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Estimating Customers' Willingness to Pay for Changes in Service at PR24

Prepared for Yorkshire Water

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Executive Summary

NERA Economic Consulting (NERA) and Qa Research (Qa) were commissioned by Yorkshire Water (YW) to design, implement and analyse a stated preference (SP) survey to estimate customers' willingness to pay (WTP) for improvements in the service provided by YW. YW intends to use the findings from this study to inform development of its business plan ahead of the next price control period, PR24.

We examined WTP for improvements in water service for three different categories of YW customer: household (HH) customers, non-household (NHH) customers, and future bill paying (FBP) customers. FBP customers must be aged under 34 and not currently responsible for paying the water bill.

Design of Stated Preference Survey

Our stated preference survey asked customers to choose their preferred combination of bill adjustments and service levels for eleven distinct attributes for the PR24 price control period 2025-2030. The eleven attributes over which we elicited customers' preferences are shown in Table 1.

Table 1: We Examined Customer WTP for Eleven Service Attributes

Attribute	
A	Drinking Water Colour, Taste and Smell
B	Unplanned Interruptions to the Water Supply
C	Water Lost Through Leaks
D	Using Less Water
E	Sewage Flooding Inside Properties
F	Sewage Flooding Outside Properties
G	River Water Quality
H	Sea Water Quality at Yorkshire's Beaches
I	Pollution of Watercourses
J	Low Water Pressure
K	Creating a River Wharfe Safe for Swimming

Source: WTP survey for YW

For each attribute, customers could select one of up to five service level options, each of which had a pre-defined impact on their bill. They could choose to maintain the status quo service level; they could select a small or a large deterioration in service that would reduce their bill relative to the status quo option by either a small or a large amount; or they could select either a small or large improvement in service that would increase their bill relative to the status quo option by either a small or large amount. The bill impacts that customers saw were tailored to the customer in question based on information they provided about their current bill.

After customers made their choices for each attribute individually, we presented them with a summary screen of all their choices and the total bill impact. Customers then had an opportunity to revise their choices for individual attributes. This allowed the customer to ensure that their final chosen package of service levels for all eleven

attributes did not exceed their total willingness to pay for water services, or to adjust their choices following consideration of all attributes.

We ran a pilot survey between 31 August and 4 September 2022 from which we collected stated preference data from 200 household customers. We ran the main stage survey over a period of four weeks between 12 September and 9 October 2022 and collected stated preference data from 1,282 household customers, 193 non-household customers, and 113 future bill payers. We recruited all customers through access panels.

Incorporating Guidance on Best Practice

We have adopted an innovative approach in this stated preference study that addresses a range of concerns raised by the Consumer Council for Water (CCW) and others following a review of stated preference studies conducted at PR19.

Following PR19, CCW commissioned a study from Blue Marble on water companies' customer engagement research, which identified a number of concerns about water companies' use of traditional WTP studies. Traditional WTP studies first present customers with information about a number of attributes, then ask customers to make a series of choices between pre-defined packages comprising service levels for a number of different attributes and a fixed bill amount. The CCW/Blue Marble study highlighted that such studies are often not easy for customers to complete. It found that customers struggle to retain all the information about attributes presented at the beginning of the survey and find the pre-defined packages and the requirement to make multiple choices between pairs confusing.

Our innovative approach addresses various concerns raised by the Blue Marble report. We ask customers to make decisions about only one attribute at a time and provide information about that attribute at the point where the customer is asked to make the decision, so customers are not required to retain information. We allow customers to construct their preferred package by combining choices on individual attributes, rather than requiring them to choose between pre-defined packages. Each customer is only asked to construct one preferred package.

In addition to taking steps to respond to the CCW/Blue Marble concerns about traditional WTP studies, we have also adhered to the standards for high-quality research and customer engagement set out by Ofwat in advance of PR24. In particular:

- The attributes to include in the WTP study were in part informed by other recent qualitative and quantitative research undertaken by Qa Research on behalf of YW to determine the relative priority customers place on different aspects, actions and activities that YW provides and undertakes. In addition, we used core principles learnt from qualitatively testing attribute descriptions amongst customers in other WTP studies to inform the creation of the attribute wording used in this study.

- To ensure the survey was neutral, fit for purpose, and inclusive, we adopted an iterative process of survey development that allowed us to incorporate feedback from customers (through qualitative studies and a pilot). This gives us confidence that the results presented in the report constitute meaningful evidence about customers' preferences that YW can incorporate into its business planning for PR24.

Approach to Willingness-to-Pay Estimation

To estimate customer WTP for service improvements based on the survey data we collected, we rely on an econometric model – a conditional logit model – that estimates customers' willingness to pay for changes in the service level.[1] For example, for attribute I "pollution of watercourses", the econometric model tests whether and by how much customers are willing to pay for a unit reduction in the number of pollution incidents.

The specific conditional logit model we estimate assumes that customers' per-unit WTP for changes in the service level is consistent across all possible levels of service.[2] This means we derive a single value for customers' WTP for each attribute (e.g. for the service attribute "pollution of watercourses", we get a single value for WTP for a unit reduction in the number of pollution incidents). The customer valuation framework that YW will use as part of its business planning process requires customer WTP to be expressed as a single value per attribute. We estimate this econometric model separately for each of HH, FBP, and NHH customers.

The model described above assumes that customers have the same per-unit WTP for incremental changes in service across the full range of possible service levels for each attribute. This assumption may not reflect customers' actual preferences. In particular customers may be averse to deteriorations in service, even if they are not willing to pay for improvement.

To test whether customers are more averse to deteriorations in service than they are willing to pay for improvement, we estimate a second model where we assume that all customers who chose improvements in service *would have chosen* the status quo if forced to choose between deteriorations and the status quo only. We refer to this as the "Deteriorations Model". The Deteriorations Model allows us to estimate the compensation that customers would require per unit deterioration relative to the status quo.

Willingness-to-Pay Results

Overall, we find evidence that customers are willing to pay for improvement in some, but not all, of the eleven attributes selected. Table 2 and Table 3 present the estimated WTP from our main econometric model for each of HH, FBP, and NHH customers.

The WTP values shown in the tables for HH and FBP customers are shown in terms of £ per customer, relative to the status quo. Hence, for the example of leakage, Table 2 shows HH customers would be willing to pay £2.65 on average to improve from leakage levels of 283 million litres per day to 268 million litres per day, whereas they would require compensation of £1.24 per customer to move from the status quo to 290 million litres per day.

The results for NHH customers are shown in percentage point terms, so in the case of sea water quality, NHH customers would need to see a 0.54 percentage point reduction

[1] Specifically, we estimate a model in which the outcome variable is an indicator for whether the customer chose a specific combination, or package, of service levels across all attributes. The explanatory variables are the service levels of each attribute (one variable per attribute) and the total bill impact of the package.

[2] That is, we estimate a conditional logit model that is linear in the service level for each attribute.

in their bill to accept deterioration from the status quo level to the lowest level of service (12 out of 18 beaches classified as good or excellent).

Table 2: Estimated WTP for HH, FBP, and NHH Customers (Attributes A-F)

Attribute		Service Level	Incremental WTP to switch from status quo		
			HH (£)	FBP (£)	NHH (% points)
A	Drinking water colour, taste and smell	13 contacts per 10,000 customers	0.00	0.00	0.00
		12 contacts per 10,000 customers	0.00	0.00	0.00
		11 contacts per 10,000 customers			
		10 contacts per 10,000 customers	0.00	0.00	0.00
		9 contacts per 10,000 customers	0.00	0.00	0.00
B	Unplanned interruptions to the water supply	55,000 properties interrupted	0.00	0.00	0.00
		50,000 properties interrupted	0.00	0.00	0.00
		46,000 properties interrupted			
		41,000 properties interrupted	0.00	0.00	0.00
		36,000 properties interrupted	0.00	0.00	0.00
C	Water lost through leaks	315 million litres per day (26.3% of water supplied)	-5.65	0.00	0.00
		290 million litres per day (24.2% of water supplied)	-1.24	0.00	0.00
		283 million litres per day (23.6% of water supplied)			
		268 million litres per day (22.3% of water supplied)	2.65	0.00	0.00
		239 million litres per day (19.9% of water supplied)	7.77	0.00	0.00
D	Using less water	133 litres per person per day	0.00	0.00	0.00
		132 litres per person per day			
		125 litres per person per day	0.00	0.00	0.00
		117 litres per person per day	0.00	0.00	0.00
E	Sewage flooding inside properties	1,120 properties flooded	-23.18	-41.00	0.00
		780 properties flooded	-6.05	-10.70	0.00
		660 properties flooded			
		550 properties flooded	5.54	9.81	0.00
		310 properties flooded	17.64	31.20	0.00
F	Sewage flooding outside properties	7,100 properties flooded	-13.03	-23.54	0.00
		5,000 properties flooded	-2.09	-3.77	0.00
		4,600 properties flooded			
		4,400 properties flooded	1.04	1.88	0.00
		3,700 properties flooded	4.69	8.48	0.00

Source: NERA analysis of WTP survey data.

Table 3: Estimated WTP for HH, FBP, and NHH Customers (Attributes G-K)

Attribute		Service Level	Incremental WTP to switch from status quo		
			HH (£)	FBP (£)	NHH (% points)
G	River water quality	0km of 742km	-3.28	-13.48	0.00
		25km of 742km	-1.64	-6.74	0.00
		50km of 742km			
		70km of 742km	1.31	5.39	0.00
		150km of 742km	6.55	26.95	0.00
H	Sea water quality at Yorkshire's beaches	12 of 18	-20.75	-18.18	-0.54
		14 of 18	-10.38	-9.09	-0.27
		16 of 18			
		18 of 18	10.38	9.09	0.27
I	Pollution of watercourses	175 incidents	-14.23	-19.76	0.00
		165 incidents	-11.38	-15.81	0.00
		125 incidents			
		100 incidents	7.12	9.88	0.00
		85 incidents	11.38	15.81	0.00
J	Low water pressure	14 properties affected	0.00	-12.85	0.00
		9 properties affected	0.00	-6.43	0.00
		4 properties affected			
		2 properties affected	0.00	2.57	0.00
		0 properties affected	0.00	5.14	0.00
K	Creating a River Wharfe safe for swimming	No – do not make this investment			
		Yes – do make this investment	0.00	0.00	0.00

Source: NERA analysis of WTP survey data.

As the tables show, our findings suggest that HH customers are willing to pay for improvement in service for the following attributes, covering attributes that relate to protecting the environment, reducing the risk of service failures that would have particularly unpleasant consequences, and reducing leakage (which receives substantial media attention):[3]

- C (Water lost through leaks)
- E (Sewage flooding inside properties)

[3] For all of the attributes listed except attribute G, the positive WTP is significant at the 5 per cent significance level. For attribute G, the positive WTP is borderline significant at the 10 per cent level (p-value = 0.102).

- F (Sewage flooding outside properties)
- G (River water quality)
- H (Sea water quality at Yorkshire's beaches)
- I (Pollution of watercourses)

FBP customers are willing to pay for improvement in many of the same attributes as HH customers, albeit with some differences:

- HH customers are willing to pay for a reduction in leakage (attribute C), while FBP customers are not.
- FBP customers are willing to pay for improvements in water pressure (attribute J), while HH customers are not.
- FBP customers place higher value on reducing sewage flooding inside properties and improving river quality (attributes E and G) than do HH customers.
- HH customers place higher value on improving sea water quality at Yorkshire's beaches (attribute H).
- Both groups place similar value on reducing pollution of water courses and reducing sewage flooding outside properties (attributes I and F).

