due to the prominence of drumlins and lack of elevated ground contributes to a secretive character in many places. Sense of confinement along back roads contributes to the overall character of isolation in many parts of the area given the overgrown nature of hedgerows and hedgerow trees
- Views from occasional higher ground are frequently focused on the city of Armagh, with longer views over Lough Neagh from areas to the north. This landscape forms the foreground in the more open views from the Carrigatuke Hills to the south

5.7.14. A more appropriate scale than the above regional character description on which to base this assessment is at the local level, which has been described below:

Local Landscape Character

5.7.15. The distinctiveness of the landscapes within the urban fringe setting of the study area can be sub-divided into four Local Landscape Character Areas (LLCA) with broadly homogenous features. To the west of these areas is the urban townscape that relates to and is associated with the City of Armagh.

5.7.16. The LLCAs have been defined as:

- Drumlin agricultural landscape (LLCA1)
- Residential urban fringe landscape (LLCA2)
- Industrial fringe landscape (LLCA3)
- Mixed use landscape (LLCA4)

LLCA1 Drumlin Agricultural Landscape

5.7.17. The broader landscape around the developed Armagh City consists of a drumlin agricultural landscape. The drumlins are orientated north – south and cover an extensive area. The drumlins located to the south rise to form high hills that offer views across the drumlin landscape and views to Armagh's landmark buildings.

5.7.18. Numerous small rivers and streams cross the area and most drain into the River Callan.

5.7.19. Improved pastures that are subdivided by well-maintained hedgerows and tree belts dominate the agricultural landscape in the area. The hollows between the drumlins provide a sense of enclosure for the landscape and prevent long distance views. Scattered housing and farms are found throughout although more frequent on the urban/rural fringe. The Drumlin Agricultural Landscape is well maintained and important to the appreciation of Armagh from the strategic approaches to the city. The drumlin summits and skylines have been identified as **sensitive** within the NIEA NIRLCA (1999/15).

5.7.20. The landscape is a coherent one with attractive features occurring throughout. The undulating nature of the landscape resulting in enclosed hollows means that this landscape is capable of absorbing medium scale development and as such is, considered to be of **moderate sensitivity**.

Figure 5-1- View from Ballynahonemore Road demonstrating the rolling and enclosed agricultural landscape surrounding Armagh City

LLCA2 Residential Urban Fringe Landscape

5.7.21. In modern times residential housing has spread beyond the historic city centre along the A3 road to Portadown that forms the key strategic approach to Armagh from the north.

5.7.22. The old railway line has formed a physical feature that forms the new outer limit to this more recent development. House types vary in style with brick and rendered properties present in broadly equal numbers. Houses are consistent in plot size with two storey detached properties in large gardens. The character of the houses is not related at all to the distinctive buildings of the city centre. North of the A3 the housing is located on lower lying but gently undulating topography. To the south of the A3, housing is located across higher drumlins permitting long distance views from the houses across Armagh City Centre to the west.

5.7.23. Former field patterns are no longer visible and vegetation has largely been removed during construction of the houses, replaced by garden vegetation that is inconsistent in quality and quantity. More mature trees are found in gardens of older houses immediately east of the A3 roundabout. Housing is interspersed with small pastoral fields and together with regular views to the surrounding farmland, particularly from high points, there is a sense of being more connected to a rural landscape than the urban centre of Armagh.

5.7.24. This townscape contains many landscape features that are common within the character area and there are few quality features that contribute to a sense of place. The character area is capable of absorbing medium scale development and has a **moderate sensitivity**.

Figure 5-2- View from Killuney Road across the existing roundabout and towards typical residential properties within Drumman Heights.

LLCA3 Industrial Fringe Landscape

5.7.25. Mixed industrial and commercial premises lie to the north and south of the Hamiltonsbawn Road with scattered rows of residential properties intermixed. The area is bordered by irregular pastoral fields on drumlin slopes. The appearance of the industrial premises is generally poor and detracting from the adjacent agricultural landscape and residential townscape, however the area is visually well contained by the surrounding drumlin ridgelines.

5.7.26. Buildings are predominantly steel-framed structures with external cladding of various colours. The main Armagh military barracks has been included within this landscape as it consists of buildings of a similar scale and appearance to the mixed industrial areas. Trees are generally absent from this area apart from a few overgrown field boundaries. The character area lacks particular character and has eroded historical features such as hedgerows and landscape patterns. The character area has a degree of capacity to accommodate larger-scale development and has been established as having a low sensitivity.

Figure 5-3- View from Killuney Meadows looking south towards a more industrial landscape settled and contained within drumlins on the fringe of Armagh

LLCA4 Mixed Use Landscape

5.7.27. This character area incorporates a multitude of land uses and associated built forms including residential, business, pastoral fields, the A28 corridor and the Folly Glen as well as various community services such as an artificial sports pitch, the Armagh Church and a cemetery.

5.7.28. The location of the Palace Demesne and the Folly Glen on the southern side of Armagh and to the west of this character area has created a restriction for development along the A28 Newry Road. More recent housing development has taken place within smaller plot sizes than those found to the northern suburbs. House types are predominantly rendered, single storey but larger individually designed houses are located west of the A28 and overlook the Palace Demesne estate.

5.7.29. Between the A28 Markethill Road and A3 Portadown Road the Ballynahone River has cut its way through the landscape and is known as Folly Glen. Mature beech woodland follows the banks of the River and the glen is part of the Sustrans Cycle Network (SCN) for Northern Ireland. The glen is enclosed and views are linear in nature. Armagh City and District Council have recently improved the glen with new footpaths, signage and tree planting. The NIEA NIRLCA for Armagh has identified the glen as a “distinctive

landscape setting" stating that the area is a strategic landscape feature and **particularly sensitive** to change.

5.7.30. Within the character area the A28 is the main strategic approach to the city from the south and occasional commercial premises such as garages are located on the road frontage. This mixed use character area contains many townscape features that are commonly found and as such are relatively ordinary in nature. The landscape is capable of absorbing small to medium scale development and has a **moderate sensitivity**.

Figure 5-4- View from Edenaveys Road looking south across rolling agricultural land with mixed use development.

Visual Context

5.7.31. The ZTV for this assessment has been broadly defined within the 1km study area at this stage and are shown on Drawing No 1064968-B-D-3023 and 1064968-B-D-3024 (see *Appendix A*).

5.7.32. The visual context of the study area is characterised by the rolling agricultural farmland and variety of urban fringe landscapes to the east of the City of Armagh.

5.7.33. Typically throughout the study area the rolling topography limits broader views and creates a sense of enclosure within which development has taken place through the low points in the topography. Broader views are occasionally afforded where residential development has taken place on mid to upper slopes of drumlins.

5.7.34. At the northern extent of the study area views are well contained by dense residential estate, either side of the A3 Portadown Road. While rows of properties on the edge of the estates often afford broader views across adjacent pastoral farmland from elevated positions, such as those on Lindsey's Heights. A row of properties along Killuney Meadows (see Figure 5-7) also afford views south across the less attractive industrial fringe landscape. Views into the industrial landscape are restricted locally by landform (see Figure 5-3).

5.7.35. To the east of Armagh the feeling of being in an agricultural landscape and remote from the urban fringe is quickly apparent due to the rolling landform and mature overgrown hedgerows. Occasional lanes pass through the lower topography with scattered farmsteads and overgrown hedgerows border predominantly pastoral fields. The landscape lacks well-defined landmarks, resulting in a landscape that is difficult to orientate yourself within.

5.7.36. The western extents of the study area are markedly more urbanised in character with a mix of residential estates, smaller irregular pastoral fields, business located along main

road frontages and a greater sense of being near to the City centre. Broader views are well contained in residential areas apart from those located on higher ground and on the edge of estates. However these views typically culminate at the nearest drumlin or dense belt of overgrown hedgerow and trees.

5.7.37. At the southern extent of the study area approaching the A28 Markethill Road there are dense housing estates closer to the city, while mixed use development along the A28 contain and differentiate views from the surrounding farmland. Properties on the edge of estates such as those in Greenfield Drive and Bannvale Villas (see Figure 5-8 and Figure 5-9) afford views across adjacent pasture, giving them the sense of a more rural setting to those set within the estate.

5.7.38. Urban features are prominent within views in the western extents of the study area and include a variety of housing, local roads and traffic, electricity pylons, highway lighting columns and industrial or commercial buildings. The Ballynahone River valley with linear belts of planting and small fields of rough pasture aid in softening views of the urban landscape. Vegetation helps to contain views, typically linear in nature along field boundaries or watercourses and roads while there are no notable areas of woodland. Planting within residential garden spaces give a vegetated feel to the area and also contain local views within the estates.

5.7.39. The visual context of the study area is of a varied urban fringe landscape bordered by a rolling drumlin agricultural landscape that extends into open countryside to the east.

5.7.40. Key visual receptors or viewpoints within the study area are shown below. Refer to Drawing No 1064968-B-D-3023 and 1064968-B-D-3024 see *Appendix A*) for locations of photographs.

Figure 5-5 – View south of the northern tie in where Option 12 would be cutting through fields and resulting in significant vegetation loss in front of properties on the A3 Portadown Road.

Figure 5-6 – Looking east along the A3 Portadown Road and the overlooking residential properties for the 2007 Option tie in roundabout.

Figure 5-7 – View north from the industrial landscape and the existing road tie in for the 2007 Option and Option16 looking towards elevated properties along Killuney Meadows.

Figure 5-8– View south from Bannvale Villas towards properties on the edge of Jubilee Drive and a field that the 2007 Option would pass through.

Figure 5-9 - View north from the tie in to Ardmore Road for the 2007 Option and overlooking adjacent properties on Jubilee Park and Greenfield Drive.

Figure 5-10– View south along Ardmore Road that the 2007 Option would utilise with overlooking properties.

Figure 5-11– View towards properties on Ballynahonemore Road, Option 12 and Option16 would pass through the field in the foreground.

Potential Impacts

Landscape Character

2007 Option

5.7.41. The 2007 Option is within the existing urban fringe to the east of Armagh. The alignment of the 2007 Option to the north terminates in the LLCA 2 - Residential Fringe Landscape with a proposed new roundabout that would give rise to significant local vegetation clearance of distinctive mature trees alongside a local watercourse.

5.7.42. Running south, the option passes through the centre of the LLCA 3 – Industrial Fringe Landscape on tall embankment to the south of properties on Killuney Meadows and joining with a short section of existing road between large business units on A51 Hamiltonsbawn Road.

5.7.43. To the south of the A51, the 2007 Option passes through the LLCA 4 – Mixed Use Landscape and utilises an existing section of Ardmore Road that runs through a residential estate before terminating via a new roundabout junction with A28 Markethill Road.

5.7.44. The entire section is proposed to be lit and the 2007 Option utilises existing sections of road and requires comparatively less earthworks than the Option 12 or Option 16. It would result in the least amount of modification to the existing landform. Furthermore loss of large areas of established vegetation would be limited to the tie in with Portadown Road and some field boundary vegetation.

5.7.45. Given the proximity of the 2007 Option to the urban edge of Armagh as it runs through three character areas that typically comprise of an urban fringe, and where there is a higher tolerance to accommodate this type of options into the existing landscape. The option is likely to have an **adverse** impact on the landscape character.

5.7.46. The 2007 Option estimated vegetation loss are presented in Table 5-18.

Table 5-18- Estimated Vegetation Loss - 2007 Option

Vegetation type	Total Loss
Garden	896m^2
Scrub	6994m^2
Individual mature trees	24no
Hedgerow	721m
Mature woodland	2369m^2

Option 12

5.7.47. Option 12 runs through the LLCA 1 - Drumlin Agricultural Landscape along the majority of its length and connecting to the A3 Portadown Road to the east of the residential areas associated with Linseys Heights and Kiluney Road. The option terminates in the LLCA 2 - Residential Fringe Landscape and introduces a new urban element between two groupings of properties.

5.7.48. Option 12 has been designed to follow the natural contours of the landscape but would still result in some modifications to the drumlin landforms. Furthermore the roundabout junction proposed at A51 Hamiltonsbawn Road would be a notable new feature in the landscape which would be lit to meet current road design standards. This would introduce a new urbanising element within the largely rural setting.

5.7.49. To the south of A51, Option 12 is situated at a higher elevation than the other options and would therefore be visible at a greater distance with potentially a greater influence on the perception of the rolling landscape. The option runs through an established landscape of mature hedgerows and trees.

5.7.50. To the south of Ballynahonemore Road Option 12 utilises the existing Edenaveys Road connecting with A28 Markethill Road via a new roundabout. This short section would be relatively discreet and flanked by large business units with the roundabout on an existing busy road.

5.7.51. With the exception of the proposed junctions with local roads, the option would be unlit. Lighting associated with the junctions would introduce new vertical elements within the landscape, and a light source at night in areas that currently enjoy low levels of light.

5.7.52. The option is likely to have an **adverse** impact on the rural drumlin agricultural landscape character due to proposed lit junctions and the linear nature of the road within the rolling landscape and the frequent modifications to the landform.

5.7.53. Option 12 estimated vegetation losses are presented in Table 5-19.

Table 5-19 - Estimated Vegetation Loss Option 12

Vegetation type	Total Loss
Individual mature trees	27no
Hedgerow	741m
Mature woodland	1868m^2

Option 16

5.7.54. Option 16 follows the path of the 2007 Option from the A3 Portadown Road to the rear of Bannvale Villas, at which point it bends to the west and through the more remote drumlin agricultural landscape. Option 16 would be lit along approximately half its length through the residential areas and at junctions.

5.7.55. As such the impacts on the Residential Fringe Landscape and the Industrial Fringe Landscape would be the same as for the 2007 Option and have a **low likelihood** to result in significant effects.

5.7.56. There is short section where Option 16 differs from both the 2007 Option and Option 12 passing through pastoral fields and severing a number of field boundaries with overgrown hedgerows, however this section is relatively discreet in the landscape. Option 16 passes through a short section on the western extents of the Drumlin Agricultural Landscape and although a number of fields and hedgerows are severed, and a section runs through a relatively flat area before connecting with Edenaveys Road, the likelihood of it being subject to significant effects on the perception of the broader landscape would be **low**.

5.7.57. Option 16 follows the same path as Option 12 from Ballynahonemore Road to the south to utilise the existing Edenaveys Road to connect with the A28 with this short section passing through the Mixed Use Landscape. This **would not** have an impact on the character of the area.

5.7.58. Option 16 estimated vegetation losses are presented in Table 5-20.

Table 5-20 - Estimated Vegetation Loss Option 16

Vegetation type	Total Loss
Garden	306m^2
Individual mature trees	26no
Hedgerow	1309m
Mature woodland	1594m^2

Visual Amenity

2007 Option

5.7.59. The 2007 Option would be visible from close proximity for residential receptors and commercial properties along the east of Armagh including Portadown Road and Markethill Road residential areas. The road infrastructure is broadly in keeping with the existing urban and urban fringe landscape and the change in view would be less pronounced than that of the other options for the majority of receptors. However there are a number of sensitive receptors that would be likely to be subject to potentially significant effects, where the 2007 Option passes nearby and interrupts a direct outlook and in particular where the road introduces lighting adjacent to properties.

5.7.60. A row of properties on Lindsey's Heights would have elevated rear views as the 2007 Option passes through farmland resulting in vegetation clearance and a busy lit road with traffic adjacent to the properties.

5.7.61. A row of semi-detached properties on Bannvale Villas would also have rear views to the east and the 2007 Option where the existing outlook is across farmland on a drumlin slope.

5.7.62. There is a group of overlooking properties on Greenfield Drive (see Figure 5-9), where the 2007 Option connects with an existing road and cuts through an overgrown narrow corridor between properties. Receptors would be subject to adjacent views of a busy lit road.

5.7.63. One property off Bannvale Villas would be likely subject to highly significant effects as a result of the 2007 Option going through the garden and adjacent to the property.

5.7.64. Due to the proximity of the 2007 Option to many receptors and the introduction of lighting and vegetation clearance it is highly likely that many will have **significant** visual effects.

5.7.65. Receptors with a high likelihood to receive significant effects are listed below:

5.7.66. Receptors for 2007 Option only include:

- Semi-detached properties on Bannvale Villas (VR10) with the alignment of the 2007 Option immediately to rear (12 no.)
- Bungalow on lane off Bannvale Villas (VR11) (1 no.)
- Large detached property on Bannvale Villas (VR12) (1 no.)
- Semi-detached properties on Jubilee Park with open views north (VR 13) (2 no.) (see photograph 8)
- Semi-detached properties on Jubilee Park with open direct views to the 2007 Option and significant vegetation loss (VR13) (2 no.)
- Semi-detached properties on Greenfield Drive and significant vegetation loss (VR13) (6 no.)
- Armagh Baptist Church (VR17)
- Properties on the A28 (VR18) (4 no.)

5.7.67. Receptors for 2007 Option and Option 16:

- Properties on the A3 Portadown Road (Visual Receptor (VR) 04) with open direct views to new roundabout (7 no.)
- Detached properties on Linsey's Heights (VR05) with open direct views to new roundabout and significant vegetation clearance (7 no.)
- Semi-detached properties on Linsey's Heights (VR06) with views south across Industrial Estate and the option on tall embankment. (18 no.) (See Figure 5-7)
- Large detached property on lane off Bannvale Villas (VR09) adjacent to the 2007 Option and with garden severed. Potential for significant adverse effects. (1 no.)

Option 12

5.7.68. The drumlin landscape serves to minimise views of the road for the more distant receptors to the west and for properties on the eastern fringes of Armagh for much of the length, however throughout Option 12 there are intermittent residential areas and isolated properties that would have views of the new road. In addition the northern extent of the option lies in close proximity to the Portadown residential area where a row of properties on Killuney Park Road would have nearby views of the road as it crosses a field to the east.

5.7.69. Properties on high ground, such as those along the A51 Hamiltonsbawn Road would have extensive views of Option 12 through the rural landscape, while the junction at A51 Hamiltonsbawn Road would be a large lit feature that would be a prominent and intrusive new element within a rural outlook.

5.7.70. Given the rural nature of the landscape in existing views, the road is likely to result in a **high degree** of visual intrusion due to the views of traffic and the resulting urbanisation of the landscape. Furthermore the section of the alignment at higher elevations would be visible from further afield, potentially from the city core to the west, albeit heavily filtered by intervening vegetation and not resulting in significant effects.

5.7.71. Receptors with a high likelihood to receive significant effects are listed below:

5.7.72. Receptors for Option 12 only include:

- Large detached property with open views to roundabout off Portadown Road (VR01) (1 no.)
- Large detached property on Portadown Road with views to roundabout and significant vegetation clearance to front of property (VR01) (1 no.)
- Detached property on Portadown Road with elevated views adjacent to route with in route in high proportion of view (VR02) (1 no.)
- Large detached properties along Killuney Park Road with views to rear with Option 12 on mid slope of drumlin (VR03) (17 no.);
- Views from properties on Stockingsmans Hill Road towards the realigned roundabout junction (VR08) (2 no.);
- Properties on lane off Barnvale Villas (VR11) (3 no.);
- Large detached property on Ballynahonemore Road with open views north and south. Effects higher than for Option 16 (VR15) (1 no.).

5.7.73. Receptors for Option 12 and Option 16 include:

- Large detached property on Ballynahonemore Road with views west and south across Option 12 on embankment. Impacts more than for Option 16 (VR 15) (1 no.)

Option 16

5.7.74. Option 16 follows the same path as the 2007 Option, from the A3 Portadown Road, as far south as Bannvale Villas and would result in same potential visual impacts. To the east of Bannvale Villas Option 16 travels east to cut through drumlins before following the same alignment as Option 12.

5.7.75. Visual impacts would be marginally less significant for a row of properties on Bannvale Villas as Option 16 would be further to the east and in a deeper cutting, however it would still have a **high likelihood** of significant effects given the proximity to the rear of the properties.

5.7.76. The section that follows an independent path from west to east between Option 12 and the 2007 Option would not be subject any additional visual impacts. However for one large detached property the impacts would be large as the view would look along the length of Option 16 to the north west of the property.

5.7.77. The southern extent of Option 16 follows the path of Option 12 and would be subject to the same potential impacts from Ballynahonemore Road up to connection with the A28 Markethill Road.

5.7.78. Receptors with a high likelihood to receive significant effects are listed below:

5.7.79. Receptors for Option 16 only include:

- Semi-detached properties on Bannvale Villas (VR10) with Option 16 to rear in cutting. Effects less than for 2007 Option (12 no.)
- Large detached property on Ballynahonemore Road (VR15) with views west and south across Option 16 on embankment (1 no.)
- Cemetery off Ballynahonemore Road (VR16) (1 no.)

5.7.80. Receptors for Option 16 and 2007 Option:

- Properties on the A3 Portadown Road (VR04) with open direct views to new roundabout (7 no.)
- Detached properties on Linsey's Heights (VR05) with open direct views to new roundabout and significant vegetation clearance (7 no.)
- Semi-detached properties on Lindsey's Heights (VR06) with views south across Industrial Estate and route on tall embankment. Open views as Option 16 and 2007 Option goes over a small stream with associated vegetation clearance (18 no.)
- Large detached property on lane off Bannvale Villas (VR09) adjacent to Option 16 and 2007 Option, and with garden severed. Potential for significant effects. (1 no.)

Recommended Mitigation Measures

5.7.81. A detailed landscape strategy would form part of the final option design (in accordance with DMRB Volume 10) within which it is assumed a certain level of landscape mitigation would be undertaken for the options in order to reduce or avoid potentially significant effects and achieve a good fit into the landscape. In principle the following measures should be implemented for the options in order to avoid or reduce potentially significant effects:

- The final design of the selected option should have a good fit with the contours
- Avoid the loss of townscape features
- Minimise the works area to retain existing vegetation
- Reinstate cleared trees and hedgerows where possible
- Include targeted on site screen planting

- Avoid loss or damage to existing landscape features
- Tie into existing vegetation to provide local connectivity
- A planting strategy to integrate the design sensitively into the existing landscape framework

Retention of Existing Vegetation

5.7.82. The importance of working with the existing landscape framework, and particularly the retention of existing tree and shrub cover cannot be overstated as the maturity of the existing landscape features cannot be rapidly recreated by new planting, particularly if mature planting is acting as a screen for nearby receptors. The protection and retention of established tree cover is particularly important for the following reasons:

- It maintains the existing landscape framework and screening
- It provides a backdrop to soften the visual impact of the new structures
- It maintains the local habitat diversity of the verge

5.7.83. At this stage there are specific mitigation measures which cannot be assumed and would require further assessment to determine the level of the mitigation required and the resulting potential for a significant effect following this mitigation. This includes, but is not limited to the following:

- Off-site planting
- Targeted earth mounding
- New water features
- Appearance of structures

5.7.84. The options cross or are adjacent to areas of residential townscape and individual properties and as such there is potential for high levels of visual intrusion. The options would be the subject of a robust landscape strategy aimed at integrating the alignment into the broader landscape and mitigating specific landscape and visual effects identified below, and developed further at the detailed design stage.

2007 Option

5.7.85. 2007 Option gives rise to the highest number of potential visual impacts and would require a sensitive design approach. Specific areas to develop mitigation design measures include:

- Properties with views from Lindseys Heights (Visual Receptor (VR) 5)
- Properties on Bannvale Villas (VR10)
- Two detached properties adjacent to the 2007 Option (VR9 & VR12)

5.7.86. Landscape integration for this option has the potential to be more effective than other options in tying into an urban fringe setting.

Option 12

5.7.87. Option 12 would require the most sensitive approach, focusing on earthwork design and integration into the surrounding landscape due to its rural setting and the disruption to drumlin landforms. Specific measures for visual effects would include

- Three properties on Ballynahoneymore Road (VR15)
- Two properties on Hamiltonsbawn Road (VR07 & VR08)
- Properties along Killuney Park Road (VR03)

Option 16

5.7.88. Option 16 in addition to those set out for 2007 Option would also potentially require specific mitigation measures for:

- Lindseys Heights (VR5) and Bannvale Villas (VR10)
- One detached property off Bannvale Villas (VR9)
- Three properties on Ballynahomeymore Road (VR15)

5.7.89. In the southern half of Option 16 the mitigation measures should be more focussed on landscape integration through the sensitive design of earthworks and planting.

Significant Effect

5.7.90. Based on the assumptions that are made above regarding landscape mitigation the level of certainty for potential significant effects is relatively high as it would be assumed there would be a robust landscape strategy as part of the final option design. However there remains a level of uncertainty with regards to specific visual receptors and the level of mitigation measures that could be achieved.

Landscape Effects

2007 Option

5.7.91. While the 2007 Option would potentially result in the least amount of hedgerow loss it would result in the loss of significant existing screening vegetation. Within its more urban setting this has the effect of increasing visual awareness of the 2007 Option and increasing the urbanising effect. However with effective mitigation the 2007 Option would be integrated into the urban fringe environment effectively, without the likelihood of any significant effects on landscape character.

Option 12

5.7.92. Vegetation loss for Option 12 would be more easily mitigated for in its predominantly rural setting. However there would be modifications to drumlin landforms as well as a new roundabout off Hamiltonsbawn Road which would change the character and setting of the LLCA 1- Drumlin Agricultural Landscape and introduce an urbanising element into the most rural and tranquil setting of the options. Reconnection of hedgerows and a sensitive earthwork strategy would integrate Option 12 into the landscape although it would still have a high likelihood of significant effect on the local character due to the impact on drumlin forms which cannot be mitigated.

Option 16

5.7.93. Option 16 would be well integrated into the urban fringe landscape through its northern section while the section diverging from the 2007 Option would result in significant earthworks and vegetation loss. However with mitigation involving reconnection of hedgerows and sensitive earthwork design, Option 16 would better integrate and have a lower likelihood of significant landscape effects than Option 12.

Visual Effects

5.7.94. While there is a degree of uncertainty as to the likelihood of significant effects for some receptors on all options, a landscape mitigation strategy would on the whole reduce the number of receptors subject to significant effects.

2007 Option

5.7.95. The 2007 Option would have the potential for the highest amount of receptors and significant visual effects. This is because of the introduction of a new lit road in close proximity and within the view of rows of residential receptors, as well as areas of clearance of significant mature screening vegetation. Sections of the 2007 Option that would be highly visible for nearby receptors and would be highly likely to cause significant effects include:

- The tie in with the A3 and section adjacent to Lindsey's Heights.
- The section between Hamiltonsbawn Road and Lindsey's Heights in a local valley.
- Section to the rear of and adjacent to a row of properties on Bannvale Villas in slight cutting to one side.
- The connection to Ardmore Road and crossing of Bannvale Villas.

5.7.96. The 2007 Option would be lit along its length and utilises existing sections of road in close proximity to residential properties and as a result mitigation opportunities would be more limited than for Option 12 where screen planting or mounding would be more effective.

Option 12

5.7.97. Option 12 would have the fewest potential receptors with significant effects due to Option 12 passing through a relatively rural landscape which is well contained by drumlins. Sections of Option 12 that would be highly visible for nearby receptors and would be likely to cause significant effects include:

- The junction tie in with the A3 Portadown Road
- The proposed roundabout junction with Hamiltonsbawn Road
- The large embankment and crossing of Ballynahonemore Road

Option 16

5.7.98. Option 16 avoids the visual receptors along Ardmore Road and would only be lit at junctions and the northern end of Option 16. As a result it has fewer receptors with the potential for significant effects than the 2007 Option but more than Option 12. Sections of Option 16 that would be highly visible for nearby receptors and would be likely to cause significant effects include:

- The tie in with the A3 and section adjacent to Lindsey's Heights;
- The section between Hamiltonsbawn Road and Lindsey's Heights in a local valley;
- Section to the rear of and adjacent to a row of properties on Bannvale Villas in slight cutting to one side; and

- A large embankment on the section approaching and crossing Ballynahoneymore Road would be highly visible although there are no adjacent receptors.

Summary of Likely Significant Effects

5.7.99. Table 5-21 summarises the likelihood of the options to generate significant effects on the local landscape character areas and visual receptors.

Table 5-21– Summary of Likelihood of Significant Effects on Landscape and visual receptors in Accordance with IAN 125/15.

	2007 Option	Option 12	Option 16
LLCA1 Drumlin Agricultural Landscape	No Likelihood	High Likelihood	Low Likelihood
LLCA2 Residential Fringe Landscape	No Likelihood	Low Likelihood	No Likelihood
LLCA3 Industrial Fringe Landscape	Low Likelihood	No Likelihood	Low Likelihood
LLCA4 Mixed Use Landscape	No Likelihood	No Likelihood	No Likelihood
Visual Effects	High Likelihood	High Likelihood	High Likelihood

Landscape Effects

5.7.100. While there would be a landscape planting strategy in place as part of the options, there would still be a **high likelihood** for significant effects on LLCA1 for Option 12. Mitigation planting would also integrate the 2007 Option and Option 16 into the Industrial Fringe Landscape effectively and reduce the likelihood of significant effects.

Visual Effects

2007 Option

5.7.101. The 2007 Option would have the largest number of receptors with a **high likelihood** for significant impacts due to its proximity to residential areas, being lit along the entire route and less available land within which to apply mitigation measures.

Option 12

5.7.102. Option 12 would have **high likelihood** of significant effects as a result of large earthworks and effects on views more rural in nature, although Option 12 has fewest number of affected receptors.

Option 16

5.7.103. Option 16 would have a **high likelihood** of significance effects. Option 16 has fewer receptors than the 2007 Option due to the alignment avoiding the numerous receptors along Ardmore Road.

Limitations of Assessment

5.7.104. Full details of the proposed works for each option are yet to be developed, such as lighting proposals, drainage design and any proposed signs and structures which would all have an influence on the assessment of each option and potential visual effects associated with built elements or vegetation clearance.

5.7.105. A draft ZTV has been developed for this assessment and as such the potential receptor groups and suggested extents of visibility for all options is subject to change following a more detailed study.

Recommendations for Further Works

5.7.106. A detailed visual impact assessment would be required as part of the Stage 3 assessment to fully understand the potential visual effects of any options going forward once the detail design has been developed. A simple landscape assessment would be sufficient to understand the effects on landscape character. Development of a detailed landscape design would be required to mitigate potential landscape and visual effects.

5.8. Ecology and Nature Conservation

5.8.1. The screening and scoping exercise identified that there is uncertainty regarding likely significant effects relating to the potential impact of the options on European protected species. The options will require a detailed assessment and further species and habitat specific field surveys given that land take is required and the range of habitats adjacent to and in close proximity to the options is suitable to support protected species.

5.8.2. This chapter summarises the findings of the Preliminary Ecological Appraisal (PEA) which has been informed by detailed desk studies and an Extended Phase 1 Habitat Survey. The assessment identifies ecological issues that may be constraints to the works.

5.8.3. This section identifies further survey requirements, makes recommendations for mitigation measures and provides an indication of the level of further required assessment, to determine if the options could result in likely significant effects upon nature conservation and biodiversity.

5.8.4. It is anticipated that during Stage 3 that these preliminary assessments will be refined as more detailed design information is made available and mitigation can be designed to reduce the impact identified at Stage 2.

Study Area

5.8.5. The adopted study area is appropriate to the scale of the proposed works and takes into account the hierarchical nature conservation importance of designated sites. The following statutory area for the assessment have been defined as:

- International statutory designations – 2km from the route options, 30km for sites with bats as a qualifying feature
- Nationally designated sites – 1km
- Non-statutory sites – 250m
- Habitats – within and adjacent to the route options

5.8.6. The study set out to:

- Consult records of statutory protected sites within the study area
- Identify habitats and species present or likely to be present that are ecologically important and/or have legal protection within the study area
- Identify invasive species that might be present within the study area

Methodology

5.8.7. Assessment of the effects of the proposals on ecological features was carried out in accordance with the recommendations of the Chartered Institute of Ecology and Environmental Management (CIEEM 2016), methods outlined in the DMRB Volume 11, Section 3, Part 4 Ecology and Nature Conservation and in line with IAN 130/10 Ecology and Nature Conservation: Criteria for Impact Assessment and IAN 125/15 Environmental Assessment Update.

5.8.8. The following sources were consulted to collate historical ecological records within the study area. Records were limited to statutory and non-statutory ecological designations and species records within the study area.

- Northern Ireland Environment Agency (NIEA)
- Centre for Environmental Data and Recording (CEDaR); the Local Records Centre for Northern Ireland

Preliminary Walkover Survey

5.8.9. A walkover survey, undertaken broadly in accordance with standard Phase 1 habitat survey methodology (JNCC, 2007), was carried out on 6 and 7 June 2016.

5.8.10. Habitat types were identified and mapped, with target notes made of features of interest. The suitability of habitats within the site to support legally protected, valuable or controlled species was assessed with incidental field signs or sightings of species recorded as seen.

Existing Environment

Statutory Designated Site

5.8.11. There are no statutory designated sites within the study area.

Non – Statutory Designated Sites

5.8.12. Sites of Local Nature Conservation Interest (SLNCIs) are designated by the local authority. At the time of writing, information on the location of these designations was not available. However, no SLNCIs were identified within the study area during previous ecological desk studies undertaken for the options.

Habitats

5.8.13. For detailed habitat descriptions and species assessments, refer to the PEA (see *Appendix H*) and ecological constraints location is shown on Drawing No 1064968-B-D-3025 (see *Appendix A*).

5.8.14. A summary of the main habitat types identified is provided below:

Improved Grassland

5.8.15. Improved grazing pasture is the most abundant habitat type within the study area. This habitat type is characterised by a heavily-nutrient enriched, species-poor sward of negligible biodiversity value at the site level.

Semi-Improved Grassland

5.8.16. There is a small area of more diverse grassland at Linsey's Hill with a longer sward and greater diversity of herb species. Two small areas of damp grassland are present to the north of the industrial estates on Hamiltonsbawn Road and Endeaveys Road. Frequent areas of amenity grassland are present throughout the study area, largely in the form of roadside verges. These are mainly of a short sward and appear to be regularly mown. The semi-improved grassland within the site is of low biodiversity value at the local level.

Hedgerows

5.8.17. A large number of hedgerows are present across the study area. The majority of these are dense and mature and contain mature standard trees. Some are also associated with damp ditches and / or raised banks. Hedgerows are listed as a Northern Ireland

priority habitat due not only to species within the hedgerow, but also to their wider value within the landscape, providing opportunities for foraging and movement of a number of faunal species. The hedgerows within the study area are therefore of **high biodiversity** value at the local level.

