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WASTEWATER REDUCE FLOODING RISK FOR PROPERTIES ENHANCEMENT BUSINESS CASE

WWS2 - Wholesale wastewater capital and operating enhancement expenditure by purpose Line 30

Contents

1 Executive Summary

The following table summarises the 'reduce flooding risk for properties' enhancement proposal.

Name of claim	Reduce flooding risk for properties	
Name and identifier of related claim submitted in May 2018	N/A	
Business plan table lines where the totex value of this claim is reported	WWS2 Line 30	
Total value of enhancement for AMP7	£86m	
Total opex of enhancement for AMP7	£0.000m	
Total capex of enhancement for AMP7	£86m	
Depreciation on capex in AMP7 (retail controls only)	N/A	
Remaining capex required after AMP7 to complete construction	N/A	
Whole life totex of claim	£N/A	
Do you consider that part of the claim should be covered by our cost baselines? If yes, please provide an estimate	No	
Materiality of claim for AMP7 as percentage of business plan (5 year) totex for the relevant controls	Material	
Does the claim feature as a Direct Procurement for Customers (DPC) scheme? (please tick)	Yes	No
		No
Need for investment/expenditure	We have demonstrated and evidenced in this business case that climate change and urban creep will increase the risk of flooding to properties by 16,324 properties over the next investment period. Our customers have told us that sewer flooding is one of the worst service failures that could occur. Our proactive risk reduction enhancement will focus on properties that **have never experienced** flooding in the past, but which hydraulic modelling demonstrates will be at risk as a result of climate change and urban creep increases. The purpose of the enhancement expenditure is to proactively reduce the risk of flooding to 7,400 properties over the next investment period. Climate change and urban creep present a deterioration in environmental conditions that creates an upward pressure on service delivery and consequential costs. This change is not reflected in	

	the cost drivers that base cost models use, such as property numbers and length of mains/sewers. It is therefore appropriate for including reducing the risk of flooding as an enhancement. We have referenced this business case's strong alignment to important and leading third party publications and strategies throughout, including the EA's FCERM strategy, Defra's published documentation on adapting to climate change and the outputs from UK Climate Change Projections 2009 (UKCP09).
Need for the adjustment (if relevant)	N/A
Outside management control (if relevant)	Each year we invest around £45m (£240m per investment period) as base operational expenditure to reduce the risk of sewer flooding and to improve the resilience and maintenance of our network and sewerage assets. This level of investment and the associated initiatives and activities that we undertake has enabled us to reduce internal sewer flooding by over 65%, and reduce external sewer flooding by 30% over a five year period. As a result of this we continue to outperform the performance commitments we agreed for AMP6. We have identified a significant increase in the risk of sewer flooding affecting properties in the next five years as a result of climate change and urban creep. This increase in risk is most prevalent between the present day-2030 scenario, demonstrating that this investment is required in AMP7. We are not able to reduce this risk through our base operating expenditure and need to take proactive measures now, in order to reduce the impact to our customers.
Best option for customers (if relevant)	This proposal was supported by 71% of our customers. We have considered a range of benefits evidence that supports the proposed enhancement for flood risk reduction due to climate change and urban creep: • ***Evidence on the customer valuation of reduced flooding incidents.*** The evidence from our PR19 customer valuation tool indicates that a reduction in the risk of experiencing sewer flooding results in customer benefits of £96m. This implies a positive benefit-cost position • ***Customer support for proactively reducing the risk of flooding.*** This research has been undertaken on a small sample of customers, but

	with detailed information about the costs and benefits of the programme. This implies a positive benefit-cost position.
Robustness and efficiency of claim's costs	NWG has assessed the costs for this and other enhancement claims through a structured and robust approach, involving benchmarking of cost estimates against alternatives. All costs for resilience enhancement were provided and assured by the NWG Cost Assurance team whose methodology for costing the schemes was based on a number of different approaches. For the Business Plan, Northumbrian Water commissioned Economic Insight to forecast the Relative Price Effects adjustment for capex enhancements. This was assessed at around 1% pa over 2020-25. We separately set ourselves an annual efficiency target for capex enhancements of 1% pa.
Customer protection (if relevant)	To ensure our customers are protected against under-performance we have created a penalty only incentive rate.
Affordability (if relevant)	Overall analysis shows that the bill impacts would be around £1.50 a year ranging from an increase of £0.20 from 20/21 to £2.95 in 24/25.
Board Assurance (if relevant)	Following revisions to this paper, our PR19 Board Sub–Committee reviewed and approved the business case on the 19th and 20th June 2019, and our full Sub Board reviewed and approved the business case on 26th and 27th June 2019.

Table 1. - Enhancement Expenditure: Reduce flooding risk for properties

Line 30, reduce flooding risk for properties is defined in Table WWS2 as: Capital/operating expenditure for the purposes of enhancing the public sewerage system to reduce the risk to properties and external areas of flooding from sewers.

The purpose of the enhancement expenditure is to proactively reduce the risk of flooding to 7,400 properties over the next investment period. This proposal was supported by 71% of our customers.

Our proactive risk reduction enhancement will focus on properties that have never experienced flooding in the past, but which hydraulic modelling demonstrates will be at risk as a result of climate change and urban creep.

The uplifts we have applied for both climate change and urban creep follow published industry guidance and best practice. We have then validated the applied uplifts through current and forward looking analysis, seeking third party peer reviews from the Met Office and Newcastle University to validate our observations, and to provide new evidence to support this business case need.

The results of our analysis and third party engagement strongly support the likelihood of climate change and urban creep significantly increasing the impact of sewer flooding over the next five years, and therefore further supports our need to take proactive measures now to reduce this risk.

Wastewater	CAPEX(£m)	TOTEX(£m)
		86.0
Reduce flooding risk for properties	86.0	

Table 2. Summary of expenditure

2 Drivers

Sewer flooding is extremely unpleasant and very distressing for our customers and they have told us that it is one of the worst service failures that could happen.

Each year we invest around £45m (£240m per investment period) as base operational expenditure to reduce the risk of sewer flooding and to improve the resilience and maintenance of our network and sewerage assets. This level of investment and the associated initiatives and activities that we undertake has enabled us to reduce internal sewer flooding by over 65%, and reduce external sewer flooding by 30% over a five year period. As a result of this we continue to outperform the performance commitments we agreed for AMP6.

This level of investment will continue into the next investment period alongside the activities we have successfully applied in AMP6, as well as the key areas we have identified to focus our short to medium term AMP7 strategies on. These, alongside the recent strengthening of our teams around our Service Planning Framework will help us to achieve the Performance Commitments we have set for AMP7.

However, the impact of climate change and urban creep on the ability of our sewerage service to deal with sewage and heavy rainfall effectively has already impacted our performance in 2018. Further analysis of our system using projected uplifts for climate change (10%) and urban creep (1.6%) has identified that our baseline flooding risk for properties will increase by 10% (16,324 properties) during the next investment period.

Our enhancement proposal under Line 30, reduce flooding risk for properties is to proactively reduce flood risk to 7,400 of the 16,324 properties which we have identified are at risk of flooding due to the impact of climate change and urban creep. The reduction of risk to 7,400 properties will reduce the risk of flooding to those properties that are in the most significant risk band as a consequence of climate change and urban creep (4,515 properties) and a proportion of properties identified in our next risk band (category 4, 2,885 properties).

Our proactive risk reduction enhancement will focus on properties that have never experienced flooding in the past, but which hydraulic modelling demonstrates will be at risk as a result of climate change and urban creep increases.

During AMP6, we have piloted reducing flood risk for properties through our Rainwise initiative. This has successfully reduced flooding risk to 2,050 properties to date. We have engaged with our supply chain, customers and partners to significantly increase our level of ambition for AMP7 to proactively reduce flooding risk for 7,400 properties.

This level of ambition sets a challenging target and one we believe is required to help offset the impact of future changes, whilst being deliverable within the timescales identified.

