Lincolnshire County Council

NORTH HYKEHAM RELIEF ROAD

Economic Appraisal Report

JULY 2019

CONFIDENTIAL

Lincolnshire County Council

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Economic Appraisal Report

TYPE OF DOCUMENT (VERSION) CONFIDENTIAL

PROJECT NO. 70038233

DATE: JULY 2019

Lincolnshire County **Council**

NORTH HYKEHAM RELIEF ROAD

Economic Appraisal Report

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QUALITY CONTROL

Issue/revision	First issue	Revision 1	Revision 2	Revision 3
Remarks	DRAFT	FINAL	FINAL_April19	FINAL_July19
Date	20 / 12 / 2018	21 / 02 / 19	05 / 04 / 19	08 / 07 / 19
Prepared by	BH / JKO / MB	BH / JKO / MB	BH / JKO / MB	JB
Signature				
Checked by	JC	JC	JC	JP
Signature	[signature]	[signature]	[signature]	
Authorised by	JP	JP	JP	JP
Signature				
Project number	70038233			
Report number				
File reference	738233-WSP-T01-XX-RP-TP-0002			

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1. INTRODUCTION

1.1. OVERVIEW

Lincolnshire County Council (LCC) is seeking funding to develop and construct the North Hykeham Relief Road (NHRR) scheme. WSP is appointed by LCC to produce traffic forecasts and economic appraisal outputs as part of a Value for Money (VfM) appraisal for the proposed NHRR. This VfM case will form part of the Outline Business Case (OBC) which will be submitted to the Department of Transport (DfT) in due course.

Traffic modelling for the scheme has been undertaken using the Greater Lincoln Traffic Model (GLTM). GLTM was developed in 2017 and validated to average neutral month 2016 traffic conditions. The development and validation of the GLTM is described in detail in the Local Model Validation Report (LMVR). A further local validation exercise was undertaken, focussing on the area around NHRR, and is reported in the LMVR addendum. The development and results of NHRR traffic forecasts are detailed in the Traffic Forecasting Report (TFR).

This report details the economic appraisal process for the NHRR. The economic appraisal process follows the guidance outlined by the following relevant WebTAG modules to ensure a robust estimate is made.

- Unit A1-1 cost-benefit analysis
- Unit A1-2 scheme costs
- Unit A1-3 user and provider impacts

The scheme objectives are grouped into three strategic outcomes.

- **Delivery of an effective and efficient transport network.**
  This will be assessed by cost-benefit analysis including transport user benefits, accident benefits and reliability benefits.

- **Delivery of housing.**
  This will be assessed by the user benefits relating to network performance to support housing growth and a dependent development assessment for South West Quadrant.

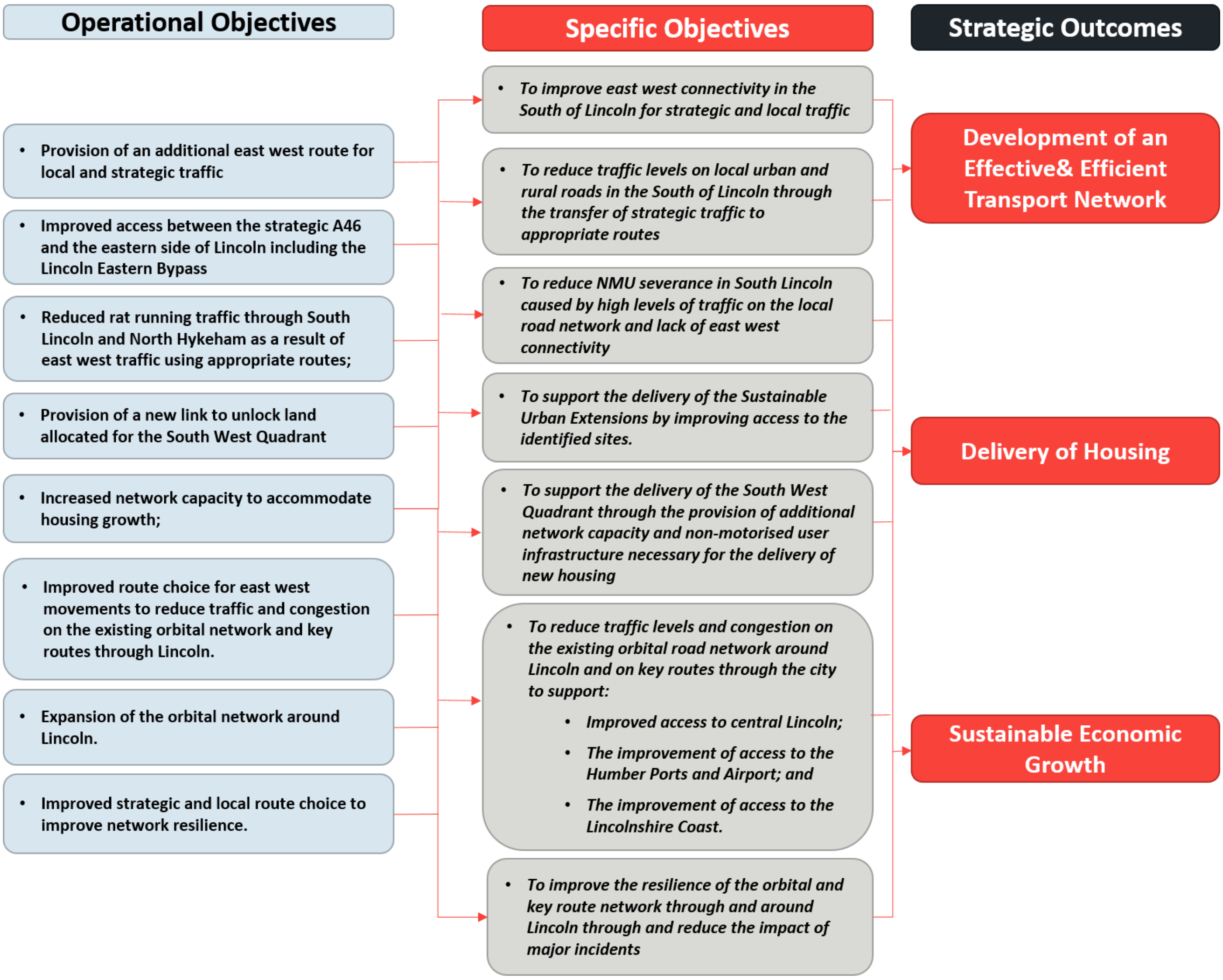
- **Sustainable economic growth.**
  This will be assessed by qualitatively assessing the improvement to network performance to support economic activity and growth plus the impact from increased resilience for the whole Lincoln urban network.

The appraisal also includes social and distributional impacts of the scheme.

1.2. SCHEME OBJECTIVES

Following WebTAG guidance, a number of strategic (high level), intermediate (specific) and operational objectives were derived in order to meet the strategic aims set out by Lincolnshire County Council. These objectives are described in full in the Options Appraisal Report and are summarised in Figure 1.

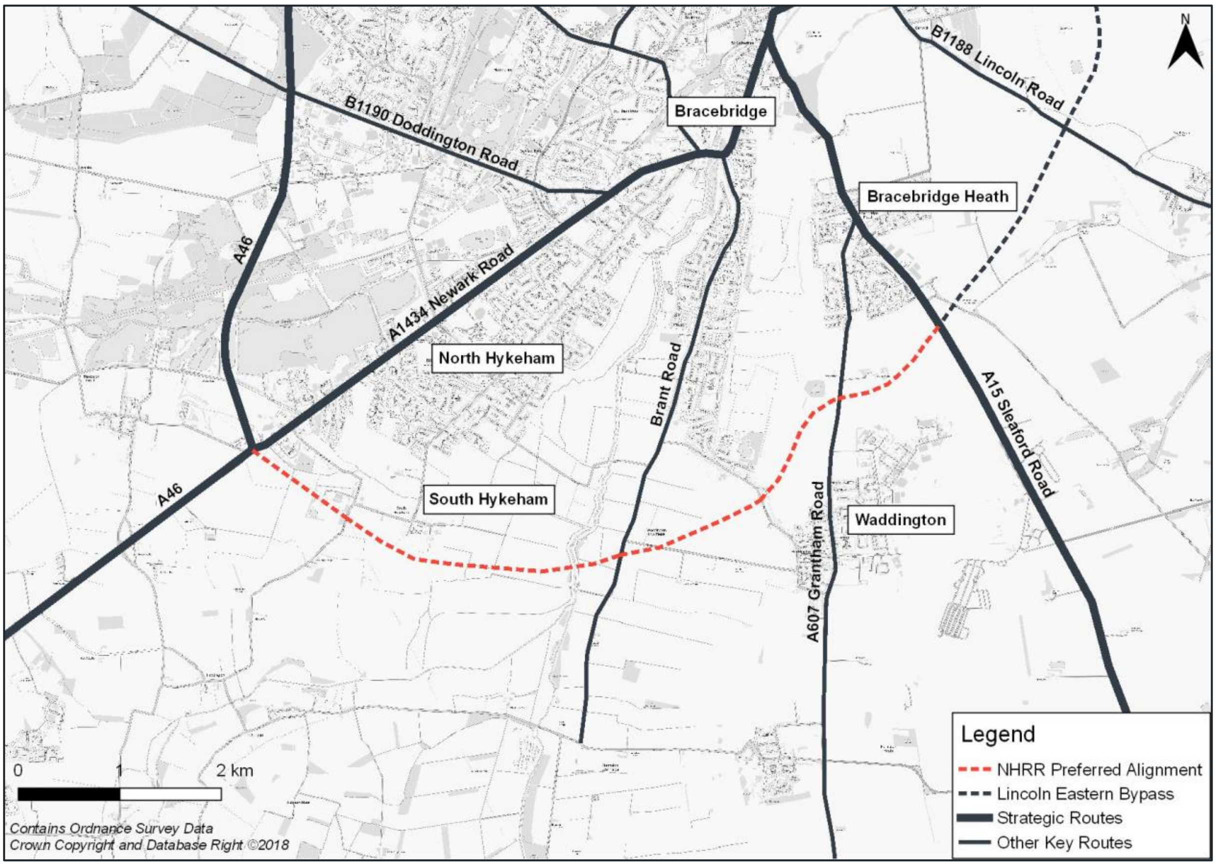
Figure 1 – Relationship between Outcomes and Objectives



1.3. SCHEME DESCRIPTION

The proposed NHRR ("the scheme") will provide a new link through a predominately rural area situated to the south of the Lincoln urban area, which is an area encompassing the district of Lincoln plus the primarily residential areas of North Hykeham and Waddington which are situated in North Kesteven district. It would link the existing Western Relief Road (A46) in the west to the A15 Lincoln Eastern Bypass (LEB) currently under construction, in the east. The preferred route alignment of NHRR is shown in Figure 3.

Figure 2 – Preferred North Hykeham Relief Road Alignment



A dual carriageway standard road was determined as the preferred option based on the outputs and conclusions from the options development process, detailed on the Options Appraisal Report (OAR). In addition, a next best alternative and low cost option have been assessed. The options tested are summarised as follows:

- Preferred option – dual carriageway
- Next best alternative – single carriageway with future proofed junctions
- Low cost option – single carriageway

The scheme will link the existing A46 Western Relief Road to the under-construction A15 Lincoln Eastern Bypass (LEB) forming a complete ring road around the Lincoln urban area.

The key features of the scheme are that it will:

- Tie into an upgraded Pennell's roundabout at the western end and tie into the under-construction LEB / A15 roundabout at the eastern end;
- Have priority roundabout junctions with South Hykeham Road, Brant Road and A606 Grantham Road; and
- Pass under Station Road which will cross the scheme with a new overbridge.

1.4. STRUCTURE OF ECONOMIC APPRAISAL REPORT

Following on from this introductory chapter, the remainder of this document is structured as follows:

- Chapter 2. Economic Appraisal Approach;
- Chapter 3. Estimation of Costs;
- Chapter 4. Estimation of Benefits;
- Chapter 5. Economic Appraisal Results; and
- Chapter 6. Summary and Conclusions

2. ECONOMIC APPRAISAL APPROACH

2.1. TRANSPORT MODEL

The Greater Lincoln Transport Model (GLTM) was used in the appraisal. This includes a highway assignment model in SATURN version 11.3.12W which determines journeys travelling on the highway network including traffic flows, speed, delays, route choice and journey costs. It is validated to an average neutral month with a 2016 base year,

The GLTM suite also includes a public transport assignment model and a variable demand model. Variable demand modelling has been applied when developing the forecast models in line guidance in WebTAG Unit M2 *Variable Demand Modelling* (March 2017) to forecast the demand responses from a scheme of this size. The public transport assignment model provides dynamic journey costs for bus and rail to facilitate mode shift in the variable demand forecasting.

There are three modelled time periods:

- AM Peak Hour: 08:00 – 09:00;
- Inter Peak Average Hour: between 10:00 – 16:00; and
- PM Peak Hour: 17:00 – 18:00.

The forecast years are:

- 2026 – scheme opening year; and
- 2041 – design year, 15 years after opening.

The development and validation of the GLTM is described in detail in the Local Model Validation Report (LMVR) and the LMVR Addendum. The development of the forecast models is detailed in the Traffic Forecasting Report (TFR).

2.2. ECONOMIC APPRAISAL PROCESS

Economic appraisal has been undertaken for the Core scenario and four alternative scenarios.

The Core scenario consists of:

- A 'without scheme forecast' referred to as Do Minimum which consists of the validated base year networks plus committed schemes, including LEB; and
- A 'with scheme forecast' referred to as Do Something which consists of the Do Minimum assumptions plus the preferred option.

The preferred option consists of:

- A dual carriageway standard link with 70mph design speed;
- Enlarged Pennell's Roundabout at the western end;
- At-grade roundabout junctions with South Hykeham Road, Brant Road and A607 Grantham Road; and
- A new overbridge for Station Road to cross over the scheme.

Two alternative scenarios have been modelled with the preferred option – Low Growth and High Growth.

Two alternative scheme configurations have been modelled with core growth assumptions – the Next Best Alternative and the Low Cost option.

The Next Best Alternative consists of:

- A single carriageway link with 60mph design speed;
- Enlarged Pennell's Roundabout;
- Future proofed at-grade roundabout junctions with South Hykeham Road, Brant Road and A607 Grantham Road; and
- A new overbridge for Station Road to cross over the scheme.

The Low Cost option consists of:

- A single carriageway link with 60mph design speed;
- Upgrade at Pennell's Roundabout sufficient to accommodate the additional arm;
- Single carriageway standard at-grade roundabout junctions; and
- A new overbridge for Station Road to cross over the scheme.

2.2.1. USER BENEFITS (TUBA)

User benefits including time savings, fuel-related vehicle operating costs (VOC), non-fuel VOC, and operator and Government revenues typically form the major element of benefit attributable to highway schemes. The assessment reported here uses the Department for Transport's (DfT) Transport Users Benefit Appraisal tool (TUBA) Version 1.9.11.

Demand, path-weighted average time, distance and toll matrix skims from the Do Minimum and Do Something tests for the opening and design years are fed into TUBA generating the following economic outputs:

- Time savings
- Vehicle Cost Operating savings
- Greenhouse gases
- Taxes

Analysis of the benefits has been carried out:

- By year, over the 60-year appraisal period
- By trip purpose/ vehicle type/by time period (AM/IP/PM periods)
- By sector of origin and destination

The appraisal area for estimating user benefits includes the full model area, and analysis at an aggregated sector level provides a summary of the findings.

2.2.2. ACCIDENT BENEFITS (COBALT)

Benefits associated with accident savings were calculated using the DfT's Cost and Benefit to Accidents – Light Touch Programme (COBALT) which assesses the safety impacts of schemes using detailed inputs of accident rates and traffic flow forecasts from the traffic model. Accident benefits were calculated over a 60-year period for a cordoned area of the model using the combined links and junctions method and COBALT default accident rates.

2.2.3. RELIABILITY BENEFITS

In addition to the benefits calculated by TUBA and COBALT, monetised benefits were also calculated for reliability using the urban area method which is based on changes in the standard deviation of travel time from changes in journey time and distance, as described in the WebTAG Unit A1.3. This was considered to be the most appropriate assessment since is considered to form the southern boundary of the Lincoln urban area and it will impact on journey time reliability for trips across the urban area network.

2.2.4. ANNUALISATION OF BENEFITS

Benefits of the scheme have been converted from the weekday traffic model period outputs to annual totals over a 60-year appraisal period. Annualisation factors for conversion of period model outputs are explained in detail in Section 4.2.

2.2.5. APPRAISAL PERIOD

The economic appraisal was carried out for a 60-year period, from 2026 (Opening Year), in accordance with DfT guidance. The final year in which benefits were calculated was 2085.

2.2.6. VALUE FOR MONEY ASSESSMENT

A cost benefit assessment was undertaken by comparing the construction and maintenance costs with the traffic benefits of the scheme over a 60-year assessment period. The Benefit to Cost Ratio (BCR) was calculated, which represents the value for money afforded by the scheme.

The results from TUBA and COBALT were used to calculate and initial BCR. The reliability benefits are added to calculate an adjusted BCR.

2.2.7. SENSITIVITY TESTS

As recommended in Section 4 of TAG Unit M4 (May 2018), sensitivity tests have been carried out whereby high and low growth projections are applied in addition to the Core Scenario forecasts. These sensitivity tests have been applied to the preferred option only.

2.2.8. DEPENDENT DEVELOPMENT

One of the strategic outcomes for the scheme, defined in the Strategic Case, is to support the delivery of housing. The South West Quadrant (SWQ) is a sustainable urban extension located adjacent to the scheme at the western end. A specific objective for the scheme is to provide the additional network capacity to support this development.

If some (or possibly all) traffic from a proposed development site would lead to an 'unreasonable level of service' on the highway network, or if the existing conditions already provide an 'unreasonable level of service', then the development will be dependent on an intervention. This dependency can be determined through traffic forecasting.

The appraisal aspect is to derive a monetised value which quantifies the benefits of 'unlocking' the development land. The key data input is land value data which has been obtained from Ministry of Housing, Communities and Lincolnshire County Council sources to derive the land value uplift for the site.

2.3. NON-STANDARD PROCEDURES AND ECONOMIC PARAMETERS

The economic assessment has adopted procedures, economic parameters and values recommended in current DfT guidance and incorporate the latest WebTAG databook, May 2018.

Wider economic analysis at level two has not been undertaken at this stage. The scheme is expected to support economic growth through improving the overall performance and reliability of the transport network however there are no specific scheme objectives around the employment effects which are covered by level two analysis. A qualitative assessment was considered proportionate at this stage.

The dependent development assessment is classified as level three analysis.

3. ESTIMATION OF COSTS

3.1. OVERVIEW

The scheme cost estimate has been prepared based on the outline design of the NHRR. In line with TAG Unit A1-2 'Scheme Costs', there are three key components of a scheme cost estimate that need to be estimated and reported in scheme appraisals:

- **Base Cost Estimate –** the basic cost of a scheme before allowing for risks. The base cost represents the basic costs of the scheme made up of investment, maintenance and operating costs, for a given price base. This includes estimates for construction, land, preparation and supervision. It incorporates a realistic assumption of changes in real costs over time (e.g. cost increases or reductions relative to the rate of general inflation);
- **Adjustment for Risk –** covers all risks that can be identified, the majority of which then need to be assessed and quantified through a Quantified Risk Assessment (QRA) and included in the risk-adjusted cost estimate; and
- **Adjustment for Optimism Bias (OB)** – reflects the well-established and continuing systematic bias for estimated scheme costs and delivery times to be too low and too short, respectively, and results in the risk and OB adjusted cost estimate.

The Financial Case provides a detailed description of the development of the outturn cost estimate for the package, following the steps outlined above. For the purposes of economic appraisal, and in line with WebTAG Unit A1-2, there are a number of further adjustments that need to be made to the scheme cost estimate:

- **Re-basing to the DfT's Base Year –** Adjustment of cost estimate (at a particular price base) to the DfT's standard price base year of 2010;
- **Discounting to the DfT's Base Year** – discounting cost estimate to 2010 and presenting as a PVC. Discount rate is 3.5% per year for the first 30 years from the current year, with a rate of 3% per year thereafter; and
- **Converting to Market Prices –** conversion from factor cost to market price unit of account using the indirect tax correction factor. Factor is 1.19.

The following sections summarise the initial base cost estimate and subsequent adjustments to arrive at the schemes PVC for use in the economic appraisal.

3.2. BASE COST ESTIMATE (INCLUDING INFLATION)

3.2.1. BASE COST OVERVIEW

The latest base package cost estimate was updated in autumn 2018 using a Quarter 4 2017 price base and includes both investment and operating costs as outlined below:

- Investment Costs:
  - Construction costs (preliminaries, structures, road works, earthworks, ancillary works & third party);
  - Land & property costs (land acquisition, legal fees, & compensation);
  - Preparation costs (project management, consultancy fees, design, public consultation, public inquiry, surveys, costs associated with gaining statutory powers / orders); and

- Traffic related maintenance costs (non-routine reconstruction, resurfacing).
- Operation Costs:
  - Operating costs (routine and non-traffic related maintenance costs (e.g. drainage, street lighting, fencing, grass cutting, repainting lines etc.).

3.2.2. INVESTMENT COST

The base investment cost estimate (excluding traffic related maintenance) is summarised in Table 1. The Financial Case of the NHRR OBC provides a more detailed description of how the investment costs, informing the estimate, have been derived.

Table 1 – Base Cost Estimate (Quarter 4 2017 Prices)

Cost Element	Cost (Q4 2017 Prices)
Contract total	£ 58,923,321
Ancillary works	£15,467,372
Stats costs / third parties	£1,546,737
Risk (Contingencies)	£2,946,166
Land & Property not including part one claims – Estimate	£1,683,068
Design / Procurement / Preparation	£ 10,473,666
Total Base Costs	**£ 91,040,330**

3.2.3. INFLATION ALLOWANCE

In line with WebTAG Unit A1-2 industry sources of information have been reviewed in order to derive appropriate inflation rates over the spend profile. The Department for Business, Innovation and Skills (BIS) Road Construction Tender Price Indices (RCTPI) and the Office for National Statistics (ONS) Construction Output Price Indices (OPI) have been analysed to identify a suitable rate of inflation for the construction related aspects of the cost estimate. Between March 2018 and February 2019 (inclusive), on average national construction prices have increased by 4.8% per annum and hence, in line with DfT guidance, inflation of 4.8% pa has been applied to the construction costs estimate.

For other elements of the cost estimate, such as land, preparation and supervision, a general inflation rate has been calculated and applied with the approach in line with WebTAG Unit A1.2.

The effect of applying general and construction inflation, over the estimated spending profile for the respective elements of the scheme, results in an additional **£29,584,993** to the package cost estimate.

3.3. ADJUSTMENT FOR RISK & OPTIMISM BIAS (OB)

3.3.1. ADJUSTMENT FOR RISK

A structured and systematic process for identifying, assessing and managing risk has been established for the NHRR. A risk log has been generated which identifies risks that may occur during the planning, design and construction phases and outlines any unrealised issues that have the potential to adversely impact on the scheme delivery programme or cost. All risks within the register are assessed and classified across three areas, the probability of the risk occurring and the most likely impact on costs and time which would arise if the risk did occur. Following the development of the risk register, the financial impact of each risk was quantified using the Palisade @RISK analysis software. The @RISK software performs the risk analysis using a Monte Carlo calculation and allows the potential impact to be considered as part of the overall scheme cost estimate.

The QRA, calculated using the @RISK software programme has identified a risk allowance of **£31,878,000.**

3.4. OUTTURN COST ESTIMATE

Table 2 summarises the outturn cost for the NHRR, comprising of base cost estimate, inflation, and risk and OB. The outturn cost estimate for the package is **£152,503,323**.

Table 2 - Outturn Cost Estimate

Cost Element	Total
Base cost at 2017 Q4 prices	£ 91,040,330
Risk allowance	£ 31,878,000
Inflation	£ 29,584,993
Total Outturn Cost	**£152,503,323**

3.5. ADJUSTMENT FOR OPTIMISM BIAS (OB)

OB is the demonstrated systematic tendency for appraisers to be overly optimistic about key parameters, estimating scheme costs and delivery times to be too low and too short respectively. To reflect this, the DfT requires that, in addition to adjusting the base scheme cost estimate for risk allowance, an OB uplift factor is also applied. The DfT recommends a range of OB factors that can be used, depending on the nature of the project and the stage of scheme development, summarised in Table 3.

Table 3 – DfT Recommended Optimism Bias (OB) Uplifts for Road Schemes

Category	Stage	OB Uplift %
Stage 1	Strategic Outline Business Case	44%
Stage 2	Outline Business Case	15%
Stage 3	Full Business Case	3%

The NHRR is at the OBC stage and as stated in WebTAG Unit A1-2 a 15% OB is appropriate. As a result, the scheme costs will be uplifted to reflect this for the purposes of the economic appraisal.

3.6. OPERATING COSTS

3.6.1. TRAFFIC RELATED MAINTENANCE

The assessment of traffic related maintenance costs focusses on the plan for non-routine reconstruction and resurfacing of the carriageway. It is assumed that major maintenance would take place every 20 years for resurfacing of the new built / upgraded sections and every 40 years for the reconstruction of the carriageway. The costs have been estimated using LCC and similar schemes (see Table 4).

Table 4 – Maintenance Cost (Q4 2017)

Maintenance Element	Total	Details
Resurfacing	£4,132,292	The resurfacing and reconstruction works are assumed to be required every 20 years.
Reconstruction	£10,961,691	The resurfacing and reconstruction works are assumed to be required every 40 years.

The DS maintenance PVC have been calculated over the appraisal period and adjusted and discounted to 2010 prices and values, as well converted to market prices (see Table 5).

Table 5 – Maintenance (traffic Related) PVC (Discounted to 2010 Prices and Values, Converted to Market Values)

Maintenance Year		DS Scenario
Year	**Works Description**	Resurfacing & Reconstruction Costs (Discounted to 2010 Prices and Values)
Total over Appraisal Period		£7,103,255
Converted to Market Prices		£8,452,873

3.6.2. OPERATING COST - NON-TRAFFIC RELATED MAINTENANCE

The operating costs for the package refer to the routine and non-traffic related maintenance costs (e.g. drainage, street lighting, fencing, grass cutting, repainting lines etc.). The costs occur year on year and are calculated over the appraisal period, adjusted and discounted to 2010 prices and values as well converted to market prices (see Table 6). The estimates have been based on similar LCC schemes.

Table 6 – Maintenance (Non-Traffic Related) PVC (Discounted to 2010 Prices and Values, Converted to Market Values

Total Routine Maintenance Non-Traffic Related Costs	DS Scenario
	Maintenance Costs (Discounted to 2010 Prices and Values)
Total over Appraisal Period	£16,570,884
Converted to Market Prices	£19,719,352

3.7. PRESENT VALUE COST (PVC) ESTIMATE

As outlined in TAG Unit A1.1 Cost Benefit Analysis and Unit A1.2 Scheme Costs, all future investment and operating costs, estimated over the appraisal period, should be converted to PVC.

This involves three key steps:

- Re-basing to the DfT's Base Year;
- Discounting to the DfT's Base year; and
- Converting to Market Prices.

3.7.1. RE-BASING

TAG Unit A1.1 Cost Benefit Analysis explains that, when applying monetary values to impacts over a long appraisal period, it is very important to take the effects of inflation in to account. Failure to do so, would distort the results by placing too much weight on future impacts, where values would be higher simply because of inflation.

