Feasibility Report

Glenavy

CO401956 / 001

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amey consulting

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Revision History

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0.0	03/04/2022	New Document (Draft)	Julie Marshall	Warren Boal
1.0	17/05/2023	Updated with DfI comments	Julie Marshall	Warren Boal
2.0	25/10/2023	Updated to an accessible document	Julie Marshall	Wallace McKay

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Executive Summary

Amey Consulting was commissioned by the Department for Infrastructure (DfI) Rivers to appraise flood risk to properties in Glenavy. This included investigating options (including economic viability) to alleviate any potential flooding from a 1% Annual Exceedance Probability plus climate change flow (1% AEP+CC). In the 1st Cycle of the Flood Risk Management Plan (FRMP), Glenavy was not identified as a Significant Flood Risk Area, however it was outlined as an Area for Further Study.

At the outset of the commission, DfI Rivers provided the existing ICM hydraulic model for the study area which was in turn updated to better reflect the current conditions along the watercourse. The investigations and updated modelling identified that the August 2008 flooding at Glen River Park was actually related to a backing up of the surface water system due to an unflapped outfall to Glenavy River. The river did not come out of bank in this location. The subsequent installation of a flap valve on the outlet has addressed this issue.

However, further downstream at Chestnut Glen / Forest Glen the investigations have identified that the flooding experienced in this location in August 2008 was due to a partial blockage of the bridge. Incremental blockage modelling has identified that a 30% of the Chestnut Glen bridge would be required to replicate the flood inundation experienced by residents. Therefore a 30% blockage has included in the baseline 'Business as Usual' scenario to replicate the realistic situation where the existing maintenance regime is continued. Hydraulic analysis was undertaken using the updated model to assess the effectiveness of the 2no. flood defence options proposed in the "Do Something" Option Scenario.

The flood damages for the 5, 25, 50, 75 and 100-year flood events plus climate change were calculated based upon the Multi-Coloured Manual and discounted over the 100 years assessment period to determine the present value damages avoided for each option.

The existing BAU scenario does not deliver the desired Standard of Protection and therefore cannot be taken forward as the preferred option.

The construction cost of each option was estimated using SPONS 2022 and tendered rates for similar schemes within Northern Ireland. The maintenance costs have been discounted over the 100-year design life of the scheme to give a Present Value (PV) maintenance cost. This has been used to determine a whole life PV cost for each option.

The only option to achieve a Benefit/Cost ratio in excess of unity (1) was Option 1. This option consists of constructing a roughing screen upstream of the Chestnut Glen bridge and results in a Benefit/Cost ratio of 3.28.

Although not the highest ranked option in the non-monetary assessment, Option 1 achieved a score of +29, which is still very favourable and supports the decision of the economic assessment.

Option 1 has an estimated whole life cost (design, construction including an optimum bias of 31.68% and ongoing maintenance) of £130,138.

The Option provides a benefit in terms of Present Value Flood Damage Avoided of £426,725.

Option 1 consisting of the construction of a roughing screen upstream of Chestnut Glen Bridge, which will provide a 1 in 100-year plus climate change Standard of Protection to the majority of properties currently at risk of flooding. The onset of flooding at property no.47 Chestnut Glen is shown to occur in a 1 in 50 year plus climate change event. However, Option 1 will reduce the depth of flooding at no.47 from >600mm to 130mm in a 1 in 100-year plus climate change event. As the property will not fully achieve the design standard of the proposed scheme, the property owner would be able to take advantage of the Homeowner Flood Protection Grant Scheme (Northern Ireland).

1. Introduction

1.1. Background

Amey Consulting has been commissioned by the Department for Infrastructure (DfI) Rivers to assess the potential flood risk to residential properties in Glenavy and to consider appropriate mitigation options. Figure 1 shows an overview of the scheme.

There is a history of fluvial flooding in village of Glenavy, with significant events recorded in 2000, 2008, 2010, 2014 and 2018. This section of the Glenavy River is designated and is on an annual maintenance schedule for DfI Rivers.

This feasibility report will assess the existing flooding mechanisms and extent of flood risk in Glenavy, before identifying potential flood risk management solutions and using a qualitative/quantitative assessment to determine the preferred option based on effectiveness, buildability, risk and economic/non-monetary appraisal. The business case is being assessed for providing protection to Glenavy against a 1% Annual Exceedance Probability (AEP) flood event with an additional 20% allowance for climate change (i.e., 1 in 100-year + CC event or Q100CC).

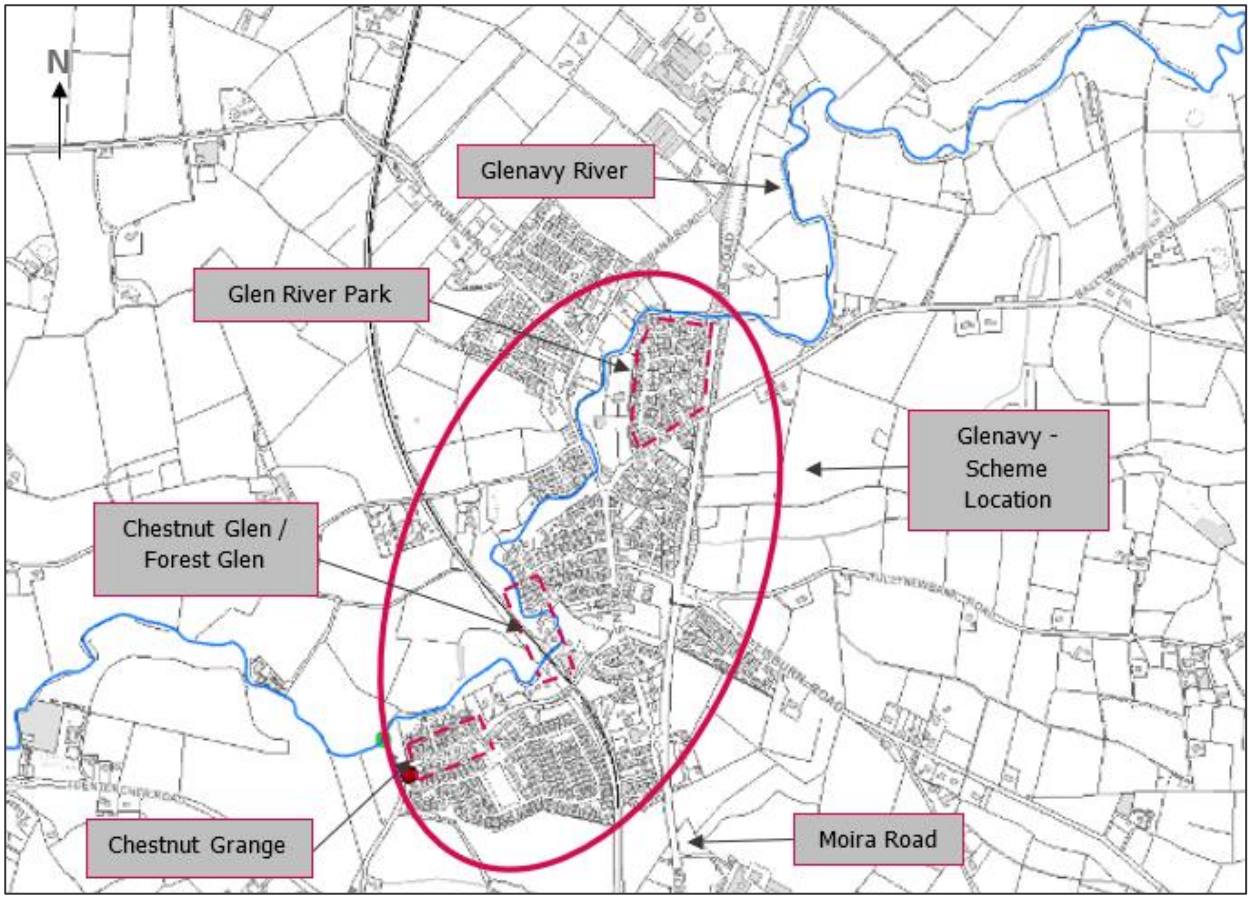

Figure 1 - Glenavy Study area

1.2. Study Area

The A26 Moira Road forms the north-eastern extent of the study area. The Glenavy River originates as the Stoneyford River from Stoneyford Reservoir, flowing south-westerly through the town of Glenavy, where it becomes known as the Glenavy River, and ultimately discharges to Lough Neagh (see Figure 2).

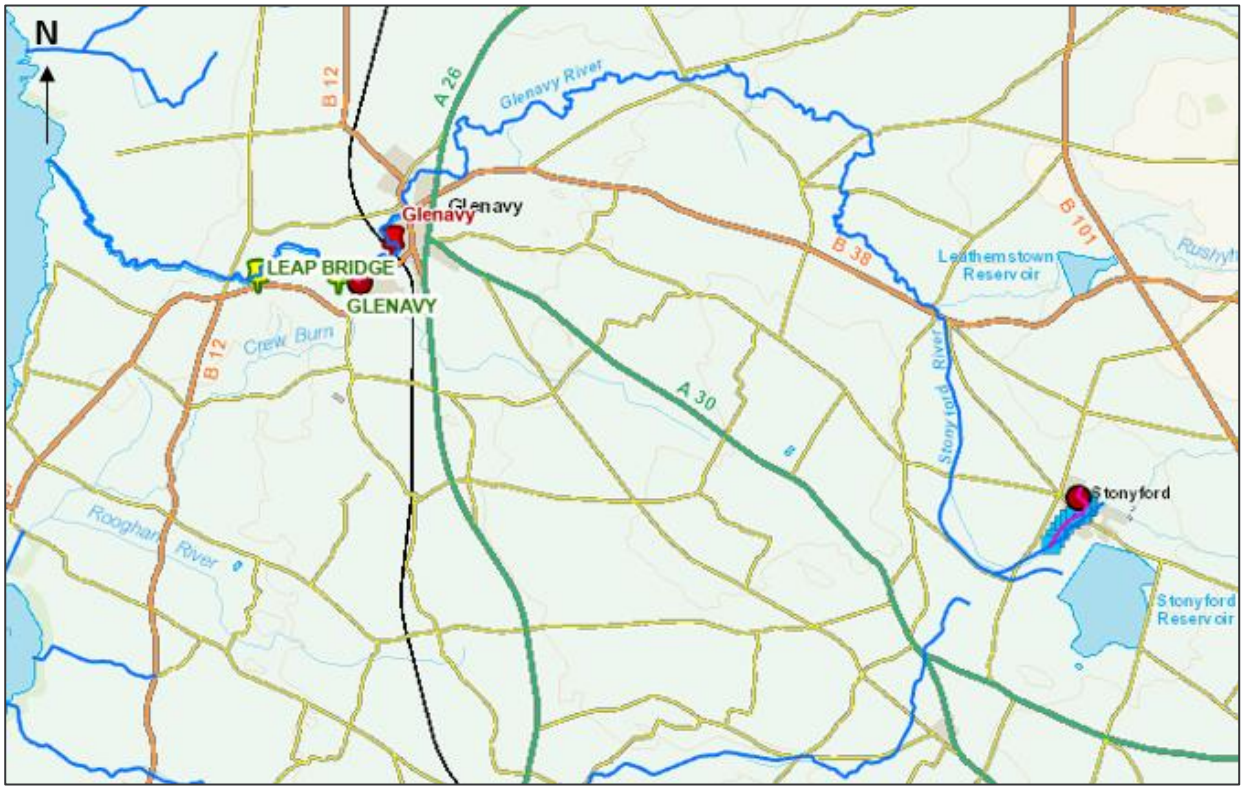

Figure 2 – Watercourses within the study area

1.3. Scope of Works

Amey Consulting has been commissioned by the Department for Infrastructure (DfI) Rivers to assess the potential causes of fluvial flooding in the Glenavy area and to consider any possible flood mitigation options. Due to the residential setting, any proposed works should minimise the visual and environmental impact on the area. Further investigations were carried out in the study area (e.g., Topographical surveys) to update the existing model and inform the assessment of flood risk up to and including the 1% AEP + CC design event. As per existing guidance, a 600mm freeboard will be included in the height of any proposed flood defences.

1.4. Methodology

To carry out a further study into the causes of flooding and the potential impact of a 1% AEP plus climate change event, Amey Consulting has commissioned experienced modellers, Waterco Ltd, to develop the following:

- Update the existing fluvial model to include any updates to the area, including schemes not included in the original model or recently built housing in the area.

- Consider the standard range of flows and produce flood maps indicating the extent of flooding anticipated for each event in the undefended and defended states.
- Consider the effects of development and climate change on flows in the relevant watercourses.
- Consider a range of options that would remove the threat of flooding up to and including the 1% AEP + CC scenario. In developing, options consideration should be given to the technical, economic, and environmental aspects of proposals.
- Ensure that the proposed flood mitigation measures remove the threat of flooding up to and including the 1% AEP + CC scenario.
- Identify and quantify the flood damage to properties presently at risk of flooding in events up to and including the 1% AEP + CC scenario.
- Recommend the most cost-effective solution for providing flood protection to the 1% AEP event + climate change.