Customers support us carrying out work to proactively identify and respond in areas at risk of flooding. Our approach to proactive flood risk reduction was tested in March 2018 through six deliberative workshops, where 71% customer support was achieved.

The Water Forum continue to support our proposals for proactively reducing the risk of flooding, and their views are shared below in the following text.

Wastewater resilience is an area of significant importance to customers and, therefore to us as the Water Forums. The company's proposed £86m enhancements to proactively reduce flood risk will see them leading the industry by innovating in this area, and we were really pleased to see that the schemes received very strong customer support of 71% in the business plan originally submitted.

In response to Ofwat's challenge, the company initially considered a move away from this ambition, at least for this business plan resubmission, as it feels time is too short to gather further evidence. We challenged this move, as we believe it is too important not to do this work, and not making an investment now could increase the cost of resilience in the future.

We are therefore pleased that the company has decided to resubmit a revised business case to Ofwat for this area of performance which is based on gathering further climate data and evidence. We understand this business case will be resubmitted on 1st July 2019 as it will take time to re-evidence this business case

properly. The Forum are fully supportive of NWL's plans for proactive flood risk work, as flooding is such an important issue for customers.

We believe that Ofwat recognises this issue, given that part of its previously stated strategy was to prevent future flooding by identifying properties at risk – their challenge does not fit with the direction of travel arising from the IAP, and we encourage them to review the methodology used. Our view is that the proposed enhancements were focused on reducing long-term risk of sewer flooding, rather than driving the shorter-term performance measure for 2020-25.

The Environment Agency work in partnership with NWL on flood risk work and NWL play a full role in the Northumbria Integrated Drainage Partnership (NIDP), Strategic Flood Partnerships, NRFCC and the Catchment Partnerships. The NIDP is a joint EA-NWL partnership including the 12 Local Authorities across the North East. Its purpose is to identify and progress future flood schemes that manage multiple sources of flood risk and require integrated working. This partnership is viewed as nationally leading practice and it won the national Flood and Coast "partnership" award in 2018. Both the EA and CCWater, which has also supported the scheme since its inception, want to see this work continue. Indeed, the Water Forums asked NWL to share their learning with other companies and we were pleased that they responded to this challenge as part of their contribution to the 21st Century Drainage Board.

The requirement for this enhancement expenditure is therefore driven by the need for us to respond now to this significant increase in risk caused by immediate future challenges. Our proposal will reduce the risk of flooding for properties above and beyond that of our existing flood risk, which we will continue to reduce and monitor through our common performance commitments for sewer flooding.

The Environment Agency's new FCERM Strategy recognises that climate change is the biggest challenge that we are likely to face. It also acknowledges the increasing trends associated with experiencing wetter winters and drier summers, with an increased likelihood of more intense rainfall leading to flooding. Flooding of any kind is a traumatic experience for everyone who is affected, it has an impact on livelihoods, mental health and natural habitats.

The strategy sets a clear recommendation for action from all Risk Management Authorities, including Water and Sewerage Companies, towards the need of enabling climate resilient areas. This will include a variety of approaches, from adaptive pathways, working in collaboration, putting communities at the heart of solutions, and encouraging a nation of climate champions.

Our proactive flood risk reduction programme is in line with the ambitions of the FCERM Strategy, which highlights the need to act now in order to be resilient to tomorrow's climate.

Our proactive risk reduction proposal will only target the most significantly affected properties that will experience flooding in the future, due to exceptional conditions beyond our normal base expenditure.

Climate change and urban creep present a deterioration in environmental conditions that creates an upward pressure on service delivery and consequential costs. This change is not reflected in the cost drivers that base cost models use, such as property numbers and length of mains/sewers.

Our proposal therefore represents investment that will enhance our overall sewerage system to reduce flood risk to properties, above and beyond our other performance commitments in AMP7.

3 Context and scope

The need for this expenditure is driven by two significant future risks that will directly impact our customers over the next investment period, namely climate change and urban creep.

We have undertaken an assessment of our northern operating region in the context of reviewing the impact of climate change and urban creep, and how these will increase our level of risk beyond our control. In order to do this, we have reviewed and assessed the uplift effects of both of these factors, using hydraulic modelling to quantify the risk. We have then reviewed the results against industry and academic literature in order to validate the level of assumptions that we have made.

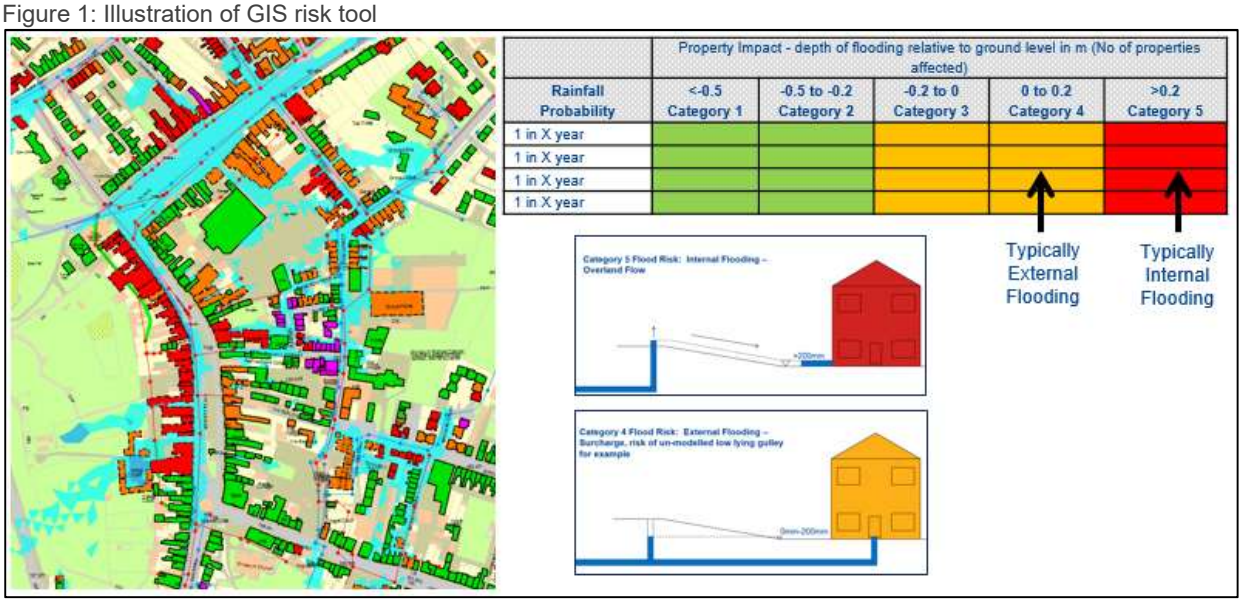
We have also sought third party peer review and commentary to support our business need to proactively reduce the risk of flooding.

3.1 Hydraulic modelling

We have completed hydraulic modelling on 134 of our drainage areas, representing 70% of the population in our northern operating region. Our hydraulic models have been constructed using information from our corporate GIS system, as well as with survey and as–built information as applicable. As well as containing both foul and combined assets, our hydraulic models also include full coverage of our surface water network and assets, and these hydraulic models were used in Water UK's 21st Century Drainage project for the trial of the surface water Capacity Assessment Framework (CAF). NWG were one of only three water companies that could provide full asset coverage for their modelled areas.

The hydraulic models were simulated for a number of rainfall return periods and durations in order to quantify the baseline performance of our network. We have also developed a GIS tool which assesses how the performance of sewerage network will impact our customers in relation to sewer flooding. This GIS tool is illustrated in the Figure 1.

