Health Impact Assessment Report

Report for Derby City Council

ED 62608 | Issue Number 4.2 | Date 14/03/2019

Customer:

Derby City Council

Customer reference:

Derby Roadside NO_2 Project

Confidentiality, copyright & reproduction:

Contact:

Guy Hitchcock
Ricardo Energy & Environment
Gemini Building, Harwell, Didcot, OX11 0QR, United Kingdom

t: +44 (0) 1235 75 3327
e: guy.hitchcock@ricardo.com

Ricardo is certificated to ISO9001, ISO14001 and OHSAS18001

Author:

Sam Stephenson;Blanca Fernandez Milan

Approved By:

Guy Hitchcock

Date:

14 March 2019

Ricardo Energy & Environment reference:

Ref: ED62608- Issue Number 4.2

Table of contents

1. Introduction 1
2. High level assessment of the measures 3
3. Health impact of air quality changes 7
3.1 Methodology 7
3.2 Model outcomes 8
4. Conclusions 9

Appendices
Appendix 1 Literature review on HIA
Appendix 2 Health impact of air quality changes: Assumptions

1. Introduction

Derby has been named as one of several cities in the UK that will not be compliant with nitrogen dioxide (NO_2) limit values by 2020 without focussed action. As a result, DEFRA's national NO_2 compliance plan named Derby as having to carry out a Feasibility Study to achieve compliance as soon as possible.

Each city must develop a Business Case which explores viable options to tackle air quality and present the case to support the preferred policy option. The Business Cases are being developed in line with guidance issued by the Joint Air Quality Unit (JAQU), which in turn is based upon HM Treasury's five case model.

JAQU have shared with the cities detailed guidance around the economic methodologies and assumptions to adopt when appraising the policy options. This guidance stipulates that deliverables to be provided by the Local Authority are:

1. Economic Appraisal Methodology Report (E1) – setting out the economic appraisal and results
2. The Economic Model (E2) and any linked documents (linked spreadsheets or user guide)
3. Distributional Analysis Methodology Report (E3) – covering the approach to distributional analysis and the results.

Health impacts are valued as part of the economic assessment reported in E1, with the distribution of changes to air pollution in relation to different social groups covered in the distributional analysis report (E3). This report sets out further analysis of the possible health impacts from the policy options considered by Derby. The aim of this health impact assessment (HIA) is to explore how the policy options impact population's morbidity and mortality due to their changes in emissions compared to a baseline scenario, along with potentially wider health impacts of the options under consideration. It should be considered in conjunction with the other economic assessment documents, rather than in isolation.

In terms of air pollution there is a substantial amount of evidence linking exposure to harmful air pollutants, particularly Nitrogen Oxides and Particulate Matter, to a significant, detrimental effect on human health[1] (see appendix 0). In urban areas a significant amount of this localised air pollution stems from cars and other road vehicles, the primary target of the measures proposed in Derby.

The two measures being assessed in this analysis comprise:

- *Stafford Street traffic management scheme:* this is a targeted set of traffic management measures designed to limit traffic flows along Stafford Street in order to achieve compliance with the NO_2 limit value in this location.

- *A benchmark Class D Clean Air Zone (CAZ)*: this scheme would apply to all vehicles entering the area within the outer ring-road and is a benchmark charging access restriction scheme against which to compare the traffic management option in terms of compliance with the NO_2 limit values as soon as possible.

[1] Wilkie, S., Price, M., Hall, N., Dent, E. & Ling, J. The Impact of Improved Air Quality through Decreased NO2, PM2.5, and PM10 on Circulatory and Respiratory Disease Mortality and Morbidity. 2018. Sunderland: Author

While both schemes are primarily aimed at improving the air quality in the city, they could have wider health benefits, including increased levels of active travel (walking and cycling) and the additional health benefits attached to this; a reduction in the number of accidents due to fewer vehicles on the road; the impacts of noise pollution; and the potential impacts on mental health. A variety of aspects are therefore considered to assess the full impact on health of both the traffic management and the Class D CAZ in Derby.

The following sections provide:

- a high-level overview of the various impacts of the two measures proposed, assessing the significance as well as the spatial and temporal dimensions of the impacts;
- a quantitative assessment of the health outcomes of changes in air quality based on the emission results from the modelling, and translating damage costs to the underlying health-based metrics;
- a summary of the overall health impacts of each option and how they compare.