Across all customer groups, customers are not willing to pay for improvements in service for attributes where the impact of service failure is small (i.e. attribute A, Drinking water colour, taste, and smell; and attribute B, Unplanned interruptions to the water supply). Customers are also not willing to pay to reduce per capita water consumption (attribute D, Using less water) or to create a River Wharfe safe for swimming (attribute K), which may be because they see these as non-essential or because they do not think these improvements would benefit them.

NHH customers only exhibit positive WTP for one attribute, attribute H (Sea Water Quality at Yorkshire's Beaches). NHH customers prefer to avoid any changes to the level of their water bill: on average, they choose a combination of service levels that results in a total change to their water bill near zero. A minority of NHH customers choose service levels that result in a reduction in their total water bill, suggesting that they prefer to reduce their water bill even at the cost of deterioration in service.

Sensitivities on Main WTP Results

If we exclude those who exhibit protest attitudes from the analysis (i.e. respondents we have reason to expect did not accept the premise of the survey that higher service levels have to be funded through higher water bills, and vice versa), then both HH and FBP customers are willing to pay for improvement in all of the attributes set out above (i.e. attributes A, C, E, F, G, H, and J). Removing respondents who exhibit protest attitudes from the analysis does not change the results for NHH customers.

We also examine whether our results for HH customers differ if we restrict the analysis to certain sub-groups based on demographic characteristics. Specifically:

- We find that WTP for service improvements differs between men and women, but not in a systematic way. Women have higher WTP than men for some attributes, while men have higher WTP than women for others.
- We observe that customers from the ABC1 socio-economic group have higher WTP than customers from the C2DE socio-economic group.

Across all customer groups, the "Deteriorations Model" shows that customers are typically averse to deterioration in service for all attributes. That is, we estimate a positive WTP if we restrict the analysis to consider only deteriorations in service compared to the status quo (and assume all customers who chose improvements would, if restricted to choose between deteriorations and the status quo, have chosen the status quo option). This positive WTP is the amount of compensation that customers would require, per unit of deterioraton from the status quo, to accept that deterioration, where compensation should here be understood as reductions in the average customer's bill.

Conclusions

The results of our WTP analysis suggests that, on average, domestic customers (i.e. HH and FBP) are willing to pay for improvement in attributes that relate to protecting the environment, reducing the risk of service failures that would have particularly unpleasant consequences (such as sewage flooding), and reducing leakage. NHH customers are willing to pay for improvement in one environmental attribute only.

It would therefore be consistent with domestic customers' preferences for YW to include in its PR24 business plan additional investments to achieve the proposed higher service levels for these attributes, provided that customer WTP is above the cost per customer of the investment. Further targeted qualitative research may be useful to understand exactly how customers would like YW to implement the additional investment, since the descriptions of improvements in this survey were necessarily high-level.

While domestic customers are on average willing to pay for improvements in some attributes, the finding that non-domestic customers as well as certain sub-groups of domestic customers are less willing to pay for improvements represents a challenge for YW in developing its business plan. YW provides services that are "public goods" from which all customers benefit, so it cannot to provide improvements for some customers but not for others. One potential avenue to address this challenge would be to adjust the tariff structure so that the burden of paying for improvements does not fall on financially vulnerable domestic customers or on non-household customers, though developing such adjustments to the tariff structure would require further research and engagement.[4]

The results of our "Deteriorations Model" also demonstrate that customers are typically averse to deterioration in service, which suggests a strong case for a PR24 business plan that maintains at least the current level of service for all attributes, unless the savings achievable as a result of service deteriortions are above the (relatively high) levels of compensation we estimate would compensate customers for these service level changes.

[4] Note, we find that vulnerable customers and those who are worried about their ability to pay their water bills are less willing to pay for improvements in service than the average household customer.

1. Introduction

NERA Economic Consulting (NERA) and Qa Research (Qa) were commissioned by Yorkshire Water (YW) to design, implement and analyse a stated preference (SP) survey to estimate customers' willingness to pay (WTP) for improvements in the service provided by YW. This study covered domestic (household, or HH) and non-domestic (non-household, or NHH) customers. It also included a sample of future bill payers (FBP), i.e. individuals under the age of 34 who currently have no responsibility for paying the water bill.

The project consisted of four main parts:

1. Set up and design of the study, defining service attributes, testing customer comprehension of attribute descriptions and then refining them, designing and building the survey, and selecting the SP technique;
2. Survey testing through pilot fieldwork and analysis of pilot results;
3. Fieldwork, consisting of online and face-to-face surveys;
4. Quantitative analysis of the fieldwork data to derive WTP estimates and conduct sensitivity and robustness checks.

This report is set out as follows:

- Section 2 explains the set-up and design of the stated preference study. This section includes a description of adjustments we made to the main survey following analysis of results from the pilot study. It also includes a discussion of how this WTP research incorporates guidance on best practice.
- Section 3 describes the data collected as a result of our main-stage fieldwork.
- Section 4 sets out the findings of our research. The main findings are the WTP estimates, and we include here a description of the statistical approach used to derive those estimates.
- Section 5 concludes.

2. Study Design

The objective of a stated preference survey is to obtain information on customers' preferences, where these preferences cannot be observed through market transactions. This constraint applies to many of the service attributes that YW can influence through its business planning process, as they are inevitably public goods (i.e. the quality or reliability of service provided by a network utility), or relate to environmental or social objectives.

A stated preference study involves giving a sample of individuals the opportunity to state their preferences about a set of hypothetical economic trade-offs. It is then possible to draw conclusions about average or typical preferences based on the data collected from that sample.

In the study at hand, we give a representative sample of the YW customer base an opportunity to state their preferences about trade-offs between attributes of the service provided by YW, and the price they would pay to receive those services. While these choices are hypothetical (as explained below), they are closely related to the real choices YW faces, and the prices shown to customers are centered around the costs YW expects to incur to provide them. We then use the data collected to draw conclusions about the preferences of the typical YW customer regarding these trade-offs, which YW can in turn use to plan investment in its service offerings in a way that responds to customer preferences.

We worked closely with YW to design the stated preference study such that we could draw robust conclusions from the data that would provide meaningful input to YW's business planning process. In this section, we set out the key design features of the study and explain how our design choices ensure that our conclusions are robust and meaningful.

- Section 2.1 lists the eleven service attributes about which we elicit customer preferences. It also explains how we ensure that the survey provides customers with appropriate information to understand each attribute and make an informed decision about the trade-offs presented to them.
- Section 2.2 explains how we used customer co-development workshops to ensure that the attributes we study reflect customer priorities and are presented in a way that is understandable to customers.
- Section 2.3 sets out the structure of the questionnaire that customers received.
- Section 2.4 describes the format of the stated preference questions that we pose to customers. It explains how we ensure that the costs that customers face are credible and relevant to them. It also explains how we have responded to customer feedback on previous stated preference surveys to reduce the complexity of the questionnaire while giving customers more flexibility in expressing preferences.
- Section 2.5 provides information on additional data we collected as part of the survey, which we use to contextualise our findings and examine whether our conclusions are robust across different YW customer sub-groups.
- Section 2.6 explains how we used a pilot study to test that the survey design was accessible to customers and elicited plausible customer preferences.
- Section 2.7 describes how we adhered to Ofwat guidance on best practice in customer engagement throughout the study.

We survey both household (HH) customers and non-household (NHH) customers. The NHH survey differs slightly to the HH survey, and we highlight this where relevant throughout this section. We also survey a sample of future bill payers (FBP); as these are future household customers, they see the same survey as HH customers.

2.1. Service Attributes Selected for Evaluation

We examine customers' WTP for eleven different service attributes in this study. Each service attribute captures an area of YW's activity where additional investment could lead to improvement, or less investment could lead to a deterioration in service. Table 2.1 shows a list of all eleven attributes. We developed descriptions of the eleven attributes to appear in the survey through an iterative process, including discussions with YW and testing of the attributes and associated material with YW customers.

Table 2.1: We Examined Customer WTP for Eleven Service Attributes

Attribute	
A	Drinking Water Colour, Taste and Smell
B	Unplanned Interruptions to the Water Supply
C	Water Lost Through Leaks
D	Using Less Water
E	Sewage flooding inside properties
F	Sewage flooding outside properties
G	River Water Quality
H	Sea Water Quality at Yorkshire's Beaches
I	Pollution of watercourses
J	Low Water Pressure
K	Creating a River Wharfe safe for swimming

Source: WTP survey for YW

YW initially provided a list of ten attributes that relate to key areas of YW's business planning. The selection of attributes was informed by the priorities identified in the Valuing Water survey conducted by Qa as well as YW's business planning requirements.

These ten attributes were attributes A to J, above. Instead of including attribute K, the potential development of the River Wharfe bathing area was included as an improvement option for attribute H, which was initially labelled "Bathing Water Quality".

We worked with YW to develop the associated material for each attribute that we shared with customers to ensure that they would make informed decisions in the stated preference study. The associated material comprised:

- **The issue:** a description of the attribute.
- **Current situation:** a description of the current service level for that attribute.
- **What could change:** a summary of how additional investment would impact the service level for that attribute.

We presented the selected attributes and associated material to household and non-household customers at a series of co-development workshops. The purpose of these workshops was to assess whether the attributes and associated material made sense to customers.

During the co-development workshops, customers found the term "Bathing Water" confusing. Most customers thought the term referred to bath water in their homes, rather than understanding it to be a catch-all term including both beaches and the proposed River Wharfe bathing area. In order to ensure customer comprehension, we decided to ask customers separately about beaches and the proposed River Wharfe bathing area. We refined attribute H to focus on beaches only, and added attribute K to ask customers a yes/no question about whether they were in favour of the proposed River Wharfe development.

In addition to adding attribute J, we made a number of further adjustments to the survey material based on the co-development workshops. These adjustments were to ensure that the survey was understandable to customers while still providing useful material for business planning purposes.

In parallel to the co-development workshops we worked with YW to define up to five service levels for each attribute that YW could achieve by varying investment in that attribute. The five possible service levels were: small and large deteriorations in service, maintaining the status quo, and small and large improvements in service.

For some attributes, we agreed with YW that it did not make sense to offer all five service levels. This was the case for the following attributes:

- Attribute D (using less water): We did not include a large deterioration in service because YW cannot feasibly offer this due to its regulatory obligations.
- Attribute H (sea water quality at Yorkshire's beaches): We did not include a large improvement because the small improvement reflects the maximum possible outcome (i.e. all 18 beaches rated good or excellent).
- Attribute K (creating a River Wharfe safe for swimming): We only offered the status quo and the small improvement options because the attribute was framed as a yes/no question.

We undertook a pilot study, based on which we revised the attributes and associated material further before finalising the main survey. The final material for each attribute is set out in the tables below. Table 2.2 shows the description of each attribute, its current service level, and the impact of additional investment. Table 2.3 shows the service levels for each attribute that customers were asked to choose between.

Table 2.2: We Provide Customers with a Description of Each Attribute, the Current Service Level, and Potential Impact of Additional Investment

Attribute	Issue	Current situation	What could change
A Drinking Water Colour, Taste and Smell	Every year some customers experience an unexpected change in the colour (normally light brown or milky) and / or the taste or smell of their water supply (normally a chlorine smell) for a short period of time. The water is still safe to drink and can be used for bathing and in washing machines and dishwashers.	Each year around 11 in 10,000 households (NHH: properties) in the region contact Yorkshire Water about a change in the look, taste or smell of their drinking water.	More investment, for example, in extra maintenance of the network or upgrading the mains pipes, would help reduce the number of times customers experience these issues.
B Unplanned Interruptions to the Water Supply	Every year a certain number of households (NHH: customers) in the Yorkshire Water region experience their water supply being cut-off for 3 to 6 hours due to unplanned interruptions such as burst pipes.	Last year 46,000 or 2% of properties experienced their water being cut-off for 3 to 6 hours due to an unplanned interruption. During an interruption Yorkshire Water delivers bottled water to vulnerable people.	More investment would enable us to invest in extra technology to identify water bursts, repair bursts more quickly, and undertake more maintenance work to reduce the chances of any lengthy unplanned interruptions happening.
C Water Lost Through Leaks	Millions of litres of clean treated water are lost from the Yorkshire Water network before it reaches customers' taps.	Last year 22% of water was lost through leaks in the network, which is 283 million litres of water per day. This is the equivalent of supplying the population of Leeds and York each day.	More investment would allow us to employ more people and invest in innovation and new technology to find and fix leaks sooner.
D Using Less Water	Ongoing challenges associated with climate change mean everyone needs to use less water for the sake of the environment and to ensure we have enough water for everyone, all of the time.	The average amount of water each person uses in Yorkshire is 132 litres per day for drinking, cooking, washing, cleaning, flushing the loo, watering plants etc.	More investment would allow us to do more communications helping customers to save water, provide more free water saving devices, and offer more customers the option to have a water meter installed so they can better keep track of the water they use.

