

Economic, Environmental and Social Impact of Changes in Maintenance Spend on Roads in Scotland

Summary Report

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Economic, Environmental and Social Impact of Changes in Maintenance Spend on Roads in Scotland

Summary Report

Transport Research Laboratory

C C Parkman, R Abell, T Bradbury and D Peeling

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1 Introduction

1.1 Overview

This report summarises the results of a study to assess the environmental, social and economic impacts of cuts to the roads maintenance budgets for trunk roads and local roads in Scotland. It highlights key aspects of the methodologies adopted before presenting the results and discussing the most significant conclusions.

1.2 Context

Maintaining Scotland's Roads (Audit Scotland, 2011) highlighted that the overall maintenance backlog on roads in Scotland is £2.25 billion. Of this, £1.54 billion relates to the maintenance backlog on Local Authority roads and £0.713 billion relates to trunk roads, including bridges. The report included a central recommendation for the Scottish Government to take forward a national review of "how the road network is managed and maintained, with a view to stimulating service redesign and increasing the pace of examining the potential for shared services."

The Government accepted the central recommendations in the report and announced on 25 February 2011 that a National Road Maintenance Review would be undertaken looking at how the road network in Scotland is managed and maintained.

The Review was taken forward by Transport Scotland in partnership with the Convention of Scottish Local Authorities (CoSLA), the Society of Local Authority Chief Executives (SOLACE), Society of Chief Officers of Transportation in Scotland (SCOTS) and the Scottish Road Works Commissioner under the guidance of a Steering Group. The Review commenced in March 2011 with a timetable to report to Ministers and Council Leaders in early autumn 2011 in time to inform a Road Maintenance Summit. The Summit was held on 2nd November 2011.

The Steering Group was supported by four Working Groups drawn from Steering Group member organisations as well as invited stakeholders. This study, with associated reports, has been commissioned by Transport Scotland on behalf of the Wider Economic Issues, Impacts, Costs and Benefits Working Group. The Working Group monitored and assessed the work in this study as it progressed.

1.3 Approach

The study approach was to assess and categorise the impacts in accordance with criteria adopted in the Scottish Transport Appraisal Guidance (STAG) (Transport Scotland, 2011):

- Environmental impacts
- Safety impacts
- Economic impacts
- Integration impacts
- Accessibility and social inclusion impacts

The impacts were considered for three Scenarios over a 20 year analysis period:

- ***Scenario 1 (Base Case).*** Maintain current (2010/11)[1] funding levels for 20 years
- ***Scenario 2[2].*** Reduce Scenario 1 funding levels by 20% for the first 10 years. Return to Scenario 1 spending levels uniformly over the following five year period, and further increase these by 2.5% per annum for the final five years of the analysis period
- ***Scenario 3.*** Reduce Scenario 1 funding levels by 40% for the first 10 years. Return to Scenario 1 spending levels uniformly over the following five year period, and further increase these by 2.5% per annum for the final five years of the analysis period

Both quantitative and qualitative impacts were considered for the scenarios. Qualitative impacts have been considered against each of the criteria noted above (i.e. environmental, safety etc) and for each criterion, specific sub-criteria have been assessed as shown in Section 4. The following impacts were quantified at 2002 prices[3]:

- ***Vehicle operating costs.*** If road conditions deteriorate, there is a cost to road users (e.g. vehicles consume more fuel and may need more frequent repairs).
- ***Travel time costs.*** If road conditions deteriorate, vehicles generally travel slower but this effect is offset by fewer planned disruptions (due to less maintenance work being carried out) resulting in less delay at roadworks.
- ***Accident costs.*** If road conditions deteriorate, there is an increased risk of accidents due to lower skid resistance. Also, if street lighting is reduced there may be a consequential increase in traffic accidents.
- ***CO_2 emissions.*** CO_2 changes related to the above impacts can be monetised.

Full details of the study analyses and results for trunk roads and local roads have been reported separately. The work to assess the impacts for trunk roads provided the foundation for the quantitative analysis methodology and a preliminary review of international evidence of work relevant to the study (Transport Scotland, 2012a). The work for local roads extended the review of published international evidence included quantitative analysis of the Scenarios for the local road network (Transport Scotland, 2012b) and aligned the analyses of the trunk road network with the analyses for local roads. This report summarises the key results from both parts of the study.

2 The Scottish Road Network – Key Information

Local Authorities and Transport Scotland spent £654m on road maintenance in 2009/10 (Audit Scotland, 2011):

- Local Authorities spent £492m on local roads which represents a 12% increase on 2004/05 expenditure levels after taking into account general inflation.

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[1] At the time of undertaking the study, 2010/11 budgets had not been finalised. Refer to Appendix B.3 for further details, which indicate some budgets have already been reduced below those assumed for the Base Case.

[2] The increase in funding for Scenarios 2 and 3 in the second 10 year period reflects an assumption that funding will become available in future to improve the network back towards current conditions.

[3] A 2002 price base was used to enable comparison across studies completed at different times, as required by STAG.

- Transport Scotland spent £162m on trunk roads which represents a 12% decrease on 2004/05 after taking into account general inflation.

The road network is 56,000km in length of which 3,400km are trunk roads[4]. These figures show the difference in costs per length of road, with trunk roads receiving approximately 5 times the expenditure per kilometre, demonstrating the difference in the asset value and strategic importance placed on the different road types.

Around 43 billion vehicle kilometres were travelled on the network in 2010, including around 16 billion travelled on the trunk road network.

These figures are examples of the significant differences between trunk and local roads which affect the type and level of the social, environmental and economic impacts of road maintenance. For example, impacts on pedestrians will be more significant on local roads than they are on trunk roads.

3 Developing the Potential Scenarios

3.1 Applying Funding Constraints in Practice

The nature and extent of the impacts of reductions in the total maintenance budget depend on how the reductions are allocated across maintenance activities. Each activity was considered in terms of its relative contribution to overall corporate objectives categorised as:

- Safety
- Access
- Reliability
- Network condition
- Sustainability
- Customer care

For example, the objective of maintaining directional road signs is primarily to enable reliable and predictable travel for road users, whereas the objective of maintaining road barriers is to enable safe travel for the road users and pedestrians.

Pragmatic views were taken of the relative importance of each of the various objectives and the contribution made to those objectives by the different maintenance activities on local and trunk roads. Application of this approach resulted in different reductions across the activity budgets for each of the reduced funding Scenarios as shown in Appendix A.

The results of applying the approach are broadly in line with road maintenance practitioners' experience. In particular, the activities which are reduced most are those related to carriageway maintenance. This has an important effect on the outcomes from this study as the quantified impacts are all related to the effect of carriageway maintenance.

[4] Further details on the road network are available at:
http://www.transportscotland.gov.uk/strategy-and-research/publications-and-consultations/j205779-00.htm

3.2 Sampled Approach for the Local Roads Analysis

There are 32 Scottish Local Authorities. For earlier studies, SCOTS has assigned each Local Authority network into one of five categories (city, urban, semi-urban, rural and island). It was not possible to carry out a quantified analysis on each Authority, so a sampled approach was adopted which considered 8 Authorities in detail, and scaled up the results from the analyses from the sample of Authorities to the full network based on consideration of the Authority types (see Appendix B for further details).

4 Summary of Impacts

The predicted conditions of the road network were derived using condition projection models currently in use by SCOTS (for the local road network) and Transport Scotland (for the trunk road network) and show that the network is expected to deteriorate over the analysis period for all three funding Scenarios.

The overall assessment has been undertaken using the standard framework recommended in STAG and summarised in Table 4.1 to Table 4.5. Each table addresses one of the STAG criteria listed in Section 1.3, assessing various sub-criteria within each of the criterion.