Trees

5.8.18. The majority of trees across the study area are found as standards within hedgerows. Many of these are mature or semi-mature specimens. The trees are suitable for a number of faunal species including bats and birds, and have their own intrinsic value within the local area. Accordingly, the trees across the study area are of **moderate biodiversity** value at the local level.

Hardstanding

5.8.19. A number of existing tarmac roads and pavements are present across the study area. These are largely devoid of any vegetation and are of **negligible biodiversity** value at the site level.

Watercourses

5.8.20. A number of watercourses are present throughout the study area, including a number of wet ditches associated with field margins. Two shallow streams are also present; one at Linsey's Hill and the other at Edenaveys Road. The watercourses are of low-**moderate biodiversity** value at the local level.

Japanese Knotweed

5.8.21. A single stand of Japanese knotweed Fallopia japonica is present within an area of amenity planting. This is an **invasive species**, the spread of which is controlled under Northern Ireland legislation.

Species Assessment

Amphibians

5.8.22. No standing waterbodies were recorded in the study area during the survey work undertaken and no records of amphibians were identified during the desk study. Suitable terrestrial habitat for amphibians is present within the study area, however, this is not extensive. Accordingly, the study area is of **negligible** value at the local level for amphibians.

Reptiles

5.8.23. The majority of the habitats within the study area are not suitable for reptiles and no records of reptiles were received during the desk based study. The areas of long sward semi-improved grassland include features that could be used by reptiles to forage and shelter, however, this habitat type covers a relatively small area and is isolated within the wider landscape. As such, the suitability of the study area for reptiles is low. Accordingly, the study area is of **negligible** value at the local level for reptiles.

Mammals

5.8.24. A number of trees within the study area have features which are suitable for roosting bats. Further survey work to determine the presence / likely absence of roosting bats

within these trees has not yet been undertaken. Accordingly, the value of the study area for roosting bats cannot be determined at this stage.

5.8.25. The habitats within the study area are also suitable for foraging and commuting bats. Further survey work to determine use of the study area by bats has not yet been undertaken. Accordingly, the value of the study area for foraging and commuting bats cannot be determined at this stage.

5.8.26. Evidence of badgers were recorded within the study area and as such, the habitats within the study area are of value to badgers. However, survey work to determine the extent of badger activity across the study area has not yet been undertaken. Accordingly, the value of the study area for badgers cannot be determined at this stage.

5.8.27. The watercourses within the study area are unsuitable for otter, being isolated, shallow and largely choked with vegetation. No otter holts or resting sites were recorded during the field survey. Accordingly, the study area of **negligible** value at the local level for otter.

Birds

5.8.28. Habitats within the study area, including hedgerows, trees and long sward grassland are suitable for use by nesting birds and are likely to support a species assemblage typical of fairly intensively managed farmland. These habitats are abundant within the wider area. Habitats within the study area are of **moderate** value at the local level for nesting birds.

Potential Impacts

Direct Habitat Loss

5.8.29. The options are likely to cause **adverse** effects as a result of the direct loss of habitat. The habitats affected by the options are similar, however, the 2007 Option would be likely to affect less habitat loss than Option 12 and Option 16 because this alignment makes use of the existing road network in a number of locations.

Habitat Fragmentation

5.8.30. The options will result in the fragmentation of habitats. The 2007 Option is expected to cause less habitat fragmentation as this makes use of the existing road network and runs close to existing development within the east of Armagh.

Impacts on watercourses

5.8.31. All three options cross watercourses along their routes. Option 12 and Option 16 are also located within close proximity to field ditches. Possible impacts on watercourses include:

- increased aquatic sedimentation/pollution
- habitat fragmentation
- altered flow dynamics and channel profiles.

Japanese Knotweed

5.8.32. The 2007 Option and Option 16 occur in proximity to stands of Japanese knotweed, a non-native invasive species, and without suitable control measures, could result in further spread of the plant.

Birds

5.8.33. The options may result in impacts on birds as a result of direct habitat loss, damage of habitats, habitat fragmentation and disturbance during construction and operation. If undertaken during the nesting season, construction risks the disturbance of nests. Although suitable habitats for birds is present along the options, the 2007 Option is likely to have the least effect on birds by virtue of it effecting the least amount of habitat loss, and least potential for disturbance because it makes use of the existing road network in places.

Bats

5.8.34. The options could result in direct and indirect effects on roosts, loss or fragmentation of foraging and commuting habitats and increased disturbance. Adverse effects on bats may have significant legal as well as nature conservation implications. Specialist surveys investigating the use of the study area by bats have not been undertaken, so full assessment of the likely impacts of the options on bats has not been made at this time.

Badger

5.8.35. The options could result in damage or disturbance of setts and habitat fragmentation and loss of foraging habitat which may affect badger. However, specific surveys to determine use of the study area by badgers have not been undertaken, so an assessment of the likely impacts of the options on badgers cannot be made at this time.

Recommended Mitigation Measures

5.8.36. This sections outlines possible mitigation measures to avoid or reduce adverse effects of the proposals on ecological resources. The specific details of mitigation measures will be developed following the identification of a preferred route option and completion of further specialist surveys.

Direct Habitat Loss

5.8.37. Minimising the footprint of the works would help to reduce the impact of direct habitat loss. The provision of new planting along the verges of the options may also provide some compensation for the loss of habitats.

Habitat Fragmentation

5.8.38. Although possible mitigation for individual receptors is described below, the options are likely to result in impacts on habitats and species through habitat fragmentation. Appropriate mitigation for this impact may include the use of underpasses and green bridges within the preferred option design.

Impacts on watercourses

5.8.39. Standard pollution control measures should be employed during construction to minimise the risk of pollution incidents occurring. This should include the provision of spill kits on site and training for all staff on how to use emergency response equipment and ensuring that drainage features retain their correct working function during any works that may be undertaken.

Japanese Knotweed

5.8.40. An 'Invasive Species Management Plan' to include how to treat/dispose of Japanese Knotweed should be produced, detailing measures to be taken to avoid the spread of this species. The plan should include a programme of eradication and control of this species that should be implemented prior to any groundworks in areas where this plant occurs, and should comply with measures recommended for the control of this species by NIEA.

Birds

5.8.41. Removal of trees and hedgerows should ideally be undertaken outside of main bird nesting season (March to August inclusive). If vegetation removal is required during this period, the vegetation should be checked for the presence of nests by an appropriately experienced ecologist prior to works. If active nests are found, it may be necessary to delay work in the immediate proximity of nests until the young have fledged.

Mammals

5.8.42. Following the findings of the specialist surveys for bats and badger, there may be the requirement for licensing from NIEA to allow works to proceed in full compliance with the legislation. Should this be the case, it is likely that mitigation measures will be required, the nature and extent of which will be informed by the results of the specialist surveys.

Significant Effects

Designated Sites

5.8.43. There are no national or international statutory nature conservation designations and no local non-statutory nature conservation designations within the study areas. There is therefore no likelihood that any of the options will have an effect on designated sites. There will therefore be **no significant** effect on designated sites from any of the options.

Habitats

5.8.44. The options will result in the habitat loss and fragmentation. It is anticipated that new planting will be provided throughout the options to compensate for these losses, however this new planting will take time to mature and provide similar levels of food, shelter etc. Accordingly, the effect on habitats present along the options will be **minor negative.**

5.8.45. The options will also require the crossing of watercourses. These include small shallow streams and damp ditches. Following the implementation of the mitigation measures outlined above, there will be **no significant** effect on watercourses from any of the options

5.8.46. The 2007 Option and Option 16 are located within close vicinity to a stand of Japanese knotweed and may risk its spread. The control and eradication of this species within the works area will avoid further spread of this species.

Species

Badger

5.8.47. Evidence of badger, including badger setts, has been recorded within the survey area. Further survey work to determine the way in which the study area is used by badger has not yet been undertaken. Accordingly, valuation of the study area and recommendations for mitigation measures cannot be made at this time. As such, the significance of the effects of the options on badger is not known.

Bats

5.8.48. Habitats suitable for roosting, commuting and foraging bats are all present within the survey area. Further survey work to determine the location of any roosts, and the levels of bat activity within the study area has not yet been undertaken. Accordingly, valuation of the study area and recommendations for mitigation measures cannot be made at this time. As such, the significance of the effects of the options on bats is not known.

Birds

5.8.49. Habitats suitable for use by nesting birds are present across the study area. The options will result in the loss of these habitats. It is anticipated that impacts on nesting birds will be minimised by the application of mitigation measures described in this report, including the provision of new planting to compensate for the loss of nesting habitat. However, it will take time for this compensatory planting to mature and provide similar value for birds. Accordingly, the effect on nesting birds as a result of the options will be **minor negative**.

Summary of Likely Significant Effect

5.8.50. Table 5-22 summarises the likelihood of the options to generate significant effects on each of the highlighted local ecology.

Table 5-22 - Summary of Likelihood of Significant Effects on Nature Conservation in Accordance with IAN 125/15.

	2007 Option	Option 12	Option 16
Designated Sites	No Likelihood	No Likelihood	No Likelihood
Habitats	Low Likelihood	Low Likelihood	Low Likelihood
Badger	Uncertain	Uncertain	Uncertain
Bats	Uncertain	Uncertain	Uncertain
Birds	Low Likelihood	Low Likelihood	Low Likelihood

Limitations of Assessment

5.8.51. The habitat and species assessments have been informed by desk study information of species records and habitat data and an extended Phase 1 habitat survey. No specific species or specialist habitat surveys have been undertaken as this stage of the assessment.

5.8.52. Due to some access restrictions, not all of the study area could be directly surveyed. Where this was the case, land was surveyed from vantage points where appropriate and safe to do so. Sufficient ecological data was obtained from the accessible land to provide an accurate description of the habitats within the survey area for the purposes of this assessment.

Recommendations for Further Works

5.8.53. Trees across the study area were noted to have features suitable for roosting bats. The network of hedgerows and watercourses across the study area may be used by bats for commuting, while the areas of open grassland may be used for foraging. As such, it is recommended that surveys are undertaken to establish use of the study area by bats to allow an assessment of the likely impact of the scheme to be made and inform any mitigation measures which may be required.

5.8.54. Evidence of badger activity was recorded within study area, including a sett to the south of Hamiltonsbawn Road, The proposals may result in damage or disturbance to this sett and others which may be present within the study area. The proposals may also result in a loss of foraging areas and impact on different territories. It is therefore recommended that surveys are undertaken to establish the use of the study area by badgers to allow an assessment of the likely impacts of the scheme to be made and inform any mitigation measures which may be required.

5.9. Geology and Soils

5.9.1. This section, relating to geology and soils, has focused on the consideration of potential impacts specific to statutory and non-statutory sites designated for their geological value; a review of geological, geotechnical and soils information to identify potential impacts on geological resources; evaluation of contaminated areas and sites relative to potential impacts / risks on environmental receptors in the vicinity of the options and an assessment of the quality of soils under or adjacent to the options.

Study Area

5.9.2. The study area comprised an area extending to 1km from the options.

5.9.3. The study set out to:

- Consult records of designated geological sites
- Identify non-designated sites downstream of the options that could be subject to geomorphological changes
- Identify potentially contaminated sites based on historical and / or present use

Methodology

5.9.4. Information relating to geology and soils and the assessment relating to contaminated land and sites has been sourced and undertaken with reference to the following guidance provided in the DMRB - Volume 11, Section 3, Part 11 Geology and Soils (1993) and DMRB – Volume 11, Interim Advice Note 125/15 (2015).

5.9.5. Information has been obtained from the following sources:

- datasets held by the Geological Survey of Northern Ireland, visible geology (http://mapapps2.bgs.ac.uk/GSNI_Geoindex/home.html);
- datasets held by the British Geological Survey- Visible geology (http://mapapps.bgs.ac.uk/geologyofbritain/home.html);
- Earth Science Conservation Review Sites (ESCRS);
- datasets held by the Northern Ireland Environment Agency (NIEA) (http://maps.ehsni.gov.uk/naturalheritage);
- The UK Soil Observatory map and World Reference Base (WRB) Classification: (http://mapapps2.bgs.ac.uk/ukso/home.html?layer=AFBIWRB); and
- DOENI - Environment & Heritage Service (EHS) (https://www.doeni.gov.uk/).

5.9.6. Further studies will involve a review of current data to verify the status of sites which have been previously considered. Reference will be made to the following data sources:

- The information included in the Armagh East Link DMRB Stage 2 Options Report (Mouchel Parkman and RPS Planning and Environment 2006 -2007) and Mouchel (2015) Armagh East Link Route Assessment Report.

Assessment of Contamination Risk

5.9.7. Potentially contaminated sites have been identified based on the type and extent of contaminants which might typically be associated with the historical and / or present use.

5.9.8. Where contaminated / potentially contaminated sites would be disturbed during construction, the risk of contaminants (a source; e.g. a historic landfill) finding a linkage (pathway) to a receptor (e.g. construction workers) has been assessed.

Existing Environment

Designated Sites

5.9.9. There are no designated sites within the study area.

Non Designated Geological / Geomorphological Important Sites

5.9.10. There are no known non-designated sites downstream of the options that could be subject to geomorphological changes.

Superficial Geology

5.9.11. Superficial deposits have been informed by geological mapping (Drawing No. 1064968-B-D-6000 in Appendix A) and historical investigations, including a Ground Investigation (GI) undertaken in 2006 along the footprint of the study area.

5.9.12. Superficial (Quaternary) deposits dominate the geology of the area and principally comprise glacial stony clay (till), though deposits of glacial sand and gravel are anticipated. Superficial deposits are extremely variable in their thickness but are indicated to be thinner in the areas of high ground such as the area between Hamiltonsbawn Road and Ballynahonemore Road.

5.9.13. Areas of alluvium (very variable soft clay mixed with loose sand) were proven in the low lying area between Hamiltonsbawn Road and Linsey's Hill Road, associated with existing watercourses namely Killuney Drain and Killuney Drain Tributary. Superficial mapping indicates a potential tract of Alluvium associated with an unnamed watercourse located in the vicinity of the Hamiltonsbawn Road and Stockingmanshill Road junction and a large potential tract associated with Ballynahone River to the south of the study area.

5.9.14. Several areas of made / worked ground identified on the geological mapping were proven and encountered in the vicinity of Ardmore Road; at the Hamiltonsbawn Industrial Estate Road and further north in the location of Lindsey Heights.

5.9.15. Geological mapping identifies a pocket of peat in the vicinity of Ardmore Road, this was not however encountered within the 2006 GI.

Bedrock Geology

5.9.16. Solid Geology mapping (Drawing No. 1064968-B-D-6001 in Appendix A) and historical ground investigations indicates the area is predominantly underlain by rocks of the Leadhills Supergroup, described as wacke and variably coloured mudstone. These rocks are indicated to be folded, dipping in variable directions (however is predominately in a south west direction), and in places the beds are shown to be overturned. The northern extent of the study area is underlain by younger

(Carboniferous age) rocks of the Killuney Conglomerate Formation (Tournasian). These are described as purple-red fine grained conglomerates, fine to coarse grained sandstones and banded siltstones.

5.9.17. The Killuney formation outcrop is bounded by a SE-NW trending fault, which is down thrown to the north. The line of the fault is shown to locally coincide with the line of the existing A3 Portadown Road.

5.9.18. North of the fault lies rocks of the Armagh Group described as Limestone (argillaceous rocks with sub ordinate sandstone interbedded); Drumman More Sandstone Formation; Retreat Siltstone Formation (described as argillaceous rocks with subordinate sandstone and limestone) and the Ballynahone Micrite (Limestone) Formation.

5.9.19. The 2006 GI proved bedrock at isolated locations. Limestone was encountered to the south of the study area at 16.3m below ground level (bgl). The underlying bedrock was however generally encountered as strong slightly weathered dark grey mudstone underlain by strong slightly weathered thickly bedded dark grey fine grained sandstone. The weathered zone overlying this was described as fine to coarse grained dark grey gravel with cobbles. Deposits ranged in depth from 4.6m bgl to 12m bgl between Hamiltonsbawn Road and the edge of Linsey's Hill.

5.9.20. The published bedrock stratigraphy is illustrated in Drawing No. 1064968-B-D-6001 (see Appendix A). The aquifer class of the underlying geology is Class BI(f) - an intermediate fractured aquifer of limited potential yield.

Soils

5.9.21. The study area is WRB classified as Stagnosols, Cambisols and Urban:

- Stagnosols are periodically wet and mottled in the topsoil and subsoils, due to redox processes caused by stagnating surface water. This includes a wide variety of unconsolidated materials including glacial till, and loamy aeolian, alluvial and colluvial deposits, but also physically weathered silt stone.
- Cambisols are moderately developed soils. Soils with at least the beginnings of horizon differentiation in the subsoil evident from changes in structure, colour, clay content or carbonate content.

5.9.22. 'Urban' is used as a shorthand for all soils occurring in urban and industrial areas; it is thus a discussion term rather than a classification. All soils in urban areas affect the life of the city and are more or less affected by human intervention.

2007 Option

5.9.23. 2007 Option is largely within an Urban corridor (Ardmore Road – Linseys Heights). There is a small section around Killuney Meadows, Bannvale Villas, and junction of A28 Market Road and Ardmore Road, are classified as Stagnosols.

Option 12

5.9.24. Options 12 is largely Stagnosols. There is a small Urban corridor at Killuney Park. The immediate vicinity of Drumman Heights / Killuney Road / A3 Portadown Road are classified as Cambisols.

Option 16

5.9.25. Options 16 is divided between Stagnosols and Urban corridor classification.

Agricultural Land Classification

5.9.26. Four Agricultural Land Classification (ALC) are within the options corridor and classified as:

- Grade 2 – very good quality agricultural land with minor limitations which affect crop yield, cultivations or harvesting. A wide range of agricultural and horticultural crops can usually be grown but on some land in the grade there may be reduced flexibility due to difficulties with the production of the more demanding crops such as winter harvested vegetables and arable root crops
- Grade 3A - good quality agricultural land capable of consistently producing moderate to high yields of a narrow range of arable crops, especially cereals, or moderate yields of a wide range of crops including cereals, grass, oilseed rape, potatoes, sugar beet and the less demanding horticultural crops
- Grade 3B - moderate quality agricultural land capable of producing moderate yields of a narrow range of crops, principally cereals and grass or lower yields of a wider range of crops or high yields of grass which can be grazed or harvested over most of the year
- Grade 5U - Built-up or 'hard' uses with relatively little potential for a return to agriculture

2007 Option

5.9.27. The land surrounding the 2007 Option is largely Grade 5U. There are small areas of land around Killuney Meadows and Bannvale Villas classified as Grade 3B. The junction of A28 Markethill Road and Ardmore Road is Grade 3A.

Option 12

5.9.28. Options 12 is largely classed as Grade 3B. A small area around Edenaveys Industrial Estate / Junction of Edenaveys Road and A28 Markethill Road is Grade 3A. In the vicinity of the existing roundabout on the A3 Portadown Road at Drumman Heights / Killuney Road, the surrounding land is classed as Grade 2.

Option 16

5.9.29. Option 16 is divided between Grade 3B and 5U. A small area around Edenaveys Industrial Estate / Junction of Edenaveys Road and A28 Markethill Road is Grade 3A.

Contaminated Land

2007 Option / Option 16

5.9.30. There are ten potentially contaminated sites identified as shown on Drawing No. 1064968-B-D-3026 (see *Appendix A*). These comprise food preparation and processing facilities, petrol station / fuel storage, reclaimed land, historic quarries and an unidentified factory works.

5.9.31. Table 5-23 shows the contaminated site in proximity to Options.

Table 5-23 - Contaminated Land Sites Identified within proximity to Options.

Location and Area (where known)	Address	Description	Proximity
Ballynahone More TD	Low	2*	Food Preparation & Processing
Ballynahone TD	Low	3*	Food Preparation & Processing
Portadown Road	Low	4*	Food Preparation & Processing
Drumadd TD – approximately 5000m2	Low	RQ1*	Reclaimed Land
Orangefield Drive	High	5*	Fuel Storage at the Council Depot
Drumadd Road	High	6*	Petrol Station / Fuel Storage
Orangefield Drive	Unknown	7*	Factory – Operations Unknown
Killuney	N/A	RQ2**	Limestone Quarry in 1860
Drumadd TD (East of Ballynahonemore River)	N/A	RQ3**	Quarry in 1860
Drumadd TD (West of Proposed Link Road) – approximately 4992m^2	N/A	RQ4**	Slate Quarry in 1948

RQ – Reclaimed Quarry
* Denotes Land Use in 1972
** Denotes information from Historical Mapping

Potential Impacts

Superficial Geology

5.9.32. The options are likely to have **permanent adverse** impacts due to the removal of superficial geology. The magnitude of impact will be influenced by the construction length and depth of cut required to install the new infrastructure.

Bedrock Geology

5.9.33. The options could have **permanent adverse** impacts on bedrock geology if intrusive construction measures such as piling of percussive drilling is required to install the new infrastructure.

Soils

5.9.34. The options are likely to have **permanent adverse** impacts on soils and agricultural land, mainly due to land take.

2007 Option

5.9.35. The land take required is largely within an urban area with little potential for a return to agriculture. Moderate / good quality agricultural land take will be required.

Option 12

5.9.36. The land take required is largely within areas of moderate agricultural land. Good / very good quality agricultural land take will be required.

Option 16

5.9.37. The land take required is within an urban area with little potential for return to agriculture and areas of moderate quality agricultural land. Good quality agricultural land take will be required.

Contaminated Land

5.9.38. Ground disturbance within close proximity to potentially contaminated sites could result in **permanent adverse** impacts due to the exposure of receptors to potentially harmful contaminants.

5.9.39. To illustrate the potential risk of disturbing contaminated sites, a simple source-pathway-receptor model for Orangefield Drive - Fuel storage at the Council Depot follows:

- Source: Orangefield Drive - Fuel storage at the Council Depot;
- Pathway: ingestion, inhalation, touch or movement of potentially contaminated material which would be most likely to occur during ground clearance, earthworks and excavations; and
- Receptors: construction workers, residents of the nearby houses or ecological receptors in the extended area.

Recommended Mitigation Measures

5.9.40. Targeted investigations are recommended as part of a wider geotechnical investigation to establish whether residual contamination associated with former land use are present along the options corridor.

5.9.41. The investigation should also determine the level of risk of potential contaminants within the vicinity of the options, or whether construction works would pose a risk to wider environmental receptors. If contaminants are present and are assessed at significant concentrations, the implementation of a remediation programme should also be undertaken.

5.9.42. Impacts from the presence of any contaminated land associated with construction activities should be managed through processes identified in the CEMP and include:

- Clearly defined working areas and access routes
- Plans to carefully strip, handle and separately store soils prior to construction

- The storage of all oil, chemical and hydrocarbon sources in accordance with legal requirements and best practice

5.9.43. The volume of soil disturbance should be kept to the minimum required for the construction of the works.

5.9.44. The CEMP should include a specific soils and contaminants management plan. The plan will require method statements for work being undertaken where the risk of contamination has been established to identify a process of investigation focused on establishing specific contaminants, appropriate working methods and protective measures to be adopted.

Summary of Likely Significant Effects

5.9.45. Table 5-24 summarises the likelihood of significant impacts on each of the identified local geology and soils for each option.

Table 5-24 - Summary of Likelihood of Significant Effects on Geology and Soils in Accordance with IAN 125/15

Assessment Area	2007 Option	Option 12	Option 16
Superficial Geology	Low Likelihood	Low Likelihood	Low Likelihood
Bedrock Geology	Low Likelihood	Low Likelihood	Low Likelihood
Grade 2	No Likelihood	Low Likelihood	No Likelihood
Grade 3A	Low Likelihood	Low Likelihood	Low Likelihood
Grade 3B	Low Likelihood	Uncertain	Uncertain
Grade 5U	Low Likelihood	No Likelihood	Low Likelihood
Contaminated Land	Uncertain*	Uncertain*	Uncertain*

**In the absence of a ground investigation / contamination report there is uncertainty regarding likely significant and adverse effects on human and ecological receptors.*

Limitations of Assessment

5.9.46. The assessment is based on desk study only. There has been no site visit or intrusive survey to give an indication of the location or mobile nature of the contaminants associated with contaminated ground.

Recommendations for Further Works

5.9.47. A detailed ground investigation along the selected preferred route is recommended as there is potential for contaminants to be mobilised or displaced during construction with the levels of any detected contaminants to be assessed

5.9.48. Consultation with ABCB Council and the Local Steering Group is recommended to identify any updated local sites of geological interest.

5.10. Materials

5.10.1. The screening and scoping assessment identified that a simple assessment of the potential impacts on materials resource and waste facilities would be required as there is a low likelihood of significant and adverse effects as a result of the options. This is due to the low likelihood of scarce or valuable resources and limited waste capacity within ABCB Council being permanently and adversely impacted upon.

5.10.2. The materials chapter focuses on the material resource required during the construction phase of the options. Following construction minimal material resources are expected to be required to operate / maintain the options. It has also focused on the generation, management and disposal of waste from the site.

5.10.3. The use of material resources and the management and transportation of waste during construction could also give rise to other adverse environmental effects such as air quality and noise impacts however this chapter does not consider these impacts. The respective specialist topic areas include an assessment of impacts during construction and are not repeated in this section. The methodology for the materials chapter will be updated once an outline cut and fill balance and book of quantities is produced during Stage 3 and a simple assessment in accordance with IAN 153/11 will be undertaken.

Study Area

5.10.4. In the absence of data relating to waste sites, construction information including a book of quantities and/or specification of materials the study area for the assessment includes the footprint of the options. This provides a basis for comparison between the options in relation to the potential amount of waste produced or materials required for construction.

Methodology

5.10.5. The assessment has been undertaken with reference to IAN 153/11. The assessment has focussed on the construction phase. Guidance on the environmental assessment of material resources and the procedure for the simple level assessment has been undertaken, where appropriate. The amounts of materials required to construct the options and potential waste produced during construction has not been calculated.

5.10.6. During scoping, the potential to generate hazardous waste was identified as being of environmental concern. Potential sources of hazardous waste have been identified from experience and knowledge of the types of waste typically generated throughout construction on large infrastructure projects. Table 5-23 and Section 5.9 have identified the potential for contamination to be encountered during construction, which are classed as hazardous waste.

5.10.7. Impacts have been identified from the storing and disposal of such hazardous wastes and the potential for the waste to impact sensitive receptors. Where such potential exists, mitigation measures have been proposed to minimise the potential impacts of hazardous waste.

5.10.8. Therefore, the assessment provides broad assumptions regarding the difference between the options. Where the option is determined to be larger than the next it is likely that this option will have the greatest magnitude of impacts on material use and waste produced.

5.10.9. Waste strategy documents relating to the management of waste within ABCB Council have been identified in order to understand the available capacity for the treatment of Construction Demolition and Excavation (CD&E) Waste in proximity to the options.

Existing Environment

5.10.10. Previous similar road schemes provide information on types of materials that could be considered in the assessment of the potential impact of the options on material resources and waste. The key materials for consideration are grouped under two main areas:

- Material Resources – this includes materials required to construct the options, for example key infrastructure such as safety barriers, environmental barriers, CCTV cameras, cables ducts and imported materials for construction such as aggregates
- Waste – excavated materials from key infrastructure locations, excess materials, redundant furniture, road planings, and contaminated materials to be disposed

5.10.11. Some of the “waste” materials can be re-used on site and may therefore be considered as material resources.

5.10.12. At this stage the availability and sensitivity of waste disposal facilities in close proximity to the options has not been obtained. However, the Joint Waste Management Plan 2016 - ABCB Council; Fermanagh and Omagh District Council and mid Ulster District Council’s priority is waste prevention, followed by materials reuse and recovery. However, there will remain a need for landfill capacity for those wastes that are not recovered or recycled. The document also promote the use of Site Waste Management Plan (SWMP) for all projects of a sizable nature.

Potential Impacts

Material Use and Disposal

5.10.13. The options will make use of sections of existing roads as well as creation of new road makeup outside of the existing road boundaries. The options are anticipated to generate waste and use of construction materials as detailed in Table 5-25.

Table 5-25 - Summary of Anticipated Waste and Construction Materials

Waste and Material Type	Description
Waste hydraulic oil	Waste hydraulic oil would be generated on site from the routine maintenance of plant and equipment. This would take place either within a plant storage area or on site as required.
Wiping cloths	Wiping cloths are used for removing excess grease and oils from plant and machinery following routine maintenance. They are disposed of after use as they cannot be viably cleaned and reused.
Oily water from separators	Separators may be present on site to remove contaminants from surface water runoff. These would be located as required based upon the surface water infrastructure.
Contaminated packing	Contaminated packaging is defined as packing material that previously held materials that would be defined as hazardous if they are disposed. Examples of contaminated packaging that would be generated during the construction of the options include grease cartridges, empty solvent containers and empty oil containers. These would be generated during routine maintenance of plant and equipment.
Contaminated soils	The potential for contaminated soils to be found on site during the construction phase is possible (see also Section 5.9)
Surplus Cut	Each option will produce surplus fill and will not be re-used or recycled but sent to landfill for disposal.
Construction Materials	Different quantities of stone, concrete and bitumen will be used for the construction of each option.

5.10.14. The options will seek to minimise the quantity of new infrastructure required. The key potential impacts associated with materials are expected to arise from:

- the transportation of materials to and from site (import and export)
- the storage of materials on site
- decommissioning of existing infrastructure
- excavation of materials at major infrastructure locations
- disposal of surplus or hazardous materials.

5.10.15. A detailed cut and fill balance or bill of quantities had not been produced at the time of assessment.

5.10.16. Table 5-26 details percentage of assumed imported materials and Table 5-46 in Section 5.12 details the required land parcel for each option's alignment within the study area.

5.10.17. Based on the land parcel area requirement within Table 5-46, it is assumed that a similar quantity of construction material will be required. Table 5-26 details the percentage estimate of construction material required for each option. This calculation was derived from the combined total and percentage fraction of each option. Compared to the 2007 Option and Option 16, Option 12 has the highest overall footprint area and it therefore follows, a higher percentage of construction material will be required.

Based on this assumption it is assumed that Option 12 will have adverse impacts of a higher magnitude on materials use and waste capacity.

Table 5-26 – Estimates of Percentage of Construction Materials

	2007 Option	Option 12	Option 16
% Imported Materials.	17.07%	47.66%	35.27%

5.10.18. Waste capacity in ABCB Council is not known. However, due to the size of options and the potential waste produced and taking into consideration the aims of the waste strategies identified, which encourage the treatment of CD&E Waste, it is not anticipated that the options will have adverse impacts on waste capacity that could be considered significant.

Storage of Hazardous Waste

5.10.19. The Options could lead to the potential disposal of hazardous wastes and environmental impacts should the waste not be managed appropriately.

Recommended Mitigation Measures

5.10.20. The following mitigation measures have been identified and will be considered in more detail at Stage 3 for development in parallel with the allocated option design:

- A Materials and Waste Management Strategy (M&WMS) would be developed for both material procurement and waste management; and
- As part of the M&WMS a Resource Management Plan (RMP) and Site Waste Management Plan (SWMP) will be produced and adhered to.

5.10.21. A draft SWMP will be produced as part of the Stage 3 detailed assessment; ensuring that targets for reporting SWMP progress are included in the contract documentation in order that the allocated option has a draft SWMP that will assist the client, consultant, construction contractors and their sub-contractors to:

- reduce raw materials costs
- reduce waste destined for landfill
- reduce waste disposal costs
- meet legislative requirements
- meet the client's expectation
- That a contractual obligation is put upon the contractor to achieve specific levels of performance relating to materials reuse and waste management

5.10.22. The following mitigation measures have been identified for implementation at Construction Stage:

- A Materials and Waste Management Strategy (M&WMS) should be developed for both material procurement and waste management as part of the M&WMS a Resource Management Plan (RMP) and Site Waste Management Plan should be produced and adhered to.

5.10.23. A number of mitigation measures are recommended to enhance the above commitments such as:

- minimising the total material demand of the design by ensuring that material inputs match demand as closely as possible
- minimise waste by matching material demand with material supply. Material supply can be met from the following prioritised sources:
    - on site reuse / recycled
    - off-site reuse / recycled.

5.10.24. Through a combination of statutory obligation and stringent target setting the mitigation measures indicated above would result in the majority of waste being diverted from landfill.

5.10.25. Based on this assessment it is considered that the following could be taken forward for treatment of materials:

- geo-technically and chemically suitable material from the excavations would be reused on site.

5.10.26. Waste management facilities are also a source for recycled construction materials, in addition to accepting CD&E waste for recycling.

5.10.27. Sourcing materials as locally as possible would reduce impacts associated with transportation.

5.10.28. Identification of CD&E sites, for the provision of recycled construction materials confirms that recycled construction materials are readily available.

Summary of Likely Significant Effects

5.10.29. Table 5-27 summarises the likelihood of the options to generate significant effects on material resource or waste capacities in ABCB Council.

Table 5-27 – Summary of Likelihood of Significant Effects on Materials and Waste Facilities in Accordance with IAN 125/15

	2007 Option	Option 12	Option 16
Materials	Low Likelihood	Low Likelihood	Low Likelihood
CD&E Waste	Uncertain	Uncertain	Uncertain
Hazardous Waste	Uncertain*	Uncertain*	Uncertain*

**Due to absence of a ground investigation / contamination report*

Limitations of Assessment

5.10.30. The assessment is based on preliminary information regarding the options. Detailed cut and fill balances and a bill of quantities are not yet available for the options.

5.10.31. The waste capacity in ABCB Council is unknown and therefore assumptions regarding this have been made.

5.10.32. The assessment did not consider temporary construction impacts associated with increased construction traffic.

Recommendations for Further Works

5.10.33. A simple level assessment in accordance with IAN 153/11 should be undertaken at Stage 3 once cut and fill balances and a bill of quantities are developed for the allocated option. A simple level assessment should be undertaken at Stage 3 to identify potential waste streams and sites and capacities within ABCB Council.

5.11. Noise and Vibration

5.11.1. The assessment is focused on the potential traffic noise operational impacts at sensitive receptors, including dwellings, schools, hospitals, care homes and places of worship.

5.11.2. The screening and scoping exercise identified that incorporating the options and changes in existing alignment could cause changes to traffic noise levels at sensitive receptors.