Attribute	Issue	Current situation	What could change
E Sewage flooding inside properties	Flooding from our sewers can sometimes get inside homes and businesses. This can be distressing for those affected and harmful to the home environment.	Around 1 in 3,500 properties each year (which is 664 homes and businesses in Yorkshire) experience a sewer flood inside the property.	Investing more in extra sewerage capacity, technology to identify and respond to issues more quickly, and education (working with customers to reduce sewer blockages) will reduce the risk of sewage flooding.
F Sewage flooding outside properties	Some customers experience sewage escaping from the sewers into their garden or a local area such as a public park. This can be caused by a blocked or collapsed sewer, which can be harmful to the environment.	There were 4,578 outside sewer floods last year in Yorkshire.	Investing more in extra sewerage capacity, technology to identify and respond to issues more quickly, and education (working with customers to reduce sewer blockages) will reduce the risk of sewage flooding outside.
G River Water Quality	Discharges from our wastewater treatment works, along with chemicals and fertilisers from agriculture, and pollution from industry can all impact on the quality of river water in the region.	The levels of damaging chemicals in some places are much higher than they should be. Last year Yorkshire Water completed several schemes which improved 50km of the rivers in Yorkshire, out of the 742 which need improving.	Although some of this is out of Yorkshire Water's control, more investment would allow us to introduce more improvement schemes including working with partners to help improve river water quality. This would benefit nature and wildlife.
H Sea Water Quality at Yorkshire's Beaches	Sea water is not always rated as excellent, based on the tests regularly undertaken by the Environment Agency. Discharges from our wastewater treatment works, along with chemicals and fertilisers from agriculture, and pollution from industry can all impact on the quality of sea water.	Out of the 18 beaches in Yorkshire the quality of the sea water was rated as being 'excellent' at 7 of them, 'good' at 9 and the minimum status of 'sufficient' at 2, with none rated 'poor'. At a beach rated 'sufficient' you could still swim in the sea, but there would be a small increase in the chance that you might get ill if you swallowed some water.	Extra investment would help reduce pollution incidents from our sewage treatment plants, and reduce the impacts caused by agriculture and industry, all of which would improve the quality of the sea water at Yorkshire's beaches.
I Pollution of watercourses	Pollution happens when sewage unexpectedly escapes from Yorkshire Water's sewerage system and spills into rivers,	Last year there were 126 minor pollution incidents in Yorkshire caused by Yorkshire Water. This was an improvement on the	More investment would allow us to employ more people to monitor and repair our sewers, along with helping customers understand what not to put down

Attribute	Issue	Current situation	What could change
	streams, reservoirs or the sea. This can cause environmental damage affecting not only the water it enters but also impacting on nature and wildlife which rely on that waterbody.	previous year where we had 159 minor pollution incidents. Minor incidents have minimal impact or effect on the environment.	the drain, which will help reduce the number of these incidents.
J Low Water Pressure	Every year Yorkshire Water invests to ensure households (NHH: properties) don't experience problems with the force that water comes out of their taps. When water pressure is low, it comes out of the tap as a trickle.	Last year we helped around 50 customers experiencing low pressure and spent approximately £1.5million on ensuring suitable pressure for all our customers. At the end of the year, we had four (4) customers who experience chronic and ongoing low water pressure and prevented it for many other customers.	More investment would allow Yorkshire Water to prevent more customers from experiencing low pressure. It will improve pressure for those customers experiencing chronic, ongoing low pressure and support other customers day to day who may experience low pressure throughout the year.
K Creating a River Wharfe safe for swimming	Yorkshire has the first Environment Agency-approved inland bathing waters, this is on a section of the river Wharfe in Ilkley, West Yorkshire. Approved swimming waters require additional investment by Yorkshire Water over and above traditional wastewater treatment to ensure they are safe to swim in (HH: for our customers).	In order for this section of river in Ilkley to meet approved Environment Agency standards for swimming water quality, Yorkshire Water must invest £100 million pounds.	This investment would allow Yorkshire Water to improve the quality of the wastewater it returns to the river via improved treatment processes, similar to how wastewater is treated when returned to the sea. It would allow for improved handling of storm water and helping customers to understand how their sewer misuse is impacting the river.

Source: WTP survey for YW

Table 2.3: Service Levels for Each Attribute

Attribute	Larger Reduction (-2)	Small Reduction (-1)	Current Level (0)	Small Improvement (+1)	Larger Improvement (+2)
A Drinking Water Colour, Taste and Smell	13 contacts per 10,000 customers	12 contacts per 10,000 customers	11 contacts per 10,000 customers	10 contacts per 10,000 customers	9 contacts per 10,000 customers
B Unplanned Interruptions to the Water Supply	55,000 properties interrupted	50,000 properties interrupted	46,000 properties interrupted	41,000 properties interrupted	36,000 properties interrupted
C Water Lost Through Leaks	315 million litres per day (26.3% of water supplied)	290 million litres per day (24.2% of water supplied)	283 million litres per day (23.6% of water supplied)	268 million litres per day (22.3% of water supplied)	239 million litres per day (19.9% of water supplied)
D Using Less Water	-	133 litres per person per day	132 litres per person per day	125 litres per person per day	117 litres per person per day
E Sewage flooding inside properties	1,120 properties flooded	780 properties flooded	660 properties flooded	550 properties flooded	310 properties flooded
F Sewage flooding outside properties	7,100 properties flooded	5,000 properties flooded	4,600 properties flooded	4,400 properties flooded	3,700 properties flooded
G River Water Quality	0km of 742km	25km of 742km	50km of 742km	70km of 742km	150km of 742km
H Sea Water Quality at Yorkshire's Beaches	12 of 18	14 of 18	16 of 18	18 of 18	-
I Pollution of watercourses	175 incidents	165 incidents	125 incidents	100 incidents	85 incidents
J Low Water Pressure	14 properties affected	9 properties affected	4 properties affected	2 properties affected	0 properties affected
K Creating a River Wharfe safe for swimming	-	-	No – do not make this investment	Yes – do make this investment	-

Source: WTP survey for YW

2.2. Initial Research to Identify Customer Views on Selected Attributes

We conducted qualitative research on the initial set of attributes and associated information with YW. This research had two objectives:

- To test customer comprehension of the attribute descriptions and associated service levels and to recommend refinements that would improve customer understanding. We examined both the wording of the descriptions and the framing of any numerical information (for example, whether customers found it easier to understand percentages or ratios); and
- To understand whether customers had stronger opinions with regard to some attributes than others and if so to understand the factors determining the strength of customer opinion.

To achieve these objectives, Qa adopted a co-development approach. The research comprised:

- 3 x 3-hour co-development workshop discussions with General Household Customers split by lifestage and social grade;
  - 1 x pre-family lifestage, all aged 18-30, ABC1 social grade
  - 1 x family lifestage, mix of ages of children, C2DE social grade
  - 1 x post family lifestage, C2DE social grade
- 2 x 3-hour workshop group discussions with Non-Household Customers; split
  - Business customers based in a city or town, mix of size & sector, all to have business premise separate to their own home
  - Business customers based in a rural, small town or rural coastal location mix of size & sector, all to have business premise separate to their own home
- 12 x individual depth interviews with vulnerable customers, split by long term health condition (including disability), very low income (e.g. dependent on benefits, are in or have experienced water debt), and elderly aged 75+ living alone
  - 4 x long term health condition (including disability)
  - 4 x very low income (e.g. dependent on benefits, are in or have experienced water debt)
  - 4 x elderly aged 75+ living alone
  - Across the 12 depth interviews 5 were digitally excluded i.e. they had very limited or no access to the internet for whatever reason.

All fieldwork took place in the week commencing 8 August 2022.

Qa presented customers with two different versions of each attribute: a version '1' provided by YW and NERA and an alternative version '2' created by Qa for use in the co-development workshop. For each attribute, versions 1 and 2 were designed to communicate the same information but using different words and numeric examples.

Participants were asked to review each version to explore whether the words made sense and whether the material was effective at explaining the attribute to customers. After exploring reactions to and comprehension of both versions, Qa showed customers both versions side by side. Customers then co-developed a revised version which either took the best bits from version 1 or 2 or developed these into something new.

Qa analysed the qualitative feedback, both verbal and non-verbal, and prepared a qualitative report which highlighted those words, phrases, and numeric expressions which participants struggled to comprehend, caused confusion, or participants deemed useful in helping them understand the descriptions. The qualitative report included a revised suggested version to use in the quantitative survey, based on the versions co-developed by customers.

The ultimate goal of this co-development process was to make each of the final attribute descriptions as customer friendly and clearly understandable as possible.

Following discussion between Qa, NERA, and YW, we made a small number of alterations to the revised set of descriptions to ensure that the survey results would still provide sufficient information to guide YW planning decisions. These descriptions were then taken forward for use in the first iteration of the survey. We describe the format of the survey in Sections 2.3 to 2.5, and then describe our iterative testing of the survey in Section 2.6.

2.3. Structure of Survey Questionnaire

The questionnaire includes three parts: an initial screening section, the stated preference exercise, and a set of closing questions on the customer's experience of the stated preference exercise and either demographic characteristics (HH and FBP respondents) or company characteristics (NHH respondents).

The initial screening section was included for two reasons.

First, the screening section ensured that ineligible respondents were prevented from completing the survey. The eligibility criteria for each group were as follows:

- HH respondents had to confirm that they are a customer of YW and have some responsibility for paying their household water bill;
- NHH respondents had to confirm that their organisation has premises in the YW operating area and some responsibility for paying their organisation's water bill; and
- FBP had to confirm they have no responsibility for paying their household's water bill but were *"currently (or mainly)"* living in the YW operating area and aged 18-34.

Secondly, as a quota sampling approach was used for the HH sample, screener questions were included to align the sample with the target quotas based on age, gender, YW Region and socio-economic group (SEG). Additional screener questions were included for the face-to-face surveys with vulnerable customers to identify those who are digitally disengaged, facing financial hardship, or have a health related vulnerability.

The stated preference exercise is the core of the survey. It collects data on customers' WTP for different service levels for each of the eleven attributes introduced in Section 2.1. The format of this stated preference exercise is explained below in Section 2.4.

The closing questions allow us to collect information that we can use to examine whether the results of the stated preference exercise differ across customer sub-groups.

2.4. Format of Stated Preference Exercise

2.4.1. Overview of the stated preference exercise

In the stated preference exercise, we ask respondents to choose between different service levels for each of the eleven attributes over the period 2025-2030, where the choice of service level affects the customer's water bill.

To obtain reliable valuations, it is important that customers believe that they may actually have to make payments in line with their stated preferences. Otherwise, respondents may not reveal their true valuations (known as "hypothetical bias"). Therefore, we explain the purpose of the survey is to inform YW's real business planning decisions.