2. High level assessment of the measures

This section takes a detailed look at the impacts of the specific measures proposed. Each measure is briefly described and then analysed in relation to their impact/significance as well as their spatial and temporal trends. The impact and significance of each measure is compared against five criteria. Table 1 gives a brief overview of the importance of each criterion and Table 2 describes the impacts in detail for each option. The information in Table 2 draws heavily on the distributional analysis of air quality and traffic impacts that has been carried out in a related piece of work and reported in E3.

Table 1 - Description of Criteria

Measure	Importance
Impacts on Air Quality	The main success criteria for all these measures is reducing the amount of pollution occurring from road transport. The options can achieve emission reductions in two main ways, either reducing the number of vehicles travelling through the area and/or improving the Euro standard of the vehicles being used..
Active Travel Benefits	Measures may also encourage people to travel by modes other than private car, including public transport, walking and cycling. When the level of walking and cycling increases there is an ancillary benefit of improving people's fitness.
Changes in accident levels	One of the key road related health issues that occur are traffic accidents, reducing the number of vehicles on the road hence has the additional benefit of reducing the likelihood of accidents on the road. Changes to accident levels can also occur from changes to speed limits and specific directional restrictions. Measures that increase the number of bicycles on the roads without dedicated cycling provision can also potentially increase the potential for accidents on the road. The impact of the measures on accident levels has been considered within the distributional impact analysis in terms of changes in traffic flows.
Changes in noise levels	Another major form of pollution from road transport is noise pollution. Noise is regularly reported as a key concern for people living near main roads. Moreover, research[2] has shown that contact exposure to noise can increase the risk of other health issues. Reducing exposure to noise pollution could occur through a number of means: reducing the number of vehicles on the road, changing speed or acceleration patterns, or even changing the vehicle type with which trips are taken (e.g. increasing the number of electric vehicles, which are significantly quieter than tradition internal combustion engines). The impact of the measures on noise levels has been considered within the distributional impact analysis in terms of changes in traffic flows
Impacts on mental health	Mental health is another potential area where transport measures can have an impact. Active travel measures can have a positive mental health impact given the relationship between mental health and physical activity. Furthermore, changes in accessibility (either on a local scale to key amenities, or city wide in terms of traffic and travel times) can also have mental health benefits. Where the options impact on the local economy and business, there may also be indirect effects on mental health through loss of employment.

[2] Babisch, W. (2011). Cardiovascular effects of noise. *Noise and Health*, *13*(52), 201 and Rosenlund, M., Berglind, N., Pershagen, G., Järup, L., & Bluhm, G. (2001). Increased prevalence of hypertension in a population exposed to aircraft noise. *Occupational and environmental medicine*, *58*(12), 769-773.

Table 2 – Policy options high level assessment

Package	Impact/significance	Spatial trends & trends over time
Traffic Management	**Impact on air quality** Given the small impacts (positive or negative) of the traffic management scheme on air quality throughout the city, the impact on health derived from it is insignificant. **Active travel benefits** Rerouting of traffic might have an impact on access to key amenities with public transport, both positive and negative. Bus priority measures are included but these are not expected to contribute to severance, hence having insignificant health benefits. There is also no great change with regards to pedestrian barriers. Some localised traffic delays may encourage some shift to walking, cycling or public transport but it would be limited. The traffic management scheme is therefore not expected to change public transport services or impact significantly on physical activity. **Changes in accident levels** The traffic management scheme shows an overall positive impact on accident rates and a clear benefit trend for low income groups, with areas with the lowest levels of income experiencing the greatest reduction in accidents. It generates greater reductions than a Class D CAZ but on fewer links. No changes are expected that would influence perception of security because there is no significant change in public transport waiting/interchange facilities. **Impact of noise on health** Changes in noise levels move in line with traffic levels. Redistribution of traffic as a result of the traffic management scheme will have both positive and negative impacts on noise levels from traffic. While streets directly impacted by the scheme (mainly Uttoxeter New Road, Stafford Street and Ford Street) will have a noise reduction, rerouting of traffic on to adjacent roads like Uttoxeter Old Road see an increase of noise. Although more streets would experience a significant decrease rather than an increase in noise levels, no clear area of the city seems to be impacted by a traffic management scheme in terms of noise levels. **Impact on mental health** Redistribution of the traffic will have both positive and negative impacts on bus journey times, car congestion, and travel times. The traffic management scheme may have a negative impact on a household if their journeys are directly impacted by the scheme and as a result suffer increased commuting time, route changes or opt to change modes. However, the traffic management scheme	**Spatial trends** Reduction in NOx concentrations are quite localised to the area of Stafford Street on the inner ring road, with some small changes on other roads as traffic is diverted. In this area, NOx emissions will decrease by more than 10% (mainly Uttoxeter New Road, Stafford Street and Ford Street), but, because of the rerouting of traffic, adjacent roads like Uttoxeter Old Road would suffer from an increase of NOx emissions by more than 50%. However, overall when considered at the LSOA area, the changes are essentially insignificant. **Trends over time** Since the scheme ceases to run in the same format after 2025 when the A38 scheme should be complete, known impacts of the traffic management scheme will not proceed past 2025.

