Newcastle City Council

Newcastle City Strategic Surface Water Management Plan

Final Report

Report No 36634/F/001

January 2016

Amec Foster Wheeler Environment
& Infrastructure UK Limited

Report for

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Civic Centre
Newcastle upon Tyne
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Doc Ref. 33634/F/001

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Document revisions

No.	Details	Date
A	Draft	15 June 2015
B	2nd Draft	24 July 2015
C	Final (for Review)	06 January 2016
D	Final	20 May 2016

Executive summary

Background

The City of Newcastle upon Tyne has a history of flooding. In the events of 2012, hundreds of residents and businesses across the city reported internal flooding and transport systems became gridlocked as everyday life ground to a halt. The social, environmental and economic costs are still being counted today.

The severe rainfall event of June 2012 captured the attention of national media, politicians, local communities, businesses, government bodies and local authorities. This has led to increased pressure on Flood Risk Management Authorities to identify, justify and implement a coherent plan for flood risk management into the future. It is accepted that it is impossible to guarantee that flooding will never happen again but there is a clear expectation that the responsible authorities will work together to minimise the impacts on society and the environment.

The Flood Risk Management Authorities (RMA) for the Newcastle City area are the Lead Local Flood Authority which is Newcastle City Council (NCC) who has responsibility for surface water and ordinary watercourses, Environment Agency (EA) who has responsibility for main rivers and the coast, Northumbrian Water (NW) who has responsibility for public sewers and Highways England who has responsibility for major highway drainage. Newcastle City Council has taken the lead role and has commissioned the "Newcastle City Strategic Surface Water Management Plan" with funding from the Environment Agency Local Levy and support from Northumbrian Water.

Objectives

The study's primary objective is to facilitate the identification of strategic needs and opportunities and deliver a robust and high level integrated surface water management plan for the City of Newcastle upon Tyne.

The plan that has been developed through this study will seek to align with the existing document "Planning for the Future – Core Strategy and Urban Core Plan for Gateshead and Newcastle Upon Tyne 2010 – 2030.

Other objectives are:

- To identify and promote sustainable surface water management opportunities within the catchment;
- Reduce flood risk to property and infrastructure whilst accommodating growth, urban creep and climate change;
- Contribute towards improving water quality in the River Tyne;
- Contribute towards improved community health and wellbeing by promoting green / blue infrastructure in amenity areas;
- Improve biodiversity and habitat creation within the catchment; and,
- To identify alignment with other strategies / policies / plans within the catchment and highlight opportunities for an integrated approach for implementation of the surface water management plan going forward.

The technical feasibility of identified opportunities has not been fully assessed and is considered a 'next step'.

The primary objective for this plan is to deliver an integrated surface water management plan for the City of Newcastle upon Tyne.

Catchment Area

The study area covers the Newcastle City Centre and the outlying areas of South Jesmond, Sandyford and Spital Tongues. Also covered are the western suburbs of Wingrove, Arthurs Hill Benwell and Scotswood. The study area is shown in the Figure A.1.

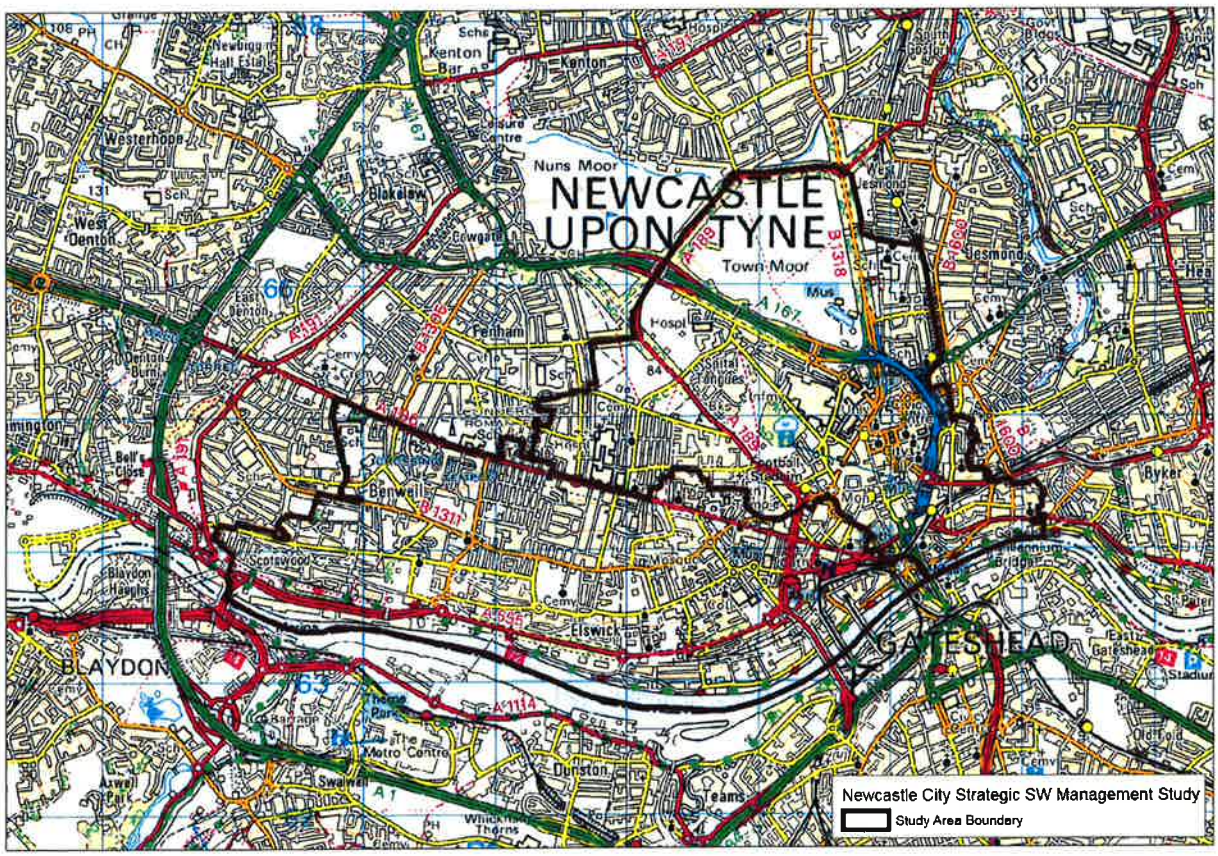
Areas to the north and west, including the Ouseburn catchment are covered by a separate report.

The primary surface water drainage system in the area is the River Tyne which is classified as a main river for which the EA has a continuing role to manage fluvial flood risk. The Tyne Catchment Flood Management Plan from December 2009 suggests that over 6,000 properties could be at risk of flooding in the Lower Tyne area, which included this study area. The preferred long term policy for managing flood risk is Policy Option 5 "Take further action to reduce flood risk" (taking into consideration the impact of climate change).

The secondary surface water drainage system is a combination of highway drains and public sewers which manage surface water run-off from land and properties. The majority of the area drains to the combined sewer network which is managed by Northumbrian Water. Northumbrian Water are actively promoting the removal of surface water from the combined sewer in order to reduce stress on the downstream sewers, combined sewer overflows, sewage pumping stations and sewage treatment works at Howdon.

Future development is proposed to the west of the city which may impact on the performance of the existing networks. The development of these sites will be controlled by the National Planning Policy Framework (NPPF) and the Newcastle Core Strategy. Within the Core Strategy, policy CS17 sets out the requirements to control, separate and minimise surface water discharges from development. The management of the flows is pivotal in managing flood risk and providing for future development.

Figure A.1 The Newcastle City Strategic Surface Water Management Plan Study Area



Summary of the Plan

A number of key opportunities have been identified to form part of the strategic surface water management plan for the study area. These are located at Scotswood and Benwell (opportunity area A), Nuns Moor, Hunters Moor, the RVI, The University of Newcastle upon Tyne and Civic Centre (opportunity area B), Studley Terrace, Barrack Road and St James Boulevard (opportunity area C) and at the Town Moor, Brandling Park and the RGS (opportunity area E).

Surface water management opportunities from the City Centre to the Quayside (Opportunity Area D) have not been investigated further as part of this study because NCC and the EA are presently engaged in strategic work in this area.

From the investigation undertaken in this study, the following can be summarised:

- Partnership working is an essential part of all of the investigated opportunities;
- All opportunities reduce the risk of flooding to both residential, non-residential and key transportation links to futureproof the city up to 2030 by taking into account any increases as a result of development, climate change and urban creep;
- Opportunities in areas A, B and E provide flood resilience to the A695 Scotswood Road, A189 Ponteland Road and Sandyford Road Underpass, respectively to ensure at least one carriageway remains operational during low intensity flood events;
- Opportunities in area B provide flood resilience to the Queen Victoria Road to ensure access to the RVI is maintained during low intensity flood events;
- Opportunities in area C reduces the run-off volumes on Barrack Road and flooding at Eldon Square, however additional property level protection is required at Eldon Square;
- Opportunities in area B and C are the most expensive scheme to implement, but generate the greatest environmental benefits and assist in opening up blue-green corridors from the northeast of the city centre to the River Tyne as well as social benefits including health and well-being
- The greatest benefits are generated from implementation of all of the opportunities and addressing any residual flood risk in the city with property level protection (PLP or Local Measures);
- Where possible natural flood risk management techniques are employed on the Town Moor to enhance the existing land drainage and therefore minimising the impact on the green space;
- Routine maintenance including; gully cleaning, highway drainage and NWL network cleaning by the asset owners is essential in maintaining an acceptable level of surface water flood risk protection; and,
- Flooding from high intensity rainfall events is still possible following the implementation of these opportunities.

The outputs of this study will be used to inform the management of surface water flood risk in Newcastle up to 2030, inform other strategic plans, and will form the basis for determining potential opportunities that could be implemented. It highlights a number of benefits available from the implementation of these surface water management measures. These could be direct flood risk benefits or secondary benefits relating to other strategies developed by NCC, NWL and Non-Government Organisations (NGOs).

Inherent assumptions are made as part of the modelling process, but are informed by best practice, and therefore the model is deemed fit for purpose and thought to be the best representation of the system available at the time of writing.

Development of any future schemes of work to investigate or address the flood risk need to be considered at an early stage. Since the city centre comprises a number of different residents and land owners including, domestic, commercial, educational and medical, it is likely that collaboration with other stakeholders and linkages with other strategies would be required in the development and implementation of any opportunities.

The opportunities investigated in this study address the surface water flood risk issues within the catchment and support a wider range of national and local Plans and Strategies produce by NCC and other key partners.

Costs and Funding

The plan has identified a number of opportunities and the estimate individual whole life costs for delivery of these ranging between £15.9M and £36.7M, with a combined cost of £77.6M for the delivery the entire plan and £87.5M for full plan plus removal of any residual flood risk through installation of property level protection (PLP or Local Measures). The whole life benefits for the implementation of the induvial opportunities range from £115.3M to £128.3M, the full plan and full plan plus PLP or local measures being £234.5M and £701.2M respectively.

There are opportunities to drive down costs by further developing the measures identified and building on the current partnerships to align resources and funding. Recognising other economic benefits, e.g. regional growth, which have not been monetised in this assessment would also increase the benefit / cost ratio

Potential sources of funding include

- Environment Agency's Flood Defence Grant in Aid (FDGiA) and Local Levy
- Newcastle City Council's capital budget
- Northumbrian Water's investment programme
- EU funding in support of Water Framework Directive (WFD) objectives
- EU funding for tackling the effects of climate change

There is also the opportunity to seek contributions from developers, either directly through funding of measures that facilitate development or indirectly through giving up land for SUDS/Surface Water Management measures, on the basis that doing so will enable development to go ahead with the development's drainage requirements incorporated into the wider SUDS measures. Other funding streams could be generated from partnerships with other key private stakeholders and beneficiaries, such as local businesses, The University of Newcastle upon Tyne and the NHS Trust.

With regards to potential FDGiA funding, the individual cost benefit ratio for the opportunities investigated are range between 0.7 and 2.4 to 1, whilst the ratio for the entire plan delivery is estimated to be 9.3 to 1.

Recommendations

The way forward is to continue the partnership approach that is already delivering benefits on surface water management projects throughout the region, and to continue to seek the means to fund and deliver solutions jointly. There is also a need to engage fully with all the key beneficiaries and stakeholders, particularly with developers, large landowners such as the university and hospitals, local businesses, other relevant bodies such as the Tyne Rivers Trust, Non-Governmental Organisation (NGOs) and the general public and residents' groups to get as wide support as possible.

It is considered critical that developers work together with one another and with the Flood Risk Management Authorities to enable such a Drainage Strategy for the area to be developed. The study that has been completed and the measures that have been proposed provide a firm basis for developing that strategy in more detail. This will require full co-operation and engagement from all relevant parties with leadership from the Flood Risk Management Authorities.

Contents

1. Introduction

1.1 Background

The City of Newcastle upon Tyne suffered severe flooding as a result of extreme rainfall on the 28 of June 2012. Hundreds of residents and businesses reported internal flooding to properties, which resulted in an estimated damage cost of £78M. There were problems with the ability of the city's road network to cope under these severe flood conditions resulting in traffic being brought to a standstill in critical locations for a number of hours. The social, environmental and economic costs of this flood event are still being counted today.

This event increased pressure on the local Flood Risk Management Authorities (RMAs) to identify, justify and implement an integrated and coherent plan for the management of flood risk for the City, facilitate further growth and futureproof against the effects of urban creep and climate change.

Although the 2012 flooding event was considered to be an 'extreme' event, it alerted the RMAs to the potential issues within Newcastle upon Tyne. It is unlikely that the implementation of any flood management strategies will eliminate the risk of flooding from an event of a similar intensity to the one experienced in 2012, but it will improve the overall level of risk throughout the city.

The lead local flood risk management authority and their partners for the Newcastle area are Newcastle City Council (NCC), Northumbrian Water (NW) and the Environment Agency (EA). These parties have been engaged at a strategic and project level for many years, which has included the development of the following activities:

- Tyneside Sustainable Sewerage Study;
- Newcastle and Gateshead Surface Water Management Plan;
- Strategic Flood Risk Assessments; and
- Newcastle and Gateshead Core Strategy.

Recently these bodies have been working with the academic consortium of the Blue-Green Cities project, in which Newcastle has been identified as a demonstration city. This is a research project that aims to develop new strategies for managing urban flood risk as part of wider integrated urban planning. It intends to achieve environmental enhancement and urban renewal in which the multiple benefits of Blue-Green Cities are rigorously evaluated and understood. It is a research project that aims to put competent authorities, business and communities at the centre of research and exchange of knowledge.

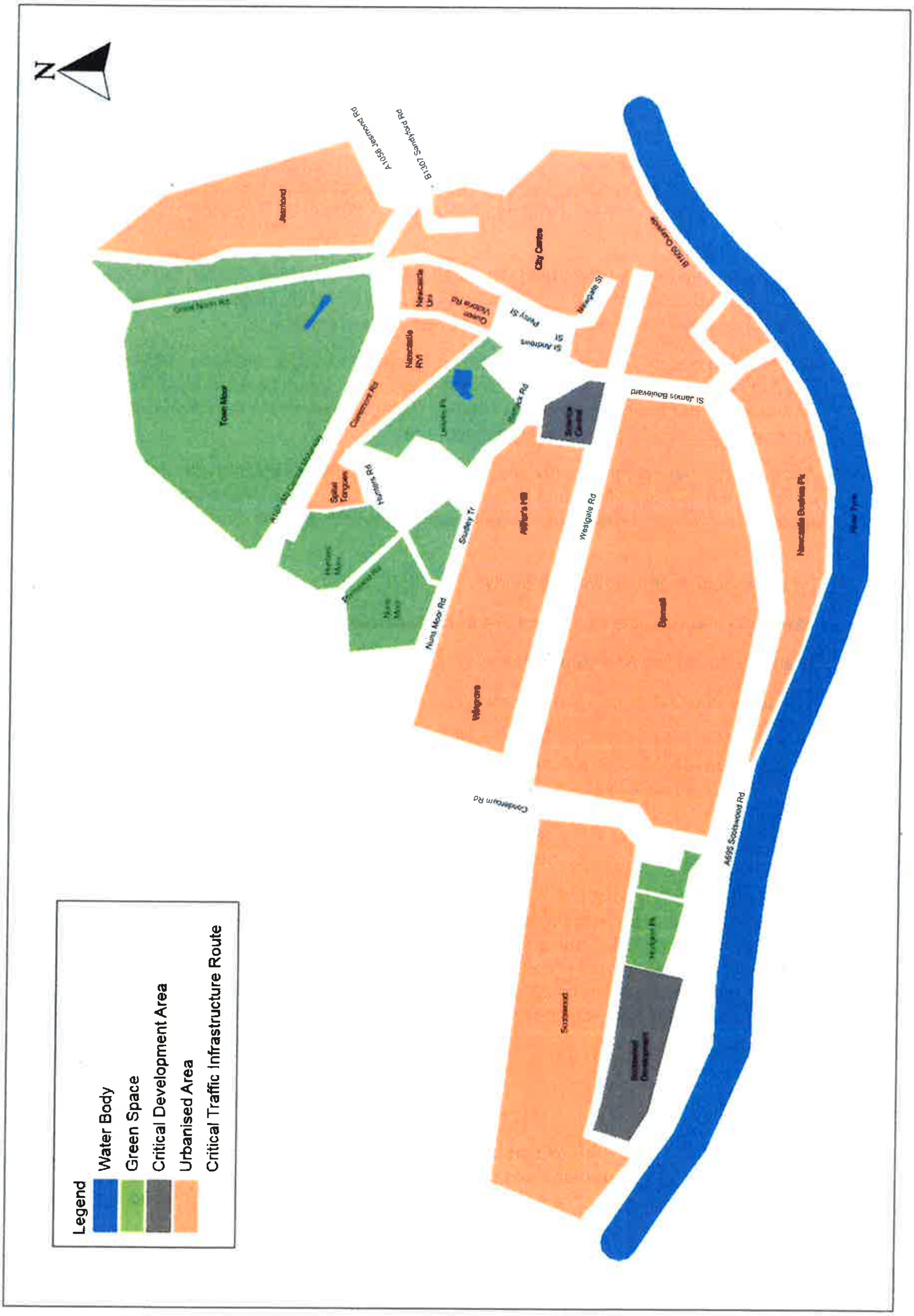
This study is considered a starting point for implementing research and ideas into practical schemes to form part of an overall surface water management strategy. It is intended to bring together the philosophies of Water Sensitive Urban Design (WSuD), Surface Water Management Plans (SWMP), Drainage Area Studies (DASs) and Highway Asset Management Plans (HAMPs) combined with the needs of residents, major land owners and the experience gained from the 2012 flooding event. This will inform individual strategies and allow major stakeholders to align their schemes and progress them on their own as part of a combined investment programme.