For cost benefit analysis purposes, all values should be in real prices (including inflation) to stop the effects of inflation distorting the results. To convert nominal prices (not including inflation) to real prices, a price base year and an inflation index are needed. The real price in any given year is then the nominal price deflated by the change in the inflation index between that year and the base year (2010).

The DfT recommends the use of the GDP (Gross Domestic Product) deflator, which is a much broader price index than consumer prices (e.g. Consumer Price Index, Retail Price Index) as it reflects the prices of all domestically produced goods and services in the economy.

3.7.2. DISCOUNTING

TAG Unit A1.1 outlines that all monetised costs (and benefits) arising in the future need to be adjusted to take account of 'social time preference', that is peoples preference to consume goods and services now, rather than in the future.

The technique used to perform this adjustment is known as discounting. A discount rate which represents the extent to which people prefer current over future consumption, is applied to convert future costs (and benefits) to their present value (the equivalent value of a cost (or benefit) in the future occurring today).

As such, the cost estimate has been discounted to the DfT's base year (2010) using the discount rates outlined in TAG Databook, summarised in Table 7.

Table 7 – Discount Rates

Years from Current Year	Discount Rate
0-30	3.50%
31-75	3.00%

3.7.3. MARKET PRICES

The final stage in preparing the package cost for appraisal is to convert the cost from the 'factor cost' to the 'market price' unit of account using the indirect tax correction factor of 1.19 (from the WebTAG Databook), which reflects the average rate of indirect taxation in the economy.

3.7.4. PRESENT VALUE ESTIMATE

Table 8 summarises the investment and operating costs in 2010 prices and values. It demonstrates that the total PVC estimate for the NHRR is **£148,500,258**.

Table 8 – Summary of Package Costs

Cost Categories	2010 Market Prices and Values
Investment Cost	£120,328,033
Operating Cost	£ 28,172,225
Total Cost	**£148,500,258**

3.7.5. CONTRIBUTIONS

The above PVC value of £148.500m is for the whole cost of the NHRR. However, for the purposes of VfM appraisal, in line with DfT guidance, the 'Costs' of a scheme should only include the 'Cost to the Broad Transport Budget', split by Local and Central government. This refers to costs (and revenues) which directly affect the public budget available for transport.

Therefore any 'Costs to the Private Sector', need to be specified separately, as outlined in the' Transport Appraisal Process' TAG Unit. For the calculation of NPV and BCR, the Costs to the Private Sector PVC are treated as a negative benefit, as outlined below:

- NPV = PVB – Private Sector PVC – Broad Transport Budget PVC.
- BCR = (PVB – Private Sector PVC) / Broad Transport Budget PVC.

From the Financial Case of the NHRR OBC, the likely level of private developer funding is expected to be a minimum of £10m.

This amounts to a private sector contribution of **£7.890m** in 2010 prices and values.

Deducting the private contribution gives an outturn cost to the Broad Transport Budget of **£140.610m** in 2010 prices and values.

3.7.6. ALTERNATIVE SCHEME CONFIGURATIONS

A similar approach was applied to derive the PVC for the Next Best Alternative and the Low Cost Option. It is assumed that the same level of contribution will be sought from developers, regardless of the option. The PVC for each scheme option is summarised in Table 9.

Table 9 – PVC Summary, Split by Contributor

Contributor	Core	Next Best	Low Cost
Central Government	£85.304m	£66.321m	£54.826m
Local Government	£55.306m	£37.734m	£33.424m
Developer Contributions	£7.890m	£7.890m	£7.890m
Total	**£148.500m**	**£111.945m**	**£96.140m**

Note: All values are at 2010 prices and values

4. ESTIMATION OF BENEFITS

4.1. INTRODUCTION

The following scheme benefits were calculated for each modelled scenario and including in the initial BCR:

- User Benefits (time, vehicle operating cost and tax savings); and
- Accident Cost Savings.

In addition the following benefits were calculated and included in the adjusted BCR:

- Reliability Benefits.

4.2. USER BENEFITS

The following section provides an overview of the TUBA economic assessment, including the key inputs and parameters used within the assessment and the outputs and results.

TUBA 1.9.11 was used to carry out an assessment of the 'user benefits' for the proposed scheme.

The Transport Economic Efficiency (TEE) benefits arise from time and vehicle operating cost savings over the 60-year appraisal period and are evaluated from the difference in costs between the Do-Minimum and Do-Something forecasts.

4.2.1. SCHEME PARAMETERS

Table 10 shows the main parameters that have been used in the TUBA scheme file.

Table 10 – Scheme Parameters

Parameter	Option
TUBA Version	v1.9.11
Opening Year	2026
Design Year	2041
Horizon Year	2085

4.2.2. TIME PERIOD AND ANNUALISATION FACTORS

TUBA is able to provide user benefits for up to 8,760 hours within a year and it allocates each hour into one of five time periods as shown in Table 11.

Table 11 – TUBA Time Periods

Period	Time
Weekday AM Period	(07:00-10:00)
Weekday Inter-Peak Period	(10:00-16:00)
Weekday PM Period	(16:00-19:00)
Weekday Off-Peak Period	(19:00-07:00)
Weekend + Bank Holiday	(24-hours)

The traffic models developed for the proposed scheme, consists of the three distinct time slices: AM peak hour (08:00-09:00), Inter-peak (average of 10:00-16:00), and PM Peak (17:00-18:00). Non-modelled hours should therefore be included in the TUBA analysis by expanding modelled hours to the relevant period.

Modelled time slices have been expanded to represent a full year by using annualisation factors. The annualisation factors are summarised in Table 12. Full details of the calculation of the factors is presented in Appendix A.

Table 12 – Annualisation Factors

Period	Donor Traffic Model	Annualisation Factor
Weekday AM Peak 07:00-09:00	AM Peak Hour Model	500
Weekday AM Peak 09:00-10:00	Inter Peak Ave. Hour Model	250
Weekday Inter Peak 10:00-16:00	Inter Peak Ave. Hour Model	1518
Weekday PM Peak 16:00-18:00	PM Peak Hour Model	507
Weekday PM Peak 18:00-19:00	Inter Peak Ave. Hour Model	244
Weekends	Inter Peak Ave. Hour Model	675

4.2.3. VEHICLE TYPE AND TRIP PURPOSE

In accordance with the DfT WebTAG guidance, TUBA benefits are required to be assessed with disaggregation to vehicle type and journey purposes. Seven user classes are defined in the TUBA standard economic file, representing 3 distinct trips purposes for car, two for LGV's and two for HGV's:

- Car – Employer Business;
- Car – Commuting;
- Car – Other;
- LGV – Personal;
- LGV – Freight;

- OGV 1; and
- OGV 2.

Each user class has a different value of time (VoT), vehicle occupancy and fuel consumption.

The traffic models developed for the proposed scheme consists of five user classes:

- UC1 Car – Employer Business;
- UC2 Car – Commuting;
- UC3 Car – Other;
- UC4 LGVs; and
- UC5 HGVs.

The user classes from the GLTM forecasts were converted to the standard TUBA user classes, using the adjustment factors provided in Table 13. The LGV split is taken directly from values in the WebTAG databook. The HGV split is derived from local classified traffic count data.

Table 13 - Modelled User Classes to TUBA User Classes

Model User Class	TUBA User Class	TUBA Input		
		Vehicle/Submode	Trip Purpose	Demand Factor
1	1	1 (Car)	1 (Business)	1.000
2	2	1 (Car)	2 (Commuting)	1.000
3	3	1 (Car)	3 (Other)	1.000
4	4	2 (LGV personal)	0 (Commuting and Other)	0.120
4	5	3 (LGV freight)	0 (Business)	0.880
5	6	4 (OGV1)	0 (Business)	0.332
5	7	5 (OGV2)	0 (Business)	0.112

The OGV factors are based on an observed split of 60:40 between OGV1 and OGV2 derived from the Lincoln survey data. An additional adjustment factor of 2.25 (GLTM HGV factor) has been applied to convert from PCUs to vehicles.

A TUBA assessment was then undertaken using the parameters described above, with demand and skimmed time and distances for Do Minimum and each Do Something forecast models to produce the user benefits for the 60-year appraisal period.

4.2.4. ANALYSIS OF USER BENEFITS

User benefits including time savings, fuel-related vehicle operating costs (VOC), non-fuel VOC, and operator and Government revenues, typically form the major element of benefits attributable to highway schemes. The assessment reported here uses TUBA Version 1.9.11.

The software provides the DfT standard approach to appraising changes in demand, travel time and operating costs. Demand, average time and average distance matrix skims from the Do-Minimum (DM) and Do-Something (DS) tests for the Opening and Design years are fed into TUBA, generating the following types of economic outputs:

- User Time Savings
- Vehicle Operating Cost savings
- Greenhouse Gases
- Indirect Taxes

Analysis of the benefits has been carried out:

- By year, over the 60 year appraisal period
- By trip purpose/ vehicle type/ by time period (AM/ IP/ PM periods); and
- By sector of origin and destination

The appraisal area for estimating user benefits includes the full model area, although analysis at sector level provides the facility to assess benefits with origins and destinations in a specific part of the modelled area.

4.2.5. BENEFITS AT SECTOR LEVEL

The geographic distribution of benefits has been assessed through an analysis of sector-based cost changes. A 20 by 20 sector system was defined for the study area to provide an overview of the distribution of benefits derived from the transport model. The sectors local to the scheme are illustrated in Figure 3. The full sectors are listed in Table 14 and illustrated in Appendix B.

Figure 3 – Local Sector System

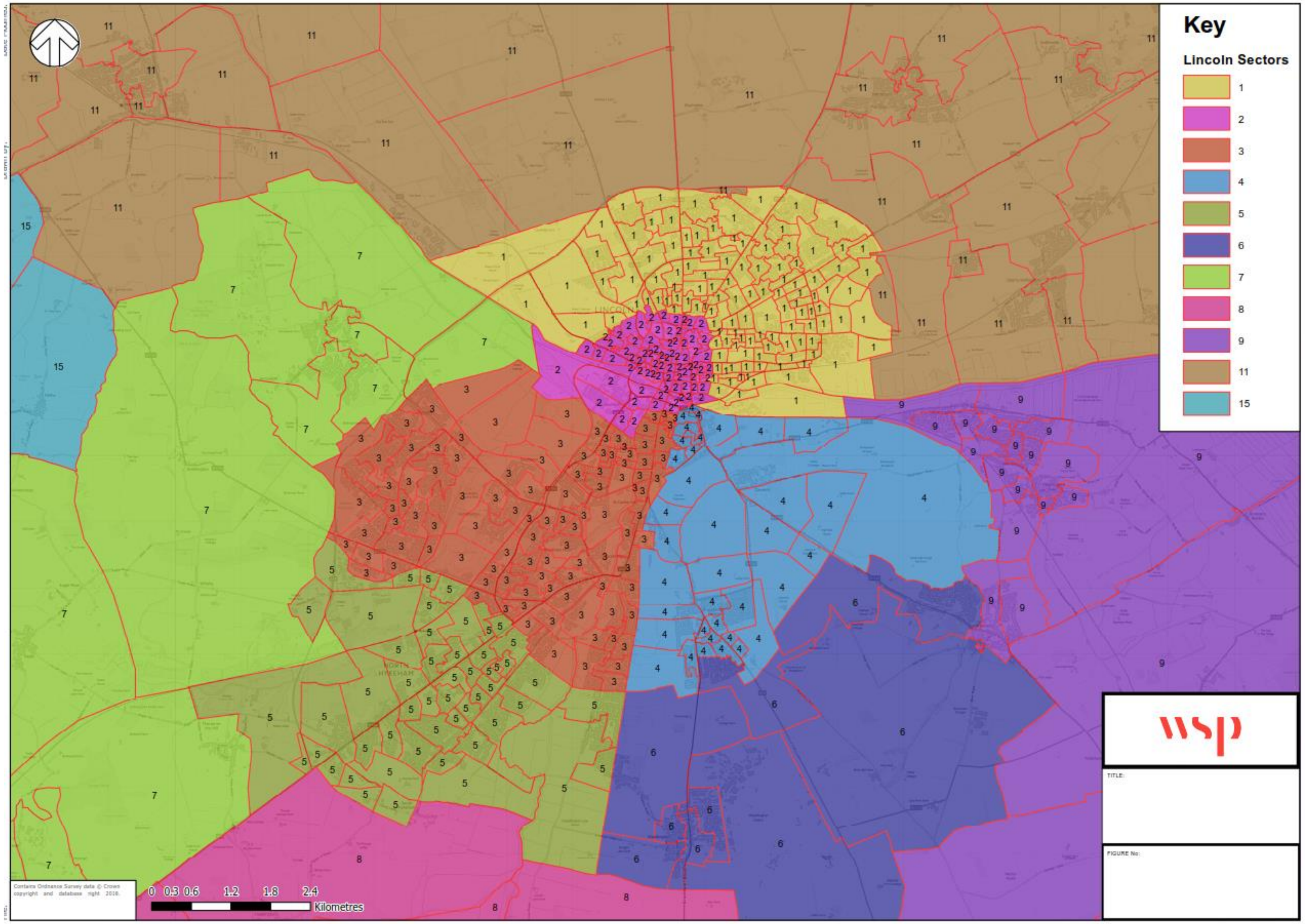


Table 14 – Sector System

Sector	Description
1	Lincoln North / East
2	Central Lincoln
3	South West Lincoln
4	Bracebridge Heath and Canwick
5	North Hykeham
6	Waddington and Branston
7	Northwest North Kesteven
8	West North Kesteven
9	East North Kesteven
10	North and North East Lincolnshire
11	West Lindsey
12	East Lindsey
13	Boston
14	South Kesteven
15	Nottinghamshire
16	Yorkshire
17	North England and Scotland
18	Midlands (excluding Lincolnshire and Nottinghamshire)
19	South England and Wales
20	East England

4.2.6. TUBA WARNINGS

TUBA produces a set of warnings as part of the standard output file. These have been investigated thoroughly to give confidence in the user benefit results as well as identifying any potentially erroneous results. TUBA warnings occur when the ratio between Do Minimum and Do Something case travel times or distances fall outside set thresholds. It should be noted that warnings of this sort are not necessarily an indicator of an error in the modelling. A summary of the warnings is presented in Table 15. Further details of the warnings, including illustrations of the associated trip rerouting, is included at Appendix C.

Table 15 – Summary of TUBA Warnings

Type	Total Warnings	Comments
Ratio of DM to DS travel time lower than the limit – Travel time increases with schemes	21 (2 serious)	The total number of DS trips of this type is less than 1, with the average travel time between the associated zone pairs being less than 3 minutes, thus even a small change in time produces a relatively high ratio causing these warnings.
Ratio of DM to DS travel time higher than the limit – Travel time reduces with schemes	121,514 (none serious)	These warnings are mostly seen between sector pairs crossing between the East and West of Lincoln, thus large reductions in time are the result of NHRR usage and are recognised as realistic benefits.
Ratio of DM to DS travel distance lower than the limit – Distance increases with schemes	151,540 (none serious)	These warnings are mostly seen between sector pairs at opposite ends of the Lincoln urban area, these are caused by trips rerouting onto the ring road instead of using a shorter, but slower speed routeings through the urban area.
Ratio of DM to DS travel distance higher than the limit – Distance reduces with schemes	16,046 (all serious)	These warnings are mostly seen between sector pairs at either end of NHRR and are caused by trips using NHRR as a more direct route.

4.3. ACCIDENT BENEFITS

The forecast number of accidents and casualties saved as a result of the introduction of the proposed scheme were calculated using the DfT's software Cost and Benefit to Accidents – Light Touch (COBA-LT v2013_02).

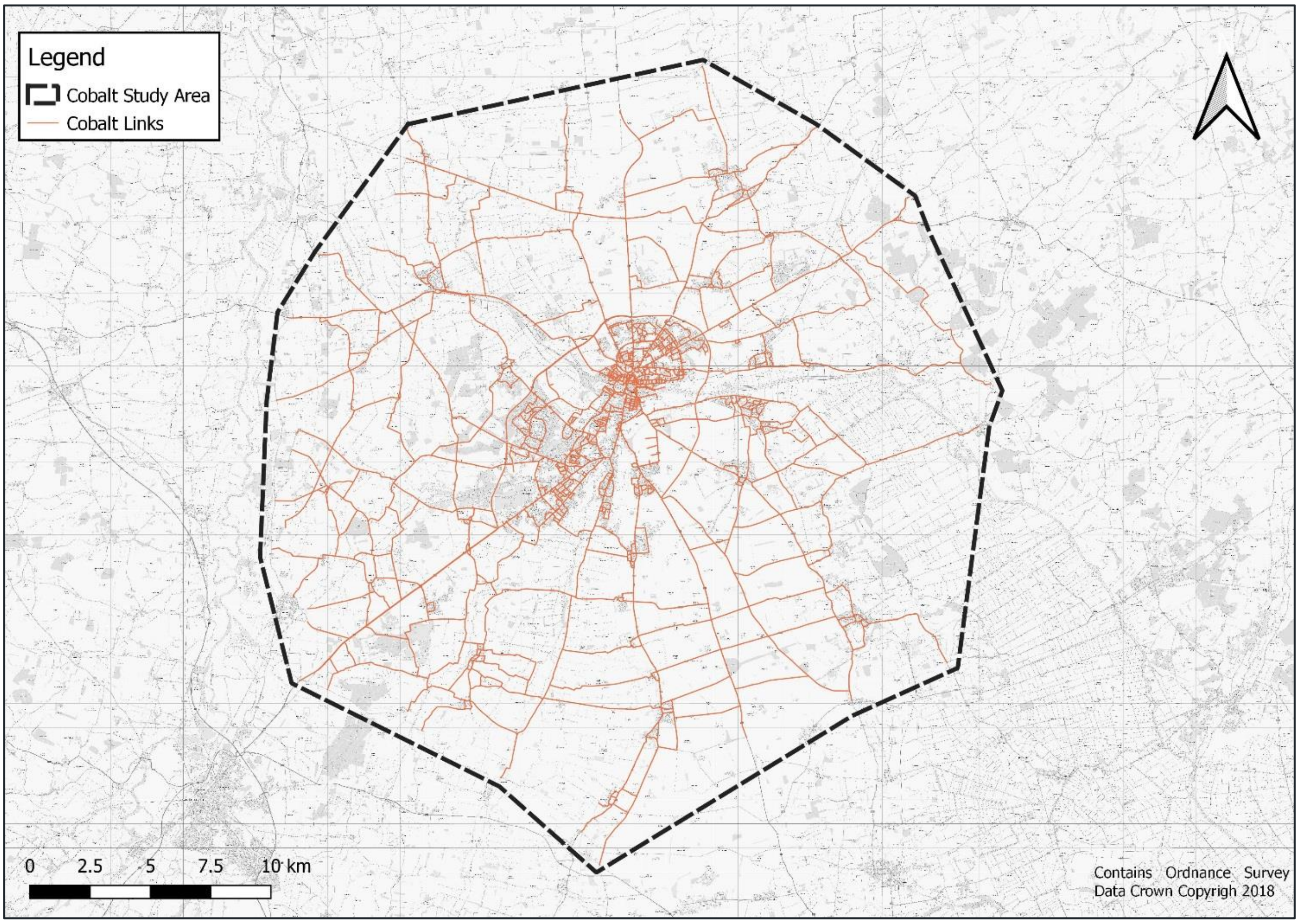
As defined in the COBALT manual, the total cost of accidents on a network is calculated by multiplying the number of accidents forecasted to occur on the network by the cost per accident. The number of accidents on a given length of road is calculated using accident rates, expressed as Personal Injury Accidents (PIA) per million vehicle kilometres travelled. The outputs are expressed as the change in the number of accidents and casualties when a scheme is introduced, and the economic cost implications of these changes.

The savings in the number of accidents / casualties as a result of the scheme were calculated from the difference between accident and casualty costs in the Do-Minimum and Do-Something. The accident benefits were calculated over a 60-year appraisal period and discounted to 2010 base prices and values.

The latest standard economic parameter file was used which contains a series of data tables of standard parameters required to calculate accident impacts in line with WebTAG guidance. Alongside the economic parameter file, the scheme specific input file is used to produce the output file. This contains comparable information for links and junctions, setting out the classification of types, traffic flows and historical accident data.

Initial flow difference plots, presented as Figure 7 in the ASR, indicated that the scheme is forecast to impact upon a wide geographic area. The extent of the study area is therefore as per simulation area of the model as illustrated in Figure 4.

Figure 4 – COBALT Study Area



COBALT has the ability to run the analysis using two different modes as summarised as follows:

- Separate mode – accident benefits are calculated separately for links and junctions (defined as those accidents occurring within 20m of a junction); or
- Combined mode – accident benefits are calculated for links in way that the junction accidents are included.

Due to the size of the study area the combined links and junctions mode was used in the accident analysis.

For each link within the study area (for both the Do Minimum and Do Something forecasts), a COBA link type was assigned from the default set of 15 available within COBALT. Default accident rates were applied to each link. Link lengths, speed limits and AADT flows were also extracted for each link from the forecast models.

A summary of the COBALT parameters is presented in Table 16.

Table 16 – Accident Benefits Calculation General Parameters

Parameter	Value
First Year of Assessment	2026
Evaluation Period	60 Years
Traffic Flow Input Format	AADT
Type of Accident Calculations	Link and Junction Combined
Traffic Flow Input Year	2026, 2041
Traffic Growth Assumption	Default Central (DEFC)
Economic Growth Assumption	Default Central (DEFC)
Fuel Cost Growth Assumption	Default Central (DEFC)

4.4. OTHER BENEFITS

4.4.1. RELIABILITY BENEFITS

WebTAG Unit A1.3 states:

"The term reliability refers to variation in journey times that individuals are unable to predict (journey time variability). Such variation could come from recurring congestion at the same period each day (day-to-day variability), or from non-recurring events such as incidents. It however excludes predictable variation relating to varying levels of demand by time of day, day of week, and seasonal effects which travellers are assumed to be aware of.

Different methods to estimate reliability impacts have been developed for public transport and private vehicle trips on inter urban motorways and dual carriageways, urban roads, and other roads. All require a unit to measure travel time variability and this is generally the standard deviation of travel time (for private travel) or lateness (for public transport)."

For inter-urban motorways and dual carriageways, impacts of journey time variability and incident delays is estimated using the Highways England's bespoke tool namely Motorways Reliability and Incident Delays (MyRIAD). For motorways and dual carriageways, alternative routes avoiding particular sections usually have limited capacity making it difficult for large number of drivers to divert if they encounter delays due to an incident, therefore, in the absence of significant demand exceeding capacity, it may be sufficient to assume that incidents are the main source of unpredictable variability.

For urban areas, alternative routes are more readily available than on the motorways and there are many ways for drivers to divert away from incidents which reduce capacity on particular routes.

Building on previous research, a model has been developed to forecast changes in the standard deviation of travel time from changes in journey time and distance, as provided in the WebTAG Unit A1.3 (March 2017):

$$\Delta\sigma_{ij} = 0.0018(t_{ij2}^{\ 2.02} - t_{ij1}^{\ 2.02})d_{ij}^{\ -1.41}$$

where:

$\Delta\sigma_{ij}$	is the change in standard deviation of journey time from i to j (seconds)
t_{ij1} and t_{ij2}	are the journey times, before and after the change, from i to j (seconds)
d_{ij}	is the journey distance from i to j (km).

To estimate the monetised benefits of changes in journey time variability, money values are needed. The reliability ratio enables changes in variability of journey time to be expressed in monetary terms. The reliability ratio is defined as:

Reliability Ratio = Value of SD of travel time / Value of travel time

The recommended value for the reliability ratio for all journey purposes by car, based on evidence compiled, is 0.4 as stated in WebTAG A1.3. The reliability benefits are then can be estimated using the "rule of half" formula:

$$Benefit = -\frac{1}{2}\sum_{ij}\Delta\sigma_{ij} * (T_{ij}^{0} + T_{ij}^{1}) * VOR$$

Note that the value of reliability (VOR) is obtained by multiplying the value of time by the reliability ratio and T_{ij}^{0} and T_{ij}^{1} are number of trips before and after the change.

WebTAG Unit A1-3 states reliability benefits calculated using this method should be identified separately from other economic benefits and only reported in the AST.

To produce reliability benefits for each scenario, only travel time saving benefits from TUBA runs were extracted since reliability benefits are associated with travel time savings. Benefits associated with fuel, non-fuel, greenhouse gas and indirect tax revenues were not included.

4.4.2. DEPENDENT DEVELOPMENT

The appraisal aspect of the dependent development assessment is to derive a monetised value which quantifies the benefits of 'unlocking' the development land. The key data input is land value data which has been obtained from Ministry of Housing, Communities and Lincolnshire County Council sources to derive the land value uplift for the site.

Offset against the benefits of the land value uplift are several costs which are included in the assessment.

- The loss of amenity, or 'pleasantness', of land due to development. Values are provided in the WebTAG worksheet for valuing housing impacts.
- Transport external costs on existing users due to the addition of development traffic. This is derived from forecast model outputs.
- The cost of non-complementary transport interventions. This can include schools or other local facilities which will be required to support large development.

The Economic Impacts Report (December 2018) describes this in detail.

4.4.3. CONSTRUCTION

WebTAG A1.3 guidance states that costs to transport users due to the construction of a project should be recorded where they are likely to be significant. It is recognised that there are likely to be some impacts to users during construction, in particular with construction of the scheme roundabouts and Station Road overbridge, however no detailed construction schedule is available at this stage. In addition, it is considered that the dis-benefits to road users during construction would be small in comparison to the overall benefits of the scheme and would be unlikely to impact the overall investment decision. As a result, costs to road users have not been considered at the Outline Business Case stage. This will be reviewed at a later stage when more detailed construction information is available.

4.5. SOCIAL IMPACTS

The following social impacts have been assessed using qualitative methods.

- Physical activity;
- Journey quality;
- Security;
- Affordability; and
- Severance.

This process involved analysing results of traffic modelling and understanding how changes resulting from the scheme affect social and economic impacts.

Access to services (referring to public transport accessibility) and option values were not assessed since the scheme does not directly impact on accessibility or availability of transport services. In addition the scheme is not within a regeneration area and so regeneration has not been assessed.

The Social and Distributional Impacts Report (December 2018) describes this in detail.

4.6. DISTRIBUTIONAL IMPACTS

The analysis of distributional impacts is mandatory in the appraisal process and is a key component of the Appraisal Summary Table (AST). The Distributional Impacts Appraisal compares the distribution of benefits arising from a transport intervention against the distributions of different social groups to assess the extent to which benefits are experienced by those groups and compared nationally.

Distributional impacts consider the benefits and dis-benefits that transport interventions have across different social groups. For example, people with access to a car may experience less benefits to those without a car for an intervention that improves local public transport services. It is important to consider vulnerable groups and that they are not disadvantaged further by receiving a disproportionately low share of the benefits provided the intervention, or a disproportionately high share of the dis-benefits.

The following impacts were assessed in the distributional impact appraisal.

- User benefits;
- Noise;
- Air quality;
- Accidents;
- Severance;

- Security;
- Accessibility; and
- Affordability.

Access to services (referring to public transport accessibility) and option values were scoped out in the screening process since the scheme does not directly impact on accessibility or availability of transport services.

The appraisal approach consists of the following three steps:

- Step 1 – Screening Process:
  - Identification of likely impacts for each indicator.
- Step 2 – Assessment:
  - Confirmation of the area impacted by the transport intervention (impact area)
  - Identification of social groups in the impact area; and
  - Identification of amenities in the impact area.
- Step 3 – Appraisal of Impacts:
  - Core analysis of the impacts; and
  - Full appraisal of DIs and input into AST

A full report on the methodology and outputs of the analysis is contained in the Social and Distributional Impacts Report.