Study Area

5.11.3. The study area for the operational assessment has been defined based on the guidance in DMRB, Volume 11, Section 3, Part 7, HD 213/11 – Revision 1 (HD213/11).

5.11.4. The study area is defined as 600m from the options edge (including proposed, or improved routes), 600m from any other affected route within 1km of the options, and 50m from any affected routes beyond 1km.

5.11.5. An affected route is one which meets the threshold criteria, which is either a change of 1dB $_{LA10,18h}$ in the Short-term or a 3dB $_{LA10,18h}$ in the Long-term, where the 'LA10,18h' noise level is arithmetic mean of all the levels of LA10 during the period from 06:00 to 24:00.

5.11.6. Calculations of noise impacts are made at sensitive receptors within the study area.

Methodology

5.11.7. The operational simple noise assessments have been undertaken with reference to the guidance provided in The DMRB Volume 11, Section 3, Part 7, HD 213/11 – Revision 1 Noise and Vibration. Reference has also been made to guidance within BS5228 Code of practice for noise and vibration control on construction and open sites (2009).

Operational Impacts

5.11.8. Traffic related noise levels have been predicted with the options in place, Do-Something, and without the options in place, Do-Minimum.

5.11.9. The assessment considers the Short-term, on options opening, and the Long-term, plus 15 years. For each option the following comparisons are made:

- Do-Something verses Do-Minimum scenario in Opening Year (2020)
- •Do-Something verses Do-Minimum scenario in Design Year (2035)

5.11.10. The change in noise levels with and without the options in place describes the noise impact.

5.11.11. HD213/11 states that a change of 1dB in the Short-term (Opening Year) and 3dB in the Long-term (Design Year) are the smallest change considered perceptible.

The classification of magnitude of noise impacts is taken from HD213/11 and is presented in Table 5-28 and Table 5-29.

Table 5-28 - Classification of Magnitude of Noise Impacts in the Short-term

Noise Change, $L_{A10, 18h}$	Magnitude of Impact
0.0	No change
0.1 - 1.9	Negligible
1.0 - 2.9	Minor
3.0 - 4.9	Moderate
5.0+	Major

Table 5-29 - Classification of Magnitude of Noise Impacts in the Long-term

Noise Change, $L_{A10, 18h}$	Magnitude of Impact
0.0	No change
0.1 - 2.9	Negligible
3.0 - 4.9	Minor
5.0 - 9.9	Moderate
10.0+	Major

5.11.12. The classification of receptor sensitivity is given in Table 5-30.

Table 5-30 – Receptor Sensitivity

Sensitivity	Description
High	Receptors sensitive to noise and vibration, including residential, schools (daytime), hospitals and places of worship
Medium	Receptors with moderate sensitivity to noise and vibration, hotels, including sports facilities, offices, cafes/restaurants
Low	Receptors not sensitive to noise, including industrial premises, transient receptors

5.11.13. World Health Organisation (WHO) guidance provides values for community noise. It states that in outdoor living areas to protect the majority of people from being seriously annoyed noise levels should not exceed 55dB $L_{Aeq,16h}$ (where L_{A10} is the A-weighted sound level in dB that is exceeded 10% of the measurement period. This is the standard index used within the UK to describe traffic noise). To protect the majority of people from being moderately annoyed noise levels should not exceed 50dB $L_{Aeq,16h}$.

5.11.14. Free-field $L_{Aeq,16h}$ noise levels can be converted to $L_{A10,18h}$ facade noise levels by adding 4.5dB.

5.11.15. The significance of noise impacts is dependent on a number of factors, including magnitude of impact, sensitivity of receptor, absolute predicted noise levels, existing noise environment (character), and population (density of receptors).

5.11.16. Based on guidance given in Noise Policy Statement for Northern Ireland (NPSNI) and National Planning Policy Framework (NPPF), the rating of significance of noise impact applies Effect Levels:

- NOAEL – No Observed Adverse Effect Level;
- LOAEL – Lowest Observed Adverse Effect Level; and
- SOAEL – Significant Observed Adverse Effect Level.

5.11.17. For this assessment the significance of noise impact is based on magnitude of impact, sensitivity of receptor and predicted noise level. In addition the assessment does provide details regarding the certainty or uncertainty relating to likely significant effects in accordance with the criteria provided in IAN 125/15.

Table 5-31 - Significance of Noise Impact

	Receptor Sensitivity		
Magnitude of Impact	Low	Medium	High
No change	No Impact	No Impact	No Impact
Negligible	No Impact	No Impact	Marginal
Minor	No Impact	Marginal	NOAEL
Moderate	Marginal	NOAEL	LOAEL*
Major	NOAEL	LOAEL*	SOAEL*

* A significant impact is deemed to occur at receptors predicted to experience a LOAEL or SOAEL impact and where the predicted $L_{A10,18h}$ noise level in the Do-Something scenario is >54.5 dB $L_{A10,18h}$

5.11.18. For this stage of assessment night-time noise levels and ground borne vibration have not been considered

Construction Noise and Vibrations

5.11.19. Construction works are known to generate noise and vibration. As the exact nature of construction activities and the plant to be used during the construction phase is not known at this time, a full construction noise assessment is not possible.

5.11.20. Road building construction works will be similar across the options, therefore, greatest impact is expected to occur at receptors located close to the new road alignment. It is expected that construction impacts for each option will be in the same locations as predicted in the operational assessments.

Noise Modelling

5.11.21. Noisemap Server Edition noise mapping software was used to predict propagation and noise levels within the study area. This commercially available 3D modelling software applies the calculation procedures as detailed in HD213/11. Information and baseline assumptions to model the noise impacts are as follows:

- Ground height information is derived from Digital Terrain Model (DTM) mapping with a 10m resolution.

- Existing road alignments are based on OSNI MasterMap. Proposed alignments are based on options drawings, including 3D earthworks information. Road surfaces in all scenarios have been modelled as impervious bitumen.
- Road links have been modelled as one or two way roads based on traffic data, with a carriageway width of 3.5m.
- Building outlines were identified from OSNI MasterMap and sensitive receptors were identified using OSNI MasterMap and OSNI address pointer data.
- Building height is set to 8m above ground level.
- Dwelling receivers were located at 4m above ground level and 1m from the facade. Other sensitive receptor receivers were located at 1.5m above ground level and 1.0m from the facade. Receiver calculations include a 2.5dB facade correction.
- Traffic data including 18h Annual Average Weekday Traffic (AAWT) flows, traffic composition expressed as the percentage of HGVs greater than 3.5 tonnes (unladen weight) and the average speed of traffic in kilometres per hour (km/h).

5.11.22. The following scenarios have been modelled:

- Do-Minimum 2020
- Do-Minimum 2035
- Do-Something 2007 Option 2020
- Do-Something 2007 Option 2035
- Do-Something Option 12 2020
- Do-Something Option 12 2035
- Do-Something Option 16 2020
- Do-Something Option 16 2035.

Existing Environment

Relevant Sensitive Receptors

5.11.23. A total of 3662 dwellings and 56 other sensitive receptors were identified within the study area shown on Drawing No.1064968-B-D-3029-A (see *Appendix A*).

Noise Monitoring

5.11.24. Baseline noise levels were predicted using the noise model for the Do-Minimum 2020 (Opening Year) scenario.

5.11.25. Noise monitoring surveys have not been completed for the Stage 2 assessment.

Potential Impact

Operational Impacts

5.11.26. As an indication of the potential for the number of receptors which may experience operational noise impacts, a proximity count exercise has been undertaken.

5.11.27. The number of dwellings and other relevant sensitive receptors (e.g. hospitals, schools) and potential Long and Short term impacts are presented in accordance with HD213/11 (magnitude impact banding) in Table 5-32 to Table 5-37.

2007 Option

5.11.28. 2007 Option short term and long term impacts are presented in Table 5-32 and Table 5-33 and shown on Drawing No.1064968-B-D-3030 and 1064968-B-D-3031 (see *Appendix A*).

Table 5-32 -2007 Option Short-term Noise Impacts

Change in Noise Level		Dwellings	Other Sensitive
Increase in noise level $L_{A10,18h}$	0.1-0.9 (Negligible)	1327	20
	1.0-2.9 (Minor)	124	1
	3.0-4.9 (Moderate)	36	0
	5.0+ (Major)	62	0
No Change	0	1127	26
Decrease in noise level, $L_{A10,18h}$	0.1-0.9 (Negligible)	793	6
	1.0-2.9 (Minor)	145	2
	3.0-4.9 (Moderate)	37	1
	5.0+ (Major)	11	0

Table 5-33 -2007 Option Long-term Noise Impacts

Change in Noise Level		Dwellings	Other Sensitive
Increase in noise level $L_{A10,18h}$	0.1-2.9 (Negligible)	3194	49
	3.0-4.9 (Minor)	58	1
	5.0-9.9 (Moderate)	34	0
	10.0+ (Major)	33	0
No Change	0	49	0
Decrease in noise level, $L_{A10,18h}$	0.1-2.9 (Negligible)	255	5
	3.0-4.9 (Minor)	30	1
	5.0-9.9 (Moderate)	9	0
	10.0+ (Major)	0	0

5.11.29. Short-term major increases are concentrated in three locations, Linsey's Heights, Bannvale Villas and Ardmore Road.

5.11.30. Short-term moderate and minor increases are principally located in the same areas as the Major impacts detailed above, but are found further away from the options alignment.

5.11.31. Long-term increases are located in the same locations as for Short-term, but at a smaller number of receptors; a function of the change in banding between Short and Long-term.

5.11.32. Short-term major, moderate and minor decreases are found along Drumadd Terrace, Orangefield Drive and Ardmore Road.

5.11.33. Long-term moderate and minor decreases are mostly found to the east of Ardmore Road.

Option 12

5.11.34. Option 12 impacts are presented in Table 5-34 and Table 5-35 and shown on Drawing No.1064968-B-D-3032 and 1064968-B-D-3033 (see *Appendix A*).

Table 5-34 – Option 12 Short-term Noise Impacts

Change in Noise Level		Dwellings	Other Sensitive
Increase in noise level $L_{A10,18h}$	0.1-0.9 (Negligible)	526	11
	1.0-2.9 (Minor)	104	1
	3.0-4.9 (Moderate)	28	1
	5.0+ (Major)	34	2
No Change	0	1329	33
Decrease in noise level, $L_{A10,18h}$	0.1-0.9 (Negligible)	1462	8
	1.0-2.9 (Minor)	179	0
	3.0-4.9 (Moderate)	0	0
	5.0+ (Major)	0	0

Table 5-35 – Option 12 Long-term Noise Impacts

Change in Noise Level		Dwellings	Other Sensitive
Increase in noise level $L_{A10,18h}$	0.1-2.9 (Negligible)	3080	49
	3.0-4.9 (Minor)	49	3
	5.0-9.9 (Moderate)	23	1
	10.0+ (Major)	17	1
No Change	0	76	0
Decrease in noise level, $L_{A10,18h}$	0.1-2.9 (Negligible)	417	2
	3.0-4.9 (Minor)	0	0
	5.0-9.9 (Moderate)	0	0
	10.0+ (Major)	0	0

5.11.35. Short-term major increases are mostly found on and around Killuney Park Road and in the vicinity of the northern end of Option 12.

5.11.36. Short-term moderate and minor increases are located in the same areas as the major impacts detailed above.

5.11.37. Long-term increases are located in the same location as for Short-term, but at a smaller number of receptors; a function of the change in banding between Short and Long-term.

5.11.38. Short-term Minor decreases are found along Drumadd Terrace, Orangefield Drive and Ardmore Road.

5.11.39. No Long-term perceptible decreases are predicted for Option 12.

Option 16

5.11.40. Option 16 short-term and long term impacts are given in Table 5-36 and Table 5-37, and shown on Drawing No.1064968-B-D-3034 and 1064968-B-D-3035 (see *Appendix A*).

Table 5-36 - Option 16 Short-term Noise Impacts

Change in Noise Level		Dwellings	Other Sensitive
Increase in noise level $L_{A10,18h}$	0.1-0.9 (Negligible)	1078	21
	1.0-2.9 (Minor)	64	1
	3.0-4.9 (Moderate)	31	3
	5.0+ (Major)	41	1
No Change	0	1132	24
Decrease in noise level, $L_{A10,18h}$	0.1-0.9 (Negligible)	1176	6
	1.0-2.9 (Minor)	140	0
	3.0-4.9 (Moderate)	0	0
	5.0+ (Major)	0	0

Table 5-37 - Option 16 Long-term Noise Impacts

Change in Noise level		Dwellings	Other Sensitive
Increase in noise level $L_{A10,18h}$	0.1-2.9 (Negligible)	3054	48
	3.0-4.9 (Minor)	46	5
	5.0-9.9 (Moderate)	33	1
	10.0+ (Major)	16	0
No Change	0	122	0
Decrease in noise level, $L_{A10,18h}$	0.1-2.9 (Negligible)	391	2
	3.0-4.9 (Minor)	0	0
	5.0-9.9 (Moderate)	0	0
	10.0+ (Major)	0	0

5.11.41. Short-term major increases are concentrated in three locations, Linsey's Heights, Lowrys Avenue and Bannvale Villas.

5.11.42. Short-term moderate and minor increases are principally located in the same areas as the major impacts detailed for the 2007 Option, but are further away from the option alignment.

5.11.43. Long-term increases are located in the same locations as the short-term but at a smaller number of receptors, a function of the change in banding between Short and Long-term.

5.11.44. Short-term minor decreases are found along Drumadd Terrace, Orangefield Drive and Ardmore Road.

5.11.45. No Long-term perceptible decreases are predicted for Option 16.

Options Comparison

5.11.46. Across all options, perceptible (minor, moderate and major) adverse impacts (increases) are found at receptors close to the options alignments.

5.11.47. Across all options, perceptible beneficial impacts (decreases) are mainly found along nearby bypassed routes.

5.11.48. The options are predicted to introduce an **overall increase in adverse** noise impacts.

5.11.49. The 2007 Option has the highest number of adverse noise impacts. The assessment predicts that there are more major and minor adverse noise impacts associated with this alignment in both the Short and Long-term. Moderate adverse impacts are broadly the same as for Option 12 and Option 16.

5.11.50. The predicted impacts for Option 12 and Option 16 are broadly similar. Option 12 has fewer larger scale adverse noise impacts (major in the Short-term and moderate in the Long-term).

Recommended Mitigation

5.11.51. We recommend that only impacts identified as significant should be considered for mitigation as per WHO guidelines.

5.11.52. This approach differs from HD213/11 which recommends that all perceptible increases in noise level should be mitigated if possible. This equates to ≥1 dB in the Short-term and ≥3 dB in the Long-term.

Predicted Significant Effects

5.11.53. A significant impact is deemed to occur at receptors predicted to experience a LOAEL or SOAEL impact and where the predicted $L_{A10,18h}$ noise level in the Do-Something scenario is >54.5 dB. WHO guidelines on community noise state that to protect the majority of people from being moderately annoyed during the daytime, the outdoor sound level should not exceed 50 dB $L_{Aeq,16h}$, this value is equivalent to 54.5 dB $L_{A10,18h}$. Impacts below these levels are not considered to be significant.

5.11.54. The predicted significant noise impacts are presented in Table 5-38.

Table 5-38 - Significant Noise Impacts

Period	Receptor	Significant Noise Impact Level		Total
		LOAEL	SOAEL	
2007 Option				
Short-term	Dwellings	12	54	66
	Other Sensitive Receptors	0	0	
Long-term	Dwellings	26	32	58
	Other Sensitive Receptors	0	0	
Option 12				
Short-term	Dwellings	1	20	21
	Other Sensitive Receptors	0	0	
Long-term	Dwellings	8	14	23
	Other Sensitive Receptors	0	1	
Option 16				
Short-term	Dwellings	5	27	32
	Other Sensitive Receptors	0	0	
Long-term	Dwellings	15	16	31
	Other Sensitive Receptors	0	0	

5.11.55. The 2007 Option has the **highest** number of significant adverse noise impacts with Option 12 has the **fewest** number of significant adverse noise impacts.

Summary of Likely Significant Effects

5.11.56. Table 5-39 summarises the likelihood of the options to generate significant operational noise impacts.

Table 5-39 - Summary of Likelihood of Significant Effects on Noise and Vibration in Accordance with IAN 125/15

	2007 Option	**Option 12**	**Option 16**
Operational Impact	High Likelihood	High Likelihood	High Likelihood

Limitations of Assessment

5.11.57. Noise monitoring has not been completed for the Stage 2 assessment. As measured noise levels are not used in the assessment of operational impacts, it is considered that readings would not provide additional information to help separate the options. It is proposed that noise surveys are completed and the results be included in the Stage 3 assessment.

5.11.58. Ground height information beyond the extent of the options engineering drawings is derived from 10m DTM mapping. At this level of resolution some local topography will be missing from the 3D model.

5.11.59. Ground height information for the option alignments is derived from 3D engineering drawings, differences in accuracy between the options alignment and the 10m DTM may result in topographic errors along the boundary between the datasets.

5.11.60. Building outline information taken from OSNI mapping required considerable manual work to identify unique dwellings.

5.11.61. The OSNI address pointer 'classification' field is used to identify sensitive receptors based by cross-referencing the geo-locations of the two datasets. Each building outline identified is a single receptor within the model. The datasets do not account for multi-occupancy receptors, e.g. flats, halls of residence.

5.11.62. Building height is set to 8m above ground level. As there are more than 7000 buildings in the study area, a uniform building height is a necessary simplification. A uniform building height of 8m is unlikely to have a significant effect on predicted impacts. Receptor height is a maximum of 4m above ground level, the shielding provided by an 8.0m building is considered to be similar to that of a taller building. For buildings shorter than 8m the noise model will include more shielding than reality and may under predict noise impacts in a small number of instances.

5.11.63. For the Stage 2 assessment night-time noise levels have not been considered. Hourly traffic data is not available, when this is the case night-time levels are derived using Method 3 of the TRL report. It is considered that as the method uses a simple factor and a correction value to generate L_{night} outside, the results would generally mirror the day time assessment and would not provide additional information to help separate the options. At Stage 3 night-time noise levels will be assessed.

5.11.64. For the Stage 2 assessment ground borne vibration has not been considered. Ground borne vibration should only be assessed if it is identified as a potential problem on existing routes. Vibration is not anticipated to be an issue as the new road surface will be smooth, and ground borne vibrations from traffic are only generally perceptible where the road surface is uneven.

5.11.65. When the construction programme, including plant noise data are confirmed it is recommended that a detailed noise impact assessment of construction works is undertaken by the Contractor as part of the CEMP. This will include any TTM plan, for example traffic re-routing and diversions.

5.11.66. It is recommended that the contractor is requested to incorporate specific noise abatement measures as part of the CEMP during construction.

5.11.67. Significant effects are based on calculated HD213/11 results, i.e. filtered for least beneficial change before filtering for absolute level. This method potentially does not include all receptors exceeding LOAEL or SOAEL threshold.

Recommendations for Further Works

5.11.68. It is recommended that noise surveys are undertaken at sample locations representative of noise sensitive receptors along the length of the selected option to inform noise thresholds as part of the construction assessment.

5.11.69. It is recommended that during Stage 3 further screening exercise is undertaken to inform discussions in relation to the potential mitigation measures (such as noise barriers or low noise surfacing) in areas of particular concern if the potential for adverse impacts is identified.

5.11.70. Furthermore and during Stage 3, it is recommended that a detailed quantitative assessment of the operational noise impacts is undertaken based on HD213/11 methodology and in agreement with ABCB Council.

5.12. People and Communities

5.12.1. The screening and scoping assessment identified that short term negative impacts are anticipated to non-motorised users, that significant beneficial effects are anticipated for motorised users and that there is a high likelihood of slight to moderate adverse effects on land ownership as a result of the options. The requirement for a detailed level of assessment for the impacts to motorised users and private assets will be required and a simple level for all other aspects addressed in this section. At this stage consultation with owners of private properties was considered inappropriate before more detailed mitigation proposals could be developed. This section provides:

- an assessment of anticipated impacts on journeys undertaken by pedestrians, cyclists and equestrians (collectively referred to as Non-Motorised Users or NMUs) on public rights of way (PRoW) (including footways) and motorists connecting to the Strategic Road Network (SRN) and local roads, in relation to changes in journey distance and time as an indicator of severance and on the amenity value of the rights of way and local roads to users
- an evaluation of driver stress
- an assessment of the drivers' experience in terms of views from the road which would be available for users of the options
- an assessment of the impacts on Commercial, Community, Residential, Agricultural and Development land using significance criteria

Study Area

NMUs and Users of Local Roads - Journey Length and Amenity Value

5.12.2. The study area for the assessment of journey length and amenity value is considered to be the network of NMUs routes in the vicinity of the options and where the options link into or cross the routes.

5.12.3. The study area has been developed to ensure that should the diversion of an NMU route be required during the construction or operational phase this is captured. A change to amenity or 'pleasantness' in the context of the options will generally be the result of increased awareness of traffic rather than the intrusion of the change in vertical alignment. Therefore, the NMU routes that were included for identification through the desk study include:

- PRoW
- Footways

Vehicle Traveller - Views from the Road

5.12.4. The study area for the assessment of changes to visual context is based on the ZTV outlined in Section 5.7. The preliminary ZTV allows for the identification of views from beyond the road from a perspective of an individual looking toward the options.

5.12.5. Although the view of the individual will be influenced by their place within the wider landscape the view of a traveller can generally be identified using the ZTV as a guide to where the wider landscape can be viewed from the road.

Land Use

5.12.6. The study area allows for the identification of impacts to present or future land use that could be permanently precluded due to land take or a change in amenity as a result of the options. Given the nature of the proposals and the land use identified during Stage 2 exercises, permanent land-take could result in likely significant effects.

Methodology

5.12.7. The assessments have been undertaken with reference to the following guidance:

- DMRB - Volume 11, Section 3, Part 8, Pedestrians, Cyclists, Equestrians and Community Effects (HA, 1993)
- DMRB - Volume 11, Section 3, Part 9, Vehicle Travellers (HA, 1993)
- DMRB - Volume 11, Section 3, Part 6, Land Use – Amendment No 1 (HA, 2001)
- DMRB – Volume 11, IAN 125/15 (HA 2015).

NMUs and Users of Local Roads

5.12.8. The method of assessment related to impacts on journeys undertaken by NMUs and users of local roads; in relation to changes in journey length and time, as an indicator of new severance; and relief of severance on the amenity value of PRoW has been undertaken based on the guidance provided in the DMRB, Volume 11, Section 3, Part 8, Pedestrians, Cyclists, Equestrians and Community Effects.

Assessment of Impacts on Journey Length and Amenity Value

5.12.9. The assessment has involved identification of the existing network of PRoW and other NMUs routes and the road network likely to be affected by the implementation of the options. Mainly through overlaying the designs on aerial photography and Ordnance Survey of Northern Ireland (OSNI) mapping. Other sources used include:

- datasets held by the Sustran National Cycle Network (NCN) (http://www.sustrans.org.uk/ncn/map)
- datasets held by the Outdoor Recreation Northern Ireland / Walk Northern Ireland (http://www.walkni.com/)

5.12.10. The options are in the preliminary stages of development and diversion lengths have not been assessed at this stage. The assessment identifies if a route is subject to a diversion and is reported as a ‘yes’ or ‘no’. The length of the potential diversion and the magnitude of impact to a route would be considered for the preferred option during the Stage 3 Assessment.

5.12.11. Impacts to amenity have been assessed by qualitatively describing the perceived changes to the relative pleasantness of a journey. This has been determined by the views afforded to travellers along an NMU route and any exposure to traffic which would potentially affect travellers in respect of fear / safety, noise pollution and air quality.

5.12.12. The number and type of paths impacted and the differences between each options is described, with any changes to amenity value reported, i.e. where there would be an increase, decrease, or no change in amenity value. Where a decrease is reported this is considered an adverse impact on the amenity of the route.

5.12.13. The assessment undertaken is subjective, qualitative and based on the likely perception of change to the individual experience.

New Severance

5.12.14. The assessment of the significance of new severance is based on:

- identification of the location of the principal communal facilities within the study area;
- categorisation of severance specific to each location where existing routes and the options cross, taking into account combinations of criteria related to vehicle flows on new sections of road, the form of crossing provided and increases in journey length.

5.12.15. The impact rating and criteria adopted for the assessment of new severance are detailed in Table 5-40.

Table 5-40 - New Severance Impact Rating

Severance	Criteria
Slight	• Pedestrian at-grade crossing of a new road carrying below 8,000 vehicles per day (AADT); or • A new bridge would need to be climbed or a subway traversed; or • Journeys would be increased by up to 250m.
Moderate	• Two or more of the hindrances set out under 'slight' applying to single trips; or • Pedestrian at-grade crossing of a new road carrying 8,000-16,000 vehicles per day (AADT) in the opening year; or • Journeys would be increased by 250m-500m.
Severe	• Pedestrian at-grade crossing of a new road carrying over 16,000 vehicles per day (AADT) in the opening year; or • An increase in length of journeys of over 500m; or • Three or more of the hindrances set out under 'slight' or two or more set out under 'moderate'.

Relief from Existing Severance

5.12.16. The assessment of relief of existing severance has involved categorisation of the predicted relief of severance for sections of local roads within the study area, using guidelines provided in DMRB and replicated in Table 6-41.

5.12.17. In accordance with the guidance, three levels of relief have been adopted; slight, moderate and substantial, according to the urban or rural location of the existing section of road and the percentage reduction in predicted traffic flows along the sections.

Table 5-41 - Relief from Existing Severance

	Level of Relief from Severance % Reduction in Existing Traffic Levels		
	Slight	**Moderate**	**Substantial**
Built-up area	c.30%	30-60%	60%+
Rural area	60-75%	75-90%	90%+

Vehicle Travellers

5.12.18. The methods of assessment related to driver stress and views from the road have been based on the guidance provided in the DMRB Volume 11, Section 3, Part 9 (Vehicle Travellers).

Views from the Road

5.12.19. The assessment of views from the road has involved understanding how the extent to which travellers would be able to perceive the landscape would vary with the relative level of the road, surrounding topography and vegetation. The categories used in assessing are as follows:

- No view - road in very deep cutting or contained by earth bunds, environmental barriers or adjacent structures
- Restricted view - road in frequent cuttings, or with deep cuttings across slopes, with frequent environmental barriers or adjacent structures blocking the view
- Intermittent view - road generally at grade but with shallow cuttings, environmental barriers or structures at intervals
- Open view - road generally at grade or on embankment with views extending over the wider landscape or only restricted by existing landscape features

Driver Stress

5.12.20. The assessment of driver stress has been based on the traffic and road conditions likely to be encountered and the certainty of the route for travellers. The following factors has been considered:

- traffic flows
- journey speed
- frustration - the inability to drive at a speed consistent with the driver's wishes in relation to the general standard of the road
- fear - the potential for accidents due to the presence of other vehicles, poor road standards and the possibility of pedestrians stepping into the road
- uncertainty - primarily due to signing that is inadequate for the driver's purpose

5.12.21. In relation to traffic flows and journey speed, the DMRB provides guidance relating levels of driver stress relative to average hourly flow per lane, average journey speed,

the urban or rural location of the road and the type of road (e.g. motorway, dual carriageway or single carriageway).

5.12.22. The options are two lane single carriageway and no reliable correlations have been established between physical factors and driver stress. Table 5-42 details the DMRB guidance / appropriate stress ratings for a single carriageway

Table 5-42 - Stress Ratings for Single Carriageway Roads

Average peak hourly flow per lane Flow units/1 Hour	Average journey speed – km/hr		
	Under 50	**50 – 70**	**Over 70**
Under 600	High*	Moderate	Low
600-800	High	Moderate	Moderate
Over 800	High	High	High

* Moderate in urban areas

Land Use

5.12.23. The methods of assessment have been informed by the guidance detailed in the DMRB Volume 11, Section 3, Part 6 Land Use (Incorporating Amendment No.1 dated August 2001). The baseline environment has been established through a desk-based assessment and review of the following resources have been consulted:

- local area plans and proposal maps for Armagh City
- desktop review of OSNI mapping
- desktop review of aerial photography
- GIS mapping quantification of land-take.

5.12.24. The overall assessment of land use has primarily involved:

- classification of land use: private property, commercial, community, agricultural and development land within the study area
- the identification of both temporary land take (licence), land take for access purposes(easement) and demolition of buildings;
- quantification of land take relative to the identified uses and description of the function of the land which would be taken in the context of the current use, taking into account amenity value where appropriate
- evaluation of the order of impact of the options on land use

Private Property

5.12.25. The assessment of private land involved:

- Identification of private land and areas of residential settlement that may be purchased to make way for the options

- evaluation of the order of impact of the options on private land and property.

5.12.26. No building or land take directly associated with agriculture has been included in this part of the assessment as they are discussed further during Stage 3.

5.12.27. Table 5-43 presents the significance criteria that have been used for the assessment.

Table 5-43 - Significant Effects / Criteria for Impact to Land Use

Impact Rating	Criteria
Negligible	A barely discernible impact on use or amenity value.
Slight Adverse	Land take peripheral to existing or intended use; Activity that temporarily compromises or precludes use; and Loss of amenity that does not compromise use.
Moderate Adverse	Land take that compromises but does not preclude existing or intended use; Activity that compromises or precludes use for a protracted period; and Loss of amenity that compromises but does not preclude use.
Substantial Adverse Impact	Land take that precludes existing or intended use; Activity that permanently compromises or precludes use; and Loss of amenity that precludes use.

Community Land

5.12.28. The assessment of impact on community land has involved:

- identification of land currently used by the community which would be required for the construction of the options
- analysis of the extent to which the options would sever or fragment areas of land used by the community, or where the proximity of the options would have a potential impact on its current and continued use;
- description of impacts related to the proximity of the options to an existing community land use where the amenity value of the environmental context is integral to the use
- evaluation of the options to establish the potential impact on land used by the community and identify appropriate design and mitigation measures
- assessment of the significance of the identified impacts taking mitigation into account

5.12.29. Land used by the community has been identified from a review of relevant policy documents and the Northern Ireland Neighbourhood Information Service (NINIS).

5.12.30. Impacts have been described, taking into account the evaluation outlined above, and impact ratings have been attributed to each area of community land that would be affected based on the criteria presented in Table 5-43.

Development Land

5.12.31. The assessment of the effects on development land has involved:

- a review of development plan documentation and local planning registers (https://www.planningni.gov.uk/index/tools/public-access-info.htm) to identify and quantify development land and its intended future use within the options footprint
- a preliminary screening exercise to screen out planning applications that would not be directly affected by the options. The impact of the options on each of the consents have been assessed based on the type of development approved and the perceived proportion of land which will be taken
- an analysis of the extent to which the options would sever or fragment areas of development land
- identification of the potential impacts on development land

5.12.32. The evaluation of the significance of impacts on development land has been informed by an analysis of the proportion of land that would be taken in the context of the overall extent of each area. Consideration has also been given to the type of land use proposed, the effect of the option on access arrangements and potential compatibility or conflict with the presence of the option.

5.12.33. An initial screening assessment was carried out on all of the approved planning applications within the fence line of the option. Planning applications that met the following criteria were screened out of the assessment:

- applications to make minor alterations to an existing structure including loft conversions, small extensions or a change in signage
- applications for developments to replace existing structures on a like-for-like basis
- applications for developments that would not be affected by the options due to the type of development including overhead power lines and utilities

5.12.34. Impact ratings have been attributed to each area of development land that would be affected based on the criteria described in Table 5-43.

Agricultural Land

5.12.35. The assessment of the impacts on agricultural land has involved:

- Identification of landholdings based on a review of information gathered during Stage 1 and updated survey access plan during Stage 2
- verification and updating of land parcel information
- identification of the agricultural land capability of the agricultural areas through which the options is aligned
- quantification of the total land take for ALC Grades of the options
- further details informing the baseline were sourced from Section 5.9: Geology and Soils.

5.12.36. Table 6-44 outlines the impact ratings described used for the assessment of agricultural land.

Table 5-44 - Impact Ratings used for Agricultural Impact Assessment

Rating	Description
Minor adverse	An inconsequential land take or minimal loss of agricultural production, relative to overall scale of the farm; Insignificant disruption to the present farm management routine; Insignificant impact on present farm output; Little or no impact, since the land is not currently used for agricultural production purposes; Little or no impact on overall farm viability.
Moderate Adverse	Small to moderate land take relative to overall scale of the farm; Small to moderate severance or disruption to the present farm management routine; Small to moderate impact on present farm output, arising from additional inputs associated with farming retained lands; Moderate impact on farm viability.
Substantial Adverse	A substantial area of the land constituting the farm would be taken by the option; Substantial disruption of the present day to day management routine; Significant impact on overall farm viability; Significant impact on farm output, arising from additional inputs associated with farming retained lands.

Existing Environment

NMUs and Users of Local Roads

5.12.37. Part of the existing Sustrans NCN 91 is signed and travels within the study area via Ballynahonemore Road – Bannvale Villas - Ardmore Drive – Ardmore Road – A28 Markethill Road as on Drawing No 1064968-B-D-3023 and 1064968-B-D-3024 (see *Appendix A*)

5.12.38. The Ulster Way circular long distance walking route is within the footprint of the options.

5.12.39. Within the study area there is a mix of urban and rural land uses. Pedestrian and vehicular traffic are separated by the provision of pedestrian facilities such as footpaths and crossings. The existing network of footways and footpaths within the study area allow for pedestrian movements to and from the residential areas and community facilities.

5.12.40. There are footpaths which will potentially be affected, in particular within larger areas of residential use, notably on:

- Ardmore Road
- Markethill Road

- Ballynahonemore Road
- Bannvale Villas
- Hamiltonsbawn Road
- Edenaveys Road
- Barrack Hill
- Linsey's Hill
- Killuney Park Road
- Portadown Road

5.12.41. There is no footfall data for bridleway or equestrian facilities within the study area. However, due to the rural nature to the east of the study area, it shall be assumed that equestrian movements may be present.

Community Facilities

5.12.42. The principal facilities within the community, which residents would be travelling to and from on a regular basis, include health facilities, schools, libraries, shops, recreational facilities, churches and public transport facilities.