The evidence was collated from international published experience with a focus on those publications with more relevance to the Scottish context. The level of evidence for the impact of maintenance varied across the different criteria. Only some of the impacts could be quantified and those impacts are discussed in more detail in Section 5. Also, some impacts relate more to one type of road network (e.g. urban, rural, trunk or local road) and comment has been made where appropriate and where the context is not clear.

There are also some impacts not described by the above criteria. One of the more significant issues excluded from these criteria is public satisfaction. Transport Scotland and Local Authorities undertake road user or public satisfaction surveys each year or biennially. Results of the surveys for Transport Scotland confirm that vehicle users consider carriageway conditions important, and their dissatisfaction has increased in the last two surveys. Similar evidence was seen for Local Authorities. Although many Local Authority surveys are concerned mainly with general levels of service provided by the Authority (e.g. ease of access to the Authority) and do not address the details of road condition, answers to the general questions on road maintenance and state of the road network show clear increases in dissatisfaction. Some surveys show how the levels of service have deteriorated while some aspects have shown improvements (e.g. the level of satisfaction with street lighting has improved in one Authority since 2004 but the satisfaction with street cleaning in the same Authority has seen a bigger fall in satisfaction).

Table 4.1 Assessment of impacts on environmental criterion

Sub-criterion	Issue	Summary
Noise and vibration	New projects	New road projects adopt the latest standards and often provide noise mitigation measures (e.g. noise barriers in urban areas). Maintenance of noise barriers has not been considered in this study but it is likely that as maintenance budgets are reduced, the funding for the repair of existing barriers will be reduced. New surfaces, to current standards, lead to low levels of vibration in adjacent buildings but in the early life of some new surfaces there may still be high levels of noise from the interaction between vehicle tyres and the road surface. The amount of maintenance reduces with the funding reductions, so this effect is likely to be reduced.
	Road surfacings and traffic noise	The desire to minimise resurfacing costs will lead to increased lives of surfacings and a pressure to adopt cheaper surfacings. After an initial settling-in period, surfacings generally generate more noise with trafficking as they age. Limited experience on Scottish local roads of potentially lower noise surfacings has been that they are of a similar final outturn cost but higher whole life cost as they do not last as long as other more traditional surfacings. The potential effect of changes in noise due to reduced maintenance expenditure is therefore considered neutral. The impact is more one of the lost opportunity to potentially invest in higher cost surfacings to reduce noise. There will only be a marginal effect due to ageing of existing road surfacings on the network. As surfaces deteriorate and funding for routine maintenance (e.g. patching) reduces, the likelihood for potholes and other sudden surface discontinuities increases. It is these sudden changes in ride quality that lead to increased vibrations and noise in near-by buildings which are likely to be a concern to local communities but these have not been quantified in this study. Increases in vibrations might also adversely affect vehicle users, particularly those who drive for long periods (e.g. truck drivers).
Global air quality	Vehicle use and road maintenance	Reduced maintenance funding leads to less works activity and therefore lower gas emissions from maintenance works. There are also fewer vehicles delayed through maintenance sites. However, as roads deteriorate, vehicle speeds reduce and fuel consumption and the levels of emissions change. As vehicle engine efficiency improves, the levels of emissions will be reduced for the same amount of travel. The effect of all these aspects has been quantified in Section 5 and shows a marginal reduction in CO_2 when maintenance budgets are reduced. It is important to note that there might also be an increase in unplanned reactive work as the network deteriorates leading to changes in levels of gas emissions but no quantification of this effect has been possible.

Sub-criterion	Issue	Summary
Local air quality	Vehicle use	Local air quality due to vehicle use will be proportional to the effects of global air quality noted above. Overall there will be a marginal reduction in amounts of NOx (nitric oxide and nitrogen dioxide) and Particulate Matter (PM10 and PM2.5) for both Scenarios (i.e. the 20% maintenance funding reduction and the 40% maintenance funding reduction). However these changes cannot be treated as indicative of changes in local air quality at specific sites.
	Maintenance activity	Reduced road maintenance will mean less planned maintenance work on the network. Particularly at major carriageway maintenance sites and for bridge or structures repairs, significant dust can be generated. With lower funding, the number of planned events may reduce and this may lead to better air quality, but this will be part offset by any increase in unplanned maintenance (e.g. more potholes and carriageway surface disintegration) and, potentially, other more significant and intrusive work (e.g. a weakened or collapsed structure requiring urgent repair).
	Street cleaning	Anecdotal evidence suggests that local air quality will deteriorate due to increased dust if streets are cleaned less but there is no quantified or reported evidence of this.
Water quality and drainage		The purpose of routine and planned drainage maintenance is to keep existing drainage functional. If such activities are reduced, the risk of local flooding will increase, deterioration of the road structure is likely to accelerate and outfall water quality will reduce if maintenance of any drainage pollution controls is delayed. There is evidence of increases in the number of flooding events in recent years but there is no published evidence on the contribution of the effects of lower maintenance funding on these events.
Geology		This sub-criterion is assumed to be unaffected by any change in road maintenance funding.
Biodiversity and habitats	Street lighting	There is evidence that bats will not fly in directly illuminated areas so any reductions in street lighting due to lower funding may be beneficial to the bat population.
	Vegetation control	Roadside vegetation provides important grassland habitats and migration routes for many species. It has been found that a reduction in appropriate vegetation control leads to increases in noxious plants and a decline in species rich habitats. Reduced funding may therefore have a negative impact on biodiversity.

Sub-criterion	Issue	Summary
Landscape, visual amenity and cultural heritage		Customer satisfaction studies have shown the public has a clear impression of their local area and numerous studies support the 'broken windows' theory (i.e. poor amenity and appearance lead to an increased deterioration in the locality and the need for higher subsequent costs). Studies have also shown the public judge the need for maintenance on appearance. Studies by the Commission for Architecture and the Built Environment (CABE) since 2001 have promoted the higher quality of life provided by improved streets (CABE, 2007). A survey has shown 85% of the people felt the standard of public space and environment provided by improved maintenance (e.g. road condition, clear signing, street furniture) and non-maintenance related expenditure (e.g. pedestrianisation, CCTV and alcohol free zones) impacted directly on the quality of life. Studies have however also shown that priorities of local residents do not always match the priorities of planners and designers and may lead to lower cost options for maintenance and improvements. The Audit Commission (2007) showed carriageway and footway repair to be a high cause of concern for the public. At a workshop for experts and practitioners in this study, it was agreed that although quantified evidence of benefits from improved public realm is scarce, there is a strong case for improved amenity and cultural provision. It was also noted that standards for public amenity in Scotland are generally below those in other parts of Europe where more importance is given to achieving high standards of public realm.
	Carriageways and footways	CABE (CABE, 2007) showed people value improvements to their streets. Studies by Transport for London have valued the increase in residential prices and retail rents achieved by roadspace improvements or close proximity to open space (e.g. parks). Transport for London has demonstrated benefit-cost ratios of between 2.5 and 5.5, without indirect benefits, from improvements in the public realm. Other studies have shown improvements to footfall for retailers after carriageway and footway improvements. As well as showing the benefits of maintenance and improvements these valuations provide measures to use in attracting private sector funding for maintenance and improvements in local areas. Poor walking environments and transport links can leave areas isolated and damage community cohesion. Increases in cat and dog mess, litter, broken glass, vandalism and uneven footways all represent disincentives to the use of pedestrian footways and reduction in visual amenity. These negative impacts will be increased with reductions in maintenance funding for footways.