5. ECONOMIC APPRAISAL RESULTS

5.1. INTRODUCTION

This section of the report provides the results of the assessment of user benefits, accident cost savings and reliability benefits.

5.2. USER BENEFITS (TUBA)

The user benefits from each scheme in the core growth scenario appraisal are summarised in Table 17.

Table 17 – TUBA Benefits

Benefits	Preferred Option	Next Best Alternative	Low Cost Option
Consumer User (Commute)	48,978	41,891	34,920
Consumer User (Other)	107,174	93,121	76,059
Business User and Provider	147,033	119,812	83,685
Indirect Tax Revenue	16,808	9,122	3,938
Greenhouse Gases	-7,850	-4,163	-1,650
Total User Benefits	**312,143**	**259,783**	**196,952**

Note: All values are in £000 at 2010 prices and values and are as abstracted from TUBA outputs.

The above results show that the total user benefits of the preferred option are forecast to be in the order of £312m. Benefits for the next best alternative are approximately £52m lower at £260m. There is a considerable difference, down to £197m, between the low cost and next best options. This can largely be attributed to the difference in capacity, and corresponding delays, at Pennell's Roundabout.

All schemes result in greenhouse gas dis-benefits and consequent indirect taxation benefit. This can be attributed to the longer journey distances and higher speeds forecast with the scheme.

The remaining TUBA analysis segments the results by:

- Time period;
- Trip purpose;
- Vehicle type; and
- Geographically.

5.2.1. BENEFITS BY TIME PERIOD

The contribution by type of benefit and by time period is summarised in Table 18 and Figure 5 for the preferred option. The corresponding benefits for the next best alternative are presented Table 19 and Figure 6 with the low cost results in Table 20 and Figure 7.

For the preferred option, user benefits (excluding costs associated with non-fuel Vehicle Operating Costs (VOC), greenhouse gases and indirect tax revenue) across the 60-year appraisal period are

£328 million. The benefits are largely associated with journey time savings whilst there is a small increase in fuel vehicle operating costs due to the increased journey distances and higher speeds.

Table 18 – Preferred Option User Benefits by Time Period (£000s)

Period	Type	2026	2041	60 years
AM Period	Time Savings	1,594	1,510	76,437
	VOC (fuel only)	-16	3	-5
	Total	**1,578**	**1,513**	**76,432**
Inter-Peak Period	Time Savings	2,362	2,502	124,586
	VOC (fuel only)	-29	-46	-1,721
	Total	**2,333**	**2,456**	**122,865**
PM Period	Time Savings	1,403	1,363	68,737
	VOC (fuel only)	-18	-14	-588
	Total	**1,385**	**1,349**	**68,149**
Weekend	Time Savings	1,174	1,245	61,974
	VOC (fuel only)	-13	-20	-765
	Total	**1,161**	**1,225**	**61,209**
Total	Time Savings	6,533	6,620	331,734
	VOC (fuel only)	-76	-77	-3,079
	Total	**6,457**	**6,543**	**328,655**

Note: All values are in £000 at 2010 prices and values and are as abstracted from TUBA outputs and may contain rounding discrepancies

Figure 5 – Preferred Option User Benefits by Time Period

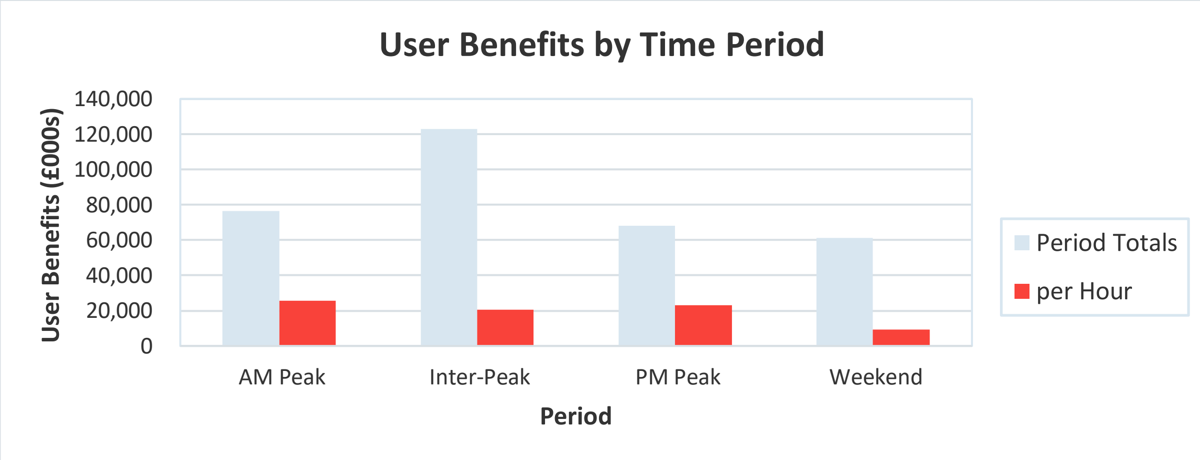


Table 19 – Next Best Alternative User Benefits by Time Period (£000s)

Period	Type	2026	2041	60 years
AM Period	Time Savings	1,307	1,273	64,146
	VOC (fuel only)	13	25	961
	Total	**1,320**	**1,298**	**65,107**
Inter-Peak Period	Time Savings	1,943	2,017	100,687
	VOC (fuel only)	17	9	478
	Total	**1,960**	**2,026**	**101,165**
PM Period	Time Savings	1,162	1,091	55,285
	VOC (fuel only)	11	10	429
	Total	**1,173**	**1,101**	**55,714**
Weekend	Time Savings	965	1,003	50,065
	VOC (fuel only)	8	5	212
	Total	**973**	**1,008**	**50,277**
Total	Time Savings	5,377	5,384	270,183
	VOC (fuel only)	49	49	2,080
	Total	**5,426**	**5,433**	**272,263**

Note: All values are in £000 at 2010 prices and values and are as abstracted from TUBA outputs and may contain rounding discrepancies

Figure 6 – Next Best Alternative User Benefits by Time Period

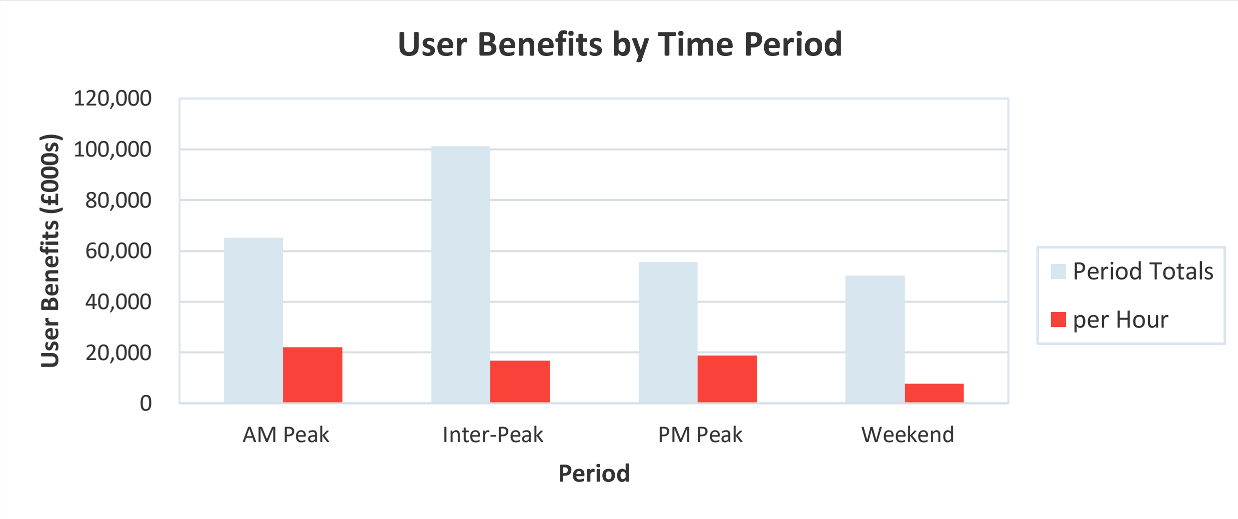
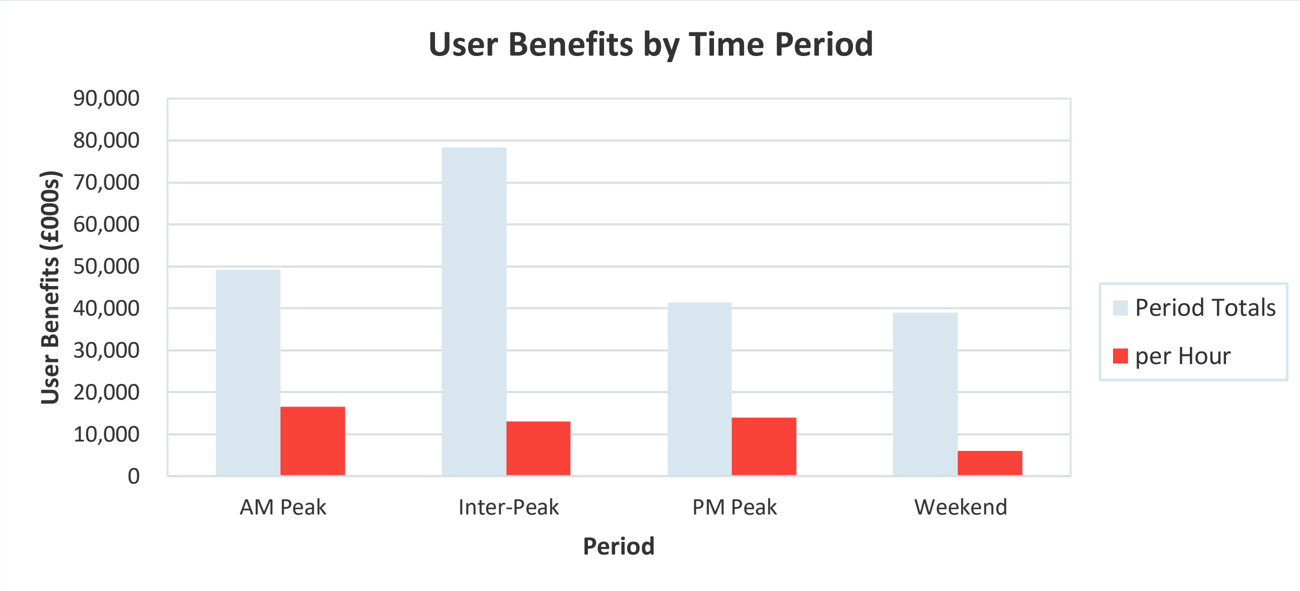


Table 20 – Low Cost Option User Benefits by Time Period (£000s)

Period	Type	2026	2041	Total
AM Peak	Time Savings	1,019	942	47,881
	VoC	26	31	1,243
	Total	**1,045**	**973**	**49,124**
Inter-Peak	Time Savings	1,846	1,483	77,136
	VoC	28	30	1,240
	Total	**1,874**	**1,513**	**78,376**
PM Peak	Time Savings	842	798	40,394
	VoC	29	22	954
	Total	**871**	**820**	**41,348**
Weekend	Time Savings	917	737	38,350
	VoC	12	14	551
	Total	**929**	**751**	**38,901**
Total	Time Savings	4,624	3,960	203,761
	VoC	95	97	3,988
	Total	**4,719**	**4,057**	**207,749**

Note: All values are in £000 at 2010 prices and values and are as abstracted from TUBA outputs and may contain rounding discrepancies

Figure 7 – Low Cost Option User Benefits by Time Period



5.2.2. USER BENEFITS BY JOURNEY PURPOSE

User benefits are presented by journey purpose in Table 21 to Table 23. Benefits for business users are just below 50%. TUBA guidance on checking outputs suggests "Road user benefits to consumers are typically a similar order of magnitude to the benefits to business travellers" which is consistent with the results presented below. The combination of weekend and inter-peak hours make up the majority of the analysis time.

Table 21 – Preferred Option User Benefits by Journey Purpose (£000s)

Purpose	Time	VOC	Total	%
Commuting	55,760	-6,712	49,048	15.3%
Other	123,870	-16,364	107,506	33.6%
Business (Car)	88,704	2,108	90,812	28.4%
Business (Freight)	63,400	297	63,697	19.9%
Greenhouse Gas			-7,850	-2.5%
Indirect Tax			16,808	5.3%
Total	**331,734**	**-20,671**	**320,089**	**100.0%**

Note: All values are in £000 at 2010 prices and values and are as abstracted from TUBA outputs and may contain rounding discrepancies

Table 22 – Next Best Alternative User Benefits by Journey Purpose (£000s)

Purpose	Time	VOC	Total	%age
Commuting	46,626	-4,670	41,956	15.7%
Other	102,283	-8,810	93,473	34.9%
Business (Car)	68,870	3,659	72,529	27.1%
Business (Freight)	52,404	2,365	54,769	20.5%
Greenhouse Gas			-4,163	-1.6%
Indirect Tax			9,122	3.4%
Total	**270,183**	**-7,456**	**267,730**	**100.0%**

Note: All values are in £000 at 2010 prices and values and are as abstracted from TUBA outputs and may contain rounding discrepancies

Table 23 – Low Cost Option User Benefits by Journey Purpose (£000s)

Purpose	Time	VOC	Total	%age
Commuting	38,023	-3,057	34,966	17.1%
Other	80,435	-4,071	76,364	37.3%
Business (Car)	45,625	3,427	49,052	23.9%
Business (Freight)	39,677	2,495	42,172	20.6%
Greenhouse Gas			-1,650	-0.8%
Indirect Tax			3,938	1.9%
Total	**203,760**	**-1,206**	**204,899**	**100.0%**

Note: All values are in £000 at 2010 prices and values and are as abstracted from TUBA outputs and may contain rounding discrepancies

5.2.3. USER BENEFITS BY VEHICLE TYPE AND MAGNITUDE OF TIME SAVINGS

Travel time benefits have been further broken down by vehicle type and magnitude of time saving for each option in Tables 24-26. Approximately 80% of journey time benefits are made up by car users. This reflects the fact that cars make up the majority of road users and users of the scheme.

Benefits arise across all the time saving bands. For the preferred option approximately 50% of time saving benefits are associated with trips with a time savings of between 0 and 2 minutes. It is noted that a small proportion of journeys incur an increase in travel time resulting in some dis-benefits.

Table 24 – Preferred Option Journey Time Benefits by Vehicle Type and Magnitude of Time Savings (£000s)

Veh	Purpose	< -5min	-5 to -2min	-2 to 0min	0 to 2min	2 to 5min	> 5min	Total
Car	Business	-138	-428	-5,577	31,157	32,101	31,589	**88,704**
Car	Commuting	-1	-94	-6,151	31,058	18,115	12,833	**55,760**
Car	Other	-64	-442	-11,030	70,300	35,715	26,260	**120,739**
LGV	Other	-12	-9	-242	1,734	851	809	**3,131**
LGV	Business	-182	-136	-3,755	26,524	13,022	12,320	**47,793**
OGV1	Business	-121	-12	-1,277	6,691	2,440	3,949	**11,670**
OGV2	Business	-41	-4	-431	2,257	823	1,332	**3,936**
Total	**Total**	**-559**	**-1,125**	**-28,463**	**169,721**	**103,067**	**89,092**	**331,734**

Table 25 – Next Best Alternative Journey Time Benefits by Vehicle Type and Magnitude of Time Savings (£000s)

Veh	Purpose	< -5min	-5 to -2min	-2 to 0min	0 to 2min	2 to 5min	> 5min	Total
Car	Business	-126	-249	-4,618	29,362	29,104	15,396	**68,869**
Car	Commuting	-1	-10	-4,832	28,719	14,757	7,994	**46,627**
Car	Other	-77	-81	-8,527	63,077	29,880	15,448	**99,720**
LGV	Other	-11	-5	-192	1,545	722	504	**2,563**
LGV	Business	-165	-86	-2,996	23,669	11,056	7,654	**39,132**
OGV1	Business	-157	-8	-992	5,937	2,094	3,049	**9,923**
OGV2	Business	-53	-3	-335	2,003	707	1,029	**3,348**
Total	**Total**	**-590**	**-442**	**-22,492**	**154,312**	**88,320**	**51,074**	**270,183**

Table 26 – Low Cost Option Journey Time Benefits by Vehicle Type and Magnitude of Time Savings (£000s)

Veh	Purpose	< -5min	-5 to -2min	-2 to 0min	0 to 2min	2 to 5min	> 5min	Total
Car	Business	-203	-253	-8,407	21,436	22,740	10,313	**45,626**
Car	Commuting	-3	-41	-5,840	25,581	12,632	5,694	**38,023**
Car	Other	-101	-115	-11,432	53,211	26,114	10,762	**78,439**
LGV	Other	-8	-5	-277	1,308	590	387	**1,995**
LGV	Business	-120	-79	-4,284	20,055	9,010	5,875	**30,457**
OGV1	Business	-116	-33	-1,695	4,539	2,065	2,133	**6,893**
OGV2	Business	-39	-11	-572	1,531	697	720	**2,326**
Total	**Total**	**-590**	**-537**	**-32,507**	**127,661**	**73,848**	**35,884**	**203,760**

5.2.4. USER BENEFITS – GEOGRAPHIC SEGMENTATION

Guidance recommends that an aggregation of modelled zones into different geographical areas should be used in the TUBA analysis. This is to ensure that the benefits produced by the proposed scheme are geographically proportionate given the scale and location of the scheme. The distribution of benefits has been analysed using the sector system described in Section 4.2. The origins and destinations of benefits are illustrated in Figure 8 to Figure 12.

The charts below show a significant proportion of the benefits are associated with trips to / from sectors 1 – 5, which make up the Lincoln and North Hykeham urban area. In addition, large benefits are forecast for sector 12 (East Lindsey) and sector 18 (Midlands). The benefits are relatively evenly split between origins and destinations which indicates the benefits are also evenly split across time periods and direction.

Figure 8 – Preferred Option User Benefits by Sector

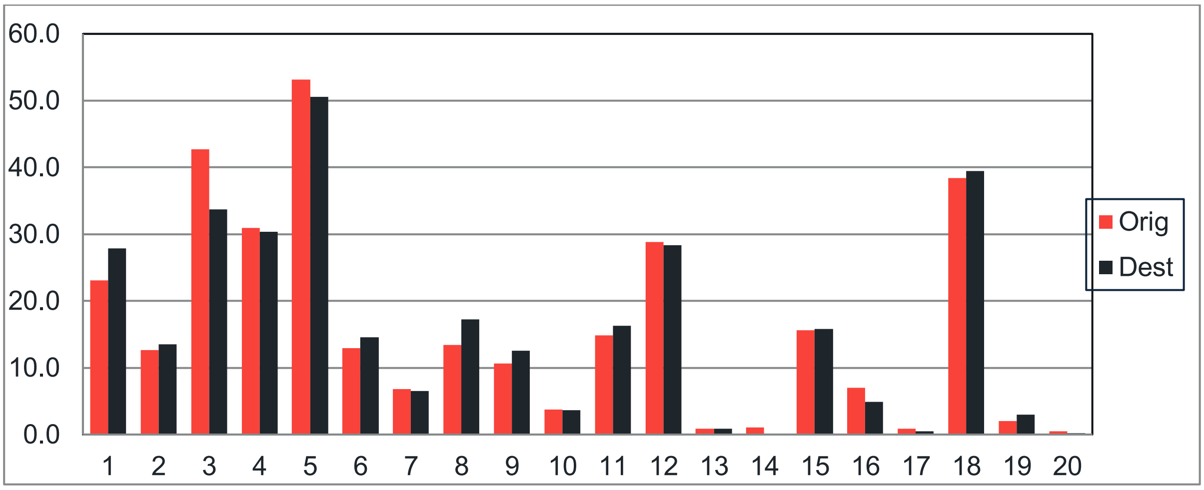


Figure 9 – Next Best Alternative User Benefits by Sector

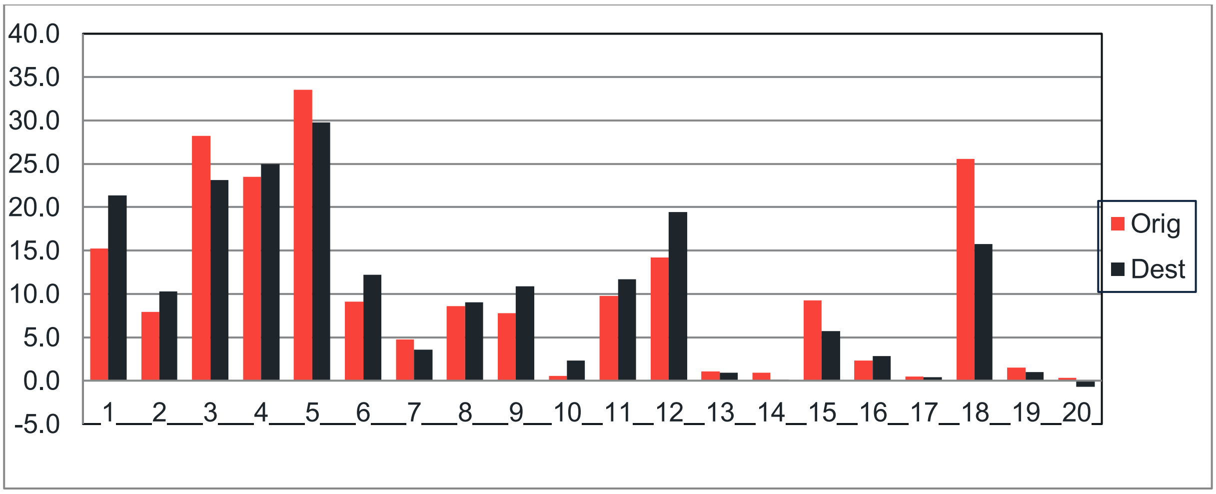
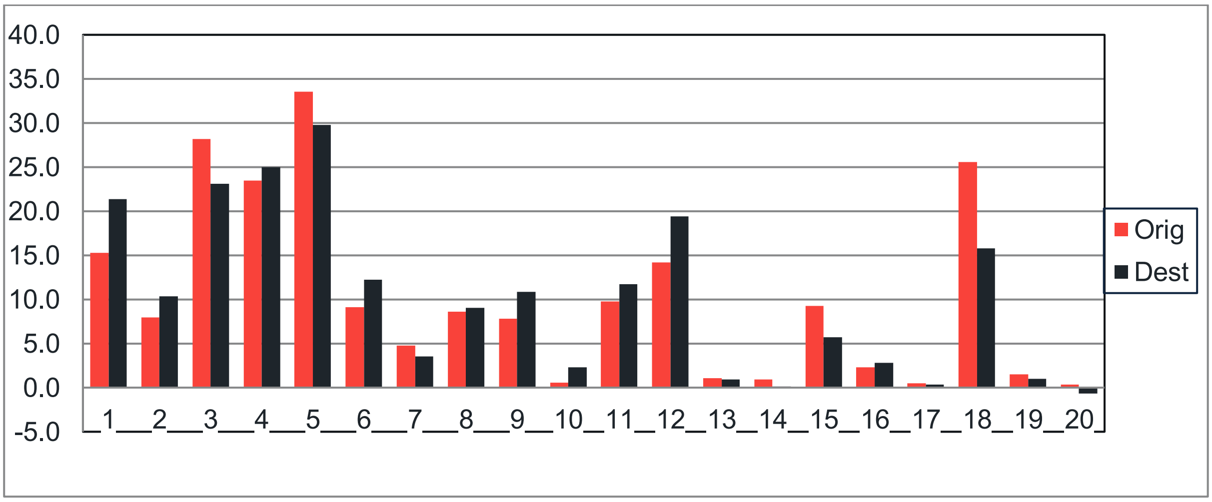


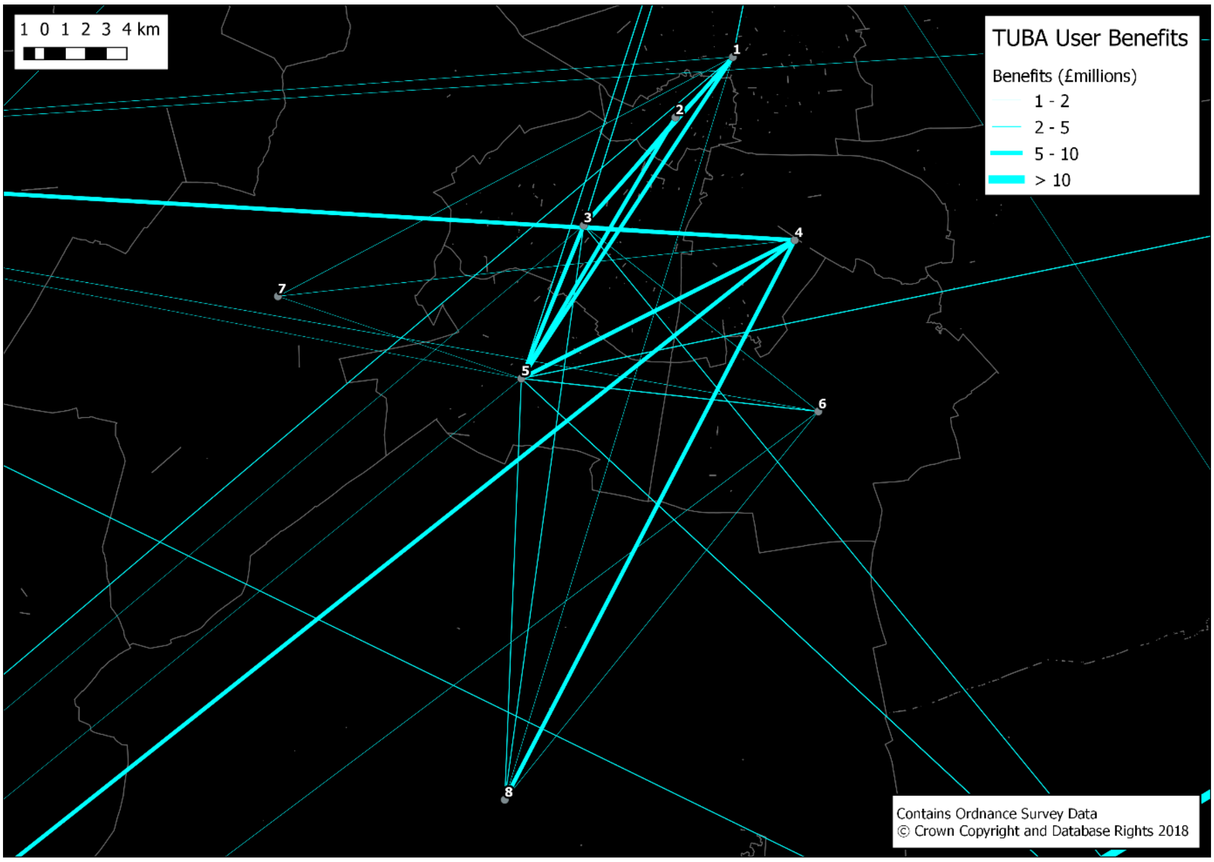
Figure 10 – Low Cost Option User Benefits by Sector



Further analysis of the geographical distribution of benefits for the preferred scheme is illustrated in Figure 11, Figure 12 and Table 27. Key findings of the results can be summarised as follows:

- Sector pairs with the largest benefits are generally east-west movements which cross the Lincoln urban area.
- The sector pairing with the highest benefits is between sector 12 (East Lindsey) and sector 18 (Midlands excluding Lincs and Notts). These are east-west movements which would be highly likely to use the scheme or the A46 where traffic flows are forecast to reduce.
- Benefits between sectors 4 and 5, which include the urban areas at each end of the scheme, are high.
- Some sector pairs incur a slight dis-benefit. These are generally trips that would either use or cross the LEB for which an increase in traffic is forecast, incurring additional delay.