5.12.43. Identified community facilities include, Grove Nursery School, Drelincourt School, Saints and Scholars Integrated Primary School, Armagh Community Hospital, Orchard Leisure Centre, Ardmore Recreation Centre and a number of churches (Armagh City Temple Elim Church, Armagh Free Presbyterian Church; and Armagh Baptist).

Vehicle Travellers

View from the Road

5.12.44. The options are located within Character Area 13 'Southern Drumlins and Orchards' of the NIRLCA. The existing environment in respect of available views across the study area can be referenced in Section 5.7.

5.12.45. Residential lands are concentrated to the southern and northern extents of the study area, in the vicinity of the A28 and A3 junctions respectively. Further residential developments are present within the study area, but in smaller clusters, or as individual dwellings.

5.12.46. The study area, in the vicinity of the A51 Hamiltonsbawn Road and Ballynahonemore Road is defined by the industrial and commercial lands, in particular the Drumadd Barracks, the Hamiltonsbawn Road Industrial Estate and the commercial premises on the Ballynahonemore Road.

5.12.47. The east of the study area is dominated by agricultural land; predominantly pasture land, this landscape provides an open, drumlin landscape, similar to that which is common to the wider Armagh countryside.

Driver Stress

5.12.48. The existing driving conditions within the traffic model indicate that for the majority of roads driver stress is likely to be **high**.

Land Use

Private Property

5.12.49. There are concentrations of residential land use within the study area, along and radiating from a number of key roads as mentioned above.

5.12.50. There are isolated single, or smaller groups of settlement / village i.e. Hamiltonsbawn / Edenaveys, in particular to the east of the study area, amidst agricultural land. Many of these dwellings are assumed to be farm houses.

Commercial and Industrial

5.12.51. The size and structure of the manufacturing sector within the study area is dominated by small areas of light industrial units.

5.12.52. The Hamiltonsbawn Industrial Estate which lies directly adjacent to the east of the Armagh Business Park is one such area of land use which maintains several light industrial units occupied by R-Tek Manufacturing, Daily Bake Limited, Farmlay Eggs and Cross Refrigeration.

5.12.53. To the south west of this site, on the Ballynahone Road there are units occupied by Shilliday Refrigeration and Air Conditioning and Tretzo Bathroom UK. Armagh Fish Hatcheries (District Angling Club) is located on Ballynahonemore Road (this facility is not connected with the river network).

Agricultural Land

5.12.54. Agricultural land dominates the east of the study area; this land is largely improved pastures and rough grazing land. Fields within the study area are both irregular in shape and scale, with most boundaries formed by mature field boundary hedgerows.

5.12.55. NINIS farming census recorded approximately 3200 farms in Armagh City, Banbridge and Craigavon District in 2015, giving full-time employment to approximately 2150 people as well as considerable amounts of agricultural labour employment. Along with dairy and meat production, the Armagh area is also home to a significant number of the province's remaining traditional orchards.

Community Land - Recreation and Amenity Open Space

5.12.56. The Ardmore Recreation Centre which is located to the east of the study area on Ballynahonemore Road forms a key area of recreational space. The facility incorporates three grass pitches and one floodlit artificial pitch with associated seated terracing.

5.12.57. The Armagh Plan 2004 notes two large Open Spaces 'Wedge' Areas have been designated within the study area. These are Drumadd (10.2ha) to the north of the Armagh Business Park Ltd. An area of 5.6ha of steeply sloping land at Edenaveys. This is intended as a buffer between the proposed industrial area and adjacent development at Ardmore. An area of 5.6ha at Ballynahone of fairly elevated land, to the west of Ballynahonemore Road.

Development Land - Proposed Housing

5.12.58. Areas zoned for housing within the study area include: Dillon Heights / Linsey Heights – 4.7ha of land alongside and accessed through existing housing estates.

5.12.59. Ardmore – 4.4ha of fairly flat, medium quality land adjacent to the proposed Ardmore Road / Markethill Road link road.

5.12.60. Markethill Road / Ardmore Road – 5.0ha of quite prominent poor quality land to be accessed by way of the existing development road.

Development Land - Existing Industry

5.12.61. There is areas of existing industry within the study area located at Hamiltonsbawn and Edenaveys Road. This is known as the Hamiltonsbawn Road Industrial Estate and Edenaveys Industrial Estate.

Development Land - Planning Applications

5.12.62. Table 5-45 details approved planning applications within the study area, lodged from the 1st of January 2010. The majority of these are focused around the larger settlements and are predominantly for housing development. In addition to approved planning applications for housing, other approved planning applications in the study area include extension to food processing facilities, biomass silos, dipole antenna installation and poultry sheds with feed bins.

5.12.63. The location of granted planning applications within the study area are shown on Drawing No 1064968-B-D-3036 and 1064968-B-D-3037(see *Appendix A*).

Table 5-45 - Planning Applications from the 1st of January 2010 within the Study Area

Planning Ref.	Description	Address	WSP Ref.
O/2013/0012/F	Proposed two storey extension to side and rear of dwelling, single storey sunroom and proposed detached garage.	19 Portadown Road Armagh	1
O/2013/0230/F	Renewal of planning permission to provide new dwelling and garage.	Adjacent to 25 Portadown Rd Armagh	2
LA08/2016/1128/F	Extension to dwelling and increase in curtilage to include additional garden space.	7 Linseys Heights Killuney Armagh BT61 9HB	3
LA08/2015/0738/F	Flat roofed ground floor conservatory extension onto kitchen and dining areas at rear of site.	30 Killuney Park Road Armagh BT61 9HG	4
O/2013/0153/F	Demolition of existing dwelling and erection of two-storey dwelling, outbuildings and all associated works.	No. 54 Portadown Road Armagh	5
O/2013/0215/F	Retrospective application for retention of prefabricated building for use as Sunday School and retention of Car Park overflow to facilitate existing church (amended siting and plans).	1 Drummanmore Rd Killoney Armagh BT618RN	6

Planning Ref.	Description	Address	WSP Ref.
O/2010/0201/F	Retention of Vechicular Access (from Killuney Road), retention of canopy with roller shutter and domestic garage.	57 Portadown Road, Armagh	7
O/2011/0246/F	Replacement nursery classroom - (Permanent Building)	Saints and Scholars Integrated Primary and Nursery School Killuney Park Armagh BT61 9HG	8
O/2013/0291/F	Proposed Waste recycling, storage and transfer facility, with offices ancillary works and associated infrastructure.	Lands adjacent to 41 Hamiltonsbawn Road Armagh BT60	9
LA08/2016/0475/F	Proposed shell building as light industrial storage and distribution facility and associated site works	Site adjacent to Linwoods at units 1-7 Hamiltonsbawn Road Business Park Hamiltonsbawn Road Armagh	10
O/2010/0286/F	Proposal is to convert part of the factory premises into a vocational training area for heavy and light vehicles and site joinery training.	56 Hamiltonsbawn Industrial Estate, Armagh	11
O/2013/0142/F	Proposed additional poultry shed with feed bin	70 Hamiltonsbawn Road Armagh	12
O/2010/0833/F	Proposed new 11kw wind turbine with a hub height of 18.3m and a blade tip height of 24.8m to serve grid	208m North from 70 Hamiltonsbawn Road Armagh BT60 1HW	13
O/2014/0130/F	Erection of proposed light industrial unit for food processing, warehouse storage and distrubtion and associated site works.	Adjacent to Linwoods at Units 1-5 Hamiltonsbawn Road Business Park Hamiltonsbawn Road Armagh	14
O/2012/0506/F	2 No. workspace units	Lands North and adjacent of 58 Hamiltonsbawn Road Hamiltonsbawn Road Industrial Estate Armagh	15

Planning Ref.	Description	Address	WSP Ref.
O/2010/0241/F	Continuance of use as office with removal of condition 2 of previous approval O/2007/0404/F	Unit 6 Armagh Business Park Hamiltonsbawn Road Industrial Estate Armagh	16
O/2010/0321/F	Extension to existing food processing facility	58D Hamiltonsbawn Road, Industrial Estate, Armagh	17
O/2014/0376/F	Housing development of 46 dwellings (mix of detached, semi-detached and town houses)	East and adjacent to (driver and vehicle testing centre 47 Hamiltonsbawn Road Co. Armagh BT60 1HW	18
O/2010/0861/F	Housing development of 46 dwellings (mix of detached, semi-detached and town houses)	East and adjacent to driver and vehicle testing centre 47 Hamiltonsbawn Road Armagh BT60 1HW	19
O/2010/0340/F	Proposed Bio-mass Silo and Guard railing	DVTA Centre, 47 Hamiltonsbawn Road, Armagh, BT60 1HW	20
LA08/2016/0988/F	Proposed extension to provide 4 no additional bedrooms, extension of dayroom, dining room and new day room with associated ancillary space and parking	Hamilton Court Care Home 45 Hamiltonsbawn Road Armagh BT60 1HW	21
O/2011/0275/F	Single storey rear extension to dwelling	10 Bannvale Villas Armagh	22
O/2014/0190/F	Single storey side extension to dwelling - additional wet room, increased kitchen area	44 Jubilee Park Armagh Co Armagh	23
LA08/2015/1055/F	The proposal involves installing 2 no. dipole antennas at the top of the existing 49.8m high lattice tower and a 0.9m diameter dish at 30m. The proposal also involves installing a cabin in place of a recently removed cabin at ground level. 2no. GPS antennas are also proposed and will be wall mounted on the proposed equipment cabin.	Existing telecommunications site approximately 120m south of 26 Ballynahonemore Road Armagh BT60 2EH	24

Planning Ref.	Description	Address	WSP Ref.
LA08/2015/0387/F	Development of no 1 commercial 8000 free range laying hen poultry house with egg and packaging store. Including new access layout and gate to existing field access, new septic tank and soakaway.	110 metres north east of 44 Ballynahonemore Road Armagh	25
O/2010/0168/F	Addition of new toilet block & referee changing room, new perimeter fencing & turnstiles, new perimeter gates & pitch access control.	Armagh City Football Club Holm Park Ardmore Newry Road Armagh	26
O/2013/0138/F	Proposed social activity building for existing supported tenancy units	The Heathers 39 Ballynahonemore Road Ardmore Armagh	27
O/2011/0366/F	Extension and alterations to dwelling	18 Markethill Road Armagh	28
O/2011/0214/O	Proposed residential development.	NIW Depot 15 Ardmore Road Armagh BT60 1AH	29
LA08/2016/0340/F	Erection of 25 no dwellings to include 22 no two storey general needs dwellings and 3 no complex needs bungalows with associated car parking, landscape and shared surface roadway	Site to rear of 24 and 26 Ardmore Hill Adjacent to 17 Ardmore Hill to rear of 1 3 & 5 Ardmore Hill Court South of Rivers Agency Depot 15 Ardmore Road Armagh BT60 1AH	30
O/2011/0271/F	Extension to rear of existing Mushroom Pack-house at 1a Edenaveys Industrial Estate, Newry Road, Armagh, BT60 1NF	Edenaveys Industrial Estate Newry Road Armagh BT60 1NF	31
O/2011/0293/F	Internal and external alterations to existing building and site to provide office accommodation for DARD Direct, plus new internal first floor plant room.	The A-Tek Building Edenaveys Industrial Estate Markethill Road Armagh BT60 1NF	32
O/2011/0322/F	New office building, car parking and associated site works	50 metres north west of 40 Markethill Road Armagh Co Armagh	33
O/2014/0536/F	Erection of dwelling	20 Metres south of 4 Edenaveys Road Armagh BT60 1NU	34

Planning Ref.	Description	Address	WSP Ref.
O/2012/0419/RM	Erection of dwelling and garage	Adjoining and east of 46 Markethill Road Armagh BT60 1NX	35
O/2011/0063/F	Installation of a 11kw wind turbine on a 18.3mt high lattice tower type mast	80mts north east of no15 Edenaveys Road Armagh	36
O/2012/0308/F	Demolition of existing store and construction of single storey kitchen extension.	4 Edenaveys Gardens Armagh	37

Other Land Use

5.12.64. Armagh Business Park is located to the centre of the study area. Directly to the south of the Armagh Business Park is the Driver and Vehicle Agency Northern Ireland (DVANI) premises.

5.12.65. On Ballynahonemore Road Department for Regional Development (DRD) Roads Service occupy a site with their Armagh Section offices.

Potential Impacts

NMUs and Users of Local Roads

5.12.66. The options will impact on existing connecting footpath and NCN 91 within the study area, which will be subjected to diversion. Footpaths leading to A3 Portadown Road and south of the study area via Hamiltonsbawn Road, Edenaveys Road, Ballynahonemore Road, Bannvale Villas and Ardmore Road will be disrupted.

5.12.67. The new roundabouts proposed for the options are within an area where the level of NMU use is thought to be relatively high, due to the density of residential properties. It is assumed that the options will result in a **slight new** severance for NMU routes. This is due to increase traffic flowing through:

- 2007 Option – residential areas along A3 Portadown Road / Lindsey Heights / A51 Hamiltonsbawn Road / Bannvale Villas / Ardmore Road and A28 Markethill Road
- Option 12 – residential areas along A3 Portadown Road / Killuney Road / Ballynahonemore Road and Farm Houses east of the study area
- Option 16 - residential areas along A3 Portadown Road / Lindsey Heights / A51 Hamiltonsbawn Road / Bannvale Villas / Ballynahonemore Road and A28 Markethill Road

5.12.68. Construction activities associated with the options would temporarily lead to a decrease in amenity value and this will result in temporary adverse impacts on amenity value within the study area. It is anticipated that the footpath within close proximity to the options alignment will be stopped up to where the proposed road intersects. This would increase the length of journey that NMUs would have to undertake to walk its entire length, hence, this is considered a temporary negative impact.

5.12.69. During construction, the options have the potential to result in **temporary adverse** community severance without suitable mitigation.

5.12.70. All options will link the existing A28 / A51 / A3, carrying traffic in / from conurbations surrounding Armagh City. Elements of the new and connecting road alignment are inclusive of features which link to existing cyclepath and footway. Post construction, the options will result in a slight relief from existing severance and increase in amenity values, as there will be a direct and improved route connecting from south to north of the study area.

Vehicular Travellers - Views from the Road

2007 Option

5.12.71. The 2007 Option follows the alignment of the existing Ardmore Road, through an established residential area. The existing cutting in which the road is set, provides limited views for the vehicle traveller.

5.12.72. From the existing setting surrounding Ardmore Road, the 2007 Option proceeds north along Ardmore Road, (towards the crossing point of Ballynahonemore Road / Bannvale Villas) providing an improved, but restricted view.

5.12.73. The 2007 Option traverses agricultural land providing an improved but still restricted view (restricted by the rising topography to the east and the necessity in part for the requirement of a cutting for the 2007 Option).

5.12.74. Upon reaching the Hamiltonsbawn Road Industrial Estate, the 2007 Option traverse lands between and alongside the industrial estate. The perimeter fencing of these sites and the related structures such as the industrial units / warehouses provide an intermittent view to vehicle travellers.

5.12.75. Further north of the industrial landscape, the 2007 Option meets the existing A3 (Portadown Road), amidst the residential landscape of Linsey's Hill. The existing built environment in this vicinity provides the driver with a restricted view.

5.12.76. The provision of open views, occurring where the 2007 Option traverses agricultural land east of Bannvale Villas, is perceived as a positive impact upon vehicle travellers.

5.12.77. The overall impact of the 2007 Option on views from roads are assessed as **minor positive** impact.

Option 12

5.12.78. Option 12 follows the alignment of the existing Edenaveys Road from the junction with A28 Markethill Road. The existing setting traverses agricultural lands between and alongside the industrial estate. The perimeter fencing of these sites and the related structures such as the industrial units / warehouses provide an intermittent view to vehicle travellers.

5.12.79. From this point, Option 12 proceeds north and traverses agricultural land (towards the crossing point of Ballynahonemore Road and Hamiltonsbawn Road) providing relatively open views (restricted only by the rising topography).

5.12.80. Option 12 provides an intermittent / open view further north of the industrial landscape and agricultural land. Option 12 meets the existing A3 Portadown Road, amidst the residential landscape of Killuney Park Road and Killuney Manor. The existing built environment in this vicinity provides the driver with a restricted view.

5.12.81. The overall impact of Option 12 on views from roads are assessed as **positive** impact.

Option 16

5.12.82. Option 16 follows the alignment of the existing Edenaveys Road from the junction with A28 Markethill Road. The existing setting traverses agricultural lands between and alongside the industrial estate. The perimeter fencing of these sites and the related structures such as the industrial units / warehouses provide an intermittent view to vehicle travellers.

5.12.83. From this point, Option 16 proceeds north and traverses agricultural land (towards the crossing point of Ballynahonemore Road and Bannvale Villas) providing relatively open views (restricted only by the rising topography).

5.12.84. Upon reaching the Hamiltonsbawn Road Industrial Estate, Option 16 traverse lands between and alongside the industrial estate. The perimeter fencing of these sites and the related structures such as the industrial units / warehouses provide an intermittent view to vehicle travellers.

5.12.85. Further north of the industrial landscape, Option 16 meets the existing A3 Portadown Road, amidst the residential landscape of Linsey's Hill. The existing built environment in this vicinity provides the driver with a restricted view.

5.12.86. The overall impact of the Option 16 on views from roads are assessed as **minor positive** impact.

Vehicle Travellers - Driver Stress

5.12.87. During construction motorised users will experience increased stress due to traffic management measures at Portadown Road, Hamiltonsbawn Road, Bannvale Villas, Ardmore Road and Edenaveys Road.

5.12.88. Post construction, motorised users are anticipated to receive beneficial impacts from the options, as speeds will increase resulting in less frustrating driving conditions.

5.12.89. The options will involve installing improved signage and street furniture to present standards, resulting in improved conditions for driving and improved safety.

Land Use

5.12.90. The information within Table 5-46 is based on information gathered and presented in Survey Access Plan Drawings within *Appendix A*, (Drawing Nos. - 1064968-2800-OD22-1002B and 1064968-2800-OD22-1001B).

5.12.91. Table 6-46 details the approximate total land parcel for the options and shows that the highest land parcel area is attributed to Options 12, mainly within agricultural land. Option 16 is a mix between rural and urban areas. The 2007 Option is the lowest of the options with regard to land parcel.

Table 5-46 – Summary of approximate Land Parcel Area (Square Meter) Under Road

Land Parcel	Land Use	2007 Option	Option 12	Option 16
01/005	Urban	3940.10	-	3940.10
01/010		2256.20	-	2256.20

01/035	Industrial / Commercial / Agricultural	7397.70	-	7397.70
01/044		7135.70	40458.90	7135.70
01/050		741.20	-	741.20
01/060	Agricultural	6910.60	20280.60	29954.80
01/075	Urban / Agricultural	3308	-	-
01/402	Agricultural	-	1815.90	-
01/403		-	29.10	29.10
01/404		-	12905.60	13119.20
01/600		-	10639.50	-
01/601		-	0.90	0.90
01/602		-	348.50	348.50
01/603		-	164.20	560.20
01/605		-	1830.10	-
Grand Total		**31689.50**	**88473.30**	**65483.60**

Private Property, Commercial / Industrial, Agricultural, Community and Development Land

2007 Option

5.12.92. The 2007 Option currently does not require demolition of dwellings however the 2007 Option may impact upon residential land both to the north and south of the proposed alignment, at Linsey's Hill / A3 Portadown Road and Ardmore Road respectively. The 2007 Option also runs close to residential properties in the vicinity of Bannvale Villas. This impact would be on areas currently used for gardens and driveways. The impact is therefore described as **slight adverse**.

5.12.93. The 2007 Option will impact upon a number of commercial land use to the centre of the study area, including Hamiltonsbawn Industrial Estate and Shilliday Refrigeration and Air Conditioning. The 2007 Option will result in **moderate adverse** impacts on the existing commercial operation, mainly around the roundabout of the 2007 Option, as land take is likely to compromise but does not preclude existing or intended use. No mitigation has been proposed.

5.12.94. The 2007 Option will impact on agricultural land, in particular to the south of the Hamiltonsbawn Road and north of Ardmore Road. This may result in the loss of agricultural land and / or severance of land parcels which may affect farming operations. The impact is therefore described as **minor adverse** on agricultural land.

5.12.95. The 2007 Option utilises elements of the existing road network, notably at Ardmore Road and Bannvale Villas, subsequently reducing the impact upon community land use. The 2007 Option alignment is described as having a **negligible** impact on community land.

5.12.96. The 2007 Option could potentially impact on two planning permissions (figure reference No. 17 and 18). The 2007 Option is described as **slight adverse** on development land.

5.12.97. The 2007 Option is designated in the Armagh Area Plan 2004 and Regional Strategic Transport Network Transport (RSTNT 2015) for road development.

5.12.98. The overall impact of 2007 Option on land use are assessed as **slight adverse** impact.

Option 12

5.12.99. Option 12 currently does not require demolition of dwellings. Option 12 would impact upon residential properties in proximity to the Killuney Road roundabout. This impact would be on areas currently used for gardens and driveways. The impact is therefore described as **slight adverse**.

5.12.100. Option 12 would impact upon a number of land uses to the centre of the study area, including Hamiltonsbawn Industrial Estate. These impacts would potentially generate issues with land lake. This option is likely to result in **moderate adverse** impacts on the existing commercial operation, mainly around the proposed roundabout with A51 Hamiltonsbawn Road. Land take is likely to compromise but does not preclude existing use or intended use. No mitigation has been proposed.

5.12.101. Option 12 has potential to generate a significant impact upon the agricultural land use which dominates the east of the study area. Option 12 traverses approximately 2.5km of farmland. In particular, the significant cuttings required would result in a considerable amount of agricultural land take. In addition to the loss of land, the proposal may result in severance of land parcels which may affect farming operations. The impact is therefore described as **moderate adverse** on agricultural land.

5.12.102. The majority of Option 12 is located outside the development limit of Armagh Plan, and as such runs through the Armagh Greenbelt. Option 12 if selected, may result in the urban fringe of Armagh City being brought out beyond the boundary of the Green Belt to a significant extent.

5.12.103. Option 12 utilises elements of the existing road network, most notably along Edenaveys Road. Option 12 will impact on the proposed Open Space Wedge at Edenaveys. The impact is therefore described as **moderate adverse** on community land.

5.12.104. Option 12 could potentially impacts on two planning permissions (site Ref. No. 12 and 33 within Drawing Nos. 1064968-B-D-3036 and 1064968-B-D-3037). Option 12 is described as **moderate adverse** impact on development land.

5.12.105. The overall impact of Option 12 on land use are assessed as **moderate adverse** impact.

Option 16

5.12.106. Option 16 does not currently require demolition of dwellings. Option 16 may impact upon residential properties to both the north of the proposed corridor, at Linsey's Hill / A3 Portadown Road. Option 16 also runs close to residential properties in the vicinity of

Bannvale Villas. This impact would be in terms of land take / areas currently used for gardens and driveways. The impact is therefore described as **slight adverse**.

5.12.107. Option 16 will impact upon a number of commercial land uses to the centre of the and south of study area, including Hamiltonsbawn Industrial Estate, Shilliday Refrigeration and Air Conditioning, Tretzo Bathroom UK, City Auto Repairs Garage on Ballynahornemore Road, Woodford Hall, J Davidson and Sons Garden Centre. This option is likely to result in **moderate adverse** impacts on the existing commercial operation, mainly around the proposed roundabout, as land take is likely to compromise but does not preclude existing use or intended use. No mitigation has been proposed.

5.12.108. Option 16 will impact on agricultural land, in particular to the south of Hamiltonsbawn Road. Option 16 alignment traverses agricultural land, north of Ballynahonemore Road which will result in the loss of agricultural land and / or severance of land parcels which may affect farming operations. The impact is therefore described as **moderate adverse** on agricultural land.

5.12.109. Option 16 utilises elements of the existing road network, most notably at Bannvale Villas and Edenaveys Road. Option 16 alignment will impact on the proposed Open Space Wedge at Edenaveys. The impact is therefore described as **moderate adverse** on community land.

5.12.110. Option 16 could potentially impacts on four planning permissions (site Ref. No. 17, 18, 25 and 33 within Drawing Nos. 1064968-B-D-3036 and 1064968-B-D-3037). Option 16 is described as **moderate adverse** impact on development land.

5.12.111. The overall impact of Option 16 on land use are assessed as **moderate adverse** impact.

Recommended Mitigation

5.12.112. The options corridors (at least in part) will involve new construction and impact upon other land uses is unavoidable. Measures should be taken to minimise any impacts in terms of land take and / or demolition of property.

5.12.113. While alterations to the options is an important tool in reducing significant impacts to land uses, a range of mitigation measures should be considered. These are likely to include:

- crossing facilities for NMUs in order to mitigate negative impacts associated with increased severance to the existing footways
- compensation for the loss of existing features such as trees, hedgerows and vegetation in areas of locally valued or important landscape
- sensible integration of landscape / townscape features and planting scheme that will soften driver views
- sensitive approach to dealing with issues relating to the severance of agricultural land parcels in order to minimise the impact on the agricultural practices of land owners
- preparation of comprehensive strategies, involving consultation with landowners and farmers to minimise impacts, reinstate facilities, water supply and access to fields
- measures should be introduced to minimise the impact on development plan zonings and granted planning permission i.e. avoid zoned lands where conflicts

occur; consult with the planning service for latest planning applications; consult with planning service regarding the new Armagh Area Plan

5.12.114. In addition, mitigation measures should be introduced to reduce the impact on development plan policies such as protection and management of the environment.

Summary of Likely Significant Effects

5.12.115. Table 5-47 summarises the likelihood of the options to generate significant effects on each of the identified aspects of peoples and community chapter.

Table 5-47- Summary of Likelihood of Significant Effects on People and Community in Accordance with IAN 125/15

Assessment Area	2007 Option	Option 12	Option 16
NMUs and Users of Local Road	Uncertain	Uncertain	Uncertain
Journey Length and Amenity Value	Uncertain	Uncertain	Uncertain
Community Severance	Low Likelihood	Low Likelihood	Low Likelihood
New Severance	Low Likelihood	Low Likelihood	Low Likelihood
Relief of Existing Severance	No Likelihood	No Likelihood	No Likelihood
Vehicle Travellers	No Likelihood	No Likelihood	No Likelihood
Land Use			
Residential / Private Property	Low Likelihood	Low Likelihood	Low Likelihood
Commercial and Industrial	Low Likelihood	Uncertain	Low Likelihood
Agricultural, Community and Development Land	Low Likelihood	Uncertain	Uncertain

Limitations of Assessment

5.12.116. The above assessment is based on a desk study. There have been no consultations undertaken with the asset owners to understand value or importance. In addition, no specific mitigation measures were proposed at this stage for NMUs. Therefore, the impact assessment is based on broad assumptions made to provide an indication of the existing or intended land use.

5.12.117. Information regarding footfall on public footpaths and data regarding present use was not readily available and therefore assumptions have been made.

Recommendations for Further Work

5.12.118. During Stage 3 consultations should be undertaken with affected asset owners and receptors identified in order for a detailed assessment of potential effects to be undertaken. The consultations should adhere to the following process:

- identification of community, agricultural and commercial holdings based on landholding information from ABCB Council
- an initial screening exercise to identify the likely level of impact on the agricultural and commercial businesses to recognise any requirements for additional information or site visits
- consultation with land owners / tenants or / and land agents who were identified as likely to be moderately or substantially affected by the selected option or for whom there was insufficient information to complete the assessment
- evaluation of selected option to establish the potential impact on landowners' agricultural businesses and identify appropriate design and mitigation measures
- assessment of the significance of residual impacts on landowners' / tenants agricultural and commercial businesses
- assessment of the significance of residual impacts on community land and facilities.

5.12.119. In addition, during Stage 3 further searches to identify planning applications that have been submitted and reviewed after November 2016 should be undertaken.

5.12.120. The options have the potential to include elements which could reduce community severance and provide better walking / cycling facilities by providing enhancements which would benefit the local NMU network. These opportunities will be further considered during Stage 3.

5.12.121. The assessment has not included identification of land known to have turbary rights for peat extraction. During Stage 3, information relating to turbary rights will be obtained from Land Registry records from Land and Property Services and landowner meetings.

5.13. Road Drainage and the Water Environment

5.13.1. The screening and scoping exercises indicated that in the absence of a drainage and flood risk strategy, there is uncertainty in the likely significant and adverse effects on the water environment. The initial assessments indicated that there is a requirement for a detailed assessment given the increase in impermeable area associated with the options and the potential for increased run-off into receiving water courses.

5.13.2. This chapter assesses the potential impacts on the water environment and takes into account surface hydrology, flood risk, hydrogeology and water quality. A desk study of the hydrological and hydrogeological features associated with the options has been undertaken and a site walk-over was carried out to supplement the desk study.

Surface Waters

5.13.3. The potential significant impacts considered are:

- Pollution during construction due to increased generation and release of sediments and suspended solids, and increased risk of accidental spillage of pollutants such as oil, fuel and concrete associated with construction activities and site storage requirements
- Pollution during road operation due to contaminants within routine road runoff. A broad range of potential pollutants, such as hydrocarbons i.e. fuel and lubricants, fuel additives, metal from corrosion of vehicles, de-icer and gritting material, can accumulate on road surfaces. These can subsequently be washed off the road surface during rainfall events, polluting the receiving surface water bodies
- Pollution during road operation due to accidental spillage. On all roads there is a risk that accidents or vehicle fires may lead to an acute pollution incident. Where commercial vehicles are involved, potential pollutants that may be spilled could range from hazardous chemicals to milk, alcoholic beverages, organic sludges and detergents. Spilled materials may drain from the road surface, polluting the receiving surface water bodies
- Alterations to the hydromorphology (fluvial geomorphological) regime, such as increased erosion, deposition and channel migration processes. These changes can occur as a result of channel modification associated with increased road surface drainage, new crossing structures, culverting, watercourse diversions and outfalls. A reduction in hydromorphological diversity can subsequently impact on water quality and biodiversity
- Increase in flood risk caused by the development, both within the vicinity of the options and also elsewhere in the catchment. This can involve a number of inter-related factors including
    - Increases in upstream water level caused by any restriction in flow (afflux) and conversely increases in downstream water levels where existing restrictions are removed
    - Loss of floodplain storage due to road infrastructure occupying areas which were previously available for flood storage or flows
    - Impediment of water flow caused by road infrastructure crossing existing drainage channels, causing potential blockage and altering local catchment area boundaries
    - Loss of standing waters where the options would be constructed through or close to existing ponds

- Loss or change to water supplies due to degradation of water quality, changes in drainage patterns or disruption to supply infrastructure due to the route options

Groundwater

5.13.4. The potential significant impacts considered are

- Pollution of groundwater and aquifers as a result of construction activities such as excavation of deep cuttings and seepage of spillages through ground profiles
- Groundwater pollution during road operation due to contaminants within routine road runoff, where groundwater infiltration is proposed as part of the drainage strategy for the options
- Groundwater pollution during road operation due to accidental spillage
- Direct loss or changes to groundwater aquifers and groundwater supported public and private water supplies, either below the footprint of the options, or as a result of changes to groundwater flows and levels associated with the dewatering of deep cuttings and foundation excavations
- Indirect loss or change to surface water receptors, as a result of dewatering of groundwater aquifers
- Loss or changes to Groundwater Dependent Terrestrial Ecosystems (GWDTEs), including peatland habitats, either below the footprint of the options, as a result of severance of habitat or as a result of changes to groundwater flows and levels associated with dewatering activities.

Study Area

5.13.5. The study area defined for the road drainage and the water environment assessment refers to a 1km buffer surrounding the extent of all the options, on the eastern fringe of the city of Armagh. Surface water receptors have also been considered within 5km downstream of the options.

Methodology

5.13.6. The assessment has been carried out in accordance with the guidance contained in the DMRB, Volume 11, Section 3, Part 10 Road Drainage and the Water Environment (HD 45/09). The assessment does provide details regarding the certainty or uncertainty relating to likely significant effects in accordance with the criteria provided in the IAN 125/15.

5.13.7. Other DMRB guidance documents used to inform this assessment:

- DMRB Volume 11, Section 4, Part 1 HD 44/09 – Assessment of Implications (of Highways and/or Road Projects) on European Sites (Including Appropriate Assessment)
- DMRB Part 7 HA 107/04 Design of Outfall and Culvert Details
- DMRB Volume 4, Section 2, Part 3 HD 33/16 Design of Highway Drainage Systems.

5.13.8. Baseline studies focused on the following activities for the study area:

- Identification of international / nationally designated conservation sites with citations related to the water environment

- Identification of surface water bodies; rivers, lakes, streams, ditches, ponds
- Identification of flood risk
- Collation of surface water body characteristics and Water Framework Directive (WFD) classification
- Identification of groundwater bodies and groundwater vulnerability
- Identification of water abstractions for local public and private water supplies
- Identification of existing water-related infrastructure i.e. culverts, bridges, outfalls and watercourse diversions.

5.13.9. Baseline conditions have been determined through desk studies and site survey. The desk studies included review of the following information:

- Armagh East Link Route Assessment Report Stage 1
- Northern Ireland Environment Agency (NIEA) River Basin Plan Interactive Map
- NIEA private water abstraction data
- Ordnance Survey of Northern Ireland (OSNI) raster mapping 1:25,000 scale
- Geological Survey Northern Ireland (GNSI) 1:10,000 scale Bedrock and Superficial Geology mapping
- Geological Survey Northern Ireland (GNSI) Hydrogeological Map of Northern Ireland
- British Geological Survey (BGS) Groundwater Vulnerability mapping data (2009)
- Rivers Agency Flood Hazard and Flood Risk Maps for NI
- Digital Terrain Model (provided by client).

5.13.10. A hydrological / hydromorphological walkover survey was undertaken on the 6 and 7 July 2016. This included review of existing water-related infrastructure, characterising local water features and identifying potential scheme interactions, in order to establish the sensitivity of receptors and to identify any potential water quality monitoring locations.

5.13.11. To date, no water environment specific consultation has been carried out with stakeholders.

Assessment of Surface Water Impacts

5.13.12. The approach has focused upon the characteristics and subsequent scheme impacts upon surface water hydrological catchments with reference to water bodies characterised by NIEA under the WFD. This hydrological catchment-based approach enables due consideration to be given to both individual locations and the wider cumulative impacts within larger surface water body areas.