	is unlikely to have any significant effect on mental health as a result of this. Small impacts may exist on delivery vehicles in the area around Stafford Street and access to business premises.	
Class D Clean Air Zone (CAZ)	**Impact on Air Quality** A Class D CAZ will ensure that all motorised vehicles entering the city centre of Derby will either have to pay a charge or be compliant with the required CAZ standard. The implementation of a charging scheme will significantly increase the number of compliant, and electric vehicles within the CAZ region. This means that a Class D CAZ leads to wide spread air quality improvements within the charging scheme area. Although emissions do increase outside the charging area, as a result of diverting traffic. **Active Travel Benefits** The inclusion of private cars in the charging zone will incentivise people to switch modes to active travel modes (i.e., walking and cycling). While it is difficult to determine the exact shift to the active travel modes some health benefits can be expected to accrue from the increased walking and cycling within the city centre, particularly if the people changing their mode of travel are commuters or do so regularly. **Changes in accident levels** A CAZ D reduces the number of vehicles on the roads and updates the fleet (upgrade for compliance). A reduction in the number of road accidents can therefore be expected, resulting from the decrease in the number of vehicles on the road. However, under the Class D CAZ, some cars that no longer enter the city centre are expected to travel around it via other routes, this may make these routes more congested and increase the number of accidents along them. The benefit in terms of accidents is likely to be widespread with the charging scheme, with an overall positive impact throughout the city. Based on the demographic population, this positive impact is greatest for children under 16, those on low incomes and areas with a high proportion of people with disability. A potential increase risk from encouraging more people onto bikes/ active travel (modal changes to enter the CAZ zone) may arise unless appropriate provisions are made to ensure trips are made safely. **Impact of noise on health** More streets would experience a significant decrease rather than an increase in noise levels. However, the overall impact on noise levels remains limited.	**Spatial Trends** A Class D CAZ will have a greater improvement within the charging scheme boundary, but it will be accompanied by deteriorating air quality outside the zone because of diverting traffic. The charging scheme shows significant improvements in air quality within the charged area, it mainly encompasses the town centre. Greatest benefit includes nurseries, care homes, communal residences and educational residences (CE02, RI01, RI02 and RI03). It also includes the central shopping area and several tourist attractions. Outside the Charging Scheme, it shows an increase, related to the diversion of traffic around the charging area which increases emissions. Also, open spaces (LP02) and hospitals (CM03) show least impact, as they are not in central areas. **Trends over time** Since the scheme ceases to run after 2025 when the A38 scheme should be complete, the CAZ D scheme will not proceed past 2025. All analysis conducted on the benefits of implementing a CAZ are compared against a Business as Usual (BAU) baseline. The baseline scenario will also

	Impact on mental health The charging scheme will have a more widespread impact on traffic levels than the traffic management scheme as it covers a much larger area, resulting in increases in traffic around the zone and decreases within the zone. The transport model outputs illustrate that there are some changes in travel times and significant changes in traffic flows on several links. Also, the charging scheme is likely to have a significant direct impact on households and business through the charges applied to non-compliant vehicles. There is a risk that some businesses may not be able to sustain the burden of the CAZ charge. This impact will be greatest for smaller businesses operating older vehicles, which will have less financial resource to upgrade their vehicles and less flexibility to manage vehicles accessing the zone to only compliant vehicles. A wide range of businesses will be impacted; taxis, small local bus and coach firms and small freight operators in particular.	have a natural fleet turnover where non-compliant vehicles will be replaced with complaint vehicles, eroding the benefits associated with implementing the CAZ.

3. Health impact of air quality changes

This section provides a quantitative assessment of the air quality changes on health outcomes based on the emission results from the modelling and translating damage costs to the original health metrics.

3.1 Methodology

The methodology used for this analysis is based on emissions reduction from the air quality modelling. It uses absolute emissions data for NOx and PM2.5 across the full air quality modelling domain for both baseline, traffic management scheme and CAZ D option in 2020.