Figure 1: Illustration of GIS risk tool

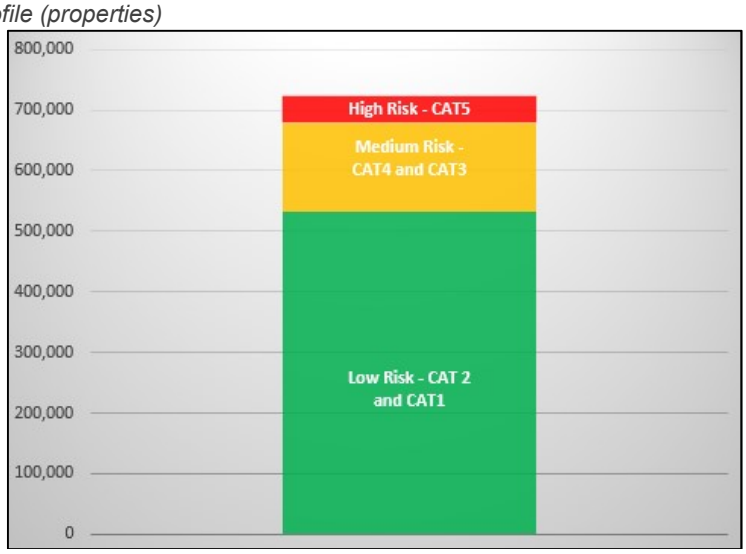


The tool assesses sewer surcharge and overland flow depths predicted by hydraulic models and compares these to threshold levels assigned to each property. This allows us to RAG assess our entire catchment and prioritise areas that are most at risk.

Properties that are assigned red (category 5) are typically those properties that we would expect to flood internally, either from sewer surcharge affecting internal connections, or via surcharging manholes causing overland flows to breach property threshold levels. Those properties that are assigned amber (category 4) are typically those properties that we would expect curtilage flooding to occur, for example because the overland flow depth is not sufficient to breach the property threshold. Green properties have been identified as low risk as there is no overland flow depth predicted, and sewer surcharge levels are not significant in comparison to property threshold levels.

The results of the hydraulic modelling exercise identified that our baseline level of risk for the most significantly affected properties is 163,243 properties (properties assigned a category 4 or a category 5) for a 1 in 20 year return period storm. The split of our baseline risk is shown in Figure 2.

Figure 2: Baseline risk profile (properties)



The hydraulic models were then updated using the following projections to account for future climate change and urban creep:

- **Climate change: An uplift of 10% was applied to peak rainfall intensities**. The 10% uplift was applied in accordance with guidance from UKWIR on the application of climate change in urban catchments.[1] A 10% uplift represents the central estimate for the present day - 2030 scenario.

  The applicability of a 10% uplift for climate change is in line with wider published documentation on climate change. For example, Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities, DEFRA[2]. Overall this also follows the general consensus of outputs from UK Climate Change Projections 2009 (UKCP09).

- **Urban Creep: Impermeable area was increased on average by 1.6% in accordance with UKWIR report, Impact of Urban Creep on Sewerage Systems (10/WM/07/14).**[3] Creep uplifts were applied for the five year projection only.

  The UKWIR study remains a "best of breed" research output for urban creep. It is one of only two identified and publicly available UK studies which mapped true urban creep at a scale to allow representative estimates to be applied to hydraulic models. It is the only study of the two identified for which readily useable and scalable methods were developed for calculation and application of urban creep to hydraulic models.

The impact of climate change and urban creep will increase our level of risk by 16,324 properties for the most significantly affected properties (properties assigned a category 4 or a category 5) for a 1 in 20 year return period storm.

The proportional spilt of this increase is shown in Table 3 below. The numbers shown in brackets show the number **of newly emerging properties** at risk of flooding that we have identified as a result of urban creep and climate change.

[1] Report available on request
[2] Report available on request
[3] https://www.floodandcoast.com/assets/Uploads/Elliot-Gill-CH2M-High-Intensity-Future-flood-risk-in-urban-and-rapid-response-catchments.pdf

Table 3: Increase in risk due to climate change and urban creep

	Property Impact - depth of flooding relative to ground level in m (No of properties affected)				
Rainfall Probability	**<-0.5 Category 1**	**-0.5 to -0.2 Category 2**	**-0.2 to 0 Category 3**	**0 to 0.2 Category 4**	**>0.2 Category 5**
1 in 20 year	464,663 **(-17,409)**	48,981 **(-1,809)**	32,077 **(2,916)**	129,899 **(11,809)**	49,668 **(4,515)**

The analysis shows that as a result of climate change and urban creep, risk in the highest band (category 5) increases by 4,515 properties, and in the next risk band (category 4) by 11,809 properties, over the next investment period.

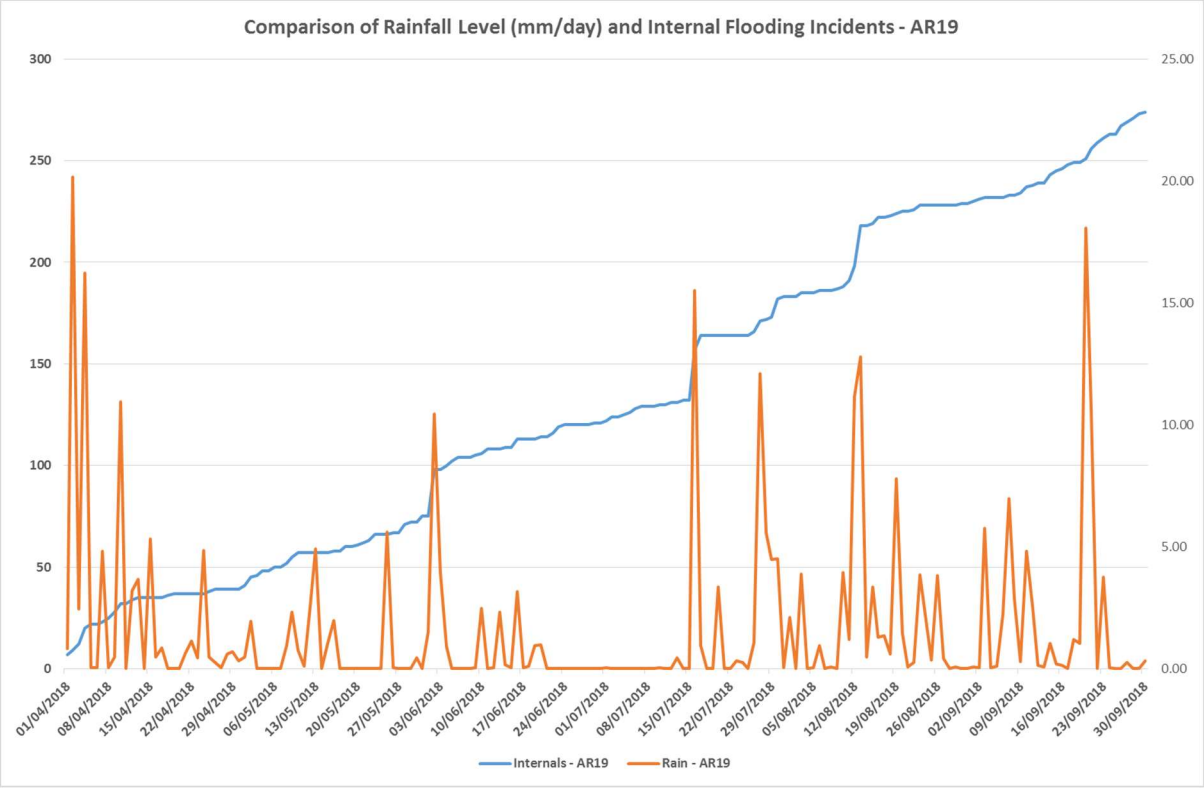
As part of our investment we will review the drainage areas where we expect our risk profile to change, and undertake further analysis and assessments to ensure that we provide the best possible solutions for our customers. We will also continue to engage throughout this process with our customers and key stakeholders to maximise any wider opportunities and benefits.