Construction Pollution

5.13.13. Evaluation of the potential for pollution of surface waters as a result of spillage and of the release of sediments into watercourses or water bodies has involved a review of areas where construction would be required within or in close proximity (i.e. within 50m) to watercourses and water bodies. The approximate length of road which lies within 50m of surface water features, the number of proposed permanent road drainage discharge structures and the number of watercourse crossings has been quantified for the options.

5.13.14. The sensitivity or importance of the surface waters has been evaluated qualitatively, as has the magnitude of impact of the options on each (as set out further below).

Pollution from Routine Runoff

5.13.15. DMRB HD 45/09 specifies procedures for the assessment of pollution impacts from routine runoff on surface waters, known as 'Method A'.

5.13.16. The Method A assessment comprises two separate elements:

- The Highways Agency Water Risk Assessment Tool (HAWRAT) Assessment is a Microsoft Excel application designed to assess the short-term risks related to the intermittent nature of road runoff. It assesses the acute and chronic pollution impacts on aquatic ecology associated with soluble and sediment bound pollutants, respectively
- Environmental Quality Standards (EQS) Assessment are the maximum permissible annual average concentrations of potentially hazardous chemicals, as defined under the WFD. The long-term risks over the period of one year are assessed through comparison of the annual average concentration of pollutants discharged with the published EQS for those pollutants.

5.13.17. To carry out these assessments a variety of baseline and drainage design information is required, including; traffic volumes, areas of impermeable and permeable road surfaces to be drained, proposed treatment train, receiving watercourse dimensions and flow data, water hardness, presence of sensitive sites (considered as international / national designated conservation sites) and in-stream structures or features which may influence the flow.

5.13.18. At this stage, a detailed road drainage design is not available and therefore a preliminary assessment has been carried out based on what is considered to be the likely proposed sustainable drainage systems (SuDS) treatment train.

5.13.19. SuDS have been considered as embedded design, rather than as specific mitigation measures, and have been assessed accordingly. Reference values for effectiveness of the various systems at removing various pollutants are based on figures published in DMRB HD33/16.

5.13.20. The HAWRAT and EQS assessments have been carried out for each road drainage outfall within each option. For each of the options, the number of outfalls passing/failing the HAWRAT and EQS assessments has been presented.

Pollution from Accidental Spillages

5.13.21. The DMRB document HD 45/09 specifies procedures for the assessment of pollution impacts from accidental spillage, known as Method D. A summary of the methodology is provided below, with full details provided in HD 45/09.

5.13.22. The assessment takes the form of a risk assessment, where the risk is expressed as the annual probability of a serious pollution incident occurring. This risk is the product of two probabilities:

- The probability that an accident will occur, resulting in a serious spillage of a polluting substance on the carriageway
- The probability that, if such a spillage did occur, the polluting substance would reach the receiving water body and cause a serious pollution incident.

5.13.23. The probability of a serious spillage occurring is dependent on a variety of factors; traffic volumes, percentage of heavy goods vehicles in the traffic volumes, whether the road is motorway, rural or urban trunk road, the road type categories within the road drainage catchment under assessment i.e. 'no junction', 'slip road', 'cross road' or 'roundabout' and the length of each road type within the catchment.

5.13.24. The probability of a serious spillage subsequently causing a serious pollution incident is dependent on the receiving surface water body and the response time of the emergency services, i.e. less than 20 minutes, less than one hour, or greater than one hour.

5.13.25. Typically an annual probability of 1% (i.e. a 1 in 100 chance of a serious pollution incident occurring in any one year) is considered by DMRB as an acceptable risk. However, where a road drainage outfall discharges within 1km of a sensitive receptor, (such as a nationally designated conservation site), a higher level of protection is required, such that the risk has no greater annual probability than 0.5% (i.e. a 1 in 200 chance of occurring in any one year).

5.13.26. Evaluation of the predicted effects has been undertaken in accordance with the guidance provided in Annex IV of HD 45/09 and outlined in the Impact Assessment Criteria section below.

Alterations to Hydromorphological Regime

5.13.27. The hydromorphology assessment has involved a desk study and walkover survey to determine the specific character of the geomorphological forms and processes in each of these watercourses.

5.13.28. The above information, in conjunction with data on the WFD status of the relevant water bodies, has been used in the evaluation of the sensitivity of the watercourses.

5.13.29. For each option, the indicative location of proposed bridges, culverts, watercourse diversions and outfalls has been reviewed. The magnitude of potential impacts on channel form and gradient, flow volumes and rates, and erosion and sedimentation processes were evaluated qualitatively.

5.13.30. As part of the options, it has been anticipated that the design of structures and any diverted channels will incorporate standard good practice measures, considered as embedded design for this assessment.

5.13.31. It should be noted that the DMRB does not outline a specific methodology or guidance on the evaluation of hydromorphological impacts. Therefore, hydromorphological sensitivity and impact magnitude criteria have been developed based on guidance provided in the DEFRA/EA R&D Report FD1914 Guide Book of Fluvial Geomorphology.

Increased Flood Risk

5.13.32. A Flood Risk Assessment (FRA) has not been carried out for Stage 2. A review has been undertaken of flood mapping of Annual Exceedance Probabilities (AEP) for both river and surface water flood extents, sourced via the Rivers Agency 'Flood Maps NI' website and digital data provided for the study area. River flood extents are presented as 0.1%, 1%, and 10% AEP and surface water extents are presented as 0.1%, 0.5%, and 3.3% AEP.

5.13.33. The maps have been reviewed to establish potential scheme interactions with the options and 1% AEP river flood outline digital data has been used to compare the options and assign appropriate impact magnitude based on their proximity from flood extents.

5.13.34. The selected option is scheduled to be assessed within a hydraulic model at Stage 3.

Loss of Standing Water

5.13.35. Where standing water bodies will be partially or totally lost under the footprint the area of loss has been calculated. Where there are losses to larger lakes, particularly those that are designated, the actual area and the percentage of area lost shall be calculated for each individually. For smaller ponds, the number of ponds lost and the aggregate area loss shall be calculated, for all ponds within 250m of the proposed scheme.

5.13.36. Activities occurring close to standing water bodies can also cause indirect effects, interrupting flows feeding the local water body and potentially resulting in total or partial drying up of the water body. The distance to each standing water body from the nearest point of the options has been measured using OSNI 1:50,000 scale mapping. Using this data the magnitude of impact on water bodies within 250m of the proposed scheme has been evaluated qualitatively.

Assessment of Groundwater Impacts

Construction Pollution

5.13.37. The potential for pollution of groundwaters / aquifers is greatest where cuttings are proposed which would be close to, or potentially penetrate the water table, and locations where there are permeable drift deposits. In the absence of site specific groundwater level data, the length of cutting has been quantified for each option.

5.13.38. The sensitivity of the groundwater has been evaluated based on the groundwater vulnerability classification and the magnitude of impact has been evaluated qualitatively.

Loss or change to groundwater aquifers and supported water supplies

5.13.39. Groundwater aquifers were identified and their sensitivity evaluated through review of BGS aquifer productivity and groundwater vulnerability mapping, and review of the WFD groundwater body status.

5.13.40. Private groundwater abstraction data was provided by NIEA. Public water supplies were not authorised for release into the public domain. These will be viewed in person at Stage 3. Private water supply owner/occupier consultations are also planned for Stage 3.

5.13.41. For each of the options, the locations of the cuttings have been identified and the aquifers and water supplies within the Study Area to each quantified. In the absence of site specific groundwater data at DMRB Stage 2, the magnitude of impact on each aquifer and supply has been estimated based on the proximity to the options and potential cuttings in relation to areas with high groundwater productivity.

Indirect Loss or Change to Surface Water Receptors

5.13.42. Surface water bodies such as streams, lakes and wetlands can receive or recharge groundwater, with movement likely between the two receptors. Any changes to

groundwater as a result of dewatering may indirectly impact surface water bodies and resulting in changes to surface water flow.

5.13.43. For each of the options, the impact on surface water receptors has been assessed qualitatively. Due to the lack of information on the depth and location of cuttings, or where dewatering is likely to take place, it is assumed all receptors could be potentially impacted by cuttings.

5.13.44. As there are a number of attributes contributing to the overall sensitivity of each watercourse, the highest sensitivity has been considered for this impact.

Loss or change to Groundwater Dependent Terrestrial Ecosystems (GWDTEs)

5.13.45. NIEA Practice Guides highlight the importance of wetlands and identification of wetland features which may be impacted. In the absence of the specific guidance available via NIEA relating to identification of potential GWDTEs, the Scottish Environment Protection Agency (SEPA) LUPS Guidance Note 31 sets out the method for identification of GWDTEs, based on National Vegetation Classification (NVC) communities. Where NVC survey data is not available, the guidance recommends using Phase 1 habitat survey data in conjunction with the SNIFFER Wetland Typology guidance to identify potential GWDTEs in the initial stages of assessment.

5.13.46. A Preliminary Ecological Appraisal (*Appendix H*), including Phase 1 habitats survey, has been carried out by the Ecology Team and is summarised in Chapter 5.8 Nature Conservation and Drawing No.1064968-B-D-3025 NVC surveys have not been carried out at this stage and therefore, potential GWDTEs have been identified using the alternative method, as discussed above.

5.13.47. Quantification of groundwater dependency cannot be established at this stage and therefore those habitats which could potentially include groundwater dependent NVC communities have been assessed qualitatively as part of an initial comparison of potential impact of each option.

5.13.48. Sensitivities have been assigned based on the assessment criteria outlined in the following section and magnitude of impacts to any potential GWDTEs has been evaluated qualitatively.

Impact Assessment Criteria

5.13.49. The predicted significance of impacts on surface waters have been based on an evaluation of the feature and the potential impact from the options, as recommended in HD 45/09.

Sensitivity

5.13.50. The sensitivity of the water bodies have been evaluated taking into account their quality, rarity, scale and substitutability. The criteria used in determining the sensitivity of each water body are detailed in, these are in accordance with the guidance and examples provided in HD 45/09.

Table 5-48 - Criteria Used to Estimate the Sensitivity of Receptors

Sensitivity	Criteria
Very High	**Surface Water Quality and Biodiversity** Large or medium water bodies with pristine / near pristine water quality 'High' WFD Overall Status surface water body Sites protected under EU wildlife legislation (Special Area of conservation (SAC), Special Protection Areas (SPA) and Ramsar) Watercourses supporting a wide range of significant species and habitats sensitive to changes in suspended sediment concentrations and turbidity such as salmonids or freshwater pearl mussels Water dependent ecosystems of international/national biodiversity value **Hydromorphology** Dynamic watercourses showing evidence of channel migration and recent morphological changes, channels with regular morphological features such as pools and riffles, active gravel bars and varied river banks, and minimal modification **Hydrology & Flood Risk** Watercourses or floodplains, with direct flood risk to adjacent populated areas and/or presence of critical infrastructure such as schools and hospitals etc, which are highly sensitive to increased flood risk by the possible increase in water levels Watercourses or floodplains that provide critical flood alleviation benefits **Groundwater** 'Good' WFD Overall Status groundwater body Highly productive aquifers Groundwater vulnerability Class 5 Designated GWDTEs and GWDTEs located within designated areas **Water Supplies** Watercourse supporting major/critical public water supplies Public water supply or large private water supply serving >10 properties
High	**Surface Water Quality and Biodiversity** Medium or small water bodies with minor degradation of water quality as a result of anthropogenic factors 'Good' WFD Overall Status surface water body Sites protected under UK wildlife legislation (Areas of Special Scientific Interest (ASSI) and National Nature Reserves (NNR)) Water dependent ecosystems of regional/county biodiversity value Watercourses supporting some species and habitats sensitive to changes in suspended sediment concentrations and turbidity **Hydromorphology** Dynamic watercourses showing limited evidence of channel migration and historic morphological changes, channels with some morphological features such as pools and riffles, with very little modification

Sensitivity	Criteria
	Hydrology & Flood Risk Watercourses or floodplains, with a possibility of direct flood risk to less populated areas without critical infrastructure, which are sensitive to increased flood risk by the possible increase in water levels Watercourses or floodplains that provide significant flood alleviation benefits **Groundwater** 'Good' WFD Overall Status groundwater body Locally important aquifers Groundwater vulnerability classes 4a to 4e Non designated GWDTEs with highly groundwater dependent NVC communities **Water Supplies** Watercourses supporting minor/non-critical public drinking water supplies Private water supply serving 2-10 properties
Medium	**Surface Water Quality and Biodiversity** Small water bodies with degradation of water quality as a result of anthropogenic factors 'Moderate' WFD Overall Status surface water body Water dependent ecosystems of county/district biodiversity value Watercourses supporting limited species and habitats sensitive to changes in suspended sediment concentrations and turbidity **Hydromorphology** Watercourses showing limited evidence of historic channel migration and other morphological changes, channels with limited morphological diversity, signs of modification **Hydrology & Flood Risk** Watercourses or floodplains, with a possibility of direct flood risk to high value agricultural areas, which are moderately sensitive to increased flood risk by the possible increase in water levels Watercourses or floodplains that provide some flood alleviation benefits. **Groundwater** Aquifers with limited or local potential Groundwater vulnerability classes 2 and 3 Non designated GWDTEs with moderately groundwater dependent NVC communities **Water Supplies** Watercourses supporting private drinking water supplies or for agricultural/industrial use Private water supply serving a single property
Low	**Surface Water Quality and Biodiversity** Small, heavily modified water bodies or drains with poor water quality as a result of anthropogenic factors

Sensitivity	Criteria
	'Poor'/'Bad' WFD Overall Status surface water body
	Water dependent ecosystems of local/less than local biodiversity value
	Watercourses which do not support any significant species and habitats sensitive to changes in suspended sediment concentrations and turbidity
	Hydromorphology
	Defined as a heavily modified waterbody
	Watercourses showing no evidence of active fluvial processes, channels with no morphological diversity
	Hydrology & Flood Risk
	Watercourses or floodplains passing through low value agricultural areas, which are less sensitive to increased flood risk by the possible increase in water levels
	Watercourses or floodplains that provide limited flood alleviation benefits
	Groundwater
	'Poor' WFD Overall Status groundwater body
	Regions underlain by impermeable rocks; generally without groundwater except at shallow depth
	Groundwater vulnerability classes 0 and 1
	Water Supplies
	Watercourses not supporting water abstractions.

Magnitude of Impacts

5.13.51. The magnitude of the various impacts is evaluated taking into account the extent of loss and effects on integrity of the relevant water body attributes. The criteria used in determining the magnitude of impact are detailed in Table 5-49, below, and are in accordance with the guidance and examples provided in HD 45/09.

Table 5-49 - Criteria Used to Estimate the Magnitude of an Impact on Receptors

Magnitude	Criteria
Major Adverse	**Surface Water Quality and Biodiversity** High risk of pollution to surface water during construction, significant temporary or long-term change in water quality, resulting in a permanent change in WFD status Failure of both soluble and sediment bound pollutants in HAWRAT and EQS routine runoff compliance failure Risk of pollution from accidental spillage during operation > 2% annually **Hydromorphology** Major channel realignment (>10m length) Loss of features or failure of hydromorphological elements Replacement of natural bed and/or banks with artificial material Extensive change to channel planform **Hydrology & Flood Risk** Loss of >50% of any individual large lake/lough Loss of >50% of aggregated small pond area, or >50% loss of total number of small ponds within Study Area Results in major loss of floodplain, or major effect on watercourse flows, floodplain or flooding vulnerability **Groundwater** High risk of pollution to groundwater during construction, significant temporary or long-term change in water quality, resulting in a permanent change in WFD status or permanent loss of surface water supply High risk (risk score >250) of pollution of groundwater from routine runoff Risk of pollution from accidental spillage during operation >2% annually Major loss of an aquifer in terms of water level or yield, with total loss of or major changes to dependent abstractions/habitats Major change or total loss of a GWDTE, where the value of the site would be severely affected **Water Supplies** Permanent loss of surface water supply
Moderate Adverse	**Surface Water Quality and Biodiversity** Moderate risk of pollution to surface water during construction, moderate temporary change in water quality, resulting in a temporary change of WFD status or preventing attainment of target overall status of 'Good' Failure of both soluble and sediment bound pollutants in HAWRAT routine runoff but compliance with EQS limits Risk of pollution from accidental spillage during operation > 1% annually

Magnitude	Criteria
	Hydromorphology Degradation of features or loss of part of feature Failure of one or more hydromorphological elements Replacement of the natural bed and/or banks with artificial material **Hydrology & Flood Risk** Loss of 25-50% of any individual large lake/lough Loss of 25-50% of aggregated small pond area, or 25-50% loss of total number of small ponds within Study Area Results in loss of part of floodplain, or moderate effect on watercourse flows, floodplain or flooding vulnerability **Groundwater** Moderate risk of pollution to groundwater during construction, moderate temporary change in water quality, resulting in a temporary change of WFD status or preventing attainment of overall status of 'Good', or temporary loss of water supply Medium risk (risk score 150-250) of pollution of groundwater from routine runoff Risk of pollution from accidental spillage during operation > 1% annually Changes to an aquifer in terms of water level or yield, with small changes to nearby dependent abstractions/habitats Partial change or loss of a GWDTE, where the value of the site would be affected **Water Supplies** Temporary loss of water supply
Minor Adverse	**Surface Water Quality and Biodiversity** Minor risk of pollution during construction to surface water, relatively minor temporary changes in water quality such that ecology is temporarily affected. Equivalent to a temporary minor, but measurable, change within WFD status class Failure of either soluble or sediment bound pollutants in HAWRAT routine runoff but compliance with EQS limits Risk of pollution from accidental spillage during operation > 0.5% annually **Hydromorphology** Potential failure of one hydromorphological element Results in minor impact on feature or a minimal shift away from baseline conditions **Hydrology & Flood Risk** Loss of <25% of any individual large lake/lough, or any lake/lough located within 250m of the Proposed Scheme Loss of <25% of aggregated small pond area, or <25% loss of total number of small ponds within Study Area, or any small pond

Magnitude	Criteria
	within 250m of the Proposed Scheme Results in minor measurable change in watercourse flows, floodplain or flooding vulnerability **Groundwater** Minor risk of pollution during construction to groundwater, relatively minor temporary changes in water quality such that ecology is temporarily affected. Equivalent to a temporary minor, but measurable, change within WFD status class or temporarily reduced quality of water supply Low risk (risk score <150) of pollution of groundwater from routine runoff Risk of pollution from accidental spillage during operation > 0.5% annually Small change to an aquifer in terms of water level or yield, with little discernible change to dependent abstractions/habitats Small change to or loss of a GWDTE, where the value of the site would not be affected **Water Supplies** Temporarily reduced quality of water supply
Negligible	**Surface Water Quality and Biodiversity** Negligible risk of pollution to surface water during construction, very slight temporary change in water quality with no discernible effect on watercourse ecology or water supply All elements of HAWRAT and EQS routine runoff assessments passed Risk of pollution from accidental spillage during operation < 0.5% annually **Hydromorphology** No alteration to hydromorphological elements Negligible impact on features **Hydrology & Flood Risk** Over 250m from nearest surface water body Results in effect on watercourse flows, but of insufficient magnitude to affect the use or integrity. Negligible influence on floodplain **Groundwater** Negligible risk of pollution to groundwater during construction, very slight temporary change in water quality with no discernible effect on watercourse ecology or water supply Risk of pollution from accidental spillage during operation < 0.5% annually Minimal or no change to an aquifer in terms of water level or yield, with no discernible change to dependent abstractions/habitats Minimal or no change to or loss of a GWDTE

Magnitude	Criteria
	Water Supplies No anticipated effect on water supply

Impact Significance

5.13.52. The estimation of the impact significance has been arrived at by combining the estimated sensitivity of the affected water bodies and the magnitude of the impacts as indicated in Table 5-50, prior to consideration of any potential mitigation, and the guidance provided in HD 45/09.

Table 5-50 - Criteria Used to Estimate the Significance of Potential Effects

Sensitivity	Magnitude of Impact			
	Major	Moderate	Minor	Negligible
Very High	Very Large	Large / Very Large	Moderate / Large	Neutral
High	Large / Very Large	Moderate / Large	Slight / Moderate	Neutral
Medium	Large	Moderate	Slight	Neutral
Low	Slight / Moderate	Slight	Neutral	Neutral

Existing Environment

Designated Areas

5.13.53. There are no international or nationally designated sites relevant to the water environment within 1km of the study area or within 5km downstream of surface water interactions.

Loss or Change to Water Supplies

5.13.54. NIEA private abstraction licence information was provided in April 2016 for the Blackwater Local Management Area (LMA). There are no NIEA registered private surface water or groundwater abstractions within 1km of the proposed scheme, or within 5km downstream in the case of surface water abstractions. Therefore, no impacts are anticipated on private water supplies.

Groundwater Pollution from Accidental Spillage and Routine Runoff

5.13.55. There are no planned groundwater discharges from any of the proposed scheme options, therefore no impacts are anticipated as a result of any pollution from accidental spillage or routine run-off.

Rainfall

5.13.56. Northern Ireland has a temperate climate characterised by cool summers and mild, wet winters. The annual average rainfall in Armagh is 831mm, based on 1853 – 2015 data from Armagh monitoring station, located less than 1km west of the Study Area, at Irish

Grid Reference (IGR) 2879 3456. Monthly rainfall averages are shown graphically on Figure 5-12.

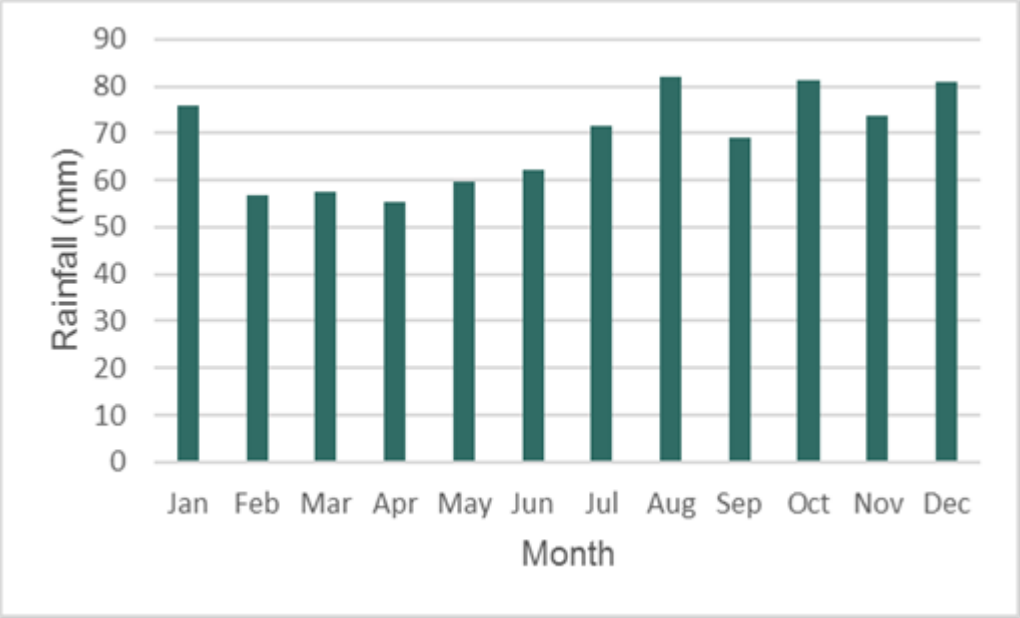

Figure 5-12 - Average monthly rainfall (1853 – 2015) at Armagh

5.13.57. The UK Climate Projections Report provides an indication of regional climate trends across the UK taking account of climate change. Within this document probabilistic projections of climate change suggest that Northern Ireland will experience slightly increased temperatures in both summer and winter. This may result in a reduction in summer precipitation and an increase during winter.

5.13.58. If climate change leads to drier summers, low flows and water shortages may occur in prolonged periods of dry weather. Increase in winter precipitation could increase the risk of and extent of flooding. Climate change rainfall factors are accordingly included within peak flows.

Surface Watercourses

5.13.59. For the purpose of this report watercourses are referred to using both NIEA's WFD waterbody naming convention, wherever applicable, and Rivers Agency designations as referenced on Drawing 1034968-B-D-5001(see *Appendix A*).

5.13.60. The study area is entirely located within the Callan River hydrological catchment, part of the larger River Blackwater catchment. All watercourses relevant to the scheme are therefore tributaries of the overall River Blackwater system.

Callan River

5.13.61. The Callan River, a tributary of the River Blackwater has a total catchment of approximately 180km^2, predominantly draining agricultural grassland via smaller tributaries, including networks of field drains. It originates at Thompson's Hill, Tullynageer, in the Republic of Ireland, approximately 17km south from the proposed options. The watercourse flows generally north, passing Armagh on its western fringe before its confluence with the River Blackwater approximately 11km north of Armagh. Mapping suggests that the watercourse has retained some degree of naturalness with meandering reaches fairly common; however, long straight sections are also apparent, particularly in near proximity to Armagh.

Unnamed tributary of the Callan River (Unnamed Watercourse 1)

5.13.62. Unnamed watercourse 1 is located on the north eastern fringe of the city and drains a number of smaller field drains in the area with a total catchment of approximately 1.5 km^2 at its confluence with Killuney Drain (WC Ref: U4409). Limited data is available and may require further investigation during a future site visit.

5.13.63. The channel shown in Figure 5-13 converges with the Killuney Drain approximately 280m north west of Killuney Bridge. From here it flows generally northwest to its confluence with an unnamed tributary approximately 950m north of the Killuney Drain confluence, then flowing west to converge with the Callan River. The watercourse has been heavily modified, including straightening and culverting, particularly adjacent to the A3 Portadown Road. The channel has a gentle sloping gradient and at the time of survey flows were moderate and shallow, exhibiting riffles and some small step features. The bed was mainly angular cobbles with finer sediments deposited throughout. There was some evidence of scour observed on the right bank, below overhanging bank vegetation as shown on the following figure.

Figure 5-13 - View Upstream of the unnamed Tributary of the Callan River

Killeen Water (known locally as the Ballynahone River)

5.13.64. The Killeen Water (WC Ref: U4410) originates to the south of the Study Area, draining a network of smaller tributaries, including field drains. The main channel flows north, broadly parallel to the western boundary of the Study Area, via a long straight section of channel, before its confluence with the Callan River north of St Luke's Hospital (approximately 1.5km north-west of Dean's Bridge crossing College Hill). The watercourse is highly modified with straightening, culverting and bank protection noted in the reaches surveyed.

5.13.65. An unnamed tributary converges with the Killeen Water from the north-east, in the southern section of the Study Area (approximately 160m west of BRC02). As shown in

Figure 5-14 and Figure 5-15, this tributary is an example of a long straightened section draining agricultural land, with bank collapse and poaching by cattle evident in the upstream view, and a large retaining wall leading to the concrete box culvert, visible downstream. The slope gradient is gentle, slow to moderate flows were observed during the time of survey. The bed material was predominantly gravel with fine sediment coating the bed in the upstream section where the channel was wider. Downstream, gravels appeared to be aggrading on the right bank causing the channel to migrate left and erode the left bank just before an existing culvert entrance.

Figure 5-14 – View upstream of the tributary of the Killeen Water from approx. 160m west of BRC02

Figure 5-15 - View downstream of the tributary of the Killeen Water towards BRC02

5.13.66. The main channel of the Killeen Water, as shown in Figure 5-15, features a large concrete retaining wall lining the right bank. Upstream of this location, a wider channel was noted with riffles observed from the existing road bridge (BRC02) at Edenaveys Road.

5.13.67. Immediately downstream of the location pictured in Figure 5-16 below, the channel is diverted to the right, under a large stone open arch bridge, with remnants of an engineered stone channel bed and bank protection on the left bank. The bed material along this reach is predominantly cobbles and gravel with finer silty sediment deposits. OSNI Mapping and DAERA digital rivers data suggests that a bifurcated channel may have been realigned along this course or culverted below the housing estate to the north of this location, whereas Rivers Agency have confirmed they have no record of this. This will require further investigation at Stage 3.

Figure 5-16 - View downstream of the Killeen Water south of 2007 Option / A28 Junction

Killuney Drain

5.13.68. A small watercourse, known locally as the Killuney Drain, flows south to north, roughly parallel and to the west of the 2007 Option and Option 16, draining smaller tributaries, and is crossed by the existing A3 Portadown Road, before converging with the unnamed tributary of the Callan River. Figure 5-17, below, features a large concrete watercourse crossing structure (KDC01) associated with the Killuney Drain and existing A3 Portadown Road.

Figure 5-17 - Large concrete watercourse crossing structure at A3 Portadown Road (KDC01)

Smaller Unnamed Tributaries

5.13.69. There are also a number of unnamed watercourses throughout the study area, associated with field drainage on agricultural land. These watercourses are typically heavily modified in character, generally straightened in-line with field boundaries.

Surface Water Flow Patterns

5.13.70. Surface water drainage patterns in the study area include a network of small artificial drainage channels and minor natural watercourses which drain to larger watercourses, including the main channels of the Killeen Water and the Callan River. Watercourse flow values vary depending on the size of watercourse catchment, seasonality and due to characteristics within each catchment, such as rainfall, and underlying soils and geology.

5.13.71. There is one Rivers Agency gauging station located downstream of the proposed scheme; the 'Callan at Martin's Bridge' site. This is located approximately 10km downstream from the options, with a hydrological catchment area of 166.9km2. National River Flow Archive (NRFA) gauged data for the Callan at Martin's Bridge reports a mean flow of 2.78m3/s and a Q95 low flow (i.e. the flow exceeded 95% of the time) of 0.168m3/s, as shown in Table 5-51- Watercourse Flow Values.

5.13.72. For the smaller ungauged watercourses within the Study Area, theoretical runoff rates have been estimated for the full extent of each defined stretch of catchment, i.e. for the flow of the Killeen Water upstream of meeting the Callan River. Peak flows have been estimated using the Flood Estimation Handbook (FEH). Catchment characteristics have been used with the 'FEH Rainfall-Runoff' method to derive a range of peak flow return periods. It is recognised that the FEH rainfall-runoff method may not be the best estimation method for some watercourses, depending on their size and other attributes, however for general characterisation of the watercourses these approximate flow values are considered suitable. Low flow measurements have been determined from the LowFlows 2 software and are quoted as Q95 (i.e. the flow exceeded 95% of the

time). Mean flows have also been determined from the LowFlows 2 software. This data is shown in Table 5-51.

5.13.73. The LowFlows 2 software has also been used to determine theoretical flow values for the Callan River, for comparison with actual flow measurements. The theoretical mean flow and low flow values of 2.62m3/s and 0.182 m3/s, respectively, are reasonably consistent with the actual values recorded for the Callan River, giving confidence in the methods applied.

Table 5-51- Watercourse Flow Values

Watercourse	Approx Catchment Area (km^2)	Mean Flow Qmean (m^3/s)	Low Flow Q_{95} (m^3/s)	Peak Flow (m^3/s) Return Periods (yrs)						
				5	10	25	50	100	200	200 + CC
Callan River at Martin's Bridge	166.9	2.8*	0.168*	68.5	81.5	100.0	115.4	130.4	148.1	177.7
Unnamed tributary of the Callan River	9.5	0.1	0.007	6.9	8.3	10.3	12.2	14.1	16.4	19.6
Killeen Water	15.5	0.2	0.012	11.0	13.1	16.4	19.4	22.4	25.8	31.0

*Measured values

5.13.74. The Hydrology of Soil Types (HOST) is a hydrologically-based classification of soils on the basis of their physical properties and their effects on the storage and transmission of water. It makes use of the fact that the physical properties of soils have a major influence on the hydrological response of a catchment. Other parameters can then be derived from the HOST classification.

5.13.75. For the purposes of hydrological assessment the Baseflow Index (BFI) and Standard Percentage Runoff (SPR) are the most useful parameters. BFI is the long-term ratio of baseflow to total stream flow, where baseflow represents the contribution to total flow from groundwater. BFI values range from 0.1 in relatively impermeable clay catchments to 0.99 in highly permeable chalk catchments. A very low BFI of 0.15 represents a flashy catchment with minimal storage, low BFI values (e.g. 0.3) indicate a catchment with little storage and active runoff, a BFI of 0.7 (or greater) indicates a significant contribution to flow from a major aquifer. SPR is the average percentage of rainfall that causes the short-term increase in flow seen at a catchment outflow following a storm event.

5.13.76. Using the Flood Estimation Handbook, the watercourses noted in Table 5-51 have BFI-HOST values ranging between 0.36 – 0.39, with the Callan River exhibiting the upper value of the range. These outcomes indicate moderate contribution from stored water sources, such as the underlying bedrock. Smaller watercourses will respond fairly quickly to rainfall events, with a moderate lag time between rainfall occurring and increased stream flow values. The SPR values for the same watercourses range from 38 – 42%, indicating a moderately flashy response to rainfall, attenuated by local conditions.

Flood Risk

5.13.77. Data for the 1% AEP Flood Extents, shown on Drawing No 1064968-B-D-5002 and 1064968-B-D-3038 (see *Appendix A*), have been provided by Rivers Agency and flood risk from rivers and surface water has been collated from the Rivers Agency Flood Maps (NI) interactive web mapping.

5.13.78. Areas at risk of flooding are generally immediately adjacent to the watercourses and drains within the study area. However, flooding is more extensive in specific areas, such as the vicinity of the proposed roundabout on the A28 Markethill Road where the Killeen Water flows north-west, adjacent to the existing road. The surrounding land use is mainly residential and non-residential properties.

5.13.79. Further downstream, where the Killeen Water flows north and west of the options, there are a number of vulnerable receptors in the vicinity of the watercourse, including Armagh Community Hospital, within 100m of the 1% AEP Flood Extent, and a number of schools, all located to the west. The surrounding land use is predominantly residential properties, with non-residential properties between A51 Hamiltonsbawn Road and A3 Portadown Road, including the Hamiltonsbawn Road Industrial Estate.

5.13.80. There is more extensive flooding indicated adjacent to Option 16 and the 2007 Option, west of the proposed roundabout on the A51 Hamiltonsbawn Road. This extends along the route of the Killuney Drain from the residential area surrounding the A51, flowing north past the Hamiltonsbawn Road Industrial Estate, where it appears to have been culverted extensively, before then flowing through field drains toward the existing culvert on the A3 Portadown Road.