Development of the model was contingent on surveys being procured for the area. The following surveys were carried out for the scheme.

- Topographical survey
- Finished Floor Level Survey – Floor levels of residential properties potentially affected by flooding.

From the information produced in the final modelling report, Amey Consulting will be able to support various mitigation options to alleviate the flooding.

The main outputs will consist of:

- Updated ICM model for the study area.
- Technical Modelling Report.
- Flood Maps showing the full extent of flooding in option scenarios up to and including the 1% AEP + CC scenario.
- Environmental desktop study with recommendations for the construction of preferred option.
- Geotechnical desktop study and site walkover with recommendations for the construction of preferred option.
- A full Economic Appraisal (EA) in accordance with the Five Case Model (if required).
- A Feasibility Report, supported by drawings, calculations, cost estimates and photographs. The report will outline the options and recommend the most advantageous way that DfI Rivers can counter potential flooding present and future.

1.5. Strategic Context

The powers delegated to DfI Rivers by the Department for Infrastructure as the statutory Drainage and Flood Defence authority for Northern Ireland derive from the Drainage (NI) Order 1973 as amended. In respect of these powers, DfI Rivers have a vision to "manage the flood risk to facilitate the social, economic and environmental development of Northern Ireland".

To support this vision DfI Rivers aims to reduce the risk to life and damage to property as a result of flooding from rivers and the sea. This involves undertaking watercourse and coastal flood risk management in a sustainable manner.

To achieve these aims and vision DfI Rivers will, as resources permit, take forward the implementation of the NI Flood Risk Management Plans 1st cycle 2015-2021 and the 2nd Cycle 2021-2027, developed as a requirement of the EU Floods Directive.

In support of these aims DfI Rivers' objectives are to:

- Implement sustainable flood risk management policies to facilitate development management and planning decisions. This assists in meeting society's social, environmental, and economic needs;
- Reduce the number of properties currently at risk of flooding from rivers and the sea;
- Maintain as necessary the designated watercourse network;
- Provide flood maps and risk information;
- Discharge our Lead Government Department responsibility of the co-ordination for the Emergency response to flooding incidents.
- Support and motivate all our people to achieve DfI Rivers' objectives; and
- Deliver quality services for our customers and stakeholders in a fair and equitable way.

1.6. Identification of Need

Glenavy has a history of flooding and was identified as an "Area for Further Study" (AFS) in the Neagh Bann Flood Risk Management Plan 2015-2021. DfI has attended several flood events in the Glenavy area, dating back to 2000, with the most recent event occurring in 2018. During the 2018 event, 4 no. properties were recorded to have flooded.

The Pre-feasibility report that was produced by DfI, identified 4 no. residential properties at risk of flooding in a 1% AEP event. This current study will model the Glenavy River more accurately and update river levels to include the effects of climate change.

Flooding has become more regular in recent years, as shown in Section 4.1, coming at a great cost to local authorities, residents, and business owners. To remove the long-term financial strain on this community, mitigation options to alleviate the flooding will be outlined in this report.

2. Surveys & Existing Data

2.1. Walkover Survey

An initial site inspection was undertaken by Amey Rivers Team / DfI Rivers on 20th July 2021 to gain an understanding of the existing problem, site constraints and the requirements of the study.

Amey personnel undertook separate site visits on the 7th and 27th July 2022, to improve local knowledge of the area and gather further evidence of previous flooding events from the residents.

2.2. Hydraulic Features

The study area consists of 1 main watercourse, the Glenavy River, which starts as the Stoneyford River as it discharges from Stoneyford Reservoir. The significant tributary in the upper catchment is the Stoneyford Tributary, which joins Stoneyford River approximately 600m downstream of the reservoir. A further urban watercourse, St Aidan's Stream, discharges into the Glenavy River downstream of the village, to the west of Chestnut Grange.

2.2.1. Glenavy River

From its headwaters at Stoneyford Reservoir, the Glenavy River flows for c.19km through open countryside and the village of Glenavy before discharging into the eastern side of Lough Neagh. There are several drains and tributaries of the Glenavy River, most of which are field drainage and man-made.

The Glenavy River is crossed by 11no. road bridges and 1no. railway line, see Figures 3 and 4 below. There are 2no. gauging stations and 1no. alert station along the full length of the river. The alert station is located between Chestnut Glen and Forest Glen. A gauging station is located towards the western side of Chestnut Grange whilst the other gauging station is located upstream of the bridge on the Lurgan Road.

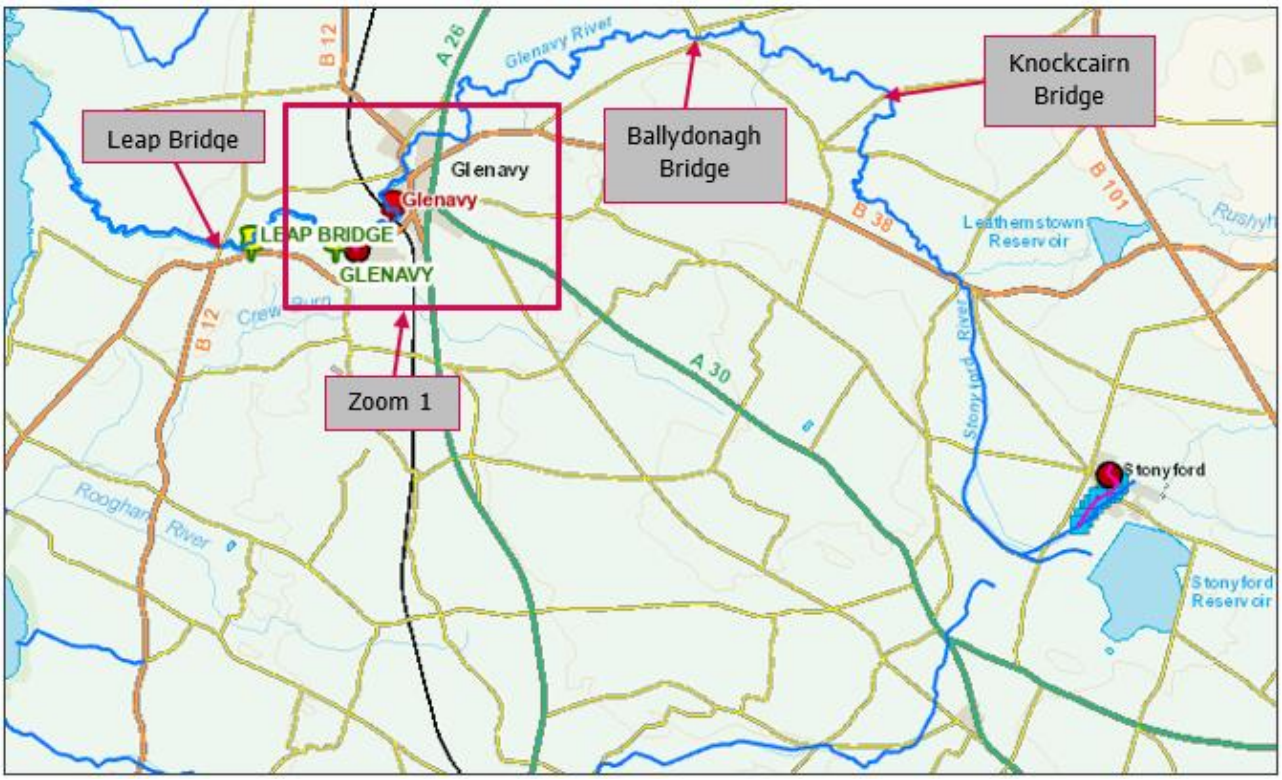

Figure 3 - Bridge Locations

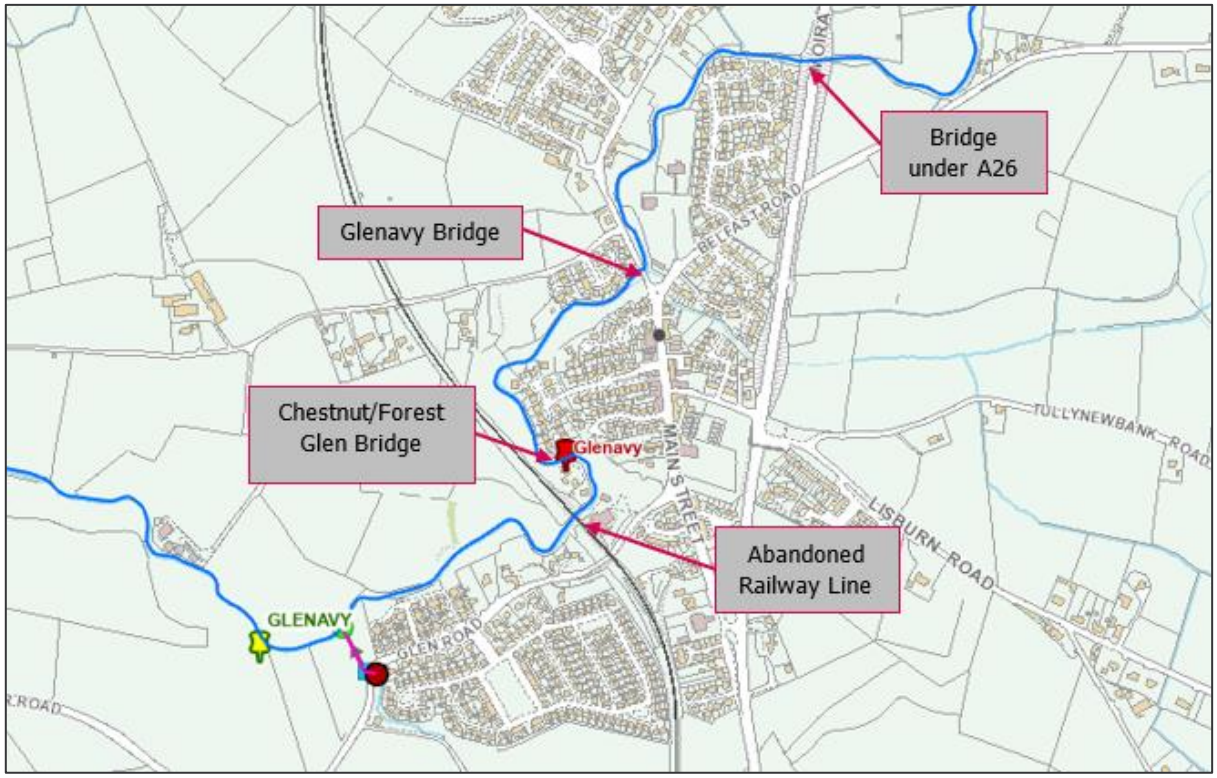

Figure 4 - Zoom 1 Bridge Locations in Glenavy

Figure 5 - Glenavy River Upstream of Knockcairn Bridge

Figure 6 - Glenavy River Downstream of Knockcairn Bridge

Knockcairn bridge is a masonry bridge located upstream from Glenavy village (see Figure 3 for location). As illustrated in Figures 5 and 6, there are medium density trees lining both banks upstream and downstream of the bridge.

Figure 7 - Glenavy River Upstream of bridge of A26

Figure 8 - Glenavy River Downstream of bridge of A26

Figures 7 and 8 show the river upstream and downstream from the A26 bridge (see Figure 4 for location). Upstream on both sides of the watercourse there are agricultural fields, with heavy vegetation lining both banks. Downstream of the A26, there is agricultural fields to the right bank, and residential properties to the left. Again, both banks and heavily vegetated, allowing for debris to build-up in the watercourse during times of excessive rainfall.

Figure 9 - Glenavy River Upstream of Glenavy Bridge

Figure 10 - Glenavy River Downstream of Glenavy Bridge

Figures 9 and 10 illustrate both upstream and downstream of Glenavy Bridge (see Figure 4 for location). Glenavy Bridge is located within the Glenavy village, which is predominately a residential area. There is a Youth Centre along the right bank, although there is evidence of undercutting along this bank. It is clearly displayed in the figures above, that tree cover increases as you progress downstream.

Figure 11 - Glenavy River Upstream of Chestnut/Forest Glen Bridge

Figure 12 - Glenavy River Upstream of Chestnut/Forest Glen Bridge

A road bridge located within Chestnut Glen and Forest Glen is shown in Figure 4, with views from the bridge provided in Figures 11 and 12 above. Access to the river is difficult in this location due to the heavy vegetation and substantial number of trees located along the banks. The bridge was newly constructed as part of the development and used for access to the properties in Forest Glen.

Figure 13 - Glenavy River Upstream of Leap Bridge

Figure 14 - Glenavy River Downstream of Leap Bridge

Leap bridge is the final bridge on the Glenavy River before it discharges to Lough Neagh (see Figure 3 for location). Leap bridge is located in a rural area with agricultural fields on both banks. Again, these are heavily vegetated with a large number of trees in close proximity to the top of bank (see Figures 13 and 14).