We also present the costs (savings) associated with an improvement (deterioration) in service as a change to the respondent's own water bill. To help achieve this, we ask customers to state what their current total water bill is. For HH customers that do not know their bill, we provide them with an estimated average bill based on whether they report that they are metered or not, and on the number of people they report to be living in the household. Unmetered customers are shown the typical average household bill of £492 per year (irrespective of household size). For metered customers, we show them a bill based Table 2.4 below.

Table 2.4: We Give HH Customers Who Do Not Know Their Bill an Estimated Value

HOUSEHOLD OCCUPANCY	AVERAGE ANNUAL METERED CHARGE
1	£286
2	£417
3	£547
4	£677
5	£743
6 or more	£874

Source: YW

For NHH customers who do not know their bill, we ask them to choose one of the options from Table 2.5 below.

Table 2.5: We Ask NHH Customers Who Do Not Know Their Bill to Select an Option

Annual usage	Comparison with an average household	Approximate annual water bill
100 m^3	Equivalent to 1 household	£375
200 m^3	Equivalent to 2 households	£700
300 m^3	Equivalent to 3 households	£1,025
400 m^3	Equivalent to 4 households	£1,350
500 m^3	Equivalent to 5 households	£1,725
1,000 m^3	Equivalent to 10 households	£3,395
50,000 m^3	Very high usage - equivalent to 500 households	£169,250
250,000 m^3	Very high usage - equivalent to more than 500 households	£841,200 or more

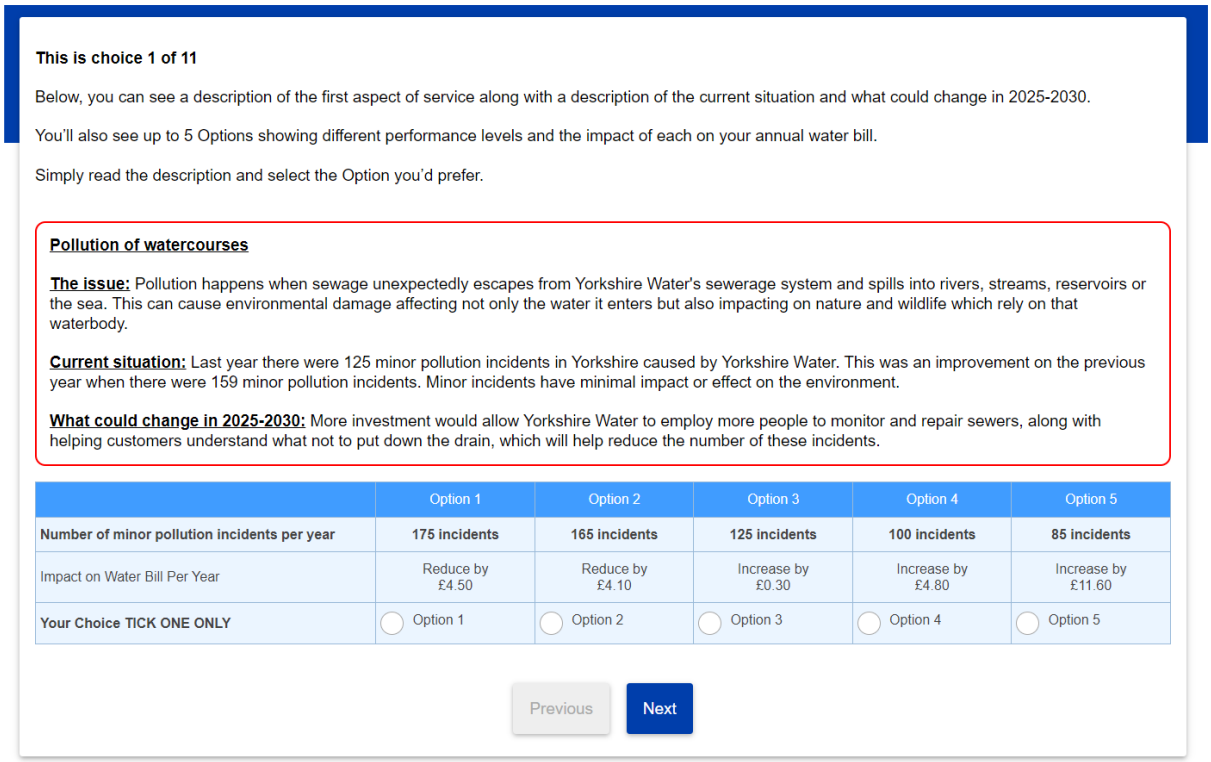
Source: YW

For economic valuation of service changes, we require that respondents state values that they would actually be willing to pay, taking into account their income and other costs. Therefore, we also remind customers that their bills may go up due to inflation, and that other household bills may go up or down, affecting the total amount of money they have to spend.

The survey then moves onto the choice exercises.

First, we ask respondents to consider each attribute in isolation. In all versions of the survey, respondents see a single attribute per screen as shown as in Figure 2.1.

Figure 2.1: We Asked Customers to Choose Their Preferred Service Level for Each Attribute in Turn



This is choice 1 of 11

Below, you can see a description of the first aspect of service along with a description of the current situation and what could change in 2025-2030.

You'll also see up to 5 Options showing different performance levels and the impact of each on your annual water bill.

Simply read the description and select the Option you'd prefer.

Pollution of watercourses

The issue: Pollution happens when sewage unexpectedly escapes from Yorkshire Water's sewerage system and spills into rivers, streams, reservoirs or the sea. This can cause environmental damage affecting not only the water it enters but also impacting on nature and wildlife which rely on that waterbody.

Current situation: Last year there were 125 minor pollution incidents in Yorkshire caused by Yorkshire Water. This was an improvement on the previous year when there were 159 minor pollution incidents. Minor incidents have minimal impact or effect on the environment.

What could change in 2025-2030: More investment would allow Yorkshire Water to employ more people to monitor and repair sewers, along with helping customers understand what not to put down the drain, which will help reduce the number of these incidents.

	Option 1	Option 2	Option 3	Option 4	Option 5
Number of minor pollution incidents per year	**175 incidents**	**165 incidents**	**125 incidents**	**100 incidents**	**85 incidents**
Impact on Water Bill Per Year	Reduce by £4.50	Reduce by £4.10	Increase by £0.30	Increase by £4.80	Increase by £11.60
Your Choice TICK ONE ONLY	Option 1	Option 2	Option 3	Option 4	Option 5

Previous Next

Source: WTP survey for YW

For each attribute, we show respondents the name of the attribute alongside the associated material for the attribute, as per Table 2.2. We give respondents the following information about each attribute:

- **The issue:** a description of the attribute.
- **Current situation:** a description of the current service level for that attribute.
- **What could change:** a summary of how additional investment would impact the service level for that attribute.

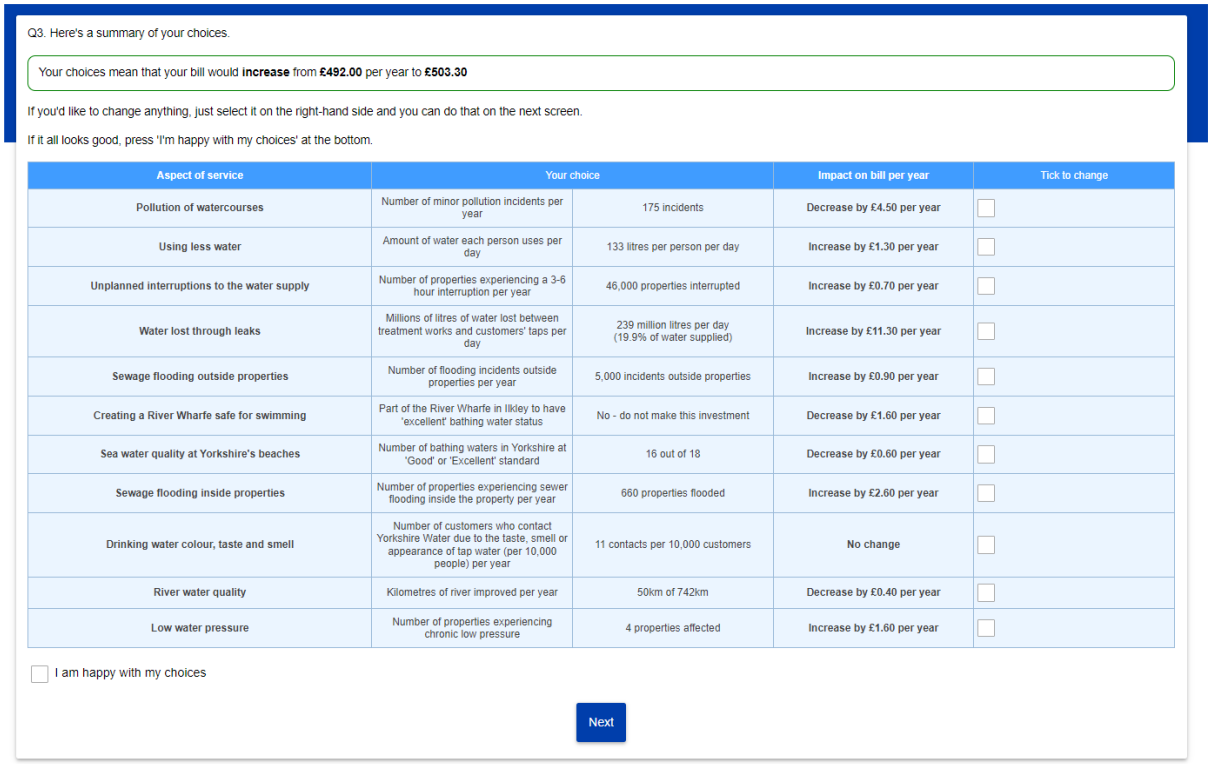
We then present respondents with different options of service levels that YW could provide for that attribute, as per Table 2.3. Option 1 shows a large deterioration in service, Option 2 shows a small deterioration in service, Option 3 is to maintain the current service level (status quo), Option 4 shows a small improvement in service, and Option 5 shows a large improvement in service. For each option, the customer sees a customer-specific bill impact, as we explain below in Section 2.4.2.

We ask customers to select one of the available options for each attribute. Once they make their selection for that attribute, they progress to the next attribute. We randomise the order in which attributes are displayed to different respondents, to mitigate the risk of bias from order effects.

Once customers have made their selection for each attribute, they see a screen summarising their choices for all eleven attributes and the total impact of their choices on their bill for 2025-2030, as shown in Figure 2.2.

Customers are informed that they can revise their choices for any of the attributes by clicking on the attribute in question. This takes them back to the attribute screen as shown in Figure 2.1. After they select an option at that screen, they are returned to the screen shown in Figure 2.2 and see an updated summary of their choices and the total bill impact.

Figure 2.2: Customers Saw a Summary of Their Choices and Had the Option to Revise Their Choices



Q3. Here's a summary of your choices.

Your choices mean that your bill would **increase** from **£492.00** per year to **£503.30**

If you'd like to change anything, just select it on the right-hand side and you can do that on the next screen.

If it all looks good, press 'I'm happy with my choices' at the bottom.