5.13.81. More widespread flooding is also noted at the confluence with the Callan River and Killeen Water, approximately 800m north-west of the 2007 Option. The unnamed tributary of the Callan also contributes to this flood extent in the area surrounding Court Hill, before converging with the Callan River. The 1% AEP Flood Extent extends to cover an area of both residential and non-residential properties including St Luke's Hospital. A vulnerable receptor, Hamilton Court Care Home, is located in the 1% AEP Flood Extent along Hamiltonsbawn Road. The surrounding land use includes residential and non-residential properties, agricultural and industrial.

5.13.82. Sensitivities have been assigned based on the above and the impact assessment criteria outlined. This has resulted in the Callan River, Killeen Water, and the Killuney Drain, in the vicinity of Hamiltonsbawn Road Industrial Estate being assigned very high sensitivity. The unnamed tributary of the Callan River and the unnamed tributary of the Killeen Water have both been assigned high sensitivity.

5.13.83. No information on groundwater flooding has been gathered at this time.

Standing Water

5.13.84. One standing water body has been identified within 1km of the study area using OSNI scale mapping and digital water body data available from the NIEA website.

5.13.85. Drumman More Lough is a small lake, with a surface area of approximately 1.8ha, and is intersected by the 1km study area buffer to the north of Option 12. This water body is assumed to be of medium sensitivity.

5.13.86. Further investigations will be undertaken at Stage 3 to confirm likelihood of any impacts.

Surface Water Quality

5.13.87. The WFD categories water bodies based on a risk-based classification system. This highlights such issues as stream morphology and existing artificial structures in addition to chemical water quality and ecological diversity. Heavily modified water bodies, which can no longer be considered to be natural, are classified on the basis of 'ecological potential'.

5.13.88. The WFD applies to all surface waters, but for practical purposes, NIEA has defined a size threshold above which a river or lake qualifies automatically for characterisation. Rivers must have a catchment area of 10km2 or more and in addition to these larger water bodies, smaller waters have been characterised where there is justification by conservation interests and to meet the requirements of regulatory legislation such as for drinking water supplies. All surface water bodies have an objective to meet or exceed 'Good' overall status by 2027 .

5.13.89. Watercourses in the study area have been identified as ranging from low to medium sensitivity in relation to water quality, based on their WFD overall status as shown in Table 5-52. Field drains in the area have been classified as low sensitivity based on the local conditions observed during the site visit.

5.13.90. For water bodies that have not been classified, the normal convention is to assume a classification based on downstream or adjacent water bodies, unless there are specific indications to the contrary. On this basis, the unnamed tributary of the Callan River is considered to have 'Moderate' status.

5.13.91. Hydromorphological sensitivity has been evaluated with reference to the NIEA hydromorphology classification under the WFD, where possible. The two main watercourses in the Study Area, the Killeen Water and the unnamed tributary of Callan River, are considered as having high hydromorphological sensitivity. This based on the 'Good' WFD status of hydromorphological elements for the Killeen Water and the Callan River. Their highly modified characteristics noted within the Study Area, such as straightening, bank protection and culverting would suggest a lower sensitivity; however, in the absence of a full hydromorphological assessment at this stage, a cautious approach has been taken.

Table 5-52 - Water Framework Directive Status of Surface Waters, 2015

NIEA Water Body Name	Callan River (Derryscollop)	Killeen Water
Water Body Type	River	River
Water Body ID	UKGBNI1NB030308225	UKGBNI1NB030307109
Heavily Modified	No	Yes
Overall status (2015)	Moderate	Poor EP
Benthic Invertebrates	Moderate	Poor
Macrophytes	Good	High
Phytobenthos	Good	Good
Biological Oxygen Demand	Good	Not reported
Temperature	Good	Not reported
Dissolved Oxygen	Good	Not reported
pH	High	Not reported
Soluble Reactive Phosphorus	Moderate	Not reported
Ammonia	Good/High	Not reported
Arsenic (dissolved)	Good/High	Not reported
Chromium (dissolved)	Good/High	Not reported
Iron (dissolved)	Good/High	Not reported
Hydrological Regime	Good	Good
Morphological conditions	Not reported	Good
Cadmium (dissolved)	Good	Not reported
Lead (dissolved)	Good	Not reported
Nickel (dissolved)	Good	Not reported

Fisheries

5.13.92. The Fisheries Conservancy Board for Northern Ireland have stated concerns over effects to the lower reaches of the Killeen Water, which is a salmonid fishery. This will be considered as part of the Stage 3 assessment with reference to ecological assessments.

5.13.93. A fish hatchery has been identified along Ballynahonemore Road (approximately 200m from the junction with Edenaveys Road), within 250m of Options 12 and 16. This is located approximately 400m upstream from the options, positioned immediately adjacent to the unnamed tributary of the Killeen Water. The hatchery is owned by Armagh Angling Club and is used to rear brown and rainbow trout to stock their club waters, according to their website .

5.13.94. It is possible that the hatchery relies on abstraction from the adjacent watercourse; however, given its upstream location, this receptor is not anticipated to be affected by the proposed scheme.

Hydrogeology

5.13.95. Based on the GSNI bedrock geology mapping, the majority of the options are underlain by the wacke and mudstones of the Leadhills Super-group. These are separated by a series of faults to the north, from units including conglomerate, sandstone and siltstone of the Killuney Conglomerate formation, argillaceous rocks of the Retreat Siltstone Formation and limestone of the Ballynahone Micrite Formation, sandstones of the Drumman More Sandstone Formation and interbedded limestone, argillaceous rocks subordinate sandstone of the Armagh Group.

5.13.96. The study area features three different hydrogeological units. The wackes and mudstones of the Leadhills Supergroup are classified as a low productivity area (class Bl(f)) with groundwater limited to the near surface weathered zone and secondary fractures. The Killuney Conglomerate Group, Retreat Siltstone Formation, Ballynahone Micrite Formation and Drumman More Sandstone Formation are considered moderately productive aquifers (class Bm(f)), with flow virtually all through fractures and discontinuities. Limestones within these formations may support some high yielding (up to 10l/s) springs and boreholes, where the limestone is sufficiently pure. The Armagh Group, located in the north-east area of the scheme, is also classified as a moderately productive aquifer (class Bm(f)), with flow through fractures and discontinuities and yields of up to 10 l/s (where fractured or secondary permeability is available).

5.13.97. The majority of the study area is underlain by diamicton (glacial) till, with smaller areas of alluvium, primarily along the Killeen River. There is a small area of peat north of Markethill Road, in the south of the study area. The alluvial deposits along the Killeen River have the potential to be a moderately productive aquifer with intergranular flow.

5.13.98. Based on the information presented above, the groundwater bodies of the study area are considered to be of medium sensitivity in relation to groundwater quantity in terms of their hydrogeology.

Groundwater Quality

5.13.99. The study area is located within the boundary of the Keady groundwater body (Water body ID: UKGBNI4NB011) which has been classified under the WFD as having Poor overall status in 2015, as a result of being classified as having 'Poor' status for both chemical and quantitative factors.

5.13.100. Based on the information presented above, the Keady groundwater body is considered to be of low sensitivity in relation to groundwater quality.

Groundwater Vulnerability

5.13.101. Groundwater vulnerability data (2009) has been reviewed and indicated that the vast majority of the site, within 1km of the route options, has been classified as vulnerable to some pollutants, but only when continuously discharged/leached (groundwater vulnerability category 2).

5.13.102. There are smaller regions in the northern and southern extents of the Study Area, associated with superficial alluvium deposits, which are classified as vulnerable to those pollutants not readily adsorbed or transformed (groundwater vulnerability category 4e)[i]. These occur to the north and west of the Mullynure area, including the Court Hill area and Long Stone area. The area south of Armagh Cemetery and the adjacent playing fields, including Ardmore Hill, the Edenaveys Road junction with the

A28 and extending further south to the east of the Killeen Water, is also classified as more vulnerable.

5.13.103. The sensitivity of the groundwater in relation to vulnerability for Options 12 and 16 is high as a result of crossing groundwater vulnerability class 4e at their southern extent (Edenaveys Road), whereas the 2007 Option is classified as medium.

Groundwater Dependent Terrestrial Ecosystems (GWDTEs)

5.13.104. GWDTEs are types of wetland which are specifically protected under the WFD and can include: fens, springs, flushes, seepages, quaking bog, wet woodland, marshy grassland and some types of wet heath, reedbed and swamp.

5.13.105. Whilst a full NVC survey has not been completed at Stage 2, a number of areas of semi-improved grassland have been identified within the PEA (see *Appendix H*) as hosting plant species that can be indicative of NVC communities potentially dependent upon groundwater, based on the Land Use Planning System SEPA Guidance Note 31, and with reference to SNIFFER WFD 95 criteria. Given the lack of definitive information at this stage, areas identified as semi-improved grassland have been considered as having the potential to for supporting GWDTEs. Such areas have been identified in the following locations:

- Embankments along the existing Ardmore Road at the southern extent of the 2007 Option
- Areas to the south and west of Lindsay's Heights at the northern extents of the 2007 Option and Option 16
- Southern extent of Options 12 and 16 adjacent to A28 Markethill Road at proposed roundabout location
- East of Edenaveys Road, towards the southern extent of Options 12 and Option 16, adjacent to the unnamed tributary of the Killeen Water

5.13.106. At this stage there is insufficient resolution of data to identify GWDTEs of either high or moderate groundwater dependence present within the semi-improved grasslands outlined above. However, given that a number of species have been identified within the PEA that can be indicative of high dependence, as part of specific NVC communities, a precautionary approach has resulted in all areas of semi-improved grassland being assumed as potentially highly dependent and therefore of high sensitivity.

Discharges

5.13.107. A total of 12 consented discharges have been identified by reference to NIEA records within 1km of the options. There are two discharges located under the footprints of 2007 Option and Option 16, associated with private sewage and site drainage. There is one discharge under the footprints of Option 16 and Option 12, associated with private sewage.

5.13.108. The remaining discharges within the study area are associated with private sewage, site drainage and food processing, however, there is no confirmation as to whether these are discharged to surface waters or groundwater. This will be investigated further at Stage 3.

Receptor Sensitivity

5.13.109. Receptor sensitivity has been evaluated on the basis of the baseline data available. Given data limitations at DMRB Stage 2, as previously outlined, a precautionary approach has been adopted.

5.13.110. Table 6-53 presents a summary of the sensitivity of water receptors.

Table 5-53 - Summary of Water Body Receptor Sensitivity

Receptor	WFD Catchment	Attribute	Comment	Sensitivity
Surface Water - Callan River	Callan River (Derryscollop)	Surface Water quality & biodiversity	'Moderate' overall WFD status	Medium
		Hydromorphology	'Good' WFD status for hydromorphological elements	High
		Hydrology & Flood Risk	Vulnerable Receptors in the vicinity include a hospital and wastewater treatment works downstream of the Study Area	Very High
		Water Supplies / Abstractions	None within 1km of the proposed scheme, or within 5km downstream	Low
Surface Water - Killeen Water	Killeen Water (Callan River)	Surface Water quality & biodiversity	'Poor Ecological Potential' overall WFD status	Low
		Hydromorphology	'Good' WFD status for hydromorphological elements	High
		Hydrology & Flood Risk	Vulnerable receptors in the vicinity include hospital and schools	Very High
		Water Supplies / Abstractions	None within 1km of the proposed scheme, or within 5km downstream	Low
Surface Water -	Callan River (Derryscollop)	Surface Water quality & biodiversity	'Moderate' overall WFD status (Callan River)	Medium

Receptor	WFD Catchment	Attribute	Comment	Sensitivity
Unnamed tributary of Callan River		Hydromorphology	'Good' WFD status for hydromorphological elements of the receiving watercourse, Callan River	High
		Hydrology & Flood Risk	Watercourse flows adjacent to residential properties	High
		Water Supplies / Abstractions	None within 1km of the proposed scheme, or within 5km downstream	Low
Surface Water - Unnamed tributary of Killeen Water	Killeen Water (Callan River)	Surface Water quality & biodiversity	'Poor Ecological Potential' overall WFD status	Low
		Hydromorphology	'Good' WFD status for hydromorphological elements	High
		Hydrology & Flood Risk	Watercourse flows adjacent to residential properties	High
		Water Supplies / Abstractions	None within 1km of the proposed scheme, or within 5km downstream	Low
Surface Water - Killuney Drain and other unnamed field drains	Callan River (Derryscollop)	Surface Water quality & biodiversity	Field drains	Low
		Hydromorphology	Field drains with little and/or uniform flow	Low
		Hydrology & Flood Risk	1% AEP Flood Extent in the Hamiltonsbawn Road proposed roundabout area encroaches on vulnerable receptor	Very High
		Water Supplies / Abstractions	None within 1km of the proposed scheme, or within 5km downstream	Low
Surface Water - Drumman More Lough	Callan River (Derryscollop)	Undesignated lake	Approximately 1km north-east of Option 12	Medium

Receptor	WFD Catchment	Attribute	Comment	Sensitivity
Groundwater	Keady	Groundwater Quality	'Poor' overall WFD status	Low
		Groundwater Vulnerability	Class 2 / Class 4	Medium / High
		Water Supplies / Abstractions	None within 1km of the proposed scheme	Low

Potential Impacts

Surface Water Impacts

Construction Pollution

5.13.111. Silt and sediment laden site runoff generated during construction activities, such as soil stripping and earthworks can have a detrimental impact if allowed to enter watercourses untreated. Fine sediments can increase water turbidity and smother stream beds, affecting water quality and causing harm to fish, aquatic invertebrates and plants by interfering with feeding, respiration and spawning. The effects of sediment release can extend considerable distances downstream.

5.13.112. In addition, spillages of potential pollutants such as oils, fuels, concrete, cement and sewage from construction staff welfare facilities can potentially occur during construction. Oils form a film on the water surface and can coat organisms, blocking respiration, photosynthesis and feeding. Biodegradation of oils in aquatic systems can lead to oxygen depletion and many hydrocarbons are toxic, persistent and bio-accumulate in the environment i.e. they build-up in the body tissue both directly and from feeding on other contaminated organisms. Concrete and cement is highly alkaline and can harm aquatic organisms if the pH of the receiving waters are affected.

5.13.113. The highest risk of sedimentation or spillage affecting water bodies, and dependent private water supplies would be at locations where construction would be required alongside and within 50m of a watercourse and also at locations where direct interaction with the water environment occurs, such as bridge and culvert crossing structures, where watercourse diversions are required and at drainage discharge outfalls.

5.13.114. Construction is anticipated within 50m of water bodies for each of the options, as detailed in Table 5-54 - Potential Construction Pollution Interactions for the Options. For 2007 Option, Options 12 and Option 16, the total length of road within 50m of a water body is approximately 550m, 460m and 790m respectively. This is based on rivers mapping data from DAERA, field drains observed during the walkover survey and drainage channels identified using aerial imagery.

5.13.115. Based on the preliminary road drainage information, it is anticipated that there would be two road drainage outfalls associated with Option 12 and three outfalls associated with both 2007 Option and Option 16, with each of the options drainage networks discharging to surface waters. These outfalls would require construction activity on channel banks, including pipe-laying and installation of appropriate outfall structures.

Details of the watercourses affected by outfall construction are provided in Table 5-54 - Potential Construction Pollution Interactions for the Options.

Table 5-54 - Potential Construction Pollution Interactions for the Options

Receptor	Sensitivity	2007 Option			Option 12			Option 16		
		Interactions	Magnitude	Significance	Interactions	Magnitude	Significance	Interactions	Magnitude	Significance
Killeen Water	Low	150m 1 x O	Moderate Adverse	Slight Adverse	220m 1 x EC	Moderate Adverse	Slight Adverse	220m 1 x EC	Moderate Adverse	Slight Adverse
Unnamed tributary of Killeen Water	Low				170m 1 x O 1 x EC	Moderate Adverse	Slight Adverse	170m 1 x O 1 x EC	Moderate Adverse	Slight Adverse
Unnamed tributary of Callan River	Medium				160m 1 x O 1 x EC	Moderate Adverse	Moderate Adverse			
Killuney Drain and other unnamed field drains	Low	400m 2 x O 2 x C 78m D	Moderate Adverse	Slight Adverse	180m 1 x C 26m D	Moderate Adverse	Slight Adverse	400m 2 x O 2 x C 78m D	Moderate Adverse	Slight Adverse

Interactions are listed by water body as:
*m – length of option within 50m of a water body
*m D – length of diversion
1 x O – number of outfalls discharging to a water body
1 x EC, 1 x B – number of watercourse crossings on a water body (EC – Extend/re-construct existing culvert, C – new culvert, B – Bridge, representing all structures >2m diameter)

5.13.116. It is anticipated that there shall be a requirement for watercourse crossing structures (existing structures to be extended/upgraded/replaced, plus new structures) on all of the options, with two required for the 2007 Option and four required for Options 12 and 16. It is anticipated that the current structure dimensions in most cases will be indicative of the minimum size of the new crossing structures to be installed in their place. Details of indicative watercourse crossing structures are provided in Table 5-54 - Potential Construction Pollution Interactions for the Options

5.13.117. It may be necessary to alter the alignment of specific watercourses in order to avoid excessive culverting or where a watercourse may be affected by proposed cutting slopes. A preliminary review of potential watercourse realignments/diversions has been undertaken for all options, and these are summarised in Table 5-54 - Potential Construction Pollution Interactions for the Options

5.13.118. It is anticipated that each of the options would require diversions of the Killuney Drain or other unnamed field drains, with the 2007 Option and Option 16 requiring 78m of diversion, and Option 12 requiring 26m of diversion.

5.13.119. It is assumed that construction will be carried out following good practice guidance and with appropriate mitigation wherever required.

5.13.120. Taking a precautionary approach, the information and construction details discussed above, each of the options have been assigned impact magnitudes of **moderate adverse**. This results in an impact significance of **slight adverse** across 2007 Option and Option 16, with Option 12 as **moderate adverse** significance (due to interactions with the medium sensitivity unnamed tributary of Callan River).

Pollution from Routine Runoff

5.13.121. During operation, a broad range of potential pollutants, such as hydrocarbons i.e. fuel and lubricants, fuel additives, metal from corrosion of vehicles, de-icer and gritting material, can accumulate on road surfaces. These can subsequently be washed off the road during rainfall events, polluting the receiving water bodies. Routine runoff from road drainage networks can result in both acute and chronic impacts on water quality and subsequently on the biodiversity of the receiving watercourses, due to both soluble (in particular, dissolved copper and dissolved zinc) and sediment bound pollutants.

5.13.122. There have been eight potential locations identified for discharge outfalls, with all discharging to surface waters. Each of these surface water outfalls have been subject to preliminary HAWRAT and EQS assessments.

5.13.123. At this stage, with limited watercourse data available, Tier 1 simple assessments have been carried out. At Stage 3, a Tier 2 detailed assessment will be carried out which will utilise more detailed site specific survey data for each receiving watercourse. The results are summarised in Table 5-55.

5.13.124. At present, given the absence of a drainage design and inherent mitigation, one network on the 2007 Option passes all elements of the HAWRAT and EQS routine runoff assessments. Three networks fail all elements which relate to each of the options.

5.13.125. The results of these assessments shall be communicated back to the drainage engineers to advise on treatment requirements and the development of the detailed drainage design, which will be designed to sufficiently treat all surface water discharges to pass all elements of the HAWRAT and EQS assessments, which will subsequently

result in neutral significance. Given that this is the realistic scenario rather than the scenarios based on the preliminary HAWRAT results, for the purpose of this assessment, all impacts associated with pollution from routine runoff, are considered to be of neutral significance based on standard design and good practice.

Table 5-55 - Summary of Routine Runoff Assessment for the Options

Options	Drainage Network ID	Receptor	Sensitivity	Routine Runoff Result	Magnitude	Significance
2007 Option	2007 OF 01	Killeen Water	Low	Pass	Negligible	Neutral
	2007 OF 02	Unnamed Drain	Low	Fail	Major Adverse	Slight / Moderate Adverse
	2007 OF 03	Killuney Drain	Low	Fail	Minor Adverse	Neutral
Option 12	Option 12 OF 01	Tributary of Killeen Water	Low	Fail	Minor Adverse	Neutral
	Option 12 OF 02	Tributary of Callan River	Medium	Fail	Major Adverse	Large Adverse
Option 16	Option 16 OF 01	Tributary of Killeen Water	Low	Fail	Minor Adverse	Neutral
	Option 16 OF 02	Unnamed Drain	Low	Fail	Major Adverse	Slight / Moderate Adverse
	Option 16 OF 03	Killuney Drain	Low	Fail	Minor Adverse	Neutral

Pollution from Accidental Spillage

5.13.126. During operation, there is a risk that road traffic accidents or vehicle fires may result in accidental spillage of potential pollutants on the road surface. These may then enter the road drainage network and subsequently be discharged to the water environment, causing an acute pollution event.

5.13.127. The results of the calculations relating to accidental spillage during use demonstrate that, whilst applying conservatively high traffic data, all options surface water discharge networks meet the minimum DMRB standard for sensitive watercourses of a 1 in 200 year return period (0.5% probability), with preliminary outcomes estimating a 1 in 379 year return period for the worst-performing drainage network (Option 12 OF 02). These outcomes determine that no further mitigation would be required. Outcomes for individual drainage networks are provided in Table 5-56.

5.13.128. It has accordingly been concluded that the magnitude of potential impact on the receiving surface watercourses would be negligible for all options, with the associated significance being neutral.

Table 5-56- Summary of Accidental Spillage Assessment for the Options

Options	Drainage Network ID	Receptor	Sensitivity	Accidental Spillage Result	Magnitude	Significance
2007 Option	2007 OF 01	Killeen Water	Low	Pass	Negligible	Neutral
	2007 OF 02	Unnamed Drain	Low	Pass	Negligible	Neutral
	2007 OF 03	Killuney Drain	Low	Pass	Negligible	Neutral
Option 12	Option 12 OF 01	Tributary of Killeen Water	Low	Pass	Negligible	Neutral
	Option 12 OF 02	Tributary of Callan River	Medium	Pass	Negligible	Neutral
Option 16	Option 16 OF 01	Tributary of Killeen Water	Low	Pass	Negligible	Neutral
	Option 16 OF 02	Unnamed Drain	Low	Pass	Negligible	Neutral
	Option 16 OF 03	Killuney Drain	Low	Pass	Negligible	Neutral

Alterations to Hydromorphological Regime

5.13.129. Typical hydromorphological impacts upon receptors may include channel realignments, loss of features and potential failure of hydromorphological elements (morphology, quantity and dynamics of flow) resulting from works, loss or damage to existing habitats, replacement of natural bed and/or banks with artificial materials and changes to platform.

5.13.130. Preliminary drainage information with regards to crossing structures and potential watercourse diversions has been made available at Stage 2. As shown in Table 5-57 - Summary of Hydromorphological Interactions., each of the options would require more than one crossing structure, more than one outfall location and more than 10m of watercourse realignment. It is assumed that good practice guidance will be followed with appropriate mitigation applied wherever required.

5.13.131. Option 12 and Option 16 both have a number of locations that would require the development or replacement of existing culverts which have been considered as having a **minor adverse** impact magnitude, representing a minimal shift away from baseline conditions.

5.13.132. Each of the options require new crossing structures and diversion of watercourses affecting lengths greater than 10m. Taking the precautionary approach, this has been considered as a **major adverse** impact magnitude.

5.13.133. It is anticipated that following good practice guidance and with suitable applied mitigation, there will be a reduction in impact magnitude.

5.13.134. Outfall locations have been considered as having a **minor adverse** impact magnitude.

5.13.135. The impacts span the construction and operational phase of the proposed scheme. The overall significance of the impacts does not vary between the options.

5.13.136. All watercourses affected by the options have an impact significance of **slight / moderate adverse**.

Table 5-57 - Summary of Hydromorphological Interactions.

Receptor	Sensitivity	2007 Option			Option 12			Option 16		
		Interactions	Magnitude	Significance	Interactions	Magnitude	Significance	Interactions	Magnitude	Significance
Killeen Water	High	1 x O	Minor Adverse	Slight / Moderate Adverse	1 x EC	Minor Adverse	Slight / Moderate Adverse	1 x EC	Minor Adverse	Slight / Moderate Adverse
Unnamed tributary of Killeen Water	High				1 x O 1 x EC	Minor Adverse	Slight / Moderate Adverse	1 x O 1 x EC	Minor Adverse	Slight / Moderate Adverse
Unnamed tributary of Callan River	High				1 x O 1 x EC	Minor Adverse	Slight / Moderate Adverse			
Killuney Drain and other unnamed field drains	Low	2 x O 2 x C 78m D	Major Adverse	Slight / Moderate Adverse	1 x C 26m D	Major Adverse	Slight / Moderate Adverse	2 x O 2 x C 78m D	Major Adverse	Slight / Moderate Adverse

Interactions are listed by water body as:
*m D – length of diversion
1 x O – number of outfalls discharging to a water body
1 x EC, 1 x B – number of watercourse crossings on a water body (EC – Extend/re-construct existing culvert, C – new culvert, B – Bridge, representing all structures >2m diameter)

Increased Flood Risk

5.13.137. In the absence of hydraulic modelling, the options have been reviewed against the 1% AEP Flood Extent within the study area. None of the options involve crossing extensive regions of the 1% AEP Flood Extent, with the most notable interactions being 2007 Option and Option 16 where the northern section comes within close proximity of the Killuney Drain, and the southern extent of the 2007 Option at A28 Markethill Road, adjacent to the Killeen Water.

5.13.138. Each watercourse or floodplain identified as being potentially affected by the scheme has been assigned an impact magnitude of **minor adverse** which has resulted in significance ranging from **slight / moderate adverse** to **moderate / large adverse**, depending on the sensitivity assigned, as shown in Table 5-58.

5.13.139. It is, however, anticipated that inherent mitigation within the drainage design at Stage 3 will attenuate flows to that of the baseline greenfield runoff rates, which would likely result in a **negligible** magnitude, resulting in **neutral** significance in each case.

Table 5-58 - Summary of Floodplain Interactions

Receptor	Sensitivity	2007 Option		Option 12		Option 16	
		Magnitude	Significance	Magnitude	Significance	Magnitude	Significance
Killeen Water	Very High	Minor Adverse	Moderate / Large Adverse	Minor Adverse	Moderate / Large Adverse	Minor Adverse	Moderate / Large Adverse
Unnamed tributary of Killeen Water	High			Minor Adverse	Slight / Moderate Adverse	Minor Adverse	Slight / Moderate Adverse
Unnamed tributary of Callan River	High			Minor Adverse	Slight / Moderate Adverse		
Killuney Drain	Very High	Minor Adverse	Moderate / Large Adverse			Minor Adverse	Moderate / Large Adverse

Loss of Standing Water

5.13.140. Drumman More Lough is within the 1km study area to the north of Option 12. Given the proximity of this feature, an impact magnitude of negligible is applied, resulting in a neutral impact significance.

Groundwater Impacts

Construction Pollution

5.13.141. At Stage 2 there is limited information on groundwater levels in the vicinity of the proposed cuttings, although it is anticipated that groundwater levels will be shallow in the higher permeability superficial deposits. Similarly, there is little information on the depth of individual cuttings. It is likely that groundwater will be intercepted in some of the cuttings which are excavated into both superficial and bedrock deposits, with a subsequent potential for introduction of pollutants.

5.13.142. For each option the total length of cutting within each groundwater vulnerability class have been calculated to provide an indication of the risk of pollution to groundwater quality associated with each option.

Table 5-59 - Length of cutting for each option within each vulnerability class

Options	Length of cutting (m)	
	Class 4 Groundwater Vulnerability	Class 2 Groundwater Vulnerability
2007 Option	0	1836
Option 12	46	1985
Option 16	45	1478

5.13.143. Option 16 has the shortest length of total cutting, with Option 12 the longest. Options 12 and Option 16 feature cutting within areas of higher vulnerability; Class 4.

5.13.144. The potential impact from construction pollution for the 2007 Option would be of **minor adverse** magnitude, with an associated significance of **slight adverse**.

5.13.145. For Options 12 and 16, the impact would be of **minor adverse** magnitude with a significance of **slight/moderate adverse**.

Loss or change to groundwater aquifers and supported water supplies

5.13.146. As no information is available on the location of groundwater fed public water supplies, any potential supply within 1km of the scheme may be impacted by changes to groundwater aquifers. This will be investigated further and any potential impacts will be assessed at Stage 3.

5.13.147. There are no private water supplies within 1km, therefore no impact is anticipated on private water supplies.

Indirect loss or change to surface water receptors

5.13.148. Changes to groundwater flow may indirectly impact surface water features (rivers, streams etc.) partially or entirely as a result of changes to baseflow. Cuttings associated with the 2007 Option run roughly perpendicular to the Killeen Water which may minimise the impact, with smaller cuttings associated with both the 2007 Option and Option 16 running parallel to smaller field drains in the north at Killuney.

5.13.149. Cuttings associated with Options 12 and Option 16 run roughly perpendicular to the unnamed tributary of the Killeen Water in the south, with cuttings associated with Option 12 running parallel to smaller field drains in the north.

5.13.150. At this stage there are no clear differentiator between the options and it is currently unknown where dewatering sites may occur. It is anticipated that the indirect impact of groundwater changes to surface water receptors will be **minor adverse**, resulting in **neutral** significance for each of the options.

Loss or change to Groundwater Dependent Terrestrial Ecosystems (GWDTEs)

5.13.151. Based on the available information, the potential impact to GWDTEs magnitude is considered to be minor adverse for all options, with a resulting significance of **slight/moderate adverse**.

Recommended Mitigation Measures

5.13.152. To ensure the selected option achieves WFD 'Good' status for receiving watercourses or increase in flood risk, the objective is to keep water quality and runoff to pre-development levels, whilst recognising that natural variability in flow values and water quality do occur.

Construction Pollution

5.13.153. There are a number of Pollution Prevention Guidelines (PPGs) good practice guidance documents available from NIEA and organisations such as CIRIA for site environmental management. From such documents there are a number of mitigation measures which would be applied in all cases and some which are specific to particular design features and locations. These mitigation measures would be anticipated to be collated within the CEMP.

5.13.154. Pollution prevention planning prioritises prevention at source, followed by mitigation measures local to source. Pollution incident management would operate on two main principles:

- reducing the likelihood of an incident occurring
- minimising the magnitude (or severity) of any incident that does occur.

5.13.155. In tandem, these principles would reduce the potential for contamination of surface water and associated habitats. To achieve this, the following principles would be expected to be included:

- preparation of method statements and environmental incident response plans, including staff training, to be agreed prior to commencement of works with NIEA, with specific additional detail for all locations where working is required within 50m of existing watercourses
- secure storage of fuels and other potentially hazardous construction materials
- good practice in earthworks, structural and drainage installation to minimise and treat sediment-laden runoff
- where feasible, new culverts and diversions to be constructed offline, with water diversion to the new channel timed to allow for the establishment of vegetation within the channel. Construction would proceed from the low end of the newly constructed watercourse channels, to minimise sedimentation, with 'breakthrough' of upper end of the channel and release of flow only when new channel is suitably prepared. It is recommended that culverts will be open base
- use of pre-cast concrete structural materials, where feasible, to minimise use of wet concrete in near-channel or in-channel works
- watercourse monitoring at locations where construction activity has reasonable potential to affect water quality.

Flood Risk

5.13.156. To protect the site and third party land from increased flood risk during the construction phase of the proposed scheme, a 'flood warning and emergency evacuation plan' the following should be considered as part of the CEMP provided by the Contractor.

5.13.157. To ensure the effects of flood risk are minimised during construction, the work will be undertaken when flood events are unlikely and not predicted. Should a storm with flood potential be predicted then measures will be put in place to reduce the impacts of flooding, e.g. remove machinery from low-lying areas.

5.13.158. All temporary channels and pumping operations to be sized in accordance with the flood risk for each location.

5.13.159. The excavation and construction works could lead to the blockage and severance of existing surface water drainage systems and watercourse crossing structures, which could result in low frequency localised flooding to the site. The CEMP will outline the mechanisms to manage surface water flooding and will mitigate the risk from the blockage and severance of drainage pathways.

5.13.160. Stockpiles and site compounds should all be located outwith the 0.5% AEP flood envelope.

5.13.161. During construction, the operation of machinery may result in compaction of the soil which will reduce the infiltration capacity. This could result in an increase in surface water runoff and could lead to localised flooding and runoff into the watercourses and rivers. As part of the CEMP, surface water runoff will be managed such that it will not increase the risk of flooding at the proposed development site, or to land within the surrounding area.

Groundwater

5.13.162. The impacts on groundwater aquifers due to the dewatering of cuttings and deep excavations during construction could be minimised through sensitive design of the dewatering operations or permanent drainage. Groundwater seeping into cuttings would be contained, channelled and directed to the down gradient side of the cutting, allowing the discharge to infiltrate to groundwater.

5.13.163. Private water supplies identified as being at risk at Stage 3 will have detailed surveys and groundwater monitoring carried out to establish the magnitude of the potential impact on yields. Depending on the potential level of impact anticipated mitigation may include monitoring throughout the construction phase and/or provision of a permanent alternative supply.

5.13.164. In relation to GWDTEs, following the detailed Stage 3 assessments those GWDTEs considered to be at risk of impact may be monitored prior, during and after construction to determine the level of impact. Monitoring may involve both groundwater readings and repeated NVC surveys. Where road embankments may result in severance of a GWDTE, consideration will be given to the use of permeable fill in the embankment construction to maintain groundwater flows. As discussed above, groundwater entering cuttings will be directed to the down gradient side and allowed to infiltrate. Where possible the location and frequency of these discharges will be designed to replicate the natural groundwater flow as closely as possible.

Summary of Likely Significant Effects

5.13.165. Prior to further detailed developments in the design, and additional survey data to be gathered, potential significant effects have been identified in relation to construction pollution, pollution from routine runoff, hydromorphological regime, flooding, and GWDTEs.

5.13.166. Assessment of the proposed scheme indicates that there is uncertainty over whether significant effects are likely in relation to construction pollution.

5.13.167. There is uncertainty over whether significant effects are likely in relation to alterations to hydromorphological regime and flood risk in the absence of a full drainage design and flood risk assessment.

5.13.168. There is uncertainty over whether significant effects are likely in relation to loss or change to GWDTEs in the absence of NVC survey work.