Sub-criterion	Issue	Summary
Landscape, visual amenity and cultural heritage	Street cleaning	If street cleaning is reduced, the amenity and cultural heritage of an area will decrease and levels of crime may increase. Evidence suggests that the public places importance on a clean environment such that, for example, only partial graffiti removal would still impact negatively. However, studies in New York have shown the public believed the cost of maintaining cleaner streets to improve the public realm was too high. Experience from Perth and Kinross Council shows the severe impact on street cleaning costs from clearing the grit on footways used to reduce accidents during bad winter weather.
	Street lighting	Better street lighting leads to improved perception of an area and an increase in commercial development.
Agriculture and soils		This sub-criterion has been assumed to be unaffected by the changes in the level of road maintenance funding considered in this study. (N.B. Winter maintenance is not included in this study).

Table 4.2 Assessment of impacts on safety criterion

Sub-criterion	Issue	Summary
Accidents	Carriageways	Road engineering is only one of the factors which might contribute to road accidents. For the reductions in maintenance funding considered, maintenance activities related directly to safety have been protected so the effects on accidents are minimised. Poor condition of the road surface can increase the risk of accidents due to skidding and also due to road users taking evasive action to avoid hazards (e.g. potholes). A majority of Scottish Local Authorities consider current levels of maintenance funding are a threat to road safety and that the threat has increased in the last year (Asphalt Industry Alliance, 2011). This view is likely to be exacerbated with the funding cuts considered in this study. On Scottish trunk roads, a skid resistance policy has been implemented. A review of condition and accident trends suggests accidents due to skidding could increase from their current levels of around 400 to around 450 per year for the 40% funding reduction Scenario and this effect is monetised in Section 5. Only three Scottish Local Authorities that have implemented a similar policy have been identified and there is not enough evidence to draw any conclusions on the impacts in these Authorities. International evidence suggests the risk of skidding will reduce with the introduction of skid resistance policies. Introduction of a skid policy might only reprioritise existing road surfacing funds and it will inevitably require start-up and monitoring investment which may be considered unaffordable if road maintenance funding is reduced. Funding reductions potentially represent a lost opportunity to reduce road accidents due to poor skid resistance on local roads.
	Structures	Failure of a structure can be catastrophic and make headline news. Funding for recovery from such failures would likely be found from other parts of the maintenance budget. Whilst maintenance funding for road safety aspects has been protected in each of the funding reduction Scenarios in this study, there will almost inevitably be an increase in the risk of failures as budgets reduce. Infrastructure failures (e.g. failures of structures) potentially result in accidents for all types of road users. The likely costs of those accidents have not been estimated in this study.

Sub-criterion	Issue	Summary
Accidents	Street lighting	Historically, one of the justifications for the introduction of street lighting has been to reduce road accidents. With recent constrained funding and an aim to reduce the carbon footprint of road network operations, some UK Authorities have reduced the level of street lighting and reported no disbenefit, but the balance of evidence still suggests lighting reduces the risk of accidents (e.g. street lighting enables pedestrians to identify and avoid defects which could cause accidents). With selective (e.g. part of the night) reductions in street lighting (i.e. targeting low risk areas first), it might be possible to avoid significant increases in the risk of accidents but for the 40% funding reduction Scenario (which assumed a reduction of 23% in street lighting budgets) it is likely that safety risks will increase. For example, a coarse analysis quantified in Section 5 suggests accidents (all injuries) could increase by around 46 per year (from current levels of around 2000) on the local road network following a 40% reduction in maintenance funding.
	Footways and cycle-tracks	All evidence suggests increased deterioration of footways and cycle-tracks will cause an increased safety risk to pedestrians and cyclists but it has not been possible to quantify the impact for the Scenarios in this study. Over 10 years, one Scottish urban council paid out nearly 10 times more for claims due to footway incidents than claims due to car damage.
Security	Street lighting	Low levels of street lighting and poorly maintained street lighting furniture increase the public fear of crime. Funding reductions that lead to lower levels of lighting will therefore reduce the use of streets for walking and cycling. Studies in Dudley, West Midlands and in Stoke-on-Trent found that improved levels of street lighting lead to reductions of more than 40% in recorded crime and that crime is not displaced.
	Street cleaning	This issue has been discussed under landscaping and amenity in Table 4.1.
	Footways	Reduced care of footways and roadside environments (e.g. fence repairs, surface repairs, vegetation control) increases the perceived risk of crime for the public and serves as a deterrent to use. This will lead to lower social interaction in neighbourhoods which increases the risks of crime. Funding reductions will exacerbate any such risks (perceived or real), especially among certain groups (e.g. the elderly).

Table 4.3 Assessment of impacts on economy criterion

Sub-criterion	Item	Summary
Transport economic efficiency	Vehicle operating costs	Deterioration in road conditions will cause an increase in vehicle operating costs (e.g. fuel consumption, vehicle damage due to defects). The effect is quantified in Section 5. For all roads, the increased total undiscounted costs for the 40% funding reduction Scenario, compared with the constant funding Scenario are incurred by cars (around 56%), trucks (around 20%) and vans and buses (around 24%). In the 40% funding reduction Scenario for local roads, in 2020 (i.e. before expenditure is assumed to increase), the undiscounted costs represent an annual additional 0.6 pence per vehicle km for cars, 1.3 pence per vehicle km for vans, 2.2 pence per vehicle km for buses and 3.6 pence per vehicle km for trucks at 2002 prices compared to the costs for the Scenario with no funding reductions. For trunk roads, the corresponding costs are lower at 0.2 pence per vehicle km for cars, 0.3 pence per vehicle km for vans, 1.6 pence per vehicle km for buses and 1.1 pence per vehicle km for trucks.
	Journey times	Deterioration in road conditions will cause increases in travel time as vehicle travel slower on roads in poorer condition. The effect is quantified in Section 5. In the 40% funding reduction Scenario, in 2020 before maintenance expenditure is assumed to increase, the longer journey times represent an annual additional 1,349,351 hours for cars, 239,629 hours for vans, 30,998 hours for buses and 186,980 hours for trucks on all (trunk and local) roads. This effect is, however, more than offset by less disruption to journeys due to reduced roadworks, which have also been quantified. The effects of increases in unplanned maintenance or route diversions that might occur with reduced planned maintenance were not assessed. Infrastructure failures are likely to increase journey times for all types of road users due to travel diversions. The possible effects on road user journey times from potential breaks in network links has been demonstrated in this study by relating the effects to the experience gained from the earthworks failure at Rest and Be Thankful on the A83 (Argyll and Bute). Although the effects are relatively small, they can cause significant local issues and affect economic activity (e.g. freight diversions and loss of passing trade).
	Journey reliability	It was not possible to quantify the effects of decreased journey time reliability due to the potential increase in risk of disruptions on the network (e.g. due to failure of signs, signals, structures or other assets). Analysis of data from the closure of the A83 at Rest and Be Thankful demonstrated that if the disruption is of short duration, the costs to road users of that disruption are unlikely to outweigh savings from reduced direct maintenance costs or the changes in road user costs that occur when maintenance budgets are reduced. Nevertheless, no matter how small, the effect still serves to increase costs to society.

<table>
<tr><th>Sub-criterion</th><th>Item</th><th>Summary</th></tr>
<tr><td rowspan="2">Transport economic efficiency</td><td>Journey quality</td><td>The journey quality for all users will deteriorate under all the funding scenarios considered. Rougher roads are less comfortable to drive on, reduced lighting (if applied on parts of the network) will affect the ease of driving and the visual appearance of the roadway will deteriorate for both road users and local residents. Customer satisfaction surveys for the trunk road network show that road users regard roads in poor condition as one of the most significant detractors on their journeys, and Local Authorities will face similar concerns.