Using these data, the health impacts associated with the policy options considered by Derby are calculated following Defra's Supplementary Green Book Air Quality Appraisal Guidance, adopting the Impact Pathway Approach (IPA). The IPA charts the calculation of impacts from a change in concentration, through to a change in exposure, then applies baseline population and health incidence data to a response function to calculate a change in health outcomes. This calculation captures those health impacts underpinning Defra's damage costs, namely:

- Long-term mortality associated with $PM_{2.5}$ and NO_2 (chronic mortality)
- Respiratory hospital admission associated with $PM_{2.5}$ and NO_2
- Cardio-vascular hospital admissions associated with $PM_{2.5}$

Defra's damage costs are conservative in the health impacts they consider. There are a wide range of other health impacts associated with changes in air pollution. Many of these are captured by a new calculator produced by Public Health England (PHE). These health pathways have been added to an updated publication of Defra's damage costs by Ricardo[3]. This includes:

- Asthma in children associated with NOx and $PM_{2.5}$
- Stroke associated with $PM_{2.5}$
- Lung cancer associated with NO_2

In the absence of available PM concentration data we use a simplified approach based DEFRA's damage costs, which relies on emissions data only. These damage costs are calculated for each option relative to the baseline in 2020. The model assumes different health effects for each sector based on their related emissions and population density. Urban areas have four different sectors (types) depending on the population size. The modelling for Derby is based on the Road Transport Urban Medium scenario (see Appendix 0)[4]. Health impact outputs are expressed in Hospital Admissions (HA), Quality-Adjusted Life Years (QALY) and Life Years gained for reductions in both NOx and $PM_{2.5}$ emissions.

Damage costs defined by DEFRA are applied to value the economic damage avoided in monetary terms associated with the emissions savings. Monetised impacts of emission savings are reported as £ reduction in damage from air pollutant emissions. As recommended by JAQU, the model uses a 2018 price year as the basis for all calculations. Damage costs for both NOx and $PM_{2.5}$ are converted to price year 2018 using HM Treasury's GDP Deflator series and have a 2% annual uplift applied as in JAQU guidance. Each impact is assessed relative to a 'do minimum' counterfactual (Baseline 2020).

[3] Ricardo (2018) Air Quality damage cost update 2019. Report for Defra. Retrieved from: https://uk-air.defra.gov.uk/assets/documents/reports/cat09/1901300955_Damage_cost_update_2018_FINAL_Issue_1_publication.pdf
[4] Assumption: we use population from the Distributional Analysis Methodology Report (E3). The model takes a total of 702 Lower Layer Super Output Areas (LSOAs) with a total population of 116,3451.

Table 3 shows the emissions saved between the modelled scenarios and the Baseline 2020 reported by the air quality modelling, which covers the Derby City area (as defined by the model domain in the air quality modelling methodology report AQ2). These figures are used for the HIA model.

Table 3 Emissions saved between the modelled scenarios and the Baseline 2020 (annual tonnes/year all vehicles)

Pollutant	Class D CAZ	Traffic Management
NOx	-156.52	-53.39
$PM_{2.5}$	-3.04	0.88

3.2 Model outcomes

The results of the Health Impact Assessment are given in Table 4. Initial analysis of the options shows that the Class D CAZ has a significantly larger health benefit than the Traffic Management Scheme (TMS). Moreover, for the majority of health impacts analysed here they are made worse by the introduction of a Traffic Management Scheme, whereas under a CAZ, only the number of Hospital Admissions due to Respiratory Illness increases.

More specifically a Class D CAZ results in almost 29 Life-Years gained annually across the population of Derby due to reductions in NOx and PM emissions in terms of chronic mortality whereas the Traffic Management Scheme results in a benefit of only 5.6 Life-Years gained. The difference between the two policy options is clearer when considering the monetary valuation of these health benefit. The Class D CAZ would result in a monetary benefit of almost £2.5 million (£2,494,286) some six times larger than the £430,374 benefit from the Traffic Management Scheme which includes a cost of almost £200,000 (-£193,394) due to an increase in PM2.5 emissions.

The net Quality Adjusted Life Years (QALY) gained annually from the reduction in Strokes, Lung Cancer and Children's Asthma is over 21 years with a positive impact on all health outcomes for a CAZ D. In contrast, the impact on health from the Traffic Management Scheme is only 4.87 QALYs gained, and the prevalence of Strokes and Lung Cancer is likely to increase slightly as a result of a TMS.