Aspect of service	Your choice		Impact on bill per year	Tick to change
Pollution of watercourses	Number of minor pollution incidents per year	175 incidents	Decrease by £4.50 per year	☐
Using less water	Amount of water each person uses per day	133 litres per person per day	Increase by £1.30 per year	☐
Unplanned interruptions to the water supply	Number of properties experiencing a 3-6 hour interruption per year	46,000 properties interrupted	Increase by £0.70 per year	☐
Water lost through leaks	Millions of litres of water lost between treatment works and customers' taps per day	239 million litres per day (19.9% of water supplied)	Increase by £11.30 per year	☐
Sewage flooding outside properties	Number of flooding incidents outside properties per year	5,000 incidents outside properties	Increase by £0.90 per year	☐
Creating a River Wharfe safe for swimming	Part of the River Wharfe in Ilkley to have 'excellent' bathing water status	No - do not make this investment	Decrease by £1.60 per year	☐
Sea water quality at Yorkshire's beaches	Number of bathing waters in Yorkshire at 'Good' or 'Excellent' standard	16 out of 18	Decrease by £0.60 per year	☐
Sewage flooding inside properties	Number of properties experiencing sewer flooding inside the property per year	660 properties flooded	Increase by £2.60 per year	☐
Drinking water colour, taste and smell	Number of customers who contact Yorkshire Water due to the taste, smell or appearance of tap water (per 10,000 people) per year	11 contacts per 10,000 customers	No change	☐
River water quality	Kilometres of river improved per year	50km of 742km	Decrease by £0.40 per year	☐
Low water pressure	Number of properties experiencing chronic low pressure	4 properties affected	Increase by £1.60 per year	☐

☐ I am happy with my choices

Next

Source: WTP survey for YW

Customers can revise their choices an unlimited number of times, giving them the flexibility to construct the package of service levels that best reflects their preferences, given the cost they see for each service level. Once customers are happy with the package they have constructed, they proceed to the closing questions of the survey.

This final step of allowing customers to alter their attribute-by-attribute choices is important; customers' initial choices may result in them breaching budget constraints, so they can reduce the improvements they selected in any attribute, to reduce the overall costs. Conversely, if customers reach the end of the attribute-specific choices and decide they want to select more or different improvements, they can do so. Customers may also adjust their priorities as they see the full range of service changes on offer in the survey instrument.

2.4.2. Innovation relative to previous stated preference survey formats

The stated preference question format described above is a new format, developed by NERA in response to customer feedback on previous water industry stated preference surveys. The new format reduces the complexity of the questionnaire by only showing one attribute per screen, while giving customers more flexibility by allowing them to construct their preferred package of service levels across attributes.

In previous stated preference studies, customers were presented with detailed information about all attributes at the beginning of the survey. Then, each question presented customers with two pre-defined packages of service levels for all attributes and asked them to choose which package they preferred. This exercise was repeated multiple times, with each customer seeing several different pairs of packages.

Sometimes, these package exercises were combined with "max diff" choices, which ask customers to select their favoured and least-favoured service improvement (or the service failures that would have the most/least effect on them). These max-diff questions were used to value individual attributes within the package.

These package exercises were commonly used at PR19 and previous price reviews. They have been used to estimate customer WTP for service levels in a range of sectors. However, customer feedback highlighted a number of limitations of these exercises:

- Some customers found it difficult to retain all of the information about the different attributes that was presented at the beginning of the survey, and therefore struggled to fully understand the trade-offs in the package exercises.
- Some customers disliked being forced to choose between two pre-defined packages and would have preferred to be able to combine features from both packages.

Our approach in this study addresses both limitations of the package exercises:

- Customers see all of the associated information about the attribute at the same time as they make choices about the attribute, so that they can make an informed decision and are not required to remember large quantities of material.
- Customers have the flexibility to build their own preferred package, given the costs of different service levels.

The stated preference question format that we adopt materially increases the total number of package options available to customers, which creates additional challenges for data management and WTP analysis. We overcome these challenges through an analytical approach that combines modern data management tools with classic econometric techniques. We describe this analytical approach in Section 4.1.4.

2.4.3. Calculation of customer-specific bill impacts

In this section, we explain how we use information provided by customers in the screening section of the questionnaire to set the costs that the customer sees for their choices of service levels. By using information from the screening section to tailor these values to the customer, we ensure that the stated preference exercise is realistic and meaningful for the customer, so that they are more likely to report their true preferences.

In the screening portion of the questionnaire, we ask customers to state the level of their current water bill. We allow respondents to report their bill in a number of different formats based on different billing options (i.e. per week, per month, biannually, and per year), which the survey software then converts into an annual bill.

For customers who do not know their bill, we either present them with an estimated bill (HH) or ask them to choose the closest from a number of options, as described in Section 2.4.1.

We use the estimate of the customer's water bill for 2025-2030 to calculate the customer-specific bill impacts of changes in service levels for each attribute as follows.

1. First, we collect data from YW on the estimated impact of each of the service level changes on the average customer bill. These values are shown in Table 2.6. We also collect the average customer bill, which is £419.

Table 2.6: Impact of Service Level Changes on the Average Customer's Bill

Attribute		£ Impact (-2)	£ Impact (-1)	£ Impact (0)	£ Impact (+1)	£ Impact (+2)
A	Drinking Water Colour, Taste and Smell	-2	-0.5	0	1	3.1
B	Unplanned Interruptions to the Water Supply	-2.6	-0.9	0	0.9	2.4
C	Water Lost Through Leaks	-4.5	-0.5	0	1.3	6.9
D	Using Less Water	-	-1.5	0	9.6	31.2
E	Sewage flooding inside properties	-31.7	-6	0	3.9	16.1
F	Sewage flooding outside properties	-7.7	-2.1	0	0.8	4.9
G	River Water Quality	-16.8	-5.6	0	4.4	26.7
H	Sea Water Quality at Yorkshire's Beaches	-3.2	-1.1	0	4	-
I	Pollution of watercourses	-3.8	-1.7	0	2.2	5.3
J	Low Water Pressure	-0.2	-0.1	0	0.2	0.6
K	Creating a River Wharfe safe for swimming	-	-	0	9.7	-

Source: YW

2. Second, for each customer we draw a random integer value for each attribute between -£3 and £4. We "shift" the status quo bill impact in Table 2.6 by that amount. We do this for two reasons:

   A. It allows us to ensure that our results are robust to the concern that customers' preferences may be sensitive to budget constraints. The customer's bill may go up or down due to other factors not covered in this survey (e.g. the allowed cost of capital set by Ofwat). We need to be confident our analysis reflects what customers' preferences would be even if other parts of the bill were to increase (or decrease). To do this, we need to introduce a random total bill increase/decrease and test the sensitivity of the results to that. The specific range for the random bill increase of *minus* £1 to £2 generates a total change to the average bill that is typically between a

5 per cent reduction and a 7 per cent increase, which is in line with what we have used to test sensitivity to budget constraints for previous WTP studies.[5]

B. It reduces the risk of customers defaulting to the status quo by making the status quo less obvious (i.e. it has a non-zero price and is not flagged as having "No Change" in the bill), which encourages customers to engage with the survey more thoughtfully. To ensure that the scenario remains credible to respondents, we include the following text at the beginning of the survey to explain why the status quo has a non-zero price:

> *"In addition to the effects of inflation, other factors may influence the cost of providing water and wastewater services like:*
>
> *Reductions in costs due to technological improvements; or*
>
> *Increases in costs for other reasons such as the cost of energy.*
>
> *This survey accounts for some, but not all, such factors. This is why, for some aspects of service, you may see that all of the options available lead to a reduction in your bill or an increase in your bill."*

3. Based on this data, we calculate the average percentage change to the current bill associated with the change in service level. We assume that the costs of service level changes are spread across customers in proportion to the bill that they pay.

4. For each customer, for each attribute and each of the service levels we generate a random draw from the uniform distribution on the range (0, 1). This randomisation is essential to ensure different customers see different prices associated with changes in service, which is important for enabling us to apply the statistical methods used to estimate customers' WTP for changes in service.

5. We combine the percentage bill increases from step 3 with the random numbers from step 4 to get customer-specific bill impacts for each service level and attribute as follows:

   A. We set the "status quo" bill impact to the bill impact for the status quo from step 3 × the random draw from step 4.

   B. We set the "small improvement" ("small deterioration") to be a random increase (decrease), distributed around the expected proportional increase (decrease) from step 3, but "stretched" such that increases (decreases) of greater magnitude are possible. We achieve this by scaling the random draw by 2.5 × the customer's existing bill × the relevant percentage change from step 3 and adding it to the bill impact for the status quo from step 5A.

   C. We set the "large improvement" ("large deterioration") to be a random increase (decrease), distributed around the likely proportional increase (decrease) provided by YW in step 3 but stretched such that increases (decreases) of greater magnitude were

[5] We tested whether our results were sensitive to this randomly assigned bill shift. Specifically, we tested whether a higher randomly assigned total bill shift resulted in lower WTP, as this would suggest that customers' willingness to pay for improvement in water services is affected by their budget constraints. We find that customers with a higher randomly assigned total bill shift have significantly different preferences for two attributes only: attribute A (drinking water colour, taste, and smell) and attribute B (unplanned interruptions to the water supply). For these attributes, customers with higher values of the randomly assigned total bill shift have lower (more negative) WTP.

possible. We achieve this by scaling the random draw by 2.5 × the customer's existing bill × the relevant percentage change from step 3 and adding it to the bill impact for the small improvement calculated in step 5B.

The scaling factor 2.5 in step 4 is judgement-based. Since we are multiplying by a random draw between 0 and 1 to get a distribution of possible cost values, we need to scale by at least a factor of 2. Scaling by a factor of 2 would give us a distribution centered on the original cost value.

Scaling by 2.5, rather than 2, ensures that we examine WTP at values for the cost (saving) of a change to the service level beyond the estimate provided by YW. This is useful in the event that the true cost (saving) of a change to the service level exceeds the estimate provided by YW and allows us to capture information on individual customers having relatively high willingness to pay for improvement in particular attributes.

2.5. Survey Closing Questions

In the final section of the survey, we ask a number of closing questions on demographics and the customer's experience of the stated preference exercise. The answers to these questions allow us to contextualise our findings and examine whether our conclusions are consistent across different sub-groups of the YW customer base.

In both the HH and NHH surveys,[6] we include a set of questions to assess whether respondents found the survey easy or difficult to complete. This is useful to assess the reliability of our conclusions; if most customers found the survey easy to complete, we can have more confidence in our conclusions than we might otherwise do.

Among the final questions, we ask HH customers and FBP their ethnic group and questions about the household members to identify, for instance, whether there are children in the household. We also ask if they receive specific benefits, such as housing benefits or disability living allowance, and if they practice leisure activities related to water, such as fishing.

We ask NHH customers about the turnover of their organisation in recent years, and how their organisations pay their water bills, among other questions.

In order to assess customers' motivations for their choices in the stated preference exercise, in both HH and NHH surveys we include a question on the factors that the respondent considered when making their choices. We also include a question on whether the respondent has recently contacted YW, to see if this affects responses to the WTP for improved customer service.

In the HH survey only, we include additional questions to elicit customers' attitudes towards YW and towards paying for water services in general. Protest attitudes include objection to being asked to pay for certain attributes, objection to the idea that attributes can be valued in monetary terms, and mistrust of the water company. There is evidence from the literature on

[6] HH survey was used for HH customers and FBP.

stated preference studies that protest attitudes may affect estimates of WTP.[7] Therefore, it is useful for us to have the ability to assess whether our WTP estimates vary depending on whether customers exhibit protest attitudes.

2.6. Pilot Testing of Survey Instrument

We conducted a pilot to determine how the survey would work in practice when accessed by customers. The pilot provided an opportunity to test the survey among HH customers under 'real world' conditions.

The pilot was undertaken using the same methodology to be implemented for the main stage, namely using quota sampling via an access panel. To complete the pilot, we agreed a target sample of 200 HH customers and used quotas to ensure this sample was broadly representative of the YW customer base. The target of 200 survey completions was achieved.

We used the results of the pilot to:

- Confirm that the average length of time taken to complete the survey was reasonable, in that the survey did not impose an undue burden on respondents.
- Confirm that customers were not finding the survey difficult to understand or complete, by assessing responses to questions that asked customers about the ease/difficulty of the survey and by assessing customer comments in the free-text response questions of the survey.
- Conduct preliminary analysis on customers' choices, including a preliminary WTP analysis, to ensure that the survey was not producing implausible results that might suggest problems with the survey design.