Local Authority customer satisfaction surveys show the reduction in satisfaction with road maintenance and road condition to be the source of two of the biggest reductions in satisfaction with Local Authority services in recent years, although this may have been influenced by the particularly severe winter weather conditions in some of those years. The level of public satisfaction is expected to continue to fall under all 3 funding scenarios considered.</td></tr>
<tr><td>Planned maintenance</td><td>Reductions in the maintenance budget are aimed primarily at planned maintenance activities. Studies have shown that the costs of recovering from deterioration in infrastructure quality are much higher than the costs of retaining existing quality levels.</td></tr>
<tr><td colspan="3">Wider economic benefits and economic activity and location impacts have not been considered further in this study. Surveys of business attraction to Scotland include the quality of transport availability such as airport connections, but do not address the more detailed issues of maintenance of road surfaces or the value of amenity and cultural provision. The effects are therefore considered marginal.

Infrastructure failures are likely to decrease economic activity and reduce local trade. The possible effects on local trade from potential breaks in network links have not been assessed in this study. Nevertheless, it is clear that failure of a major road through an area will decrease traffic flow into the area and reduce trade.</td></tr>
</table>

Table 4.4 Assessment of impacts on integration criterion

Sub-criterion	Item	Summary
Policy integration	Physical fitness and health	The Scottish Government is seeking improved health outcomes which are in many cases strongly linked to the levels of physical fitness of a community. The potential for increased severance noted under the accessibility and social inclusion criterion will be a disincentive for affected communities to maintain physical fitness levels. There are strong connections between road condition and policies on health and obesity as poor carriageway and footway condition deter walking and cycling. Road condition also affects equalities since women will often view the public realm differently from men, primarily because of fear of crime and being alone in an unsafe environment. The success of Government policies (e.g. Cycling Action Plan for Scotland, Route Map to Healthy Weight) is directly related to the standard of provision of carriageways, footways and cycle-tracks. Scottish Government policies for Designing Streets (2007) and Designing Places (2001) set out the policies for streets and communities. They include Ministerial statements on the value placed on delivering healthy lifestyles and growing local economies which are closely linked to well designed and well maintained environments. Designing Streets puts people and places before the movement of vehicles: "Attractive and well-connected street networks encourage more people to walk and cycle to local destinations, improving their health while reducing motor traffic, energy use and pollution". The health benefits of increased walking (i.e. if 1 in 100 currently inactive people took adequate exercise) have been estimated to save the National Health Service in Scotland £85m per year (Scottish Government, 2003).
Transport integration and *transport and land-use integration* have not been considered further in this study. The effects of levels of maintenance funding on these aspects are considered marginal.		

Table 4.5 Assessment of impacts on accessibility and social inclusion criterion

Sub-criterion	Item	Summary
Community accessibility	Remote communities	New investment may be focused on improving links with rural communities which often do not show a quantifiable economic benefit. Lifeline roads, where there is usually only one route for access to a community, will be strongly affected if the condition of the route significantly deteriorates. Road maintenance management approaches inevitably focus funding where risks and traffic are most significant, therefore it is expected that remote communities will suffer a bigger disadvantage if maintenance funding is reduced and less used routes are not prioritised.
	Structures, footpaths, cycle-tracks	Potential increases in risk of structural failure could have a significant effect on community accessibility (e.g. a bridge spanning a river with a community on both sides of the river). However, due to safety concerns it is likely that such assets will be shielded the most from the effect of budget reductions but catastrophic failures of these assets would likely result in diversion of funding from other parts of the maintenance budget. If facilities such as pedestrian underpasses or footpaths are poorly maintained and suffer reduced use due to fears of crime and accidents, as noted elsewhere, a similar effect of severance will be realised in the long term. Studies in the Netherlands have shown that well kept public areas had fewer incidents of dishonesty, suggesting they reduce the propensity to criminal activity, echoing the broken window theory noted in Table 4.1.
Comparative accessibility	Older people	Older people are more likely to be adversely affected if there are more and worse defects on footways and if street lighting and other amenity assets and activities are reduced. The elderly have a greater fear of crime and potential accidents and will therefore experience a comparatively bigger effect from these impacts than other road users.
	People with disabilities	Under the Disability Discrimination Act (Transport Scotland, 2009) Local Authorities must ensure that road maintenance policies do not disadvantage disabled people. Uneven footways have a bigger impact on people with disabilities (e.g. visual impairment, or mobility) so that deterioration in the quality of such assets will have a comparatively bigger effect on disabled people. The Disability Discrimination Act: Good Practice for Roads (2009) lays out clearly the accessibility standards needed to enable disabled people to use road environments. If carriageways and footways fall below accepted standards of accessibility then this will have a direct impact on the use of the road network by disabled people by affecting access to local businesses and facilities, and thus increasing the severance for those affected.

Sub-criterion	Item	Summary
Comparative accessibility	Pedestrians	An increase in roadside noise or deterioration in local air quality, visual amenity and appearance (e.g. graffiti) and street lighting will have a comparatively bigger effect on pedestrians than other road users. Deterioration in road and footway condition can deter movement by pedestrians, particularly the elderly, adults with young children and the disabled. Reductions in planned maintenance will put more pressure on the need for unplanned maintenance and delays to unplanned maintenance will further deter pedestrians.
	Cyclists	Reduction in traffic calming measures will lead to less favourable conditions for cyclists (where the measures adequately address the needs of cyclists). Poorly maintained road surfacing with loose material, uneven edges and potholes increase the risk of accidents and are a major deterrent for cyclists. Such budget areas are often one of the first carriageway items to be reduced when funding is constrained. It is therefore likely that, for a given level of reduction in funding, cyclists will experience comparatively bigger impacts than other road users. Reductions in planned maintenance will put more pressure on the need for unplanned maintenance and delays to the unplanned maintenance will further deter cyclists.

5 Summary of Quantifiable Impacts

The analysis over a 20 year period compared the savings to Government, through reduced maintenance works activity from budget reductions, with the costs to society in terms of various economic, environmental and social impacts. All figures are quoted at 2002 prices as required by STAG to enable comparison with different studies over time. Further details on the key aspects of the methodology and assumptions are given in Appendix B.

As noted in Section 4, not all impacts can be quantified. The impacts that can be quantified are derived from the effect on road users of predicted network conditions for each of the 3 Scenarios.

The following aspects have been assessed in the analysis:

- ***Vehicle operating costs.*** As carriageways deteriorate in condition due to reduced funding, vehicles incur more costs through increased fuel consumption and wear and tear. The results of the analysis confirm the vehicle operating cost increases and show they are the most significant quantifiable cost impact. For the 40% funding reduction Scenario, the total increase in vehicle operating costs, for local roads and trunk roads, discounted over 20 years, is estimated to be more than £3.5 billion. Whilst a large figure, it represents an increase of only around 1% compared with Scenario 1 (Base Case). For this reason, these costs have been the subject of sensitivity testing in this study (see Section 6.3).
- ***Travel time costs.*** As carriageways deteriorate in condition, vehicles travel slower and journey times increase. The evidence on which the effect is based is earlier work in the UK and is considered only applicable for higher speed roads. The analysis has therefore only been applied to trunk roads and A class local roads. For this reason, the effect is more significant for the trunk road results.
- ***Skid related accident costs.*** Transport Scotland and some Local Authorities monitor skid resistance and apply skid resistance management policies. The justification of such strategies is that skidding accidents increase on lower quality road surfaces in wet conditions. Trends on the trunk road network allowed the effect to be quantified and suggest that, if the aim is to maintain road safety standards as far as possible, then only in the most extreme funding Scenario considered (i.e. a 40% funding reduction) will there be any effect. There was not enough evidence for local roads for the effect to be quantified in this study.
- ***Delay costs at roadworks.*** Reductions in roadworks due to funding constraints will generate less disruption to travel. The effect is proportionally more significant on the local road network because maintenance work zones on single carriageway roads cause comparatively more disruption than on multilane highways. Note that delays due to the potential increase in the need for unplanned maintenance, as a result of the reduction in planned maintenance, have not been assessed.
- ***Lighting related accident costs.*** The justification for provision of street lights is primarily a reduction in night-time accidents on well lit roads. The effect of budget cuts has therefore been considered by reviewing current accident levels on roads with street lighting, and postulating predicted increases (based on UK evidence) should the lights be switched off. The effect for both the trunk road and local road networks is not significant in comparison with other impacts, but takes no account of other aspects such as the public realm, amenity value and

security which are also associated with levels of street lighting, particularly in urban areas. In 2010/11 there were around 2000 night-time accidents on the road network and for the 40% funding reduction Scenario, this figure is estimated to increase by 46 by 2020.