2.2.2. Inlet Structures

There are 2no. grilles present within the Glenavy catchment area. The first of these (145-004) is located upstream within the village of Stoneyford. It is a single stage grille with a flowforge platform (see Figure 15).

Figure 15 – Image and Location of Inlet Structure 145-004

The second inlet grille (145-002) is located further downstream beside Killultagh Park, just off Glen Road (see Figure 16). The structure itself is on St Aidan's Stream, a tributary of the main Glenavy River. It is a singular security screen with a flowforge platform. There is also a flap valve at the outlet of the stream where it joins the Glenavy River.

Figure 16 – Image and Location of Inlet Structure 145-002

2.3. Topographical Surveys

Amey Consulting and Waterco Ltd were provided with the existing ICM model for the area to develop the study. Although an extensive model, further survey was identified to refine the model in critical areas.

The additional information requested to complete the model consisted of:

- Topographical survey – Topographical survey of property finished floor levels and bank levels along the Glenavy River.

2.4. Environmental Constraints

A desktop review of publicly available information was undertaken to identify any environmental constraints. The main environmental constraints in the area are the residential/commercial properties and the floodplain.

The scheme is hydrologically connected to Lough Neagh through Glenavy River. Lough Neagh is designated as an Area of Special Scientific Interest (ASSI), Ramsar site and Special Protection Area (SPA). The Glenavy River is of local importance for wildlife and acts as a wildlife corridor to and from Lough Neagh. The banks of the river in the village have large mature trees in places that would support species such as breeding birds and bats. Otter may be found along the river.

There are several cultural heritage assets located around the area of Glenavy. The Glenavy Bridge on Main Street is a grade B1 listed structure, located approximately 320m from Chestnut Glen. There are

two industrial heritage sites found within 100m of the scheme, a mill pond and mill race associated with the Glenavy River.

As the scheme is located in the village, there are residential properties that have potential to be affected by any proposed mitigation works. Residents would be affected by any construction noise or dust, disruption to accesses and visual impacts from flood defences.

Further environmental surveys or assessment may be required as the scheme progresses through preliminary design stage.

Further detail is provided in the EA12 record of environmental considerations in Appendix E.

2.5. Geotechnical Desk Study

The Amey Geotechnical team carried out a desk study to evaluate the potential flood alleviation options and the geology of Glenavy. It is recommended that site-specific GI is carried out for any identified works. The investigation should comprise soil and rock sampling, in-situ and laboratory testing. Scheduled depths of exploratory holes will be between 8m to 10m, to account for the level difference between the riverbank and riverbed, and to obtain sufficient information on the ground conditions to inform detailed design.

It is possible that soft/loose river terrace deposits could be encountered in the vicinity of any proposed works. Soil and rock laboratory tests are recommended on samples obtained from the proposed GI to classify and test the shear strength and compressibility of the soils and strength of rock. In particular, particle size distribution, bulk unit weight, effective shear strength, and if cohesive deposits are encountered plasticity and compressibility testing is required. Permeability would be required for any proposed floodwalls to inform seepage control checks.

Results from the Ground Investigation would be used at detailed design stage to assign design strength values to the various soil and rock materials along any proposed flood defences. These will be used to perform global stability checks including bearing, sliding and overturning checks, along with slope stability for the riverbanks in accordance with Eurocode 7. Settlement analysis would be undertaken to determine that differential settlement is not excessive between different ground profiles. Seepage analysis will be required for any floodwalls to determine cut-off depth requirements.

The Preliminary engineering assessment indicated the existence of the Glaciofluvial Deposits at anticipated formation level. Due to the granular nature and associated high permeability values of this material, seepage control measures should be considered, including dig and replace with cohesive imported fill. A GI confirming the site-specific ground conditions will allow a more extensive investigation into seepage and control measures required for any proposed floodwalls.

Further detail is provided in the Geotechnical Desk Study & Preliminary Engineering Assessment in Appendix D.

2.6. Related Projects

There are no related projects in the study area.

3. Stakeholder Engagement

Amey Consulting contacted numerous stakeholders in relation to this flood risk study in the Glenavy area. The findings from these consultations have been outlined in the sections below and have been considered when developing potential alleviation options.

3.1. Department for Infrastructure

Amey undertook consultations with the following DfI Departments.

3.1.1. Rivers

Amey met with DfI Rivers at Glen River Park to scope out the study and gain a full understanding of the area and key local issues. Areas of interest visited were those sites that had previously been impacted by flooding. As the study developed, monthly progress meetings were held with DfI Rivers to maintain communication routes and identify potential barriers and opportunities for the study.

3.1.2. Emergency Planning Response

DfI Rivers have local stockpiles and emergency response materials available throughout Northern Ireland. DfI Rivers currently have no designated areas within Glenavy to store materials required for emergency response, although they do have a rest centre at St Aiden's Parish Church Hall illustrated in Figure 17.

- St Aiden's Parish Church Hall – Rest Centre

Figure 17 - Location of Rest Centre

The nearest stockpiles used to store materials required for emergency response are located in Crumlin (see Figure 18).

- Crumlin Glen – Capacity 500 bags
- Crumlin Leisure Centre – Capacity 150 bags

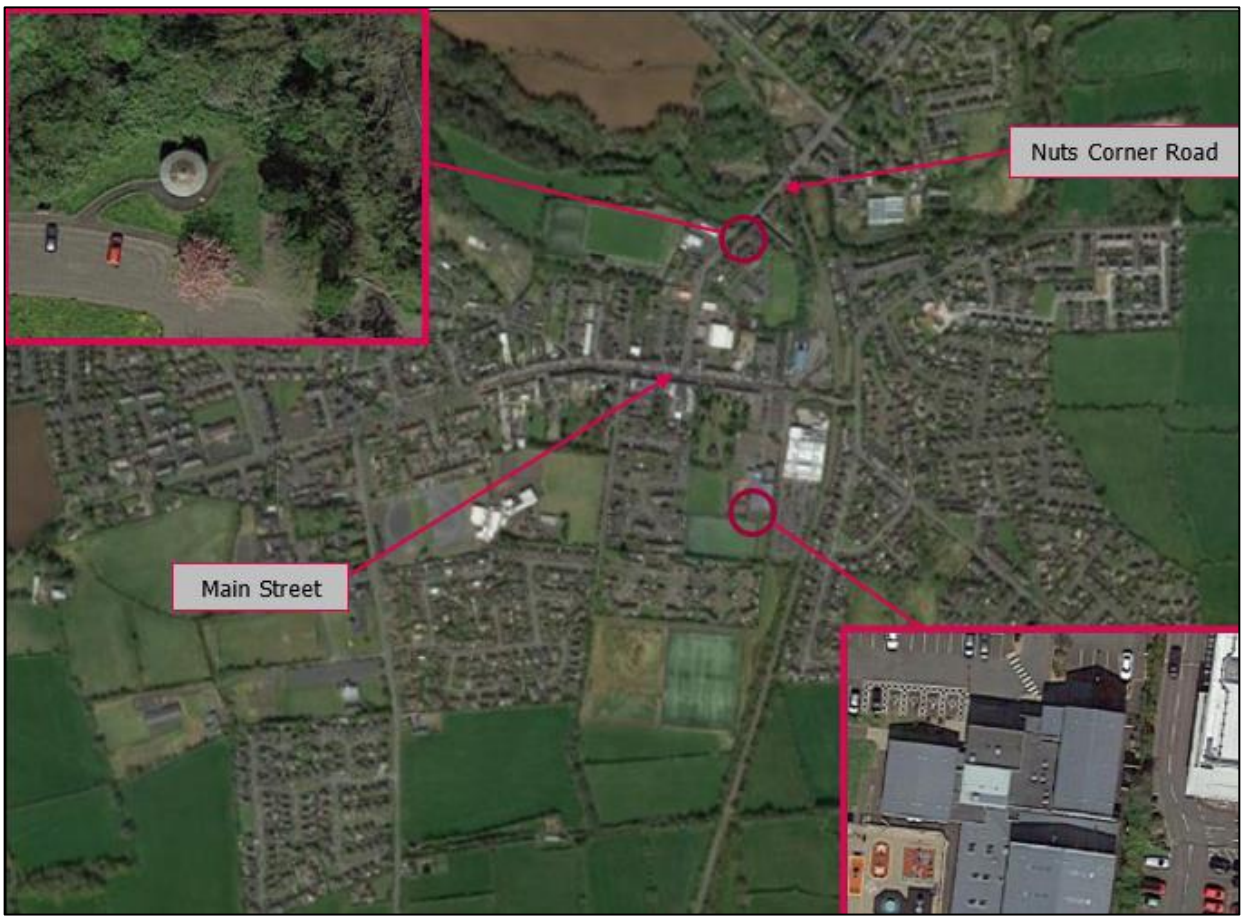

Figure 18 - Location of Emergency Response Sandbags

3.1.3. Roads

DfI Roads were contacted about the infrastructure in the area. Main roads in the study area are the A26 Moira Road, Belfast Road, Crumlin Road and Glen Road.

3.1.4. Hydrometrics

There are 2no. gauging stations in the Glenavy catchment, one called Glenavy (station number 203026), and one called Leap Bridge (station number 203063). Amey consulted with DfI Hydrometric Unit to gather the most up to date information for inclusion in the model.

The gauge at Glenavy closed in 2001 and the gauge at Leap Bridge opened in 2001, suggesting this gauge replaced the older one. Although the Leap Bridge gauge is not included in the latest NRFA dataset and is not on the NRFA website (despite it having a station number), the FEC record concluded that the gauge could be used in combination with the other Glenavy gauge to derive a more improved estimate of QMED.

There is also 1no. alert station within the Glenavy catchment, called the Glenavy River Alert Station. Figure 19 below shows the location of both gauging stations and alert station.

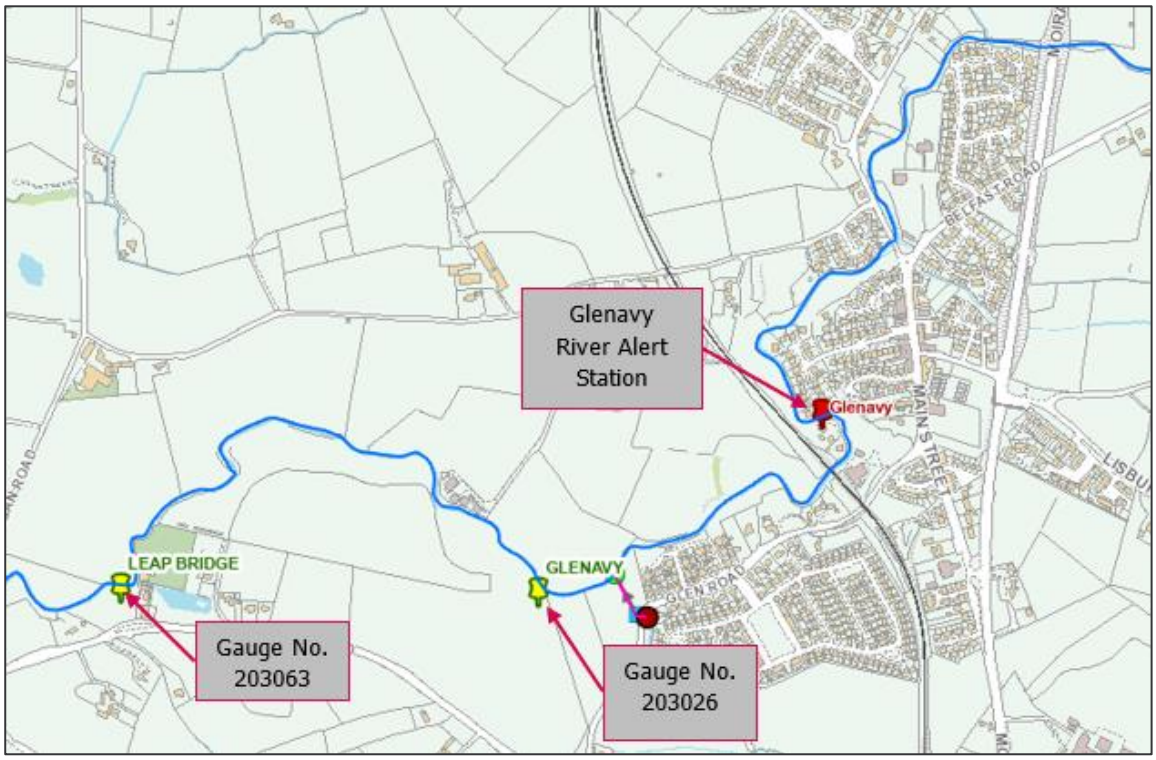

Figure 19 - Location of Gauging Stations and Alert Station

3.2. Ecology and Amenity

No consultation was carried out with NIEA or DAERA at this stage.