Figure 11 - Preferred Option User Benefits by Sector Pair



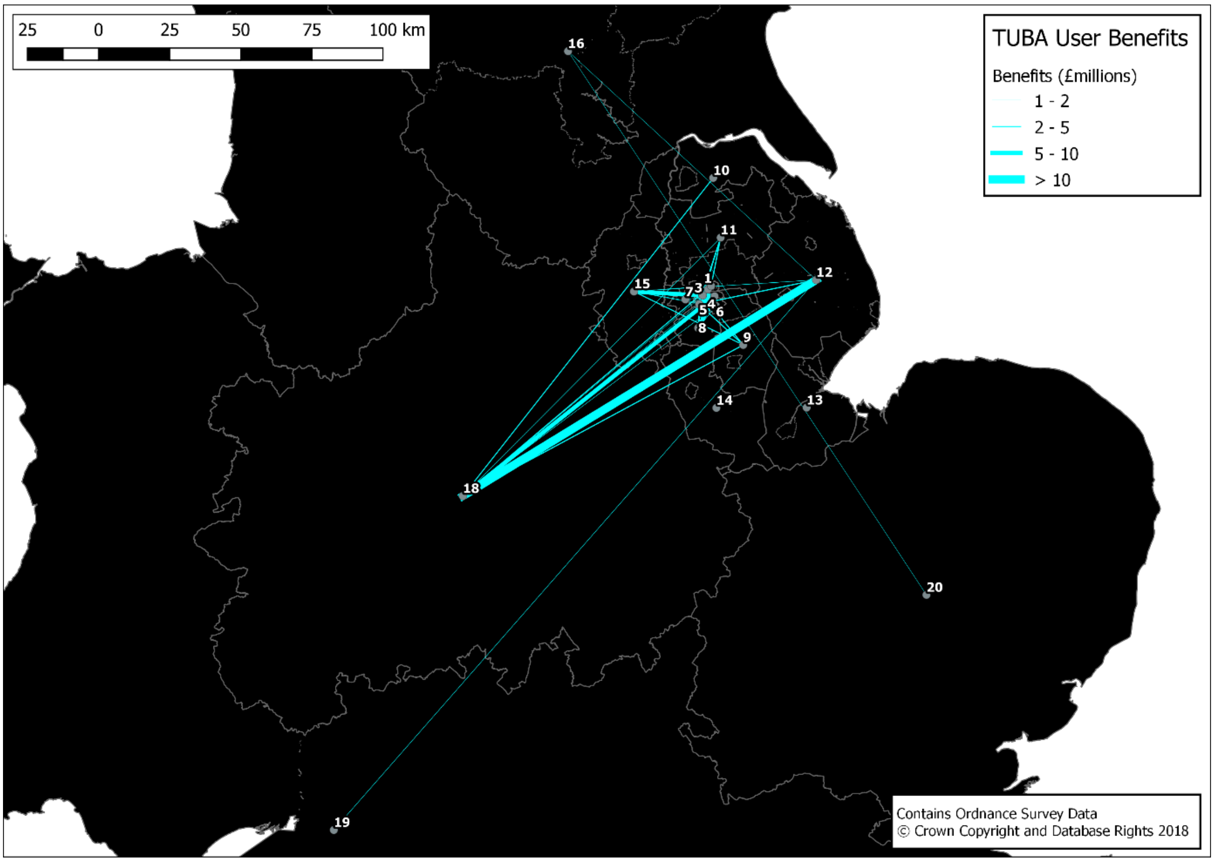


Figure 12 - Preferred Option User Dis-Benefits by Sector Pair

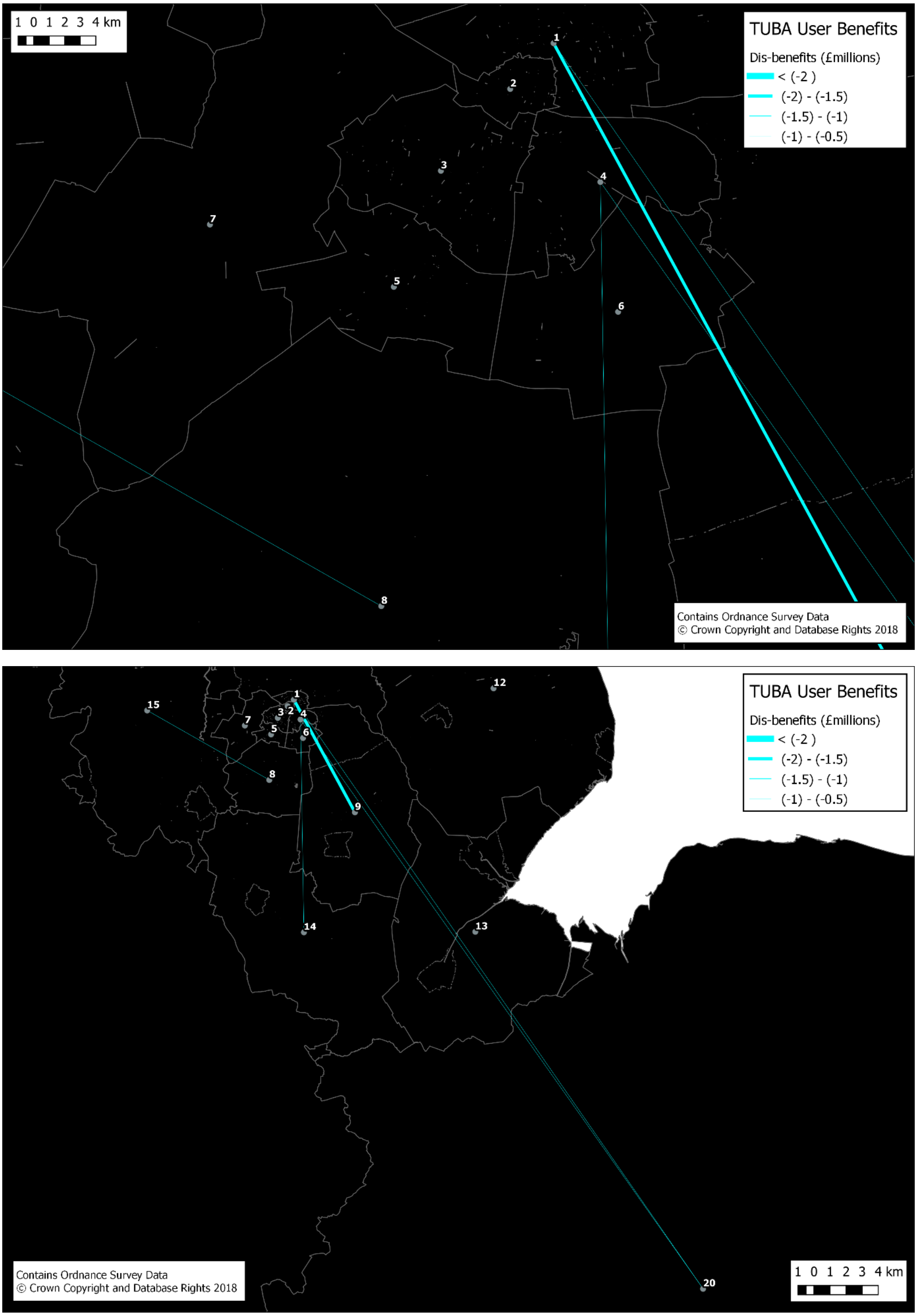


Table 27 – Preferred Option User Benefits by Sector Pair (£000s)

Sec	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Orig
1	2.9	1.2	6.2	-0.3	4.8	0.8	1.0	1.9	-1.7	0.2	2.4	0.5	-0.4	0.1	1.1	0.8	0.2	1.9	0.1	-0.8	**23.1**
2	1.6	0.5	3.2	0.2	5.2	-0.1	0.3	0.3	-0.4	0.0	0.8	0.2	-0.1	-0.1	0.4	0.2	0.0	0.5	0.0	-0.2	**12.6**
3	7.5	4.1	6.4	3.7	7.6	1.5	0.9	2.4	2.1	0.3	2.9	1.0	0.2	-0.0	0.8	0.3	0.0	1.1	0.0	-0.3	**42.7**
4	-0.0	0.5	2.6	-0.1	7.5	0.5	1.7	5.5	-0.3	-0.0	-0.0	-0.1	-0.0	-0.5	6.4	0.5	0.3	6.8	0.3	-0.5	**31.0**
5	5.4	4.3	6.2	7.4	6.9	3.3	1.0	3.0	4.3	0.3	3.2	2.8	0.9	0.2	1.7	0.2	-0.1	1.3	0.1	0.5	**53.1**
6	0.5	0.0	1.1	0.2	3.8	1.4	0.4	1.4	0.7	0.0	0.5	0.5	0.0	0.0	1.1	0.2	0.0	1.1	-0.1	0.0	**12.9**
7	1.1	0.4	0.6	1.9	0.6	0.4	-0.0	0.1	0.3	0.1	0.6	0.6	0.1	0.0	-0.0	0.0	-0.0	-0.0	-0.0	0.1	**6.8**
8	1.8	0.2	1.3	5.1	1.2	1.7	-0.1	0.4	1.0	0.2	1.0	0.4	0.0	0.0	-0.6	-0.0	-0.0	-0.2	-0.0	-0.0	**13.4**
9	-1.3	-0.0	1.2	-0.3	4.4	0.9	0.4	1.0	0.0	0.0	-0.1	-0.2	-0.0	0.1	1.4	0.0	-0.0	2.8	0.2	-0.0	**10.6**
10	0.2	0.1	0.2	-0.0	0.3	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	-0.0	-0.0	2.1	0.3	0.0	**3.7**
11	2.9	1.0	2.3	-0.2	2.4	0.5	0.4	0.9	-0.4	0.2	1.4	0.5	0.0	0.1	0.8	0.3	0.1	1.7	0.1	-0.0	**14.9**
12	-0.0	0.2	0.9	-0.3	2.8	0.6	0.3	0.6	-0.1	-0.0	0.2	-0.2	-0.0	0.0	2.0	0.9	0.0	19.3	1.6	-0.0	**28.8**
13	-0.3	-0.1	0.2	-0.0	0.9	0.0	0.1	0.0	0.0	0.0	-0.2	0.0	0.0	-0.0	0.1	0.0	-0.0	0.0	0.0	0.0	**0.9**
14	0.1	-0.0	-0.2	0.1	0.3	0.1	0.0	0.0	0.1	0.1	0.1	0.0	-0.0	-0.0	0.0	0.2	-0.0	0.1	0.0	-0.0	**1.1**
15	1.4	0.5	0.6	6.0	0.6	1.3	-0.1	-0.5	2.5	0.1	0.7	1.8	0.1	0.0	0.1	0.1	-0.0	0.1	-0.0	0.2	**15.6**
16	0.7	0.3	0.3	0.2	0.4	0.1	0.0	0.3	0.1	-0.0	0.2	1.7	-0.0	0.2	0.3	0.0	0.0	0.8	0.3	1.2	**7.0**
17	0.2	0.1	0.0	0.2	0.0	0.1	-0.0	-0.0	0.0	-0.0	0.1	0.1	-0.0	-0.0	-0.0	0.0	0.0	0.0	-0.0	-0.0	**0.8**
18	3.3	0.5	0.7	6.5	0.6	1.2	-0.0	-0.2	4.1	2.0	1.9	17.4	-0.0	-0.1	-0.0	0.6	0.0	0.0	0.0	-0.0	**38.4**
19	0.1	0.0	-0.1	0.2	0.0	0.0	-0.0	-0.0	0.2	0.1	0.1	1.2	-0.0	-0.0	-0.0	0.1	0.0	0.0	0.0	0.0	**2.0**
20	-0.2	-0.2	-0.1	-0.2	0.3	0.0	0.0	0.0	-0.0	0.0	0.3	-0.0	-0.0	-0.0	0.1	0.5	-0.0	0.0	-0.0	0.0	**0.5**
Dest	**27.9**	**13.5**	**33.7**	**30.4**	**50.6**	**14.6**	**6.5**	**17.3**	**12.6**	**3.7**	**16.3**	**28.3**	**0.8**	**0.1**	**15.8**	**4.9**	**0.5**	**39.5**	**3.0**	**0.2**	**320.1**

5.3. ACCIDENT BENEFITS (COBALT)

5.3.1. PREFERRED OPTION

Accident benefits for the scheme have been calculated with COBALT using the methodology described in section 4.3. The forecast accident savings and corresponding monetary benefit for the preferred scheme are summarised in Table 28. The scheme is forecast to result in a reduction of 427 accidents with a corresponding benefit of £16.7m over the 60-year appraisal period.

Table 28 – Preferred Option Accident Benefits

AREA	DM	Preferred Option	Saving
Number of Accidents	16,166	15,739	427
Cost of Accidents (£000s)	754,432	737,733	16,669

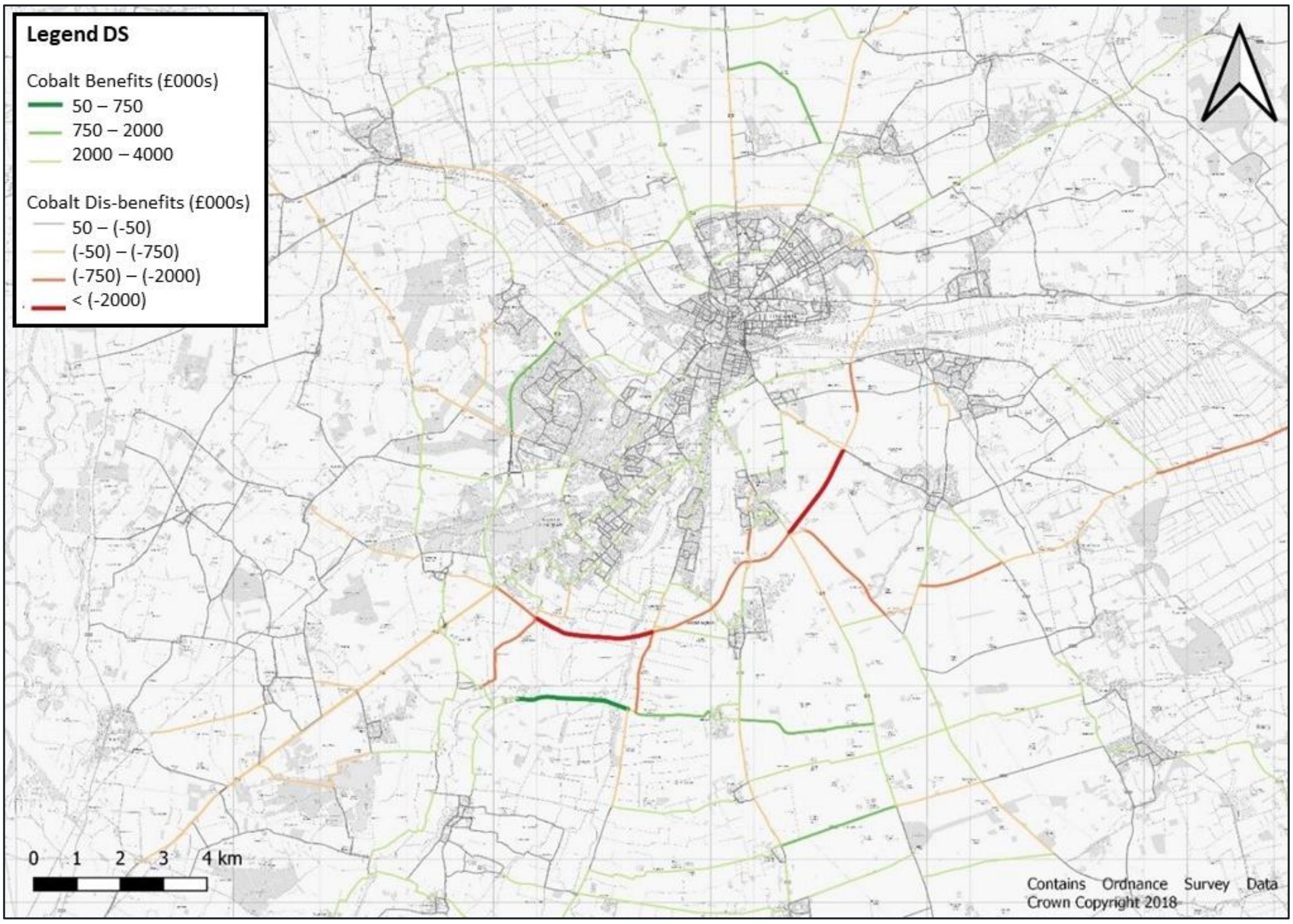
Table 29 summarises the forecast savings in casualties. The results show that there has been a reduction in all casualty severities with a total casualty reduction of 559.

Table 29 – Preferred Option Casualty Savings

Casualty Severity	DM	Preferred Option	Saving
Fatal	245	244	1
Serious	2,428	2,370	58
Slight	20,010	19,510	500
Total Number of Casualties	22,683	22,124	559

The COBALT results are illustrated by link in Figure 13. This demonstrates that accident benefits are forecast on most sections of the A46 around Lincoln, the urban areas to the north of the scheme and the east-west route through Aubourn and Harmston. In addition to the scheme itself, increases in accidents are forecast on the Lincoln Eastern Bypass (LEB) and on the A46 to the south of the scheme. This is due to the forecast increase in traffic on these routes with the scheme in place.

Figure 13 – Preferred Option Accident Benefits



5.3.2. NEXT BEST ALTERNATIVE

The forecast accident savings and corresponding monetary benefit for the Next Best Alternative are summarised in Table 30 with the casualty savings summarised in Table 31. Whilst the scheme is forecast to result in a reduction in accidents, there is a net dis-benefit of £5.1m. This can be attributed to the increase in fatal and serious casualties.

Table 30 – Next Best Alternative Accident Benefits

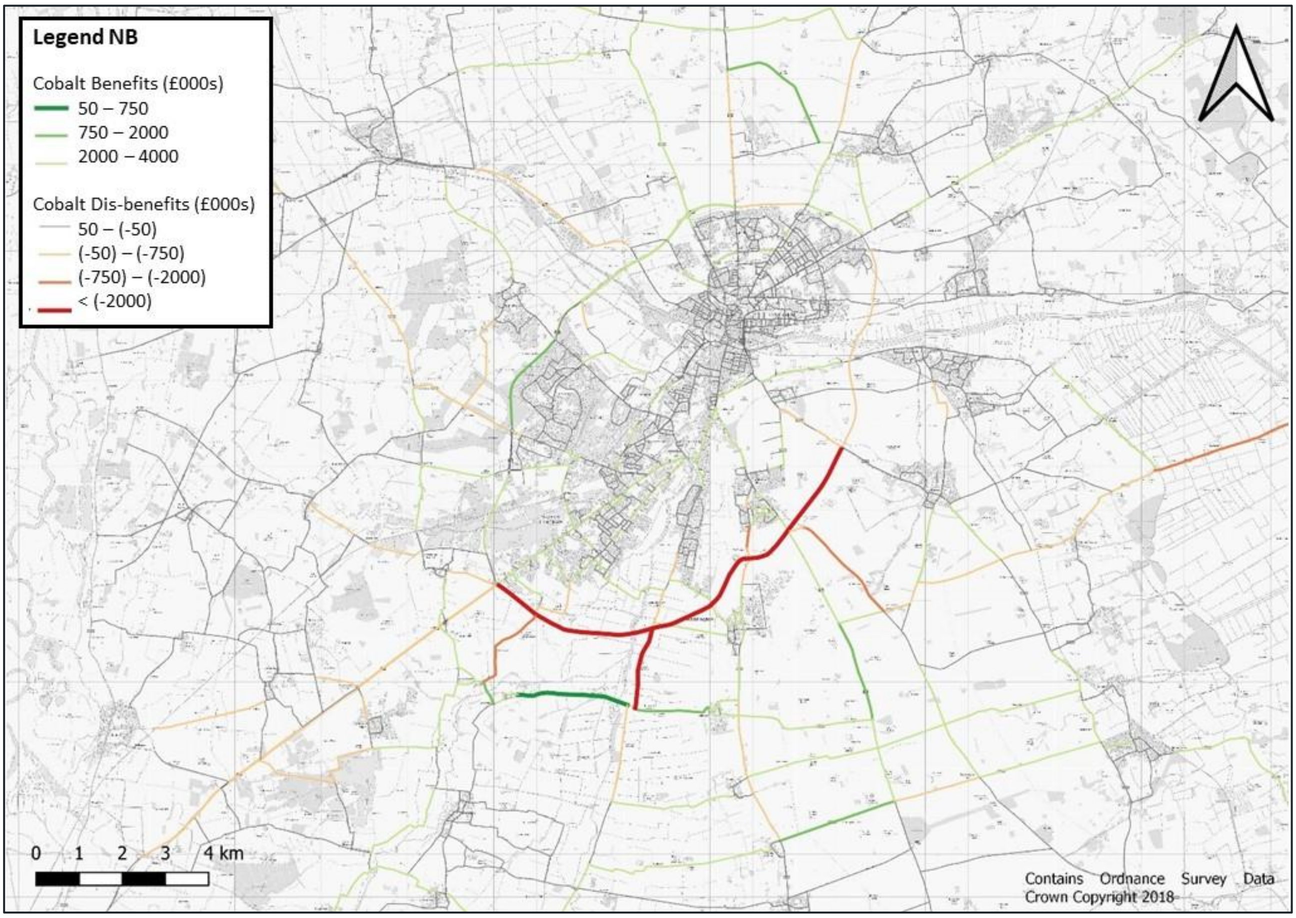
	DM	Next Best	Saving
Number of Accidents	16,166	16,084	82
Cost of Accidents (£000s)	754,432	759,557	-5,125

Table 31 – Next Best Alternative Casualty Savings

Casualty Severity	DM	Next Best	Saving
Fatal	245	255	-9
Serious	2,428	2,447	-20
Slight	20,010	19,970	40
Total Number of Casualties	22,683	22,672	11

The Next Best Alternative COBALT results are illustrated in Figure 14. The dis-benefit from accidents on the scheme are higher than the preferred option. This can be attributed to the higher accident rates associated with a single carriageway compared to a dual carriageway.

Figure 14 – Next Best Alternative Accident Benefits



5.3.3. LOW COST OPTION

The forecast accident savings and corresponding monetary benefits for the Low Cost option are summarised in Table 32 with the casualty savings summarised in Table 33. Whilst the scheme is forecast to result in a reduction in accidents there is a net dis-benefit of £4.3m. This can be attributed to the increase in fatal and serious casualties. The results are similar to those for the Next Best Alternative.

Table 32 – Low Cost Option Accident Benefits

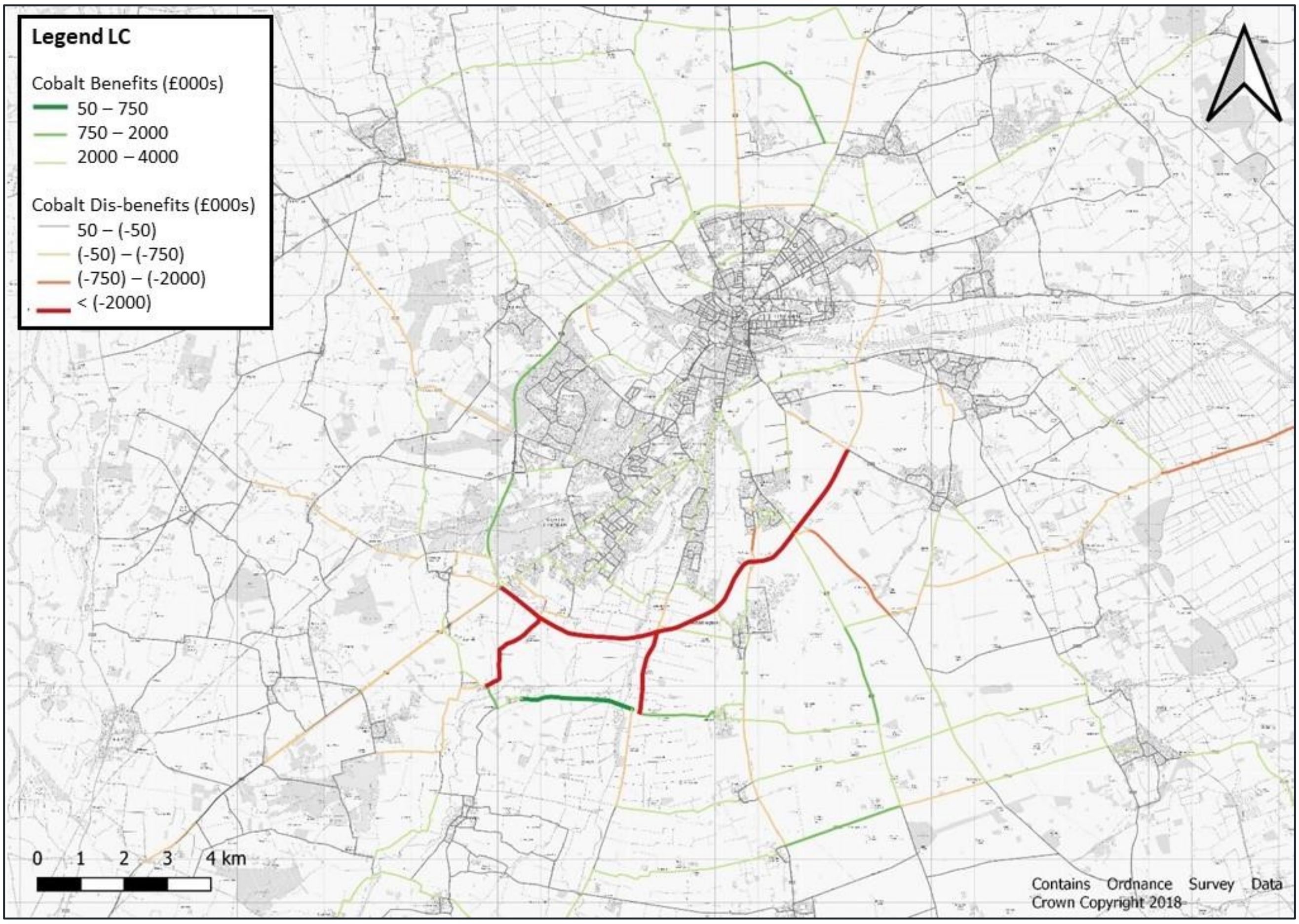
	DM	Low Cost	Saving
Number of Accidents	16,166	16,102	64
Cost of Accidents (£000s)	754,432	758,761	-4,329

Table 33 – Low Cost Option Casualty Savings

Casualty Severity	DM	Low Cost	Saving
Fatal	245	253	-8
Serious	2,427	2,444	-17
Slight	20,010	19,980	30
Total Number of Casualties	22,683	22,672	11

The Low Cost option COBALT results are illustrated by link in Figure 15. As with the next best results the costs of accidents on the scheme are considerably higher than with the preferred option.

Figure 15 – Low Cost Option Accident Benefits



5.3.4. ACCIDENT SUMMARY

The COBALT results for each scheme configuration are summarised in Table 34.

Table 34 – COBALT Results Summary

	Preferred Option	Next Best Alternative	Low Cost Option
Number of Accidents Saved	427	82	64
Cost of Accidents (£000's)	16,699	-5,125	-4,329

Of the above, only the preferred option is forecast to result in a positive accident benefit. Whilst the Next Best and Low Costs options forecast a reduction in accidents there is a monetised dis-benefit due to an increase in fatal and serious casualties. A further analysis of the results, broken down by scheme and non-scheme links is presented in Table 35.