Following the pilot, we made only one change, to one of the supplementary questions at the end of the survey. This question asks customers about their motivations for their choices. We decided to add the option "Other" with a free-text response box, to allow for customers whose motivations are not adequately described by the predetermined responses. We also removed the option "You were happy to leave decisions about the aspect of service to Yorkshire Water" as the free-text responses suggested that some customers had interpreted this option to mean that Yorkshire Water would also pay for any changes in the service level.

Otherwise, the survey remained unchanged as a result of the pilot.

2.7. Incorporating Guidance on Best Practice

Throughout the project, we have worked to incorporate guidance on best practice from both Ofwat and the CCW.

We explain how we have accounted for Ofwat's standards for customer engagement in Section 2.7.1 and describe how we incorporated guidance on best practice from the CCW in Section 2.7.2.

[7] See for example Meyerhoff and Liebe (2009), *Status quo effect in choice experiments: empirical evidence on attitudes and choice task complexity, Land Economics 85*, pp. 515-528

2.7.1. Addressing Ofwat's customer engagement policy

In advance of PR24, Ofwat has defined a set of standards for high-quality research, customer challenge, and assurance of customer engagement during price reviews.[8] Ofwat states that water company research and engagement should provide evidence of a meaningful, significant understanding of customers' and wider stakeholders' preferences. In particular, water company research should be:

- **Useful and contextualised**: The objectives of the research and the potential implications of the findings (i.e. how they will be used) should be clear from the final output.[9]
  - We clearly state the objective of the research at the beginning of this report (Section 1); that is, to *"estimate customers' willingness to pay (WTP) for improvements in the service provided by YW"*. Later in the report (Section 2), we explain that the results of this study will be used to *"draw conclusions about the preferences of the typical YW customer regarding these trade-offs [between service attributes and costs], which YW can in turn use to plan investment in its service offerings in a way that responds to customer preferences"*. We set out our conclusions and final recommendations in Section 5.
- **Neutrally designed**: The research should be designed to be neutral and free from bias. Sources of bias should be considered at every stage of the research. If some type of bias in unavoidable, this should be noted and explained in the research findings.[10]
  - At every stage of the research process, we took steps to mitigate sources of bias.
    - ***Survey development:*** We used qualitative engagement to assess the accessibility of the survey design to customers (see Section 2.6). We made changes to the survey based on customer feedback from to mitigate the potential for bias arising from customer differences in understanding of attribute or service level descriptions.
    - ***Survey design:*** We randomise the order in which attributes are displayed to different respondents to ensure that the results are not biased by order effects.
    - ***Survey design:*** We anchor customers' expectations about future bill increases, thus preventing any systematic bias in valuations caused by customers' preconceptions about future bill levels, by introducing random variation to the cost of the status quo option for all attributes.
  - Where we were unable to mitigate sources of bias, we note and explain the potential impact of that bias on our results in Section 4.
- **Fit for purpose**: Both the sample and the methodology should be appropriate for the research setting. Ofwat welcomes innovation as long as "it is likely to lead to meaningful

[8] Ofwat (February 2022), PR24 and beyond: Customer engagement policy – a position paper, p. 4

[9] Ofwat (February 2022), PR24 and beyond: Customer engagement policy – a position paper, p. 6

[10] Ofwat (February 2022), PR24 and beyond: Customer engagement policy – a position paper, p. 6

and trusted insight and learning".[11] Further, respondents should be able to understand the questions they are asked.

  - We adopt an innovative format for the survey (i.e. our stated preference exercise allows respondents to build their own preferred package) because it addresses concerns raised by respondents about previous survey formats (see Section 2.4.2).
  - Moreover, asking about one attribute at a time allows us to display a brief description of the attribute next to the question, hence helping respondents understand what they are being asked. Descriptive analysis of the survey data shows that respondents generally report that they have understood the survey well (see Sections 3.2.3.1, 3.3.3.1, and 3.4.3.1 for HH, FBP, and NHH customers respectively).
  - For estimation of WTP from the survey data, we use an approach that is standard in both academic and industry literature, i.e. using "conditional logit" models to estimate utility functions.

- **Inclusive**: The sample should be representative of the full spectrum of the company's customers. Results should consider and report differences in preferences by socio-demographics and consumer types.[12]
  - As mentioned above, we designed the sampling approach to provide a robust and representative sample of all YW customers.
  - We provide summary statistics on the representativeness of the household, future bill payer, and non-household samples in Sections 3.2, 3.3, and 3.4, respectively.
  - We estimate and report the impact of socio-demographic characteristics and customer type (i.e. billing characteristics) on WTP.
- **Continual**: Companies should carry out research on a continual basis, enabling both day-to-day and longer-term research.[13]
  - Immediately before this WTP study, YW carried out a separate, comprehensive study to understand customers' priorities for the service they receive from the company. The purpose of this was to ensure a full understanding of customer preferences and requirements as well as their expectations of YW and to provide evidence to underpin other research YW will undertake for PR24.
  - We are conducting a benefits transfer study to accompany this stated preference study, which will incorporate results from customer preference research conducted by YW at PR14 and PR19. We will triangulate the stated preference results from this study with the results of the benefits transfer study to ensure continuity in YW's customer preference research.

[11] Ofwat (February 2022), PR24 and beyond: Customer engagement policy – a position paper, p. 6

[12] Ofwat (February 2022), PR24 and beyond: Customer engagement policy – a position paper, p. 6

[13] Ofwat (February 2022), PR24 and beyond: Customer engagement policy – a position paper, p. 7

  - This research will itself feed into the next phase of YW's research to inform its business plan development.

- **Independently assured**: Research should be reviewed by entities that are independent of water companies and have the relevant skills and know-how to evaluate the research findings.[14] We assume YW will commission advisors to provide assurance on its business planning and/or customer engagement programmes.

- **Shared in full with others**: Research findings should be made available in full, as early as possible, and include detailed discussions around the methodology employed (including, e.g., questionnaires and discussion guides).[15] Publishing research will allow methodologies to be improved on, build a common knowledge base about customers' views, and allow similar research to be compared.

- **Ethical**: Research should adhere to "the ethical standards of a widely recognised research body".[16]

  - Qa Research adhered to the Market Research Society (MRS) Code of Conduct in administering the survey.

2.7.2. Addressing the CCW critique of the PR19 approach

Following PR19, the CCW commissioned Blue Marble to conduct a study on water companies' customer engagement research. The study examines how customers feel about the research processes in which they are asked to participate, in particular, whether customers feel that the research processes enable them to make meaningful contributions.

CCW and Blue Marble identify five themes on which customer engagement research could improve to ensure that customers feel that their contribution is meaningful.

[14] Ofwat (February 2022), PR24 and beyond: Customer engagement policy – a position paper, p. 7

[15] Ofwat (February 2022), PR24 and beyond: Customer engagement policy – a position paper, p. 7

[16] Ofwat (February 2022), PR24 and beyond: Customer engagement policy – a position paper, p. 7

Figure 2.3: CCW/Blue Marble Identify Five Themes that Customers Require for Meaningful Research

Criteria		Threshold questions
	**Ease**	• Am I able to answer the questions that I am being asked? • Is what I'm being asked to do straightforward and reasonable?
	**Relevance**	• Is the topic relevant / of interest to me? • Do I actually have a view on what I am being asked?
	**Listening**	• Do I feel like the organisation that has commissioned the research is paying attention to what I say?
	**Making a difference**	• Do I think anything will happen as a result of taking part? • Will taking part benefit others / the wider community?
	**Financial incentive**	• Do I receive a financial incentive for taking part? Or the prospect of a prize?

Source: CCW and Blue Marble[17]

- **Ease:** CCW and Blue Marble were concerned that traditional WTP studies are not easy for customers to complete. They are particularly concerned about the cognitive burden of remembering all the attribute descriptions (traditionally provided at the beginning of the survey) and that asking customers to make multiple choices between paired bundles is confusing.[18]

  – The innovative format of our WTP study, described in Section 2.4.2, addresses both points of concern to CCW. Customers do not have to remember attribute descriptions, because we ask customers about one attribute at a time and so can show the description alongside the choice exercise. There is no risk of confusion from being asked to make multiple choices between paired bundles, as each customer is asked to build their preferred bundle only once.

- **Relevance:** Customers only want to be consulted on a subset of the decisions made by water utilities. The CCW/Blue Marble study finds that customers do want to be consulted on near-future investment scenarios (5-15 years) and prefer consultations that are framed in terms of the impact on the customer's own bill and services.[19] Customers also feel that "it is more valid to ask for consumers' views on specific business planning topics once they are briefed and feel able to give a considered answer".[20]

  – Our WTP exercise falls within the set of topics that CCW and Blue Marble identify as relevant to customers, because it focuses on how near-future investment might impact customers' own bills and service experiences, as well as environmental attributes about which it is reasonable to think customers might have opinions. To ensure that

[17] CCW and Blue Marble Research (April 2020), Engaging water customers for better consumer and business outcomes, p. 4

[18] CCW and Blue Marble Research (April 2020), Engaging water customers for better consumer and business outcomes, p. 37

[19] CCW and Blue Marble Research (April 2020), Engaging water customers for better consumer and business outcomes, p. 21

[20] CCW and Blue Marble Research (April 2020), Engaging water customers for better consumer and business outcomes, p. 8

customers are able to give considered answers, we provide contextual information about each attribute; we tailored this contextual information to customer needs through focus group interviews and cognitive testing.

- **Listening:** Customers view research as more meaningful when it is clear that someone is actually listening. CCW and Blue Marble suggest that this can be achieved in quantitative research through a well-introduced survey and expressions of gratitude.[21]
- **Making a difference:** CCW and Blue Marble find that customers are more likely to feel that their contribution is meaningful if they believe that their participation in research will have a real impact.
  - Qa and Yorkshire Water worked in collaboration to design an introduction to the survey that succinctly explains its purpose and why customers' views were important, to address the suggestions from CCW and Blue Marble that customers want to see that someone is listening to their opinions and that their opinions will make a difference.
- **Financial incentive:** Offering a financial incentive makes it more likely that customers will make time to participate in the survey.
  - Respondents who participated in the qualitative research received a cash payment in recognition of their contribution and time.
  - For the main survey, HH respondents, FPBs, and NHH respondents were all surveyed via access panels and as a result received an incentive for completing the survey from the panel company. No incentive was paid for those completing the face-to-face survey of digitally disengaged/vulnerable customers.

In addition to the five themes outlined above, CCW and Blue Marble identify a number of other factors that should be taken into consideration as part of customer engagement research.

- CCW and Blue Marble highlight the importance of adopting "an iterative process to questionnaire development" and ensuring that feedback from cognitive testing and pilots is incorporated in the survey design.[22] We provide further details on how we adapted our survey based on feedback from focus groups and the pilot study in Section 2.6.
- CCW and Blue Marble find that a number of customers are happy to leave decisions about water services to experts working within the water company and regulator.[23]

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[21] CCW and Blue Marble Research (April 2020), Engaging water customers for better consumer and business outcomes, p. 19

[22] CCW and Blue Marble Research (April 2020), Engaging water customers for better consumer and business outcomes, p. 24

[23] This "leave it to the experts" type is one of four customer types that CCW and Blue Marble identify. Most customers were either of this type or of a second "I want to be involved, but I'm struggling" type, who want to give feedback but struggle with cognitively demanding research formats. The other two minority types were "I don't care" and "Give me everything you've got" (very disengaged and very engaged, respectively). See CCW and Blue Marble Research (April 2020), Engaging water customers for better consumer and business outcomes, p. 5

3. Survey Implementation

In this section, we explain the implementation of the survey, describe the data collected through the survey, and consider whether there is evidence that the data collected through the survey can be used to generate reliable estimates of YW customers' WTP.