Table 4 - Health related benefits and total £ benefits derived from the NOx and PM2.5 emissions saved between the modelled scenarios and the Baseline 2020

Disease	Class D CAZ		Traffic Management Scheme	
Chronic Mortality	28.80 Life Years gained		5.60 Life Years gained	
Respiratory Hospital Admissions	0.53 HA		0.35 HA	
Cardiovascular Hospital Admissions	- 0.13 HA		0.05 HA	
Stroke	1.53 QALY		-0.17 QALY	
Lung Cancer	0.09 QALY		-0.01 QALY	
Children Asthma	19.43 QALY		5.05 QALY	
	NOx	**PM2.5**	**NOx**	**PM2.5**
Total benefits by pollutant	£1,828,639.55	£665,646.65	£623,723.71	-£193,349.22
Total benefits	£2,494,286.19		£430,374.49	

Key: Positive (green) and negative (red) impacts on health: Hospital Admissions (HA) (light green/red), Quality-Adjusted Life Years gained (QALY) (green/red)

The increasing number of Respiratory Hospital Admissions stems from the relatively large reduction of NOx compared to the smaller reduction (or in the case of TMS, increase) of PM2.5. Reducing the exposure to PM2.5 does reduce the number of hospital admissions (HA). However, for NOx the opposite reaction occurs and a reduction in NOx increases the amount of HA, this is due to a chemical reaction that results in an increase in O_3 which has its own health risks associated. Typically, the NOx impact is small and offset by a PM2.5 benefit, however, due to significantly smaller change in PM levels compared to NOx levels an increase for Respiratory HA occurs for both the CAZ D and the TMS.

These outcomes suggest that overall, a Class D CAZ will have a more positive impact on health, when considering air quality, than the traffic management system.

3.3 Population

Table 5 shows the population breakdown for the area for which the change in emission levels were calculated (for both the CAZ and the TMS). We can see that a third of the entire population is made up of groups (those under 16 and over 65) that are deemed to be at greater risk of health impacts from changes in emission levels.

The effected population is determined by summing the population of the LSOA's for which the air quality assessment has been carried out. Therefore, it may be the case that individuals who regularly commute in to Derby from outside the Air Quality Domain may be impacted by the change in emission levels but are not considered here.

Table 5 - Population affected by the change in emissions

	Total	Under 16	Over 65
Population	105,144	22,686	11,572
Percentage of total	-	21.6%	11%

A more detailed assessment of changes on air pollution levels as a result of the two schemes in relation to different social groups was conducted as part of the distributional analysis and reported in Distributional Impact Assessment Report (E3).

4. Conclusions

There are obviously significant challenges associates with comparing different policy options, particularly between charging and non-charging packages. Moreover, the Class D CAZ covers a large area of the city whereas the traffic management scheme is quite localised to the area around Stafford Street and the inner ring road.

The Class D CAZ requires all vehicles that enter the city to comply with the emission standards or pay a charge. Moreover, while a Class D CAZ has the largest NO_2 reduction of the two policy options, it shows an increase outside the CAZ zone, this is due to the amount of car traffic that would be re-routed around the Class D CAZ boundary. Nevertheless, the Class D CAZ reduces average air pollutant concentrations, due to a very strong decrease within the charging scheme area. The traffic management scheme shows very small absolute change in modelled NO_2 concentrations and can be considered as neutral on average across the assessed areas (outside and inside the charging scheme).

The distribution of changes in air quality in relation to different social groups was carried out as part of the distributional analysis and reported in E3. This indicated that under a CAZ D, improvement is greatest for the most deprived population and the areas with the lowest proportion of children. However, the overall trend remains the same, with lower income groups still experiencing the highest levels of pollution, but the reductions generated by the charging scheme are greatest for low income groups, so this inequality is being reduced. Higher income groups live outside the charging zone where increasing levels of NO_2 occur. This is relevant from a health impact point of view, as the health impacts associated with increasing air pollution concentrations are already more prevalent in the most deprived quintile[5]. This measure will also likely have an active travel benefit as people who currently commute in by car may potentially shift mode to cycling and walking (and public transport). Moreover, research conducted suggests that the benefits associated with cycling in polluted cities outweigh the harms from pollution and accidents[6].