1.2 Study Area

The study area which is being considered as part of this strategic surface water management study is the City of Newcastle upon Tyne and the urban areas of Benwell and Scotswood. The study area can be considered as city centre or urbanised area, with limited green space which are concentrated around the Town Moor in the north western part of the city.

A plan showing the study area is shown in Figure 1.1

Figure 1.1 Study Area Schematic



1.3 Strategic Aims

It is important that the benefits from any opportunities investigated within this study are considered as being strategically aligned to other environmental and sustainable drivers developed by NCC and their partners.

A review of the wider strategic aims are illustrated in Appendix A.

1.4 Study Objectives

The study's primary objective is to facilitate the identification of strategic needs and opportunities and deliver a robust and high level integrated surface water management plan for the City of Newcastle upon Tyne.

This will include a scoping study to gather information and identify any knowledge gaps and further develop modelling for the city's drainage plans. The study will need to be future proofed to account for any changes due to development, urban creep and climate change. Also, it will be required to assess how flooding effects the city over the agreed over the 50 period of the plan.

In addition, this plan will require building on and forming new relationships with a number of stakeholders, including; hospital, transport organisations, universities, emergency services, major landowners, city centre business and other interested independent companies and NGOs. The study has identified a wide range of benefits that will accrue through the implementation of surface water management throughout the study area. The outcomes arising from these measures will benefit numerous stakeholder groups.

Further objectives of the plan are:

- To identify and promote sustainable surface water management opportunities within the catchment;
- Reduce flood risk to property and critical infrastructure whilst accommodating growth, urban creep and climate change;
- Contribute towards water quality improvements in the River Tyne;
- Contribute towards community health and wellbeing benefits by promoting green/blue infrastructure in amenity areas;
- Improve biodiversity and habitat creation within the catchment;
- To identify alignment with other strategies / policies / plans within the catchment and highlight opportunities for an integrated approach for implementation of the surface water management plan going forward; and,
- Effective communication to all stakeholders is fundamental for the success of the strategy.

The study identifies potential opportunities and surface water management measures, which includes 'Do Nothing' and 'Do Minimum' scenarios. From the long list of potential measures, a shortlist of options has been developed and an assessment made of the costs and benefits associated with those measures. Annual average damages and Ecosystem Services Assessment methods of evaluating benefits of preferred opportunities have been applied, and included in the wider benefits assessment.

There is a potential for this study to advance to subsequent stage which would incorporate activities to deliver individual projects or integrate with other schemes, however this is dependent upon the ability to secure future funding by the RMAs or other interested parties. Within this plan partnership funding calculator scenarios have been presented in accordance with DEFRA funding policy to assess the potential Flood Defence Grant in Aid (FDGiA), but it is important to note that other sources of funding are potentially available.

2. Stakeholders & Partnerships

2.1 Establishment

Early engagement with stakeholders is considered critical for the success of any potential opportunities.

Stakeholders for this study can be considered at two levels, those of key stakeholders and those of other interested parties. Key stakeholders are those from organisations with flood risk management responsibilities and are listed in Table 2.1.

Table 2.1 Newcastle City Surface Water Management Plan – Key Individuals

Stakeholder	Contact	Title
Newcastle City Council	John Robinson	Flood Risk Management Authority lead
Newcastle City Council	Darren Varley	Flood Risk Management Authority lead
Northumbrian Water	Martin Kennedy	Technical Advisor
Northumbrian Water	Linzie Pentleton	Sewer Network Advisor
Northumbrian Water	Michael Ciaraldi	Asset Delivery Project Manager
Environment Agency	Stephen Merrett	Partnership & Strategic Overview Team Leader
Amec Foster Wheeler	Garry Edwards	Consultant Project Director
Amec Foster Wheeler	Ian Wilson	Consultant Project Manager
Amec Foster Wheeler	Peter Foskett	Consultant Technical Advisor
Amec Foster Wheeler	Waseem Ahmad	Consultant Project Modeller

The second level of stakeholder engagement is comprised of other interested parties, which includes; The Freemen of Newcastle, The University of Newcastle upon Tyne, the Blue-Green Cities Research Project, The University of Northumbria, The Newcastle Upon Tyne NHS Trust, Greening Wingrove, other major landowners and also certain NGOs. During this stage, consultation was linked to The University of Newcastle upon Tyne and the Blue-Green Cities Research Project. Further consultation with these second level stakeholders will be required for on-going work and further development of the opportunities investigated in this study.

2.2 Communication

The communication plan developed as part of the Newcastle City Strategic Surface Water Management Plan is shown in Appendix B.

2.3 Data Gathering

The full list of information requested during the data gathering exercise is shown in Appendix C.

3. Historical Surface Water Flooding

3.1 Reported Incidents

A number of flooding incidents have been reported in the study area. These are summarised in Table 3.1.

Table 3.1 Summary of Reported Flooding Incidents

Reported to	No of Incidents	Causes
Newcastle City Council	42	Mixture of flooding to basements in Jesmond and Brandling Village area and internal flooding to properties from surface water in Benwell, Rye Hill and Spital Tongues areas. In response to the 2012 flood, approximately 181 (1) residents report flooding within the confine of the study area.
Northumbrian Water	714	Mixture of flooding reports from 2002 to 2015 as a result of blockages, flooding to highway and property curtilage as well as property flooding currently under investigation by NWL.

(1) This data was taken from the NCC Summer 2012 Flood Report (July 2013) for the wards of South Jesmond, Scotswood, Benwell, Westgate, Wingrove and Elswick.

3.2 Surface Water Flood Maps

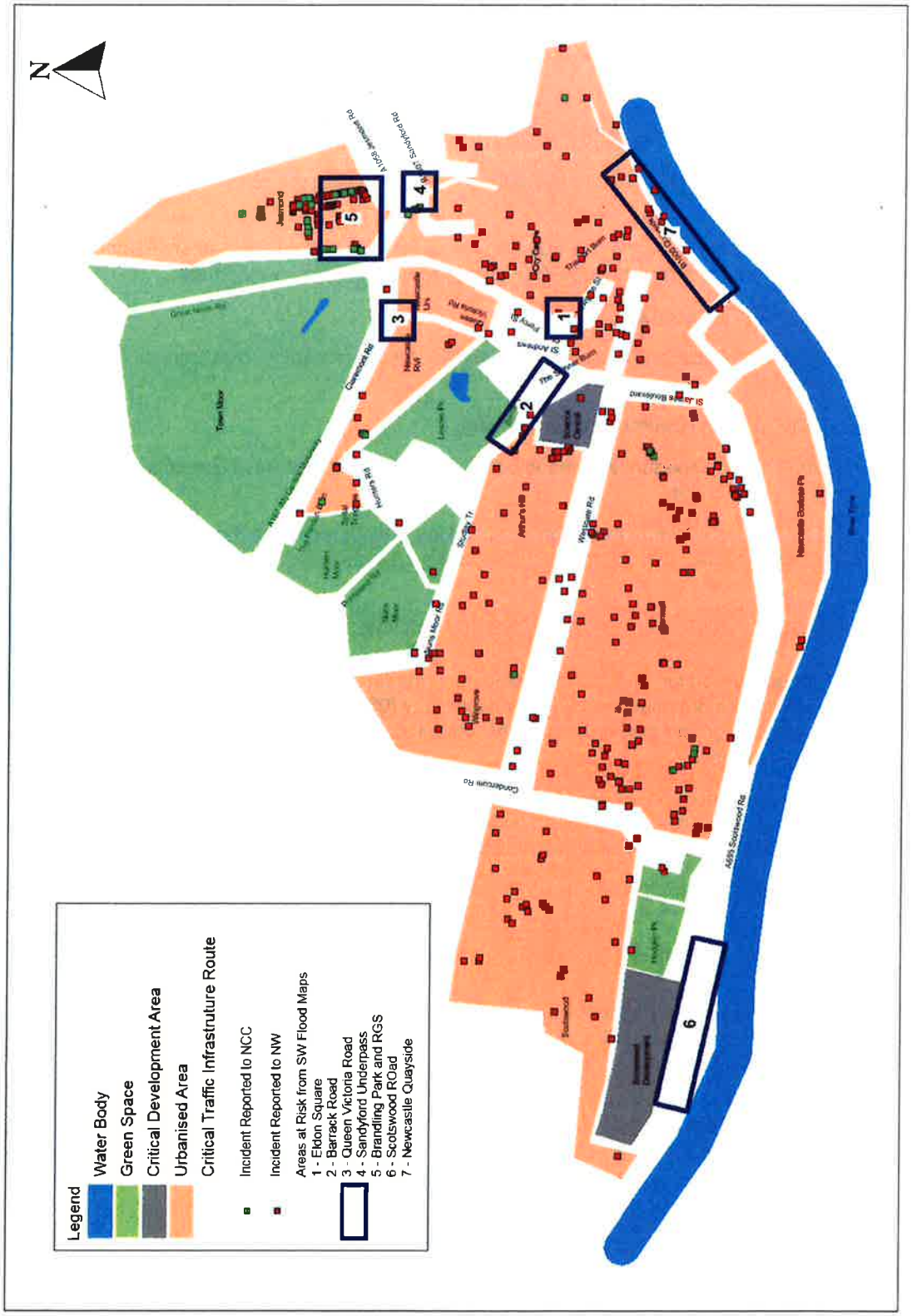
Further reports including the NCC 2012 Summer Flooding Report along with information from the key stakeholders and other interested parties have identified numerous surface water flooding issues. These were qualified against the outputs from the surface water flood risk maps and summarised in Table 3.2. It has been estimated that the approximate cost of damages caused as a result of the June 2012 floods was in the order of £78M.

Reported flood distribution is shown in Figure 3.1 and further details on flooding is held within Appendix D.

Table 3.2 Study Area Surface Water Flooding

Location	Inspection of SW maps	Possible Causes of flooding
Eldon Square (Newgate Street)	Flood risk predicted at 30yr return period events with significant depth	Low spot in highways, which is exacerbated by drainage incapacities. Significant overland flow on St Andrews Street and further up Newgate Street/Percy Street.
Barrack Road	Minor flood risk predicted at 30yr return period, flooding fully envelopes road in excess of 100yr return period	Significant overland flow from highway on Barrack Road, Gallowgate and down onto Newgate Street
Queen Victoria Road	Flood risk predicted at 30yr return period flood risk with significant depth	Low spot in highway outside Merz Court and route is on historic path of the Pandon Burn
Sandyford Road underpass	Flood risk predicted at 30yr return period with significant depth	Low spot in highway underpass
Brandling Park & RGS	Minor flood risk predicted at 30yr return period, flooding fully envelopes road in excess of 100yr return period.	Low spot in pedestrian underpass. Royal Grammar School affected by overland flow.
Scotswood Road	Flood risk predicted at 30yr return period events with significant depth adjacent to Rolls Royce building and minor flooding in the rest of Scotswood Road. Flooding fully envelopes road in excess of 100yr return period.	Significant flooding overland across Hodgkin Park, combined with run-off from Scotswood development site which drains to a low spot on Scotswood Road.
Newcastle Quayside	Minor flood risk predicted at 30yr return period, flooding fully envelopes road in excess of 100yr return period.	Low spot in highway adjacent to Law Courts, exacerbated by high river levels and overland flow from City Road/Broad Chare

Figure 3.1 Reported Flooding Incidents and Known Surface Water Flooding in Newcastle upon Tyne



4. Flood Risk Modelling

4.1 Model Scenarios

An integrated hydraulic model was used to establish the baseline surface water flooding and the predicted impact of any opportunities as well as being used as a tool to establish the flood risk and cost benefit assessments. Further information on the hydraulic modelling undertaken as part of the study can be viewed in Appendix E.

In-line with "Planning for the Future – Core Strategy and Urban Core Plan for Gateshead and Newcastle Upon Tyne 2010 – 2030", scenarios for 2015 (existing) and 2030 were investigated;

- 2015 existing scenario;
- 2030 future scenario containing known SHLAA developments data, climate change and urban creep;
- 2015 existing opportunity scenario; and,
- 2030 future opportunity scenario containing known SHLAA developments data, climate change and urban creep.

It was decided by the stakeholders that each identified opportunity would be modelled and assessed in isolation and that any combination of intervention would not be considered at this stage.

4.2 Statement on Fit for Purpose for Study Area

The hydraulic model utilised for this study is based upon the one dimensional model of the NW sewerage network which covers the drainage areas of Newcastle City (05-D28) and Benwell (05-D27). The model was developed into a 2D integrated model using LiDAR data and combined with data from the Environment Agency's River Tyne model.

It is considered that this model is suitable for the purpose of assessing the opportunities established in this study. A limited validation exercise has been undertaken however, further model development will be required for any subsequent stages at which time additional validation or verification is recommended.

Details of model limitations along with notes for future users of the model are held in Appendix E.

4.3 Flood Risk Methodology

Further details on the flood risk methodology used in the assessment of these opportunities can be viewed in Appendix F along with the details of the risk categorisation. The types of receptors assessed in this investigation is shown in Table 4.1

Flood risks are categorised in low, moderate, significant; and very significant risk. However, very significant risks are defined by outputs from the 1 in 20 year events or less, with significant risks defined by outputs from 1 in 40 and 50 year events and moderate risks to 1 in 100 and 150 year events. Low risks are restricted to outputs to events greater than 1 in 150 years.

Analyse were undertaken for the full set of storm return period events including 1 in 5, 20, 40, 50, 100, 150 and 200 years at a duration of 90 minutes and a winter design profile. This was established as the critical duration and profile of the drainage network for this study area.

The flood risk plans are located within Appendix J. Only flood risk plans for the 40 year and 100 year events have been supplied with this report, other return period plans are available on request.

Table 4.1 Receptors

Receptor	Description
Properties	
Residential	All residential properties as listed on the national receptor database (NRD) equating to approximately 10,585 registered residential dwellings in the study area. Covering the postcodes of NE1, NE2, NE3, NE4, NE5, NE6 and NE15
Commercial	Comprises the following buildings usage listed in the NRD for Newcastle and Scotswood area: - Shops and Shopping Malls, Supermarkets, Public Houses, Offices, Hotels, Garages and Services Stations, Car Dealers and Car Services, Taxi Services, Hire Shops, Car Washes, Takeaways, Cafes and Restaurants, Hairdressers, Betting Offices, Estates and Travel Agencies, Dry Cleaners and Launderettes, Amusement Arcades, Casinos and other General Commercial properties.
Critical Buildings and Infrastructure	Comprises the following buildings usage listed in the NRD for Newcastle and Scotswood area: - Public Services (Governments Offices, Community Centres, Television Studios, Tourist Information, Courts and Police, Fire and Ambulance Stations); - Transport Infrastructure (Train, Metro and Bus Stations); - Utility Infrastructure (Electrical Sub-Stations, Gas Regulators and Telecommunications); - Medical (Health Centre, Clinics, Hospitals, Surgeries, Nursing Homes, Chemists and Dental Practices); - Financial (Banks, Building Societies and Other Financial Services); and, - Education (Nurseries, Pre-Schools, Schools (Including Primaries), Further and Higher Education University and Research Establishments.
Other Buildings	Comprises the following buildings usags listed in the NRD for Newcastle and Scotswood area: - Factories, Depots, Warehouses, Engineering Works and other Industrial Services, Car Parks, Shelters, Public Conveniences, Bandstands, Sports Pavilions, Gyms, Places of Worship, Clubs, Art Centres, Museums, Concert Halls, Leisure Centres pool and Garden Centres.
Critical Traffic Infrastructure Routes	
A695 Scotswood Road	Flooding predicted at the Western end of the A191 Scotswood Road, between Whitehouse Road and the Scotswood Bridge junction
A189 Ponteland Road	Flooding predicted the A189 Ponteland Road adjacent to Hunters Moor, between Fenham Hall Drive and Brighton Grove
Queen Victoria Road	Flooding predicted adjacent to Mertz Court at The University of Newcastle upon Tyne
Sandyford Road Underpass	Flooding predicted at Sandyford Road underpass
A189 Barrack Road and Newgate Street	Significant volumes of run-off experienced which lead to the flooding of areas at Gallowgate and Newgate Street.

5. Strategic Opportunities

5.1 Opportunities Methodology

The scope of the study was to identify a shortlist of opportunities, which are likely to have the greatest benefit. The methodology used was:

- Identify opportunities from the high level strategies and interventions identified previously;
- Undertake a scoring exercise to rank opportunities; and,
- Development of a 'Short list' of preferred opportunities.

Where possible, green infrastructure measures are proposed as recommended by DEFRA's FCERM Strategy and surface water management guidance, the Newcastle and Gateshead Green Infrastructure (GI) Study and the Core Strategy for Newcastle and Gateshead.

5.2 Long List Opportunity Assessment

To assist in the identification of potential opportunities the following data sets were considered:

- Updated EA Flood Maps for Surface Water (December 2013);
- Outputs from 2012 NW Sustainable Sewerage Plan;
- Flood incident reports (from NW and NCC);
- Routes of historic or abandoned watercourses; and
- Collated information and knowledge on flooding and flood risks in the study area.