- ***Emissions costs (global air quality).*** Reduced maintenance funding leads to less maintenance works activity and therefore lower emissions from maintenance works. There is also less travel through work sites. However, as roads deteriorate, vehicle speeds reduce and fuel consumption and the level of emissions change. Based on the projected model outputs for these impacts, the cost of CO_2 emissions has been assessed in accordance with STAG appraisal parameters. Results for all roads show that the biggest reduction in emissions is due to the decrease in roadworks (but note that any potential increase in unplanned maintenance, which has not been assessed, will tend to increase the impact).

Table 5.1 shows the monetised costs and benefits and gives a Net Present Value[5] (NPV) for the maintenance funding reduction scenarios with a 20% funding reduction and a 40% funding reduction compared to the Base Case Scenario for which 2010/11 budgeted maintenance funding levels are retained. The NPV for each Scenario is negative and shows that the overall impact of cuts to road maintenance budgets is an increase in economic welfare cost for Scotland.

The NPV for the full road network (trunk and local roads) for the Scenario with a 40% funding reduction is worse than the Scenario with a 20% funding reduction, showing that greater funding reductions increase the economic welfare cost to Scotland[6].

Asset valuation information is also shown in Table 6. Whilst this is not an impact on society and is a figure used only for financial reporting, it does show that the asset value of the network will decrease with time (due to increases in the accumulated depreciation). This illustrates in financial terms the effect of deterioration in network condition for all three funding Scenarios (including maintaining existing budgets).

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[5] Net Present Value is the difference between the present value of costs and benefits, discounted to 2002 prices. A negative NPV means that the reduction in benefits caused by reduced road maintenance expenditure is larger than the saving made in the road maintenance expenditure.

[6] It is noted that specifically for trunk roads, the NPV for Scenario 2 is slightly worse than Scenario 3 but the difference is small. The result is considered within the margins of error due to challenges of modelling long term road conditions, as discussed further in Appendix B.

Table 5.1 Summary of quantified economic impacts for 20 year analysis period

Cumulative discounted[1] costs (£m 2002[2] Prices)	Trunk Roads[3]			Local Roads[3]			All Roads[3]	
	Scenario 1 (Base Case)	Scenario 2	Scenario 3	Scenario 1 (Base Case)	Scenario 2	Scenario 3	Scenario 2	Scenario 3
Financial Costs to Government								
Maintenance works	2,152	-266	-568	5,677	-688	-1,459	-954	-2,027
Impacts on Society								
Vehicle operating costs	73,223	+376	+625	274,246	+1,485	+2,966	+1,861	+3,591
Travel time (due to surface condition)	362	+57	+94	1,572	+77	+158	+134	+252
Accidents (skid related)	345	0	+21	N/A	N/A	N/A	0	+21
Delays (at roadworks)	119	-25	-38	1,480	-354	-712	-379	-750
Lighting (accidents)	128	+1	+2	2,155	+18	+37	+19	+39
CO_2 Emissions	5,765	-36	-58	14,971	-14	-16	-50	-74
Overall impact on society	79,942	+373	+646	294,424	+1,212	+2,433	+1,585	+3,079
Economic analysis								
Works costs reduction	Base Case	266	568	Base Case	688	1,459	954	2,027
Increase in user costs	Base Case	+373	+646	Base Case	1,212	2,433	1,585	3,079
Net Present Value[4]	Base Case	-107	-78	Base Case	-524	-974	-631	-1,052
Effect on Asset Valuation (undiscounted costs)[5]								
Reduction in asset value	-487	-489	-531	-727	-845	-961	-1,334	-1,492
Difference compared to Base Case	Base Case	-2	-44	Base Case	-118	-234	-120	-278

(1) Annual discount rate = 3.5%.
(2) 2002 prices are 2010 prices factored by 0.81.
(3) Scenario 2 (20% reduction) and Scenario 3 (40% reduction) figures are shown as differences compared to figures for Scenario 1 (2010/11 funding retained).
(4) Negative NPV shows an overall increase in cost (i.e. user costs increase more than the reduction in maintenance expenditure).
(5) Valuation/depreciation information is shown at 2002 undiscounted prices. The information was provided as different parameters for local roads and trunk roads. The 2010 asset value for the trunk road network was estimated at £5,928m. The accumulated depreciation for the local road network in 2010 was estimated at £4,105m.

6 Discussion of Results

6.1 Key Conclusions

The analyses and reviews undertaken during the study have generated a considerable amount of data and information and there are a number of resulting issues that could be discussed and investigated further. This Section highlights the key conclusions that are most significant to the original aims of the study and highlight the major assumptions and sensitivities that might affect those conclusions.

There is an overall disbenefit to society of reducing road maintenance expenditure on the Scottish road network. The qualitative review of each criterion highlights the various impacts, almost all of which are negative. This supports the traditional view held by highway engineers that reductions in road maintenance lead to long term disbenefits for developed road networks such as those in Scotland. The quantitative analyses, which have only addressed certain aspects of the qualitative analysis, further support the qualitative conclusions and show that for every £1 reduction in road maintenance, there is a cost of £1.50 to the wider economy[7]. If figures were available to quantify aspects not currently included in the quantitative analyses, it is expected that these would only enhance the conclusion. For example:

- Impacts of any increase in road closures due to unforeseen events
- Costs of delaying major repair work on significant structures leading to possible closures, weight restrictions or more extensive maintenance work
- Wider economic disbenefits such as reduced tourism or local economic activity

It should also be noted that the two funding reduction Scenarios considered only reduced budgets below the Base Case Scenario in the first 10 years and already allow for a future attempt to restore road network condition and improve the network beyond 2020. If the budget reductions were continued for longer or the increases in funding were at a lower rate, the conclusions would be strengthened further.

It is often thought that road maintenance only impacts on vehicle journeys. However, the review shows that there are wider impacts on society. Remote communities will be affected by poorer lifeline links. Pedestrians and particularly older people and those with disabilities will be affected if footways deteriorate. Cyclists will be affected if traffic calming measures are reduced and if the conditions of cycle-tracks and the edges of roads deteriorate. Communities in general will feel less secure and the quality of the public realm will deteriorate as road network conditions deteriorate, lighting is reduced and streets are cleaned less. Based on the literature review, the user group most affected by a reduction in road maintenance would be pedestrians, especially those with mobility and visual impairments. Pedestrians would be affected in every aspect including noise and vibration, global air quality, visual amenity, cultural and landscape, physical fitness, accidents, security, community and comparative accessibility.

[7] The ratio of reduction in benefits to reductions in expenditure from Table 5.1.

For the same proportional budget reductions, the effect on road users of reduced local road maintenance budgets is greater than the effect of reduced trunk road maintenance budgets. From the quantitative analyses, the Net Present Value for both networks is negative. But (for the 40% funding reduction Scenario) for every £1 saved there is a disbenefit on local roads of £1.67 and on trunk roads of £1.12. The qualitative assessment shows that the types of the disbenefits are also different for each network. For the local road network, comparatively greater disbenefits will be realised in the form of social impacts on pedestrians, cyclists and local residents. For the trunk road network, the impact of the reductions will be more focused on vehicle users of the network and the associated economic impacts.

It should also be noted that the quantified disbenefits take no account of the effect of changes on any wider economic activity (e.g. the loss in income from businesses and visitors deterred from Scotland, or a local area, due to poor road network condition).