The above shows that the health benefits associated with implementing the traffic management scheme are likely to be less than the benchmark Class D CAZ. Specifically, when looking at our five main health criteria we see that:

- **Impact of air quality:** The charging scheme has an air quality benefit for most LSOAs in the city with the greatest benefit being within the charging zone and some small dis-benefits outside. The traffic management scheme on the other hand has a very small impact overall (on average less than 0.2 $\mu.mg^{-3}$). However, when considered for individual roads there are significant reductions in emissions and concentrations along Stafford Street and some related roads, as well as increases where traffic has been displaced. This HIA has indicated that the traffic management scheme has positive health outcomes due to the reduction in NOx but balanced by negative outcomes from the increase in $PM_{2.5}$. Overall the Class D CAZ has better health outcomes, for the health impacts assessed, compared to the traffic management scheme. In terms of life-years gained across the population of Derby the CAZ scheme shows a benefit of 28.8 years compared to 5.6 years for the TM scheme. In terms of total valued health benefits the CAZ scheme shows a benefit of £2,494,286.19 compared to only £430,374.49 for the TM scheme.
- **Active Travel Benefits:** CAZ D is expected to see some people shift mode from private cars to active travel, which will have a further health benefit in addition to reducing the number of vehicles on the road. Importantly, because the air quality improves within the CAZ zone, adverse health impacts related to active travel modes will be reduced. The traffic management scheme is expected to have no significant effect on active travel benefits.
- **Changes in Accident Levels:** Overall about 10% of total links for the traffic management scheme and over 30% of links with a charging scheme will have a significant change in traffic characteristics. Both schemes are generating benefits in terms of expected accident reduction. The traffic management scheme shows higher localised accident benefits, while more LSOAs will see accident reductions with a CAZ D.
- **Impacts of Noise on Health:** CAZ D is expected to have no clear area impacted by in terms of noise levels. The traffic management street will have some localized positive impacts near Staffford Street. However, the overall impact remains limited for both schemes.
- **Impact on Mental Health:** CAZ D has a potential impact on the mental health on individuals living in and around the CAZ due to the impact of charges on households and businesses in the charging zone. This is potentially a significant impact on smaller businesses who may not be able to afford the added expense of operating within the zone and whom tend to employ

[5] Cumella A. and Haque A. (2018). On the edge: How inequality affects people with asthma. Asthma UK. Retrieve from: https://www.asthma.org.uk/globalassets/get-involved/external-affairs-campaigns/publications/health-inequality/auk-health-inequalities-final.pdf
[6] Tainio, M., de Nazelle, A. J., Götschi, T., Kahlmeier, S., Rojas-Rueda, D., Nieuwenhuijsen, M. J., ... & Woodcock, J. (2016). Can air pollution negate the health benefits of cycling and walking? Preventive Medicine, 87, 233-236.

more locally. The impacts of these charges will have an impact on employment and add an increased layer of uncertainty to residents. The traffic management scheme may have small impacts on delivery vehicles in the area around Stafford Street and access to business premises but is unlikely to have any significant effect on mental health.

Table 6 - Summary of air quality health impacts

	Air Quality		Active Travel	Road Accidents	Noise	Mental Health
	CAZ	City				
Traffic Management Scheme	0	+/-	0	+	0	0
CAZ D	++	+	+	+	0	-

Key: ++ strong positive impact, + positive impact, 0 no impact, - negative impact, -- strong negative impact, +/- has both positive and negative impacts

More broadly it is clear from the Health Impact Assessment that the Traffic Management Scheme has limited but measurable health benefits, with a predicted overall gain of 5.6 life years compared to a scenario without the scheme. The level of health benefit is directly related to the scale of the scheme, which is focussed on addressing the air quality exceedance on one road link in Derby, as required by DEFRA's NO_2 compliance plan. As set out in the Business Case and other technical documents, the Traffic Management Scheme has been selected as the preferred option for a number of evidence based reasons, the most important of these, according to the criteria set out by the Joint Air Quality Unit, being the ability to achieve compliance in the shortest possible time.

The benchmark Class D CAZ used for comparison would result in more significant overall health benefits and 28.8 life years gained. However, it is a much bigger scheme with further reaching impacts that would also include far greater overall disbenefits to Derby, as demonstrated in the NPV calculations provided in the Economic Case in the Full Business Case and in the economic model, technical document E2. It is also important to note that the tested benchmark CAZ does not include the sunset periods or exemptions that would be required for a deliverable scheme. Critically, the benchmark CAZ could not deliver compliance in the shortest possible time and so cannot be the preferred option. However, there has been criticism of the preferred option through consultation and stakeholder feedback that the Traffic Management scheme does not do enough to improve wider air quality.

This has been considered as part of Derby's bid for Clean air Funding, set out in the Full Business Case. Derby City Council believe that Derby's CAF bid has been proposed at an appropriate level to achieve the right balance, mitigate negative impacts of the Traffic Management scheme, manage risk and, in doing so, improve wider air quality. It is also consistent with the growing body of evidence from organisations such as Public Health England who, in March 2019, have published a report, advocating actions that would be provided by the proposed CAF measures.