Inspection of this information identified a number of potential strategic 'Blue-Green' corridors within the city in which the natural flow routes and urbanised streetscapes could be further integrated. These were considered as five individual areas of potential opportunities (A, B, C, D and E) and in-line with the 'Blue Green Cities' concept and follow the five identified areas.

These 'corridors' were used as basis for identifying the 'Long List' opportunities. A schematic of the location of these areas is shown in Figure 5.1 and illustrated further in Table 5.1.

These opportunities were assessed by the first level stakeholders on factors including; benefits, costs, buildability, environmental, health & safety, ownership and maintenance. Following an opportunity review meeting with the key stakeholders it was agreed that there was merit to take forward the majority of the opportunities identified in the long list, with the exception of those contained within Opportunity Area D. Although a number of potential opportunities were identified for Opportunity Area D from Newgate Street to Newcastle Quayside it was established that NCC were already engaged in flood management activities in this area.

However, the surface water issues identified at the northern extent of Newgate Street at Eldon Square would be included in Opportunity Area C. In addition, NCC were already engaged in surface water management work in the Brandling Village area of Newcastle. Due to the timing of these investigations, it was decided that these works could be combined with Opportunity Area E.

The opportunity identified at The University of Northumbria would not be taken forward at this time because it was considered that this was not part of the critical strategy for Opportunity Area B. In subsequent stages, it would be possible to integrate the university into the strategic vision with no significant alterations.

The summary of this long list of potential opportunities is held within Appendix G and examples of some of these SUDS techniques discussed for use within the Newcastle City plan are illustrated in Appendix H.

Figure 5.1 Location of 'Blue-Green' Corridors

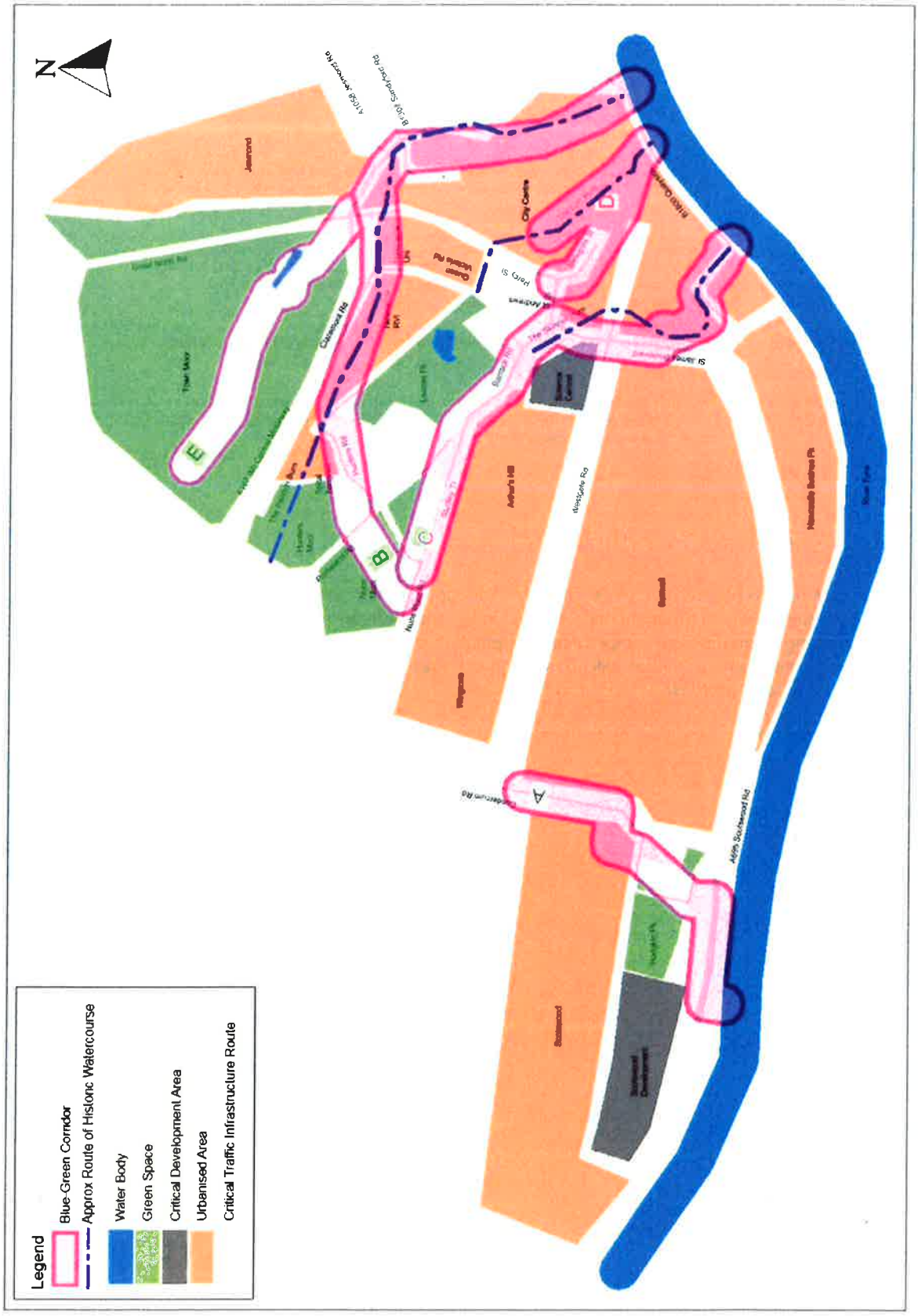


Table 5.1 Blue-Green Corridors

Location	Route of Potential Blue-Green Corridor	Opportunity Area (Shown on Fig 5.1)
Benwell to Scotswood Road	Route starts from the north of Benwell and traverses down Condercum Road and Atkinson Road then heading across Hodgkin Park and Whitehouse Road before turning onto Scotswood Road and discharging into the River Tyne.	A
Newcastle North to Quayside	Route B(1) is from Wingrove in the northwest of the city traversing across Nuns Moor and Hunters Moor before running along the north of the Newcastle RVI and then through The University of Newcastle upon Tyne Campus. The route then follows the line of the old Pandon Burn from the Civic Centre to Broad Chare at the Quayside.	B
Newcastle West to Quayside	Route is from Wingrove in the northwest of the city traversing down Studley Terrace and Barrack Road before turning onto St James Boulevard and running south towards the route of the old Skinner Burn from Westgate Road to Skinnerburn Road at the Quayside.	C
Newcastle City to Quayside	Route is from the city centre and Newgate Street traversing down Grey Street and Dean Street along the route of the old Lort Burn to the Quayside	D
Town Moor to Newcastle City	Route is from the north of the City from the Town Moor and Brandling Park joining in the area of The University of Newcastle upon Tyne, which then joins corridor B from Newcastle North	E

5.3 Short List Opportunity Assessment

In accordance with FDGiA procedure, the short list opportunities will include a 'Do Nothing' and a 'Do Minimum' scenarios. All potential opportunities in isolation will form the 'Do Something' scenarios and the 'Do Everything' scenarios will comprise implementation of all the potential opportunities as well as an opportunity where any properties still considered to be 'as risk' from surface water flooding will be addressed using property level protection (PLP or local Measures).

The finalised opportunity short list, along with high-level explanations are shown in Table 5.2.

Table 5.2 Short List Opportunities

Opportunity		Brief Description
Do Nothing		Assumes that regular maintenance by NCC and NW is not undertaken (worst case Scenario) *
Do Minimum		Assumes that the current maintenance regimes undertaken by NCC and NW are continued (continue as normal scenario)
Do Something	Opportunity Area A: Scotswood and Benwell SW Improvements	Surface water separation in Benwell and Scotswood, plus drainage improvements in Scotswood Road A694 and provision of flood walls on central reservations so eastbound carriageway towards city centre can act as sacrificial flood area Ensure any flows originating from 'The Rise' development in Scotswood is maintained and managed on site. Retro fitting of SUDS into a number of schools in the Benwell catchment and provision of natural flood management techniques on Hodgkin Park and Scotswood Embankment.
	Opportunity Area B: Nuns Moor and Hunters Moor	Greening of residential streets in Wingrove and Spital Tongues, plus retro-fitting of SUDS at commercial properties at Holland Park, the Royal Victoria Infirmary (RVI) and at Newcastle University with a new surface water outfall to the River Tyne (via the NWL Broad Chare Storm Sewer option). Provision of natural flood management techniques on Nuns Moor and Hunters Moor. Drainage improvements on Ponteland Road and Brighton Grove, plus re-profiling of highway and verge on eastbound carriageway towards city centre to act as sacrificial flood area whilst maintaining 2 lanes of traffic.
	Opportunity Area C: Studley Terrace, Barrack Road & St James Boulevard	Greening of residential streets in Wingrove, plus surface water attenuation on Nuns Moor Park and new combined flow tank on Leases Park. Drainage improvements on Barrack Road and St James Boulevard (possible new open channel or swale) with a new surface water outfall to the River Tyne. Ensure any surface water originating from 'Science Central' development in Newcastle is maintained and managed on site.
	Opportunity Area D: Newcastle Quayside	Formulise exceedance route down Newgate Street and Dean Street to the River Tyne at the Quayside, relocation of Tuthill Stairs CSO plus flooding protection on the Quayside to protect against high river levels.
	Opportunity Area E: Town Moor, Brandling Park and RGS	Provision of natural flood management techniques on Town Moor, and retro-fitting of SUDS to building at Exhibition Park with a new surface water outfall to the River Tyne (via the NWL Broad Chare Storm Sewer option).
Do Everything	Combination of all Opportunity Areas	Assumes that all four of the above surface water opportunities are implemented
	Combination of all Opportunity Areas with Property Level Protection or Local Measures	Assumes that all four of the above surface water opportunities are implemented, plus the remaining properties in the study area which are deemed to be 'at risk' from surface water flooding to be installed with property level protection or PLP or Local Measures.

* NW has a legal obligation to maintain the public sewer network.

5.4 Assumptions for Retro-Fitting SUDS

Significant opportunities have been identified for retro-fitting SUDS in the Newcastle City study.

The 'Do Something' opportunities involve SUDS retrofitting to existing buildings along the pathways identified in the Blue/Green corridors. With the exception of the greening of residential areas of Wingrove and Spital Tongues in Opportunities B and C, the remaining potential retrofit sites have been restricted to larger public buildings such as schools, hospitals, universities and government owned sites with single landlords or landowners.

For Opportunity Area B some larger private buildings at Holland Park Industrial Estate were identified for retrofit due to their strategic location.

Table 5.3 Retro-Fit Assumptions shows the assumptions and concepts considered when identifying SUDS retro fit opportunities.

Table 5.3 Retro-Fit Assumptions

SUDS	Key Assumptions
Green roofs, rain garden rain water harvesting	Assumed to be installed to 50% of the available roof area, proportion of area allocated to green roofs, rain gardens and harvesting has been equally distributed
Permeable paving	Assumed to be installed to 50% of the paved area (i.e. car parking, pedestrian walkways and estate roads etc.)
Residential rain water harvesting	Residential house assumed to have 60m^2 roof area with 50% set aside for rainwater harvesting/water butts.
Residential rain gardens	Residential gardens assume to be 15m^2 with 50% set aside for rain gardens

5.5 Do Nothing (Baseline)

5.5.1 Overview

This is considered to be the 'baseline' model for the assessment process and used as the comparison scenario for FDGiA assessment and comprises the whole study area. It was developed under the assumption that no maintenance (routine or otherwise) is carried out by NW and NCC.

The following changes have been made to the 2015 and 2030 models to represent the absence of any maintenance on the sub-surface and surface drainage networks:

- Sediment levels increased to 50% for all sewers with 1 in 5yr flows less than 1.0m/s;
- Sediment levels increased to 50% for all sewers with high downstream head-losses;
- Sediment levels in all other sewers increase to 10%;
- Roughness levels of all sewers increased and degraded; and,
- All highway gullies assumed to be fully blocked.

Although, it has been assumed that no maintenance of the sewer network has taken place, NW have a legal obligation to maintain the public sewers in a satisfactory condition.

5.5.2 Flood Risk Assessment

The surface water flood risk ascertained at various receptors for the 2015 scenario is shown in Table 5.3 whilst the flood risk when development, climate change are urban creep up to the 2030 timeline is considered is shown in Table 5.4.

Table 5.4 Flood Risk Assessment Summary for 'Do Nothing' (2015)

Receptor Type	Low Risk	Moderate Risk	Significant Risk	Very Significant Risk
Residential Buildings	10,138	71	32	118
Commercial Buildings	961	29	11	150
Critical Infrastructure	178	6	0	25
Other Buildings	1,525	52	26	195
Total Buildings	12,802	158	69	488
Critical Traffic Infrastructure Routes				
A695 Scotswood Road	Flooding is considered to be in the 'Very Significant Risk' category, model predicts in excess of 300mm during the 1 in 5 year RP event.			
A189 Ponteland Road	Flooding is considered to be in the 'Very Significant Risk' category, model predicts in excess of 300mm during the 1 in 5 year event.			
Queen Victoria Road	Flooding is considered to be in the 'Very Significant Risk' category, model predicts flooding in excess of 300mm during the 1 in 5 year event			
Sandyford Road Underpass	Flooding is considered to be in the 'Very Significant Risk' category, model predicts flooding in excess of 300mm during the 1 in 20 year event.			
A189 Barrack Road and Newgate Street	Flooding is considered to be in the 'Low Risk' category, model predicts run-off however depths are low due to the steep gradient. Significant impacts are noted downstream during events greater than 1 in 5 year return period. Flooding at Newgate Street is considered to be in the 'Very Significant Risk' category, model predicts flooding in excess of 300mm during the 1 in 20 year event			

Need to check in model to confirm levels prior to final issue of report

Table 5.5 Flood Risk Assessment Summary for 'Do Nothing' (2030)

Receptor Type	Low Risk	Moderate Risk	Significant Risk	Very Significant Risk
Residential Buildings	10,066	89	44	160
Commercial Buildings	904	49	20	178
Critical Infrastructure	161	16	5	27
Other Buildings	1,455	84	28	231
Total Buildings	12,586	238	97	596
Critical Traffic Infrastructure Routes				
A695 Scotswood Road	Flooding is considered to be in the 'Very Significant Risk' category, model predicts in excess of 300mm during the 1 in 5 year return period event.			
A189 Ponteland Road	Flooding is considered to be in the 'Very Significant Risk' category, model predicts in excess of 300mm during the 1 in 5 year return period event			
Queen Victoria Road	Flooding is considered to be in the 'Very Significant Risk' category, model predicts flooding in excess of 300mm during the 1 in 5 year return period event			
Sandyford Road Underpass	Flooding is considered to be in the 'Very Significant Risk' category, model predicts flooding in excess of 300mm during the 1 in 20 year return period event			
A189 Barrack Road and Newgate Street	Flooding is considered to be in the 'Low Risk' category, model predicts run-off however depths are low due to the steep gradient. Significant impacts are noted downstream during events greater than 1 in 5 year return period event. Flooding at Newgate Street is considered to be in the 'Very Significant Risk' category, model predicts flooding in excess of 300mm during the 1 in 20 year return period event			

Need to check in model to confirm levels prior to final issue of report

5.5.3 Summary

'Do Nothing' opportunity does not require any expenditure from either NCC or NW.

The opportunity results in a significant numbers of properties being placed in the 'Very Significant Risk' banding for the 2015 and 2030 scenarios respectively. There is a significant increase in the flood risk in the study area as a result of the on-set of climate change, urban creep and future development.

This opportunity clearly demonstrates the need for continual maintenance of the drainage infrastructure, it is considered by the key stakeholders to be an unacceptable. However, it should be noted that NW do have a legal obligation to maintain the public sewer network.

5.6 Do Minimum

This comprises the whole study area and has been developed under the assumption that regular maintenance (routine or otherwise) is carried out by NW and NCC and the sewers and gullies are unblocked and operating as design.

5.6.1 Flood Risk Assessment

The surface water flood risk ascertained at various receptors for the 2015 scenario is shown in Table 5.5 whilst the flood risk when development, climate change are urban creep up to the 2030 timeline is considered is shown in Table 5.6.