There is limited published evidence of many of the disbenefits arising from the reduction of road maintenance budgets and few have been quantified in economic terms. The literature review has highlighted that there is a considerable amount of information available which recommends good road maintenance practice and discusses the implications of a lack of road maintenance. However, there is much less information available which provides evidence based information of the impacts of changing the levels of road maintenance undertaken. Of this information, only a small proportion attempts to quantify the impacts. The majority of quantifiable impacts described in the literature are associated with the effects of carriageway maintenance on vehicle users. There is limited published evidence of any quantifiable impacts due to changes in conditions of non-carriageway assets on road networks.

The most significant quantified impact of reduced road maintenance budgets is the increase in vehicle operating costs. Vehicle operating costs represent the cost to road users (e.g. from fuel consumption, vehicle repairs, tyres, maintenance and depreciation). For the Scenario with a 20% maintenance funding reduction, the increase in vehicle operating costs is 40% more than the savings in road works expenditure on the trunk road network and more than double the savings for the local road network. By comparison, increases in each of the other quantified impacts are significantly less than the savings in the maintenance works expenditure. However, the vehicle operating cost increases in themselves are small compared to the total annual vehicle operating costs on the network (for the 20% maintenance funding reduction Scenario, the increase in vehicle operating cost is around 0.5%).

Road conditions are predicted to deteriorate even with no reduction to maintenance budgets. For the Scenario based on retaining 2010/11 maintenance funding levels, the asset values of both networks are predicted to be lower at the end of the analysis period than in 2010/11, and the reduction in value increases as maintenance budgets reduce further. This effect is a monetary representation of the predicted deterioration in carriageway condition and reflects, in some way, the cost to return the network to the current (2010/11) conditions at the end of the analysis period.

Public dissatisfaction with road conditions is likely to increase. Results of public satisfaction surveys for both Transport Scotland and Local Authorities confirm that road conditions are important. For trunk roads, surveys have suggested increased dissatisfaction with road conditions although it was not possible to assess this in any rigorous way[8]. Local Authority public satisfaction surveys have also shown similar concerns with many surveys showing increases in dissatisfaction over recent years. However, surveys have also shown improvements in satisfaction in some aspects (e.g. levels of street lighting). This may have been where an Authority has directed a higher proportion of funding to meet a particular local need and so is not necessarily a reliable indicator of improved overall satisfaction.

6.2 Key Assumptions

The results are considered to represent the most likely outcome of the impacts investigated. However, a considerable number of assumptions were made in order to complete the quantitative analyses and the most significant issues are described in Appendix B.

One of the most obvious effects of some of the assumptions made is in the variation of the Net Present Value for each Scenario. In particular, the variation is different for trunk roads compared to local roads. For the local road network, the NPV is predicted to become more negative as maintenance expenditure is reduced. However, for the trunk road network, the NPV for the Scenario with a 40% funding reduction is predicted to be marginally less negative than the NPV for the Scenario with a 20% funding reduction. This effect is not considered realistic or significant in practice as the differences are within the expected error of such modelling analyses. The effect is explained further in Appendix B. The key conclusion is that all Scenarios with funding reductions show an overall disbenefit (i.e. a negative NPV).

6.3 Sensitivity Analysis

Based on an understanding of the key assumptions, sensitivity tests were undertaken to assess the robustness of the conclusions. The results of these analyses are shown in Table 6.1.

6.3.1 Time profile of cost and benefit streams

The effect of road maintenance on road conditions (and hence user impacts) is long term. The effect of timing on costs and impacts has therefore been considered by reviewing the results of the trunk road analysis for a reduced analysis period of 10 years (i.e. before budgets in Scenarios 2 and 3 are increased).

The analysis showed that the NPV becomes positive (i.e. maintenance expenditure savings outweigh user cost increases) for both Scenarios based on reduced maintenance funding when the shorter analysis period is adopted. This is due to the long term effects of budget reductions on network conditions and shows that the budget savings in Years 1 to 10 are not realised as increased costs to road users until Years 10 to 20.

[8] It is likely that winter maintenance issues are a major driver of public perception of road performance. Whilst winter maintenance was not the subject of this study, it is important to note that there is a link between overall maintenance impacts and the effects of winter conditions and operations but this has not been investigated.

Table 6.1 Sensitivity of quantified economic impacts

Net Present Value[1] for different assumptions (£m 2002 Prices)	Trunk roads		Local roads	
	Scenario 2 (20% cut)	Scenario 3 (40% cut)	Scenario 2 (20% cut)	Scenario 3 (40% cut)
Base analysis (20 years, standard growth[2] and indexing assumptions)	-107	-79	-524	-974
Reduced time period analysis (10 year analysis period) (Section 6.3.1)	112	263	-	-
Higher inflation rates on works costs (Section 6.3.2)	-62	44	-	-
Varied assumptions on vehicle operating costs (traffic growth and projected fuel price increases removed)(Section 6.3.3)	307	983	332	743
Different scaling up methodology for local road sample to network effects (Section 6.3.4)	-	-	-447	-806

(1) For clarity, only the Net Present Value data for each Scenario is brought forward from Table 5.1. The purpose of the table is to show how NPV varies with different assumptions. All footnotes for Table 5.1 are applicable to this table where relevant.
(2) Base assumptions are for traffic growth rates as per national transport model.

6.3.2 Inflation on maintenance works costs

Inflation of road maintenance costs has been up to 8% per annum in recent years, which is higher than general rates of inflation (Audit Scotland, 2011). Even if current maintenance budget levels are maintained, if the same inflationary pressure continues in future, road authorities will be able to buy less maintenance work than they can today for the same level of budget.

The effect of differential inflation on maintenance works costs was explored in this study by projecting an annual increase in works costs for each of the Scenarios. A differential rate of 4% was used which is consistent with the rate that has been experienced in recent years (see Appendix C).

The results show that the NPV of each funding reduction Scenario becomes less negative compared to the case with no differential rate for road maintenance costs. This result implies that it becomes more attractive to consider reductions to road maintenance budgets if there is high inflation for maintenance works, since the cost of delivering the benefits of road maintenance will increase during the analysis period.

However, with higher inflation for maintenance works costs, it is more beneficial to invest now in maintenance than to defer spending to a time when road authority buying power is reduced (i.e. the case not to reduce the current levels of maintenance budgets is strengthened).

6.3.3 Vehicle operating costs

The dominant influence on the quantified economic impacts of road maintenance funding reductions has been shown in the study to be vehicle operating costs. A significant number of assumptions were made which contribute to the assessment of vehicle operating costs. A 'lower bound' sensitivity has been undertaken by changing some of the key assumptions.

From the analysis of vehicle operating costs using the HDM-4 model, fuel can make up nearly half of the total vehicle operating cost. Fuel cost impacts are affected by assumptions on fuel price increases, traffic growth and predicted improvements in vehicle efficiency. The base analysis assumes fuel price increases, traffic growth and improving vehicle efficiency with time. If fuel prices are instead considered to remain static and there is no projected increase in traffic, then this could be considered a potential lower bound on the impact of fuel on the results.

The test showed that with the new assumptions, the conclusions in the original analysis were reversed and it became economically advantageous to reduce road maintenance budgets. The impact of the change was most significant for trunk roads. In summary, with no increase in fuel costs and no traffic growth, there would be benefits in terms of reduced overall cost to society with reductions in the maintenance budget. With fuel increases and traffic growth assumed in the original analyses there is an increased overall cost to society (i.e. a disbenefit) if the maintenance budgets are reduced. Therefore, it is reasonable to assume that if the fuel increases and/or traffic growth are greater than assumed in the original analyses the effect of reducing the maintenance budget will be a bigger increase in the overall cost (i.e. disbenefit) to society.