3.2 Impact of climate change on our current performance

We have successfully achieved sustained reductions in sewer flooding incidents year on year from 2013/14 until 2016/17, before the number of sewer flooding incidents plateaued in 2017/18, before seeing an increase in 2018/19 due to a series of stepped increases during the hot and largely dry summer of 2018.

These notably stepped increases in incidents can be clearly observed in Figure 3, which shows our internal sewer flooding performance in relation to observed climate conditions for 2018.

Figure 3: 2018 Internal sewer performance in relation to climate conditions.



A review of the data above shows that we experienced significant step changes in the number of incidents we were reporting, following sustained periods of dry weather, followed by short periods of intense rainfall.

In order to quantify and validate our observations, we commissioned the Met Office to review the information and to provide commentary in relation to how common this type of weather pattern has been historically in our region. A copy of the report that the Met Office have produced is available on request.

The Met Office analysis of the rainfall and antecedent conditions associated with these stepped increases highlights an extended dry spell (19 months) during 2017 and into the middle of 2018. Further Met Office analysis has looked at the importance of hourly rainfall totals combined with antecedent conditions when determining likely 'trigger' thresholds for sewer flooding in our operational area.

The result of this analysis has shown that there has been an increase in 'trigger' days with heavy rainfall following dry antecedent conditions in 2017/18, while we also remain susceptible to increased flooding from rainfall events with high hourly, or sub hourly rainfall totals.

The assessment from the Met Office has confirmed that the unusually long hot and dry weather, followed by intense rainfall has not been experienced over the past two investment periods to the same order of magnitude as we experienced in 2018.

Although the evidence confirmed that we have not experienced these types of weather patterns in recent investment periods, based on the future projections described, it is likely that these weather patterns, which we experienced in 2018 will become more frequent in the future due to the impact of climate change.

In order to provide the best possible service to our customers and to prevent our base level risk significantly worsening, it is therefore important that we plan for these future risks now, focussing on the consequences we have evidenced in our region.

3.3 Impact of climate change on our future performance

As a company we have been monitoring the future projections of climate change for a considerable period of time, and we appointed a senior manager as Climate Change Manager to oversee activity in this area in 2008, in recognition of its growing importance to our business.

The high level message about the future changes we will face has been a consistent one since the publication in 2002 of the UKCP02 projections. This message is one of hotter drier summers, warmer wetter winters, and more frequent and more intense extreme events. Subsequent published projections in 2009 (UKCP09) and 2018 (UKCP18) have confirmed this view, whilst adding more detail.

In 2011 we published in our response to the requirement under the Adaptation Reporting Power legislation our view of the risks that climate change posed to our functions as a water company. The risk of sewer flooding was highlighted as one of the two most significant challenges we face. It was also identified as the most immediate risk.

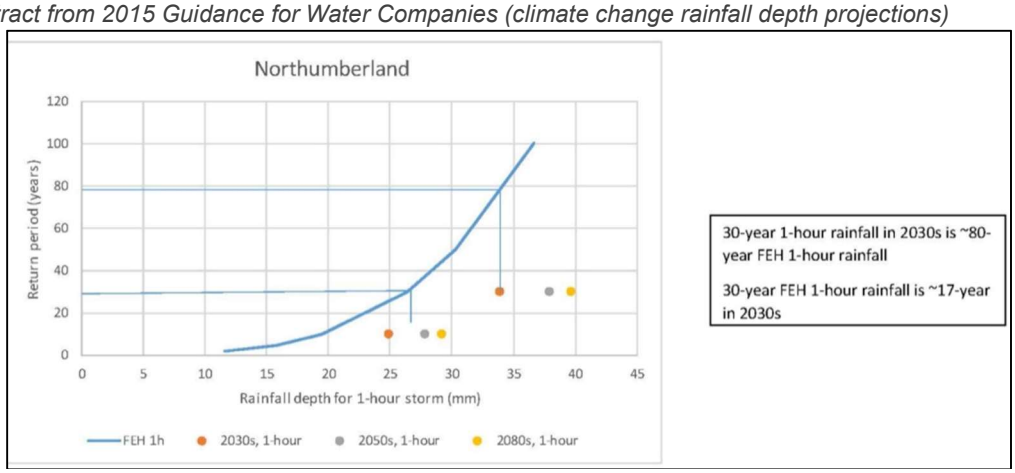
As described in Section 3.2, the evidence shows that we are already beginning to see the impact of the change predicted, and it is highly probable that change will be most noticeable in terms of the extreme events, rather than change in the mean weather, where the impacts are likely to be more subtle and difficult to discern.

There is overwhelming evidence from work undertaken on behalf of UKWIR that the intensity of rainfall will increase markedly over the coming decades. This work is founded on the three year CONVEX project undertaken by researchers at Exeter, Reading and Newcastle Universities in partnership with the UK Met Office, the Environment Agency and UCKIP.

Figure 4 below is an extract from Figure 4.1 from the 2015 Guidance for Water Companies report number 15/CL/10/16-2[4]. It compares the current FEH rainfall with that resulting from the CONVEX research.

[4] Report available on request

Figure 4: Extract from 2015 Guidance for Water Companies (climate change rainfall depth projections)



The blue line shows the present day 1 hour rainfall FEH rainfall depth for differing return periods. The one hour rainfall with a 30 year return in the 2030s equates to a return of around 1 in 80 years period today using the FEH.

By joining the two orange dots showing the 2030 1 hour rainfall, it is also possible to estimate what the return period will be then of the current FEH 30 year rainfall. This equates to around 1 in 17 years.

The clear message is that within little more than ten years, a given rainfall event will be occurring twice as frequently than it is at present, representing a significant change in the level of risk. This will inevitably lead to increased property flooding, unless we proactively take steps to avoid it.

Table 4 below is an extract from Appendix 2 of the report. It shows the recommended percentage change in rainfall for our northern operating area. These are the recommended uplifts to be applied to 2015 FEH rainfall intensities, with the central estimates shown in red.

Table 4: Extract from 2015 Guidance for Water Companies (recommended uplifts for rainfall intensities)

Location	Water & sewerage company applicability	Duration (hours)	Epoch								
			2030s			2050s			2080s		
			L	C	H	L	C	H	L	C	H
NE (Newcastle)	Northumbrian Water, Anglian Water (north), Severn Trent (north east), Scottish Water (east), Yorkshire Water	**1H**	20	**28**	40	24	**44**	75	45	**50**	60
		3H	12	**15**	16	18	**29**	41	35	**53**	76
		6H	5	**7**	10	8	**17**	30	33	**51**	75

As it can be seen, the latest research shows clearly that a very significant increase in rainfall is expected, even by 2030.

This is markedly greater than the 10% uplift we have applied when modelling the potential increase in the number of properties likely to be at risk of flooding over the next investment period.

Whist evidence confirms that changes in weather patterns due to climate change are likely to exacerbate sewer flooding in the future, ensuring that the representation of climate change in urban drainage models is a key consideration for confirming our network performance and risk, as well as for the design of resilient and adaptive strategies and interventions.

The UKWIR research project "Rainfall Intensity for Sewer Design (Dale et-al 2017)"[5] sought to overcome some of the limitations of UKCP09 and other models by providing a method to improve the estimation of changes in convective rainfall which is associated with flash flooding.

The research is particularly important for how these changes should accurately be applied to hydraulic modelling.

The UKWIR research project used a very high-resolution climate model in (Kendon, et al., 2014) to examine 1.5 km land-based cells over the UK. The data analysed were from two time periods:

- A 'current climate' simulation representing the period 1996-2009 – a 13-year, 1-hour resolution time series.
- A 'future climate' centred on the year 2100 (RCP8.5 scenario) – also a 13-year, 1-hour resolution time series.