Table 5.6 Flood Risk Assessment Summary for 'Do Minimum' (2015)

Receptor Type	Low Risk		Moderate Risk		Significant Risk		Very Significant Risk	
Residential Buildings	10,183	45	68	-3	19	-13	89	-29
Commercial Buildings	983	22	39	10	7	-4	122	-28
Critical Infrastructure	179	1	6	0	0	0	24	-1
Other Buildings	1,562	37	49	-3	25	-1	162	-33
Total Buildings	12,907	105	162	4	51	-18	397	-91
(+ X) (- Y)	The (+/-) indicate the moving of properties between risk bandings when compared to the 'Do Nothing' opportunity for the 2015 time scenario							
Critical Traffic Infrastructure Routes								
A695 Scotswood Road	Flooding is considered to be in the 'Very Significant Risk' category, model predicts in excess of 300mm during the 1 in 5 year return period event							
A189 Ponteland Road	Flooding is considered to be in the 'Very Significant Risk' category, model predicts in excess of 300mm during the 1 in 5 year return period event							
Queen Victoria Road	Flooding is considered to be in the 'Significant Risk' category, model predicts flooding in excess of 300mm during the 1 in 40 year return period event							
Sandyford Road Underpass	Flooding is considered to be in the 'Significant Risk' category, model predicts flooding in excess of 300mm during the 1 in 20 year return period event.							
A189 Barrack Road and Newgate Street	Flooding is considered to be in the 'Low Risk' category, model predicts run-off however depths are low due to the steep gradient. Significant impacts are noted downstream during events greater than 1 in 5 year return period event. Flooding at Newgate Street is considered to be in the 'Significant Risk' category, model predicts flooding in excess of 300mm during the 1 in 40 year return period event							

Table 5.7 Flood Risk Assessment Summary for 'Do Minimum' (2030)

Receptor Type	Low Risk		Moderate Risk		Significant Risk		Very Significant Risk	
Residential Buildings	10,183	45	68	-3	19	-13	89	-29
Commercial Buildings	983	22	39	10	7	-4	122	-28
Critical Infrastructure	179	1	6	0	0	0	24	-1
Other Buildings	1,562	37	49	-3	25	-1	162	-33
Total Buildings	12,907	105	162	4	51	-18	397	-91
(+ X) (- Y)	The (+/-) indicate the moving of properties between risk bandings when compared to the 'Do Nothing' opportunity as the result of this intervention for the 2030 time scenario							
Critical Traffic Infrastructure Routes								
A695 Scotswood Road	Flooding is considered to be in the 'Very Significant Risk' category, model predicts in excess of 300mm during the 1 in 5 year return period event.							
A189 Ponteland Road	Flooding is considered to be in the 'Very Significant Risk' category, model predicts in excess of 300mm during the 1 in 5 return period event							
Queen Victoria Road	Flooding is considered to be in the 'Very Significant Risk' category, model predicts flooding in excess of 300mm during the 1 in 20 year return period event							
Sandyford Road Underpass	Flooding is considered to be in the 'Significant Risk' category, model predicts flooding in excess of 300mm on during the 1 in 20 year return period event							
A189 Barrack Road and Newgate Street	Flooding is considered to be in the 'Low Risk' category, model predicts run-off however depths are low due to the steep gradient. Significant impacts are noted downstream during events greater than 1 in 5 year return period event. Flooding at Newgate Street is considered to be in the 'Very Significant Risk' category, model predicts flooding in excess of 300mm during the 1 in 20 year return period event							

5.6.2 Summary

The following flood risk benefits have been established for the 'Do Minimum' scenario:

- There is a noticeable reduction in both residential and non-residential properties at risk of flooding, or movement in properties from higher risk bands to lower risk bands from the instigation of a planned maintenance routine;
- The study area flood risk increases for the 2030 scenario as the impacts due to urban creep, climate change and development take effect and,
- There are minor improvements in the predicted flooding at the five critical infrastructure transport routes.

5.7 Do Something - Opportunity Area A

5.7.1 Overview

This opportunity is centred in the areas of Scotswood Road and Benwell on the western edge of Newcastle and are a combination of the following 'Long List' opportunities; Scotswood Road highway improvements, Benwell SUDS for School and Hodgkin Park and Wellfield Road SW Separation.

This opportunity proposes that SUDS (green roofs, rain gardens, rainwater harvesting and permeable paving) are retrofit to a number of schools and community buildings in this area, including:

- St Joseph's RC Primary School;
- Atkinson Road Primary School;
- South Benwell Primary School;
- The Adelaide Centre;
- Canning Street Primary School; and,
- Wingrove Primary School.

A schematic of the proposed opportunity is shown in Figure 5.2.

5.7.2 Flood Risk Assessment

The surface water flood risk ascertained at the 316 associated receptors in the Scotswood area for the 2015 scenario is shown in Table 5.7 whilst the flood risk when development, climate change are urban creep up to the 2030 timeline is considered is shown in Table 5.8.

Table 5.8 Flood Risk Assessment Summary for Opportunity Area A (2015)

Receptor Type	Low Risk		Moderate Risk		Significant Risk		Very Significant Risk	
Residential Buildings	218	6	0	-5	2	0	8	-1
Commercial Buildings	14	5	5	2	1	-2	8	-5
Critical Infrastructure	6	0	1	0	0	0	3	0
Other Buildings	39	10	0	-1	1	-1	10	-8
Total Buildings	277	21	6	-4	4	-3	29	-14

(+ X)
(- Y)

The (+/-) indicate the moving of properties between risk bandings when compared to the 'Do Nothing' opportunity as a result of this intervention for the 2015 time scenario

Critical Traffic Infrastructure Routes

A695 Scotswood Road	Flooding retained in sacrificial flood area on eastbound carriageway towards city centre during the 1 in 20 year return period event. However, westbound carriage does not exceed 300mm until the 1 in 100 year return period event.

Table 5.9 Flood Risk Assessment Summary for Opportunity Area A (2030)

Receptor Type	Low Risk		Moderate Risk		Significant Risk		Very Significant Risk	
Residential Buildings	214	11	5	-2	2	-6	7	-3
Commercial Buildings	14	5	5	3	0	-3	7	-7
Critical Infrastructure	6	4	2	-2	2	1	2	-1
Other Buildings	38	9	1	0	1	-2	10	-7
Total Buildings	272	29	13	-1	5	-10	26	-18

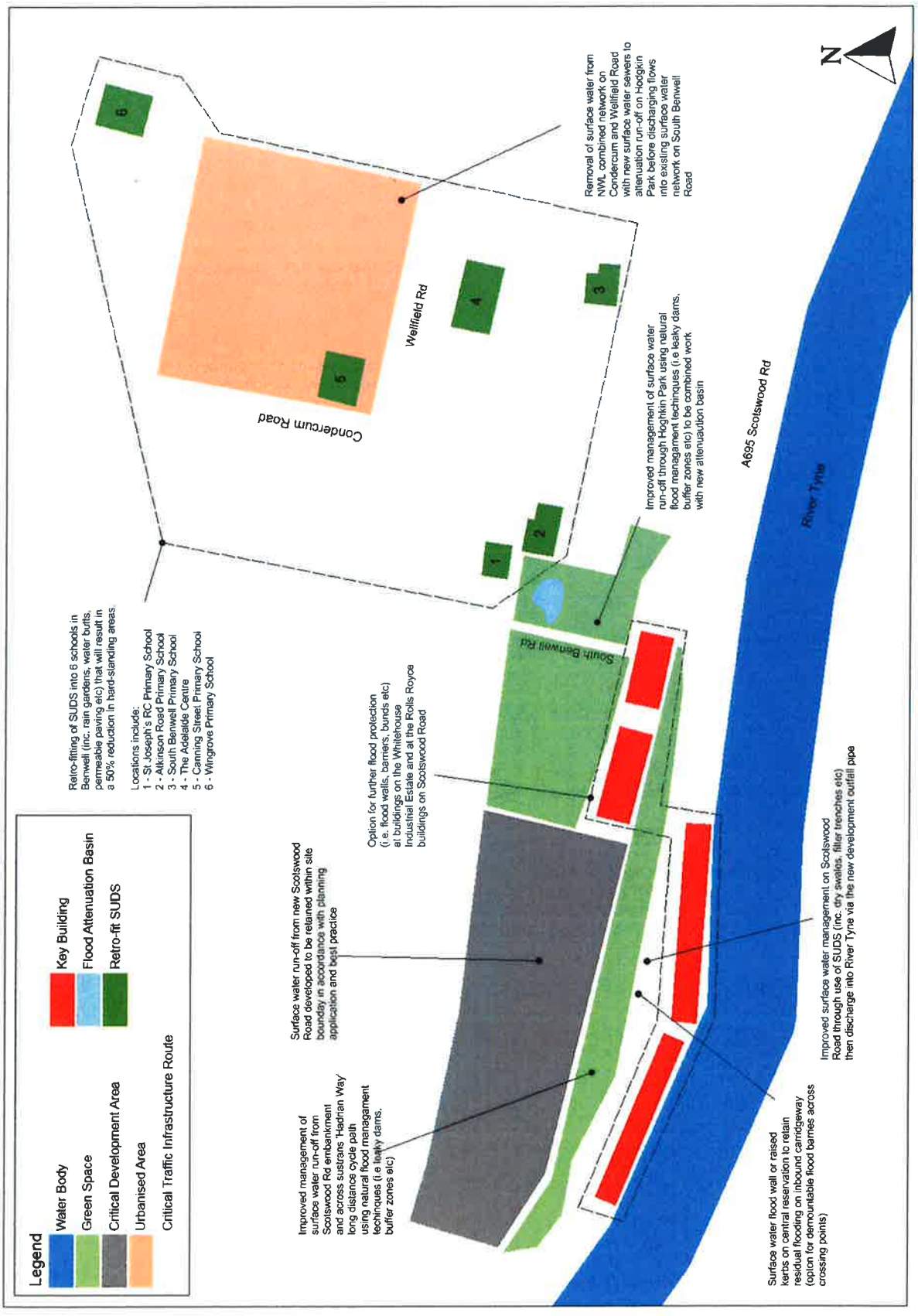
(+ X)
(- Y)

The arrows indicate the moving of properties between risk bandings when compared to the 'Do Nothing' opportunity as a result of this intervention for the 2030 time scenario

Critical Traffic Infrastructure Routes

A695 Scotswood Road	Flooding retained in sacrificial flood area on eastbound carriageway towards city centre during the 1 in 20 year return period event. However, westbound carriage does not exceed 300mm until the 1 in 100 year return period event.

Figure 5.2 Opportunity Area A



5.7.3 Summary

The following flood risk benefits have been established for Opportunity Area A.

- Interventions provide a general reduction in flood risk to nearby buildings both residential and non-residential (including B&A systems, Rolls Royce Marine Electrical Systems, Volvo and Benfield Motors and the buildings within the Whitehouse Road Industrial Estate);
- Risk reduction from higher to lower, properties within the higher risk bandings are moved to lower risk categories;
- There will still be some residual flood risk in this opportunity area, which may need to be addressed through the installation of PLP or Local Measures;
- Ensures resilience of the A695 Scotswood Road at the low spot up to the 100 year flood event and maintains access along this corridor using the west bound carriageway only, supporting economic growth for the region and aligning with the Traffic Asset Management Plan (TAMP);
- The study area flood risk increases for the 2030 scenario as the impacts due to urban creep, climate change and development take effect. However, the level of flood risk reduction as a result of the opportunity is maintained from the 2015 to the 2030 scenarios; and,
- There is an improvement in flood risk in 2030 as a result of measures incorporated in 'The Rise' development in Scotswood, as when the site is fully developed any overland flows from the site will be managed on site in accordance with the planning conditions and discharged via the newly constructed surface water culvert under the Scotswood Road. This significantly reduces flows from the site onto Scotswood Road and the buildings directly to the south.

There are historical reports of property flooding incidents in the proximity of the rise development which could potentially be addressed with the implementation of this opportunity, further increasing the flood risk benefits.

In addition, the above opportunity aligns with the NCC Green Infrastructure Strategy and the Environment Agency's River Basin Management Plan for the lower Tyne.

Other strategic benefits include:

- Removing surface water from the combined network by the separation of the flows further up the catchment to reduce the volumes and frequencies of CSO spills into the River Tyne and thus improving water quality. This also reduces the amount of surface water in the combined network and the volumes of sewerage which require pumping at terminal pumping stations and treatment. This aligns strategically with objectives set out in the Water Cycle Study and Climate Change Strategies;
- NCC have already removed flows from the NWL combined sewer though the disconnection of the Delaval drift mine;
- Community involvement and 'SUDS for Schools' educational benefits from the retrofitting of SUDS to schools in the Benwell catchment which compliments the aims of the Blue Green Cities Concept;
- Creation of new habitats within new greened areas including the proposed swale along Scotswood Road;
- Provide improvements to the water quality of the River Tyne from the use of SUDS; and;
- Provides further community benefits and an improved sense of wellbeing as a result of proposed works to Hodgkin Park, which also aligns with objectives set out in the NCC Biodiversity Action Plan, Green Space and Tree Strategy.

5.8 Do Something - Opportunity Area B

5.8.1 Overview

This opportunity is centred in the areas of Nuns Moor, Hunter Moor, the RVI and The University of Newcastle upon Tyne in the north west of the city centre and are a combination of the following 'Long List' opportunities; Nuns Moor SW Improvements, Hunters Moors and Local SUDS Opportunities, The University of Newcastle upon Tyne & RVI SUDS and Newcastle Civic Centre SUDS as well as integrating it into the proposed plans for the Broad Chare storm sewer.

This opportunity proposes that SUDS (green roofs, rain gardens, rainwater harvesting and permeable paving) are retrofitted to a number of large public and private buildings in this area, including:

- Residential area in Wingrove and Spital Tongues;
- Holland Park (Inc. the BBC);
- Newcastle RVI;
- Castle Leazes Student Accommodation;
- Richardson Road Student Accommodation;
- Newcastle University Campus; and
- Newcastle Council's Civic Centre.

A schematic of the proposed opportunity is shown in Figure 5.3.

5.8.2 Flood Risk Assessment

The surface water flood risk ascertained at 1,205 associated receptors in northwest of the city for the 2015 scenario is shown in Table 5.9 whilst the flood risk when development, climate change are urban creep up to the 2030 timeline is considered is shown in Table 5.10.

Table 5.10 Flood Risk Assessment Summary for Opportunity Area B (2015)

Receptor Type	Low Risk		Moderate Risk		Significant Risk		Very Significant Risk	
Residential Buildings	943	29	22	-7	11	-3	16	-19
Commercial Buildings	36	4	2	-1	0	0	11	-3
Critical Infrastructure	12	1	0	-1	0	0	3	0
Other Buildings	106	18	6	-11	3	0	34	-7
Total Buildings	1,097	52	30	-20	14	-3	64	-29

(+ X) (- Y) The (+/-) indicate the moving of properties between risk bandings when compared to the 'Do Nothing' opportunity as a result of this intervention for the 2015 time scenario only

Critical Traffic Infrastructure Routes

A189 Ponteland Road	Flooding retained in sacrificial flood area on eastbound carriageway towards city centre during the 1 in 20 year return period event. However, westbound carriage does not exceed 300mm until the 1 in 200 year return period event.
Queen Victoria Road	Flooding now considered to be 'Low Risk' only

Table 5.11 Flood Risk Assessment Summary for Opportunity Area B (2030)

Receptor Type	Low Risk		Moderate Risk		Significant Risk		Very Significant Risk	
Residential Buildings	936	36	28	4	3	-16	25	-24
Commercial Buildings	36	6	3	0	0	0	10	-6
Critical Infrastructure	12	3	0	-2	0	-1	3	0
Other Buildings	103	13	7	-5	4	-1	35	-7
Total Buildings	1,087	58	38	-3	7	-18	73	-37

(+ X) (- Y) The (+/-) indicate the moving of properties between risk bandings when compared to the 'Do Nothing' opportunity as a result of this intervention for the 2030 time scenario only

Critical Traffic Infrastructure Routes

A189 Ponteland Road	Flooding retained in sacrificial flood area on eastbound carriageway towards city centre during the 1 in 20 year return period event. However, westbound carriage does not exceed 300mm until the 1 in 200 year return period event.
Queen Victoria Road	Flooding now considered to be 'Low Risk' only

Figure 5.3 Opportunity Area B

5.8.3 Summary

The following flood risk benefits have been established for Opportunity Area B.

- Provides a general reduction in flood risk to nearby buildings, both residential properties in Wingrove and Spital Tongues and non-residential properties at The University of Newcastle upon Tyne including Mertz Court, the RVI, the BBC studios and the buildings within the Holland Park Industrial Estate;
- Risk reduction from higher to lower, properties within the higher risk bandings are moved to lower risk categories;
- There is a general reduction in the overland flow route which affects the north of the city centre;
- Ensures the flood resilience of the on A189 Ponteland Road and allows access and egress to Newcastle City Centre via the outbound carriageway up to and including a 100 year event in line with the TAMP;
- Ensures access to the RVI Hospital via Queen Victoria Road can be maintained up to and including a 1 in 200 year event in line with the TAMP;
- The study area flood risk increases for the 2030 scenario as the impacts due to urban creep, climate change and development take effect, however the level of flood risk reduction as a result of the opportunity is maintained from the 2015 to the 2030 scenarios; and,
- Provides future opportunities for working with other stakeholders and communities including; The University of Newcastle upon Tyne, Newcastle Upon Tyne NHS Trust, the Freeman of Newcastle and other private landowners and local residents.

This opportunity could be enhanced further by combining with the Broad Chare storm sewer opportunity. This would allow for further development of this area and provide a dedicated surface water outlet for future development or SUDS measures, as well as improving sewer discharges to the River Tyne through screening of the storm flows.

The above opportunity aligns with the NCC Green Infrastructure Strategy, the Environment Agency's River Basin Management Plan for the Lower Tyne and the Newcastle Partnerships Climate Change Strategy.

Other strategic benefits include:

- Reducing run-off from Wingrove, Spital Tongues, The University of Newcastle upon Tyne, RVI Hospital and 'greening' of the areas through the installation of SUDS (water butts, rain gardens etc) will improve the sense of well-being for these areas as well as providing further opportunities for community involvement. This aligns with the objectives set out in the Blue Green Cities concept and the Water Cycle Study;
- Provide improvements to the water quality of the River Tyne from the use of SUDS;
- Increases the value of the amenity through the potential for the creation of green roofs at Holland Park Industrial Estate, Castle Leazes and Richardson Road student accommodation, the RVI, The University of Newcastle upon Tyne and the Civic Centre.
- Improve drainage of Nuns Moor and Hunters Moor, which may increase the potential of the land for agricultural use and grazing of cattle which is an essential component of the NCC Biodiversity Action Plan and Green Space and Tree Strategies; and,
- Allows the opening of a green corridor across the Nuns Moor and Hunters Moor, through The RVI and The University of Newcastle upon Tyne campus along the route of the old Pandon Burn. This could contribute to further sustainable measures being developed by third parties, which is aligned with the Blue Green Cities Concept.

5.9 Do Something - Opportunity Area C

5.9.1 Overview

This opportunity is centred of the areas of Studley Terrace, Barrack Road and St James Boulevard to the west of the city centre and are a combination of the following 'Long List' opportunities; Studley Terrace SW Improvements, Barrack Road Highway Improvements, St James Boulevard SW Sewer; and Newgate Street.

This opportunity proposes that SUDS (green roofs, rain gardens, rainwater harvesting and permeable paving) are retrofitted toa residential area in Wingrove.