6.3.4 Scaling methodology for local roads

To calculate the costs for the whole local road network based on the analyses of the 8 sample Local Authorities, the results of the analyses for the sample Authorities were scaled to the whole local road network. For the sensitivity test, because the dominant cost in the overall analysis is the vehicle operating costs, the sensitivity of only that aspect of cost was considered in the sensitivity analysis.

For scaling up the results in the base analysis, the percentage of the network (for each road type) in need of repair within one year (i.e. categorised as red in the SRMCS report for 2009/10) was used for each Authority not in the sample of 8 Authorities analysed. However, an alternative assumption that may better reflect the overall condition of the network would be to scale the results based on the percentage of the network (for each road type) showing signs of deterioration (i.e. as categorised red or amber in the SRMCS report for 2009/10).

The revised scaled values continue to show a worsening in the overall NPV if maintenance funding is reduced but the worsening is less severe.

6.4 Overall conclusions on quantitative analysis after sensitivity testing

The sensitivity tests show that the most significant influence on the quantified impacts is from the vehicle operating costs. If some base assumptions are changed to reduce the impact of vehicle operating costs then the effect of reducing road maintenance budgets, for those aspects that were quantified, was shown to be an overall economic benefit. A similar change to the conclusion was also reached if a shorter analysis period was used.

The results show that reductions in road maintenance budgets considered in this study lead to an overall disbenefit to society. The effect is long term and the conclusion could change if different assumptions are made to calculate vehicle operating costs. However, based on standard assumptions adopted for transport investment appraisals in Scotland, there will be an economic welfare disbenefit if maintenance budgets are reduced, compared with retaining the 2010/11 levels of maintenance funding.

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- Mr Bill Barker (Dumfries and Galloway Council), Secretary of Society of Chief Officers of Transportation in Scotland
- Members of the Wider Economic Issues, Impacts, Costs and Benefits Working Group

Provision of the network condition and asset depreciation analyses with supporting information from WDM Ltd is also acknowledged.

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Provision of the network condition and asset depreciation analyses with supporting information from WDM Ltd is also acknowledged.

Appendix A Effect of budget constraints on activities

A road authority considers many aspects when applying road maintenance budget cuts across its range of activities. As well as any overall strategic aims, consideration must also be given to legislative requirements, contractual obligations and the ability to react to unforeseen circumstances. It is not possible to account for all such issues in a study of this type and scope, and given the focus on long term impacts, the approach adopted in the study has been to apply spending reductions in a way which will minimise the impact on typical long term aims of a road authority.

The objectives of each maintenance activity were rated for their contribution to the corporate objectives of Transport Scotland for the trunk road network (safety, accessibility, reliability, condition, sustainability and customer care). Given the high level nature of the assessment, these objectives were also considered appropriate to use in the assessment for local roads.

The breakdown of maintenance budgets into the different activities differs for trunk roads and local roads. For trunk roads, information was supplied by Transport Scotland at a detailed activity level of disaggregation, and the results of the analysis have been grouped into the summary headings used in the Trunk Road Asset Management Plan and summarised in Table A.1.

For local roads, the figures were adopted from the Audit Scotland report (Audit Scotland, 2011) and the results of the analysis are summarised in Table A.2.

Table A.1 Estimated reductions for different activities on trunk roads

Activity	Activity spend as percentage of current budgeted activity spend	
	Scenario 2 (Overall 20% cut)	Scenario 3 (Overall 40% cut)
Inventory, inspection, testing, routine and cyclic activity	87	72
Miscellaneous	88	71
Structural maintenance – pavements (carriageways)	56	24
Structural maintenance – structures	96	86
Minor improvements	93	75
Total overall budget (%)	**80**	**60**

Table A.2 Estimated reductions for different activities on local roads

Activity	Activity spend as percentage of current budgeted activity spend	
	Scenario 2 (Overall 20% cut)	Scenario 3 (Overall 40% cut)
Capital	**75**	**50**
Traffic Calming	96	92
Road Safety	96	92
New Road Schemes	89	77
Lighting	92	85
Structural Maintenance (Carriageway)	65	31
Other	81	63
Revenue	**83**	**66**
Road Construction	89	77
Structural Maintenance (Carriageway)	65	31
Environmental Maintenance	73	47
Winter Maintenance	96	92
Lighting	89	77
Safety Maintenance and Emergency Patching	96	92
Routine Repairs	67	33
Total Overall Budget (%)	**80**	**60**

The significant results to note are:

- Activities which have a significant contribution to safety or route reliability have been assumed to be less affected by the maintenance budget reductions than those contributing to, for example, asset condition. This approach accords with general road asset management experience.
- The activity which is used as the basis for the quantitative analysis (i.e. structural maintenance of carriageways) is significantly reduced. For the Scenario based on a 40% reduction in funding, such maintenance is reduced to 44% of existing levels for trunk roads, and 31% of existing levels for local roads. These figures were used to scale the results of the quantitative analysis from the effects of the funding reductions of 20% and 40% respectively.

Appendix B Key aspects of methodology and assumptions for the quantified analyses

B.1 Overview

Various assumptions have been made in order to complete the quantitative analysis. This Appendix describes those assumptions considered to have most significance in terms of the results.

B.2 Assumptions on scaling

For the local road network, assumptions were made in order to scale the results to the full economic impact of the Scenarios. A sample of Local Authorities (8) was analysed in detail. These were selected to be representative of the 32 Local Authorities in terms of the differences across the network (ranging from rural to city networks). In order to scale the results from 8 to 32 Local Authorities, a methodology was developed to account for the different authority and road types, the existing road conditions and the different amounts of travel across the network.

Full details of the sampling approach and the scaling methodology are provided in the detailed report (Transport Scotland, 2012b)(Transport Scotland, 2012b).

B.3 Assumptions on budgeting

For Scenario 1 (retaining 2010/11 funding levels), the trunk road analysis was based on the budgets given for 2010/11 in September 2010. Similarly, the local road analysis was based on budgets reported for 2009/10 by Audit Scotland (Audit Scotland, 2011) and increased for 2010/11 using a 2.5% increase. In practice, budgets have since been further reduced for both networks compared with those used in the Scenario. The implication is that there is already a long term disbenefit to society if current investment levels continue.

For both networks, the reduction in budget for each Scenario has been allocated differently across different activities (see Section 3.1 and Appendix A). In each case this results in the budget reduction for carriageway maintenance being significantly greater than the overall budget reduction. The effect of this change has been assumed to be linear with the 20% and 40% funding reductions.

The significance of the above effect is shown particularly in the trunk road results. The NPV for Scenario 3 with a 40% funding reduction is predicted to be marginally less negative than for Scenario 2 with a 20% funding reduction because:

- The overall budget reduction generates a benefit (expenditure reduction) of over twice as much for Scenario 3 compared with Scenario 2[9]
- The increase in vehicle operating costs, the component of the impacts which represent the most significant reduction in benefit, is based on the effect of carriageway maintenance reductions, which increase from 44% (20% funding reduction Scenario) to 76% (40% funding reduction Scenario) (see Appendix A). The carriageway maintenance reductions with an overall 40% reduction are 73%

[9] The reason it is not exactly twice as much is due to the different funding streams in Years 10 to 20.

more than for the Scenario with a 20% overall reduction in funding (i.e. significantly less than twice as much difference).

The effect is exacerbated further by the methodology to predict performance of the network described in Appendix B (Section B.5.1).

The effect is not seen in the local road analysis because the reduction in carriageway maintenance budgets from the 20% funding reduction Scenario to the 40% funding reduction Scenario (from 35% to 69%) is nearly twice as much, so the impact on vehicle operating costs is more significant.

B.4 Travel data

Travel data was taken from published figures for Scotland (Scottish Government, 2011). The total travel on the networks, for each road type, was distributed equally across the parts of the network in different condition (i.e. no account was taken of condition or location of a link within the network).