5.13.169. In relation to all other potential impacts there is a high degree of certainty that there is a low likelihood of significant effects, assuming that good practice design measures as outlined in the mitigation section are embedded within the scheme design.

5.13.170. Further iterative design and assessment work, in particular development of the preliminary drainage design in conjunction with a flood risk assessment and the routine runoff assessment, will ensure the proposed scheme is developed to minimise potential effects on the water environment.

5.13.171. Table 5-60 summarises the likelihood of the options to generate significant effects on the water environment.

Table 5-60 - Summary of Likelihood of Significant Effects on Water Environment in Accordance with IAN 125/15

Receptors	2007 Option	Option 12	Option 16
Designated Areas	No Likelihood	No Likelihood	No Likelihood
Loss or Change to NIEA Registered Water Supplies	No Likelihood	No Likelihood	No Likelihood
Groundwater Pollution from Accidental Spillage and Routine Runoff	No Likelihood	No Likelihood	No Likelihood
Surface Water Impact, inc. Flood Risk	Uncertain	Uncertain	Uncertain
Groundwater Impact	Uncertain	Uncertain	Uncertain
Other Potential Impacts	Low Likelihood	Low Likelihood	Low Likelihood

Limitations of Assessment

5.13.172. Detailed information was not available on the location of public water supplies within the study area.

5.13.173. There was no detailed drainage design or FRA available at this stage of the assessment.

5.13.174. There was no NVC survey data available.

5.13.175. The limitations discussed above are typical of Stage 2 assessment, and the assessment detailed herein is considered to be robust and of an appropriate level of detail to inform the option selection. As noted above, further detailed investigations and assessments will be undertaken to inform the Stage 3 – Preliminary Design.

Recommendations for Further Works

5.13.176. Further design and assessment work at Stage 3 will include development of a drainage design which will confirm the location of outfalls in relation to local watercourses and impacts of any potential discharges to groundwater, with identification and evaluation of appropriate treatment techniques. This will involve further assessments, including a DMRB HD 45/09 'Method A' assessment to assess the impact of routine runoff on local watercourses, and a DMRB HD 45/09 'Method C' groundwater assessment for any potential groundwater discharges. The potential for accidental spillages within drainage networks to cause an impact on receiving waterbodies will be assessed following DMRB HD 45/09 'Method D'.

5.13.177. Given the increase in impermeable areas for all options and the potential impacts from increased flood risk it is recommended that assessment, in accordance with DMRB, is undertaken to understand the potential issues in relation to, and the need for, attenuation. It is recommended that a Flood Risk Assessment is undertaken at Stage 3.

5.13.178. Further data on local abstractions and private water supplies within the study area should be sought to determine the level of impact on these supplies.

5.13.179. Consultation with Northern Ireland Water with regards to public water supplies within the area will allow a more detailed assessment to take place.

5.13.180. NVC surveys should be carried out to determine the presence and extent of GWDTEs.

5.13.181. There is an opportunity to address any existing water quality or flooding issues for this section of the strategic and local road network or bring it to a higher standard.

5.14. Assessment of Cumulative Effects

5.14.1. This assessment focuses on the main likely significant cumulative effects rather than reporting every interaction. Where possible impact interactions between environmental subject areas exist and no project specific environmental effects are predicted for one interacting subject area, potential for cumulative effects have been scoped out as the probability of cumulative effects occurring is low.

5.14.2. No assessment of cumulative effects has been undertaken for materials use and waste generation as waste generation will be restricted to development boundaries and any requirements for materials and waste disposal will be dealt with on a development by development basis.

5.14.3. Potential cumulative effects could arise in two forms. One, referred to as interactive cumulative effects in this report, results from effects (e.g. noise, visual, air quality) on the same receptors or resources due to their location or impacts. The second referred to as in-combination cumulative effects include effects resulting from the options in combination with effects of other proposal and local developments on either: the same receptors / resources or receptors / resources in general.

5.14.4. Interactive cumulative effects would generally be confined to receptors adjacent to the options, and would derive from the additive effect of the options: e.g. deterioration in air quality through increased vehicle emissions; increases in traffic-sourced noise levels; and heightened visual intrusion through increased visual exposure to new highway infrastructure (e.g. environmental barriers).

5.14.5. In-combination cumulative effects include effects resulting from the options in combination with effects of other options and local developments on either: the same receptors / resources or receptors / resources in general. Current DMRB guidance (Volume 11, Section 2, Part 5) requires the cumulative effects assessment of trunk roads that have been confirmed (i.e. gone through the statutory processes) and development projects with valid planning permissions as granted by LPAs, and for which statutory EIA is a requirement or for which non-statutory EIA has been undertaken.

Study Area

5.14.6. The interactive cumulative study area has been dictated by the study areas adopted for the interacting environmental aspect being considered . These are as detailed in the respective assessment sections (Section 5.5 to 5.13). For all potential interactions, the smaller study area has been adopted as possible interactions will not exist outside the scope of one interacting aspect.

5.14.7. For instance, for possible interaction between nature conservation and air quality with regards to habitat loss and dust generation during construction, where habitat loss is restricted to the “immediate zone of influence of the options”, interactive cumulative effects outside the proposed scheme’s immediate zone of influence is not considered as the potential for interaction is removed outside this area. The study area in this instance will be the proposed scheme’s immediate zone of influence as defined in Section 5.8.

5.14.8. In light of the above, further explanation on the study area adopted for potential interactive cumulative effects will be given in the respective impact assessment sections.

Methodology

Interactive Cumulative Effects

5.14.9. As described in Section 5.3, collaborative work has been undertaken between environmental and traffic modelling disciplines to capture the data interdependencies between the two and these have been highlighted within this report.

5.14.10. This ensures that the traffic model meets the requirements for further environmental assessment, at a detailed level, during Stage 3. Further, the work undertaken between disciplines at Stage 1 and 2 ensures that the detailed assessments requiring traffic are inherently cumulative as the performance of other road network influencing the operation of the options are provided for in the traffic model. As a result of this, the air quality and noise assessments are inherently cumulative assessments.

5.14.11. Identification of interaction between potential / predicted impacts (before mitigation) as reported in Section 5.5 to 5.13 that would result in significant cumulative effects. Where neutral or slight (adverse/beneficial) effects are concluded in both subject area assessments, the potential for these to result in significant interactive cumulative effects were ruled out.

5.14.12. GIS spatial analysis in the form of overlay mapping makes use of mapping layers prepared as part of the subject assessment to identify the spatial distribution of impacts and identify where impact interaction may occur as a result of the proposed project.

5.14.13. The assessment also considers potential cumulative environmental effects arising from past actions in considering the baseline environment; present and future actions in considering the proposed scheme during the construction and operational phases as well as other planned schemes in the vicinity of the options. It considers effects during the construction (temporary / short term effects) and operation phase (permanent / long term effects). In doing this, highly mobile receptors have not been considered as a level of immobility is required be subject to significant interactive cumulative effects. Users of footpaths, roads and railway lines have therefore not been considered.

5.14.14. Confirmation of study area / a process of identifying clusters or groups of receptors which experience multiple potential significant interactive cumulative effects was undertaken.

5.14.15. The assessment of significance of Cumulative Effects was undertaken with reference to Table 2.4 of the DMRB Vol.11, Section 2, Part 5, HA 205/08.

In-combination Cumulative Effects

5.14.16. Information gathering of planning developments, mainly to establish a baseline of which developments may contribute to likely significant in-combination cumulative effects adjacent to the options. Planning application which had approval from ABCB Council (PlanningNI Portals) were identified. The parameters used to identify an initial list of developments included:

- Description of the development
- Proximity to known environmental receptors assessed

5.14.17. Establishment of the potential interaction between the options and other developments.

5.14.18. Confirmation of the study area and baseline conditions for the elements with potential to result in in-combination effects.

5.14.19. Review of the impact assessment and conclusion regarding these elements. Where a scheme is not expected to result in a topic related effects, in-combination cumulative effects are ruled out. Where topic related effects are expected for both projects being considered, an assessment of overlaps between areas of predicted effects has been undertaken as the potential for cumulative effects exists within these overlap areas.

5.14.20. Based on current information and guidance, projects scoped in to the in-combination cumulative assessment are development projects within the study area with valid planning permissions as granted by LPAs, and for which statutory EIA is a requirement or for which non-statutory EIA has been undertaken.

5.14.21. To arrive at a significance of effects, Table 2.6 of DMRB Volume 11, Section 2, Part 5: HA 205/08 has been used.

Potential Impact

5.14.22. The scoping exercise concluded that there is the potential for interactive cumulative effects on receptors and resources.

5.14.23. Table 5-61 – The Options Potential for Interactive Cumulative Effects within the Study Area provides details on the potential key interactions identified and reported in Sections 5.5 to 5.13.

Table 5-61 – The Options Potential for Interactive Cumulative Effects within the Study Area

Subject Areas	Air Quality	Cultural Heritage	Landscape Effects	Nature Conservation	Geology and Soils	Noise and Vibration	The Water Environment
Air Quality		**None**	**Yes** – slight adverse visual effects identified and potential increase in dust deposition during construction not considered significant.	**None** –slight adverse impact expected from loss of habitat and increased dust deposition on habitats. No potential for significant adverse cumulative effects.	**None**	**Yes** – increase in noise levels and dust deposition during construction. Increase in traffic noise levels (short and long term) and NO_2 during operation.	**None**
Cultural Heritage	None		**Yes** – potential adverse impacts on settings and visual impacts	**Yes –** only neutral or slight adverse effects are predicted. Interactive cumulative effects may arise from activities such as: • Trial holes/bore pits; • Noise/lighting schemes; and • Drainage and flood compensation schemes.			
Landscape Effects	Yes	Yes		**Yes** – loss of habitat and visual screening vegetation	**None**	**Yes** – noise increase during construction and visual impacts on same receptors.	**None**
Nature Conservation	Yes	Yes	Yes		**None**	**None**	**None** –slight adverse impact from potential water works and subsequent impact on salmon.
Geology and Soils	None	Yes	None	None		**None**	**None**
Noise and Vibration	Yes	Yes	Yes	None	None		**None**
The Water Environment	None	Yes	None	None	None	None	

Notes:
To avoid repetition, cells have been greyed out.

Interactive Cumulative Effects

5.14.24. The scoping exercise indicated that the following environmental aspects could be subject to cumulative interactive effects.

Air Quality and Noise

5.14.25. Relevant sensitive receptors within 200m of the options could experience cumulative air quality and noise impacts. Based on the current options 'footprint' the options could impact 2552 receptors. The air quality and noise assessment in this report indicated that there is uncertainty regarding likely significant effects. The combination of both air quality and noise impacts would increase the likelihood of these receptors receiving significant effects. A review of areas predicted to experience air quality and noise impacts was undertaken. During construction, potential exists for interactive cumulative effects resulting from deterioration in air quality (increase in PM_{10} and dust deposition) and increases in traffic noise levels. Following the methodology outlined in Section 5.5, the study adopted for this assessment has been 200m from the options – the HD207/07 defined area for the air quality construction assessment as beyond this area, the potential for interaction with construction noise impacts in the additional 100m considered as part of the construction noise assessment is removed.

Cultural Heritage and Landscape

5.14.26. Interactions could potentially occur in relation to landscape character and tree planting and setting of cultural heritage assets. Option 12 junction with A3 Portadown Road may have visual impact on the settings of Little Castle Dillon, Grade B Listed Building. The listed building has already been assessed as a visual receptor within the landscape and visual assessment (Section 5.7). However, further assessment is required for both environmental aspects during Stage 3 to determine the extent to which mitigation measures, which will comprise of replacing verge planting, to reduce potential impacts should be included into the design. There is uncertainty regarding cumulative likely significant and adverse effects as a result of the options on these two environmental aspects.

Cultural Heritage and Nature Conservation, Geology and Soils, Noise and Vibration and The Water Environment

5.14.27. Cumulative effects to cultural heritage assets may arise from activities related to other disciplines. Examples of such activities might include drainage and flood compensation schemes, landscaping and tree planting, trial holes/bore pits, noise and lighting schemes. Known heritage assets have been mapped and design and mitigation issues discussed so that other disciplines are aware of issues which may affect cultural heritage. Regular communication regarding any further design strategies particularly in relation to planting, drainage, flood compensation areas and landscaping will ensure that any possible impact will be minimised.

5.14.28. Cumulative effects are also possible during the operational phase, for example through maintenance works and long term change to the setting of historic buildings and the historic landscape.

5.14.29. It should be noted that lived in cultural heritage assets have been assessed as potentially residential dwellings.

5.14.30. A large part of the 2007 Option is online, with limited sections passing through undeveloped or agricultural land. The setting of surviving areas of the historic agricultural landscape has already been adversely impacted by proximity to existing

development. No impact is predicted to designated or industrial heritage assets. The presence of sub-surface archaeological assets is undefined. The cumulative effects of the 2007 Option on cultural heritage assets is assessed as **minor adverse**.

5.14.31. Option 12 passes through a predominantly agricultural landscape. The character of the historic agricultural landscape at the north and centre is largely consistent with the landscape shown on late 19th century Ordnance Survey mapping. However, the agricultural landscape at the south has seen rationalisation through removal of field boundaries. This option may have a minor adverse impact on one designated built heritage asset (Castle Dillon: Grade B), dependent on the junction design with the Portadown Road, but no impact is predicted to industrial heritage assets. The presence of sub-surface archaeological assets is undefined. The cumulative effects of Option 12 on cultural heritage assets is assessed as **moderate adverse**.

5.14.32. The majority of the northern section of Option 16 is online, with the centre and south passing through agricultural land. The historic agricultural landscape at the centre of the option is largely consistent with the landscape shown on late 19th century Ordnance Survey mapping, but the southern section has been adversely impacted by removal of field boundaries. No impact is predicted to industrial or built heritage assets. The presence of sub-surface archaeological assets is undefined. The cumulative effects of Option 16 on cultural heritage assets is assessed as **minor adverse.**

Landscape and Nature Conservation

5.14.33. Interactions would potentially occur during the construction phase of the options. During construction, cumulative effects could arise from the loss of habitat in addition to the potential effects on landscape character from the removal of roadside vegetation and its contribution to local character. Mitigation proposals would seek to replace vegetation removed with native planting which in the medium to long term would restore both habitat and capacity to integrate the corridor within the wider landscape framework. As mitigation of the potential impacts to receptors will be developed as part of iterative, and later stages of, design uncertainty regarding likely significant effects remains.

Landscape Effects, Noise and Air Quality

5.14.34. Potential for visual impacts have been predicted on a number of receptors (see section 5.7). In these areas there is also potential for noise and air quality impacts. The significance of these interactive cumulative effects will be further determined during Stage 3 using the results of the noise / air quality monitoring or surveys data and the detailed visual impact assessment. As mitigation of the potential impacts to receptors will be developed as part of iterative, and later stages of, design uncertainty regarding likely significant effects remains.

In Combination Effects

5.14.35. Table 5-45 and Drawing No 1064968-B-D-3036 and 1064968-B-D-3037 (see *Appendix A*) indicates the approved development within the study area. The highlighted developments could result in ‘in combination’ effects, however, uncertainty remain regarding likely significant effects.

5.14.36. The options with other potential development could result in cumulative effects for receptors experiencing noise and air quality impacts. The updated traffic model that will be utilised for the noise and air quality modelling includes all of the above developments. Therefore, the assessment of air quality and noise impacts during Stage

3 will, in effect, be a cumulative impact assessment for the DM (2020) and DS (2035) scenarios.

5.14.37. There is potential for in-combination effects for the options with Nature Conservation, People and Communities and the Water Environment. The options will require landtake adjacent to the several habitats, watercourse linkages, PRoW / residential / community / agricultural land.

5.14.38. For People and Communities the options create severance of agricultural land parcels. There is uncertainty regarding likely significant and adverse in-combination effects on the landowner as the construction of a road here may preclude future and intended use of these land parcels.

Limitation of Assessment

5.14.39. During consideration of the options at DMRB Stage 2 there is limited opportunity to identify in-combination effects, due to factors such as the early development of the design; absence of details on construction programming and methods; and the need to consider the options.

5.14.40. The EIA Regulations require cumulative impacts to be considered as part of a statutory EIA, and as such this will form part of the scope for EIA at DMRB Stage 3. This will include identification of other major projects that could contribute to a cumulative impact.

Recommendations for Further Works

5.14.41. It is recommended that during Stage 3, ABCB Council is consulted to update the planning application information by requesting GIS data held by the local authority to identify if there are any new planning applications which should be considered in further assessments of in-combination effects.

5.15. Consultations

5.15.1. No Statutory Consultees have been involved at this stage of assessment.

5.16. Summary of Environmental Assessment

5.16.1. The local and regional air quality impacts of implementing any of the options are predicted to be predominantly beneficial. However, the magnitude of changes of these improvements are relatively small. As such, the options are not predicted to result in a significant environmental effect with respect to local and regional air quality.

5.16.2. There is one designated built heritage asset identified with the potential to be impacted upon. The junction of Option 12 with A3 Portadown Road may impact on the settings of Little Castle Dillon, a Grade B Listed Building.

5.16.3. While there would be a landscape planting strategy in place as part of the options, there would still be a high likelihood for significant effects on the drumlin agricultural landscape for Option 12. Mitigation planting would integrate the 2007 Option and Option 16 into the Industrial Fringe Landscape effectively and reduce the likelihood of significant effects.

5.16.4. With regard to visual impact, the 2007 Option would have the largest number of receptors with a high likelihood for significant impacts due to its proximity to residential areas, being lit along the entire route and having less available land within which to apply mitigation measures. Option 12 would have high likelihood of significant effects as a result of large earthworks and effects on views more rural in nature, although Option 12 has fewest number of affected receptors. Option 16 has fewer receptors than the 2007 Option due to the alignment avoiding the numerous receptors along Ardmore Road.

5.16.5. A detailed visual impact assessment would be required as part of the Stage 3 assessment to fully understand the potential visual effects of any options going forward once the detail design has been developed.

5.16.6. There are no national or international statutory nature conservation designations and no local non-statutory nature conservation designations within the study areas. There is therefore no likelihood that any of the options will have an effect on designated sites. There will therefore be no significant effect on designated sites from any of the options. With regards to European Protected Species like Badgers and Bats, survey work to date identified habitats within the study area that are suitable for these species. Further survey work to establish the presence and extent of activity should be undertaken at Stage 3 when the preferred route option has been identified.

5.16.7. With regard to Noise and Vibration adverse impacts are found at receptors close to the proposed road alignments across all options. The 2007 Option can be seen to have the highest number of adverse noise impacts of the three. The assessment predicts that there are more major and minor noise impacts associated with this route in both the short and the long term. It is recommended that during Stage 3 a further screening exercise is undertaken to inform discussions in relation to the potential mitigation measures (such as noise barriers or low noise surfacing) in areas of particular concern if the potential for adverse impacts is identified.

5.16.8. The impact on People and Communities have been assessed as similar across the three routes. Despite specific concerns over severance in the Ardmore area being raised at previous public information events the relatively low traffic volumes (approximately four thousand cars daily) have resulted in the impact of severance for NMU routes being categorised as slight. Notwithstanding, it is proposed that during the Stage 3 assessment, consultations should be undertaken with affected asset owners and receptors identified in order for a detailed assessment of potential effects to be undertaken. The options have the potential to include elements which could reduce

community severance and provide better walking / cycling facilities by providing enhancements which would benefit the local NMU network. These opportunities will be further considered during Stage 3.

5.16.9. In terms of Road Drainage and the Water Environment, for the areas assessed, the impacts are identified as being broadly similar across all three route options. This assumes that there have been good practice measures outlined in the mitigation sections within the design of the schemes. There are still uncertainties for the three routes concerning ground / surface water impact and flood risk which will be assessed further as part of the Stage 3 assessment.

5.16.10. A high-level summary of the environmental assessment undertaken for each option with a RAG rating applied, as outlined in Table 5-62 - RAG Application, is attached in Appendix I.

Table 5-62 - RAG Application

High Likelihood	Where there is a high degree of confidence that impact / effects will be significant. This may be because the receiving environment may already be close to its carrying capacity for change or large scale and permanent effects are thought likely to occur. However, these impacts could be reduced through further assessment of mitigation measures.
Uncertain	Where it is judged impacts / effects are likely; however, there is enough uncertainty as to whether they are likely to be significant. Further survey and assessment is likely to be required to further understand significance.
No/Low Likelihood	Where there is a high degree of confidence that no significant impacts / effects will occur due to either: • no effects occurring (lack of a source pathway or receptor) (No), or • effects will occur but not deemed significant. (Low)
	N/A

5.16.11. In summary, the environmental assessment concludes that there are no significant barriers to the development of the route options proposed. However, it recognises that, with regard to noise and visual amenity, further consideration at detailed design stage is required to identify appropriate mitigation to address any adverse effects, particularly for the 2007 Option which has a higher number of sensitive receptors.

6. Traffic and Economic Assessment

6.1. Modelling

6.1.1. Following consultation with DFI a traffic model for Armagh, using the SATURN software (Version 11.1.09) was built to allow a comprehensive review of the proposed link road junction strategy. The following paragraphs highlight the main points in developing the model.

6.1.2. A programme of surveys was undertaken during Autumn of 2014, comprising Automatic Traffic Counts, Turning Movement Counts and Journey Time surveys. This data was used to update the previous 2006 base year model to a 2014 base model.

6.1.3. The data collection programme comprised:-

- 31 Manual Turning Counts
- 21 Automatic Traffic Counts
- 10 Classified Link Counts
- 4 Journey Time Routes

6.1.4. On the basis of the survey data (Automatic Traffic Counts and Manual Classified Counts) analysis, and in order to be consistent with national methodologies for forecasting, which usually operate on whole hour periods, two time periods were modelled separately as follows:-

- AM Peak hour (08:00 – 09:00)
- PM Peak hour (17:00 – 18:00)

6.1.5. The network has been specified by a simulation network over the study area where the junctions are coded and junction delays are modelled explicitly. The highway network was modelled in detail to ensure that all major local and through traffic routes were included. Figure 6-1 below presents the coverage of the traffic model.

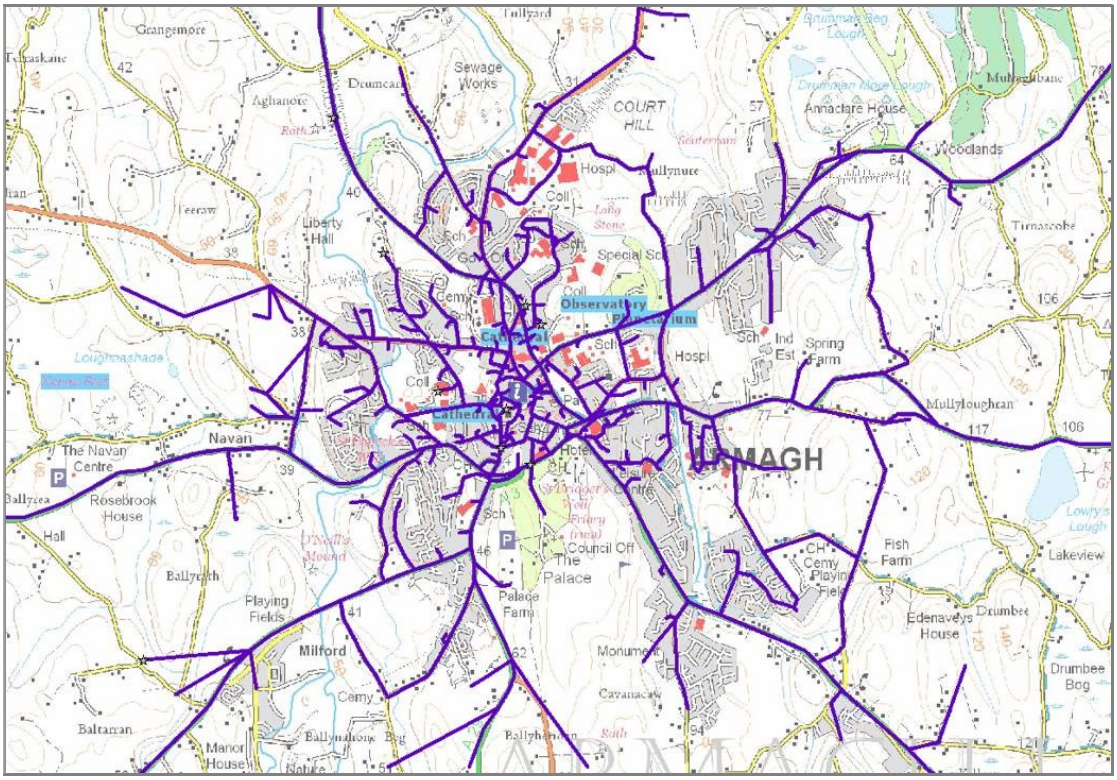

Figure 6-1 - Traffic Model Study Area Network

6.1.6. Information on the existing road network was gathered from maps and plans, aerial photography, inventory surveys and site visits. Speed-flow relationships were then allocated to links based on the following criteria:-

- Their locations and functions (rural, urban, suburban)
- Dual or single carriageway standard
- Number of lanes
- Class of road (motorway, A, B, C)
- Quality of road (good, average, poor)
- Speed limit
- Level of frontage development

6.1.7. Highway junctions were modelled in detail in order to take account of traffic flows and conflicting movements as well as to represent the effect of traffic delays and queues. Each junction was coded by using detailed information of the highway network, which included:-

- Junction type (signalised, priority, roundabout)
- Number of arms
- Allowed turns
- Turning capacities based on geometric parameters
- Traffic signal details (stage/phase arrangements and timings)
- Vehicle circulating capacity and travel time (for roundabouts)

6.1.8. A zoning system was defined to provide geographical sub-division of the modelled area. A total of 146 zones were defined. The purpose of defining the zoning system is to facilitate the allocation the Roadside Interview Survey (RSI) / Pedestrian Survey (PS) survey responses to a geographical area. Each zone is then represented by column and a row in what is called the demand (or trip) matrix, where the rows represent the trip origin and the columns represent the trip destination. A graphical representation of the zoning system is shown in Figure 6-2 below.

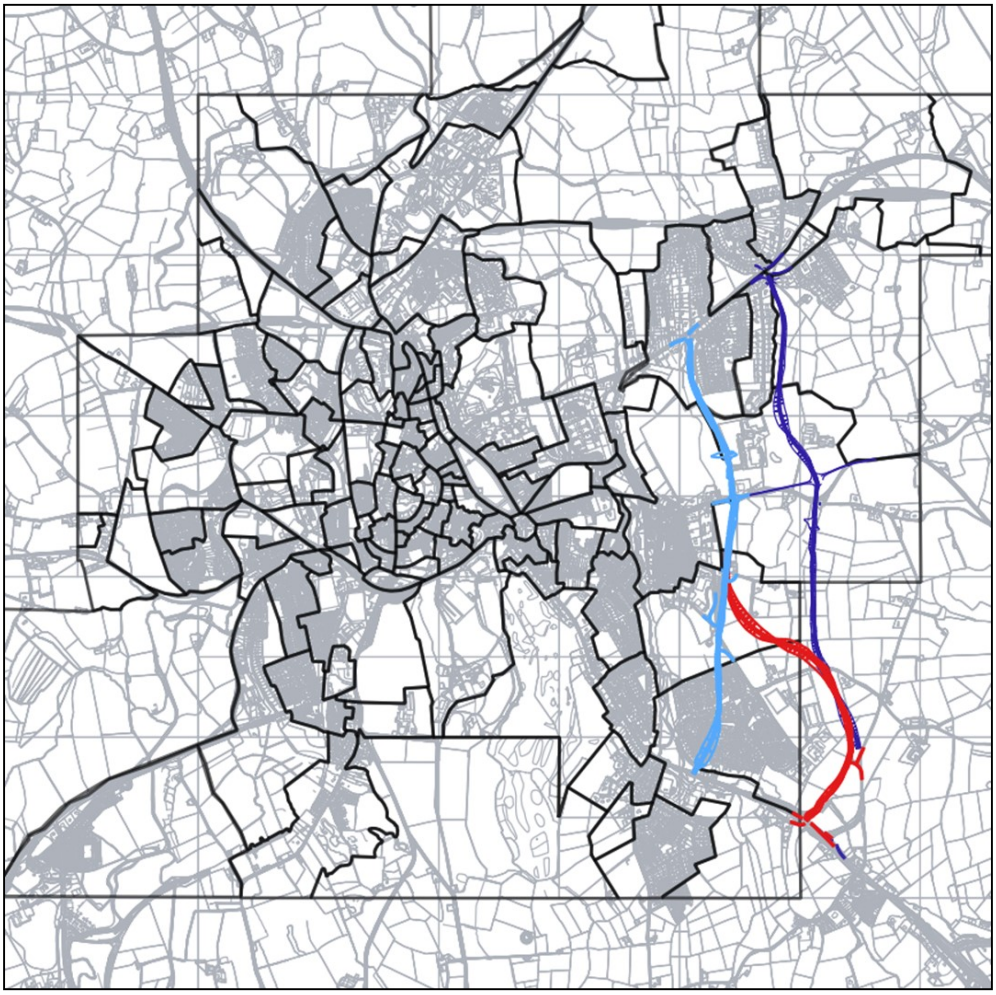

Figure 6-2 - Zoning System / Allocations

6.1.9. The Base year matrices for this study have been developed to represent an average weekday in 2014. They have been based on the Roadside Interview Survey data which was collected for an earlier study in 2004, used in the absence of other sources of information relating to trip origins and destinations within the area.

6.1.10. Data from DFI census points at strategic network locations are collected annually and provide a reliable source of traffic flow information. Analysis of the traffic census data at a number of locations, shown in Figure 6-3, in the vicinity of the study area revealed that during the intervening years between 2004 and 2014 the traffic flow levels have remained relatively unchanged. It was concluded that the 2004 trip origin and destination data could be deemed relevant and could reasonably be used in developing the model. The traffic levels at the specific locations for the period 2004-2012 are presented in Figure 6-4 - Traffic flow levels at DFI Census Locations below.

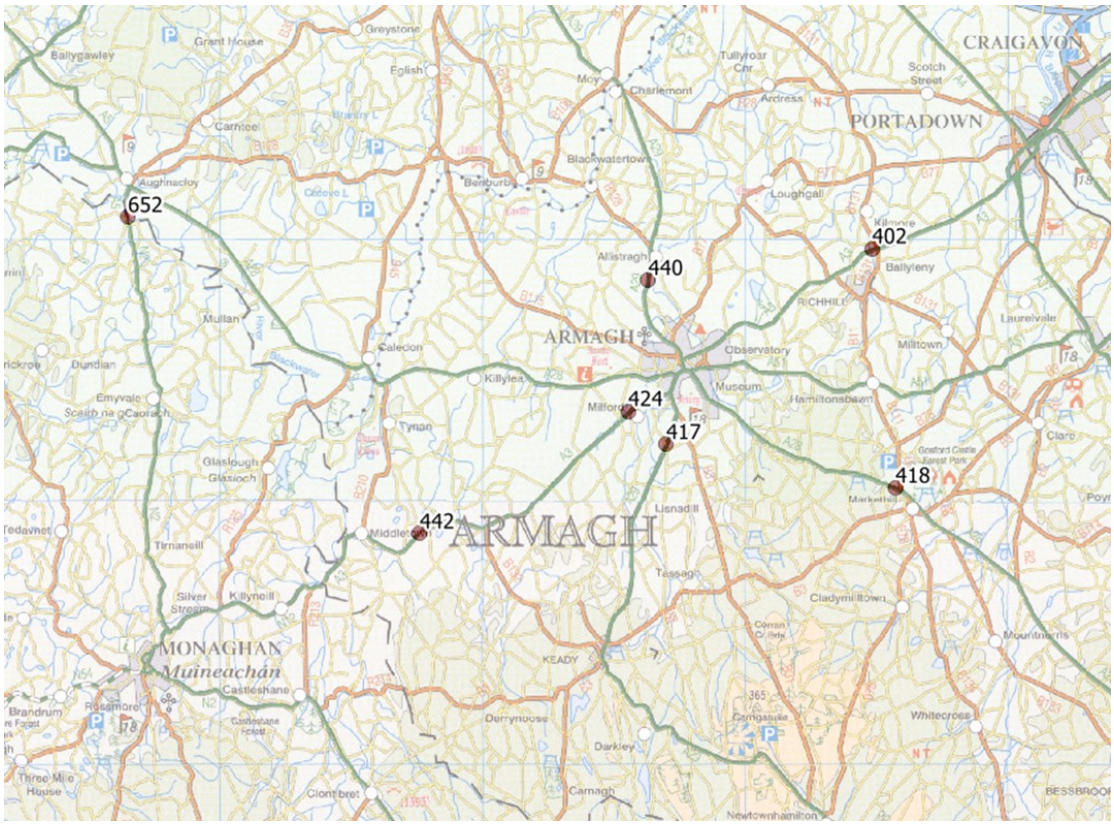

Figure 6-3 – DFI Traffic Census Locations

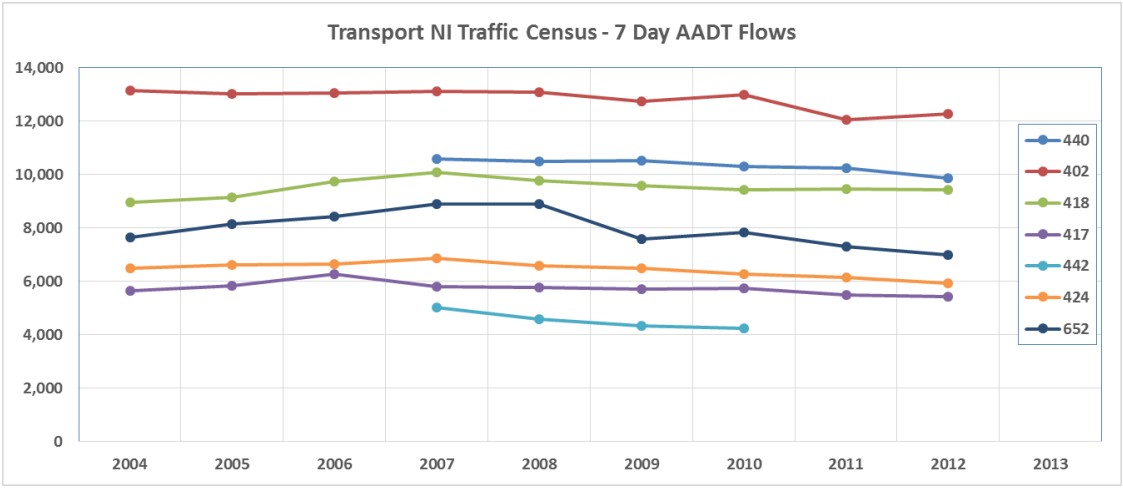

Figure 6-4 - Traffic flow levels at DFI Census Locations

6.1.11. The calibration of the traffic model was undertaken using a standard approach where the network is adjusted to ensure that the model realistically replicates routeing and vehicle speeds through the study area.