Key outputs from the project included:

- A series of regional design storm uplifts (see Table 5 below) for design storms.
- A fully automated climate perturbation tool to derive and apply time series data representative of future climates at a convective scale. These can be generated for nine regions London, Glasgow, Aberdeen, Plymouth, **Newcastle**, Liverpool, Leeds, Cardiff, Cambridge and Birmingham. The tool can generate a climate perturbed series from historical data for the 2030s, 2050s and 2080s.

Table 5 below is a reproduction of Table 4-3 from the UKWIR Rainfall Intensity for Sewer Design – Stage 2 Technical Report (Dale et-al 2017) Uplift mean percentages (across all durations).

Table 5: Extract from UKWIR Report (recommended uplifts for rainfall intensities for sewer design).

		2030s	2050s	2080s
North West UK	Central estimate	20%	35%	55%
	High estimate	*35%*	*65%*	*110%*
North East UK	**Central estimate**	**10%**	**20%**	**35%**
	High estimate	***30%***	***50%***	***85%***
South UK	Central estimate	10%	15%	25%
	High estimate	*20%*	*35%*	*65%*

The evidence from all of the studies referenced demonstrates that the uplift we have applied to our hydraulic models to allow us to confirm our future risk is appropriate. These studies and the use of hydraulic modelling to quantify our risk follow a robust methodology, and removes any uncertainties around rainfall patterns and how these will be conveyed and discharged into our sewerage network.

3.4 Impact of urban creep on our current performance

The Royal Horticultural Society[6], RHS recognises that there is a general trend in the contribution of surface runoff from impermeable surfaces and has concluded from a study done in Leeds that over a 33-year period, that there was a 13% increase in impervious areas, 75% of which was due to paving of residential front garden. This was linked to higher frequency and magnitude of flooding in the area.

[5] Report available on request
[6] https://www.rhs.org.uk/science/pdf/climate-and-sustainability/urban-greening/gardening-matters-urban-greening.pdf

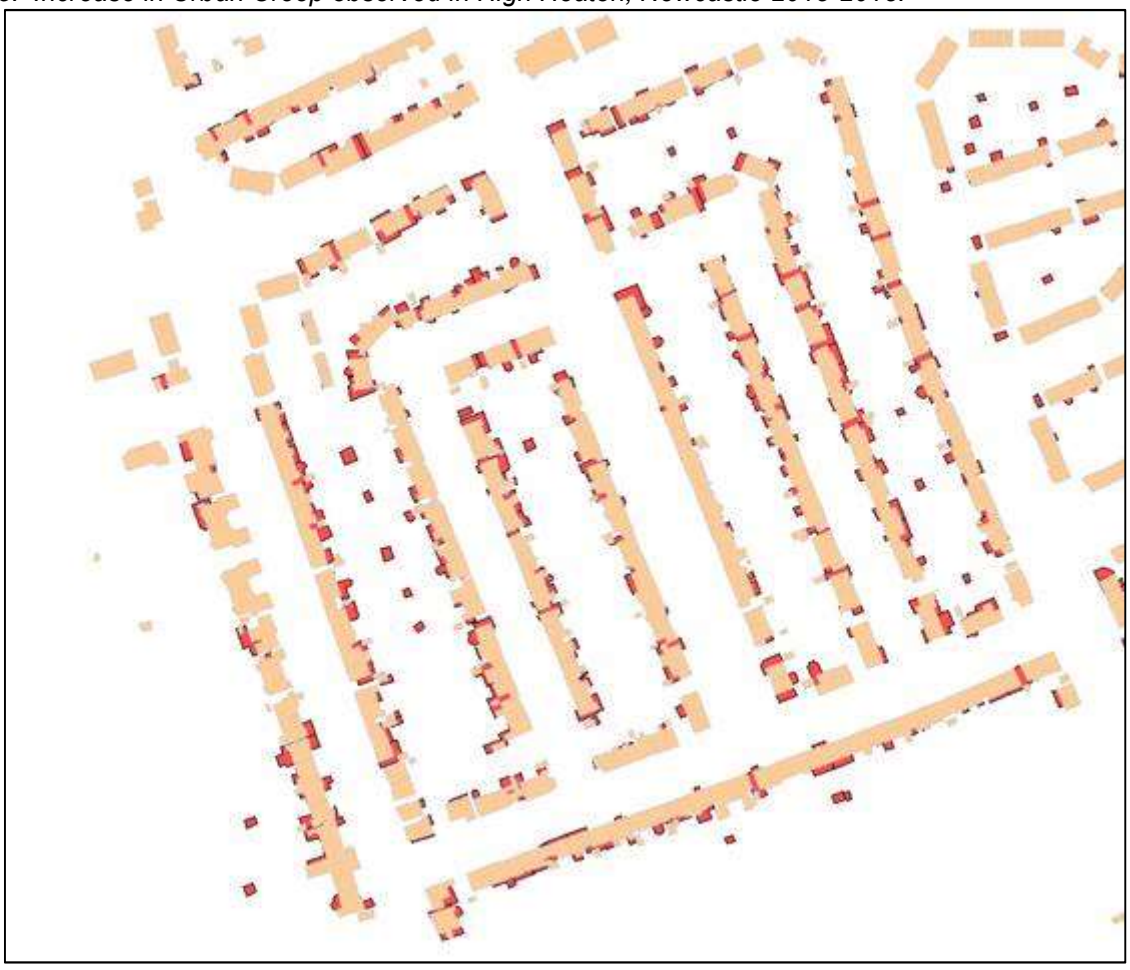
The 2006 RHS study highlights that almost a quarter of front gardens in the North-East of England are now completely paved, with 47% of front gardens having more than 75% paved with impermeable materials. The study states that whereas gardens can soak up rainfall, paving and tarmac are less porous and can increase the amount of rainwater that runs off as much as 50%.

In relevance to the North East, Newcastle City Council commissioned a pilot study[7] on creeping impermeability, which is a supplement to a Planning Document on their Integrated Water Management Plan. This report concluded that on average, over a period of nine years from 1996 to 2005, there was a 1.44% increase in impermeable areas contributing to more surface runoff.

A UKWIR report, Impact of Creep on Sewerage Systems[8] also concluded that for a densely populated and urban area of Newcastle, an increase of 0.58% in impermeable surfaces was observed over the period of 2002-2007.

More recently, we have undertaken a sample analysis of an area in High Heaton, Newcastle. Figure 5 illustrates the impact that urban creep has had on the sample area, with the red outlines highlighting the increases in impermeable area with the catchment.

Figure 5: Increase in Urban Creep observed in High Heaton, Newcastle 2015-2018.



The sample analysis concluded that over a more recent period of three years (2015-2018), there was a 3.95% increase in impermeable area that can directly discharge into our public sewerage system.

Newcastle University has peer reviewed the sample analysis on High Heaton and concluded that the modelling applied is realistic for the trends that they have observed through their work, which has identified an average of a 4% increase in impermeable area over a similar period.

[7] Available on request : Urban flood risk and integrated drainage ; Ouseburn and North Gosforth Pilot Project
Report of Newcastle City Council on creeping impermeability and drafting of an SPD on Integrated Water Management, March 2008

[8] UKWIR Report Impact of Creep on Sewerage Systems

3.5 Impact of urban creep on our future performance

The future predictions acknowledge that there is a general upward trend and an increase in impermeable surfaces leading to an increase in runoff, which therefore contributes to flooding incidents.

For the purposes of our modelling assessment, we have followed the methodology described in the UKWIR report, Impact of Urban Creep on Sewerage Systems. The application of this methodology follows industry best practice for the modelling of the impact of urban creep, and its approach is also referenced in the CIWEM Urban Drainage Group Code of Practice for the Hydraulic Modelling of Urban Drainage Systems, 2017.

Applying this methodology to our modelled catchments, increases impermeable area on average by 1.6% over the next investment period.

The Defra – EA - Rainfall runoff management for developments Report - SC030219[9], recommends that an allowance should be made by factoring the impermeability percentage by 1.1 (10% increase) for the purposes of modelling the future impact of urban creep on catchments now. This therefore validates that the uplift of 1.6% we have applied to our catchments is a conservative estimate of the likely increase in urban creep during the next investment period.