A schematic of the proposed opportunity is shown in Figure 5.4.

5.9.2 Flood Risk Assessment

The surface water flood risk ascertained at 1,682 associated receptors in the west of the city for the 2015 scenario is shown in Table 5.11 whilst the flood risk when development, climate change are urban creep up to the 2030 timeline is considered is shown in Table 5.12.

Table 5.12 Flood Risk Assessment Summary for Opportunity Area C (2015)

Receptor Type	Low Risk		Moderate Risk		Significant Risk		Very Significant Risk	
Residential Buildings	1,269	3	12	2	8	4	17	-9
Commercial Buildings	153	10	4	-2	1	-1	26	-7
Critical Infrastructure	9	1	0	-1	0	0	7	0
Other Buildings	133	5	3	-1	4	2	36	-6
Total Buildings	1,564	19	19	-2	13	5	86	-22

(+ X)
(- Y)

The (+/-) indicate the moving of properties between risk bandings when compared to the 'Do Nothing' opportunity as a result of this intervention for the 2015 time scenario only

Critical Traffic Infrastructure Routes

A189 Barrack Road and Newgate Street	Flooding now considered to be reduced on Barrack Road and considered to be in the 'Moderate Risk' category on Newgate Street as flood depths do not exceed 300mm until the 1 in 100 year return period event.

Table 5.13 Flood Risk Assessment Summary for Opportunity Area C (2030)

Receptor Type	Low Risk		Moderate Risk		Significant Risk		Very Significant Risk	
Residential Buildings	1,276	16	5	-6	5	0	21	-10
Commercial Buildings	157	32	5	-6	1	-6	21	-19
Critical Infrastructure	9	0	1	0	0	0	6	0
Other Buildings	135	19	5	-2	0	-4	36	-13
Total Buildings	1,577	67	16	-14	6	-10	84	-42

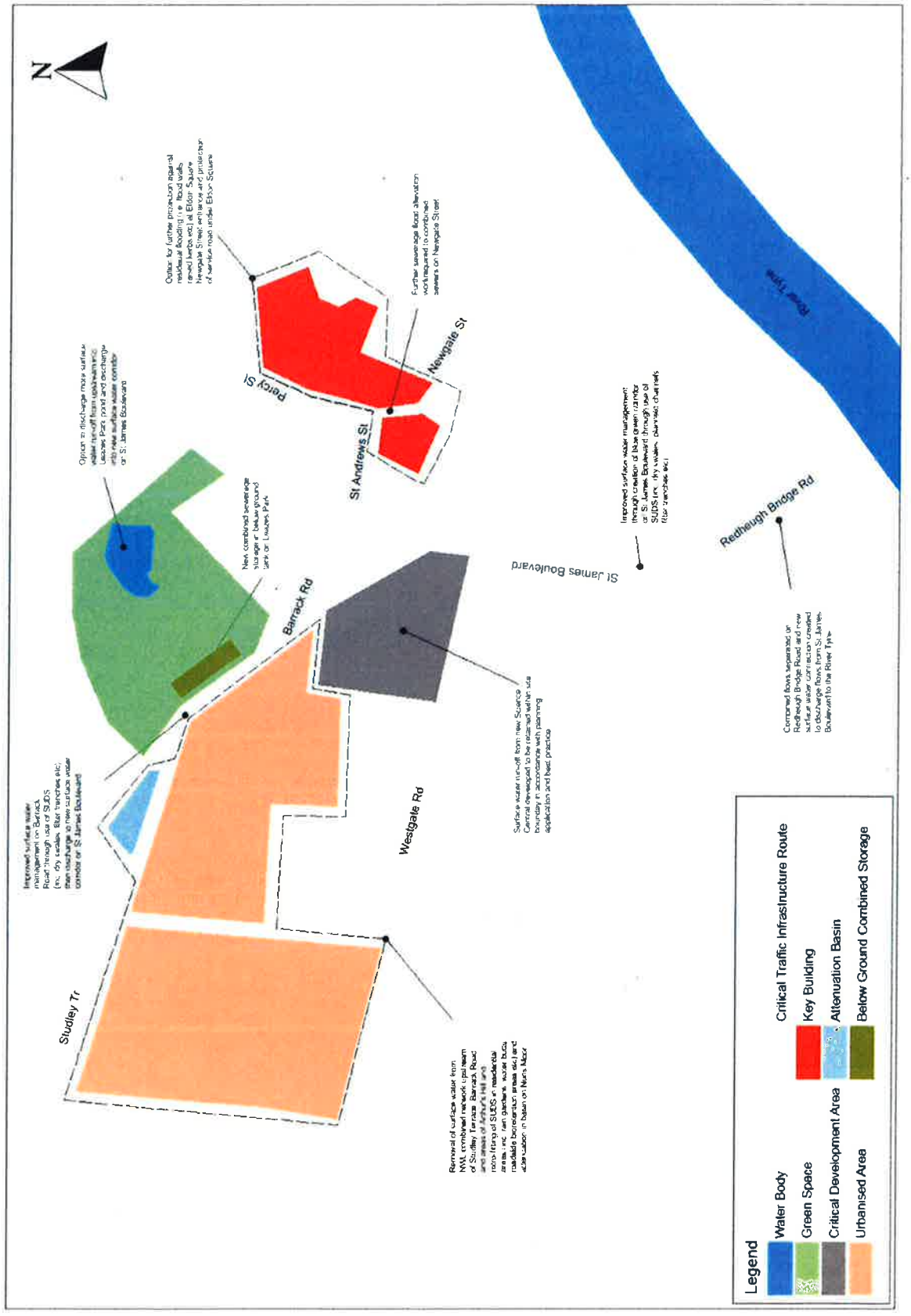
(+ X)
(- Y)

The (+/-) indicate the moving of properties between risk bandings when compared to the 'Do Nothing' opportunity as a result of this intervention for the 2030 time scenario only

Critical Traffic Infrastructure Routes

A189 Barrack Road and Newgate Street	Flooding now considered to be reduced on Barrack Road and considered to be in the 'Moderate Risk' category on Newgate Street as flood depths do not exceed 300mm until the 1 in 100 year return period event.

Figure 5.4 Opportunity Area C



5.9.3 Summary

The following flood risk benefits have been established from interventions in Opportunity Area C:

- Provides a general reduction in flood risk to nearby buildings, both residential properties in Wingrove and Arthur's Hill and some non-residential properties within the City Centre, St James Boulevard and Westgate Road;
- Risk reduction from higher to lower, properties within the higher risk bandings are moved to lower risk categories;
- There is a reduction in flood volumes arriving at Eldon Square as a result of this opportunity, however further reduction is demonstrated through the construction of a small flood wall or raised kerbs on Newgate Street which mitigates residual flood risk;
- Flood risk reduction to the highways at the junction of Newgate Street and St Andrews Street as well as a significant reduction of the volume of run-off on Barrack Road. This helps to increase the resilience of the highway network during flood event which supports economic growth for the region and aligns with the TAMP;
- During the 2030 scenario there is additional impact from any new developments, including Science Central. When fully developed it is assumed that any overland flows from the development will be managed on site in-accordance with the local planning conditions. This will significantly reduce the flows from the site affecting some of the affecting the downstream properties and infrastructure;
- The study area flood risk increases for the 2030 scenario as the impacts due to urban creep, climate change and development take effect, however the level of flood risk reduction as a result of the opportunity is maintained from the 2015 to the 2030 scenarios; and,
- Provides future opportunities for working with other stakeholders and communities including; the Freeman of Newcastle and other private landowners and local residents.

It should be noted that the above opportunity aligns with the NCC Green Infrastructure Strategy, the Environment Agency's River Basin Management Plan for the lower Tyne and the Newcastle Partnerships Climate Change Strategy. In addition, the development of a surface water corridor along St James Boulevard aligns closely with the objectives set out in the Blue Green Cities Concept.

Other strategic benefits include:

- Reduces run-off from the Studley Terrace area and the general 'greening' of the areas through the installation of SUDS (water butts, rain gardens etc.) as well as increased further opportunities for community involvement, which aligns with the objective in the Water Cycle Study;
- Provides a surface water conduit along the western edge of the city from St James Park to the Quayside, which could be used to serve the high profile Science Central Development. Also, this could help reduce the volume of surface water in the combined network to help increase sewer capacity to facilitate future growth and development in the west of the city;
- Provide improvements to water quality of the River Tyne from the use of SUDS; and,
- Further opportunities for the 'Greening' of Barrack Road and St James Boulevard, through the provision of swales or other similar open water sections of green infrastructure.

5.10 Do Something - Opportunity Area D

This opportunity is centred in the areas of Newgate Street and down to Newcastle Quayside. These opportunities were not taken further as part is this strategic study for the reasons illustrated in section 5.2

Further information on the opportunity being investigated by NCC in this area of Newcastle can be view in the appropriate URS/AECOM report available from NCC.

5.11 Do Something - Opportunity Area E

5.11.1 Overview

This opportunity is centred in the areas of the Town Moor, Brandling Park and the RGS in the north of the city centre and comprise the 'Long List' opportunity identified at the Town Moor. It was established that NCC were presently engaged in flood risk management planning in the area local to Brandling Park and Sandyford Road underpass. It was agreed to incorporate results from this local investigation into this strategic study, specifically relating to the Broad Chare storm sewer opportunity.

For further detail on these investigation refer to the 'Sandyford Road Underpass Surface Water Study (July 2015)' produced by Grontmij.

This opportunity proposes that SUDS (green roofs, rain gardens, rainwater harvesting and permeable paving) are retrofitted to public spaces and private buildings in the vicinity of the Toon Moor and Brandling Park.

A schematic of the proposed strategic opportunity is shown in Figure 5.3.

5.11.2 Flood Risk Assessment

The surface water flood risk ascertained at 632 associated receptors in the north of the city for the 2015 scenario is shown in Table 5.13 whilst the flood risk when development, climate change are urban creep up to the 2030 timeline is considered is shown in Table 5.14.

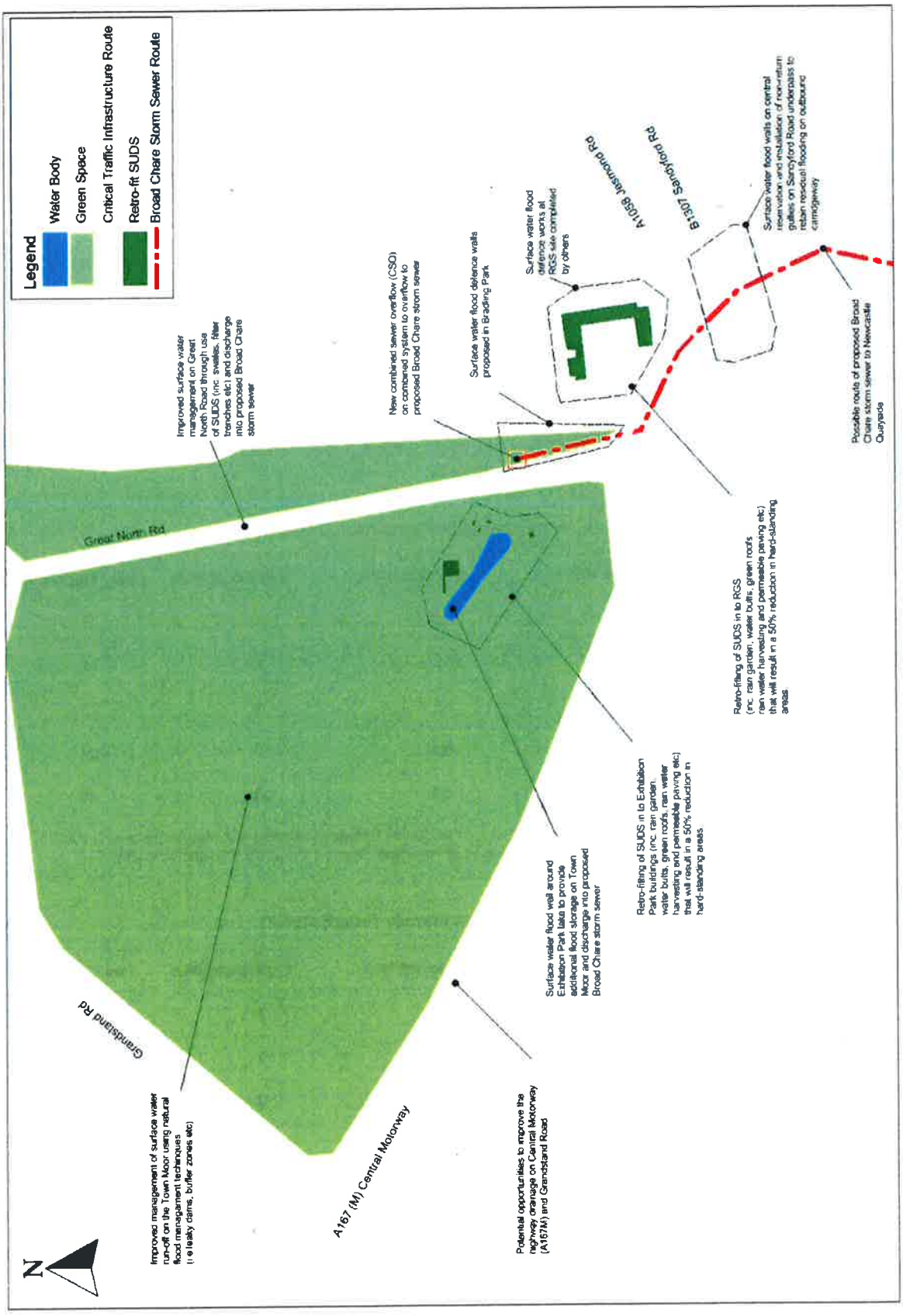
Table 5.14 Flood Risk Assessment Summary for Opportunity Area E (2015)

Receptor Type	Low Risk		Moderate Risk		Significant Risk		Very Significant Risk	
Residential Buildings	344	20	10	-9	8	2	9	-13
Commercial Buildings	40	1	1	0	2	2	4	-3
Critical Infrastructure	17	0	2	1	0	0	2	-1
Other Buildings	156	6	11	-1	1	-4	24	-1
Total Buildings	557	27	24	-9	11	0	39	-18
(+ X) (- Y)	The (+/-) indicate the moving of properties between risk bandings when compared to the 'Do Nothing' opportunity as a result of this intervention for the 2015 time scenario only							

Table 5.15 Flood Risk Assessment Summary for Opportunity Area E (2030)

Receptor Type	Low Risk		Moderate Risk		Significant Risk		Very Significant Risk	
Residential Buildings	277	48	17	-14	3	-5	7	-29
Commercial Buildings	60	3	7	4	0	-3	2	-4
Critical Infrastructure	25	3	2	0	0	-3	1	0
Other Buildings	188	-1	17	10	2	-1	23	-8
Total Buildings	550	53	43	0	5	-12	33	-41
(+ X) (- Y)	The (+/-) indicate the moving of properties between risk bandings when compared to the 'Do Nothing' opportunity as a result of this intervention for the 2030 time scenario only							

Figure 5.5 Opportunity Area E



5.11.3 Summary

The following flood risk benefits have been established from interventions in Opportunity Area E:

- Provides a general reduction in flood risk to nearby buildings, both residential properties in the southern area of Jesmond and some non-residential properties within the north of the city centre;
- Risk reduction from higher to lower, properties within the higher risk bandings are moved to lower risk categories;
- Reduces the flooding impacts on Brandling Park and the RGS from run-off generated on the Town Moor;
- Any further resilience of the Sandyford Road underpass maintains access along this corridor using the west bound carriageway, supports economic growth for the region and aligns with the TAMP;
- The study area flood risk increases for the 2030 scenario as the impacts due to urban creep, climate change and development take effect, however significant flood risk is still maintained during the future scenario; and,
- Provides future opportunities for working with other stakeholders and communities including; the Freeman of Newcastle and other private landowners and local residents.

This opportunity could be enhanced further by combining with the Broad Chare storm sewer opportunity. This would allow for further development of this area and provide a dedicated surface water outlet for future development or SUDS measures, as well as improving sewer discharges to the River Tyne through screening of the storm flows.

It should be noted that the above opportunity aligns with the NCC Green Infrastructure Strategy, the Environment Agency's River Basin Management Plan for the lower Tyne and the Newcastle Partnerships Climate Change Strategy.

Other strategic benefits include:

- Provide improvements to the water quality of the River Tyne from the use of SUDS; and;
- Improved drainage of the Town Moor, which may increase the potential of the land for agricultural used and grazing of cattle which is an essential component of the NCC Biodiversity Action Plan and Green Space and Tree Strategies.

5.12 Do Everything

5.12.1 Opportunity Overview

This considers the numbers of properties at risk flooding from implementing all of the four surface water management opportunities investigated in this study and assess the results on a catchment wide basis.

5.12.2 Flood Risk Assessment

The surface water flood risk ascertained at all 13,517 receptors for the 2015 scenario is shown in Table 5.15 whilst the flood risk when development, climate change are urban creep up to the 2030 timeline is considered is shown in Table 5.16.

Table 5.16 Flood Risk Assessment Summary for Do Everything (2015)

Receptor Type	Low Risk		Moderate Risk		Significant Risk		Very Significant Risk	
Residential Buildings	10,214	76	50	-21	29	-3	66	-52
Commercial Buildings	990	29	36	7	6	-5	119	-31
Critical Infrastructure	182	4	3	-3	0	0	24	-1
Other Buildings	1,568	43	37	-15	23	-3	170	-25
Total Buildings	12,954	152	126	-32	58	-11	379	-109
(+ X) (- Y)	The (+/-) indicate the moving of properties between risk bandings when compared to the 'Do Nothing' opportunity as a result of this intervention for the 2015 time scenario only							

Table 5.17 Flood Risk Assessment Summary for Do Everything (2030)

Receptor Type	Low Risk		Moderate Risk		Significant Risk		Very Significant Risk	
Residential Buildings	10,137	71	62	-27	19	-25	75	-85
Commercial Buildings	1,010	106	44	-5	8	-12	110	-68
Critical Infrastructure	190	29	7	-9	0	-5	19	-8
Other Buildings	1,586	131	58	-26	17	-11	175	-56
Total Buildings	12,923	337	171	-67	44	-53	379	-217
(+ X) (- Y)	The (+/-) indicate the moving of properties between risk bandings when compared to the 'Do Nothing' opportunity as a result of this intervention for the 2030 time scenario only							

5.13 Do Everything with PLP or Local Measures

5.13.1 Overview

This considers the numbers of properties at risk flooding from implementation of all of the four surface water management opportunities investigated in this study and assess the results on a catchment wide basis. In addition, it considers use of property level protection (PLP or local measures) such as flood doors, non-return valves and air break covers as a measure to reduce surface water flood risk to any properties remaining 'at risk' after the implementation of the proposed opportunities.