- Section 3.1 provides an overview of the fieldwork methods adopted to collected the data, as well as information on how survey respondents were sampled to be represenatitve of the YW customer base.
- Sections 3.2 to 3.4 summarise the data collected from each of the HH, FBP, and NHH surveys respectively. In each case we consider whether the customer characteristics in the sample are reflective of the YW customer base; the extent to which customers express concern about the uncertain financial future; and evidence on customer understanding of and meaningful engagement with the survey.
- Section 3.5 concludes, reflecting on how the information in the preceding sections gives us confidence that the results of our WTP analysis are reflective of YW customers' WTP.

3.1. Fieldwork and Sampling Approach

3.1.1. Household survey

For HH customers, we designed the sampling approach to provide a robust and representative sample of YW customers while at the same time balancing the practicalities of implementing a complex survey within the available budget and timeframe. We used a variety of different survey formats to collect responses from HH customers, which we describe in turn below.

3.1.1.1. Main survey

The survey amongst HH bill payers was carried out online via a commercial access panel provider, Dynata. Qa designed the survey (in conjunction with NERA and YW) and then programmed this into an online survey using the Askia software package. Qa hosted the survey and provided a survey link to the panel provider, who was responsible for sampling panelists. To ensure that the final achieved sample was broadly representative of the YW HH customer base, Qa and YW set minimum quota targets based on age, gender, YW Region, and SEG. The panel provider was responsible for ensuring these quotas were met.

We achieved 1,282 main stage survey completions. The average time taken to complete the survey was 23 minutes. It is not possible to determine a response rate for the survey because it was carried out via an access panel.

3.1.1.2. Pilot survey

Since the pilot survey was almost identical to the main stage survey, with the exception of the minor adjustment to Question 9 described in Section 2.6, we used the 200 responses to the pilot along with the responses to the main stage in our final analysis.

3.1.1.3. Vulnerable customer survey

The purpose of the vulnerable customer survey was to supplement the HH Main survey with a sample of HH customers who were digitally disengaged and/or experiencing health or

financial vulnerabilities. Specifically, respondents had to fall into at least one of the following 3 vulnerable groups;

- **Digitally Disengaged**: those who report that they 'Never' OR 'Rarely (few times in the year)' use the internet.
- **Financial Vulnerability**: those who report that they struggle to pay their bills either 'most of the time' or 'all of the time'.
- **Health Vulnerability**: those who report that they have someone in their household who is disabled or suffers from a severe health condition.

Qa and YW set minimum quotas on each of these groups. All respondents were free-found and interviewed face-to-face, with interviewing shifts carried out in a range of locations throughout the YW operating area. The average time taken to complete the survey was 24 minutes.

3.1.2. Future bill payers survey

As with the main survey amongst HH bill payers, the FBP survey was carried out online via commercial access panel providers, Dynata and Norstat. The survey design was similar to that of the HH survey. Qa hosted the survey and provided a survey link to the panel provider, which was responsible for sampling panelists. We did not set quotas on recruitment; any respondent was eligible to complete the survey if they met the criteria for inclusion in the FBP sample, i.e. that they:

- Have no responsibility for paying the water bill;
- Are aged under 34;
- Mainly live in Yorkshire; and
- Are living at home with parents / somewhere else in Yorkshire, including student accommodation.

The final sample consists of responses from 113 FBP customers.

3.1.3. Non-household survey

As with the main survey amongst HH bill payers, the NHH survey was carried out online via a commercial access panel provider, Norstat. Again, Qa designed the survey (in conjunction with NERA and YW) and programmed it into an online survey using Askia. Qa hosted the survey and provided a survey link to the panel provider, which was responsible for sampling panelists. Due to the scarcity of suitable contacts, we did not set quotas on recruitment and any respondent was eligible to complete the survey provided the organisation had premises in the YW operating area and the respondent personally had some responsibility for paying their organisation's water bill.

We achieved a total sample of 193 survey completions. The average time taken to complete the survey was 25 minutes. It is not possible to determine a response rate for the survey because it was carried out via an access panel.

3.2. Summary of Data Collected from Household Customers

We have 1,666 completed surveys from HH customers. Of these, 1,282 are from the main survey conducted via an online panel, 200 are from the pilot survey, and 184 are from the face-to-face survey of digitally excluded and vulnerable customers. All respondents were 18 or over and lived in the YW operating area.

We omit 46 completed HH surveys from our analysis because they report an implausibly high annual water bill (i.e., exceeding £ 1,000 per year). Therefore, we perform the main stage analysis on a sample of 1,620 responses.

The following subsection describes the characteristics of the HH customers and how the sample of YW's customer base of HH bill payers is representative. Section 3.2.2 describes the financial uncertainty of these customers and how it can affect the WTP estimations. Finally, Section 3.2.3 represents the respondents' experience with the survey.

3.2.1. Household bill payers' characteristics

To ensure the online sample was representative of YW's customer base, Qa and YW agreed minimum gender, age, social grade and YW region quotas. The panel provider used the initial screening questions in the survey to ensure that the sample collected met the quotas. The sample is broadly representative of YW's customer base of HH bill payers in terms of gender, age, socio-economic group, region, and meterage, as shown in Table 3.1. Women, individuals aged over 55, and ABC1 social grade are slightly over-represented. We analyse how WTP differs by demographic characteristics and socioeconomic status and summarise our findings in Section 4.2.2.

Table 3.1: The Achieved Sample is Representative of YW HH Bill Payers

	All HH Bill Payers	Achieved Sample	
Gender	**%**	**n**	**%**
Male	49%	748	45%
Female	51%	911	55%
Other	-	4	<1%
Prefer not to say	-	3	<1%
Age	**%**	**n**	**%**
18-34	18%	269	16%
35-44	17%	243	15%
45-54	20%	278	17%
55-64	17%	324	19%
65+	28%	550	33%
Prefer not to say	-	2	<1%
Socio-Economic Group	**%**	**n**	**%**
ABC1	48%	880	53%
C2DE	52%	758	45%
Prefer not to say		28	2%
Region[24]	**%**	**n**	**%**
North	16%	274	16%
West	45%	742	44%
South	27%	431	26%
East	12%	214	13%
Not known	-	5	<1%
Meterage	**%**	**n**	**%**
Metered	57%	953	57%
Unmetered	43%	641	38%
Don't know	-	72	4%

Source: Qa.

3.2.2. Financial uncertainty

There is evidence that a significant minority of household respondents are concerned about their ability to pay bills, which is to be expected in the context of the recent increases in the cost of living. Households that are already struggling with paying their bills may be less willing to pay for improvements.

When asked, more than half of the respondents said they never or rarely struggle to pay their bills. However, 18 per cent struggle "most" or "all the time" (see Figure 3.1). In addition, 27 per cent "agree" or "strongly agree" with the statement "I worry about not being able to afford

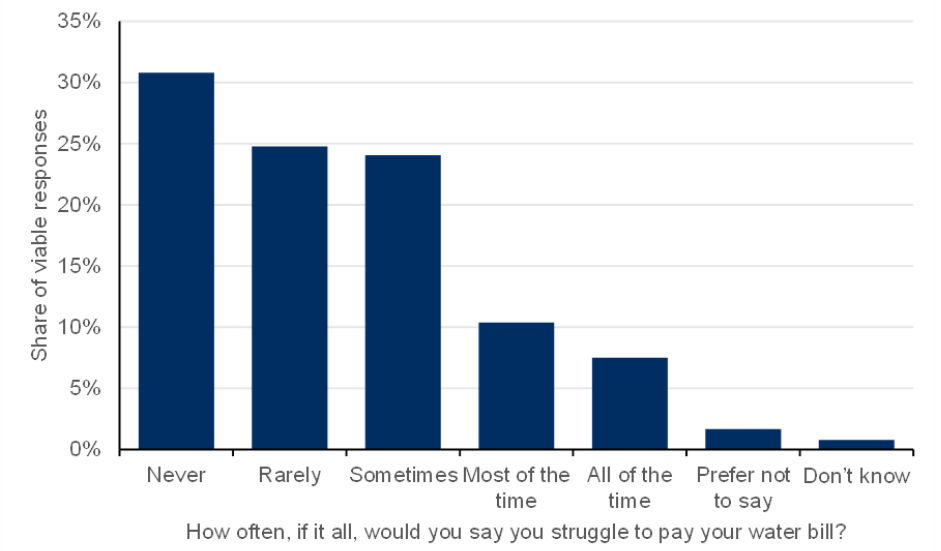
[24] North includes North Yorkshire and York; West includes Bradford, Calderdale, Kirklees, Leeds and Wakefield; South includes Barnsley, Sheffield, Chesterfield DC, Rotherham and Doncaster; and East includes East Yorkshire and Kingston upon Hull.

my water bill", and 17 per cent affirm that they already can't afford their water bill (see Figure 3.2).

There is also evidence that most HH customers are pessimistic about their future financial situation. 64 per cent of respondents expect that their household's financial situation will worsen over the next twelve months, and only 11 per cent expect it will get better.[25] This concern about their future financial situation may reduce respondents' willingness to select costly improvements in the service.

The proportion of respondents expressing concern about their financial situation in this survey is higher than in similar surveys we have conducted in the past. This may lead to lower estimates of HH WTP than observed in previous studies.

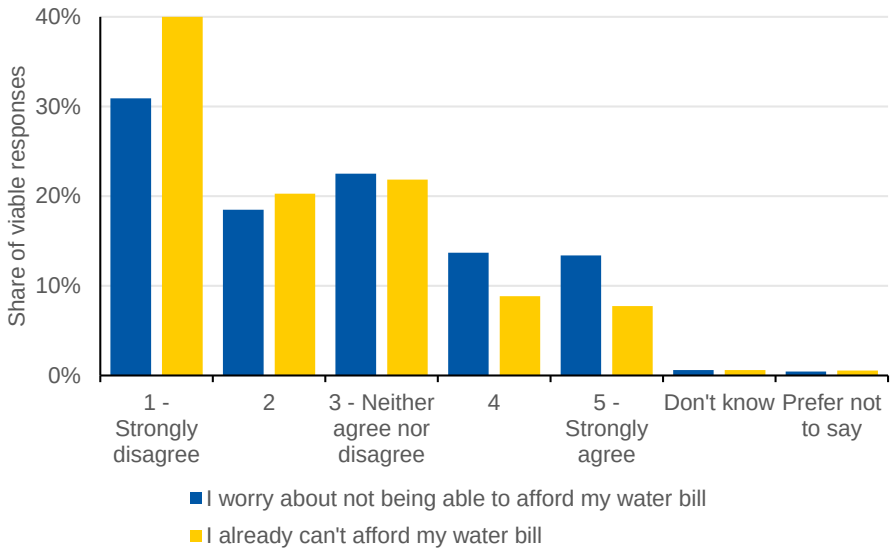
Figure 3.1: 1-in-5 HH Customers Struggle Most or All the Time to Pay Their Bills



Source: NERA analysis of WTP survey data.

[25] The question was, "How do you expect the financial situation in your household to change over the next 12 months?" There were five options; option 1 was "it will get a lot better", and option 5 was "it will get a lot worse". In particular, we consider that respondents who selected 4 or 5 expect that their household's financial situation will worsen over the next twelve months; and those who chose 1 or 2 expect it will get better.

Figure 3.2: More Than a Quarter of HH Customers are Worried About Being Able to Afford Their Water Bill



Source: NERA analysis of WTP survey data.