3.3. Lisburn and Castlereagh City Council

Amey Consulting contacted Lisburn and Castlereagh City Council Emergency Planning and Planning Departments.

3.3.1. Planning

Lisburn and Castlereagh City Council have no major developments to note in the study area. For further information on active planning applications in the area the portal is available online.

Planning portal public access was utilised for applications within the area that may have a significant impact on the damages of the flood. In the past 2 years there has been 8no. planning applications in the study area, consisting of 5no. extensions to existing properties, 2no. garage conversions and 1no. minor alterations.

3.3.2. Environmental Protection

No stakeholder engagement was undertaken in Planning and Environmental Protection at Lisburn and Castlereagh City Council. This would be further developed when any scheme progresses to detailed design.

3.4. Local Residents

Due to the residential setting of the Glenavy study area, Amey Consulting utilised DfI's GIS tool and 'Pointer data' in order to identify residences/properties which are within close proximity to any proposed works.

A letter drop to residents will be undertaken once it has been determined that there is a viable scheme to be taken forward to detailed design.

3.5. Service Provider Consultations

Any proposals considered will also need to take into account the services within the area.

Amey Consulting under The Street Works (Northern Ireland) Order 1995 – Diversionary Works have requested and compiled the service information from statutory authorities via the scheme Identification and Preliminary Inquiries (C2) process, including Northern Ireland Water (NIW), Northern Ireland Electricity (NIE) and other service providers. Table 1 below details the providers contacted for information.

Table 1 - Preliminary Services Enquiries

Utility Provider	Information Received	Existing Utilities	Drawing/Map Provided
Atkins (Vodafone Cable & Wireless)	Yes	No	N/A
Firmus Energy	Yes	No	N/A
NI Water	Yes	Yes	Yes
NI Electricity	Yes	Yes	Yes
Phoenix Natural Gas	No	TBC	
Rivers Agency	Yes	Yes	Yes
DfI (Street Lighting)	No	TBC	
Virgin Media	Yes	Yes	Yes
BT (Online Service)	Yes	Yes	Yes
Open Eir	Yes	No	N/A

NIE infrastructure in the area includes 33kV underground cables, 11kV overhead cables and poles and low voltage underground cables.

4. Desk Study Investigation of Historical Flooding

4.1. Historical Flooding

Glenavy has a history of localised flooding to the area, most notably, the event that occurred in August 2008. DfI records show that properties in Glen River Park, Chestnut Glen and Forest Glen, all experienced flooding during this event. Figures 20 and 21 capture the river levels to the rear of properties, in Glen River Park, in 2008. As shown in Figure 21, the water levels were high but did not appear to overtop the riverbank in this location.

Figure 20 - Flooding to rear of property no. 68 Glen River Park (2008)

Figure 21 - River level at no. 68 Glen River Park (2008)

Figure 22 below shows ponding to the front of properties 69-70 Glen River Park.

Figure 22 - Flooding to the front of properties 69 & 70 Glen River Park (2008)

Evidence of flooding in Chestnut Glen is illustrated in Figures 23 – 25. Figures 23 and 24 show the progression of the flood event at no.47 Chestnut Glen. Figure 25 shows the flood event and water levels at property no.22, taken from no.47.

Figure 23 - Flooding at property no. 47 Chestnut Glen (2008)

Figure 24 - Flooding at property no.47 Chestnut Glen (2008)

Figure 25 - Flooding to the front no.22 Chestnut Glen (2008)

4.2. Areas of Risk

The main area at risk of flooding are Glen River Park and Chestnut Glen / Forest Glen.

4.3. Future Development

As outlined in Section 3, the Lisburn and Castlereagh City Council have no major developments of note in the study area.

4.4. Tidal Influence

There is no tidal influence on the watercourse in the study area.

5. Hydrological Analysis

Amey Consulting Ltd. commissioned Waterco Ltd. to complete a hydraulic assessment of the existing ICM Model and run the options developed to combat the flooding within the study area. The Hydraulic Model was provided by DfI Rivers, this included the 'Glenavy_2014_09_08.icmt'. Further information can be found in the Waterco Ltd. modelling report in Appendix B.

5.1. Hydrological Background

DfI records show that properties in Glen River Park, Chestnut Glen and Forest Glen, all experienced flooding during August 2008 flood event.

5.2. Availability of Data

To aide with the development of a working ICM model the existing model was provided to the modellers. This are outlined below.

- Glenavy_2014_09_08.icmt'

The existing model was updated so that events and options could be run for the scheme. The additional data which was used to update the model was provided by DfI Rivers and Amey Consulting and is listed below:

Once the model was built the modellers required the following additional information to provide the required flood mapping outputs for the Glenavy area:

- A LiDAR DTM at 1m resolution for the Glenavy study area. This was provided by OpenDataNI.
- Topographical Survey Data, including Finished Floor Levels where possible, to supplement the LIDAR and DTM data.
- Shapefile provided by DfI Rivers containing polygons for buildings and roads.
- Pointer Data – related to the residential properties was required to complete the damage assessment for each flood event.
- Historical Flood Data – Previous flood event extents provided by DfI Rivers were used to support the calibration and verification of the model.

5.3. Hydrological Analysis

The hydrological analysis undertaken to derive the flow estimates within the supplied model was originally undertaken in 2012.

As part of this study the original hydrology was reviewed and subsequently updated using the FEH Statistical method and the ReFH2 methodology.

The completed hydrological calculations, summarised in a Flood Estimation Calculation (FEC) Record, are included in Appendix B along with the final design hydrographs used. Peak flow estimates for the present-day events are summarised in Table 2 below.

Table 2 - Present Day Peak Flows

Watercourse	Flood peak (m3/s) for the following return periods (in years)						
	2	5	10	25	50	100	200
Glenavy River	18.66	26.24	31.20	37.28	41.67	45.93	53.89

The impact of climate change has been modelled as an increase in flows by 20% for all the simulated return period events.

5.4. Climate Change

The proposed flood defences are designed to mitigate against a 1% AEP event with an allowance for climate change, in accordance with the latest guidance. DfI Water & Drainage Policy – Technical Flood Risk Guidance in relation to Allowances for climate change in Northern Ireland (February 2019) advises that "a single climate change allowance of +20% additional flow is applied to the estimated 'Present Day' 100-year peak flow".

5.5. Design Flows

The Glenavy River catchment is located to the east of Lough Neagh where it drains in a westerly direction through the village of Glenavy, before eventually discharging to Lough Neagh. The distribution of inflows applied to the model is shown in Figure 26 below.

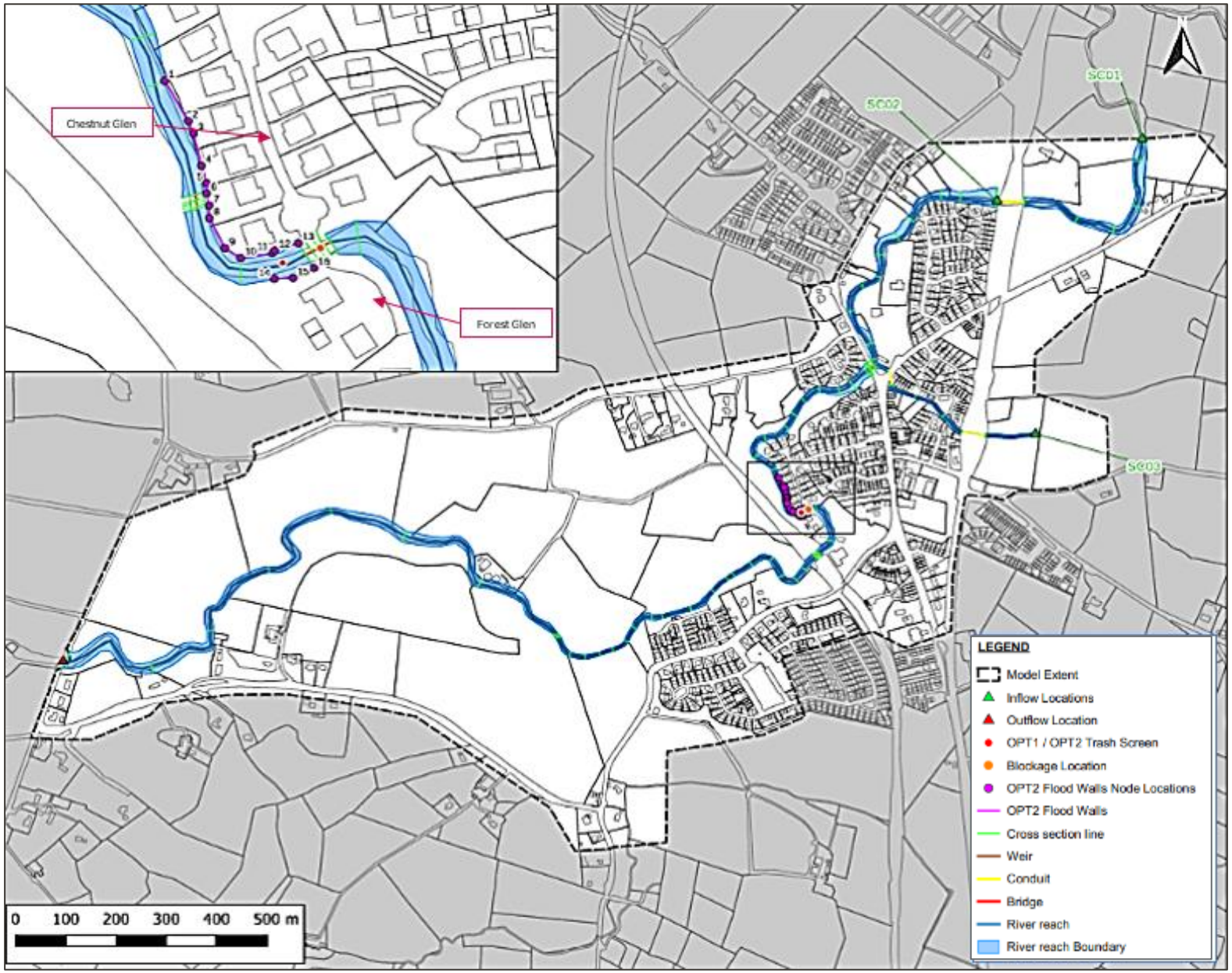

Figure 26 – Model Extent

6. Hydraulic Modelling of the Existing System

6.1. Infoworks ICM Modelling

Waterco Ltd. received and reviewed the existing fluvial model for the Glenavy River provided by DfI Rivers. A linked 1D-2D InfoWorks-ICM model has been developed for the study area, based on supplied information. The model was upgraded with survey information of the urban watercourse to allow a detailed assessment of the flood risk. ICM modelling was considered the most appropriate for this study as it is industry-standard software which has been widely used for fluvial modelling. Version 10.5 (64 bit) was used following the upgrade on the supplied model.

The floodplain has been modelled as a 2D domain which is a triangular irregular mesh. The flexible mesh representation of the ground surface used by the ICM improves representation of roads and other topographic features, meaning that flow routes are more accurately modelled.

6.2. Hydraulic Assessment of Existing System

An existing model had been created by JBA in 2012 but the supplied model did not include any results files. The following updates have been made to the baseline model to address comments found during the model review and to improve the representation of the study area within the model:

- Watercourse channel and bank survey (Feb 2022) has been utilised to update the modelled river section geometry, bank levels and hydraulic structures within the study area.
- The latest LiDAR data (2022) has been used to update the ground model.
- Latest topographical survey has been utilised to update Finished Floor Levels (FFLs) of buildings at key locations within the study area.
- Latest OSNI Mastermap data has been used to include representation of roads as roughness zones and buildings as porous polygons within the model.
- The watercourse inflows in the model have been updated using the updated hydrology.
- Updated pointer dataset has been utilised to assign damage receptors to buildings which will enable damage assessment calculations.

6.3. Model Calibration and Verification

Once the baseline model was completed, it was run with the flows generated through the hydrological assessment.

The model outputs have been compared against the original as-received DfI model outputs and available historical flood evidence of Glenavy, to verify the model performance. For detailed information on the historical flood events that occurred in Glenavy, photographs of the 2008 flooding were provided in the pre-feasibility report (September 2019).

This evidence indicated that the properties at Glen River Park experienced flooding during the August 2008 flood event. However, the modelled flood extents do not show flooding to these properties. Therefore, a detailed assessment of the available evidence and additional model simulations have

been completed to verify the accuracy of the model outputs. A summary of the findings is provided below.

- The original DfI model also shows flooding of properties in Glen River Park during the 1% AEP event, however, the updated model does not show flooding to these properties. The mismatch in flood extents shown between the two models was found to be due to presence of a low spot in the modelled bank levels within the original DfI model which caused the onset of flooding. The updated model bank levels are based on 2022 survey and does not include the low spot, so floodwater is shown to remain in-channel. A site visit completed by Amey in 2022 confirmed the absence of low spots in the bank levels so the current model representation was deemed appropriate providing confidence in the model outputs.
- Flood event photographs within the pre-feasibility study report show residents attending to a manhole cover at this location, which suggests the possibility of surface water drainage issues causing flooding of the road. A flap valve was installed after the flood event which also suggests surface water issues. Without evidence related to the source of flooding, further comparison against the model outputs was not possible.
- Outputs from model sensitivity tests showed that the in-channel water levels vary, however, the properties remain flood free providing confidence in the model outputs.