It is important to note that any properties experiencing flood depths in excess of 600mm are unsuitable for the installation of PLP. Other local measures or emergency flood plans would need to be introduced.

5.13.2 Flood Risk Assessment

The surface water flood risk ascertained at various receptors for the 2015 scenario is shown in Table 5.15 whilst the flood risk when development, climate change are urban creep up to the 2030 timeline is considered is shown in Table 5.16, with a breakdown of the different property types required PLP or Local measures shown in Table 5.17.

Table 5.18 Flood Risk Assessment Summary for Do Everything with PLP or Local Measures (2015)

Receptor Type	Low Risk		Moderate Risk		Significant Risk		Very Significant Risk	
Residential Buildings	10,337	199	1	-70	0	-32	21	-97
Commercial Buildings	1,127	166	1	-28	0	-11	23	-127
Critical Infrastructure	200	22	0	-6	0	0	9	-16
Other Buildings	1,769	244	0	-52	0	-26	29	-166
Total Buildings	13,433	631	2	-156	0	-69	82	-406
(+ X) (- Y)	The (+/-) indicate the moving of properties between risk bandings when compared to the 'Do Nothing' opportunity as a result of this intervention for the 2015 time scenario only							

Table 5.19 Flood Risk Assessment Summary for Do Everything with PLP or Local Measures (2030)

Receptor Type	Low Risk		Moderate Risk		Significant Risk		Very Significant Risk	
Residential Buildings	10,271	205	2	-87	1	-43	37	-123
Commercial Buildings	1,147	243	1	-48	0	-20	12	-166
Critical Infrastructure	209	48	0	-16	0	-5	3	-24
Other Buildings	1,800	345	1	-83	0	-28	25	-206
Total Buildings	13,427	841	4	-234	1	-96	77	-519
(+ X) (- Y)	The (+/-) indicate the moving of properties between risk bandings when compared to the 'Do Nothing' opportunity as a result of this intervention for the 2030 time scenario only							

Table 5.20 Approximate Number of Properties Still 'At Risk' Requiring PLP or Local Measures

Receptor Type	2015	2030
Residential Buildings	123	134
Commercial Buildings	137	137
Critical Infrastructure	18	19
Other Buildings	201	214
Total Buildings	**479**	**504**

6. Economic Impact Assessment

6.1 Opportunity Costs Estimations

The capital and operation costs for the opportunities considered in this study have been estimated using the following sources:

- Cost Estimation for SUDS: Summary of Evidence, The Environment Agency, March 2015
- Natural Water Retention Measure (http://nwrm.eu/), circa 2013;
- The Tyneside Sustainable Sewerage Study, Amec E&I Ltd, June 2012;
- Nuns Moor Road Flooding Pilot Feasibility Study, Mott MacDonald, May 2013.

All costs have been estimated to the nearest £0.1M. It should be noted that estimates have been calculated without the benefit of ground investigation, utility information or other surveys. The accuracy of the cost estimates is commensurate with the amount of information available and the detail to which the proposals have been developed.

Costs in addition to the estimated capital value have been assumed as follows:

- Procurement and design have been assumed to be 15% of the estimated capital costs;
- Due to the high level nature of these costs estimates, a level of risk has been associated with these values and final costs could differ from these estimations by an order of magnitude. The risks associated with the estimations developed as part of this study are between – 25% and +60%. Scheme costs have been development assuming a worse case of 60% risk.
- Whole life costs illustrations have been prepared over a 50 year period over the estimated duration of the asset life (2065). A discount rate of 3.5% has been used to establish the Present Value (PV) calculations, up to 30 years and 3.0% for 30 to 50 years.
- A total routine maintenance estimated spend of £200,000 per year for NW and NCC has been assumed, plus other maintenance of SUDS features including, swales, rain gardens, green roofs and permeable paving has been applied to the 2015 and 2030 cost illustrations. It should be noted that the higher maintenance costs for opportunity area B are due to the number of green roofs proposed, which required a more complex regime and therefore assumed to have a higher maintenance cost.

Property level protection or local measure have been assumed at £6,000 per property and will require a full replacement every 20 years.

A summary of the high-level capital scheme costs, annual maintenance costs and whole life PV costs are provided in Table 6.1, with detail breakdown of costs shown in Appendix J.

Table 6.1 Estimated Scheme Costs, Annual Maintenance Costs and Whole life PV costs

Opportunity		Scheme Costs	Annual Costs	Whole Lifetime PV
Do Nothing		-	-	-
Do Minimum		-	£0.2M	£4.7M
Do Something	Opportunity Area A 'Scotswood and Benwell SW Improvements	£8.5M	£0.2M	£13.6M
	Opportunity Area B 'Nuns Moor and Hunters Moor'	£25.9	£0.2M	£31.8M
	Opportunity Area C 'Barrack Road & St James Boulevard'	£28.9	£0.2M	£33.6M
	Opportunity Area E 'Town Moor, Brandling Park and RGS'	£8.9M	£0.2M	£14.4
Do Everything	Combination of Opportunities	£72.2M	£0.3M	£79.3M
	Combination of Opportunities with PLP or Local Measures	£78.7M	£0.5M	£90.0M

6.2 Economic Viability Assessment

An early stage economic viability assessment was undertaken to study the impact of the implementation of different opportunities and scenarios. The assessment was carried out using depth-damage data obtained from the Multi-Coloured Manual (MCM) produced by the Flood Hazard Research Centre (FHRC). Depth/Damage costs curves were obtained for various property types including residential and non-residential.

A further cost appraisal was undertaken using the MCM with regards to the losses exhibited as a result of highway flooding on specific key transportation routes at Scotswood Road and Sandyford Road underpass which have been included in opportunity areas A and E respectively. However, these were not produced directly from modelling outputs and were established using data from the MCM.

The estimated annual damages (EAD) and whole-life Present Value (PV) costs and benefits predicted to occur as a result of the Do Nothing, Do Minimum, Do Something and Do Everything' opportunities are shown in Table 6.2. These are comparable to the estimated £78M of damages resulting from the June 2012 floods.

The following assumptions have been made when assessing the study area damage costs:

- Estimated damage costs have been capped at no more than the 2015 average market value of the property, which has been estimated from government statistics with the exception of Eldon Square which due to the large number of tenants on site has capped at approximate value of £1.0M;
- Damage costs are based on the predicted model results for the 2015 and 2030 time scenarios;
- Annual damage costs up to 2065 are assumed to be the same as 2030;
- Damage costs for disruption at Scotswood Road and Sandyford Road underpass have been calculated using MCM and estimated to be £40,000 and £10,000 per year, respectively.
- In accordance with MCM, an uplift on damage costs of 5.56% has been assumed to account of emergency services costs;
- Additional damage costs and monetary losses from rail disruption, school closures, vehicle damages, evacuations costs and other health and wellbeing impacts have not been included in the cost benefit analysis at this stage, but consideration of these may increase the viability of any opportunities; and,

- The expected annual damages (EAD) for the various opportunity scenarios are delivered from the total damages predicted by the model only during the 5yr, 20yr, 40yr, 100yr and 200yr return period multiplied by the annual probability of occurrence of the event.

Table 6.2 Do Nothing and Do Minimum: Capped EAD, PV Damages and Benefits

	EAD	50yr PV Damages
Do Nothing	£64.2M	£1,585.3M
Do Minimum	£59.5M	£1,469.2M

Table 6.3 Opportunity Areas: Capped EAD, Whole Life Cumulative PV Damages and Benefits

Opportunity		EAD Do No.	50yr PV Do No. Damages	EAD Opp.	50yr PV Opp. Damages	50yr PV Benefits
Do Something	Opportunity Area A 'Scotswood and Benwell SW Improvements	£6.2M	£153.1	£4.9M	£121.0M	£32.1M
	Opportunity Area B 'Nuns Moor and Hunters Moor'	£10.4M	£256.8	£9.1M	£224.5M	£32.3M
	Opportunity Area C 'Studley Terrace, Barrack Road & St James Boulevard'	£13.9M	£343.2	£11.5M	£284.0M	£59.2M
	Opportunity Area E 'Town Moor, Brandling Park and RGS'	£5.6M	£138.3	£5.2M	£128.4M	£9.9M
Do Everything	Combination of Opportunities	£64.2M	£1,585.3	£54.3M	£1,304.8M	£280.5M
	Combination of Opportunities with PLP or Local Measures	£64.2M	£1,585.3	£30.4M	£775.3M	£810.0M

6.3 Flood Defence Grant in Aid (FGDiA) Funding Scenarios

A number of assumptions have been made when developing the FDGiA scenarios, these include:

- Maintenance costs have been included in the scenario calculations;
- Properties within the opportunity area A in Scotswood are within the 'most deprived areas';
- Properties within the opportunity area E in north of city centre and Jesmond are within the '60% least deprived areas';
- Properties within the opportunity areas B and C in the north west of the city centre and Wingrove are generally equally split between the '21% to 40% most deprived area' and the '60% least deprived areas';
- PV whole life benefits have been based on the average between the 2015 and 2030 scenario results and calculated over a 50 year life span, at a PV discount rate of 3.5% up to year 30 and 3.0% from year 31 to 50;
- Residential, non-residential and transport infrastructure savings have been included with the PV whole life benefits summations;
- Whole life flooding benefit from interventions are to be compared to the 'Do Nothing' scenario however it should be noted that NW have a legal obligation to provide routine maintenance to the sewerage network;
- No funding has been attributed to outputs from OM3 (residential - coastal erosion);
- No funding has been attributed to outputs from OM4 (environmental improvements), however it may be possible to gain additional contributions in this area as the opportunities are progressed further;
- PV appraisal costs are established by assuming maximum risk (i.e. +60%); and

The funding scenarios using the FDGiA procedure are illustrated in

Table 6.4 and the preliminary forms have been supplied as information in Appendix I

Table 6.4 Potential FDGiA Funding Scenarios for Do Something and Do Everything Scenarios

	Do Something				Do Everything	
	Area A	**Area B**	**Area C**	**Area E**	**All Ops.**	**All Ops+ PLP**
50yr PV Whole Life Costs	£13.6M	£31.8M	£33.7M	£14.4M	£77.6M	£87.5M
50yr PV Whole Life Benefits	£32.1M	£32.3M	£59.2M	£9.9M	£280.5M	£810.0M
Raw Partnership Funding Score	14%	6%	10%	5%	20%	54%
Adjusted Partnerships Funding Score	101%	100%	100%	101%	100%	100%
Estimated Contributions	£7.4M	£24.2M	£21.0M	£8.6M	£58.0M	£32M
Potential FDGiA Contribution						
OM1 (All Damages)	£1.7M	£1.8M	£3.2M	£0.5M	£15.5M	£44.8M
OM2 (Residential Only)	£0.2M	£0.2M	£0.2M	£0.1M	£0.4M	£1.1
Total	£1.9M	£2.0M	£3.4M	£0.6M	£15.9M	£45.9M
Scheme Benefit to Cost Ratio	**2.4 to 1**	**1.0 to 1**	**1.8 to 1**	**0.7 to 1**	**3.5 to 1**	**9.3 to 1**

6.4 Economic Summary

The following can be summarised from the Economic Impact Assessment:

- Significant and noticeable benefits are gained from continuing with the current NW and NCC assets maintenance regimes across the whole study area (Do Minimum);
- Significant benefits are generated from the implementation of either or all of the opportunities highlighted in the study;
- Noticeable benefits are apparent for the 'Do Something' opportunities areas A, B and C and E with ratios of 2.4, 1.0 and 1.8 respectively. Further study is required to confirm economic benefits from opportunity area E as it currently has a cost benefit ratio of only 0.7 to 1;
- Benefits are also noticeable for the 'Do Everything' scenarios with the greatest benefit being generated from the installation of PLP or local measures to all properties with a residual risk;
- The level of FDGiA funding which is available as a result of improved flood management to residential properties (OM2) is low due to small proportion of residential house areas affected by flooding in Newcastle City Centre and the western end of Scotswood compared to other non-residential properties;
- Efficiencies could be generated by aligning these opportunities with other projects and network regeneration schemes, including highway improvement works, cycleway development etc; and,
- There may be potential for further funding (i.e. local levy etc.) as a result of benefits to non-residential properties, which is evident from the high OM1 scoring.

It should be noted that beyond OM2, damages have only been limited to those relating to traffic disruptions and emergency services costs. It is expected that significant additional damages and benefits could be found following a more detailed assessment, particularly with respect to Newcastle City Centre.

7. Ecosystem Services Assessment

An ecosystem assessment has been undertaken in-line with recently development Ciria BeST (Benefits of SUDS Tool) evaluation methodology.

BeST provides a structured approach to evaluating a wide range of benefits, often based upon the overall drainage system performance overall. It follows a simple structure that begins with a screening and qualitative assessment to identify the benefits to evaluate further. Then it provides support to help quantify and monetise each benefit. On completion of the evaluation, the tool provides a series of graphs and charts to present the benefits based on Ecosystem Services (ESS) and Triple Bottom Line (TBL) criteria

The BeST methods considered the following aspects shown in Table 7.1 and applied a monetarised values of the potential benefit with the results from the assessment shown in Table 7.2.

Outputs from the BeST evaluation are shown in Appendix K.

Table 7.1 Environmental Benefits of Opportunities

Ecosystem	Details of Assessment
Air Quality	Specifically the greening of areas in Wingrove and Spital Tongues in opportunities in areas B and C will promote a greener and cleaner environment and improve the 'sense of wellbeing'. Also, any additional planting and vegetation on the Town Moors will provide air qualities benefits.
Amenity and Biodiversity	Opportunities in areas B and C result in the creation of the most amount of new green infrastructure with the introduction of new SUDS scheme in to residential areas in Wingrove and Spital Tongues and includes the potential for retrofitting SUDS in major land area such as the RVI and The University of Newcastle upon Tyne's main campus. The opening up of St James Boulevard as a green corridor provides valuable new green infrastructure for the city. There will still be areas of new green infrastructure for opportunity Area A and E, but these will be more localised. With regards to opportunities in areas B and E, improvement in the management of the run-off from the Town Moors will add to the biodiversity of the area through the creation of new habitats in the swales, basins and flood buffer zones. The improved biodiversity for opportunities in areas A and C will depend on the type of SUDS structures used. However, for opportunity area A, any work in Hodgkin Park will help to improve the area's biodiversity. There is very little increase in recreational land as a result of these opportunities, but they all involve improvements to existing green space and linking of areas to green/blue corridors through the study area. However, all opportunities have been proposed considering the benefit to the communities including improvements at Hodgkin Park (A) and the town moors (B, C and E).
Building Temperatures	Provision of green roofs and additional planting within Opportunities B and E will help to regulate building temperatures. Also, there are noticeable benefits to building temperature from the additional planting at Hodgkin Park for Opportunity A.
Carbon Sequestration	All opportunities may impact the carbon levels in the catchment. These may be reduce from the reduction in the amount of flows to be pumps through removing surface water from the combined sewage flows, reducing in water consumption from the installation of rainwater harvesting devices and from the reduction in the need to cool building from the provision of green roofs and additional planting (see Building Temperatures), as well as increasing carbon uptake.
Education	There are significant benefits expected to the human environment from all of the opportunities. These includes educational benefits from retro-fitting of SUDS to schools in Benwell and at the RGS in opportunities in areas A and E, but also from retrofitting at The University of Newcastle upon Tyne in opportunity area B

Ecosystem	Details of Assessment
Flooding	All of the opportunities will assist in the futureproofing against the impacts of climate change. Future scenarios have been developed with climate change in mind and it can noted from the assessment results that flood risk protection is maintained up to the year 2030. Also, significant flood risk reduction is observed as a result of all the opportunities to both commercial and residential properties for all the investigated return periods.
Rainwater Harvesting	Opportunities B, C and E involves water recycling facilities (i.e. water butt, rainwater harvesting) resulting in reducing in water usage and water efficiency in accordance with the Code for Sustainable Homes (CSH
Treatment Wastewater	All opportunities will result in a decrease in the amount of surface water draining to the combined network leading to a reduction in flows which will need to be treated at Howdon STW.
Water Quality and Resources	All of the opportunities comprise the introduction of SUDS measures (mainly retrofitting into existing buildings and infrastructure). Wherever SUDS are implemented there will be an improvement in water quality. This is combined with the removal of surface water from the combined system which will result in the reduction in the operation of CSOs leading to improvements in the water quality of the River Tyne. Also, opportunities in areas B and E will help to slow the flows across the town moors, resulting in improved natural drainage, increase infiltration and aquifer recharge.
Economic Growth	Although significant benefit would be provided in relation to economic growth it is not possible to quantity any monetary values at this time and this may form part of future cost benefit analysis.
Enabling Development	All of the opportunities assessed will reduce the amount of flow conveyed by the existing combined sewerage network and increase the available capacity for future development. Also, maintaining traffic flows on Scotswood Road (A) Ponteland Road (B), Barrack Road (C) and Sandyford Road underpass (E) will help to facilitate future residential and non-residential growth. Although significant benefit would be provided in relation to enabling development it is not possible to quantity any monetary values at this time and this may form part of future cost benefit analysis.
Tourism	Both an increase in the green space and an improved flood protection at significant sites such as Eldon Square may lead to an increase in tourist numbers visiting Newcastle City Centre. Newcastle involved in the Blue/Green Cities initiative will assist in a potential further increase the number of people wishing to visit the city. Although significant benefit would be provided in relation to tourism it is not possible to quantity any monetary values at this time and this may form part of future cost benefit analysis.
Traffic Calming	Provision of additional bioremediation pits in Opportunities B and C in the residential areas of Wingrove and Spital Tonges will have a positive benefit on the flow of traffic, resulting in a decrease of speeds and potentially leading to an increase in public safety. Although significant benefit would be provided in relation to traffic calming it is not possible to quantity any monetary values at this time and this may form part of future cost benefit analysis.