6.1.12. The calibration procedure can be broken into the following activities:-

- Checks to ensure that link speeds on the network are realistic
- Checks that the delay calculations at junctions are operating realistically

- Adjustment and checking of the network properties to ensure realistic routeing of traffic

6.1.13. Following the model calibration process, model validation was undertaken where the model outputs are compared against independent observed data that have not been used in the model development process. Network validation was also undertaken to establish that the network structure was accurate and that characteristics of the network are suitably represented in the model. A number of range and logic checks were undertaken such as routeing checks. Assignment validation was then undertaken for traffic flows (links and turns) and journey times. The journey time routes that have been evaluated are presented in Figure 6-5 - Surveyed Journey Time Routes below.

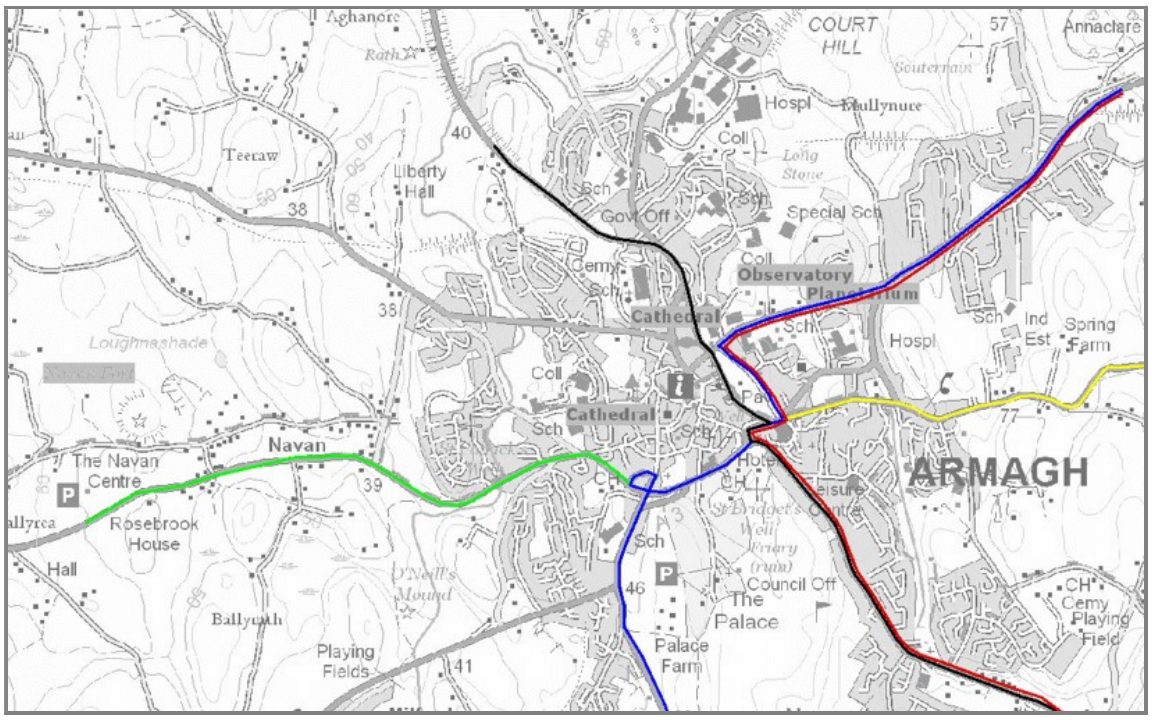

Figure 6-5 - Surveyed Journey Time Routes

6.1.14. Table 6-1 and Table 7-2 below present the validation statistics for the journey time validation. The model compared well with the observed data, and met the DMRB validation criteria at 19 out of 20 locations. Overall it can be said that the Armagh base model for 2014 represents to a good degree the current traffic conditions and can therefore be used to form the basis for the forecasting and economic evaluation of the proposed options for the Armagh East Link scheme.

Table 6-1 - AM Peak Journey Time Validation

Route	Direction	Distance (km)		Journey Times (mm:ss)						
		Obs	Model	Observed			Modelled			
				Obs	Lower	Upper	Model	Diff	%Diff	Pass?
1	NB	3.34	3.36	09:19	07:44	10:55	10:32	01:13	13%	✓
	SB	3.36	3.16	11:22	09:54	14:08	10:05	-01:17	-11%	✓
2	EB	0.97	0.96	02:00	01:43	02:13	01:52	-00:08	-7%	✓
	WB	0.97	0.96	01:48	01:42	01:55	01:49	00:01	1%	✓

Route	Direction	Distance (km)		Journey Times (mm:ss)						
		Obs	Model	Observed			Modelled			
				Obs	Lower	Upper	Model	Diff	%Diff	Pass?
3	NB	3.19	2.85	08:48	08:48	08:48	08:31	-00:18	-3%	✓
	SB	2.42	2.45	07:15	06:29	08:01	07:00	-00:15	-3%	✓
4	EB	1.76	1.75	02:49	02:46	02:52	02:51	00:02	1%	✓
	WB	1.76	1.75	02:51	02:51	02:51	03:08	00:17	10%	✓
5	NB	3.51	3.59	10:55	10:55	10:55	10:10	-00:45	-7%	✓
	SB	3.47	3.61	10:26	10:26	10:26	09:44	-00:42	-7%	✓

Table 6-2 - PM Peak Journey Time Validation

Route	Direction	Distance (km)		Journey Times (mm:ss)						
		Obs	Model	Observed			Modelled			
				Obs	Lower	Upper	Model	Diff	%Diff	Pass?
1	NB	3.34	3.36	09:33	08:31	10:25	10:46	01:13	13%	✓
	SB	3.36	3.16	11:00	09:33	13:42	10:23	-00:37	-6%	✓
2	EB	0.97	0.96	01:55	01:46	02:03	01:52	-00:03	-2%	✓
	WB	0.97	0.96	01:57	01:51	02:07	01:53	-00:03	-3%	✓
3	NB	3.19	2.85	10:03	09:44	10:21	08:14	-01:48	-18%	✗
	SB	2.42	2.45	08:07	07:03	09:41	07:45	-00:22	-5%	✓
4	EB	1.76	1.75	02:55	02:42	03:07	03:07	00:12	7%	✓
	WB	1.76	1.75	03:00	02:41	03:35	02:50	-00:10	-5%	✓
5	NB	3.51	3.59	09:39	09:39	09:39	10:30	00:51	9%	✓
	SB	3.47	3.61	09:56	09:56	09:56	09:39	-00:17	-3%	✓

6.2. Forecasting

6.2.1. The 2014 Base year traffic model forms the basis for the development of the future year traffic models to support the design and appraisal of the Armagh East Link. The future year models were developed for a scheme opening year of 2020 and a design year of 2035. Global growth factors, extracted from the information contained in the Department's "Road Transport Forecasts 2013" document, have been used to produce the future year trip matrices for 2020 and 2035. Traffic census data highlighted that there has been minimal growth over the past 10 years and therefore Low growth was considered appropriate for the economic benefit calculation. For comparison purposes the results for the Central growth assumption are presented in Appendix J.

6.2.2. Future year networks for 2020 and 2035 were developed by coding in the proposed highway improvement schemes. Committed schemes were included to create the Do-Minimum networks and the scheme options for the proposed Armagh East Link were then included to represent Do-Something options.

6.2.1. The committed developments consist of two key development sites (identified in Figure 6-6), assumed to be fully developed by the opening year. These are listed below:

- Drummad Barrack: Industrial estate (7.5 hectare) and housing (160 households) with access from Hamiltonsbawn Road (or AEL Central route option); and
- Mullinure Estate: additional 500 households, accessed from the proposed North/West Link and from Portadown Road

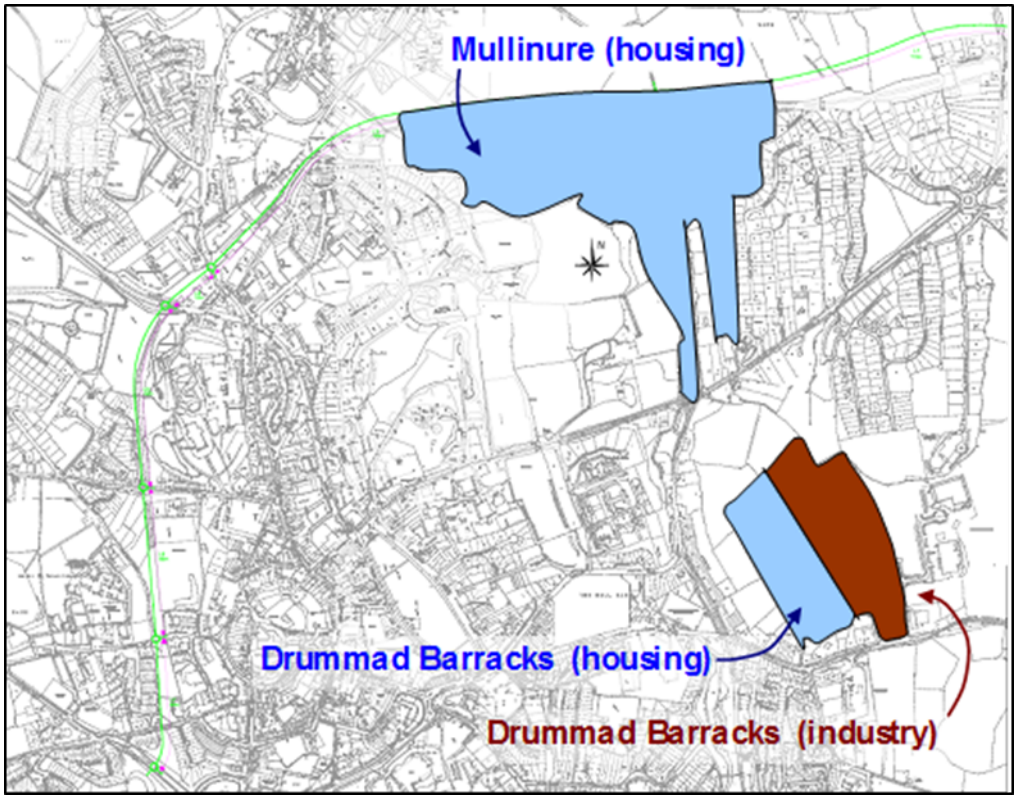

Figure 6-6 - Committed Developments

6.3. Effects of Scheme Options

6.3.1. The forecast matrices were assigned to the future year networks (Do-Minimum and Do-Something). The assignment process for each scenario has been observed to converge and meets the convergence criteria set out in the Department's guidance notes.

6.3.2. The forecast Annual Average Daily Traffic (AADT) flows are presented in *Appendix K.*

6.3.3. The modelling exercise has considered four alternative Do-Something scenarios against a Do-Minimum scenario. Low and Central Growth scenarios have been considered. Analysis has been conducted primarily on the AM peak as this represents the highest levels of congestion in Armagh.

6.3.4. The 2007 Option is the most westerly alignment linking the A3 to the A28 from the Linsey's Heights area and the existing Ardmore Road. Option 12 is a more easterly alignment to this. Option 16 is a combination of the 2007 Option to the North and Option 12 to the south.

6.3.5. Each option offers various permutations of linkage with the intervening arterial network. Hamiltonsbawn Road is served by each option. A southern access via either Bannvale Villas, Ballynahonemore Road or Edenaveys Road is included in each Option.

6.3.6. Each of the options has been evaluated using a fixed matrix and therefore the traffic impacts reflect the impact of traffic assignment and the impacts of capacity constraint on flow patterns.

6.3.7. The following commentary reflects the Low Growth scenario in 2020, but the general patterns are also representative of Central Growth and later forecast years.

6.4. Peak Hour Traffic Flows

6.4.1. In traffic terms the 2007 Option decants around 250 vehicles two-way peak-hour flow away from the A3. A proportion of the traffic on the northern section is involved in accessing the adjacent development site. South of Hamiltonsbawn Road the flow is around 100 vehicles. Flows at the southerly end of the alignment are higher at around 390 vehicles but also represent access and egress for local traffic in the vicinity. Traffic relief in the centre of Armagh (College Hill and The Mall Area) is modest and the greatest impact is felt on Drumadd Road where approximately 150 vehicles are decanted. Hamiltonsbawn Road traffic to and from Armagh is elevated. Other areas of relief include the A28 Markethill Road as far as Ardmore Rd.

6.4.2. Option 12 attracts around 160 vehicles on the northern section and around 260 vehicles on the central section. Flows to the south are around 290 vehicles. Traffic relief in the City Centre is reduced as the route is further out and less favourable for diversion in comparison with the 2007 Option.

6.4.3. This option has high flows to the North (350 vehicles) and 260 to the south. A proportion of the traffic on the northern section is involved in accessing the adjacent development site. Traffic relief in the City Centre is modest due to the southerly link into the A28 coupled with limited connectivity with the arterial network in the Ardmore area.

6.5. Journey Times

6.5.1. To assess the effect of the proposed options the journey time between two points at the perimeter of the study area has been compared against the modelled time for the Do-Minimum. Figure 6-7 - Do-Minimum Survey Points below presents these two points.

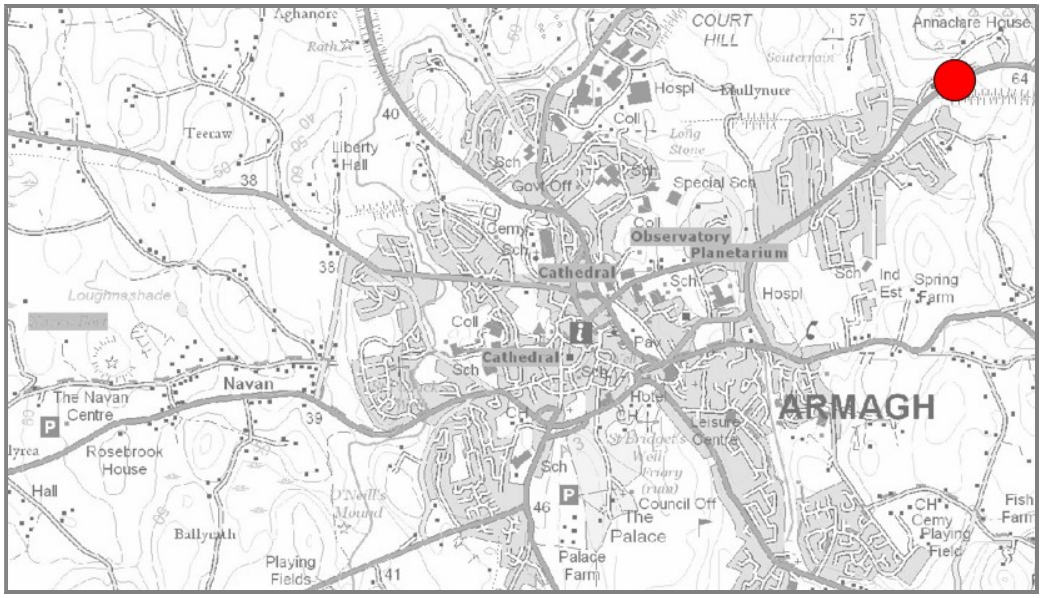

Figure 6-7 - Do-Minimum Survey Points

6.5.2. All options result in reducing journey times between the two given points. The journey time used for the Do-Minimum scenario is based on travel via the town centre.

6.5.3. Journey time comparisons in Figure 6-8 - Journey Time Comparison Opening Year 2020, AM Peak to Figure 6-11 - Journey Time Comparison Design Year 2035, PM Peak show significantly reduced journey times where trips use the Armagh East Link. The highest reduction observed consistently across all time periods, and for the opening and design year, is Option 12. Option 16 and the 2007 Option achieve similar reductions in journey time. These results are to be expected given that Option 12 is proposed closer to the origin and destination points and allows for higher speeds along its length.

6.5.4. It is important to recognise the limitations of the Journey Time Comparison highlighted here as it only compares results for a single route. However, it should be recognised that journey time savings for each option across the network have been identified and recorded as part of the Present Value of Benefits (PVB), see Tables 6-7 and 6-8.

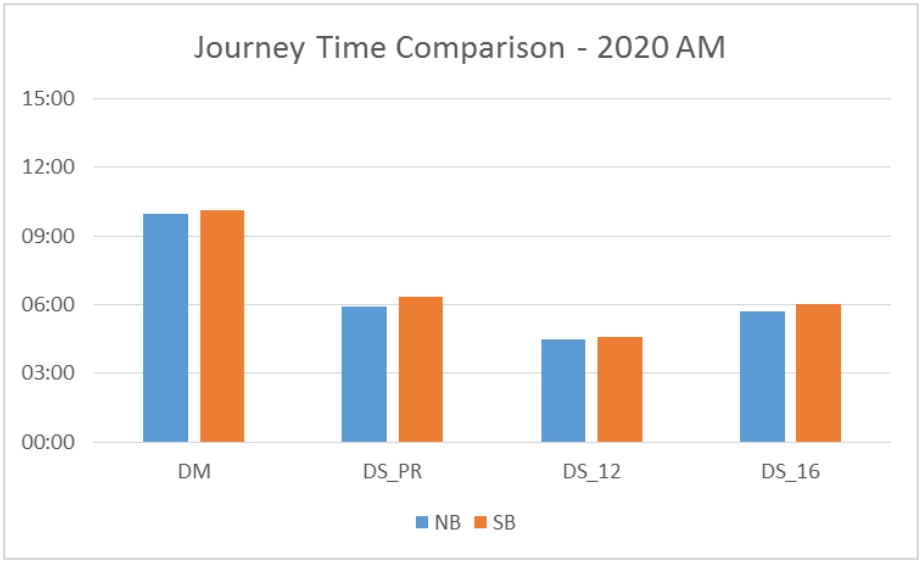

Figure 6-8 - Journey Time Comparison Opening Year 2020, AM Peak

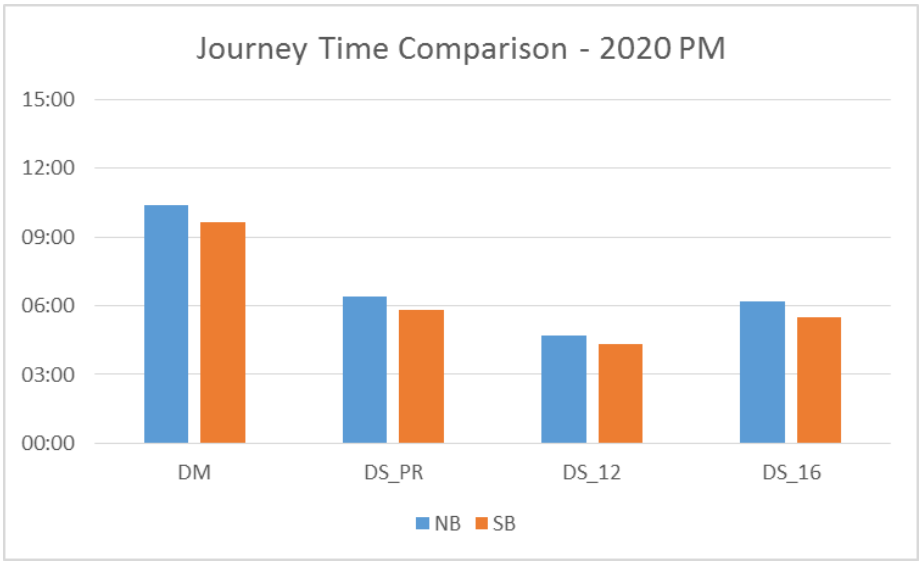

Figure 6-9 - Journey Time Comparison Opening Year 2020, PM Peak

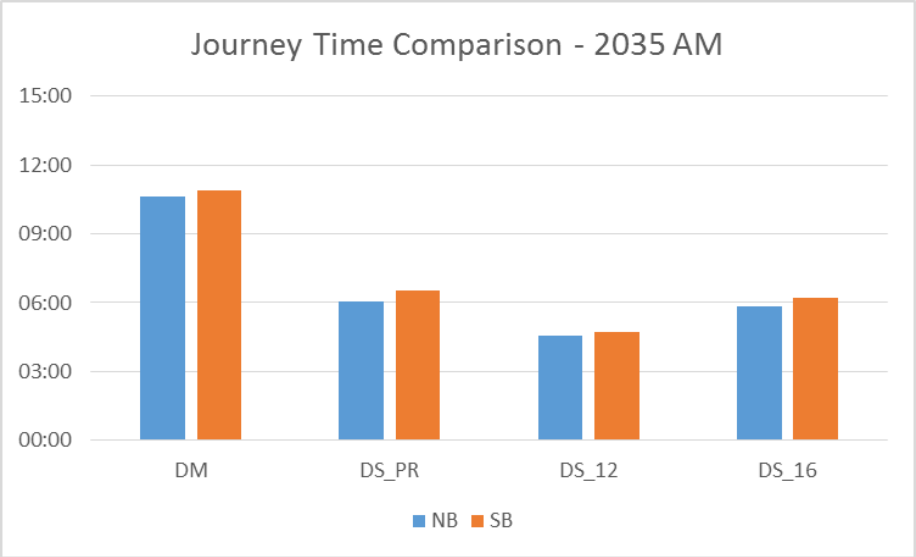

Figure 6-10 - Journey Time Comparison Design Year 2035, AM Peak

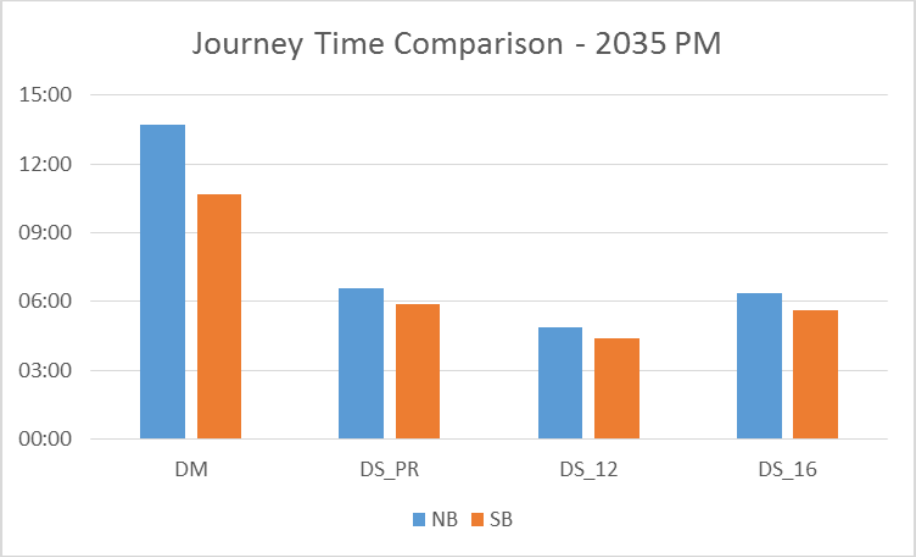

Figure 6-11 - Journey Time Comparison Design Year 2035, PM Peak

6.5.5. The forecast Annual Average Daily Traffic (AADT) flows are presented in *Appendix K.* The key points are highlighted below;

- All options serve to provide improved access and an alternative route to and from the city centre via Hamiltonsbawn Road, with Option 12 drawing significant volumes of traffic onto sections of Hamiltonsbawn Road.
- All options reduce traffic at The Mall.
- All options reduce traffic on Drumadd Road.
- Traffic is redistributed in and around Barrack Hill and Victoria Street.
- All options decrease traffic on the A28 to and from Friary Road.
- The 2007 Option provides the most relief to the A28 and significant relief to Drumadd Road.

6.5.6. Table 6-3 presents the collision savings resulting from the introduction of the proposed options (measured in persons involved in collisions) and Table 6-6 presents the casualty savings (measured in the number of persons).

Table 6-3- Scheme Option Collision Savings (Low Growth Assumptions)

Option	Yr	Collisions											
		Do-Minimum (Existing)				Do-Something (Proposed)				Collision Savings			
		Fatal	Serious	Slight	Total	Fatal	Serious	Slight	Total	Fatal	Serious	Slight	Total
2007	2020	0	3	38	41	0	3	37	40	0	0	1	1
	2035	0	4	41	45	0	4	40	44	0	0	1	1
	60 yr	17	189	2250	2455	16	183	2181	2379	1	6	69	76
12	2020	0	3	38	41	0	3	38	41	0	0	0	0
	2035	0	4	41	45	0	4	41	45	0	0	0	0
	60 yr	17	189	2247	2453	17	188	2233	2438	0	1	14	15
16	2020	0	3	38	41	0	3	37	40	0	0	1	1
	2035	0	4	41	45	0	4	40	44	0	0	1	1
	60 yr	17	189	2250	2455	17	187	2215	2418	0	2	35	37

Table 6-4- Scheme Option Casualty Savings (Low Growth Assumptions)

Option	Yr	Casualties											
		Do-Minimum (Existing)				Do-Something (Proposed)				Casualty Savings			
		Fatal	Serious	Slight	Total	Fatal	Serious	Slight	Total	Fatal	Serious	Slight	Total
2007	2020	0	6	47	53	0	6	45	51	0	0	2	2
	2035	0	7	52	59	0	7	50	57	0	0	2	2
	60 yr	25	376	2798	3199	25	364	2705	3094	1	12	92	105
12	2020	0	6	47	53	0	6	47	53	0	0	0	0
	2035	0	7	52	59	0	7	52	59	0	0	0	0
	60 yr	25	376	2795	3196	25	374	2781	3180	0	2	14	16
16	2020	0	6	47	53	0	6	46	52	0	0	1	1
	2035	0	7	52	59	0	7	51	58	0	0	1	1
	60 yr	25	376	2798	3199	25	371	2761	3156	0	5	37	42

6.6. Economic Performance of Options

6.6.1. Following production of the traffic forecasts an assessment of the economic benefits of each option was undertaken.

6.6.2. The cost benefit assessment compares value for money provided by each of the proposed options. The chosen tool for this part of the project was TUBA (Transport User Benefit Appraisal), a computer program developed for the Department for Transport to undertake the appraisal of highway schemes and multi-modal transport studies. The accident benefits were assessed using a spreadsheet tool which utilises the same principles as DFT's Cost Benefit Analysis (COBA) software. The benefits were compared against the scheme's cost to obtain a Benefit to Cost Ratio (BCR) for each of the proposed options.

6.6.3. TUBA undertakes a matrix-based appraisal using inputs of trip, time and distance and cost matrices. Costs associated with the Do-Minimum and Do-Something schemes are also input to the program. Using these inputs TUBA calculates the user benefits in terms of time, fuel vehicle operating costs (VOC), non-fuel VOC and charge; operator and government revenues; and scheme costs. Costs and benefits arising in different years are expressed in terms of their value from the standpoint of a given year known as present value year. Summing the present values of costs and subtracting these from the present value of benefits gives the 'net present value' of the scheme.

6.6.4. TUBA Version 1.9.4 was used to perform the economic analysis, which uses 2010 as the base year for its economic parameters, hence the value of time, fuel, etc. are defined in 2010 prices. The scheme costs that were used as input into the TUBA program are defined for the following four categories:

- Construction costs (including Risk and Optimism Bias)
- Land costs (including Optimism Bias)
- Preparation costs
- Supervision costs

Table 6-5 details the BCR's for the options assessed with low growth assumptions.

6.6.5. Table 6-6 details the BCR's associated with the central growth assumptions for comparison purposes. These values are taken from the Analysis of Monetised Costs and Benefits Worksheet that summarise the output from TUBA. The higher the ratio the higher the financial benefits of the scheme in relation to the cost.

6.6.6. The BCR is a reflection of all the monetised costs and benefits associated with a highway scheme and the PVB typically includes any collision benefits. For schemes where it is important to understand the relative Economic Efficiency (time savings and operating cost savings) the PVB is also presented with and without collisions included.

Table 6-5 - Economic Assessment Summary (Low Growth Assumptions)

Analysis of Monetised Costs and Benefits	2007 Option	Option 12	Option 16
Greenhouse Gases	209	187	12
Economic Efficiency: Consumer Users (Commuting)	2,795	4,980	955
Economic Efficiency: Consumer Users (Other)	2,634	4,749	947
Economic Efficiency: Business Users and Providers	7,969	12,365	3,390
Wider Public Finances (Indirect Taxation Revenues)	-524	-481	-18
Present Value of Benefits (PVB)	**13,083**	**21,800**	**5,286**
Broad Transport Budget	15,558	26,268	23,834
Present Value of Costs (PVC)	15,558	26,268	23,834

Analysis of Monetised Costs and Benefits	2007 Option	Option 12	Option 16
OVERALL IMPACTS			
Net Present Value (NPV)	-2,475	-4,468	-18,548
Benefit to Cost Ratio (BCR)	**0.841**	**0.830**	**0.222**
Collision Benefits	4,580	716	1,910
Benefit to Cost Ratio (BCR) (including collision benefits)	**1.135**	**0.857**	**0.302**

Table 6-6 - Economic Assessment Summary (Central Growth Assumptions)

Analysis of Monetised Costs and Benefits (£000s)	2007 Option	Option 12	Option 16
Greenhouse Gases	243	190	34
Economic Efficiency: Consumer Users (Commuting)	3,512	5,766	1,484
Economic Efficiency: Consumer Users (Other)	3,322	5,495	1,464
Economic Efficiency: Business Users and Providers	9,464	13,394	4,474
Wider Public Finances (Indirect Taxation Revenues)	-587	-500	-57
Present Value of Benefits (PVB)	**15,954**	**24,345**	**7,399**
Broad Transport Budget	15,558	26,268	23,834
Present Value of Costs (PVC)	15,558	26,268	23,834
OVERALL IMPACTS			
Net Present Value (NPV)	396	-1,923	-16,435
Benefit to Cost Ratio (BCR)	**1.025**	**0.927**	**0.310**
Collision Benefits	5,187	833	1,843
Benefit to Cost Ratio (BCR) (including collision benefits)	**1.359**	**0.958**	**0.388**

Notes:

1. All Values (except BCR) are in £000
2. Greenhouse Gases benefits are part of the vehicle operating costs and refer to benefits of the reduction of vehicle carbon emissions (based on fuel consumption). These benefits are the difference between the Do-Minimum and the Do-Something.
3. Economic Efficiency - Consumer user benefits refer to users who are not in the course of business; for example shopping, or as stated above commuting from home to work, returning from work etc.
4. Economic Efficiency – Business user benefits refer to users who are in the course of business; for example travelling on business trips, travelling between work places on working time etc.
5. Indirect Taxation Revenue refers to the extra tax that the consumer pays due to fuel consumption because of the scheme. Positive values indicate that the drivers consume more fuel and thus pay more fuel tax to the government and vice versa.
6. Broad transport budget refers to the total cost of investment and includes construction costs, maintenance costs and land costs etc.

6.7. Summary of Traffic and Economic Assessment

6.7.1. The forecasts indicate that continued traffic growth, in the absence of the scheme, would have an adverse impact on traffic flows through Armagh City centre with increased pressure on the wider road network, where higher flows in the future will cause severe congestion and significantly reduce traffic speeds and journey times.

6.7.2. Forecast results show that each of the proposed route options will have a moderate impact in relieving congestion in the city centre and will provide increased capacity which will improve speed and journey times on the eastern side of the city.

6.7.3. The economic assessment of the proposed link roads highlights that only one of the scheme options, the 2007 Option, provides a BCR higher than one and therefore a positive return on investment (value for money). In addition, the 2007 Option has the highest savings from accident reductions and the highest NPV (Net Present Value of benefits).

6.7.4. Forecasts show that each of the three proposed options will offer benefits to traffic.

6.7.5. On the basis of the above assessment the 2007 Option is recommended to be developed as the preferred route for the scheme from a traffic and economic perspective.

7. Conclusions and Recommendations

7.1. Engineering Assessment

7.1.1. The Engineering Assessment has identified that in key areas such as land take, cut/fill earthworks volumes and the requirement for structures the 2007 Option is the more favourable of the options assessed. No significant differences have been highlighted between the routes with regard to hydrology and only a marginally higher impact on utilities for the 2007 Option was identified.

7.2. Environmental Assessment

7.2.1. In summary, the environmental assessment concludes that there are no significant barriers to the development of the route options proposed. However, it recognises that, with regard to noise and visual amenity, further consideration at detailed design stage is required to identify appropriate mitigation to address any adverse effects, particularly for the 2007 Option which has a higher number of sensitive receptors.

7.3. Traffic and Economics Assessment

7.3.1. Forecast results show that each of the proposed route options will assist in providing moderate relief to congestion in the city centre and will provide increased capacity which will improve speed and journey times on the eastern side of the city.

7.3.2. The economic assessment of the proposed routes show that only one of the scheme options, the 2007 Option, provides a BCR higher than one and therefore a positive return on investment (value for money). In addition, the 2007 Option has the highest savings from accident reductions and the highest NPV (Net Present Value of benefits).

7.4. Recommendations

7.4.1. Considering the key areas of assessment outlined above it is recommended that the 2007 Option is taken forward to Stage 3. The proposed route has been identified as having the highest return on investment, is more favourable with regard to engineering constraints and has no significant barriers with regard to environmental impact.

7.4.2. In addition, the 2007 Option addresses the objectives outlined at the outset of this report;

- Improve journey times for both strategic and local traffic in and around Armagh City Centre;
- Improve road safety by relieving congestion in Armagh City Centre;
- Improve the road network between the North and South of the Province;
- Develop a scheme offering value for money.

7.4.3. Within the scope of Stage 3 design development, the junction type and layout at A28 Markethill Road, A51 Hamiltonsbawn Road and A3 Portadown Road shall be finalised.

7.4.4. Design development of the selected preferred route shall be undertaken to allow the Environmental Impact Assessment Report, identifying appropriate mitigation, and draft Statutory Orders to be published subject to funding.