3.6 Summary of the context and scope

The purpose of the enhancement expenditure is to proactively reduce the risk of flooding to 7,400 properties over the next investment period. This proposal was supported by 71% of our customers.

Our proactive risk reduction enhancement will focus on properties that have never experienced flooding in the past, but which hydraulic modelling demonstrates will be at risk as a result of climate change and urban creep increases.

The uplifts we have applied for both climate change and urban creep follow published industry guidance and best practice. We have then validated the applied uplifts through current and forward looking analysis, seeking third party peer reviews from the Met Office and Newcastle University to validate our observations, and to provide new evidence to support this business case need.

The results of our analysis and third party engagement support the likelihood of climate change and urban creep significantly increasing the impact of sewer flooding resulting from our sewerage network over the next five years, and therefore further support our need to take proactive measures now to reduce this risk.

Climate change and urban creep present a deterioration in environmental conditions that creates an upward pressure on service delivery and consequential costs. This change is not reflected in the cost drivers that base cost models use, such as property numbers and length of mains/sewers.

This level of expenditure will only proactively target the most significantly affected properties that are very likely to experience flooding **in the future,** due to exceptional conditions beyond our normal base expenditure. Our proposal therefore represents investment that will enhance our overall sewerage system to reduce flood risk to properties above and beyond our other performance commitments during AMP7.

We will measure and report our flooding risk to properties across the investment period, using the results of hydraulic modelling to demonstrate the changing risk profile and the effectiveness of the schemes that we construct. We will also continue to engage with the Met Office, Newcastle University, and with the rest of the industry to review and monitor the impact that climate change and urban creep has on property flood risk, ensuring that we are adaptive in our approach to reducing risk to our customers.

[9] Report available on request

4 Customer expectation

Our customer research and engagement results consistently tell us that sewer flooding is the worst service failure our customers can experience and that customers are highly supportive of reducing flood risk.

In March 2018 we conducted six deliberative workshops with customers to explore their acceptability of a range of discretionary enhancement schemes. The schemes were presented in the context that by 2020 customers' bills would be reduced by 10%, and that the schemes could be funded by making the 10% reduction smaller.

One of the schemes tested was for overall flood risk reduction. We told participants that we had used specialist software to understand which communities in the North East, which have not flooded before, were at most risk of flooding in future from specific events such as heavy rainfall. We told participants that we would like use this information to lower the risk of these communities flooding.

We shared several examples of ways that we would achieve this such as; re-routing rainwater, creating ponds, lakes and rain-gardens, giving customers water butts and having community plans to prepare for flooding. Participants were clearly told that this work would not mean that these communities would never flood, just that the risk of them flooding will be reduced.

Customers were asked whether or not they accepted this scheme in return for taking 1.29% less of the 10% bill decrease we had committed to giving. They were told that this would be equivalent to £5.04 per year. This scheme achieved 71% acceptance from customers.

We presented this result to the Enhancement Sub Group of the Water Forums on 19 April 2018. Members agreed that the overall customer engagement approach and rigour was good. Members did not agree on a definitive threshold for support in percentage terms, however some views shared were that anything over about 60% would be acceptable – which this enhancement surpasses.

All enhancements were presented back to participants at our PR19 Acceptability Research deliberative workshops. They were available on request to the quantitative participants. Our Plan, including these enhancements was supported by 91% of customers.

5 Current and historical service delivery and expenditure

Over a number of years, NWG has invested both CAPEX and OPEX on a range of assets which have been reported as part of our base expenditure. Typically the investment has resulted in the identification of issues raised and risk prioritised against a number of other ones. Each risk is then assigned a risk reduction per pound score, before acquiring the required investment.

Each year we invest around £45m (£240m per investment period) as base operational expenditure to reduce the risk of sewer flooding and to improve the resilience and maintenance of our network and sewerage assets. This level of investment and the associated initiatives and activities that we undertake has enabled us to reduce internal sewer flooding by over 65%, and reduce external sewer flooding by 30% over a five year period. As a result of this we continue to outperform the performance commitments we agreed for AMP6.

During AMP6, we have trailed a number of initiatives that seek to enhance the wider benefits to customers through the construction of capital schemes associated with known flood risk. During this period we introduced the concept of Community Action Plans (CAPs). CAPS were pilot schemes launched in AMP6 to look at proactive flood risk reduction on the back of known flooding issues. The programme has been hugely successful and has since been brought under our Rainwise strategy. To date we have provided flood risk benefit to just over 2,000 properties.

However, this is a very reactive approach and does not reduce the impact that climate change and urban creep will have on our catchments, and our proactive risk reduction enhancement will focus on properties that have never experienced flooding in the past.

This level of ambition sets a challenging target and one we believe is required to help offset the impact of future changes, whilst being deliverable within the timescales identified.

6 Forward looking analysis

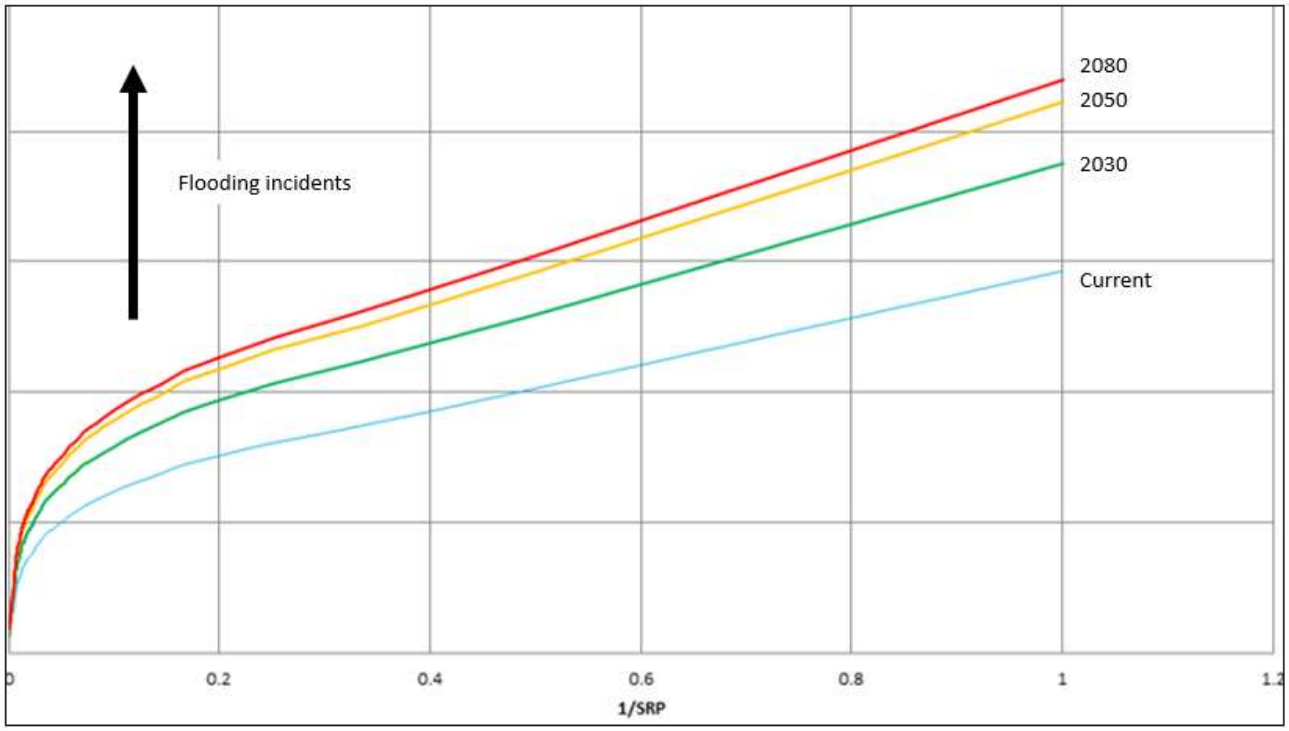
The hydraulic modelling studies that we have undertaken demonstrate that our risk of flooding to properties increases as a result of urban creep and climate change.