Table 35 – COBALT Results by Link Type

		Accident Savings	Accident Benefit (£000s)
Scheme Links	Preferred Option	-171	-7,992
	Next Best Alternative	-449	-26,989
	Low Cost Option	-392	-23,608
Non-Scheme Links	Preferred Option	598	24,723
	Next Best Alternative	531	21,880
	Low Cost Option	456	19,305
TOTAL	Preferred Option	427	16,669
	Next Best Alternative	82	-5,125
	Low Cost Option	64	-4,329

The above shows that the benefits for the non-scheme links are similar across all options. The preferred option has the highest non-scheme link benefits due to the higher amount of traffic diverting to the scheme.

It is notable that for the scheme links the forecast number of accidents and costs are considerably lower for the preferred option compared to the next best and low cost options. Whilst the preferred option has higher flows the accident rates applied in COBALT are considerably lower for dual carriageways in comparison to single carriageways. As a result, the forecast number of accidents on the single carriageway options are considerably higher than for the dual carriageway.

Further investigation in to the overall dis-benefits associated with the single carriageway options identified that they are likely to be associated with the increase in overall vehicle distance travelled with the scheme. This is demonstrated by results presented in the Traffic Forecasting Report. The increase on overall vehicle distance can be attributed to a combination of the variable demand response in the Do-Something scheme combined with trips diverting to longer distance, but lower journey time routes. The resulting dis-benefits on the scheme links therefore outweigh the benefits on the non-scheme links in the single carriageway scenarios.

5.4. RELIABILITY BENEFITS

The reliability benefits are summarised in Table 36, Table 37 and Table 38.

for the preferred, next best and low cost options respectively. The overall reliability benefits can be summarised as follows:

- Preferred Option: £29.1m
- Next Best Alternative: £24.3m
- Low Cost Option: £20.2m

The reliability benefits are in the order of 10% of the corresponding TUBA results. The key findings from these results are as follows:

- The preferred option has the highest level of benefits which is 20% higher compared to the Next Best Alternative.
- The preferred option also provides greater resilience as a dual carriageway than the single carriageway alternatives. This is due to the additional capacity in the event of an incident on another major route (particularly the A46) or incidents on the scheme, which are less likely to affect both directions of a dual carriageway. The resilience benefits are not captured in the monetary value since there is no established method to derive such a value.
- These benefits align with the scheme objective to provide improved resilience to the network.

Table 36 – Preferred Option Reliability Benefits (£000s)

Year	2026	2041	60 years
Business	125	125	6,294
Commuting	146	143	7,212
Other	302	312	15,593
Total	573	580	29,099

Table 37 – Next Best Alternative Reliability Benefits (£000s)

Year	2026	2041	60 years
Business	102	100	5,016
Commuting	125	122	6,163
Other	253	264	13,156
Total	480	486	24,335

Table 38 – Low Cost Option Reliability Benefits (£000s)

Year	2026	2041	60 years
Business	90	76	3,936
Commuting	108	104	5,255
Other	234	216	10,980
Total	432	396	20,171

5.5. DEPENDENT DEVELOPMENT

A primary objective of the scheme is to support housing growth. A dependent development assessment of SWQ was undertaken as Level 3 wider impact analysis which is detailed in the Economic Impacts Report (December 2018).

The whole of the SWQ development was determined to be dependent on the scheme. The baseline scenario established an unacceptable level of service at Pennell's Roundabout and rat-running on local roads adjacent to the site location as the result of congestion. Pennell' Roundabout was a key issue as this junction provides the primary access from the site to the A46 and from there other strategically important routes. There is poor access across the River Whitham towards the A15 and LEB in the east. The scheme resolves these key issues by providing additional an entry and wider capacity at Pennell's Roundabout and a direct link to the A15 / LEB.

An assessment of the benefits from unlocking dependent development estimated the monetised value at **£18.785m**.

5.6. SOCIAL IMPACTS

The assessment of social impacts is detailed in the Social and Distributional Impacts Report. Table 39 summarises the qualitative assessment score and summary of the impact.

Table 39 – Summary of Social Impacts

Impact	Qualitative score	Summary
Physical activity	Slight beneficial	The scheme provides new walking, cycling and equestrian infrastructure separated from vehicular traffic which will encourage physical activity. Decreases in traffic flow on local roads in the Lincoln urban area reduce a perceived barrier to walking and cycling.
Journey quality	Slight beneficial	The scheme provides alternative route choice which reduces route uncertainty; in particular if there is an incident on the existing orbital route. The scheme also reduces congestion across the Lincoln urban area which reduces driver frustration.
Security	Slight beneficial	The scheme has opening year AADT up to 27,000 in the busiest section at the western end which provides informal surveillance for pedestrians. Pedestrian facilities will be designed to the latest DMRB guidance. There are no service stations of car parks within the immediate vicinity of the scheme for HGV (or other user) stops.

Impact	Qualitative score	Summary
Affordability	Moderate adverse	The scheme increases travel distance which leads to a net increase in vehicle operating costs across all users. There is a very small increase in user charges incurred from a net increase in flow on toll routes (Humber Bridge, Dunham Bridge).
Severance	Large beneficial	The scheme reduces the overall level of traffic across the network in the residential areas of North Hykeham and Waddington. This improves accessibility to local community facilities and services for motorised users through reduced delay in the area and for non-motorised users through reducing the level of congestion as a perceived barrier to travel.

5.7. DISTRIBUTIONAL IMPACTS

The social and distributional impact assessment has been completed in line with the state of development of the scheme. The indicators and their respective assessments that were carried out as included in the Social and Distributional Impact report in Appendix F and are summarised below in Table 40.

Table 40 - Summary of Distributional Impact Appraisal

Impact	Distributional scale	Summary
User impacts	Moderate beneficial	Around 85% of the benefits are experienced by people living in the impact area, of which: ▪ 20% are experienced by people in the 40% most deprived communities; and ▪ 57% are experienced by people in the 40-80% income deprived group.
Noise	Slight beneficial	There are positive impacts for all income quintiles including large beneficial for the lowest quintile. There are neutral to slight beneficial impacts for education facilities (except for one receptor major adverse) and elderly facilities.
Air Quality	Moderate beneficial	Most of the benefits are concentrated in the lower two income deprivation quintiles, however negative impacts in the third quintile may have a negative impact on the positive impacts in the lower two quintiles. Positive impacts in the upper two quintiles, though they are smaller overall, may offset this.
Accidents	Moderate beneficial	There is a positive impact for all vulnerable groups assessed through a reduction in casualties – children (<16), young adults (16-25), older people (65+) and pedestrians.
Affordability	Moderate adverse	There is a dis-benefit across all income groups. ▪ The highest dis-benefit is in the least deprived income group (80-100%). ▪ The lowest dis-benefit is in the 40-60% deprived income group. ▪ There is a moderate adverse impact in the 40% most deprived income groups.
Severance	Large beneficial	The WebTAG worksheet was completed and determined a large beneficial impact for all vulnerable groups assessed – children (<16), older people (65+), no car households and residents with long term health problems or disabilities.

A full quantitative distributional assessment of noise and air quality impacts will be delivered in the Full Business Case.

5.8. TRANSPORT ECONOMY EFFICIENCY (TEE)

The results of the assessment in terms of user costs and benefits are summarised in the Transport Economic Efficiency (TEE) table, reproduced in Table 41 to Table 43 for the preferred, next best and low cost options respectively.

Table 41 – Preferred Option TEE

Non-business: Commuting	**ALL MODES**		**ROAD**		**BUS and COACH**	**RAIL**		**OTHER**
User benefits	**TOTAL**		**Private Cars and LGVs**		**Passengers**	**Passengers**		
Travel time	55,760		55,760					
Vehicle operating costs	-6,712		-6,712					
User charges	-70		-70					
During Construction & Maintenance	0		0					
COMMUTING	48,978	*(1a)*	48,978		0	0		0
Non-business: Other	**ALL MODES**		**ROAD**		**BUS and COACH**	**RAIL**		**OTHER**
User benefits	**TOTAL**		**Private Cars and LGVs**		**Passengers**	**Passengers**		
Travel time	123,870		123,870					
Vehicle operating costs	-16,364		-16,364					
User charges	-332		-332					
During Construction & Maintenance	0		0					
NET NON-BUSINESS BENEFITS: OTHER	107,174	*(1b)*	107,174		0	0		0
Business								
User benefits			**Goods Vehicles**	**Business Cars & LGVs**	**Passengers**	**Freight**	**Passengers**	
Travel time	152,104		63,400	88,704				
Vehicle operating costs	2,405		297	2,108				
User charges	-360		-103	-257				
During Construction & Maintenance	0		0	0				
Subtotal	154,149	*(2)*	63,594	90,555	0	0	0	0
Private sector provider impacts						**Freight**	**Passengers**	
Revenue	831				831			
Operating costs	0							
Investment costs	0							
Grant/subsidy	0							
Subtotal	831	*(3)*			831	0	0	0
Other business impacts								
Developer contributions	-7,890	*(4)*	-7,890					
NET BUSINESS IMPACT	147,090	*(5) = (2) + (3) + (4)*						
TOTAL								
Present Value of Transport Economic Efficiency Benefits (TEE)	303,242	*(6) = (1a) + (1b) + (5)*						

Notes: Benefits appear as positive numbers, while costs appear as negative numbers.
All entries are discounted present values, in 2010 prices and values

Table 42 – Next Best Alternative TEE

Economic Efficiency of the Transport System (TEE)

Non-business: Commuting	**ALL MODES**		**ROAD**		**BUS and COACH**	**RAIL**		**OTHER**
User benefits	**TOTAL**		**Private Cars and LGVs**		**Passengers**	**Passengers**		
Travel time	46,626			46,626				
Vehicle operating costs	-4,670			-4,670				
User charges	-65			-65				
During Construction & Maintenance	0			0				
COMMUTING	41,891	*(1a)*		41,891	0		0	0
Non-business: Other	**ALL MODES**		**ROAD**		**BUS and COACH**	**RAIL**		**OTHER**
User benefits	**TOTAL**		**Private Cars and LGVs**		**Passengers**	**Passengers**		
Travel time	102,283			102,283				
Vehicle operating costs	-8,810			-8,810				
User charges	-352			-352				
During Construction & Maintenance	0			0				
NET NON-BUSINESS BENEFITS: OTHER	93,121	*(1b)*		93,121	0		0	0
Business								
User benefits			**Goods Vehicles**	**Business Cars & LGVs**	**Passengers**	**Freight**	**Passengers**	
Travel time	121,274		52,404	68,870				
Vehicle operating costs	6,024		2,365	3,659				
User charges	-300		-11	-289				
During Construction & Maintenance	0		0	0				
Subtotal	126,998	*(2)*	54,758	72,240	0	0	0	0
Private sector provider impacts						**Freight**	**Passengers**	
Revenue	761				761			
Operating costs	0							
Investment costs	0							
Grant/subsidy	0							
Subtotal	761	*(3)*			761	0	0	0
Other business impacts								
Developer contributions	-7,890	*(4)*		-7,890				
NET BUSINESS IMPACT	119,869	*(5) = (2) + (3) + (4)*						
TOTAL								
Present Value of Transport Economic Efficiency Benefits (TEE)	254,881	*(6) = (1a) + (1b) + (5)*						

Notes: Benefits appear as positive numbers, while costs appear as negative numbers.
All entries are discounted present values, in 2010 prices and values

Table 43 – Low Cost Option TEE

Economic Efficiency of the Transport System (TEE)

Non-business: Commuting	**ALL MODES**		**ROAD**		**BUS and COACH**	**RAIL**		**OTHER**
User benefits	**TOTAL**		**Private Cars and LGVs**		**Passengers**	**Passengers**		
Travel time	38,023		38,023					
Vehicle operating costs	-3,057		-3,057					
User charges	-46		-46					
During Construction & Maintenance	0		0					
COMMUTING	34,920	*(1a)*	34,920		0	0		0
Non-business: Other	**ALL MODES**		**ROAD**		**BUS and COACH**	**RAIL**		**OTHER**
User benefits	**TOTAL**		**Private Cars and LGVs**		**Passengers**	**Passengers**		
Travel time	80,435		80,435					
Vehicle operating costs	-4,071		-4,071					
User charges	-305		-305					
During Construction & Maintenance	0		0					
NET NON-BUSINESS BENEFITS: OTHER	76,059	*(1b)*	76,059		0	0		0
Business								
User benefits			**Goods Vehicles**	**Business Cars & LGVs**	**Passengers**	**Freight**	**Passengers**	
Travel time	85,302		39,677	45,625				
Vehicle operating costs	5,922		2,495	3,427				
User charges	-39		65	-104				
During Construction & Maintenance	0		0	0				
Subtotal	91,185	*(2)*	42,237	48,948	0	0	0	0
Private sector provider impacts						**Freight**	**Passengers**	
Revenue	448				448			
Operating costs	0							
Investment costs	0							
Grant/subsidy	0							
Subtotal	448	*(3)*			448	0	0	0
Other business impacts								
Developer contributions	-7,890	*(4)*	-7,890					
NET BUSINESS IMPACT	83,743	*(5) = (2) + (3) + (4)*						
TOTAL								
Present Value of Transport Economic Efficiency Benefits (TEE)	194,722	*(6) = (1a) + (1b) + (5)*						

Notes: Benefits appear as positive numbers, while costs appear as negative numbers.
All entries are discounted present values, in 2010 prices and values

5.9. PUBLIC ACCOUNTS

A summary of the scheme costs and their allocation between providers is accounted for in the Public Accounts (PA) table, shown in Table 44 for the preferred option.

Table 44 - Preferred Option PA

Public Accounts (PA) Table

	ALL MODES		ROAD	BUS and COACH	RAIL	OTHER	CORE SCEN
Local Government Funding	TOTAL		INFRASTRUCTURE				
Revenue	0		0			0	FINAL
Operating Costs	28,172		28,172			0	FINAL_JULY1
Investment Costs	35,024		35,024			0	
Developer and Other Contributions	-7,890		-7,890	0	0	0	
Grant/Subsidy Payments	0		0	0	0	0	
NET IMPACT	55,306	(7)	55,306	0	0	0	
Central Government Funding: Transport							
Revenue	0		0			0	
Operating costs	0		0			0	
Investment Costs	85,304		85,304			0	
Developer and Other Contributions	0		0	0	0	0	
Grant/Subsidy Payments	0		0	0	0	0	
NET IMPACT	85,304	(8)	85,304	0	0	0	
Central Government Funding: Non-Transport							
Indirect Tax Revenues	-16,808	(9)	-16,808	0	0	0	
TOTALS							
Broad Transport Budget	140,610	(10) = (7) + (8)					
Wider Public Finances	-16,808	(11) = (9)					

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers.

All entries are discounted present values in 2010 prices and values.

5.10. SUMMARY OF MONETISED COSTS AND BENEFITS

5.10.1. INITIAL BCR

The Benefit-Cost Ratio (BCR) is defined by dividing the Present Value of Benefits (PVB) by the Present Value of Costs (PVC).

The calculation of the PVB used to derive the initial BCR includes the monetised benefits of transport economic efficiency, safety, greenhouse gases, noise, air quality and indirect taxation.

The initial BCR of the scheme is **2.31.**

The Analysis of Monetised Cost and Benefits (AMCB) table in Table 45 details the calculation.

Table 45 – Preferred Option Analysis of Monetised Costs and Benefits (AMCB) Table

Analysis of Monetised Costs and Benefits

Noise	5,212	*(12)*
Local Air Quality	-9,152	*(13)*
Greenhouse Gases	-7,850	*(14)*
Journey Quality		*(15)*
Physical Activity		*(16)*
Accidents	16,699	*(17)*
Economic Efficiency: Consumer Users (Commuting)	48,978	*(1a)*
Economic Efficiency: Consumer Users (Other)	107,174	*(1b)*
Economic Efficiency: Business Users and Providers	147,033	*(5)*
Wider Public Finances (Indirect Taxation Revenues)	16,808	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*
Present Value of Benefits (see notes) (PVB)	**324,902**	*(PVB) = (12) + (13) + (14) + (15) + (16) + (17) + (1a) + (1b) + (5) - (11)*
Broad Transport Budget	140,610	*(10)*
Present Value of Costs (see notes) (PVC)	**140,610**	*(PVC) = (10)*
OVERALL IMPACTS		
Net Present Value (NPV)	**184,292**	NPV=PVB-PVC
Benefit to Cost Ratio (BCR)	**2.31**	BCR=PVB/PVC

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

5.10.2. ADJUSTED BCR

The scheme has a reliability benefit of **£29.099m** (2010 prices and values) over the 60year assessment period. By completing the route around Lincoln to the south and east, the scheme should provide greater day-to-day reliability in journey time.

The calculation of the PVB used to derive the adjusted BCR includes adding the monetised impact of reliability benefits onto the initial PVB.

The adjusted PVB of the scheme is **£354.001m**. The adjusted BCR of the scheme is **2.52.**

5.10.3. ALTERNATIVE SCENARIOS

Alternative scenarios are modelled to understand the extent that the appraisal conclusions vary, including cost-benefit analysis and value for money, through changing specific parameters or assumptions.

Assessments for noise and air quality have only been undertaken for the Core scenario. As a result, in order to enable a direct comparison between the options, this section does not reference those impacts and the outputs. Reliability is also omitted, so comparisons are to the initial BCR rather than the Adjusted BCR.

Alternative Scheme Configurations

Alternative scheme configurations consider a Next Best option and a Low Cost option.

As shown in Table 45, there is a benefit for noise and a dis-benefit for air quality. Omitting these impacts generates an equivalent initial BCR for the Core scheme of 2.34. Table 46 presents this analysis alongside comparative initial and adjusted BCRs for the Next Best and Low Cost options.

Table 46 – Cost-Benefit Analysis for Alternative Scheme Configurations

Impact	Core	Next Best	Low Cost
Greenhouse Gases	-7,850	-4,163	-1,650
Accidents	16,699	-5,125	-4,329
Economic Efficiency – Commuting	48,978	41,891	34,920
Economic Efficiency – Other	107,174	93,121	76,059
Economic Efficiency – Business	147,033	119,812	83,686
Indirect Tax Revenues	16,808	9,122	3,939
Noise	*n/a*	*n/a*	*n/a*
Air Quality	*n/a*	*n/a*	*n/a*
Equivalent Present Value of Benefits	**328,842**	**254,658**	**192,624**
Present Value of Costs	**140,610**	**104,055**	**88,250**
Net Present Value	188,232	150,603	104,374
Equivalent Initial Benefit-Cost Ratio	**2.34**	**2.45**	**2.18**
Reliability	29,099	24,335	20,171
Equivalent Adjusted Value of Benefits	**357,941**	**278,993**	**212,794**
Equivalent Adjusted Benefit-Cost Ratio	**2.55**	**2.68**	**2.41**

Table 47 to Table 49 present the AMCB tables for these 3 initial BCR scenarios.

Table 47 - Preferred Option AMCB

Analysis of Monetised Costs and Benefits

Noise		*(12)*
Local Air Quality		*(13)*
Greenhouse Gases	-7,850	*(14)*
Journey Quality		*(15)*
Physical Activity		*(16)*
Accidents	16,699	*(17)*
Economic Efficiency: Consumer Users (Commuting)	48,978	*(1a)*
Economic Efficiency: Consumer Users (Other)	107,174	*(1b)*
Economic Efficiency: Business Users and Providers	147,033	*(5)*
Wider Public Finances (Indirect Taxation Revenues)	16,808	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*
Present Value of Benefits (see notes) (PVB)	**328,842**	*(PVB) = (12) + (13) + (14) + (15) + (16) + (17) + (1a) + (1b) + (5) - (11)*
Broad Transport Budget	140,610	*(10)*
Present Value of Costs (see notes) (PVC)	**140,610**	*(PVC) = (10)*
OVERALL IMPACTS		
Net Present Value (NPV)	**188,232**	NPV=PVB-PVC
Benefit to Cost Ratio (BCR)	**2.34**	BCR=PVB/PVC

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

Table 48 – Next Best Alternative AMCB

Analysis of Monetised Costs and Benefits

Noise		*(12)*
Local Air Quality		*(13)*
Greenhouse Gases	-4,163	*(14)*
Journey Quality		*(15)*
Physical Activity		*(16)*
Accidents	-5,125	*(17)*
Economic Efficiency: Consumer Users (Commuting)	41,891	*(1a)*
Economic Efficiency: Consumer Users (Other)	93,121	*(1b)*
Economic Efficiency: Business Users and Providers	119,812	*(5)*
Wider Public Finances (Indirect Taxation Revenues)	9,122	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*
Present Value of Benefits (see notes) (PVB)	**254,658**	*(PVB) = (12) + (13) + (14) + (15) + (16) + (17) + (1a) + (1b) + (5) - (11)*
Broad Transport Budget	104,055	*(10)*
Present Value of Costs (see notes) (PVC)	**104,055**	*(PVC) = (10)*
OVERALL IMPACTS		
Net Present Value (NPV)	**150,603**	NPV=PVB-PVC
Benefit to Cost Ratio (BCR)	**2.45**	BCR=PVB/PVC

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

Table 49 – Low Cost Option AMCB

Analysis of Monetised Costs and Benefits

Noise		*(12)*
Local Air Quality		*(13)*
Greenhouse Gases	-1,650	*(14)*
Journey Quality		*(15)*
Physical Activity		*(16)*
Accidents	-4,329	*(17)*
Economic Efficiency: Consumer Users (Commuting)	34,920	*(1a)*
Economic Efficiency: Consumer Users (Other)	76,059	*(1b)*
Economic Efficiency: Business Users and Providers	83,686	*(5)*
Wider Public Finances (Indirect Taxation Revenues)	3,938	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*
Present Value of Benefits (see notes) (PVB)	**192,624**	*(PVB) = (12) + (13) + (14) + (15) + (16) + (17) + (1a) + (1b) + (5) - (11)*
Broad Transport Budget	88,250	*(10)*
Present Value of Costs (see notes) (PVC)	**88,250**	*(PVC) = (10)*
OVERALL IMPACTS		
Net Present Value (NPV)	**104,374**	NPV=PVB-PVC
Benefit to Cost Ratio (BCR)	**2.18**	BCR=PVB/PVC

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

Alternative Growth Scenarios

Alternative growth scenarios consider High and Low Growth scenarios.

As shown in Table 45 there is a benefit for noise and a dis-benefit for air quality. Omitting these impacts generates an equivalent initial BCR for the Core scheme of 2.34.

Table 50 presents this analysis alongside comparative initial BCRs for the Next Best and Low Cost options. There is no equivalent adjusted BCR as reliability benefits have not been calculated for the alternative growth sensitivity scenarios.

Table 50 – Cost-Benefit Analysis for Alternative Growth Scenarios

Impact	Core	Low Growth	High Growth
Greenhouse Gases	-7,850	-15,735	-12,682
Accidents	16,699	7,744	11,191
Economic Efficiency – Commuting	48,978	30,678	42,979
Economic Efficiency – Other	107,174	75,047	98,552
Economic Efficiency – Business	147,033	103,790	123,337
Indirect Tax Revenues	16,808	33,602	28,165
Noise	*n/a*	*n/a*	*n/a*
Air Quality	*n/a*	*n/a*	*n/a*
Equivalent Present Value of Benefits	**328,842**	**235,126**	**291,542**
Present Value of Costs	**140,610**	**140,610**	**140,610**
Net Present Value	188,232	94,516	150,932
Equivalent Initial Benefit-Cost Ratio	**2.34**	**1.67**	**2.07**

They show a decrease in benefits for both high and low growth. This is to be expected for low growth because there is less traffic flow throughout the network. For the high growth this may be less intuitive; the decrease is caused by more congestion on the network in the design year, which reduces the impact of the scheme. This is shown in Figure 16.

Figure 16 – TUBA User Time Benefits by Year

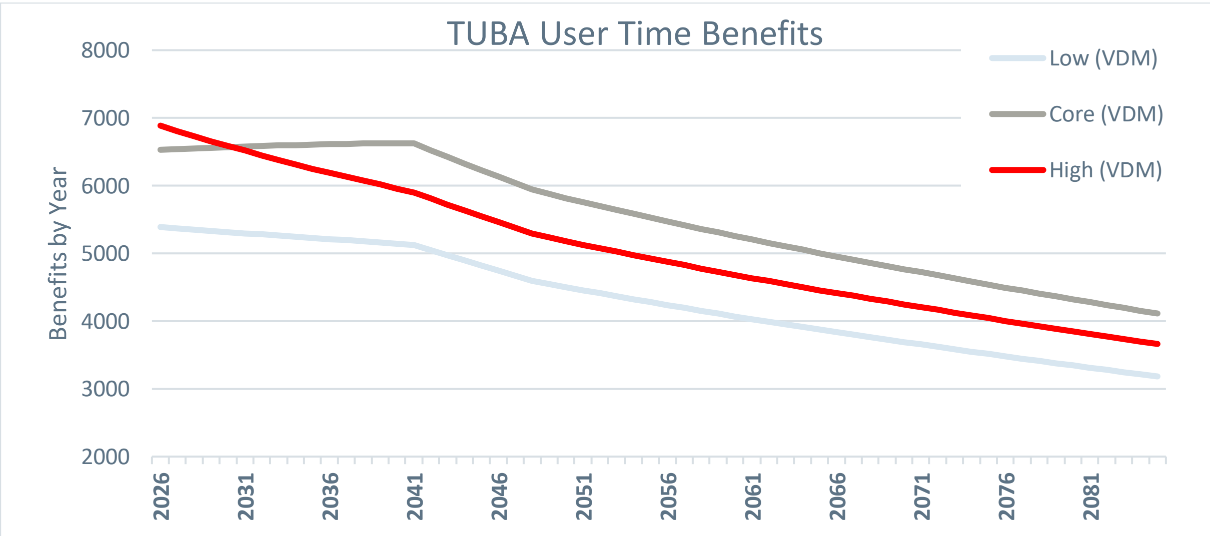


Table 51 and Table 52 present the AMCB tables for the Low and High growth scenarios. The AMCB for the Core is presented in Table 47 (Preferred Option).

Table 51 – Low Growth AMCB Table

Analysis of Monetised Costs and Benefits

Noise		*(12)*
Local Air Quality		*(13)*
Greenhouse Gases	-15,735	*(14)*
Journey Quality		*(15)*
Physical Activity		*(16)*
Accidents	7,744	*(17)*
Economic Efficiency: Consumer Users (Commuting)	30,678	*(1a)*
Economic Efficiency: Consumer Users (Other)	75,047	*(1b)*
Economic Efficiency: Business Users and Providers	103,790	*(5)*
Wider Public Finances (Indirect Taxation Revenues)	33,602	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*
Present Value of Benefits (see notes) (PVB)	**235,126**	*(PVB) = (12) + (13) + (14) + (15) + (16) + (17) + (1a) + (1b) + (5) - (11)*
Broad Transport Budget	140,610	*(10)*
Present Value of Costs (see notes) (PVC)	**140,610**	*(PVC) = (10)*
OVERALL IMPACTS		
Net Present Value (NPV)	**94,516**	NPV=PVB-PVC
Benefit to Cost Ratio (BCR)	**1.67**	BCR=PVB/PVC

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

Table 52 - High Growth AMCB Table

Analysis of Monetised Costs and Benefits

Noise		(12)
Local Air Quality		(13)
Greenhouse Gases	-12,682	(14)
Journey Quality		(15)
Physical Activity		(16)
Accidents	11,191	(17)
Economic Efficiency: Consumer Users (Commuting)	42,979	(1a)
Economic Efficiency: Consumer Users (Other)	98,552	(1b)
Economic Efficiency: Business Users and Providers	123,337	(5)
Wider Public Finances (Indirect Taxation Revenues)	28,165	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*
Present Value of Benefits (see notes) (PVB)	**291,542**	*(PVB) = (12) + (13) + (14) + (15) + (16) + (17) + (1a) + (1b) + (5) - (11)*
Broad Transport Budget	140,610	(10)
Present Value of Costs (see notes) (PVC)	**140,610**	(PVC) = (10)
OVERALL IMPACTS		
Net Present Value (NPV)	**150,932**	NPV=PVB-PVC
Benefit to Cost Ratio (BCR)	**2.07**	BCR=PVB/PVC

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

5.11. APPRAISAL SUMMARY

The Appraisal Summary Table (AST) presents a single table of all the evidence from the preferred options analysis. It records all the impacts which have been assessed and described above – economic, fiscal, social distributional and environmental impacts – assessed using monetised, quantitative or qualitative information as appropriate. The AST for the scheme, in line with WebTAG requirements, is shown in Table 53.