B.5 Vehicle operating costs

B.5.1 Methodology

The predictions of conditions for each network and each budget Scenario have been derived using existing condition projection models. WDM Ltd provided predictions of the future condition of the trunk road network to Transport Scotland, and similar information for the local road network to SCOTS. The models for the networks are conceptually similar but differ in the technical implementation.

Standard UK models take no account of changes in road condition on vehicle operating costs, assuming that conditions across the road network in the future are similar to today. To assess the impact of road conditions on vehicle operating costs, the World Bank HDM-4 models have been used with parameters set (where applicable) in accordance with vehicle types used in the UK and with standard requirements for appraisals in Scotland (e.g. predicted traffic growth, fuel price increases and vehicle efficiency gains).

A specific anomaly regarding future network conditions was identified by the trunk road analysis. Both reduced expenditure Scenarios include a return to current expenditure levels in year 15 (i.e. 2025) and then a 2.5% per annum increase until year 20 (i.e. 2030). This resulted in the predicted condition of the trunk road motorway network becoming slightly better for the 40% funding reduction Scenario between years 15 and 20 than for the Scenario with a 20% funding reduction, which in turn is predicted to be slightly better than the Scenario with a constant (2010/11) budget. The effect is small and, accounting for the level of confidence in the analyses, considered insignificant but further contributes to the effect of the calculated NPV for the 40% funding reduction Scenario being slightly less negative than that for the 20% funding reduction Scenario, which has been discussed in Section B.3.

B.5.2 Key assumptions

A number of detailed assumptions were made for modelling the effect of road maintenance funding on future network condition. Some of the more significant assumptions were:

- Standard and consistent unit rates were assumed for works across both networks
- For trunk roads there was a consistent proportional allocation of the works budgets to different work types (i.e. if x% of the budget is currently allocated to road resurfacing as a proportion of the overall spend on carriageway maintenance, then this is continued through the analysis period)
- For local roads there was a consistent proportional allocation of the maintenance works budgets to different road hierarchies (i.e. A, B, C and U class roads)
- There was no effect on condition from the impact of unplanned maintenance
- Future budgetary regimes and condition drivers were assumed to be similar to past experience. In particular, the Scenario with a 40% reduction in overall maintenance funding considered cuts to carriageway budgets of 56% for trunk roads and 69% for local roads. These are significantly beyond the range of previous budget variations. Further, the models were developed primarily as a tool to predict performance over the next 10 years, and differences between predicted and actual performance will be increased for longer term projections.

B.6 Travel time costs

The effect of reduced maintenance funding on travel time costs was assessed using the outputs from the condition projection models and standard costs of travel time as required by standard requirements for appraisals in Scotland. The evidence on which the effect was based was past research in the UK and is considered primarily applicable for higher speed roads (Cooper, Jordan, & Young, 1980). The analysis has therefore only been applied to trunk roads and A class local roads.

B.7 Skid related accident costs

Skid resistance data from the last 10 years was reviewed and suggests that there have been improvements to skid resistance over time which have levelled out in recent years. A simple link with historic road resurfacing budgets was also established.

Recent accident figures were assessed and the potential increase in accidents was estimated based on an assumption that skid resistance might deteriorate for the 40% funding reduction Scenario, given the evidence of historic budgets and skid resistance above. The most recent risk models for accidents on roads with poor skid resistance were adopted (Coyle & Viner, 2009).

B.8 Delay costs at roadworks

The effect on the total delays to traffic at roadworks sites was quantified using standard UK delay cost models in accordance with requirements for transport appraisals in Scotland.

B.9 Emissions costs and air quality

B.9.1 Methodology

The calculation of Carbon Costs considered carbon dioxide emissions from 3 sources:

1. CO_2 emissions from vehicles travelling over the network under normal running conditions;
2. CO_2 emissions from vehicles as they travel through roadwork sites (associated with traffic delays); and.
3. The CO_2 emissions from road maintenance activities (embodied Carbon).

The methodology for calculating the CO_2 emissions from vehicles under normal running conditions used the predicted condition of the network for each budget Scenario. The methodology built on that described in Section B.5.1. Using the fuel consumption outputs and CO_2 output data from HDM-4, the total emissions were calculated based on the number and types of vehicles travelling over parts of the network with different levels of roughness.

The CO_2 emissions from vehicles delayed through roadwork sites were quantified using UK traffic delay cost models in accordance with standard requirements for appraisals in Scotland. The QUADRO (Queues and Delays at Roadworks) model provided a CO_2 cost output based on user defined traffic management arrangements.

A number of representative (notional) maintenance schemes were modelled using QUADRO and the resulting CO_2 costs scaled by the number of notional schemes that would be required to treat the length of network predicted to be in need of maintenance, based on the predicted network conditions.

The CO_2 emissions from maintenance works were based on default values used in the asPECT model used in the LifeCycle Carbon Assessment of asphalt materials in compliance with PAS2050 (British Standards Institution, 2008)(British Standards Institution, 2008).

From the predicted mass of CO_2, masses of other pollutants were derived based on typical combustion equations and fuel type (e.g. diesel and petrol).

B.9.2 Key assumptions

All key assumptions in Section B.5.2 apply to the emissions analysis.

B.10 Asset valuation

B.10.1 Methodology

Valuation of the road network was based on the replacement cost of the network calculated using standard maintenance cost unit rates for different types of road (supplied to this study).

Depreciated road asset value was assessed using the predictions of network condition over time. For roads in an as new condition, no depreciation was assumed. For roads showing some signs of deterioration, a reduction in service life was derived which enabled an assessment of the depreciation to be made. The assessment was made for each length of the network so that a total value of depreciation could be assessed.

Valuation figures were supplied by WDM Ltd in different forms for local and trunk roads. For local roads, the predicted accumulated depreciation was provided. For trunk roads, the predicted depreciated replacement cost was provided.

B.10.2 Key assumptions

Assumptions given in Section B.1 are also applicable for the valuation methodology. In addition, it should be noted that there are numerous other assets on the network besides carriageways (e.g. bridges, streetlights and other road furniture). No assessment is made of the depreciation of these assets.

Appendix C Assessment of Differential Inflation Rates

Road authorities use standard indices to update the value of maintenance work prices each year, to manage the risk of inflation in contract costs.

No prediction of specific road cost indices was available for the 20 years analysis period used in this study as the costs are considered too volatile to predict over the time period. Predictions for broader indices are available for more general construction costs but these are less applicable for road maintenance activities (BCIS, 2011a). To overcome the difficulties in predicting future price increases, a more appropriate assessment method was considered to be the use of historic trends of various indices to represent the future potential changes.

The ROCOS index (Road Construction Resource Cost Index) (BCIS, 2011b) was compared against the Treasury GDP deflator, Retail Price Index and Consumer Price Index. Since 2000, the average annual differential between ROCOS and the various indices was around 4%, and against the Treasury GDP deflator it was 3.9%. Based on experience of the last 10 years, an annual rate of 4% seemed a reasonable basis on which to test the sensitivity of maintenance works costs.

The assumption was also tested finally against oil price predictions from the Department of Energy and Climate Change (Department of Energy and Climate Change, 2011). There were a range of predictions, ranging from low increases (average prices from 2010 onwards varying from 40-50% below 2008 prices) to high increases (prices rising to 40% above 2008 prices by 2015 and peaking and stabilising at 50% above 2008 prices from 2020 onwards). With the differences in these estimates and difficulties with forecasting, and the fact that prices impact on both inputs (e.g. construction price inflation) and impacts (e.g. vehicle operating costs) it was considered that for the purposes of this study, the 4% figure derived from cost price indices described above, would be adopted for the sensitivity tests described in Section 6.3.2.

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