In order to undertake some forward looking analysis for the impact of future projections, we have assumed that if the future the number of storms with a particular storm return period (SRP) of X increases by Y%, then we could expect an extra Z% of flooding incidents due to storms of that SRP as well, assuming no change in the network and population etc. We have then looked at Table 4 in Section 3.3 which estimates the percentage uplift in rainfall, compared to current rainfall rates.

For the purposes of the assessment we have taken the central estimate rather than the upper and lower bounds, and used the 1hr duration values as this is more likely to relate to intense rainfall of high SRPs. At a high level we have assumed that for the 2030s, the 28% increase in rainfall will correspond to a 28% increase in storms of each SRP.

The forward looking curves for the projected time periods is shown in Figure 6.

Figure 6: Projected impact of climate change on sewer flooding incidents.



This assessment supports the increase in flooding incidents as a result of climate change, and shows that there is a diverging correlation from our current incident list. The graph also shows that the largest increase in incidents occurs in between the present day and the 2030 scenario.

If we did not intervene and did not plan for the future, our customers would experience sewer flooding more frequently. Our assets would be put to further stress by treating surface water inundating our network. It would have a further impact on local and regional infrastructure that would cause disruptions to peoples' livelihoods and the regional economy.

This therefore supports our need for undertaking proactive risk reduction during the next investment period.

7 Option appraisal

Our proactive flood risk reduction enhancement will focus on properties that have never experienced flooding in the past, but which hydraulic modelling demonstrates will be at risk as a result of climate change and urban creep. Based on our forward-looking analysis, we have identified 16,324 properties as being at risk as a direct consequence of these factors.

Our enhancement proposal is to proactively reduce flood risk to 7,400 of the 16,324 properties during AMP7. This represents the 7,400 properties which we have identified as being in the most significant risk band as a consequence of climate change and urban creep (category 5, 4,515 properties), and a proportion of properties identified in our next risk band (category 4, 2,885 properties).

Our focus on these higher risk properties is driven by what we can feasibly deliver during AMP7. This sets us a challenging target, over and above our other performance commitments in AMP7, and one that is required to help offset the impact of future changes, whilst being deliverable within the timescales identified.

This section sets out our approach to assessing the costs and benefits to customers from reducing the risk of flooding due to the effects of climate change and urban creep to the 7,400 properties identified.

Costs

The proposed enhancement of flood risk reduction has been based on modelling the projected impacts of climate change and urban creep. From our assessment and as described in Section 8, we estimate that the costs of mitigating against these future risks will cost £11,650 per property.

Overall, this leads to a total enhancement cost of £86m.

Benefits

The direct approach to quantifying benefits would be to estimate the damages that customers could avoid through the reduction of flood risk at properties. However, while we can estimate with reasonable certainty the monetary costs needed to clean up the damages resulting from sewer flooding, it is also very important to recognise that our customers suffer further distress and harm from experiencing such an event. Additionally, customers will also benefit from the peace of mind that any actions taken to reduce the risk of such a flooding incident offers.

Estimating the scale of these additional wider benefits and the value that customers place on avoiding these is challenging.

Given this challenge, our approach to benefit assessment is to consider a wide range of evidence. In particular, we first consider the valuation evidence for specific benefits that will arise from the proactive flood risk reduction programme. Secondly we have also considered direct customer evidence in support of the proposed programme from the engagement that we have undertaken during PR19.

Scale of customer valuation

During PR19 we have undertaken a range of research on specific areas. One core piece of research was an innovative customer valuation research tool developed collaboratively with Explain, Frontier Economics and Supercharge[10]. This tool covered a number of service areas, including reducing internal and external sewer flooding. The valuation results from the research were as follows:

- Internal sewer flooding – customers valued a reduction in internal flooding at a value of £26,351 per incident per year.

- External sewer flooding – customers valued a reduction in external flooding at a value of £3,922 per incident per year.

[10] NWG PR19 Research Tool, Striking the right balance between delivering business plan insights and cognitively valid results, January 2018.

Using these valuations, we are able to estimate a range for the total benefits that customers expect to receive from our proactive flood risk reduction enhancement by applying the following approach:

- Using historical feasibility study data and piloted rainwise project information for flood risk reduction within a range of our catchments,[11] we can estimate the number of properties that move from one risk category to another (for example, the number of properties that are expected to move from a 1 in 5-year return period, to a 1 in 10-year return period for experiencing a sewer flooding). From this, we can determine the expected number of proactively reduced flooding incidents by scaling the estimated reduction in sewer flooding incidents calculated to the 7,400 properties. This provides an estimate of the expected reduction in internal and external flooding incidences for these properties.

- We can also use the results of the hydraulic modelling exercise described in Section 3.1 to quantify the increase in properties at risk of internal flooding (4,515 properties), and at risk of external flooding (2,885 properties) as a result of climate change and urban creep.

- We can then multiply these calculated values by the customer valuation figures above for internal and external sewer flooding to determine the range of total benefits that customers will receive.

Based on the approach described above, we have calculated the total customer benefits to range from £96m to £130m, and we anticipate the actual benefit being at the top end of this range.

Lastly, we estimate the benefit-cost ratio based on the present value of the total costs set out above. Assuming a discount rate of 3.5%, this amounts to £77m, and implies a benefit cost ratio ranging from 1.24 to 1.68. Therefore, the implied benefit to customers exceeds the costs that they would incur from supporting the enhancement ranging from 24% and 68%.

Customer support for the proposed enhancement

A recurring theme from our engagement is that customers highly value a reduction in the risk of sewer flooding. However, our customers do not always understand how the enhancement work we do delivers against these. Our discretionary enhancement research set out to explain why enhanced flood risk reduction is necessary to deliver the benefits that our customers have identified as valuable to them.

We have therefore considered the results of the customer research and engagement that we have carried out, and the level of customer support that this indicates for the proposed level of enhancement spend. This provides an indication of the value of the benefits that customers derive from the delivery of proactive flood risk reduction.

Through deliberative workshops conducted in March 2018 (and as described above), our customers have told us that sewer flooding is the worst service failure our customers can experience. They have further told us that they are highly supportive of reducing flood risk, and of the enhancement schemes that we have proposed for AMP7 to achieve this.

The results shown in Table 6 below show that more customers voted 'Yes' than 'No', with the overall level of support being higher than for other discretionary wastewater programmes.

Table 6: Customer acceptability – overall flood risk reduction.

	Yes	No	Unsure
Customer acceptability	71%	20%	10%

To express these results in cost-benefit terms, we have translated the research results in to benefit-cost ratios. To do this we assume that the 'demand curve' is linear and we consider price elasticities ranging from 0.5 (inelastic) to 2.0 (elastic). We also remove the 'Unsure' respondents from the calculation. These results are shown in Table 7 below.

Table 7: Benefit-Cost Ratios for enhanced flood risk reduction based on customer acceptability

[11] Namely, Tyne Dock, Thornfield Road, Redcar, North Billingham, Darlington North, Corbridge, Berwick , Bedlington, Barnard Castle and Ashington

	Low	High
Benefit cost ratio	1.18	1.72

The tables show that the proposed enhancement programme has support from customers and implied benefit cost ratios greater than 1.0. Based on this approach that the implied benefit to customers exceeds the costs that they would incur from supporting the enhancement by 18 to 72%.

In comparing this range of benefit cost ratios with the figures of 1.24 and 1.68 above, it is not clear to what extent the additional benefits, such as increased peace of mind from the reduced flooding risk, is captured in these amounts. To an extent, this will be dependent on the design of the customer valuation and acceptability research, and how the issue was framed in each context. Given that the lower value of 1.24 lies towards the lower end of the range in the table above, this might imply that these additional benefits are not being fully captured in this estimate of the benefit-cost ratio.