Table 53 - Appraisal Summary Table

Appraisal Summary Table

Date produced:	4	7	2019

Contact:	
Name	Sam Edwards
Organisation	Lincolnshire County Council
Role	Promoter/Official

Name of scheme:	North Hykeham Relief Road
Description of scheme:	The NHRR is a proposed new link road to the south of Lincoln urban area. It will be dual carriageway standard providing a connection between the A46 / A1434 Pennell's Roundabout and the under-construction A15 / LEB roundabout. The scheme will include a new bridge over the River Witham and over Station Road; a shared pedestrian and cycle route on the north side; a bridleway on the south side of the new link; and three NMU structures.

Impacts		Summary of key impacts	Assessment: Quantitative	Assessment: Qualitative	Assessment: Monetary £(NPV)	Assessment: Distributional 7-pt scale/ vulnerable grp
Economy	Business users & transport providers	The scheme reduces total vehicle hours across the wider Lincoln network. The primary impacts for business users are: - Providing alternative route choice to the A46 for users to travel around (or bypass) the urban area which provides direct (scheme users) and indirect (non-scheme users) journey time savings for medium and longer trips on those routes; and - Reduced congestion on some radial routes into the city centre, in particular the A1434 Newark Road / A15 corridor plus Brant Road and A607 Grantham Road. For business users, the split of monetised benefit is broadly even between the three net change journey time categories. Business users make up just under half of all journey time benefits.	Value of journey time changes(£): £152.1m Net journey time changes (£): 0 to 2min: £55.6m 2 to 5min: £47.8m > 5min: £48.7m	-	£147.0m	Moderate Beneficial
Economy	Reliability impact on Business users	The scheme produces some benefits for journey time reliability of business users but this is relatively small compared to the impact on non-business users since the proportion of business users is low relative to total car travel. The scheme produces benefits for journey time reliability through providing additional network capacity and route choice, in particular for east-west movements and as an alternative route around the city to the existing orbital network.	-	-	£6.3m	
Economy	Regeneration	The scheme is not within a regeneration area and so this impact has not been assessed.	-	-	-	
Economy	Wider Impacts	The scheme provides an overall improvement to the performance and reliability of the local transport network which improves the efficiency of businesses and will promote sustainable economic growth. In particular, this increases businesses effective catchment areas which has positive benefits for labour supply and move to more productive jobs. For Tier 3 analysis, a dependent development assessment concluded the scheme would unlock South West Quadrant providing additional induced investment benefits.		Moderate Beneficial	-	
Environmental	Noise	Receptors located in proximity to the scheme and existing routes feeding into the scheme are predicted to experience a significant increase in noise levels, however, overall the effects once operational are considered beneficial. Opening Year Daytime noise level of 66 dB LAeq, 16h or higher - Do Minimum (DM) 822 properties, Do Something (DS) 796 Design Year Daytime noise level of 66 dB LAeq, 16h or higher - 710 properties DM, 603 properties DS No properties subject to road traffic noise levels in excess of 80 dBLAeq, 16h	Households experiencing increased daytime noise in opening year: 156 Households experiencing reduced daytime noise in opening year: 19,353 Households experiencing increased daytime noise in design year: 644 Households experiencing reduced daytime noise in design year: 3,869	-	£5.2m *Based on least beneficial change	Slight Beneficial
Environmental	Air Quality	The scheme is not situated within an AQMA, however, several road links including A15 and B1262 feed in to the city centre AQMA.. All roadside NO2 Concentrations predicted for the opening year (2026) and operating year (2041) of the Proposed Scheme are below the annual mean NO2 EU limit value for Defra PCM model road links overlain by the Proposed Scheme. Links indicating the potential for exceedances no longer present in the opening year and operating year scenarios. In the majority of cases where significant changes in air quality were predicted these were improvements. Significant deteriorations in air quality were predicted on the A15 St Catherines junction in the city centre, and at the A46 Hykeham Roundabout.	Overall deterioration in property weighted air quality despite a greater number of properties experiencing an improvement compared to those experiencing no change or a deterioration in concentrations of air pollutants (see table below)	-	-£9.2m	Moderate Beneficial
Environmental	Greenhouse gases	Predicted increase of GHG emission from road-based fuel consumption attributed to a predicted increase in fuel consumption as the scheme will attract / generate additional traffic flow and links the existing A46 bypass with Lincoln Eastern Bypass.	Change in non-traded carbon over 60y (CO2e): 181,041 Change in traded carbon over 60y (CO2e): 2,962	-	- £7.8m	

Scenario	Properties: Improvement	Properties: No Change	Properties: Deterioration	Score	Emissions (tonnes)
NO_2 2026	16345	86	2977	-454.87	-
PM_{10} 2026	15430	0	3978	3130.11	-
NO_2 2041	12979	39	6390	1221.83	-
PM_{10} 2041	13044	0	6164	3550.42	-
NOX 2026	-	-	-	-	+14.09
NOX 2041	-	-	-	-	+12.08

	Impacts	Summary of key impacts	Assessment: Quantitative	Assessment: Qualitative	Assessment: Monetary £(NPV)	Assessment: Distributional 7-pt scale/ vulnerable grp
	Landscape	Permanent change to the pattern of the landscape. Road alignment at odds to the pattern of the existing road layout within the surrounding area creating a perceivable change to landscape character. Directly sever Area of Great Landscape Value, Green Wedge and linear features of cultural significance within the landscape including Viking Way. Change to the nature of the existing view through the introduction of scheme. Demolition of a number of residential properties along Station Road. Construction will result in significant impacts on the visual amenity, from areas of higher ground where long distance views over the floodplain are discernible.	-	Large Adverse	-	
	Townscape	Townscape was screened out as not applicable to the scheme.	-	-	-	
	Historic Environment	The scheme has: - Potential for direct impacts upon below-ground heritage remains (known and unknown) within the scheme footprint. Four known below-ground heritage assets within the scheme area. - Potential for indirect impacts to the settings of 17 Listed Buildings within 1 km of the scheme. - Direct impact on the historic landscape, through visual intrusion and an alteration of the landscape use.	-	Moderate Adverse	-	
	Biodiversity	The scheme has potential to impact: - Bat roosts, damage or removal to habitats currently contributing to foraging and commuting, and disturbance from lighting. - Great Crested Newt, Otters, badgers, water voles and reptiles due to the loss of suitable habitat for these species associated with land take - Birds due to removal of suitable nesting, over wintering and foraging habitat. - Plants by spread of Schedule 9 species and removal of species-rich hedgerow.	-	Moderate Adverse	-	
	Water Environment	The scheme has potential: - For road runoff to impact surface and groundwater quality. - To impact the hydromorphological and ecological quality of the watercourses and drains. - To impact the flood conveyance routes and floodplain storage due to the embankments of the Proposed Scheme. - To impact catchment hydrogeology and groundwater flow due subsurface structures associated with the embankment.	-	Moderate Adverse	-	
Social	Commuting and Other users	The scheme reduces total vehicle hours across the wider Lincoln network. The primary impacts for commuting and other users are: - Reduced congestion within the Lincoln urban area, in particular North Hykeham and Waddington, which reduces travel time for shorter local trips within that area; and - Reduced congestion on some radial routes into the city centre, in particular the A1434 Newark Road / A15 corridor plus Brant Road and A607 Grantham Road. There are substantially higher benefits for trips less than 5 minutes (and less than 2 minutes in particular) because Other Users comprise the largest proportion of all user classes and it has the shortest average trip length. Commuting and other users account for just over half of all journey time benefits.	Value of journey time changes(£): £179.6m Net journey time changes (£) 0 to 2min: £85.7m 2 to 5min: £54.1m > 5min: £39.8m	-	£156.2m	Moderate Beneficial
	Reliability impact on Commuting and Other users	The scheme produces benefits for journey time reliability through providing additional network capacity and route choice, in particular for east-west movements and as an alternative route around the city to the existing orbital network.	-	-	£22.8m	
	Physical activity	The scheme provides new segregated walking, cycling and equestrian infrastructure which will encourage physical activity not only for existing residents, but also for the SWQ. In addition, decreases in traffic flow on local roads in the Lincoln urban area reduces perceived barriers to walking and cycling.	-	Slight Beneficial	-	
	Journey quality	The scheme provides alternative route choice for strategic trips bypassing Lincoln and local trips. This reduces traveller stress through reduced congestion and improved journey times; the provision of an additional route; and improved network resilience when an incident does occur. A decrease in traffic flow within the urban area also contributes to reducing perceived barriers to accidents. In addition, NHRR itself will be adequately signed in line with DMRB guidance which provides route certainty and the landscape strategy will be sensitive to travellers' views of the surrounding countryside and townscape including the historic Lincoln.	-	Slight Beneficial	-	

Impacts		Summary of key impacts	Assessment			
			Quantitative	Qualitative	Monetary £(NPV)	Distributional 7-pt scale/ vulnerable grp
	Accidents	The scheme reduces the total number of accidents through the transfer of traffic from less appropriate routes, in particular the rural roads to the south of the Lincoln urban area, onto a dual carriageway standard road with a typically lower accident rate. A key example is the route through the villages of Harmston and Aubourn which has a large benefit due to users rerouteing onto the scheme.	An assessment in COBALT derived a total of 427 accidents saved over the 60 year appraisal period.	-	£16.7m	Moderate Beneficial
	Security	The scheme has an opening year AADT up to 27,000 which provides informal surveillance for pedestrians and freight traffic. Pedestrian facilities will be designed to the latest DMRB guidance and there are no service stations or car parks within the immediate vicinity of the scheme for HGVs (or other user) to stop and leave their vehicle.	-	Slight Beneficial	-	Slight Beneficial
	Access to services	The reduction in traffic on existing bus routes may result in more reliable local bus services through the improvements in congestion. However, the addition of public transport services and changes to existing services is beyond the scope of this project. Therefore, access to services has been scoped out of this assessment.	-	-	-	Not assessed
	Affordability	The scheme increases travel distance which leads to a net increase in vehicle operating costs across all users. There is a very small increase in user charges incurred from a net increase in flow on toll routes (Humber Bridge, Dunham Bridge).	The monetary NPV of vehicle operating costs in the TUBA output is -£20.7m. The monetary NPV of user charges in the TUBA output is -£0.8m.	Moderate Adverse	-	Moderate Adverse
	Severance	The scheme reduces severance on key routes including radial, city centre and local roads in North Hykeham. This improves accessibility to local community facilities and services for motorised users through reduced delay in the area and for non-motorised users through reducing the level of congestion as a perceived barrier to travel.	The net impact for the number of residents experiencing a change in severance is: - Children (under 16) +12,645 - Older People (over 65) +12,795 - People with disabilities +14,609 - No car households +7,871	Large Beneficial	-	Large Beneficial
	Option and non-use values	New transport services could be introduced as part of the new development (SWQ) associated with the scheme. However, the impact on public transport services is outside the scope of this project.	-	-	-	
Public Accounts	Cost to Broad Transport Budget	The scheme has an overall present value of costs of £145.8m (2010 prices and values), which includes a 15% optimism bias, through the delivery period up to scheme opening in 2026. This includes a Local Government contribution of £27.3m, a Central Government contribution of £82.4m plus a developer contribution of £7.9m (all 2010 prices and values) which has been subtracted from that value to give the outturn cost to the Broad Transport Budget.	-	-	- £140.6m	
Public Accounts	Indirect Tax Revenues	The scheme increases travel distance and average travel speed which leads to a net increase in fuel consumption and consequently indirect tax revenue.	-	-	£16.8m	

6. SUMMARY & CONCLUSIONS

6.1. SUMMARY

The purpose of this report has been to detail how the benefits and costs of the NHHR scheme have been derived as part of the economic appraisal process, and to subsequently present the results. Results have been derived for the following scheme configurations:

- Preferred Option – Dual Carriageway
- Next Best Alternative – Single Carriageway with Future Proofed Junctions
- Low Cost Option – Single Carriageway

In addition to the above results have also been calculated for the preferred option for high and low growth alternative scenarios.

The following is a summary of the steps taken and methodology used to undertake the economic assessment:

- The economic assessment has been undertaken in accordance with the relevant guidance documents (WebTAG);
- The economic appraisal uses outputs from the Greater Lincoln Traffic Model. This is a strategic model developed in 2017 and validated to average neutral month 2016 traffic conditions;
- All traffic data used in the economic assessment is consistent with those presented in the Traffic Forecasting Report;
- The economic assessment has been undertaken over the standard 60-year assessment period from a 2026 opening year. All costs and benefits have been discounted to the Present Value Year of 2010;
- Industry-standard computer programmes TUBA and COBALT have been used to undertake the user benefit and accident assessments respectively;
- User benefits and accident savings were monetised and used in the BCR calculation for each option;
- Reliability benefits have also been calculated and incorporated in to an adjusted BCR for each scheme; and
- In addition to the monetised appraisal, a qualitative assessment was also undertaken on other economic, environmental and social impacts and are reported in the Appraisal Summary Table.

6.2. CONCLUSIONS

The appraisal resulted in the following initial BCR values:

- Preferred option: 2.34
- Next Best Alternative: 2.45
- Low Cost Option: 2.18

These values do not reference the assessed noise and air quality impacts, in order to provide a direct comparison between the options.

In accordance with categorisation taken from “Guidance on Value for Money” from the DfT website each option falls in to the High Value for Money category. The BCR is slightly higher for the Next Best

Alternative however this is due to the preferred option having the highest cost. The Preferred option has the highest PVB and NPV.

The adjusted BCR values are summarised as follows, with all results remaining in the High Value for Money category:

- Preferred option: 2.55
- Next Best Alternative: 2.68
- Low Cost Option: 2.41

The BCR values for the High Growth and Low Growth sensitivity tests are summarised below. With low growth the scheme remains economically viable in the medium Value for Money Category. The High Growth still falls within the High Value for Money category but with a lower BCR than the Core growth due to the level of congestion by 2041 constraining the scheme benefits.

- Core: 2.34
- High growth: 2.07
- Low growth: 1.67

A Value for Money Statement will conclude the NHRR Economic Case. That takes into account the outcomes presented above alongside the assessment of dependent development, non-monetised social impacts and the environmental appraisal outcomes to present a conclusion on the Value for Money of the scheme.

Appendix A

ANNUALISATION FACTORS

TECHNICAL NOTE – ANNUALISATION FACTORS FOR TUBA

<table>
<tr><td rowspan="2">Project:</td><td rowspan="2">North Hykeham Relief Road (NHRR)</td><td>Date:</td><td>14 / 06 / 2018</td></tr>
<tr><td>TN Ref:</td><td>NHRR ASR TN01</td></tr>
<tr><td>Subject:</td><td colspan="3">Annualisation Factors for TUBA Analysis</td></tr>
<tr><td>Author:</td><td>BP</td><td rowspan="2">Project Ref:</td><td rowspan="2">70038233</td></tr>
<tr><td>Reviewed:</td><td>BH</td></tr>
</table>

INTRODUCTION

This technical note has been written to describe the methodology for deriving annualisation factors for the economic appraisal of the North Hykeham Relief Road.

It is attached as an appendix to the Appraisal Specification Report (ASR).

The parameters for running TUBA and derivation of transport user benefits were given in the ASR.

MODELLED PERIODS

The forecast models are developed for three modelled periods:

- AM Peak Hour (08:00-09:00);
- Inter Peak Average Hour 10:00-16:00); and
- PM Peak Hour (17:00-18:00).

It is advised in WebTAG Unit A1-3 User and Provider Impacts (March 2017) that the benefits estimated from model outputs will need to be expanded to cover the whole day and then a full year.

The guidance advises this can take multiple forms:

- Expanding benefits from a modelled hour to cover a longer period – for example expanding the AM peak hour to cover a three hour weekday AM peak period for a full year; and
- Estimating benefits in non-modelled periods from the modelled results – for example estimating off-peak or weekend benefits from a modelled inter peak hour.

This note has been prepared to document the calculations used to derive these factors.

NON-MODELLED HOURS AND ANNUALISATION FACTORS

The non-modelled hours include:

- Weekday AM peak shoulders (07:00-08:00 and 09:00-10:00);
- Weekday PM peak shoulders (16:00-17:00 and 18:000-19:00);
- Weekday off peak period (19:00-07:00);

- Weekends; and
- Bank holidays.

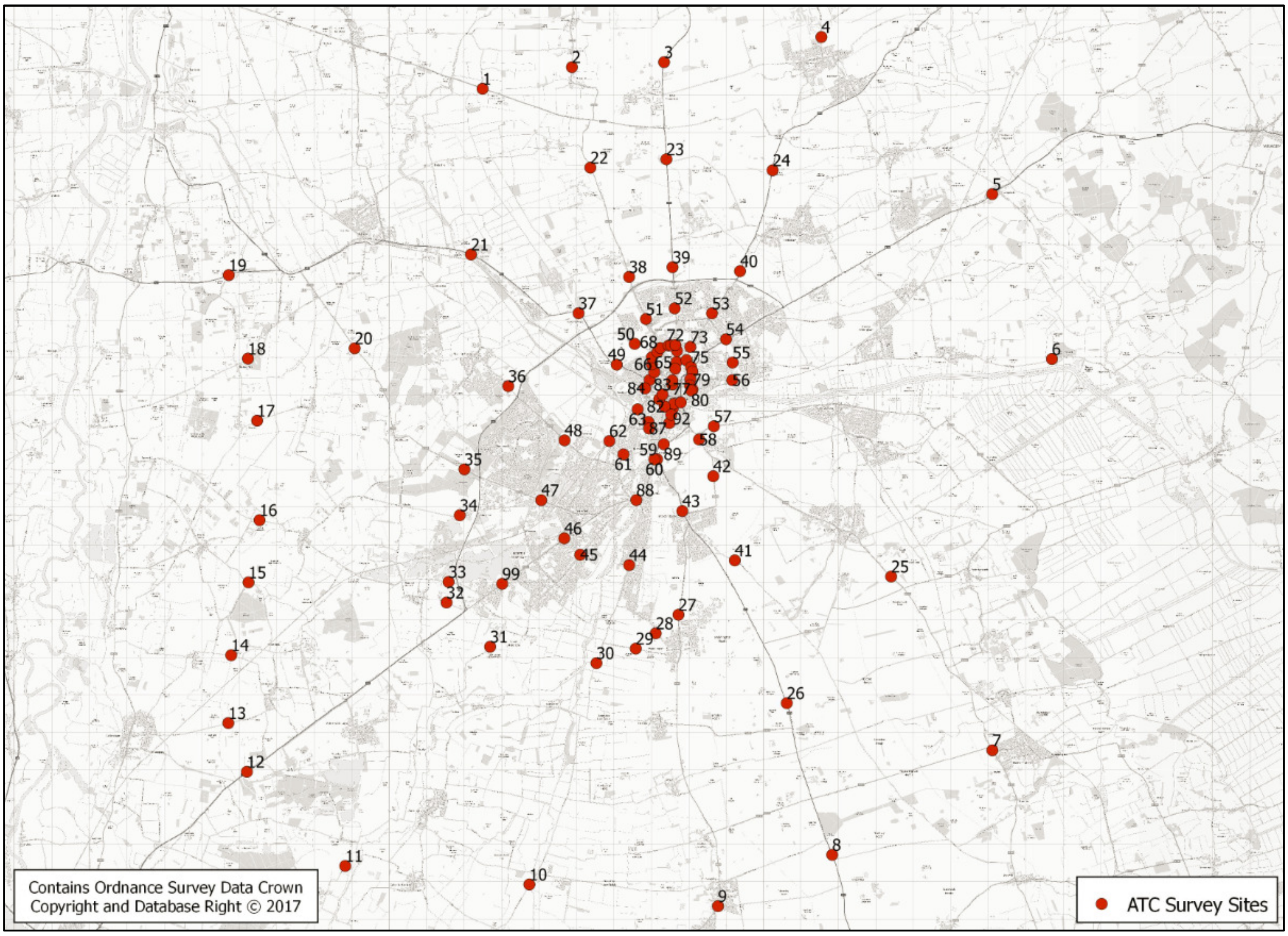
However, it is only appropriate to calculate benefits for hours in which traffic levels are similar to the modelled hours. For example, it would only be appropriate to expand the AM peak hour to the AM peak period if traffic in the peak shoulders was at a similar level to the peak hour. If the traffic was significantly lower in the peak shoulders it would result in lower actual delays compared to the peak hour and thus overestimate the benefits of the scheme.

It is common practice that peak shoulder traffic exceeding 90% of that in the peak hour should be included in the derivation of the annualisation factors for the peak hour, since the change in travel time with and without scheme would be close to the changes experienced in the peak hours. The 90% threshold has been employed.

SOURCE OF OBSERVED DATA

Ninety-nine ATCs were commissioned to be undertaken in November 2016 as part of the data collection process for the development of the updated Greater Lincoln Transport Model. The locations are mapped in Figure 1 and provide extensive coverage of traffic patterns in the Greater Lincoln urban area, but with particular focus on key radial routes and within the boundary of the existing Western Bypass, under-construction Eastern Bypass and preferred alignment of the North Hykeham Relief Road.

Figure 1 Surveyed ATC Locations



DERIVATION OF WEEKDAY FACTORS

It is summarised in Table 1 for each hour:

- Observed volume from surveys;
- Factor for observed volume against AM peak hour volume (where appropriate);
- Factor for observed volume against inter peak average hour volume; and
- Factor for observed volume against PM peak hour volume (where appropriate).

The observed volumes are also presented in Figure 2.

The appropriate donor model periods are highlighted in green, through application of the 90% threshold for peak shoulder volume mentioned previously.

It can be seen that:

- The AM peak hour should be expanded to the period 07:00-09:00 for this analysis;
- The PM peak hour should be expanded to the period 16:00-18:00 for this analysis;
- The inter peak is the appropriate donor model to derive benefits for the peak shoulders 09:00-10:00 and 18:00-19:00;
- The benefits will be conservative for the period 15:00-16:00 since the observed volume is closer to the PM peak hour (within the 90% threshold) than the inter peak average hour; and
- There are no off peak hours that hit the 90% threshold when applied inter peak so the off peak factor will be zero.

Figure 2 Weekday Flow Profile (November 2016 ATCs)

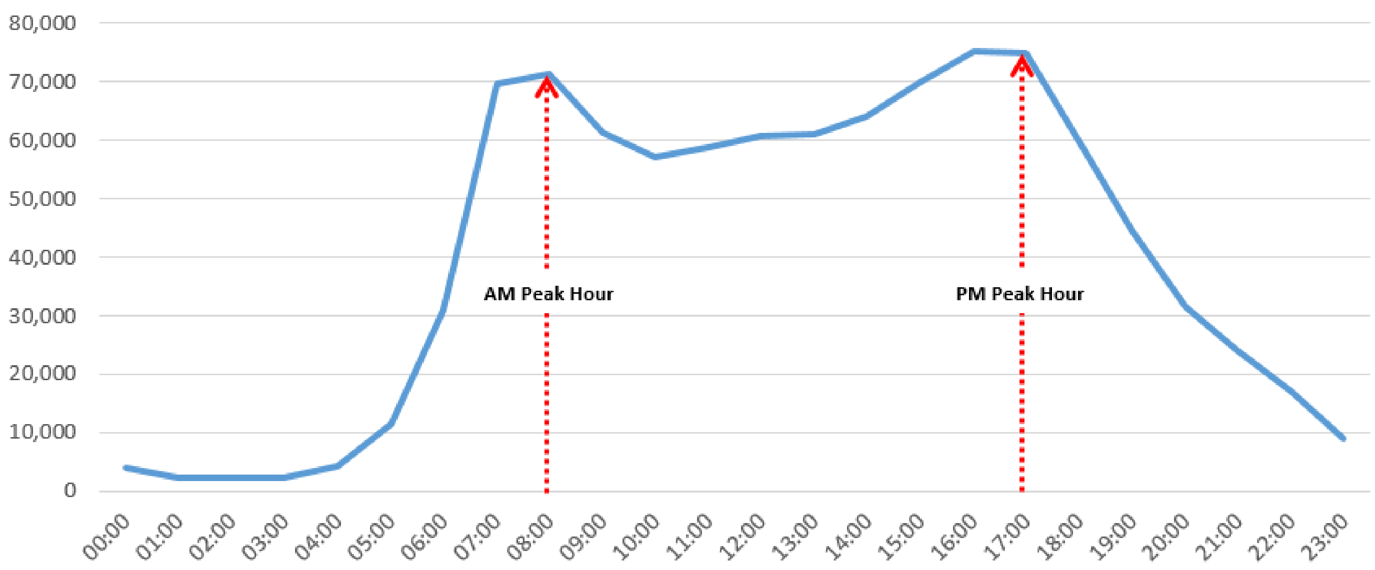


Table 1 Derivation of Weekday Factors

Period	Hour	Observed Volume	AM Peak Hour	IP Average Hour	PM Peak Hour
			71,226	**61,958**	**74,997**
			Factor	**Factor**	**Factor**
Off Peak	00:00	3,995		0.06	
	01:00	2,408		0.04	
	02:00	2,408		0.04	
	03:00	2,271		0.04	
	04:00	4,252		0.07	
	05:00	11,620		0.19	
	06:00	30,856		0.50	
AM Peak	07:00	69,545	0.98	1.12	
	08:00	71,226	1.00	1.15	
	09:00	61,338	0.86	0.99	
Inter Peak	10:00	57,167		0.92	
	11:00	58,905		0.95	
	12:00	60,635		0.98	
	13:00	60,896		0.98	
	14:00	64,097		1.03	
	15:00	70,048		1.13	
PM Peak	16:00	75,349		1.22	1.00
	17:00	74,997		1.21	1.00
	18:00	59,765		0.96	0.80
Off Peak	19:00	44,707		0.72	
	20:00	31,526		0.51	
	21:00	24,097		0.39	
	22:00	16,986		0.27	
	23:00	9,021		0.15	

DERIVATION OF NON-WORKING DAY FACTORS

Non-working day refers here to the non-modelled periods of weekends and bank holidays, where bank holidays are assumed to have significantly different traffic patterns than the (working) weekday factors derived in the previous section.

A similar method has been applied to derive weekend annualisation factors, through comparing the observed volume against the weekday inter peak average hour. This approach is evidenced by Figure 3 which shows the observed volume for a time on Saturday and Sunday is similar to the weekday inter peak average hour volume. The 90% threshold (see previous sections) has been applied for consistency.

Note that the weekday inter peak average hour comparator is lower than its equivalent in Table 1 due to nine sites being removed from the analysis for weekends. This is due to a combination of the survey sites being set up at weekends and equipment failure giving insufficient weekend data at those locations.