An overview of the calibrated model is shown below in Figure 27.

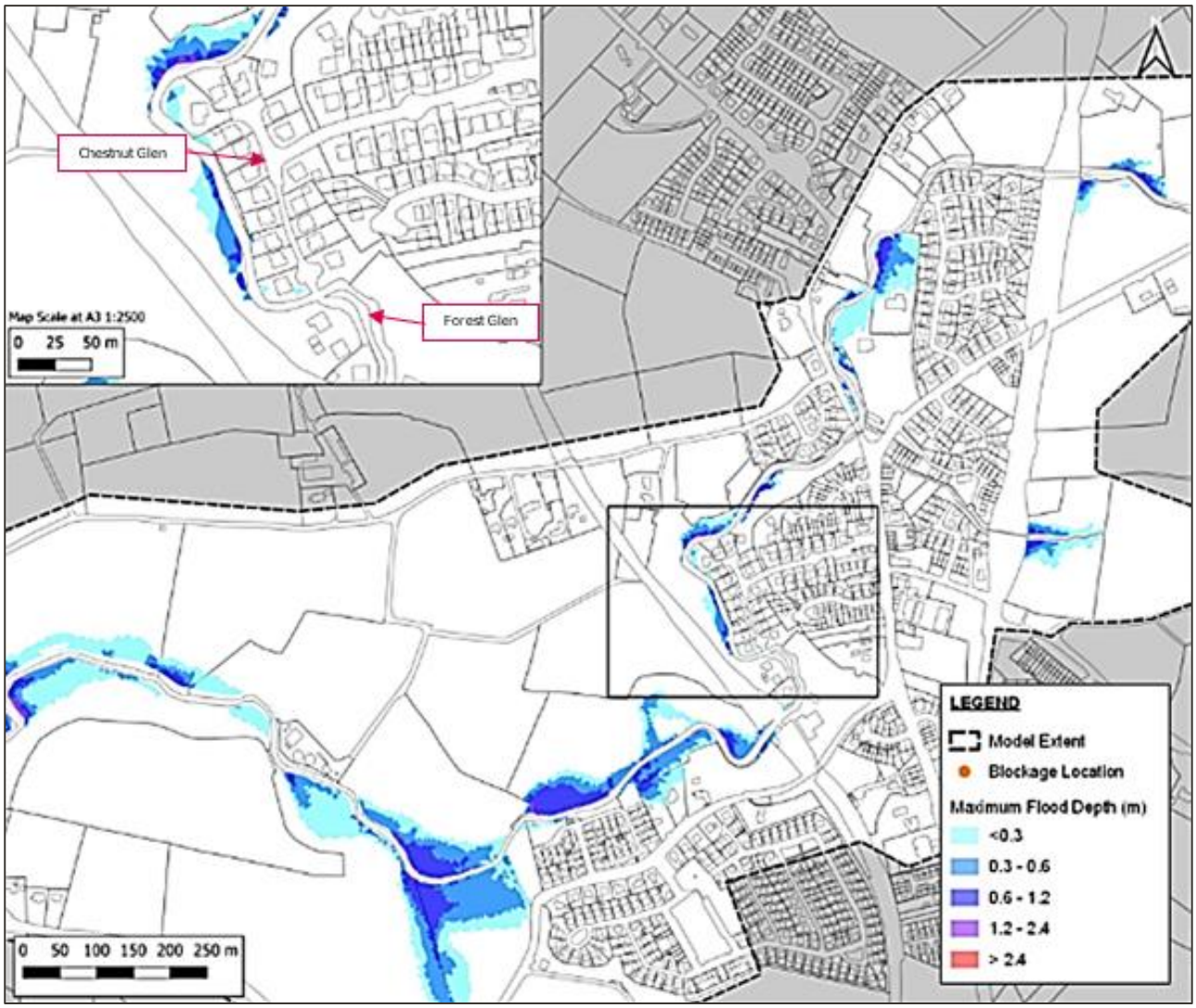

Figure 27 - Overview of the Calibrated and Verified model in Q100+CC flow

Further downstream at the Chestnut Glen / Forest Glen bridge, the model was unable to replicate the flooding experienced in 2008 as shown in Figures 23, 24 and 25. Significant and unrealistic additional flow would have been required to result in the flooding shown in the photographs. It was therefore evident that there must have been an obstruction which resulted in the flooding that was experienced in 2008.

Consultation with residents identified that in the 2008 event, the out-of-bank flow was because of a blockage at the bridge. The calibrated/verified model was therefore re-run, incrementally increasing the size of the blockage until a good correlation with the known flood extents was achieved. A 30% blockage of the bridge resulted in the flood extents/depths identified in photographs from 2008. Therefore, a 30% blockage has been adopted in the BAU scenario (see Figure 28).

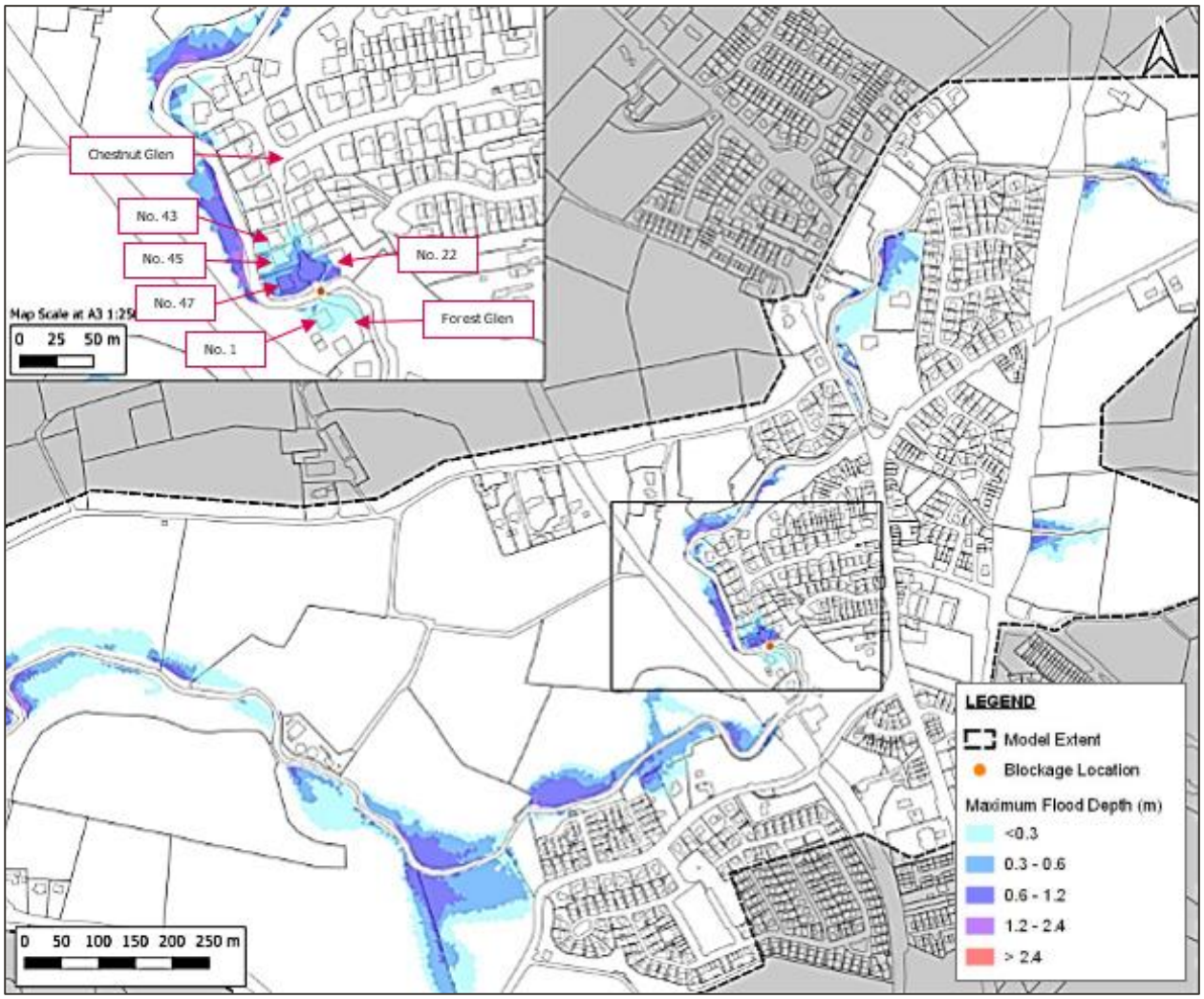

Figure 28 - Overview of the Business as Usual Scenario in Q100+CC flow

Further downstream at Chestnut Grange, all properties remain flood free up to the Q100+CC event.

6.4. Sensitivity Analysis

Sensitivity testing allows for greater understanding of the impact caused by the various assumptions made during model development. This was carried out on the parameters and inputs detailed in Table 3 below and expanded upon in the Waterco Report in Appendix B.

Table 3 - Sensitivity analysis scenarios

1% AEP Water Level (m AOD)	DfI Model Survey					2022 Survey			
	DfI Inflows	Waterco Inflows 2022							
	1	2	3	4	5	6	7	8	9
	Roughness unchanged	Roughness unchanged	Channel and Bank Roughness 20% increase	Bank Roughness 20% increase	Channel Roughness 10% increase & Bank Roughness 20% increase	Roughness as per 2022 survey photos	Roughness as per Column 4	Roughness as per Column 3	Roughness as per Column 3; upstream survey sections removed
Upstream of Road Bridge	67.50	67.04	67.26	67.06	67.17	66.61	66.64	66.77	66.77
Downstream of Road Bridge	66.43	66.30	66.54	66.34	66.45	65.62	65.70	65.90	65.90
Adjacent to 66 Glen Park	65.74	65.64	65.83	65.65	65.74	65.17	65.30	65.56	65.56
Out of Bank Flooding?	Yes	No	Yes	No	Yes	No	No	No	No

Properties Flood?	Yes	No	Yes	No	No except 70 Glen Park garage	No	No	No	No

7. Flood Risk Management Options

7.1. Business as Usual

For the 'Business as Usual' baseline scenario, where a 30% blockage was applied to the Chestnut Glen bridge, properties were shown to be at risk of flooding immediately upstream of the bridge. Figure 29 shows the 5no. properties in Chestnut Glen / Forest Glen which are at risk of flooding in this scenario.

Figure 29 - Business as Usual scenario at Chestnut Glen in a Q100+CC flow

7.2. 'Do Something' Options

7.2.1. Option 1 – Roughing Screen

Option 1 considers a roughing screen arrangement immediately upstream of Chestnut Glen bridge. The purpose of this option is to help reduce the blockage potential at this structure and thereby alleviate flood risk to properties at Chestnut Glen.

The debris accumulation on the roughing screen located approximately 10m upstream of the bridge structure, has been represented in the model as a weir. The weir crest level has been set at 58.01mAOD to replicate the volume of debris on the roughing screen which would have resulted in a 30% blockage at the Chestnut Glen bridge.

Model outputs show that the introduction of the roughing screen significantly reduces the flood risk to the properties at Chestnut Glen, relative to the BAU Scenario (See Figures 30 & 31). Although, this option does not fully remove the risk of flooding. Property no.47 Chestnut Glen is the only property to still experience flooding during a Q100+CC event where the height of flood water is

60.095mAOD against a finished floor level of 59.965mAOD (i.e., 130mm of flooding within the property).