Appendices

Appendix 1: Literature review on HIA

Appendix 2: Health impact of air quality changes: Assumptions

Appendix 1 - Literature review on impacts on health

Cardio Vascular Disease

Outdoor air pollution is recognised as an important risk factor affecting the level of cardiovascular disease (CVD) in the UK. The British Heart Foundation estimates the cost of CVD to be £9 billion annually and results in 420 deaths every day. A number of studies report the effects of reducing the level of PM2.5, PM10 and NO2 on the prevalence of CVD.

Particulate Matter reduction has the clear potential to reduce circulatory disease mortality. Using estimates of disability-adjusted life years (DALYs), a 2016 study determined that 4579 DALYS per 100,000 people were lost in London due to CVD and that is PM2.5/10 concentrations were reduced by 10ugm3 then 582 DALYs per 100,000 people would be gained.

In 2015, UK CVD-related hospital admissions were estimated to cost £537 a day. Coronary-related events can be reduced by lowering PM2.5 levels. In a study of the West Yorkshire Low Emissions Zone, if buses and HGVs that were current meeting Euro IV standards were upgraded to Euro VI it was estimated that it could save approximately £250,000 annually.[7]

Respiratory Disease

Public Health England estimate that 1 in 5 people have a respiratory condition; and the British Lung Foundation estimate the respiratory disease costs to be £11 billion in direct and indirect costs annually. The evidence collected in Wilkie e al (2018) indicates the clear potential of reduction in PM and NO2 to improve respiratory disease-related burden.

It is estimated that 2191 DALYS per 100,000 people are lost in London due to respiratory diseases and, if PM concentrations were reduced by 10 ugm3, * DALYs would be gained. In Switzerland, a PM10 reduction of 3 ugm3 over a 10-year period saved 112 respiratory disease hospital days within a region of 300,000 residents, resulted in27 fewer cases of bronchitis in adults and almost 150 fewer cases in children. Almost 450 adult asthma attacks and 970 fewer days with asthma for kids between 2005-2015.

An area of further cost saving is the impact of reduced air pollution on the need for respiratory medication. A Belgian study found that a 10% reduction in NO2 produced substantial savings. Specifically, it was estimated that over €1 million could be saved from fewer prescription costs within the 40 - 64 age bracket across the country. The author notes that the economic benefit was likely to be even higher when costs such as GP time was taken in to account.[8]

Other Public Health Outcomes

27% of studies specifically included findings regarding whether decreased levels of particulate matter or nitrogen dioxide influenced circulatory or respiratory outcomes. A number of them have indicated that NO2 can have both chronic and acute effects[9]. Acute effects include cardiovascular disease and

---

[7] Lomas J, Schmitt L, Jones S, et al. A Pharmacoeconomic Approach to Assessing the Costs and Benefits of Air Quality Interventions That Improve Health: A Case Study. BMJ Open. 2016; 6(6): e010686. doi: 10.1136/bmjopen-2015-010686 [published Online First: 2016/06/23]

[8] Simons K, Devos S, Putman K, et al. Direct Cost Saving Potential in Medication Costs Due to a Reduction in Outdoor Air Pollution for the Brussels Capital Region. *Sci Total Environ.* 2016; 562: 760-65. doi: 10.1016/j.scitotenv.2016.04.022 [published Online First: 2016/04/26]

[9] Orellano P, Quaranta N, Reynoso J, Balbi B & Vasquez J Effect of outdoor air pollution on asthma exacerbations in children and adults: Systematic review and multilevel meta-analysis. *PloS one.* 2017; *12*, e0174050

exacerbation of asthma, whilst chronic respiratory effects include impacts on COPD.[10] A further study found that a 10ugm^3 increase in NO2 could increase mortality by 2.5%[11].

Traffic and Freight Management

- The use of charging low emission or congestion zones may have an impact on reducing the pollution within the zone but qualitative data also suggests that it could negatively impact those outside the zone as it may redirect traffic to these zones in an effect to avoid paying the charge.