It is summarised in Table 2 for each hour:

- Observed volume for Saturday and Sunday separately from surveys; and
- Factor for observed volume against inter peak average hour volume for Saturday and Sunday separately.

The weekend hours hitting the 90% threshold are highlighted in green.

It can be seen that:

- The period 10:00-18:00 (8 hours) on Saturday should be included in the annualisation; and
- The period 11:00-16:00 (5 hours) on a Sunday should be included in the annualisation.

There were no bank holidays during the survey period and so are not represented in the total annualised hours. This therefore represents a conservative estimate for the annualised hours on non-working days.

Figure 3 Daily Flow Profile (Subset of November 2016 ATCs)

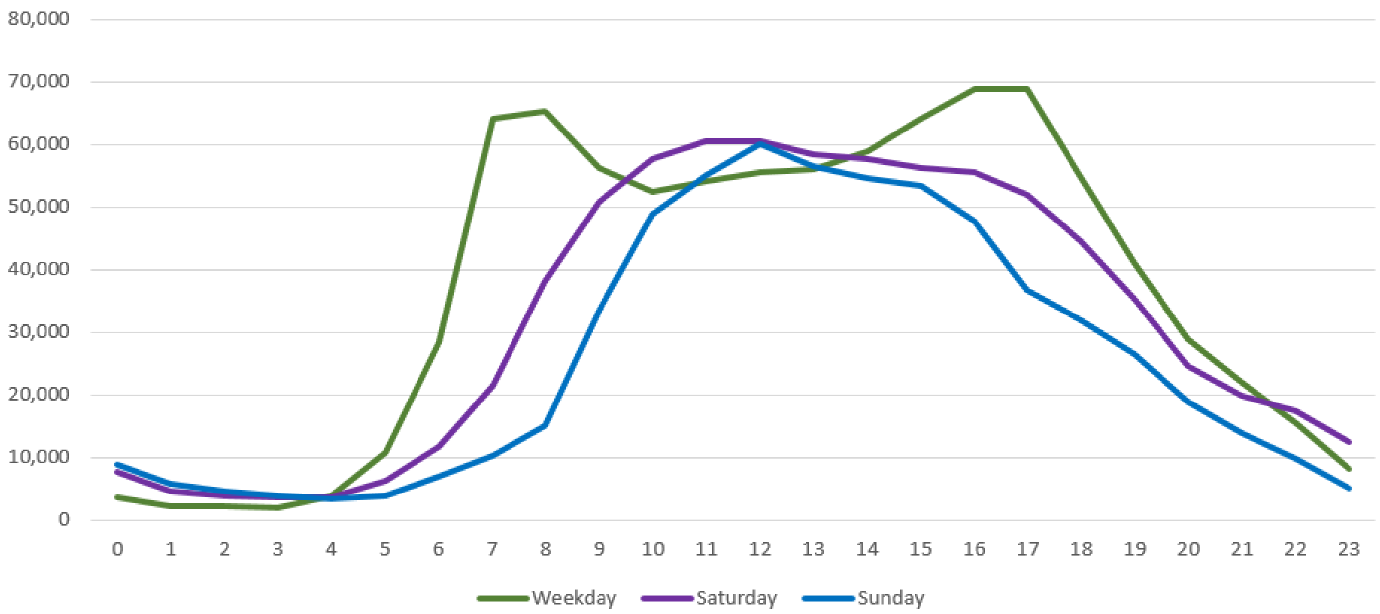


Table 2 Derivation of Weekend Factors

Hour	IP Weekday Average Hour	Observed		Factor	
	56,857	Saturday	Sunday	Saturday	Sunday
00:00		7,588	8,874	0.13	0.16
01:00		4,483	5,656	0.08	0.10
02:00		3,778	4,572	0.07	0.08
03:00		3,550	3,943	0.06	0.07
04:00		3,578	3,381	0.06	0.06
05:00		6,129	3,875	0.11	0.07
06:00		11,761	7,048	0.21	0.12
07:00		21,538	10,256	0.38	0.18
08:00		38,257	15,054	0.67	0.26
09:00		50,765	33,440	0.89	0.59
10:00		57,742	48,972	1.02	0.86
11:00		60,653	55,033	1.07	0.97
12:00		60,516	60,057	1.06	1.06
13:00		58,493	56,417	1.03	0.99
14:00		57,708	54,671	1.01	0.96
15:00		56,231	53,299	0.99	0.94
16:00		55,486	47,727	0.98	0.84
17:00		51,994	36,811	0.91	0.65
18:00		44,477	31,941	0.78	0.56
19:00		35,195	26,474	0.62	0.47
20:00		24,477	18,937	0.43	0.33
21:00		19,893	13,899	0.35	0.24
22:00		17,479	9,750	0.31	0.17
23:00		12,485	5,128	0.22	0.09

SUMMARY OF ANNUALISATION FACTORS

From the calculations set out in Tables 1 and 2, the following annualisation factors have been derived to be applied to the relevant modelled hour to include non-modelled hours in the calculation of TUBA benefits.

It is assumed:

- 253 working weekdays;
- 52 weekends; and
- 8 bank holidays.

The total number of annualised hours is 3,694 which represents around 42% of total annual hours.

It is noted that the ATCs were collected in November 2016 and do not represent the whole year of traffic travelling in the area, particularly during summer months where demand increases on the strategic routes with residual impact on the local network. Analysis from GLTM showed August traffic volume is 5% higher than neutral months on strategic routes – this is largely attributed to trips using the A46 towards the Lincolnshire East Coast.

The factors can therefore be considered conservative overall.

Table 3 Annualisation Factors

Period	Donor Traffic Model	Annualisation Factor
Weekday AM Peak Period 07:00-09:00	AM Peak Hour Model	1.976 x 253 = **500**
Weekday AM Peak Period 09:00-10:00	Inter Peak Ave. Hour Model	0.990 x 253 = **250**
Weekday Inter Peak Period 10:00-16:00	Inter Peak Ave. Hour Model	6.000 x 253 = **1,518**
Weekday PM Peak Period 16:00-18:00	PM Peak Hour Model	2.005 x 253 = **507**
Weekday PM Peak Period 18:00-19:00	Inter Peak Ave. Hour Model	0.965 x 253 = **244**
Weekday Off Peak Period	Inter Peak Ave. Hour Model	0.000 x 253 = **0**
Weekends	Inter Peak Ave. Hour Model	12.985 x 52 = **675**
Total Annualised Hours		**3,694**

COMPARISON WITH LEB APPRAISAL

The previous Greater Lincoln Traffic Model was used to prepare a business case for the Lincoln Eastern Bypass, which undertook a similar appraisal.

For that study, the total number of annualised hours was 3,504 representing roughly 40% of total annual hours.

The overall values are presented in Table 4, aggregated to donor traffic model. This comparison shows that the derived factors are in line with the previous study, with a small increase in the total annual hours attributed to background growth in demand and displacement of some annualised hours from the inter peak donor period to the AM peak period from the hour 07:00-08:00, evidenced by the surveyed daily profile.

Table 4 Comparison with LEB appraisal

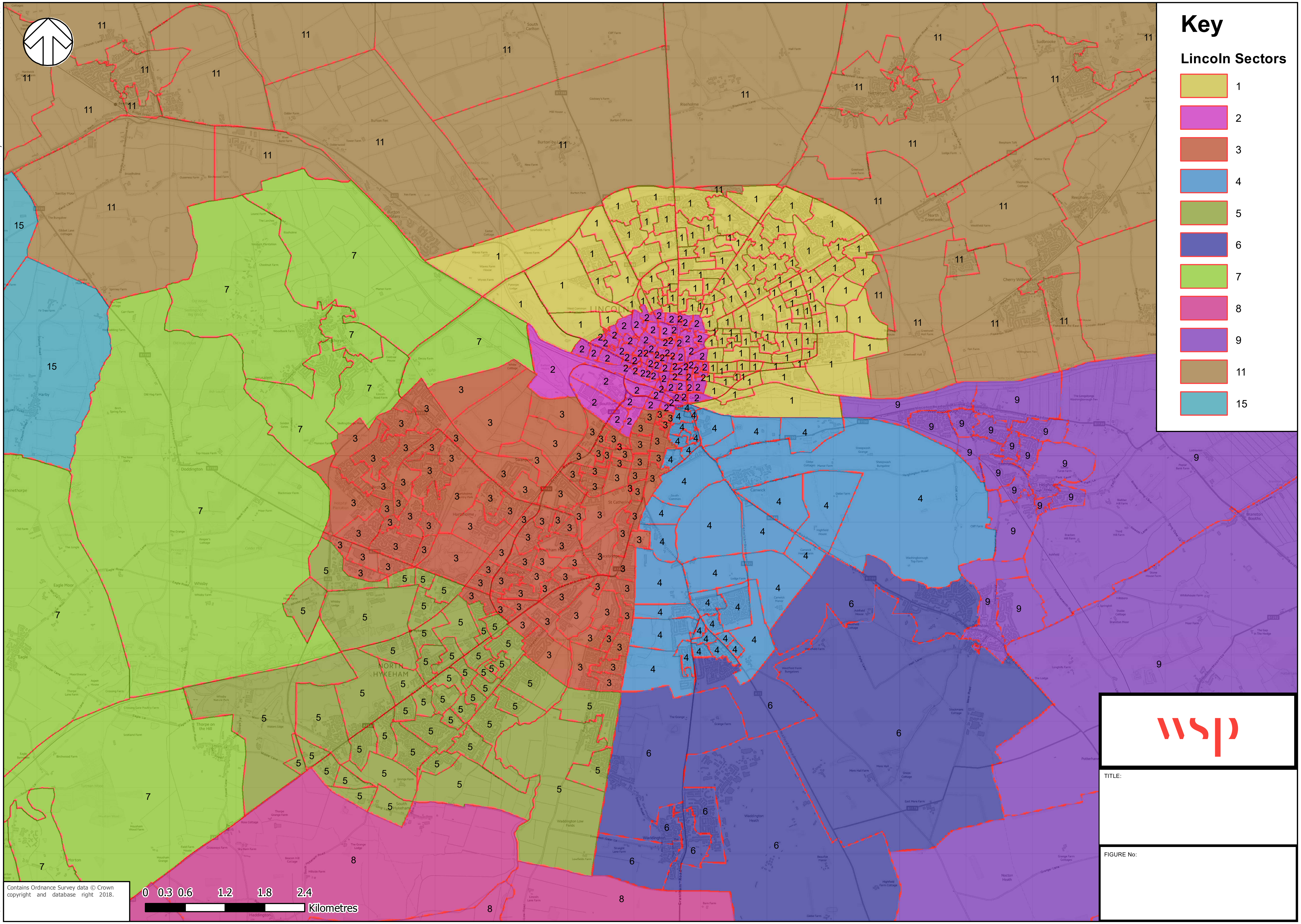
Donor Traffic Model	Derived Annualised Hours	Annualised Hours from LEB study
AM Peak Hour Model	500	253
Inter Peak Ave. Hour Model	2,687	2,745
PM Peak Hour Model	507	506
Total Annualised Hours	**3,694**	**3,504**
Proportion of Annual Hours	**42%**	**40%**

Appendix B

TUBA SECTOR PLANS

Date Modified:

Drawn By:



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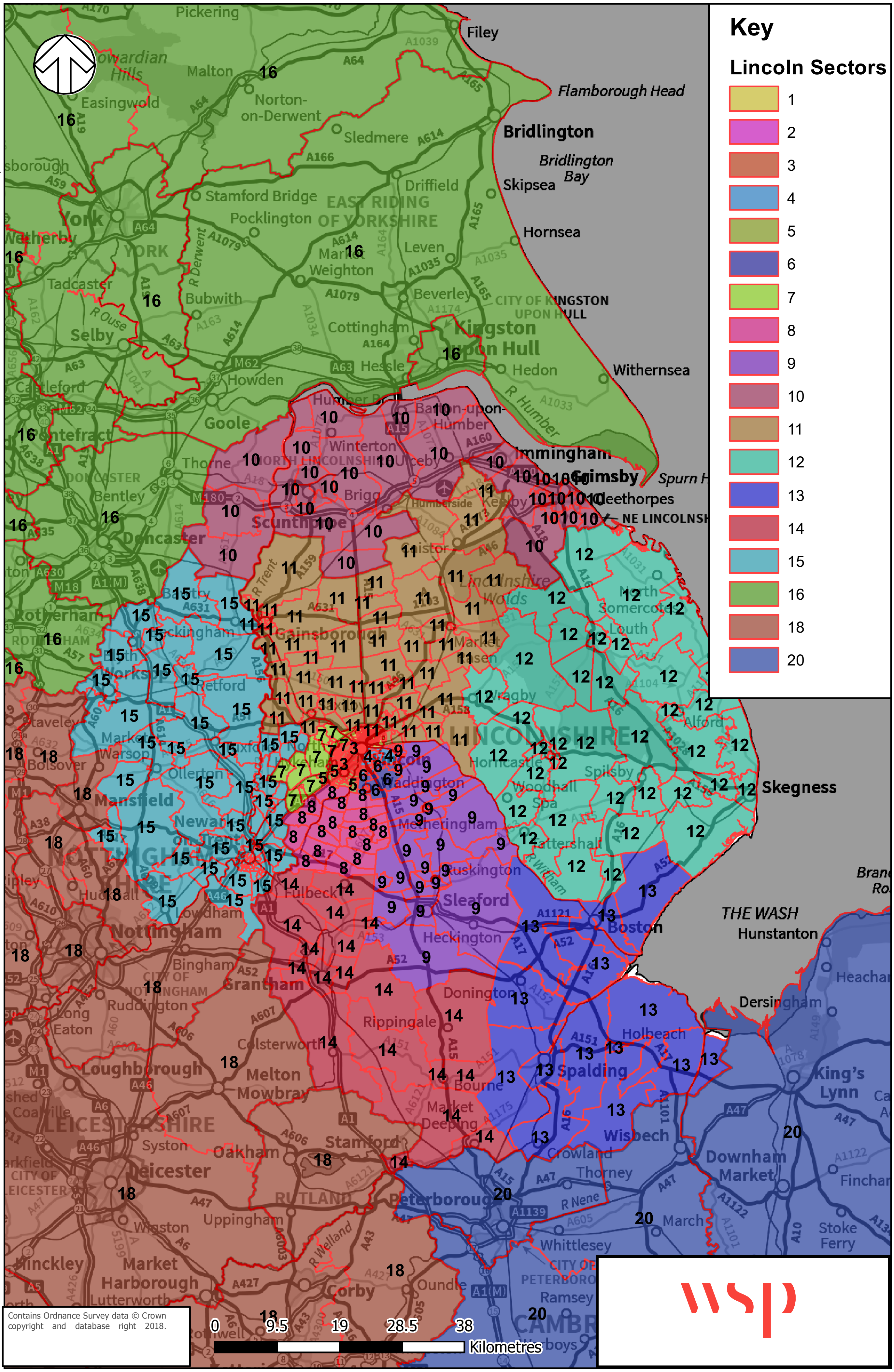

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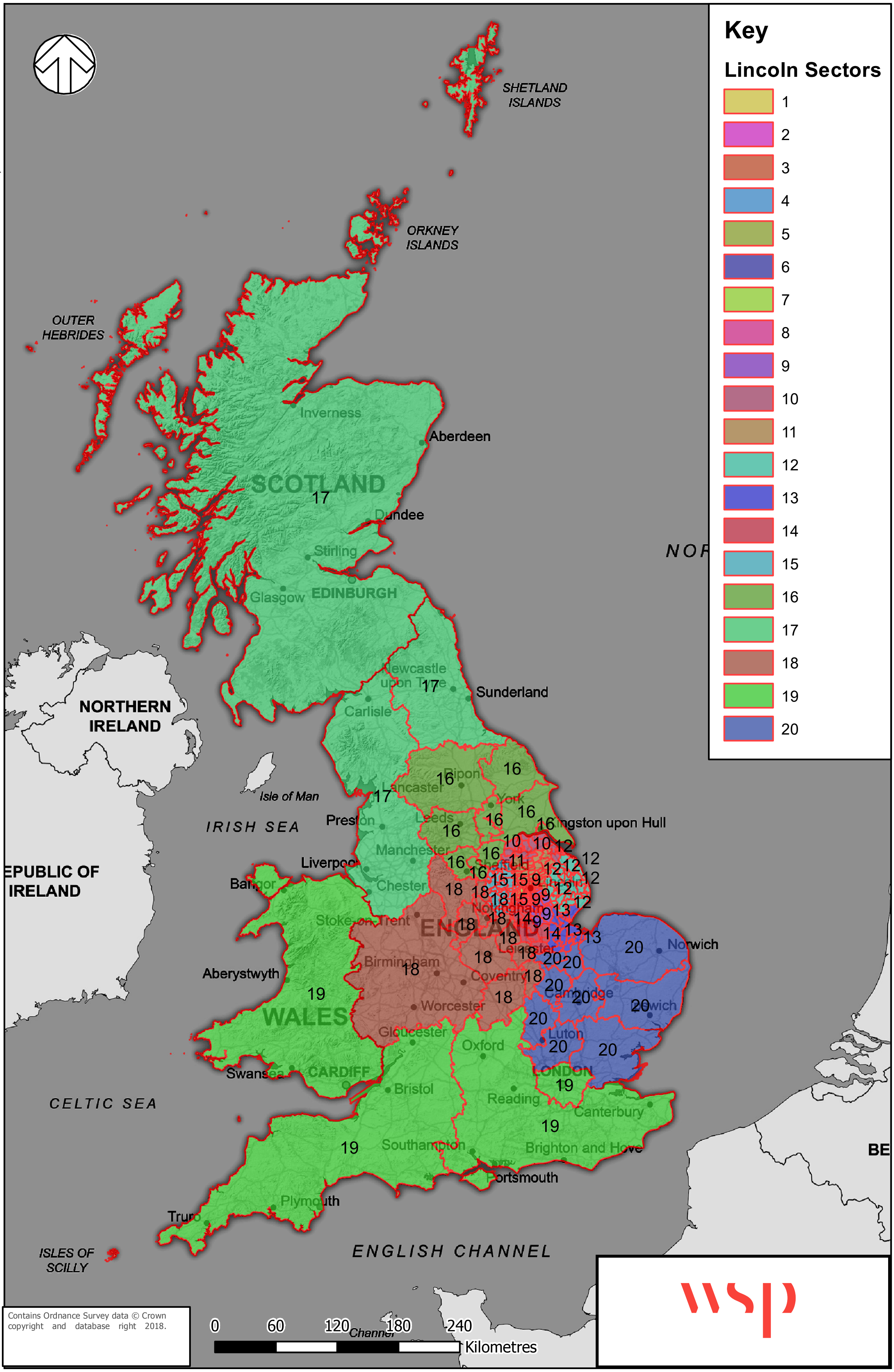

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Appendix C

TUBA WARNING CHECKS

TUBA ECONOMIC ANALYSIS

TUBA Checks (warnings)

TUBA produces a set of warnings as part of the standard output file. These have been analysed to give confidence in the user benefit results as well as identifying any modelling, or TUBA specific, errors; although the warnings are not necessarily caused by errors. They are based on the ratio between Do Minimum and Do Something and fall into four categories dependent on ratios exceeding time or distance thresholds. A summary table of the warnings is shown below (Table 1).

Type	Total Warnings	Comments
Ratio of DM to DS travel time lower than the limit – Travel time increases with schemes	21 (2 serious)	The total number of DS trips of this type is less than 1, with the average travel time between the associated zone pairs being less than 3 minutes, thus even a small change in time produces a relatively high ratio causing these warnings.
Ratio of DM to DS travel time higher than the limit – Travel time reduces with schemes	121,514 (none serious)	These warnings are mostly seen between sector pairs crossing between the East and West of Lincoln, thus large reductions in time are caused by the use of NHRR, two examples of this rerouting is seen in Figures 1 – 4.
Ratio of DM to DS travel distance lower than the limit – Distance increases with schemes	151,540 (none serious)	These warnings are mostly seen between sector pairs at opposite ends of the Lincoln urban area, these are caused by trips rerouting onto the ring road instead of using a short, but slower, route through the urban area. Figures 5 – 8 show two examples of this rerouting.
Ratio of DM to DS travel distance higher than the limit – Distance reduces with schemes	16,046 (all serious)	These warnings are mostly seen between sector pairs at either end of NHRR and are caused by trips using NHRR as a more direct route. Figures 9 – 12 show two examples of this rerouting.

Table 1 - TUBA Warning Summary

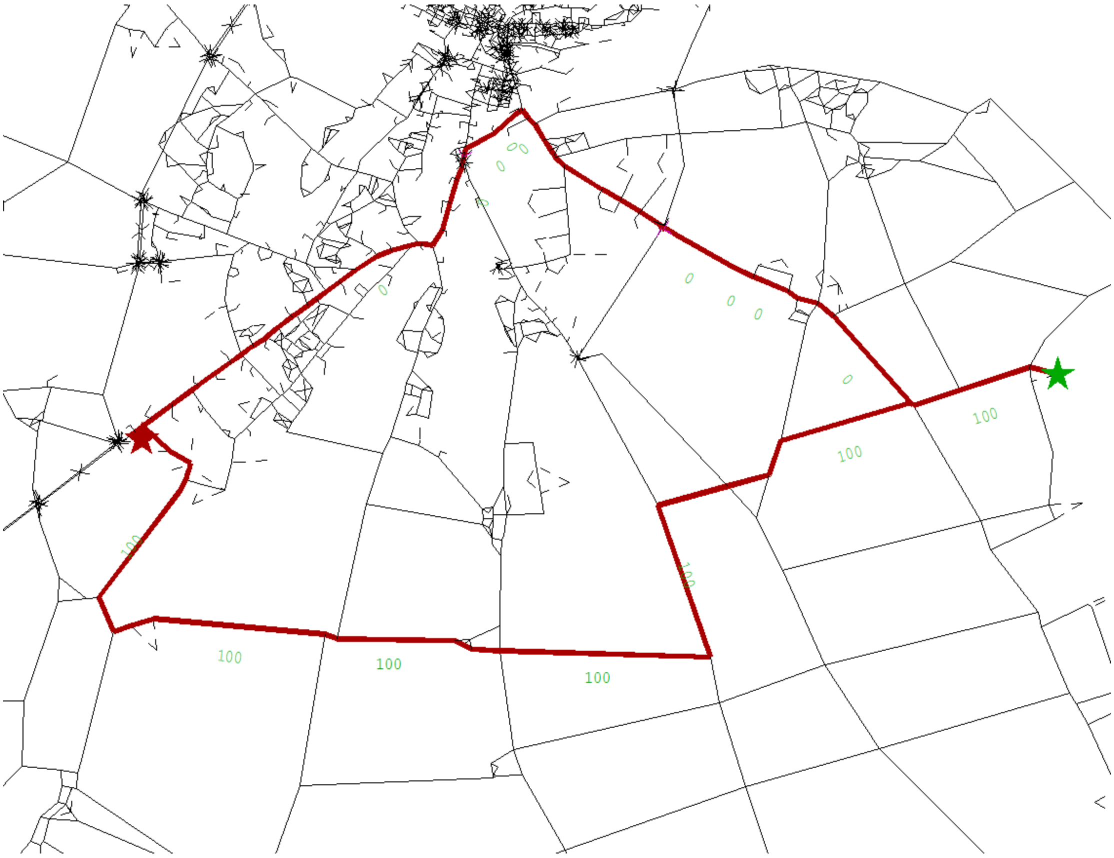

Figure 1 - DM 2041 AM Sectors 9-5 for user class 4

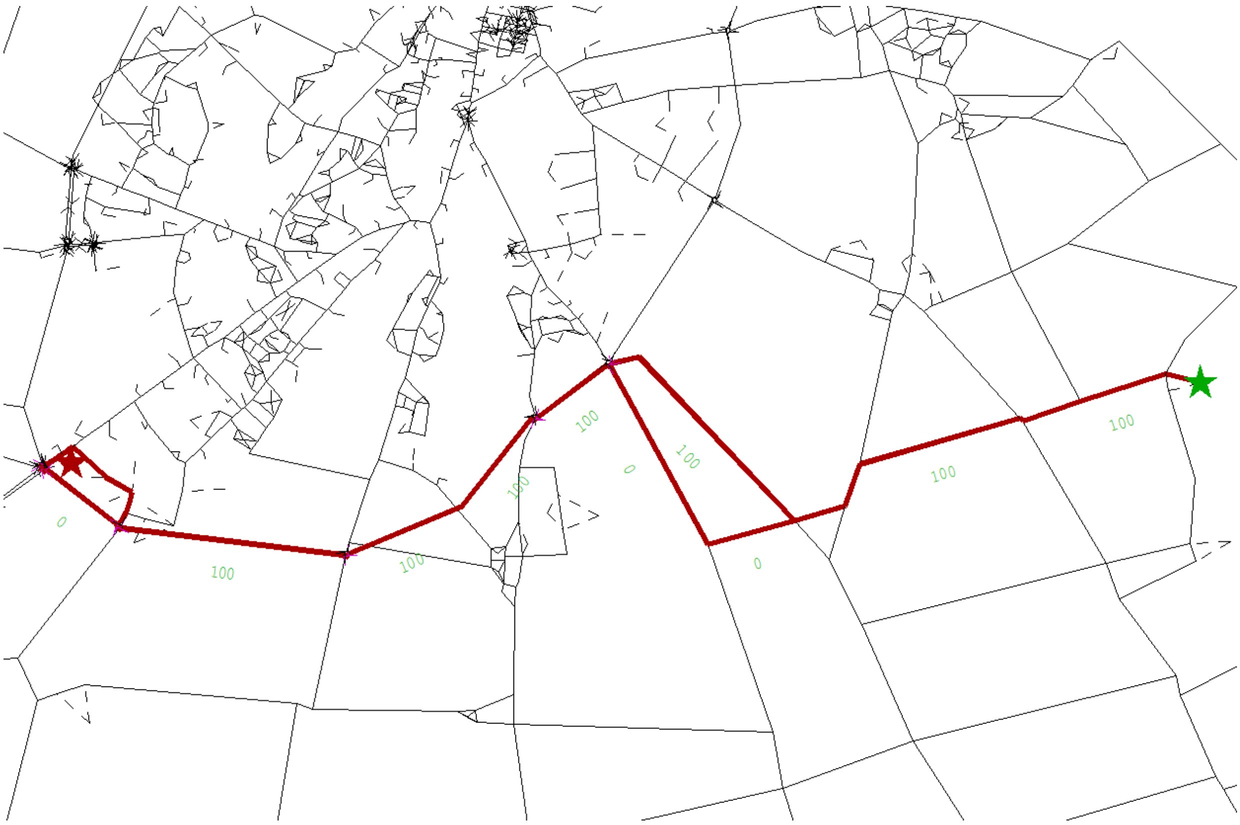

Figure 2 - DS 2041 AM Sectors 9-5 for user class 4

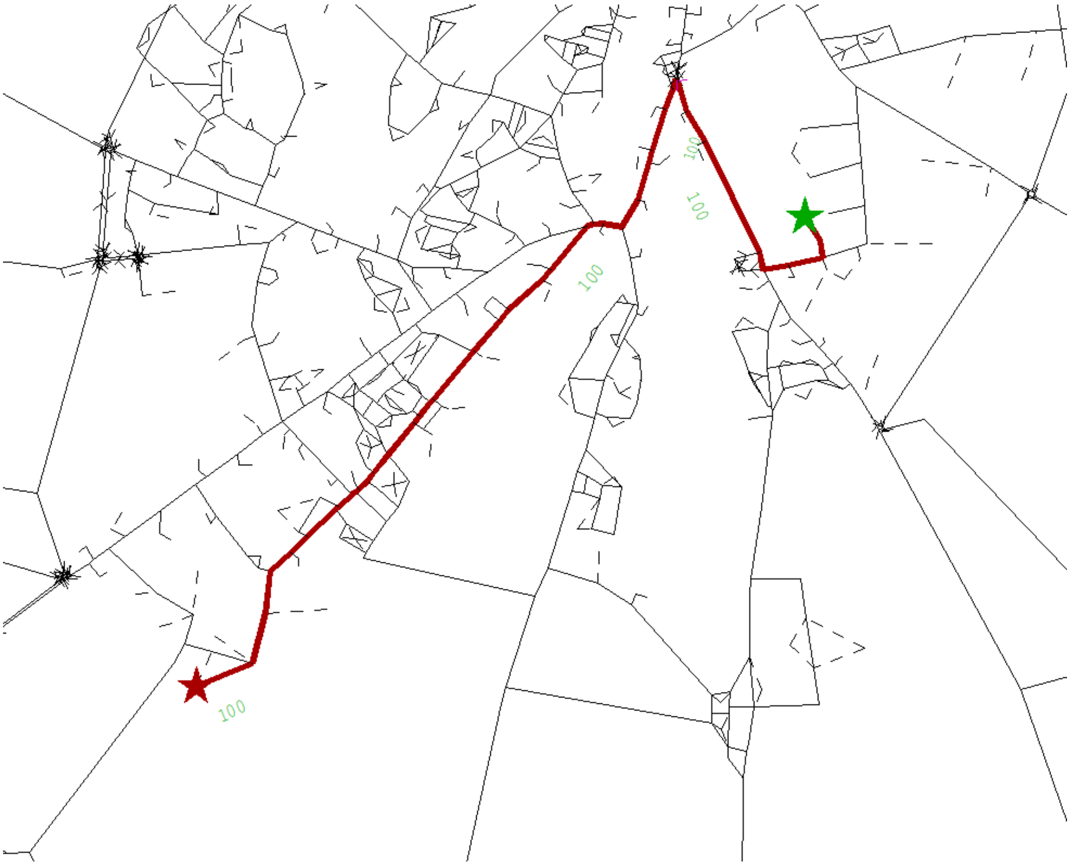

Figure 3 - DM 2026 AM Sectors 4 - 8 user class 2.