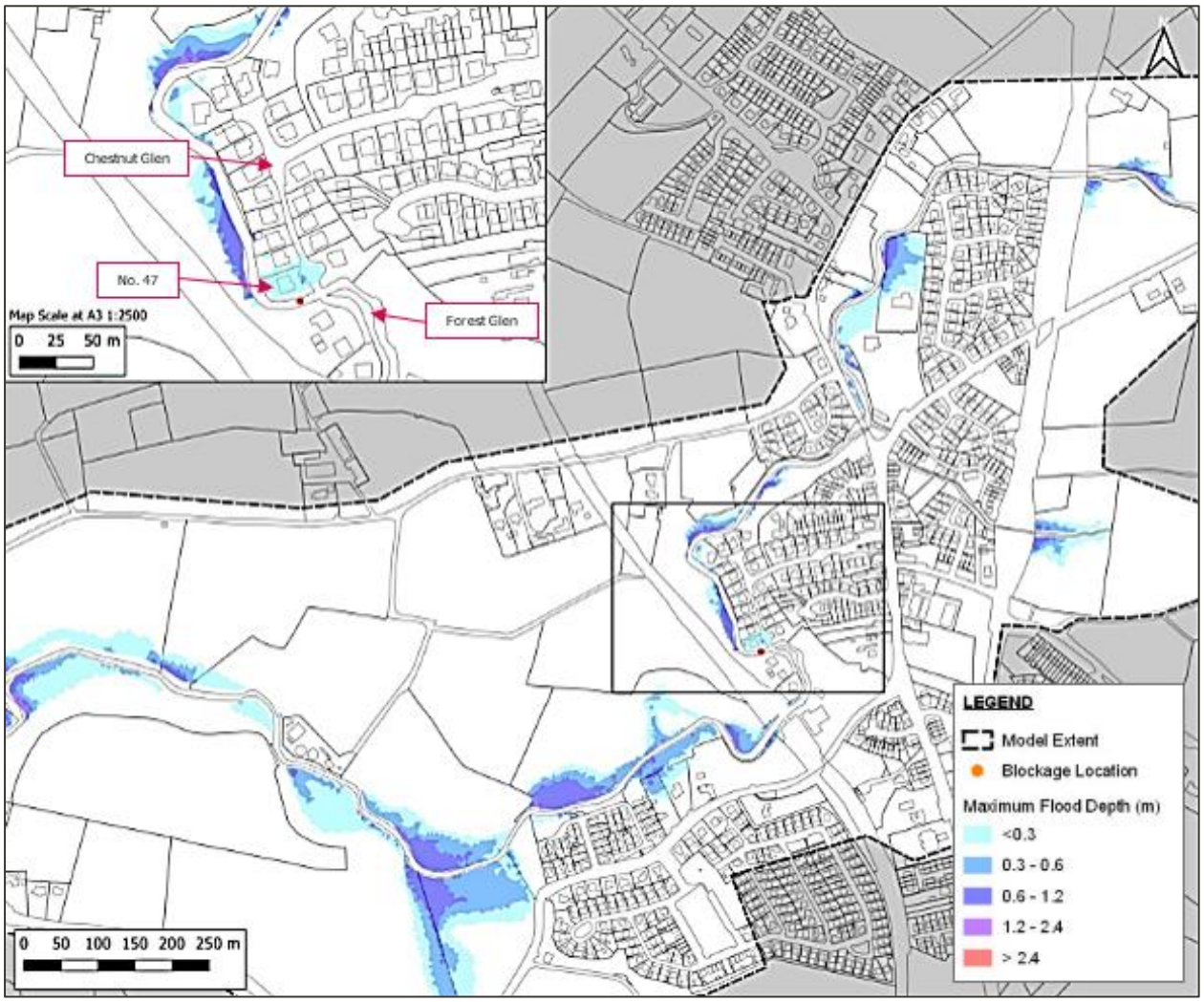

Figure 30 - Overview of Option 1 in a Q100+CC flow

Figure 31 - Option 1 at Chestnut Glen in a Q100+CC flow

7.2.2. Option 2 – Roughing Screen and Flood Walls

Option 2 is similar to Option 1, with a roughing screen immediately upstream of Chestnut Glen bridge (See Figure 32 below). For this option flood walls are also proposed along both banks of the watercourse, see below. Approximately 102m of floodwall has been proposed along the left bank with a further 16m along the right bank of the channel.

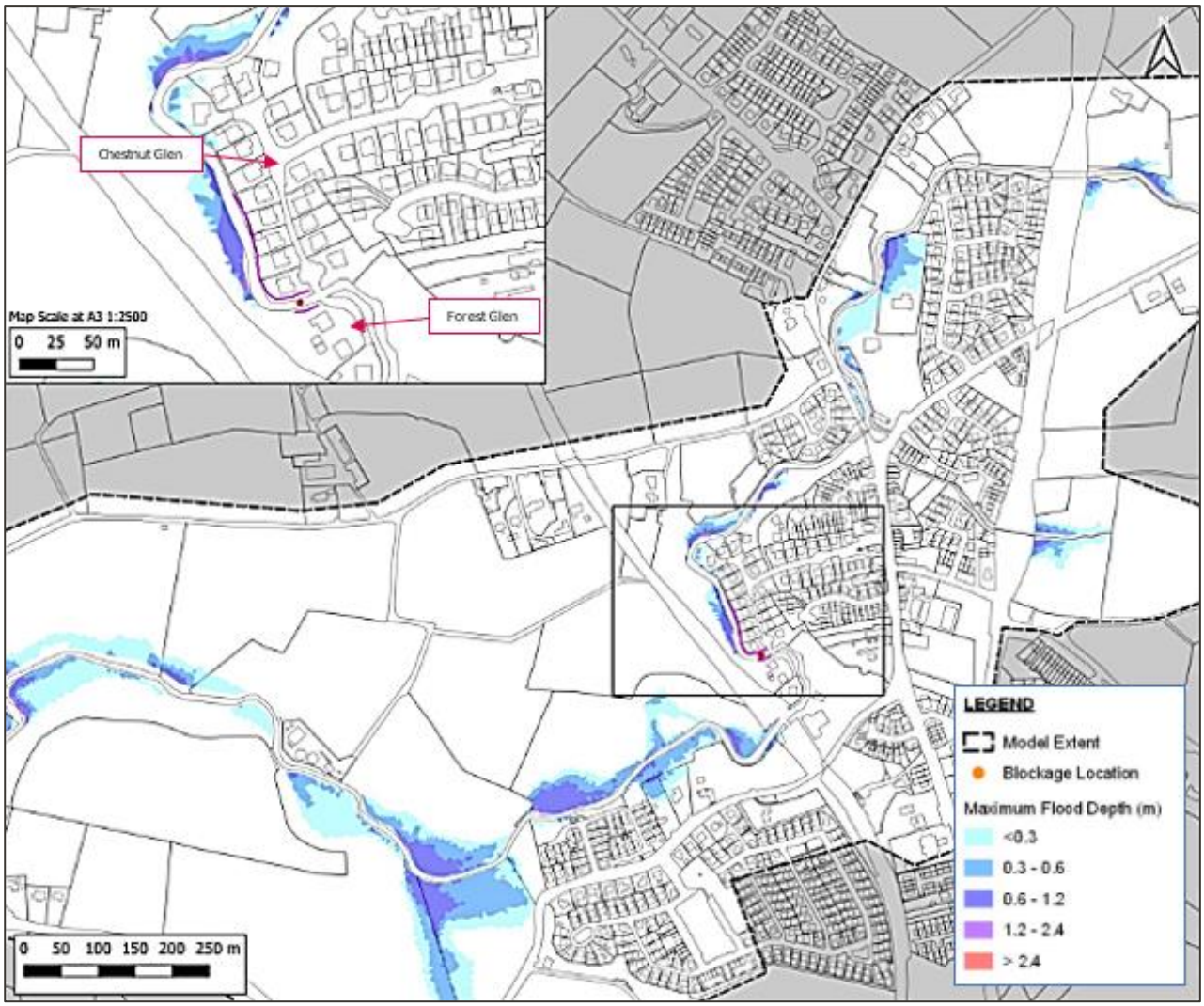

Figure 32 - Overview of Option 2 in a Q100+CC flow

The outputs from the modelling show that flooding of properties in Chestnut Glen / Forest Glen are completely removed in the Q100+CC event. Based on modelling results, a maximum wall height of 1.37m above existing ground level is required. Table 4 below illustrates required wall heights, inclusive of 600mm freeboard, with accompanying locations in Figure 33.

Table 4 - Option 2 proposed Wall heights

ID	Easting	Northing	Modelling Ground Level (mAOD)	1% AEP + CC event Maximum Water Level (m AOD)	1% AEP + CC event Maximum Water Level plus 600mm freeboard (m AOD)	Minimum Recommended Wall Crest Level (m AOD)	Appropriate wall height (m)	Chainage (m)
1	315282	372905	60.43	60.56	61.16	61.20	0.77	0.00
2	315291	372889	60.30	60.56	61.16	61.20	0.9	18.36
3	315293	372884	60.32	60.56	61.16	61.20	0.88	23.74
4	315296	372871	59.83	60.56	61.16	61.20	1.37	37.08
5	315298	372864	60.23	60.56	61.16	61.20	0.97	44.36
6	315298	372860	60.12	60.44	61.04	61.05	0.93	48.36
7	315299	372855	59.95	60.44	61.04	61.05	1.1	53.46
8	315299	372850	59.77	60.44	61.04	61.05	1.28	58.46
9	315305	372838	59.75	60.44	61.04	61.05	1.3	71.88
10	315311	372834	59.73	60.24	60.84	60.85	1.12	79.09
12	315323	372836	59.64	60.24	60.84	60.85	1.21	91.26
13	315324	372837	59.64	59.72	60.32	60.35	0.71	92.67
14	315324	372825	59.97	60.24	60.84	60.85	0.88	0
15	315331	372826	59.97	59.72	60.32	60.35	0.38	7.07
16	315339	372830	59.96	59.65	60.25	60.25	0.29	16.0154

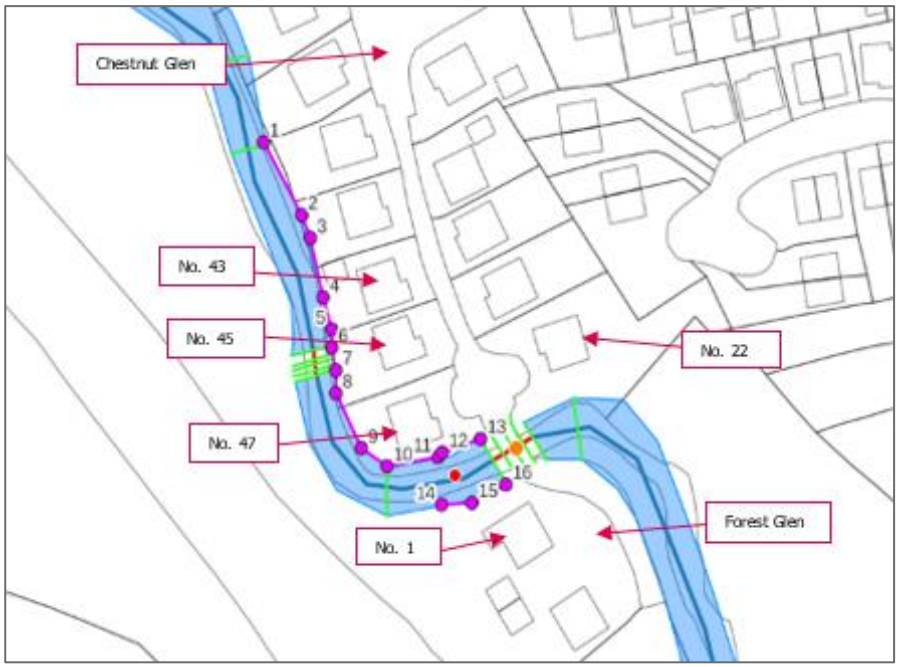

Figure 33 - Location of defence nodes

8. Economic Assessment

8.1. Cost Estimation

Table 5 illustrates costs for the options considered for the Glenavy study. The baseline and Business as Usual scenarios have been included in the assessment for comparison. The construction costs have been estimated using SPONS 2022 and tendered rates for similar schemes within Northern Ireland. The maintenance costs have been discounted over the 100-year design life of the scheme to give a Present Value (PV) maintenance cost. For a detailed breakdown of the costs for each option refer to Appendix C.

Table 5 - Option Cost Summary

Scheme Option	Capital Cost (£)
Business as Usual	-
Option 1 – Roughing Screen	£130,138
Option 2 – Roughing Screen and Flood Walls	£578,256

8.2. Damage Assessment

The damages for the Glenavy study area were calculated in accordance with the National Flood and Coastal Erosion Risk Management Strategy appraisal guidance. The FCERM-AG is based on HM Treasury's Green Book, which forms the basis for the appraisal.

The damages for the flood events were calculated and discounted over a period of 100 years to determine the Present Value damages (PVd) for the Baseline Scenario. This is then compared against the Option Scenario damages to determine the damages avoided (or benefit) of the flood mitigation option.

The damages avoided are then compared to the costs of implementing the option to assess whether the option is economically viable.

The MCM provides guidance for range of damages which can be assessed alongside direct property damage.

8.2.1. Direct Damages

Direct property damages are calculated in accordance with the Multi Coloured Manual. These are calculated when flood water is modelled to exceed the building threshold and causes direct damage to the property. Damage curves supplied by the MCM are applied based on property types, with damages increasing with modelled flood depths. Direct damages are calculated for a range of flood events, and Present Value damage is calculated from these event damages, using formulas within Flood and Coastal Erosion Risk Management Appraisal (FCERM) spreadsheet. This in effect calculates the total damage likely to affect a property over the 100-year appraisal period and discounts the flood damage in accordance with the Green Book.