Behaviour Change

- An innovation study in Canterbury looked at the use of signs to reduce idling at a railway crossing. Three different signs were used, promoting the financial savings, health benefits or benefits to others. All three alerts reduced idling at double the rate of a control condition.
- In a review of 21 studies it was found that the percentage of adherence to alerts advising someone to limit outdoor activity was 31%; but more successful for broader behaviours such as changing travel routes or ensuring the availability of appropriate medication to control symptoms was a median of 46%.
- Multiple studies have explored the effectiveness of behaviour change interventions to encourage travel mode change, for example by replacing some or all of transportation from private transport to public or active transport. However the evidence on the success of these behavioural changes are limited.
- Active exposure rather than passive (simply residential proximity) was significantly associated with a modal shift towards active travel.
- Another popular active travel measure is the use of a walking bus for school which eliminates an estimated 900 car journeys. However, the both writers emphasised for funding and support from popular organises.

Active Travel and Physical Activity

- While increases in active transport can reduce air pollution, air pollution itself can decrease the uptake of physical activity.
- There is also a concern that an increase in active transport measure can increase the prevalence of and mortality from respiratory diseases due to an increased exposure to PM2.5 as well as a rise in road trauma.
- Nevertheless, the Cambridgeshire guided busway was found to have successfully promoted active commuting; cycling commuting time increased by 87 minutes per week amongst those living closest to the bus network. However, walking and overall physical activity did not increase for commuting or recreational purposes.
- In France, a scheme that combined infrastructure changes (bike paths, widening footpaths and the installation of speed bumps) coupled with behavioural change initiatives, including signage encouraging people to walk, lead to a 15.4% increase in the number of residents reaching recommended physical activity levels due to an increase in recreational walking.

[10] Lamichhane D, Leem J & Kim H. Associations between Ambient Particulate Matter and Nitrogen Dioxide and Chronic Obstructive Pulmonary Diseases in Adults and Effect Modification by Demographic and Lifestyle Factors. *International Journal of Environmental Research and Public Health.* 2018;*15*, 363.

[11] Department for Environment, Food & Rural Affairs (DEFRA). Valuing impacts on air quality: Updates in values of changing emissions of oxides of nitrogen (NOx) and concentrations of nitrogen dioxide (NO2). 2015. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/460401/air-quality-econanalysis-nitrogen-interim-guidance.pdf

In conclusion, infrastructure changes to promote modal shift in travel behaviour and increase physical activity varied in their effectiveness however it was clear that exposure to these infrastructure changes through proximity was not necessarily sufficient. There is some indication that when combined with techniques grounded in behavioural change theory their effectivity can be increased however it is often not possible to differentiate how much of the change stems from infrastructure improvements and how much from behavioural initiatives.

Summary

Impact of reductions in PM2.5, PM10 and NOx

- PM reduction has the clear potential to reduce circulatory disease mortality and morbidity
- A reduction in NO2 also impacts cardiovascular outcomes.
- Both PM and NO2 reduction improve respiratory disease mortality and morbidity rates; with NO2 typically having the more substantial effect
- PM and NO2 reduction reduce all-cause mortality, restricted activity days and improve quality of life.
- The behaviour change strategy analysed with the strongest evidence-base was the use of air quality alerts
- Integrated region wide planning and policy development is recommended to support a wider transport mode shift to public or active transport.
- Pedestrian, cycling and other built environment infrastructure charges in line with local transport plans need to be considered alongside traffic calming and road safety issues to ensure that any change in health outcomes are not offset by an increase in road traffic incidents.

Appendix 2 - Health impact of air quality changes: Assumptions

The model assumes different health effects depending on different sectors and their related emissions. Urban areas have a set of specific sectors (locations) depending on assumptions related to emissions and population densities. The modelling for Derby assumes emissions and population density taken from Road Transport Urban Medium scenario. Table 7 lists all scenarios possible in the model.

Table 7 PM and NOx sectors

Sectors	
National	**Scope**
Road Transport Central London	-
Road Transport Inner London	-
Road Transport Outer London	-
Road Transport Inner Conurbation	-
Road Transport Outer Conurbation	-
Road Transport Urban Big	self-contained urban areas over 250,000 population
Road Transport Urban Large	self-contained urban areas over 250,000 but not over 500,000
Road Transport Urban Medium	**over 25,000 but not over 250,000 population**
Road Transport Urban Small	over 3,000 but not over 25,000 population
Road Transport Rural	all other areas including urban areas under 3,000 population

Table 8 shows the health impact factors for each tonne of NOx and PM2.5 assumed by the model.

Table 8 PM and NOx health impact per tonne of emission

Health impact	Health impact unit	Unit/tonne of emission
Chronic mortality	LYL	2.20124
Respiratory hospital admission	HA	0.087155
Cardiovascular hospital admission	HA	0.052217
Stroke	DALY	0.361365
Lung Cancer	DALY	0.02126
Children Asthma	DALY	0.821978