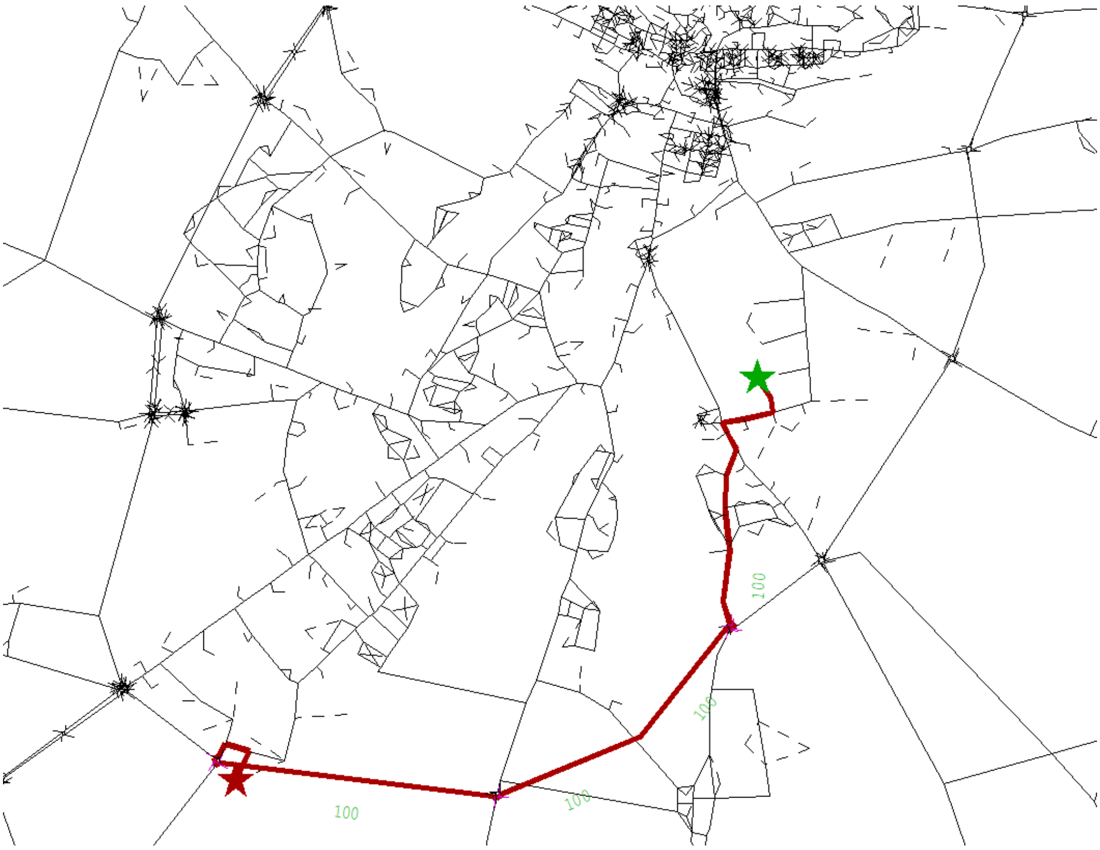

Figure 4 - DS 2026 AM Sectors 4 - 8 user class 2

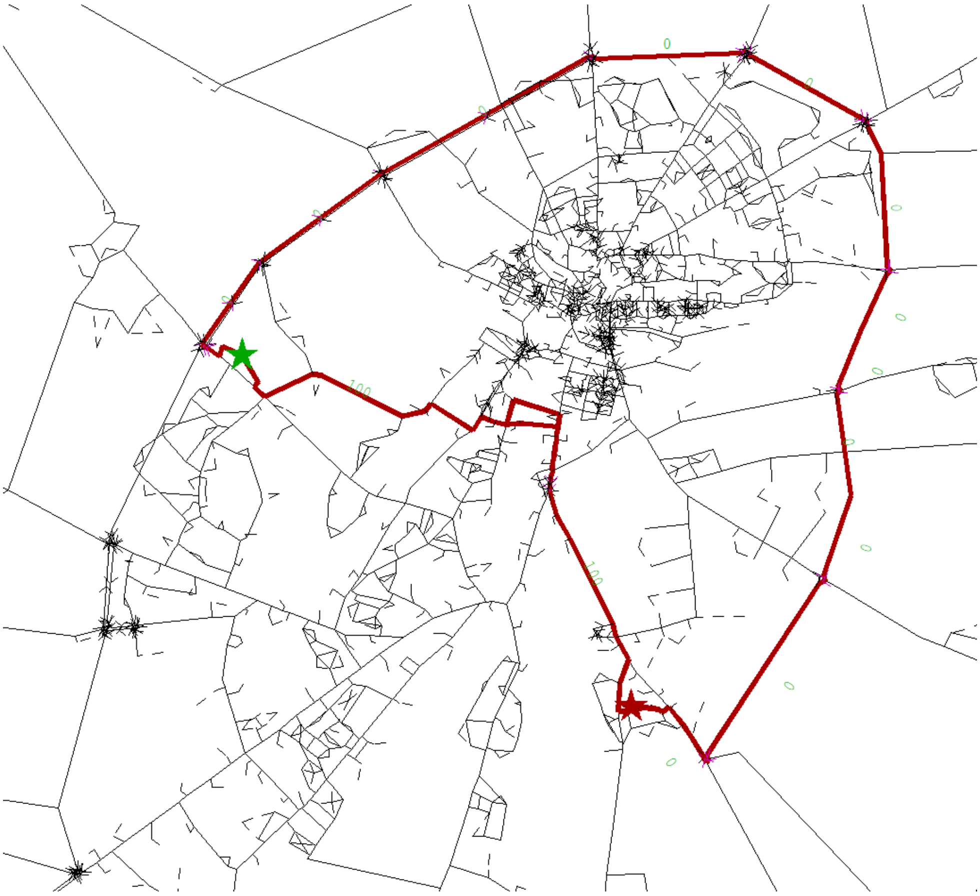

Figure 5 - DM 2041 PM Sectors 3 - 4 user class 1

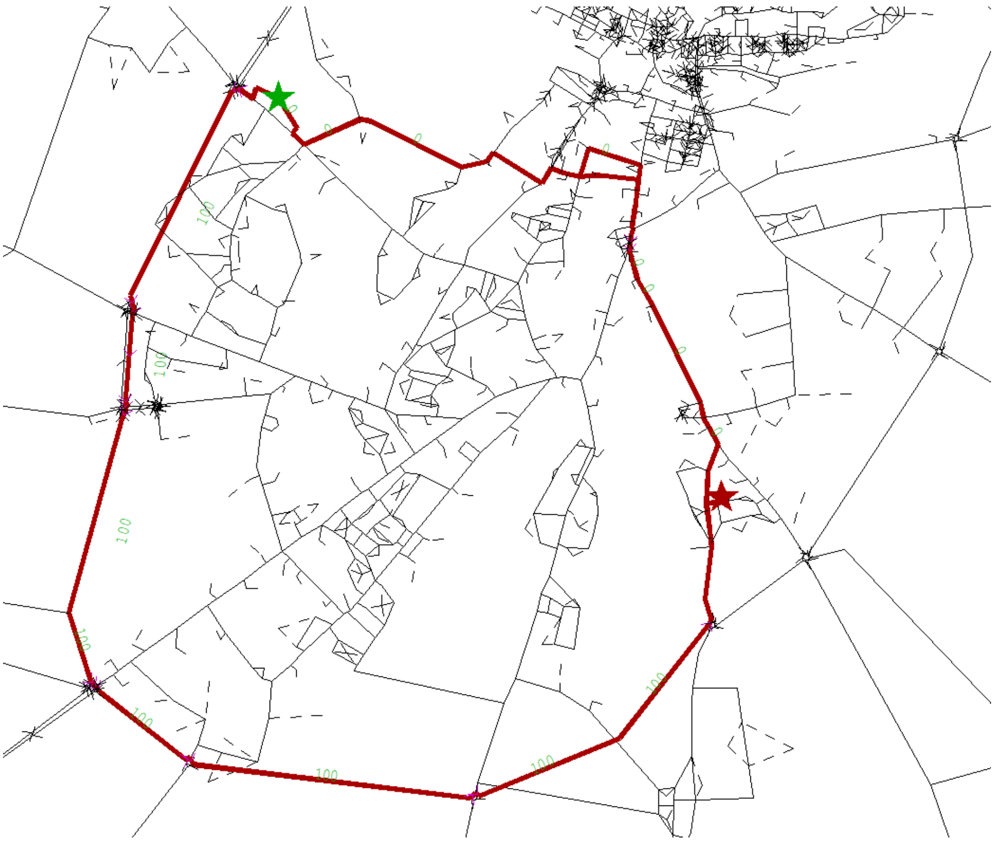

Figure 6 - DS 2041 PM Sectors 3 - 4 user class 1

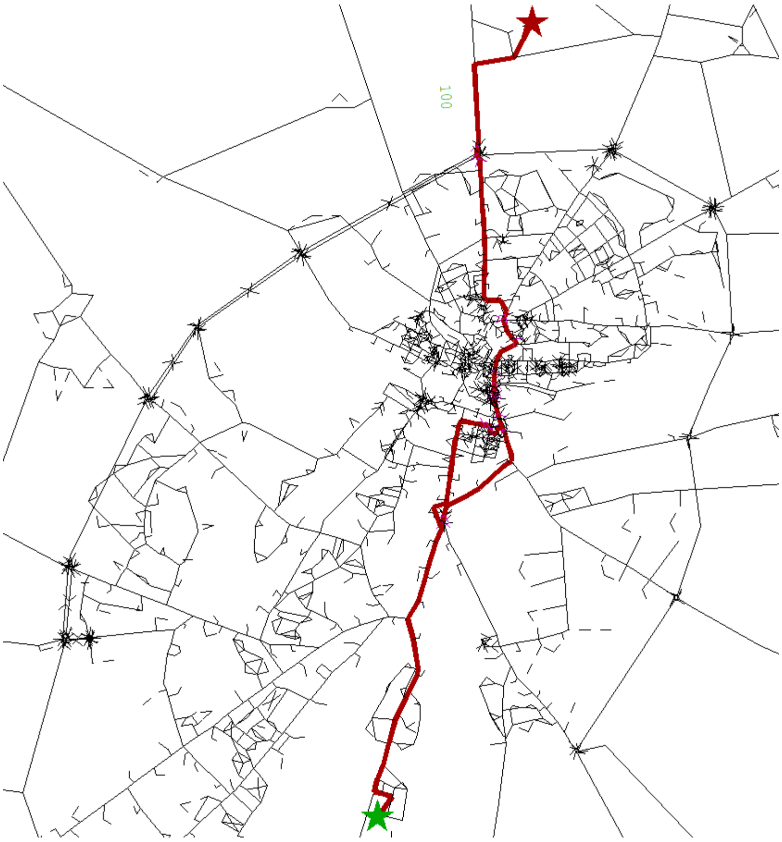

Figure 7 - DM 2041 AM Sectors 5 - 11 user class 3

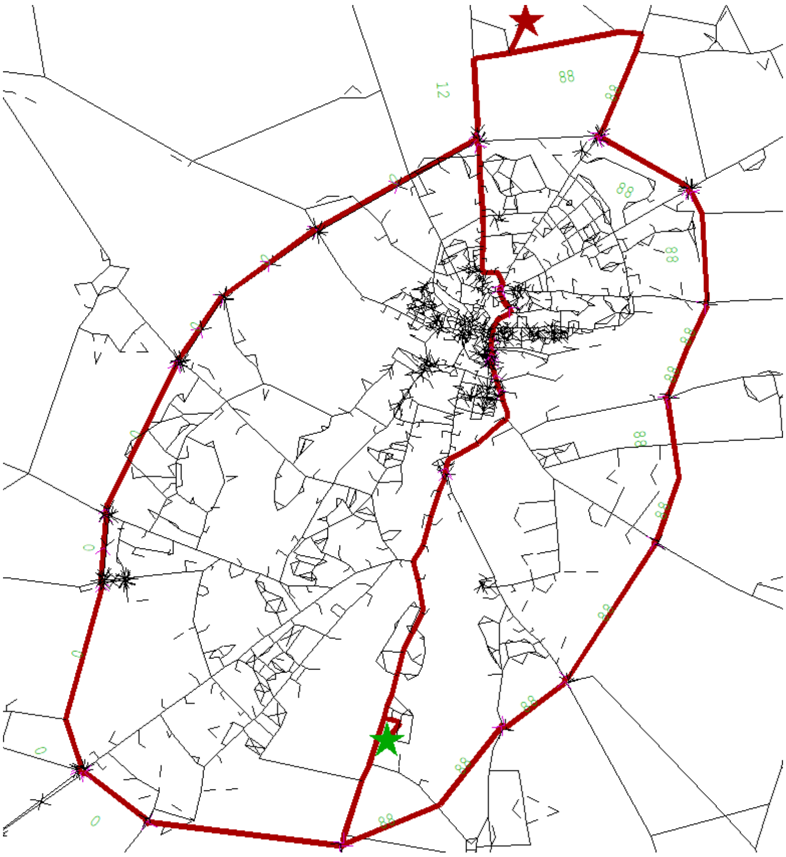

Figure 8 - DS 2041 AM Sectors 5 - 11 user class 3

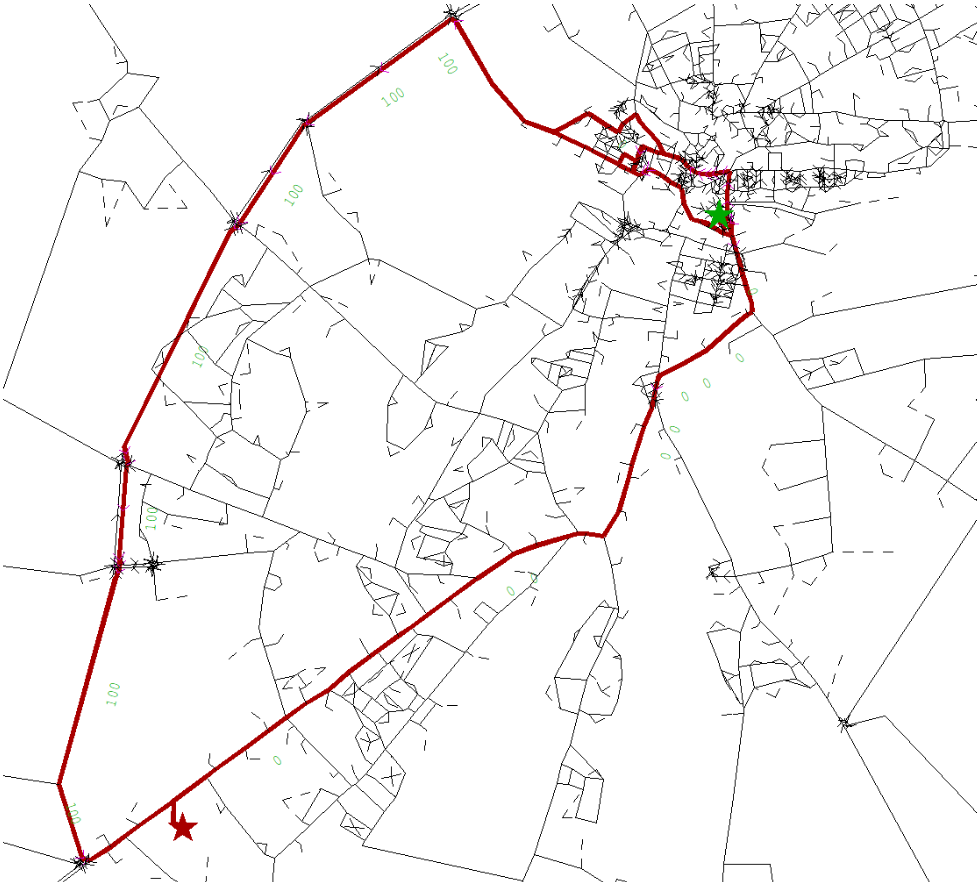

Figure 9 - DM 2041 IP Sectors 2 - 5 user class 3

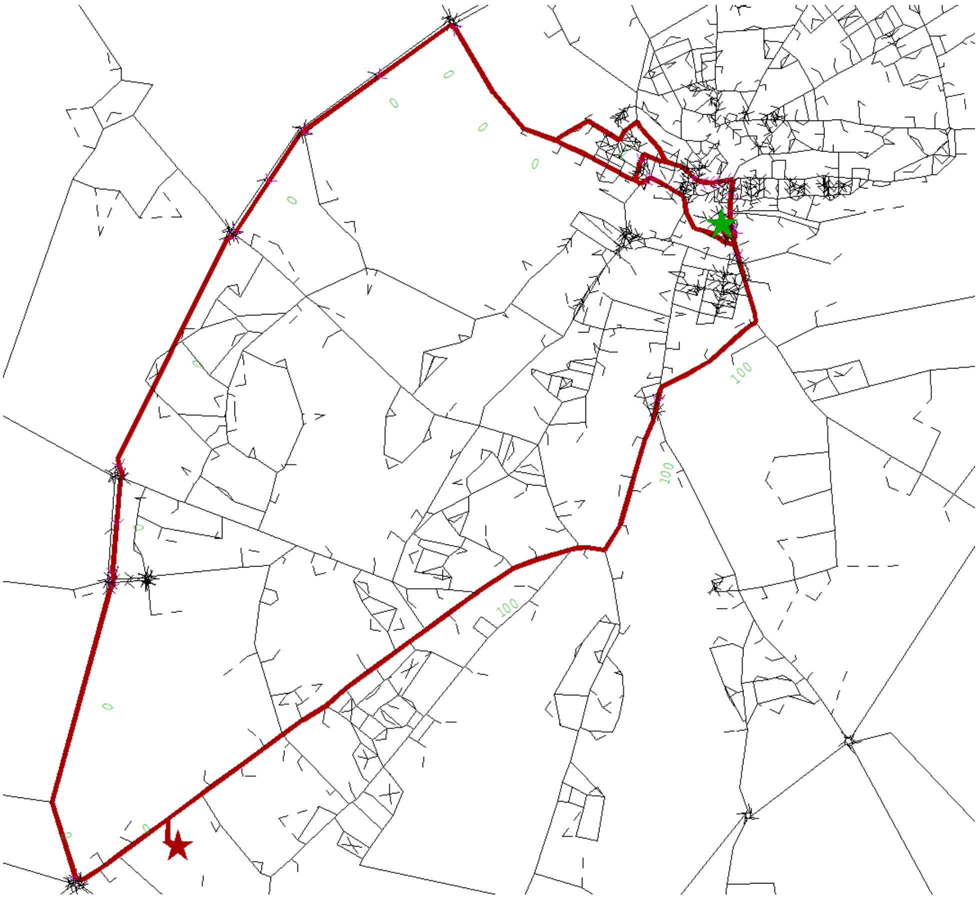

Figure 10 - DS 2041 IP Sectors 2 - 5 user class 3

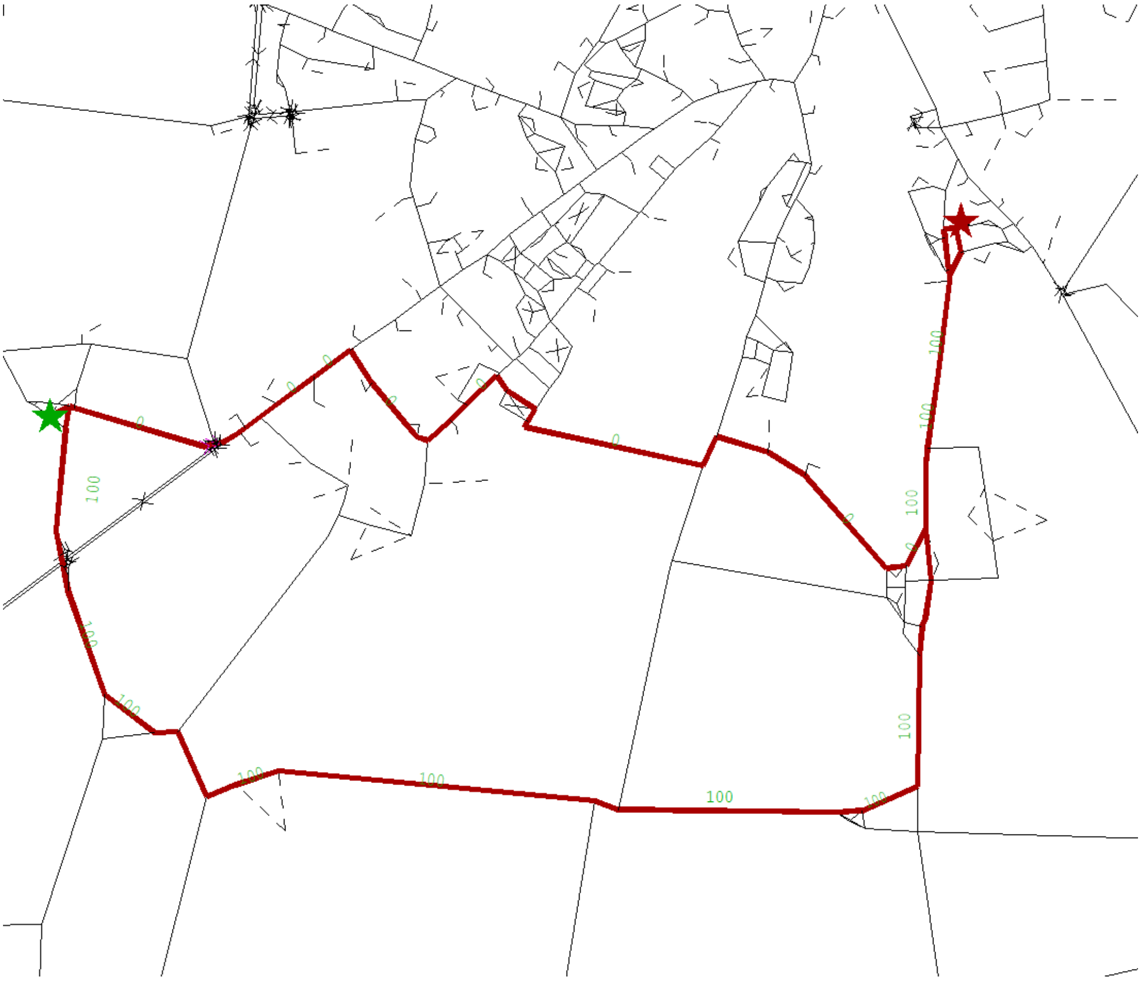

Figure 11 - DM 2041 AM Sectors 7 - 4 user class 3

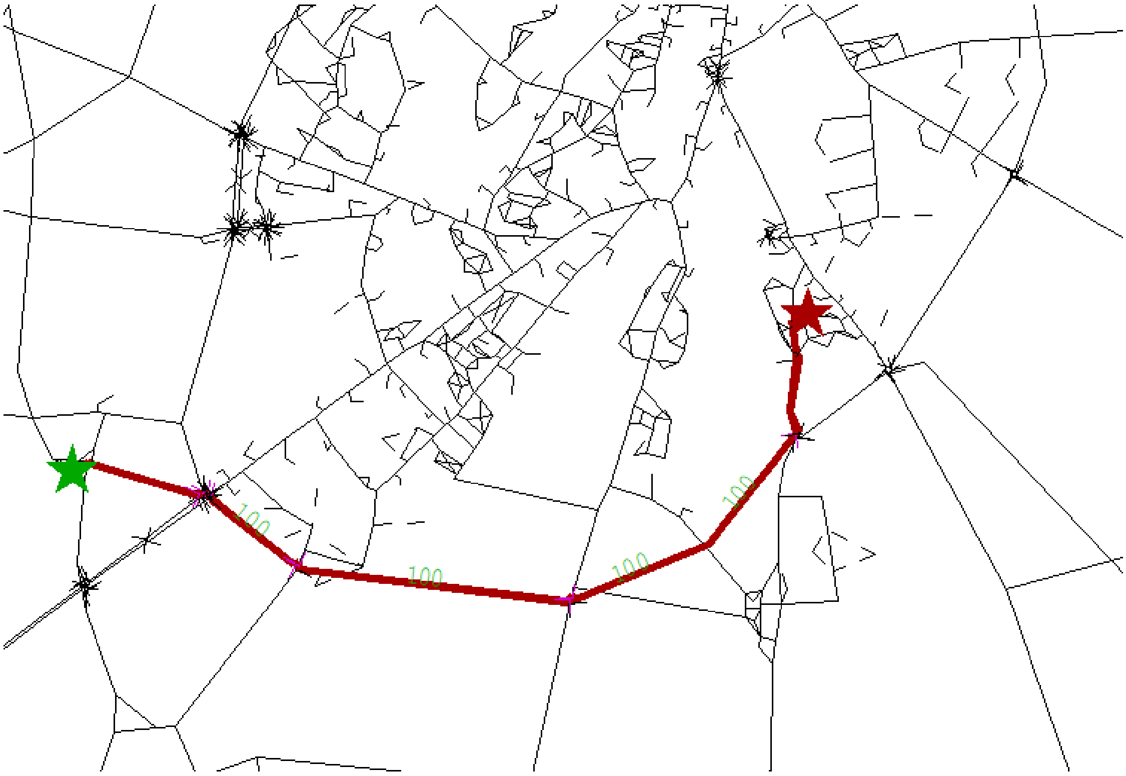

Figure 12 - DS 2041 AM Sectors 7 - 4 user class 3

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M15 4RP

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