Table 7.2 Environmental Benefits of Opportunities

BeST Ecosystem	Opportunity A	Opportunity B	Opportunity C	Opportunity E	Do Everything	Do Everything plus PLP or Local Measures
Air Quality	£90,149	£70,689	£5,410	£110,126	£276,374	£276,374
Amenity and Biodiversity	£4,510,321	£298,903	-	-	£4,809,224	£4,809,224
Building Temperatures	£36,756	£534,850	£18,500	-	£590,106	£590,106
Carbon Sequestration	£43,844	£84,467	£30,288	£57,750	£216,349	£216,349
Education	£1,346,004	£1,555,448	-	£450,174	£3,351,626	£3,351,626
Flooding	£32,100,000	£32,300,000	£59,200,000	£9,900,000	£280,500,000	£810,000,000
Rainwater Harvesting	£2,531	£36,969	£214,196	£1,396	£255,092	£255,092
Treatment Wastewater	£11,796	£85,137	£57,546	£75,677	£230,156	£230,156
Water Quality and Resources	£102,437	£102,437	£86,047	£102,437	£393,358	£393,358
Total PV Monetarised Benefit	£38,243,839	£35,073,346	£59,611,960	£10,417,685	£290,622,285	£820,122,285
Total PV Opportunity Costs	£13,600,000	£31,800,000	£33,700,000	£14,400,000	£77,600,000	£87,500,000
Cost Benefit Ratio	**2.8 to 1**	**1.1 to 1**	**1.8 to 1**	**0.7 to 1**	**3.7 to 1**	**9.4 to 1**

This above assessment confirmed that there are significant benefits generated from other ecosystems apart from flooding, which result in an increase in the cost benefit ratios from those obtain in the FDGiA assessment in Section 6.3.

8. Way Forward

The opportunities proposed and modelled in this study are high level. A further optimisation exercise to investigate the impact of individual work packages could be undertaken to refine those opportunities the stakeholders would like to investigate further.

8.1 Future Funding Partners

Future funding partners, including individuals or organisation whom have a vested interest in the outcomes of any proposed flood relief work, have been identified in the communication plan in Appendix B.

However, a final list of beneficiaries will need to be identified for each individual opportunity during the initial stages, as a full funding package would need to be secured prior to any schemes being taken forward.

8.2 Forward Programme Scenarios

The anticipated forward programme schedule for the opportunities in isolation are shown in Table 8.1.

Table 8.1 Forward Work Programme

Opportunity	Feasibility Design	Preliminary Outline Design	Detailed Design	Tender	Construction
Opportunity Area A: Scotswood and Benwell SW Improvements	6 Months	6 Months	4 Months	2 Months	12 Months
Opportunity Area B: Nuns Moor and Hunters Moor	6 Months	6 Months	4 Months	2 Months	12 Months #
Opportunity Area C: Studley Terrace, Barrack Road & St James Boulevard	6 Months	6 Months	4 Months	2 Months	18 Months
Opportunity Area E: Town Moor, Brandling Park and RGS	4 Months	4 Months	2 Months	2 Months	12 Months #

If Broad Chare Sewer opportunity is implemented as part of opportunity 2 anticipated construction period would to 18 months

8.3 Minor Works Opportunities

The following packages could be considered as possible minor work opportunities are shown in Table 8.2.

Table 8.2 Minor Works Opportunities

Opportunity	Work Packages
Opportunity Area A: Scotswood and Benwell SW Improvements	Benwell SUDS for Schools, Scotswood Development
Opportunity Area B: Nuns Moor and Hunters Moor	Retro fitting of SUDS and 'Greening' of residential areas in Wingrove and Spital Tongues, Improvements in the drainage of the Nuns Moor and Hunters Moor, Joint flood management works in conjunction The University of Newcastle upon Tyne
Opportunity Area C: Studley Terrace, Barrack Road & St James Boulevard	Retro fitting of SUDS and 'Greening' of residential areas in Studley Terrace, Additional property level protection at Eldon Square, NWL sewerage works on Newgate Street, Science Central Development
Opportunity Area E: Town Moor and Brandling Park Area	Local retro-fitting SUDs opportunities, Improvements in the surface water management of the Town Moor, flood resilience work at Sandyford Road underpass

9. Conclusion

Amec Foster Wheeler has been commissioned by Northumbrian Water (NW) and Newcastle City Council (NCC) and supported by the Environment Agency (EA) and funding from local levy to undertake an integrated flood risk management study covering The City of Newcastle Upon Tyne and the urban areas of Benwell and Scotswood.

An integrated InfoWorks ICM model was built combining sub-surface sewer system, the above ground drainage systems, rainfall and the River Tyne and was used to assess the flood risk through the urbanised catchment. The model was then used to test some high level opportunities to provide an indication of what could potentially be implemented to reduce flood risk and add to the existing strategies for the area.

Surface water flooding through the area was found to be limited to certain 'at risk' areas and due to the topography was generally shallow in depth.

A number of strategic opportunities were investigated as part of this study to investigate flood risk. At this stage none of the opportunities tested have been assessed for their feasibility, and they have not been designed in any detail.

Time scenarios comprising a 2015 and 2030 year horizon were modelled and from these it was evident that flood risk within the study area would be increased through the on-set of climate change, urban creep and by future development.

In accordance with FDGiA assessment, 'Do Nothing' and 'Do Minimum' opportunities were investigated. The 'Do Nothing' model predicted that significant additional flooding would be anticipated if this opportunity was taken forward, which in turn would lead to substantial damage costs. The 'Do Minimum' model was assessed but not in-terms of FDGiA funding as it would only comprise regular maintenance by NW and NCC, which is not eligible for contributions.

Opportunity areas A, B, C and E were investigated in terms of their flood risk improvement and potential for FDGiA funding. It was established that contributions may be available due to benefits anticipated at residential and non-residential properties as well as some key transportation links. Opportunity area D (city centre to quayside) was not investigated as part of the study due to ongoing strategic works in that area being undertaken by NCC.

Although limited funding is likely due to the none residential nature of the study area, significant benefits are still predicted if the FRMAs wish to take forward any opportunities investigated in this study. A number of minor work opportunities are recommended and could be taken forward, if partial funding becomes available.

The opportunities investigated in this study address the flood risk issues within the catchment and supports a wider range of national and local Plans and Strategies produced by NCC, the Environment Agency and other key partners. These strategies include; Green Infrastructure Strategy, Biodiversity Action Plan, Climate Change Strategies, Highway Assets Management Plan, Water Cycle Study, River Basin Management Plan, Tyne Catchment Plan and the Green Space and Tree Strategy.

The outputs also align with the objective set out in the Blue Green Cities Concept. All of the opportunities investigated require a high degree of third party involvement. This includes major landowners such as The University of Newcastle upon Tyne, the Newcastle Upon Tyne NHS Trust and the Freemen of Newcastle. There are further opportunities for community involvement with smaller landowners, residents and NGO groups.

9.1 Recommendations

The following further works or investigations have been recommended, prior to advancing this study to the next stage.

- Further develop this study as an integrated part of the futureproofing of Newcastle City Centre, Scotswood and Benwell against increased surface water flood risk from climate change, urban creep and development;
- Develop the existing partnerships as well as looking to propagate new partnerships with key stakeholders and organisations;
- Further development of the hydraulic model as a tool for assessing the detail in the 4 Opportunity Areas, which may include; details associated with the receptor databases, survey works at key areas, confirmation of connectivity issues, increase detail to the 2D model especially the road network and drainage gullies and investigation into the replication of the run-off parameter associated with different land types (road, grass trees etc.);
- Further calibration of the model against rainfall radar data for the 28 June 2012 floods and possible verification in specific areas at risk;
- Integration of this Strategic Surface Water Management Plan in current NCC environmental and sustainability policies and practices;
- More detailed and site specific assessment of the damages experienced as a result of flooding and the benefits from implementation of the opportunities; and,
- Investigation into further funding pathways including FDGiA but also local levy and other private and public partnerships etc.

Appendix A
Strategic Aims

Driver, Plan or Strategy	Originator	Key Targets and Objectives relating to Flood Risk and Surface Water Management
Green Infrastructure Strategy	Newcastle City Council and Gateshead Metropolitan Borough Council	• Identify network of multifunctional relevant land and watercourses which support the activity, health and well-being of local people and wildlife • Identify deficiencies that can be addressed through the growth programme and opportunities for improvement • Create a focus on the river Tyne as a key recreational corridor • Provide evidence to support any local and national designation of wildlife sites • Assist in complying with other national policies (i.e. National Environment and communities Act 2006 etc.) • Provide data supporting site planning and development control • Provide a physical connection between growth locations • Recognise the distinctive character of the urban environments especially the River Tyne corridor, plus biodiversity, recreation and townscape.
Biodiversity Action Plan (BAP)	Newcastle City Council and North Tyneside Council	• Promote best practise regarding biodiversity value of buildings and structures • Produce guidance on green roofs • Improve water quality through promotion of SUDS • Increase wildlife corridors through promotion of highway verges • Promote and raise awareness of open waters and wetlands • Promote and improve green spaces including hedgerows grassland and native woodland as well as habitat for native species.
Climate Change Strategy	Newcastle Partnership	• Adaption to climate change • Resilience to extreme weather • Heat island effects • Efficient transportation network • CO_2 reduction • Effective use of land • Traffic monitoring • Improve surface water management • Raise awareness to climate change
Traffic Assets Management Plan	Newcastle City Council	• Supporting economic growth • Resilience to flooding • Increase highway green spaces
Water Cycle Study	Newcastle City Council and Gateshead Metropolitan Borough Council	• Addresses the needs of the water environment with regards to future growth, planning and development • Ensure a joined up approach between landowners, water infrastructure providers and planners during strategic growth and regeneration • Protection of the natural water environment • Provides guidance and partnership working for long term planning objectives and identifies where investment is needed • Promotes sustainable development
River Basin Management Plan	Environment Agency and Defra	• Surface water flooding relating to the Lower Tyne portion of the Rive Tyne catchment area.
Blue Green Cities	Newcastle Local Action Alliance (LAA)	• Develop innovative ideas and blue green strategies and promote 'best' opportunities that incorporate blue green development • Promote and improve communications with stakeholders and communities to aid the creation of multiple benefits • Challenge traditional approaches • Develop location specific strategies that may inform stakeholders plans • Ensure communication of strategies to the Blue-Green research consortium.

Driver, Plan or Strategy	Originator	Key Targets and Objectives relating to Flood Risk and Surface Water Management
Surface Water Management Plan (SWMP)	Newcastle City Council and Gateshead Metropolitan Borough Council	• High level strategy to be used in addressing surface water flood risk • Embraces partnership working between different councils and flood risk management agencies • Identifies locations of surface water flooding susceptibility • Inform any further surface water management strategies
Tyne Catchment Plan	Tyne Rivers Trust	• Delivering better rivers for people to enjoy and value • Increase community involvement in Decision making about river issues • Engage and educate • Create environment resilient to extreme weather and climate change and best use of available resources • Deliver targets set out in Water Framework Directive and Habitats Directive.
Green Space Strategy	Newcastle City Council	• Promotion and protection of sustainable green spaces and green corridors • Develop best practise and design codes • Further development of links with landowners, partners, communities and 'friends of' organisations • Improve the management of green spaces and development of single green space estate for the City of Newcastle • Address biodiversity targets and the local tree strategy • Adopt green spaces as part of the LDF
Tree Strategy	Newcastle City Council	• Protection of existing tree, woodlands and hedgerows • Improvement management of existing tree stock and replacement of trees which need to felled • Capital investment in young woodland • Promote the use of swales and increase the amount of roadside verges • Improve consultation with landowners and encourage tree plant • Address climate change targets and promote a carbon neutral city concept for Newcastle.

Appendix B
Communication Plan

Table B.1 Suggested stakeholders, involvement and engagement

Category	Stakeholder	Agenda for Study	Level of Engagement and Action	Impact on Success	Interest in Study
Advocacy/ Ownership	Newcastle City Council (NCC)	LLFA, responsible for managing surface water flood risk within Newcastle upon Tyne; Require study to understand the problem and possible actions which could be implemented and for evidence base to secure future funding; Ensure study is in line with project brief. Owner of the Town Moor.	**Level 1 Stakeholder**; Attendance at meetings; Regular updates by email and phone; Data sharing and provision; Project Management; Agreement of technical decisions; Feedback on outputs, opportunities, draft report and sign off of final document.	High	High
Commitment/ Action	Environment Agency (EA)	Manager of the River Tyne catchment; potential to be involved in implementing actions. Ensure study is compliant with ongoing studies, existing guidance and with environmental targets. Ensure the modelling and outputs are technically sound and fit for purpose.	**Level 1 Stakeholder**; Attendance at meetings; Data sharing and provision; Agreement of technical decisions; Feedback on outputs, opportunities and draft report to sign off and confirm final report	High	High
	Northumbrian Water (NW)	Sewerage undertakers; potential to be involved in implementing actions. Ensure the underlying assumptions are acceptable. Ensure study outputs and suggested opportunities are commensurate with their understanding of the network.	**Level 1 Stakeholder**; Study project management, Attendance at meetings; Provide sewer network data; Feedback on modelling methodology, opportunities, draft report and outputs to sign off data analysis	High	High
	The University of Newcastle upon Tyne	Land owners and users of the The University of Newcastle upon Tyne campus; potential to be involved in implementing actions. Could be involved in joint funding of any schemes	**Level 2 Stakeholder**; Informed of study objectives and kept updated of progress; Attendance at a Public Event to view outputs. Needs to be involved in any decision making.	Medium	Medium
	Newcastle Upon Tyne NHS Trust	Land owners and users of the Newcastle RVI complex; potential to	**Level 2 Stakeholder**; Informed of study objectives and kept updated of progress; Attendance at a Public Event to view outputs.	Medium	Medium

Category	Stakeholder	Agenda for Study	Level of Engagement and Action	Impact on Success	Interest in Study
		be involved in implementing actions. Could be involved in joint funding of any schemes	Needs to be involved in any decision making.		
	The Freemen of Newcastle	Legal users of the Newcastle Town Moors; potential to be involved in implementing actions.	**Level 2 Stakeholder**; Informed of study objectives and kept updated of progress; Attendance at a Public Event to view outputs. Needs to be involved in any decision making.	High	High
	Independent and Free Newcastle Schools	Land owners and users of none LA registered school in the catchments; potential to be involved in implementing actions. Could be involved in joint funding of any schemes.	**Level 2 Stakeholder**; Informed of study objectives and kept updated of progress; Attendance at a Public Event to view outputs. Needs to be involved in any decision making.	Medium	Low
	Local residents, businesses and landlords	Land owners and users of properties in the catchment, possible involved in local 'SUDS' and 'Greening' Initiatives, Interest in the economic, environmental and aesthetic impacts/benefits of any proposed opportunities.	**Level 2 Stakeholder**; Informed of study objectives and kept updated of progress; Attendance at a Public Event to view outputs. Needs to be involved in any decision making.	High	Medium
Understanding/ Support	The University of Northumbria	Interest in the environmental and aesthetic impacts/benefits of any proposed opportunities. Possible involved in future flood management studies.	**Level 2 Stakeholder**; Informed of study objectives and kept updated of progress; Attendance at a Public Event to view outputs.	Low	High
	Greening Wingrove	Active local group with an interest in the management of sustainability issues in Wingrove.	**Level 2 Stakeholder**; Informed of study objectives and kept updated of progress; Attendance at a Public Event to view outputs.	Low	High
	Developers	Economic interest; developer contribution likely to be crucial for various opportunities.	**Level 2 Stakeholder**; Informed of study objectives and kept updated of progress; Attendance at a Public Event to view outputs.	Low	Medium
	River Tyne Trust	Interest in the environmental and aesthetic impacts/benefits of any proposed opportunities.	**Level 2 Stakeholder**; Informed of study objectives and kept updated of progress; Attendance at a Public Event to view outputs.	Low	Low

Category	Stakeholder	Agenda for Study	Level of Engagement and Action	Impact on Success	Interest in Study
	Friends of Nuns Moor Centre	Active local group with an interest in the management of sustainability issues within Nuns Moor Park	**Level 2 Stakeholder**; Informed of study objectives and kept updated of progress; Attendance at a Public Event to view outputs.	Low	Medium
	Friends of Leazes Park	Active local group with an interest in the management of sustainability issues within Leazes Park	**Level 2 Stakeholder**; Informed of study objectives and kept updated of progress; Attendance at a Public Event to view outputs.	Low	Medium
	Sustrans	NGO who managers the national cycle trails in the Newcastle catchments; Interest in the impacts/benefits of any proposed opportunities.	**Level 2 Stakeholder**; Informed of study objectives and kept updated of progress; Attendance at a Public Event to view outputs.	Low	Low

Table B.2 'Level 1' Stakeholders Roles and Responsibilities

Stakeholder	Role	Responsibility
Newcastle City Council	Lead Local Flood Authority Local Planning Authority Freehold owner of the Town Moor and other Parks with the city boundary	Management of local flood risk - surface water, groundwater and other sources of flooding. Encourage and influence the ad opportunity of 'sustainable drainage systems' (SUDS). Prepare development plans and determine planning applications in line with planning policy.
Environment Agency	Implement government policy on flood risk Statutory consultee	Management of flood risk from main rivers, sea, and reservoirs. Responsibility for their flood defences Powers and duties relating to the drainage, maintenance and operations of the main rivers.
Northumbrian Water	Sewerage Undertaker	Maintenance of the public sewerage systems. Management of flood risk from sewers.