Summary of benefits evidence

We have considered a range of benefits evidence that supports the proposed enhancement for flood risk reduction due to climate change and urban creep:

- ***Evidence on the customer valuation of reduced flooding incidents.*** The evidence from our PR19 customer valuation tool indicates that a reduction in the risk of experiencing sewer flooding results in customer benefits of £96m. This demonstrates a positive benefit-cost position.

- ***Customer support for proactively reducing the risk of flooding.*** This research has been undertaken on a small sample of customers, but with detailed information about the costs and benefits of the programme. This demonstrates a positive benefit-cost position.

8 Our preferred plan/option

NWG has assessed the costs for this and other enhancement claims through a structured and robust approach, involving benchmarking of cost estimates against alternatives.

All costs for resilience enhancement were provided and assured by the NWG Cost Assurance team whose methodology to costing the schemes was based on the following different approaches[12]:

- A full iMod cost estimate using business as usual processes.
- PR19 Costing Tool created from iMod base estimates.
- Traditional unit rates used to build up cost estimates.
- Assessment and forecasting of historical spend; and
- Estimates from other data.

A unit cost rate per property protected has been calculated using the actual outturn cost for 20 schemes we have constructed during AMP6 to reduce the risk of flooding. This assessment has confirmed a unit cost of £16,167.68 per property.

We have also undertaken as assessment of our performance in 2018, reviewing benefits received and actual final outturn cost of completed projects. This assessment confirmed a unit cost rate of £12,372.

As a comparison of the validity of this cost, we have compared our unit cost per property to the unit cost rate per damage to houses that the Environment Agency value within their partnership funding calculator. The partnership calculator includes an allowance of £30,000 per property.

[12] For further detail on the cost estimation approach, please see separate paper on cost assessment for enhancement schemes- NWL, 2019, Assessing efficient costs of enhancements

As these costs are based on historical cost data and are based on a smaller sample of properties experiencing a risk reduction, it is likely that our cost per property will reduce over the investment period through efficiencies. We have therefore reduced our proposed unit cost per property to £11,650.

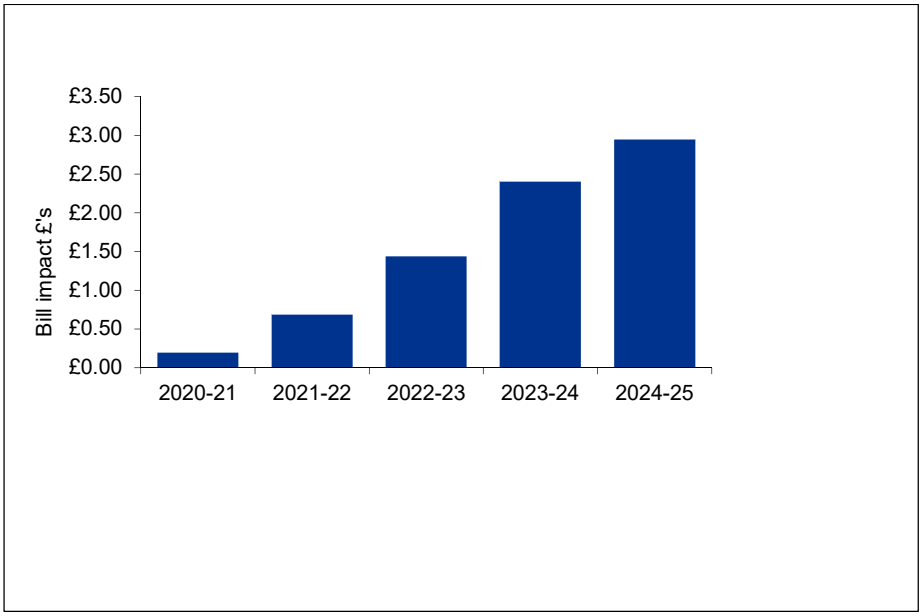
The assumed costs to reduce flooding risk for properties based on £11,650 per property is £86m.

For the Business Plan, Northumbrian Water commissioned Economic Insight to forecast the Relative Price Effects adjustment for capex enhancements. This was assessed at around 1% pa over 2020-25. We separately set ourselves an annual efficiency target for capex enhancements of 1% pa.

8.1 Affordability

The impact of this enhancement investment on customer bills are shown below in Figure 7[13].

Figure 7: Impact of enhancement investment on customer's bills.



Overall the analysis shows that the bill impacts would be around £1.50 a year ranging from an increase of £0.20 from 20/21 to £2.95 in 24/25. This is less than the likely bill impact we explained to our customers in 2018 and which was accepted by 71%.

This is set within an overall bill drop of more than 12% in AMP7, including all enhancement investments, one of the largest across the sector. At an aggregate level recent changes in average earnings have been positive and third party projections from the OBR for 2020-23 suggest that, at a national level, real earnings is predicted grow at between 0.8-1.2% per annum[14] driving significant improvements to average customer affordability.

The scheme proposed is material to the long-term stability and health of the customer service, and will contribute to a robust future network. This is in the context of an AMP7 plan which customers fully support.

Customers support these proposals and consider them to be affordable and the overall position in the plan will reduce bills considerably in AMP 7 at a time of expected real earnings increases. However, we recognise that affordability will remains a concern particularly for some low income customer groups. Our plan sets out detailed proposals and mechanisms to help our services remain affordable for our most vulnerable customers.

[13] Bill impacts were calculated using a simple ready reckoner based on profiles of opex and capex costs for the specific enhancement, asset lives and run-off rates consistent with overall price control specific rates consistent with App16 and using revenues and combined bill average values consistent with App7.
[14] See: https://obr.uk/efo/economic-fiscal-outlook-october-2018/ Table 1.1 difference between CPI and average earnings forecast

9 Alignment with stakeholder needs

Our plans for proactive flood risk reduction have been presented[15] to key stakeholders at both the Northumbria Regional Flood and Coastal Committee and the Northumbria Integrated Drainage Partnership (NIDP). At these meetings our proposals were welcomed and supported by the members.

Furthermore, our strong partnership and stakeholder engagement through the NIDP, has also influenced our proposals which aims to deliver multiple benefits as part of an integrated approach making the most of different sources of flooding.

10 Customer protection

NWG are proposing appropriate mechanisms to incentivise delivery of our proposed enhancement schemes and protect customers between 2020 and 2025 in the event that schemes are not developed or delivery is delayed.

To ensure our customers are protected against under-performance we have created a penalty only incentive rate. The penalty applies to each unit we are below our Performance Commitment for 2024/25 stated in our App1 submission.

For every unit we are below the PC of 7,400 we will incur a penalty of £100.

11 Board assurance

The details of all of our original enhancement cases have been discussed with our PR19 Board Sub-Committee on the 20th February, 8th March and 14th May and full NWL sub board on 18th July 2018.

During these discussions the full enhancement cases were shared with the Board members. During these discussions the board sub-committee have challenged the details of our enhancement proposals in a number of ways which are reflected in our final enhancement cases[16].

The full board have signed a revised Board Assurance Statement at the full board meeting on the 29th of March confirming that they have seen and are confident in the enhancement cases. To this effect the board has signed an assurance statement confirming 'that large investment proposals are robust and deliverable, that a proper assessment of options has taken place, and that the option proposed is the best one for customers'[17].

Following revisions to this paper, our PR19 Board Sub – Committee reviewed and approved the business case on the 19th and 20th June 2019, and our full Sub Board reviewed and approved the business case on 26th and 27th June 2019.

[15] Minutes available on request

[16] For further detail on how the Board has challenged our enhancement cases and the response from management pls see our 'Board engagement on enhancement cases document'

17 See Board Assurance Statement