The FCERM converts a series of flood event damages into annual average damages (AAD), based on the likelihood of any given event occurring in an individual year. Were climate change not a factor within the appraisal period, these AADs are applied each year of the appraisal and discounted appropriately. The sum of these discounted AADs, over the 100-year assessment period, is the Present Value damages of the option. If, however, it is predicated that climate change will influence the AAD over your assessment period, AAD must be calculated for each epoch within your appraisal period. NI technical guidance for climate change, describes a predicted increase in flows of 20% for the 2080s epoch. The 2080s epoch is a period from 2070 to 2099. This, in effect, indicates that there are two epochs within our 100-year appraisal period, a present-day epoch and the 2080s epoch.

To calculate the Present Value damages over our 100-year appraisal period, present day AAD and 2080s epoch AAD must be calculated. To calculate these, all flood events must be modelled under present day conditions (no increase in flows) and under 2080s epoch conditions (20% increase in flows to account for climate change.)

This allows a stream of AADs to be calculated, using 100% of the present day AAD at the beginning of the appraisal period, increasing incrementally towards the 2080 epoch AAD, with 2080 AAD fully applied from the start of the 2080 epoch (2070) to the end of the appraisal period. This is applied to both the direct property damage and intangible damages. Figure 34 illustrates how the updated stream of AADs is calculated from the two epoch AADs.

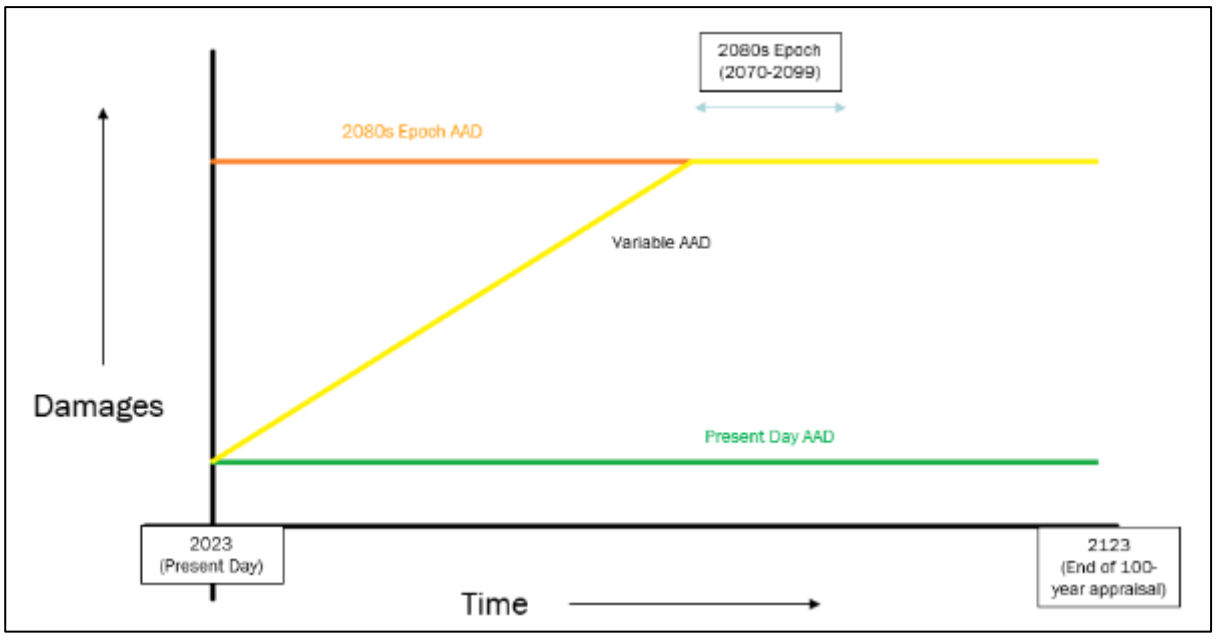

Figure 34 - Increasing AAD – The Impact of climate change on Present Value damages

8.2.2. Indirect Damages

These damages are at times referred to as "intangible" or "indirect" damages. Amey, in conjunction with our subcontractors, have analysed the MCM and believe the following damages to be the most proportionate to include in our damage analysis, to allow the benefits of the flood alleviation scheme to be maximised.

8.2.2.1. Emergency Services

The MCM 2022 provides guidance on how to account for the costs associated with flooding on the emergency services. It allows for 10.7% of property damages for "dispersed flood incidents" and 5.6% for "concentrated settlements such as large towns are cities". Given the location of Glenavy study, a percentage of 5.6% of all property damage was deemed appropriate. As per FCERM Guidance, the Green Book health discount rate is applied to Emergency Services damages.

8.2.2.2. Business Disruption / Indirect Losses

The MCM 2022 provides guidance on calculating additional damages relating to NRP (non-residential properties). This can be due to the "loss of business to overseas competitors" or "the additional costs of seeking to respond to the threat of disruption, or to disruption itself, which falls upon firms when flooded". The first of these damages is unusual, and not relevant to any NRP within the Glenavy study. It is only concerned with highly specialised companies which would be unable to transfer their production elsewhere in the country, which would therefore lead to a loss of the business to overseas competitors. The second of these damages is more common, and is related to the cost of moving inventories, hiring vehicles and/or additional staff to prepare for a forecast flood event. The MCM allows for this to be calculated at 3% of the NRP property damages. As per FCERM Guidance, the Green Book standard discount rate is applied to Business Disruption damages.

8.2.2.3. Evacuation and Emergency Accommodation Costs

The MCM 2022 recommends calculating the evacuation and emergency accommodation costs as a function of the flood depth and property type. This is based on the depth of flooding being related to the period that residents would be displaced, to allow for repair works, along with the property type being associated with varying durations of flood damage repair. The MCM provides a high, low, and average costs, average costs have been used for Glenavy. As per FCERM Guidance, the Green Book standard discount rate is applied to evacuation costs. Table 6 has been reproduced from the MCM to show the damages accrued for evacuation and emergency accommodation.

Table 6- MCM - Evacuation and Temporary Accommodation Costs - Initial

Maximum Depth Inside Property (cm)	Evacuation Costs by Property Type (£)											
	Detached			Semi-Detached			Terraced			Flat / Bungalow		
	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High
0-1	800	1,197	1,860	730	1,066	1,689	712	1,042	1,662	668	992	1,613
1-10	1,525	2,280	3,541	1,389	2,024	3,208	1,355	1,977	3,157	1,270	1,880	3,060
10-20	2,845	4,229	6,568	2,570	3,714	5,897	2,502	3,620	5,794	2,331	3,423	5,600
20-30	3,051	4,537	7,045	2,757	3,984	6,326	2,684	3,884	6,215	2,500	3,672	6,007
30-60	4,070	6,040	9,379	3,669	5,286	8,397	3,568	5,149	8,247	3,318	4,861	7,962
60-100	4,851	7,192	11,168	4,367	6,283	9,983	4,246	6,117	9,801	3,944	5,769	9,459
100+	7,660	11,319	17,575	6,865	9,826	15,629	6,666	9,553	15,330	6,170	8,983	14,767

8.2.2.4. Vehicular Damage

The MCM 2022 recommends that the average loss value of vehicles for flood damage appraisals should be £6,944, (based on the average value of a vehicle being £5,600 and the average amount of vehicles per household as 1.24). As vehicles are most likely to be damaged and written off (on health and safety grounds) at flood depths of 0.39m, this value only applies to properties where flood depths are modelled to be greater than this threshold. As per FCERM Guidance, the Green Book standard discount rate is applied to Vehicular damages.

8.2.2.5. Costs Associated with Mental Health

The Environment Agency released guidance in 2020 designed to provide direction on how to include the negative impact on mental health as part of FCERM economic appraisals. The MCM also points towards this guidance as an additional source of potential damages. The EA guidance discusses at length the growing amount of evidence suggesting that flooding has a negative impact on mental health and the need to develop approaches and data to include the costs associated with mental health issues in appraisals. The EA guidance provides values which represent the additional economic losses per adult, per flood which can be applied, depending on the flood depth inside the property. These damages are specifically related the direct treatment costs of poor mental health. Whereas the EA guidance also provides an average number of adults per property type in England, we have used the recent NI census to estimate the number of adults per property type in Northern Ireland, to apply this guidance more locally. Tables 7 and 8 provide details on how additional economic losses related to mental health, caused by flooding, has been accounted for in the damage assessment.

Table 7 - Environment Agency - Average Estimated Additional Economic Losses Per Adult, Per Flood

Flood Depth Inside a Residential Property	Additional Economic Losses Pre Adult Per Flood (calculated over 2 years)
<30cm	£1,878
30-100cm (inclusive)	£3,028
>100cm	£4,136

Table 8 - Number of Adults per Property Type – Estimated from NI Census

Property Type	Number of Adults (NI Census)
Detached	2.18
Semi-Detached	1.93
Terraced	1.77
Flat	1.17
Average	1.76

In addition to the EA guidance on the direct treatment costs of mental health, the MCM also provides a matrix to attribute damages to the intangible effects of flooding on mental health, i.e., the cost to an individual. These damages are calculated in relation to the annual flood probability of individual properties. Both sources of damages in relation to mental health are discounted using the health discount rate, as per FCERM guidance.

8.3. Accounting for Inflation

All costs within the MCM and the associated damage curves have been uplifted to the same date as the construction costs, allowing for a reliable comparison. Construction costs have been uplifted using the December 2022 Construction Price Index, damages have been uplifted using the December 2022 Consumer Price Index.

8.4. Capping of Damages

The PVd of individual properties were capped at the market value of the property. Capping of flood damages occurs because the cumulative damages are sufficient to exceed the market value of the property. Thus, damages to a property valued at £100,000, that is flooded once every ten years with a PVd of £35,000 per event would only be counted to a maximum of £100,000. Once the damages have reached the capping value, damages do not continue to accrue regardless of whether flooding continues. It is the direct property damage, which is capped in this way, with intangibles added for every year the property damage remains uncapped. Once the property damage has reached its market value cap, no further intangible damage can be added, as per MCM guidance.

The capped value of residential properties is based on property type with values reproduced from the Northern Ireland House Price Index (dated Q4 2022) as:

- Detached - £269,013
- Semi-detached - £169,656
- Terraced - £12 2,117
- Flat - £127,868

The commercial capping damages are calculated using the rateable value multiplied by the percentage rental yield. The rateable values have been taken from the Department of Finance Prime Rates Reval 2020 for the Belfast City Council district. The MCM provides a series of multipliers which are calculated based on rateable yields for various categories of NRP, these multipliers are used to calculate a cap / m^2. The capped value of commercial properties are as follows:

- Retail - £3,402.16 / m^2
- Industry – £1,256.74 / m^2
- Leisure - £1,179.56 / m^2
- Public buildings - £1,582.23 / m^2
- Warehouse - £787.61 /m^2
- Offices - £1,946.07 / m^2

8.5. Properties at risk

Numbers of properties affected by flooding in each scenario per return period have been analysed. Northern Ireland's 'Pointer' address dataset has been used to inform property numbers and types; no amendments were made to the Pointer dataset.

Where property thresholds were not available, LiDAR data has been used to define property thresholds, this has been implemented as:

- Residential properties – LiDAR elevation +150mm
- Non-residential properties – LiDAR elevation (no adjustment)

The properties at risk for the Business as Usual and Option scenarios are presented in Tables 9 and 10. The property counts in Table 9 illustrates all properties affected by flooding in the present day, including properties where flood depths are not great enough to exceed the threshold level. Flooding would therefore remain within the sub-floor void.

Table 9 – Properties accruing damages in the present-day scenarios (properties protected in brackets)

Return Period	Residential			Non-Residential		
	BAU	Option 1	Option 2	BAU	Option 1	Option 2
2	0	0 (0)	0 (0)	0	0 (0)	0 (0)
5	1	0 (1)	0 (1)	0	0 (0)	0 (0)
10	1	0 (1)	0 (1)	0	0 (0)	0 (0)
25	2	0 (2)	0 (2)	0	0 (0)	0 (0)
50	3	0 (3)	0 (3)	0	0 (0)	0 (0)
100	3	1 (2)	0 (3)	0	0 (0)	0 (0)
200	5	1 (4)	0 (5)	0	0 (0)	0 (0)

Table 10 - Properties accruing damages in the climate change scenarios (properties protected in brackets)

Return Period	Residential			Non-Residential		
	BAU	Option 1	Option 2	BAU	Option 1	Option 2
2	0 (0)	0 (0)	0 (0)	0	0 (0)	0 (0)
5	1	0 (1)	0 (1)	0	0 (0)	0 (0)
10	2	0 (1)	0 (1)	0	0 (0)	0 (0)
25	3	1 (2)	0 (3)	0	0 (0)	0 (0)
50	4	1 (3)	0 (4)	0	0 (0)	0 (0)
100	5	1 (4)	0 (5)	0	0 (0)	0 (0)
200	8	3 (5)	1 (7)	0	0 (0)	0 (0)

8.6. Benefit / Cost Assessment

Damages were calculated at the property level in accordance with FCERM-AG. The Net Present Value (NPV) has been derived and discounted appropriately, using guidance from FCERM-AG. The NPV and benefit/cost ratio for the Option Scenario are shown in Table 11 and Table 12 below. A summary of the construction costs of the Option Scenario are provided in Appendix C.