Table B.3 Stakeholder Engagement Timetable

Stage	Engagement Method	Stakeholder Involvement	Date
Stage `1	Initial Meeting	Newcastle City Council & Northumbrian Water	26 Nov 2014
	Data collection	Newcastle City Council & Northumbrian Water	19 Dec 2014, 23 Jan 2015
	Outputs and Initial Opportunities 'Long List' Workshop	All Level 1 Stakeholders	20 Feb2015
	Review of Opportunities 'Short List' Workshop	Newcastle City Council & Northumbrian Water	27 Mar 2015
	Draft Report	All Level 1 Stakeholders	15 Jun 2015
	Stakeholder Engagement Workshop		23 Jun 2015
	2nd Draft Report		24 Jul 2015
	Draft Report Review Interim Meeting 1		25 Sep 2015
	Draft Report Review Interim Meeting 2		21 Oct 2015
	Final Report		06 Jan 2016

Appendix C
Data Gathering

April 2016
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Appendix D
Study Area Flooding Information

Overview

To investigate flood risk in the catchment it was important to be able to define the primary sources of flooding and their pathways which the flooding needs to cause a risk of damage to receptors (i.e. properties, infrastructure, and public open spaces).

Details of the sources of flooding and pathways specific to the City of Newcastle are shown below.

Source Pathway Model

Source	Pathway	Explanation of Flood Mechanism
Rainfall Event	Direct overland flow	Rainfall which falls onto sections of the catchment which are not positively drained and results in overland flow
	Exceedance of sub-surface network capacity	Rainfall which falls onto sections of the catchment which are positivity drained but due to gullies effectiveness does not enter the sub-surface network resulting in overland flow
	Drainage system surcharging	Rainfall which drains direct to the sewerage system that is released through surcharging resulting in overland flow
	Direct flooding from sewer network	Properties or areas which are subject to flooding not as a result of surcharging, but due to connection levels being lower than the surcharge level of the sewer
	Groundwater (via below ground conduits, i.e. mine workings, sewers, aquifers and made ground).	Considered to be low in this location compared to national guidelines. Seepage into buildings (i.e. basements) or from embankments or retaining walls following periods of prolonged rainfall. Sites should be considered on a case by case basis #.
Watercourses (River Tyne)	Direct flooding from spring tides (high tide) or tidal surges	Flooding which occurs from high river flows escaping over flood defences onto to the urbanised catchment and resulting in flooding of properties, areas or as overland flow
	Exceedance of sewer network capacity	Flooding which occurs from high river flows escaping over flood defences getting into the drainage network and resulting in surcharging elsewhere and overland flow
	Drainage system surcharging	Flooding which occurs from the sewer system being tidal locked resulting in surcharging from the system and overland flow

Information on groundwater flooding is available in the NCC draft report 'Newcastle Groundwater Flood Risk Assessment' (February 2015).

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Appendix E
Integrated Catchment Modelling

Overview

A flood modelling exercise was undertaken to determine the surface water flood risks in the study area. The purpose of this was to examine in detail the flood mechanism occurring within an urbanised catchment such as the City of Newcastle upon Tyne and the level of interaction between the various flood pathways.

A set of notes has been prepared to assist any future users of the model.

User Notes

The model is based on the unverified 1D InfoWorks CS model prepared for NW as part of the Tyneside Sustainable Sewerage Study (TSSS) which was undertaken in 2012.

No additional enhancements have been made to the 1D model with the exception of minor changes to new survey data and changes due to recent NW schemes in the Jesmond Area.

In-order to undertake this complex modelling it was decided that InfoWorks ICM (Integrated Catchment Model) would be used. This would allow the modelling of these three main sources of flooding into one integrated model.

Representation of 2D Environment

To obtain a more robust representation of 2D surface water flows the existing sub-catchments in the 1D model were replaced with updated sub-catchments which only contained contribution from the building roof areas and 100% run-off was assumed and applied to Area 2. These flows were assume to drain directly to the below ground system.

Flows contributing from gardens were also assumed to drain directly to the below ground network via property gullies and an impermeable area allowance of either 90% for terraced housing and 10% for detected or semi-detected housing, which was and applied to Area 1.

The remaining contributing areas were allowed to drain freely to the 1D model via overland flows only by direct application to the 2D mesh. At this stage the road gullies were not modelled and therefore flows on the 2D mesh were only allowed to drain to the below ground network via the 1D/2D interface at the manholes.

Some buildings have been represented as 'voids' but these are limited in-order to obtain an efficient run time for the simulations. In-order to reduce the 'free flow' across buildings on the mesh the properties which were not voided were modelled with roughness zones with a high roughness value of 10.

Limited amount of 2D details has been included in the model as this stage to represent the urban environment. These have generally been in the form of walls and additional roughness and mesh zones and include areas at the Brandling Park underpass, central station underpass and some speed humps.

To more accurately replicate the run-off behaviour of the catchment, specific standard run-off percentages have been applied to highways, areas of hard-standing, grasses and wooded areas, and these are shown on the following table. All other surfaces (i.e. highways, paved areas etc.) were represented in the actual ICM 2D zone created to cover the study area.

With respect to the future scenario, an allowance for urban creep was calculated using the UKWIR report as stated within the project brief, however the creep was applied directly to the garden catchments in Area 1.

Standard Run-Off Percentages (http://water.me.vccs.edu/courses/civ246/table2b.htm)

Area	Run-Off Percentage
Highways, paved areas and general hard-standing	83%
Grassed areas (heavy soils)	45%
Tree and wooded areas	15%

Upon completion of the study, model data will be return to the NW hydraulic model library as a 2D ICM model and a 1D CS. Additional data (if required) can be supplied in MapInfo TAB format for inclusion in any further 2D modelling work.

2D Elements	Contained in 1D Model	Available in MapInfo TAB format
Buildings	Yes	No
Gardens	Yes	No
2D Zone	No	Yes
Infiltration Zones	No	Yes
Mesh Zones	No	Yes
Walls	No	Yes
Roughness Zones	No	Yes

Model Limitations

At present the both the 1D and 2D elements of the hydraulic model tool used in the study are not considered to be verified.

Due to the high level detail within the 2D element of the hydraulic model a number of limitations are noted, including:

- LiDAR DTM (Digital Terrain Model) data has been used to generate topographical levels, however due to the urbanised nature of the catchment combined with the steep nature of some areas of the model the removal of buildings from the DTM will increase the level of inaccuracy;
- Road gullies have not been included in the model at this stage although location were supplied as part of study. A sensitivity test was undertaken to establish if the exclusion of gullies at this high level affected the overflow flow pathways. The results showed that at this stage the affects would be negligible;
- The National Receptor Database (NRD) has been used to establish locations of buildings and threshold levels have been approximated by using points sources from the LiDAR data, however the accuracy of this is significantly reduced for larger buildings that are likely to have a large range of threshold levels (i.e. Eldon Square, RVI hospital, Central Station etc); and;
- Threshold levels for residential properties have been set at 150mm above the LiDAR level of an arbitrary point within the building polygon whilst at non-residential properties (shops etc), thresholds have been set at LiDAR level; and,
- To reduce model run times, simulations have only been considered at the critical duration of 90mins, which has been established through assessment of the model to identify the storm length that returns the maximum flood volume from the 1D model.

Model Validation

A limited exercise was undertaken to validate the hydraulic model against actual events. The event which occurred on the afternoon of 28 June 2012 was chosen since detailed data had been collected regarding flooding for that event.

Rainfall radar data was obtained from NW and used to simulate the event. The table below shows comments from the inspection of the hydraulic model at a number of key areas, which are known to have flooded on the 28 June 2012. The level of correlation between actual events and those predicted by the 2D model was sufficient to give a base level of confidence in the model and its use as a planning tool for the surface water strategy.

It is recommended that further validation and verification exercise is undertaken in the following stages, which could be undertaking in association with The University of Newcastle upon Tyne's CityCat model to add further confidence to model outputs.

Area	Inspection of Hydraulic Model for 28 June 2012 Floods	Comment of Model Accuracy
Newgate Street and Eldon Square	Model predicts significant flooding at this location up to 500mm in depth	Model appears to replicating flooding at this location but detail of flood levels/volumes require further validation to improve model confidence.
Barrack Road	Models predicts large volume of floodwater on Barrack Road which gravitates down towards the junction with St James Boulevard and on towards Newgate Street. Flood Depths in the model are only predicted to be approximately 100mm.	Model appears to replicating flooding at this location but detail of flood levels/volumes require further validation to improve model confidence.
Ponteland Road and Holland Park	Model predicts up to 350mm of flooding the highway at the junction of Ponteland Road, Brighton Grove and Hunters Road. Also, up to 450mm of flooding is predicted at certain locations in Holland Park Industrial Estate just off Barrack Road.	Model appears to replicating flooding at this location but detail of flood levels/volumes require further validation to improve model confidence.
The University of Newcastle upon Tyne, RVI and Queen Victoria Road	Model predicts up to 350mm of flooding at the Lovers Lane pedestrian walkways, however depth on the adjacent highway on Queen Victoria Road is only 150mm.	Model appears to under-predicting the extent of flooding at this location and for this event, however flood is predicted for standard design events. This could be as a result of lack of detail in the 2D model or the under-predicting of flows in below ground model.
Town Moor and Exhibition Park	Model predicts up to 2000mm of flooding in the underpass to Brandling Park, whilst it predicts 200mm within Brandling Park and 350mm at the Royal Grammar School.	Model appears to replicating flooding at this location but detail of flood levels/volumes require further validation to improve model confidence.
Coast Road Junction to the Central Motorway	Model predicts up to 2000mm of flooding.	Model appears to over-predicting the extent of flooding at this location and for this event. This could be as a result of lack of detail in the 2D model.
Sandyford Underpass	Model predicts up to 1500mm of flooding.	Model appears to replicating flooding at this location but detail of flood levels/volumes require further validation to improve model confidence.

Appendix F
Flood Risk Methodology

Overview

In order to determine the risks associated with hydraulic performance the use of modelled flow depth and velocity together with topographic flood routing (InfoWorks 2D) will provide an assessment of the consequences of the incapacity. Scenario modelling will reflect potential impacts of legislation, growth, creep and / or climate change on the sewer network.

The matrix shows the probability and depth of flooding (consequence) determined by the detailed assessment. Note that for 1 in 5 year return periods at risk properties will need to be reviewed to confirm if these are surface water risks or sewer risks. Properties at risk in a 1 in 20 year and greater event are to be assigned as a surface water risk.

Threshold levels have been established as ground level from LiDAR +150mm, with the exception of non-residential buildings which are assumed to have no threshold levels.

The impact is to be categorised as follows;

	Very Significant Risk	No of properties with flood risk of less than 1 in 40 years (0.025% AEP)
	Significant Risk	No of properties with flood risk between 1 in 40 year (0.025% AEP) and 1 in 100 years (0.01% AEP)
	Moderate Risk	No of properties with flood risk between 1 in 100 year (0.01% AEP) and 1 in 200 years (0.005% AEP)
	Low Risk	No of properties with flood risk of greater than 1 in 200 years (0.005% AEP)
AEP – Annual Exceedance Potential, return period of event expressed as a percentage change of occurrence		

The the following catergories have been selected for banding flood water depth (above ground level).

Depth (m)	Threshold
< 0.15	Less than 0.15m, flooding may exceed kerb height and has a potential to damage properties with the amount of damage depending on actual threshold levels.
0.15 - 0.30	At 0.15m, flooding would • typically exceed kerb height (standard kerb height is 125mm) • likely exceed the level of a damp-proof course • cause property flooding in some areas
0.30 - 0.60	At 0.30m flooding is likely to cause property flooding. This is based on average property threshold levels.
0.60 - 0.90	Property-level flood resilience measures are typically effective up to a water depth of 0.60m above floor level. Above depths of 0.60m these measures are likely to be much less effective and structural damage is more likely to occur. However, as floor level vary, the maximum flood depth where resilience measures are still effective may be in a range between 0.60m and 0.90m above ground level.

Appendix G
Opportunity Long List

Opportunity	Area	Brief Description	Key Benefits from Opportunity	Short List
Do Nothing	NA	Undertake no flood risk management opportunities in the catchment and no maintenance or clearing of gullies carried out.	None	✔
Do Minimum	NA	Continue with existing maintenance regimes to sewers and road gullies.	Reduces flood risk, minimum costs, minimum disruptions, maintains assets and maximises operational efficiency	✔
Nuns Moor SW Improvements	B(1)	Separation of combined flows upstream (Inc. retrofit SUDS) and improve management of storm run-off from Nuns Moor Park and reduce risk at BBC studios.	Reduces flood risk, improves water quality, improves drainage for Nuns Moor and resilience to extreme weather, increases land value in Wingrove, increases biodiversity and improves 'sense of wellbeing' from greening of urban areas.	✔
Hunters Moors and Local SUDS Opportunities	B(1)	Improve management of storm run-off from Hunters Moors and on Ponteland Road, plus retro fit SUDS into the adjacent business park, which includes BBC Broadcasting House.	Reduces flood risk, improves water quality, improves drainage for Hunters Moor and resilience to extreme weather, increases biodiversity and improves 'sense of wellbeing' from greening of the business park and greening of local areas	✔
Town Moor	B(2)	Improve management of storm run-off from the Town Moor through residential area.	Reduces flood risk, improves water quality, improves drainage for Town Moor and resilience to extreme weather, and increases biodiversity.	✔
Scotswood Road Highway Improvements	A	Improve the highway drainage on Scotswood Road and the run-off from the Scotswood development	Reduces flood risk and flows in the combined sewer, improves water quality, improves drainage of Hodgkin Park and resilience to extreme weather, and increases biodiversity.	✔
Studley Terrace SW Improvements	C	Separation of combined flows upstream (inc. retrofit SUDS) and improve management of storm run-off from Nuns Moor Park	Reduces flood risk, improves water quality, improves resilience to extreme weather, increases land value in Wingrove, increases biodiversity and improves 'sense of wellbeing' from greening of urban areas.	✔
Barrack Road Highway Improvements	C	Improve the highway drainage on Barrack Road and management of exceedance flows	Reduces flood risk, improves water quality and improves resilience to extreme weather	✔
The University of Newcastle upon Tyne & RVI SUDS	B(1)	Retro-fit SUDS and improve the flood resilience at the University of Newcastle upon Tyne campus, the new student accommodation development on Richardson Road and also at the RVI.	Reduces flood risk, improves water quality, increases biodiversity and improves 'sense of wellbeing' from greening of urban areas	✔
Benwell SUDS for Schools	A	Retro-fit SUDS at a number of schools within the Benwell catchment	Reduces flood risk, improves water quality, increases biodiversity, educational benefits and improves	✔

Opportunity	Area	Brief Description	Key Benefits from Opportunity	Short List
			'sense of wellbeing' from greening of urban areas	
Newcastle Civic Centre SUDS	B(1)	Retro-fit SUDS at the Newcastle City Council offices at the Civic Centre	Reduces flood risk, improves water quality, increases biodiversity and improves 'sense of wellbeing' from greening of urban areas	✔
Broad Chare Storm Sewer[#]	NA	Conversion of the Broad Chare sewer from combined to storm sewage only (i.e. surface water and screened sewage flows only)	Improves water quality of the River Tyne, provides surface water outlet from north of the city centre, facilitates future development and releases capacity at Howdon STW	NA
St James Boulevard SW Sewer	C	New surface water conduit on St James Boulevard from Gallowgate to the River Tyne.	Improves water quality, provides surface water outlet from west of the city centre and facilitates future development	✔
Newgate Street & Tuthill Stairs	C/D	Provide a dedicated exceedance route for flood flows from Newgate Street to the River Tyne, plus relocation of Tuthill Stairs CSO.	Improves water quality of the River Tyne, reduces flood risk and improves resilience to extreme weather	✔ (part of)
Grey Street, Markets Street, Dean Street and Newcastle Quayside	D	Provide a dedicated exceedance route for surface water flows from Blackett Street Dean Street to the River Tyne, plus flood protection on the Quayside to protect against high river levels.	Reduces flood risk and improves resilience to extreme weather and resilience to major commuter transport links	×
The University of Northumbria SUDS	B(1)	Retro-fit SUDS at The University of Northumbria	Reduces flood risk, improves water quality, increases biodiversity and improves 'sense of wellbeing' from greening of urban areas	×
Hodgkin Park and Wellfield Road SW Separation	A	Separation of combined flows from upstream at Wellfield Road improve management of storm run-off from across Hodgkin Park	Reduces flood risk and flows in the combined sewer, improves drainage for Hodgkin Park and improves resilience to extreme weather.	✔

[#] The Broad Chare storm sewer opportunities has been listed due to its strategic importance, although it has limited benefits in terms of flood risk it has a significant benefit in the on-going surface water strategy for Newcastle Upon Tyne, as it facilitates further development and surface water proposals by creating a conduit from the north of the city to the River Tyne which significant benefits to opportunity area B.

Appendix H
SUDS and Green Infrastructure

Buffer Strips

Vegetation Strips

Dry Swale

Filter Drain and French Drain

Leaky Dams

Water Butts and Harvesting Tanks

Rain Gardens

Permeable Paving

Green Roofs

Attenuation Basins

Detention Ponds

Roadside Bio-Retention/Planters

Appendix I
FDGiA Preliminary Assessments

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Appendix K
BeST Evaluation Results

April 2016
Doc Ref. 33634/F/001

April 2016
Doc Ref. 33634/F/001

April 2016
Doc Ref. 33634/F/001