Table 11 - Benefit Assessment

Scheme Option	Present Value Damages (£)	Present Value Damages Avoided (Benefits) (£)
Business as Usual	£476,013	£0.00
Option 1 – Roughing Screen	£49,288	£426,725
Option 2 – Roughing Screen & Floodwalls	£6,099	£469,914

Table 12 - Summary of Benefits and Costs

Scheme Option	Total Discounted Cost (£) (Inc. Optimism Bias)	Present Value Damages Avoided (Benefits) (£)	Net Present Value (NVP) (£)	Benefit Cost Ratio
Business as Usual	£0.00	£0.00	-	-
Option 1 – Roughing Screen	£130,138	£426,725	£296,587	3.28
Option 2 – Roughing Screen & Floodwalls	£578,256	£469,914	-£108,342	0.81

8.7. Non- Monetary Assessment

The impact of flooding from the Glenavy River has been quantified in terms of tangible costs and benefits. Costs and benefits which are not easily quantified have not been included within the monetary analysis due to the level of subjectivity associated with their assessment.

Although the intangible effects of flooding have not been included within the monetary analysis, they exist and recent research has suggested that intangible impacts (e.g., stress, loss of possessions, financial hardship) can be more significant than direct damage incurred.

The impact of flooding to public utilities, recreational facilities/spaces, shopping facilities, traffic and physical and emotional health is subjective. A description of the representation of the scoring of each intangible is included in Table 13 below.

An assessment for each option, through a weighted scoring system is shown in Table 14 The non-monetary costs and benefits are weighted individually on a scale of -5 to +5 and the ordinal rank of each scheme is presented.

Table 13 - Definition of Intangible Scoring

Intangible	-5	0	5
Reduction in Risk of Loss to Life	High Risk present or imposed	No Change	Risks Removed
Removal of Fear of Flooding	Fear Increased	No Change	Fear Removed
Elimination of Possible Collapse of Existing Defences	Collapse Risk Increased	No Change	Collapse Risk Removed
Elimination of Loss of Memorabilia and irreplaceable Items	Greater likelihood of Losses	No Change	Potential for Loss Removed
Elimination of Possible loss of Community	Greater likelihood of Loss	No Change	Potential for Loss Removed
Maintenance of Flood Protection During Construction	Removal of Flood Protection	No Change	Flood Protection Improved to Design Standard
Flooding Public Utilities	Repetitive Flooding	Satisfactory Protection	Flood Risk Removed Entirely
Flooding of Premises	Repetitive Flooding	Satisfactory Protection	Flood Risk Removed Entirely
Disruption of Traffic	Repetitive Flooding	Satisfactory Protection	Flood Risk Removed Entirely
Disruption to Telephone Service	Repetitive Flooding	Satisfactory Protection	Flood Risk Removed Entirely
Disruption to NIE Supply	Repetitive Flooding	Satisfactory Protection	Flood Risk Removed Entirely
Disruption to Water Service Services	Repetitive Flooding	Satisfactory Protection	Flood Risk Removed Entirely
Administration of Complaints	Increase in Complaints Number	No Change	Complaints Significantly Reduced
Environmental Impacts of Construction	Severe Impacts not likely to be Mitigated	No Change to Environment	Environment Significantly Improved

Table 14 - Non-Monetary Costs and Benefits

Intangible	BAU	Option 1	Option 2
Reduction in Risk of Loss to Life	-2	+4	+5
Removal of Fear of Flooding	-3	+4	+5
Elimination of Possible Collapse of Existing Defences	0	0	0
Elimination of Loss of Memorabilia and Irreplaceable Items	-2	+4	+5
Elimination of Possible Loss of Community	-3	+3	+4
Maintenance of Flood Protection During Construction	0	0	0
Benefit Score	**-10**	**+15**	**+19**
Flooding Public Utilities	-3	+4	+5
Flooding of Premises	-3	+4	+5
Disruption of Traffic	-1	+1	+2
Disruption of Telephone Service	0	+2	+3
Disruption of NIE Supply	0	+2	+3
Disruption of Water Service Services	0	+2	+3
Administration of Complaints	-1	+2	+3
Environmental Impacts of Construction	0	-3	-4
Cost Score	**-8**	**+14**	**+20**
Overall Score	**-18**	**+29**	**+39**
Ordinal Ranking	**3**	**2**	**1**

8.7.1. Business as Usual

For the 'Business as Usual' baseline option, a 30% blockage of Chestnut Glen bridge has been included. This provides a realistic scenario where existing maintenance procedures continue but, as per the 2008 flood event, blockages will still occur. This scenario is therefore the baseline used in the economic assessment in which the 'Do Something' options are assessed.

The 'Business as Usual' option would not alleviate the threat or rate of occurrence of flooding at Chestnut Glen / Forest Glen.

Significant long-term costs would be expected with this option for flood responses. A gradual increase of occurrence over time will be present due to the impacts of climate change.

8.7.2. Do Something Options – 1 & 2

Within the non-monetary assessment, the key issues which differentiate between options primarily relates to the aspects of the proposed works (roughing screen and flood walls) and their offset from existing properties and the extent of excavation.

8.7.3. Reduction in risk of loss to life

Both options propose the construction of flood defences which will defend properties against flooding, reducing the likelihood of overtopping and reducing the risk to life. However, there is still residual flooding with option 1, to 1 no property.

8.7.4. Removal of fear of flooding

The implementation of new flood defences along the Glenavy River will reduce the risk of fear of flooding for the residents.

8.7.5. Elimination of possible collapse of existing defences/protection of flood protection during construction

As there are currently no formal fluvial flood defences in the catchment the effect of these non-monetary impacts is 0 (No change).

8.7.6. Elimination of loss of memorabilia and irreplaceable items

The improved standard of flood protection provided by all potential options will reduce the risk of loss of property as a result of flooding; hence, the risk of loss of memorabilia and irreplaceable items will reduce.

8.7.7. Elimination of possible loss of community

The fear of flooding coupled with the actual risk of flooding will impact the desirability of the area as a place to live and would therefore be detrimental to the community in the area. Both options significantly reduce both the fear of flooding and the actual flooding risk and would therefore have a positive impact on the possible loss of community.

8.7.8. Flooding of public utilities/disruption of telephone services/disruption of NIE supply/disruption of NIW services.

By managing the residential flooding risk, all options can be shown to reduce the impact of flooding on public utilities and services. As all options reduce the volume of potential surface flow the potential impacts on services will reduce.

8.7.9. Flooding of premises

The improved standard of flood protection provided by all potential options will reduce the risk of flooding to the residential properties. There will, however, remain a risk of flooding from events in excess of the design standard (Q100+CC).

8.7.10. Disruption of traffic

The improved standard of flood protection provided by all potential options will reduce the risk of flooding to the roads. However, the movement of plant and materials during the construction period will cause disruption to local traffic flows. The contractor's method of working and the timing of specific high-risk elements of the work will be developed to minimise any potential disruption.

8.7.11. Administration of complaints

All potential options will reduce the risk of flooding and hence the number of public complaints to be addressed by the local council/authority.

8.7.12. Environmental impacts of construction

The environmental impact of the proposed options will be heavily influenced by the need to carry out works within or close to the watercourse. Options 1 and 2 will require a certain element of the works to be undertaken within the channel in order to install the roughing screen, however, the flood walls proposed in Option 2 pose a greater risk to the river and will also cause more disruption to the surrounding environment.

8.7.13. Summary of non-monetary impacts of the Do Something Options

The two proposed 'Do Something' options have relatively positive scores as they both reduce the overall impact of flooding on the surrounding area. Option 2 scored higher due to the fact that this option will remove all flood risk during a 1% AEP event whereas Option 2 will only reduce the extent of the flooding. Therefore, Option 2 provided greater benefits in terms of the removal of the fear of flooding and the reduction of the risk of loss to life. The short-term environmental impacts and traffic disruption during construction are outweighed by the long term, non-monetary benefits of implementing a 'Do Something' solution to the existing flooding problems.

8.8. Summary of Findings

The existing BAU scenario does not deliver the desired Standard of Protection and therefore cannot be taken forward as the preferred option.

The economic business case presented in Section 8.6 identifies that Option 1 is the only option to provide a benefit cost ratio greater than unity (>1.0).

Option 1 consisting of the construction of a roughing screen upstream of Chestnut Glen Bridge, which will provide a 1 in 100-year plus climate change Standard of Protection to the majority of properties currently at risk of flooding. The onset of flooding at property no.47 Chestnut Glen is shown to occur in a 1 in 50 year plus climate change event. However, Option 1 will reduce the depth of flooding at no.47 from >600mm to 130mm in a 1 in 100-year plus climate change event. As the property will not fully achieve the design standard of the proposed scheme, the property owner would be able to take advantage of the Homeowner Flood Protection Grant Scheme (Northern Ireland) (HFPGS). This is a government scheme which is designed to encourage the owners of residential properties that have flooded before and/or are located within known flood prone areas, to modify their properties to make them more resistant to flooding. The Grant Scheme is specifically aimed at residential properties that have flooded internally in the past and continue to be exposed

to frequent flooding. The HFPGS will provide flood resistance up to 600mm above the threshold of the property.

Option 1 achieves a Benefit/Cost ratio of 3.28. Although not the highest ranked option in the non-monetary assessment, Option 1 achieved a score of +29, which is still very favourable and supports the decision of the economic assessment.

9. Conclusion

Amey Consulting was commissioned by the Department for Infrastructure (DfI) Rivers to appraise flood risk to properties in Glenavy. This included investigating options (including economic viability) to alleviate any potential flooding from a 1% Annual Exceedance Probability plus climate change flow (1% AEP+CC). In the 1st Cycle of the Flood Risk Management Plan (FRMP), Glenavy was not identified as a Significant Flood Risk Area, however it was outlined as an Area for Further Study.

At the outset of the commission, DfI Rivers provided the existing ICM hydraulic model for the study area which was in turn updated to better reflect the current conditions along the watercourse. The investigations and updated modelling identified that the August 2008 flooding at Glen River Park was actually related to a backing up of the surface water system due to an unflapped outfall to Glenavy River. The river did not come out of bank in this location. The subsequent installation of a flap valve on the outlet has addressed this issue.

However, further downstream at Chestnut Glen / Forest Glen the investigations have identified that the flooding experienced in this location in August 2008 was due to a partial blockage of the bridge. Incremental blockage modelling has identified that a 30% of the Chestnut Glen bridge would be required to replicate the flood inundation experienced by residents. Therefore a 30% blockage has included in the baseline 'Business as Usual' scenario to replicate the realistic situation where the existing maintenance regime is continued. Hydraulic analysis was undertaken using the updated model to assess the effectiveness of the 2no. flood defence options proposed in the "Do Something" Option Scenario.

The flood damages for the 5, 25, 50, 75 and 100-year flood events plus climate change were calculated based upon the Multi-Coloured Manual and discounted over the 100 years assessment period to determine the present value damages avoided for each option.

The existing BAU scenario does not deliver the desired Standard of Protection and therefore cannot be taken forward as the preferred option.

The construction cost of each option was estimated using SPONS 2022 and tendered rates for similar schemes within Northern Ireland. The maintenance costs have been discounted over the 100-year design life of the scheme to give a Present Value (PV) maintenance cost. This has been used to determine a whole life PV cost for each option.

The only option to achieve a Benefit/Cost ratio in excess of unity (1) was Option 1. This option consists of constructing a roughing screen upstream of the Chestnut Glen bridge and results in a Benefit/Cost ratio of 3.28.

Although not the highest ranked option in the non-monetary assessment, Option 1 achieved a score of +29, which is still very favourable and supports the decision of the economic assessment.

Option 1 has an estimated whole life cost (design, construction including an optimum bias of 31.68% and ongoing maintenance) of £130,138.

The Option provides a benefit in terms of Present Value Flood Damage Avoided of £426,725.

Option 1 consisting of the construction of a roughing screen upstream of Chestnut Glen Bridge, which will provide a 1 in 100-year plus climate change Standard of Protection to the majority of properties currently at risk of flooding. The onset of flooding at property no.47 Chestnut Glen is shown to occur in a 1 in 50 year plus climate change event. However, Option 1 will reduce the depth of flooding at no.47 from >600mm to 130mm in a 1 in 100-year plus climate change event. As the property will not fully achieve the design standard of the proposed scheme, the property owner would be able to take advantage of the Homeowner Flood Protection Grant Scheme (Northern Ireland).

Appendix A: Drawings

Appendix B: Waterco Report

Appendix C: Breakdown of Cost

Appendix D: Geotechnical Desk Study

Appendix E: EA12 Form