3.2.3. Experience of completing survey

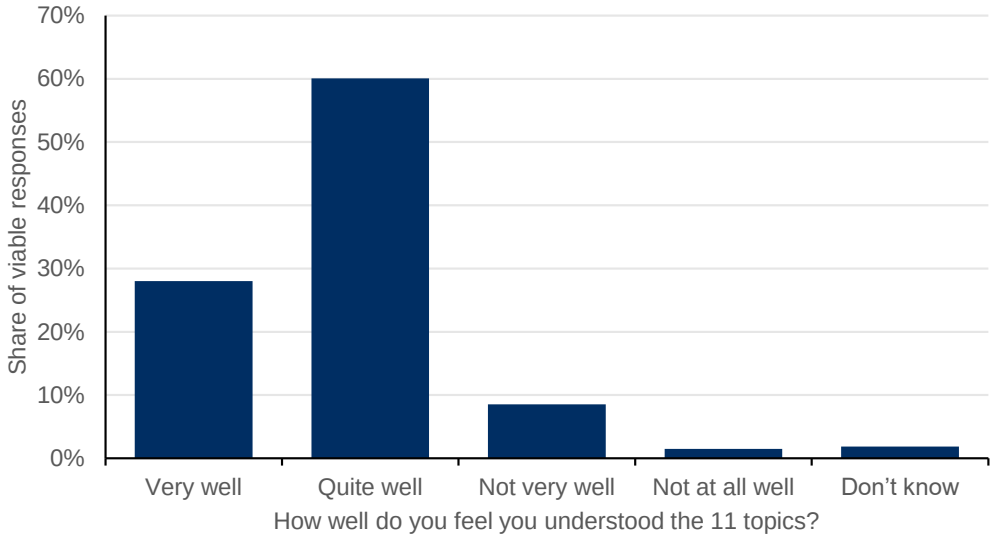
The survey includes data that allows us to evaluate whether respondents found the survey easy or challenging to complete, examine how respondents are making decisions, and understand the extent to which respondents change their decisions on individual attributes when considering their service package as a whole.

3.2.3.1. Ease of understanding topics and options

Respondents were asked to indicate how well they understood the 11 topics and how easy they found it to work out the differences between options. 90 per cent of respondents understood the 11 topics "very well" or "quite well", which suggests the descriptions of the attributes were clear (see Figure 3.3).

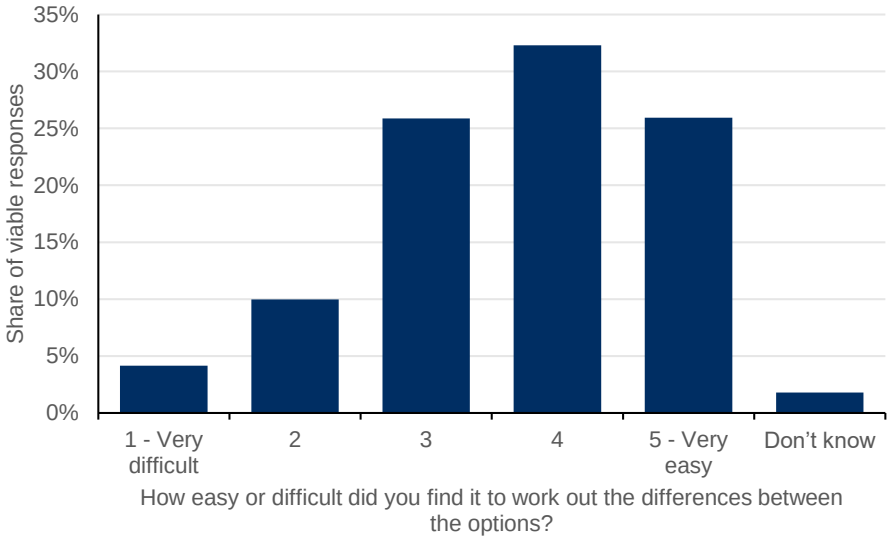
Respondents had slightly more difficulty working out the differences between options. On a scale of 1 to 5, with “1” being "very difficult" and “5” being "very easy", 14 per cent of respondents answered 1 or 2, suggesting they found it difficult to work out the differences between the options (see Figure 3.4). A further 59 per cent answered either 4 or 5, suggesting they did not find it difficult to work out the differences between options. This result is typical across surveys of this kind, and we consider that the options were reasonably understandable for customers.

Figure 3.3: Ninety Per Cent of HH Customers Understood the Attributes Well



Source: NERA analysis of WTP survey data.

Figure 3.4: Most HH Customers Found it Easy to Understand the Differences Between Service Level Options



Source: NERA analysis of WTP survey data.

3.2.3.2. Protest attitudes

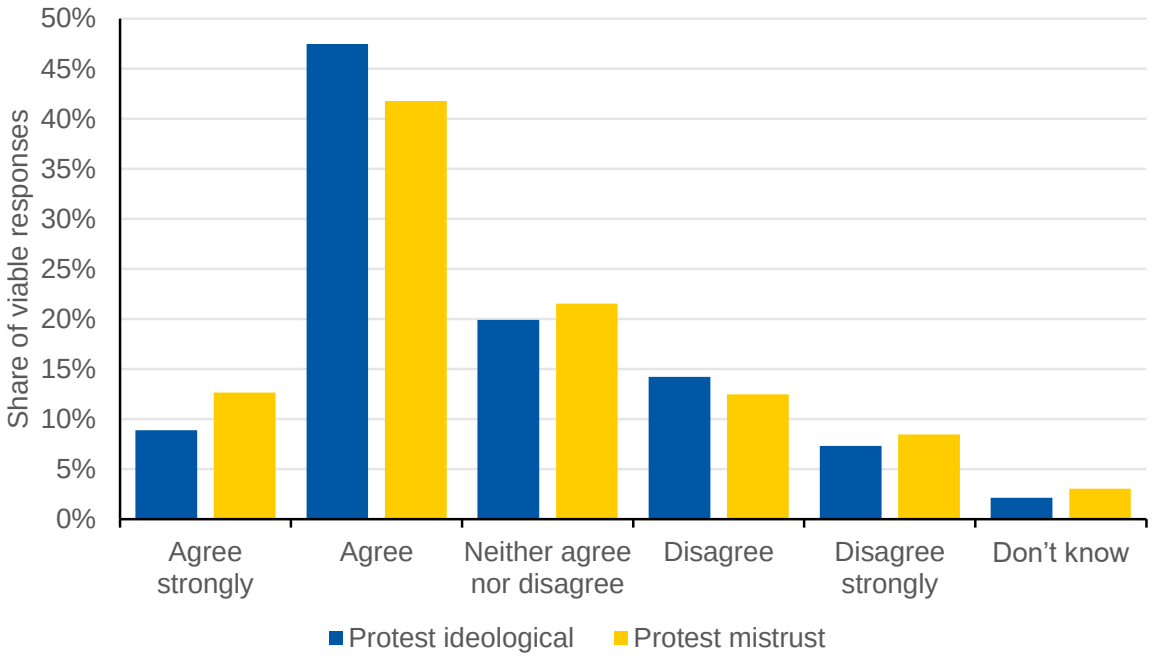
In the survey, we asked respondents two questions to elicit whether they held "protest" attitudes towards paying for water services, as there is evidence from academic literature that

protest attitudes can influence behaviour in WTP studies.[26] We examined two protest attitudes, as set out below:

- **Protest ideological:** we consider that a respondent has an ideological protest attitude when they "disagree" or "disagree strongly" with the statement *"If Yorkshire water invests more to provide a better performance for these 11 aspects of service then bills will need to increase"*. In our data, 22 per cent of respondents exhibit an ideological protest attitude.
- **Protest mistrust:** we consider that a respondent has a mistrust protest attitude when "disagree" or "disagree strongly" with the statement *"If your water bill increases in order to fund service improvements, then you would trust Yorkshire Water to invest more and deliver the service improvements"*. In our data, 21 per cent of respondents have a mistrust protest attitude.

Among HH customers, 30 percent present at least one of these types of protest attitude.

Figure 3.5: Thirty Per Cent of HH Customers Exhibit Protest Attitudes



Source: NERA analysis of WTP survey data.

During the WTP analysis, we examined how the results changed when excluding the respondents with protest attitudes (see Appendix A.1).

[26] The exemplar study of protest attitudes and status quo preferences was investigating WTP for forest diversification in Germany. It asked respondents to indicate the extent to which they agreed with four different statements on a five-point scale. The statements were as follows (1) I already pay enough for other things (2) Lower Saxony should cut public spending for other things instead of expecting a voluntary contribution from me (3) It is my right to have a high level of biodiversity in forests and not something I should have to pay extra for (4) I refuse to assess nature in monetary terms. See Meyerhoff and Liebe (2009), *Status quo effect in choice experiments: empirical evidence on attitudes and choice task complexity, Land Economics 85*, pp. 515-528.

3.2.3.3. Respondents changing decisions

After respondents had answered all survey questions, they had the option to review the total impact of their combined decisions on their bill and make changes, as explained in Section 2.4.1. 17 per cent of the sample opted to change at least one choice, suggesting that respondents are mostly happy with their initial decisions and are unlikely to change them, but that a significant minority reconsidered their choices after going through all attribute-by-attribute choice exercises.

We analysed the characteristics of respondents that changed at least one choice and found that they do not differ substantially from the characteristics of the whole sample. We observe slight differences in terms of age and financial security:

- Young people make up a higher proportion of the sample that change at least one option than the full sample: respondents aged 18-34 make up 25 per cent of respondents that change options but just 16 per cent of the whole sample. Young people may be less familiar with the topics they were asked, so they learn more in the course of the survey and are therefore more likely to change their answers after reviewing all the options and their impact on their bill.
- People who struggle to pay their bills are slightly more likely to change at least one option: respondents who report that they struggle to pay their bills "all the time" make up 11 per cent of those who changed at least one option but only 8 per cent of the whole sample.[27] This may be because people that struggle to pay their bills are more sensitive to the impact of their combined decisions on their bill. Consistent with this explanation, we also identified that the socioeconomic-group C2DE are more likely to change at least one option than the socio-economic group ABC1.[28]

3.3. Summary of Data Collected from Future Bill Payers Customers

The final sample consists of responses from 113 FBP customers, collected via an online panel. We set out the characteristics of the FBP sample in the remainder of this section.

3.3.1. Future bill payers' characteristics

We did not set quotas for the FBP sample, due to the anticipated difficulty in finding suitable respondents and expected low response rate.

We find that women are over-represented in the FBP sample, as shown in Table 3.2. Because of the small sample size, we are not able to run the model using sub-samples for FBP.

Regarding the socio-economic groups and the regions representation, the FBP sample is similar to the HH customers' sample discussed in Section 3.2.1.[29]

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[27] In the same way, people that "never" struggle to pay their bills are 24 per cent of the sample who changed at least one option and 31 per cent of the whole sample.

[28] The socio-economic group C2DE are 48 per cent of thosewho changed at least one option, but 45 per cent of the whole sample.

[29] In the HH customers sample, 53 per cent of the respondents identify themselves as ABC1, and 45 per cent as C2DE. Regarding the regions, 16 per cent were from the North, 44 per cent from the West, 26 per cent from the South and 13 per cent from the East.

Finally, we identify that 34 per cent do not know if their home has a water meter. Among HH customers, just 4 per cent of the sample did not know whether their home has a water meter (see Section 3.2.1). It is not surprising that FBP customers would be less knowledgeable about the metering status of their home, given that they are not responsible for the water bill.

Table 3.2: Women are Over-represented in the Achieved Sample for FBP Customers

	Achieved Sample	
Gender	**n**	**%**
Male	28	25%
Female	81	72%
Other	2	2%
Prefer not to say	2	2%
Socio-Economic Group	**n**	**%**
ABC1	59	52%
C2DE	46	41%
Prefer not to say	8	7%
Region[30]	**n**	**%**
North	19	17%
West	51	45%
South	28	25%
East	12	11%
Not known	3	3%
Meterage	**n**	**%**
Metered	42	37%
Unmetered	33	29%
Don't know	38	34%

Source: NERA analysis of WTP survey data.

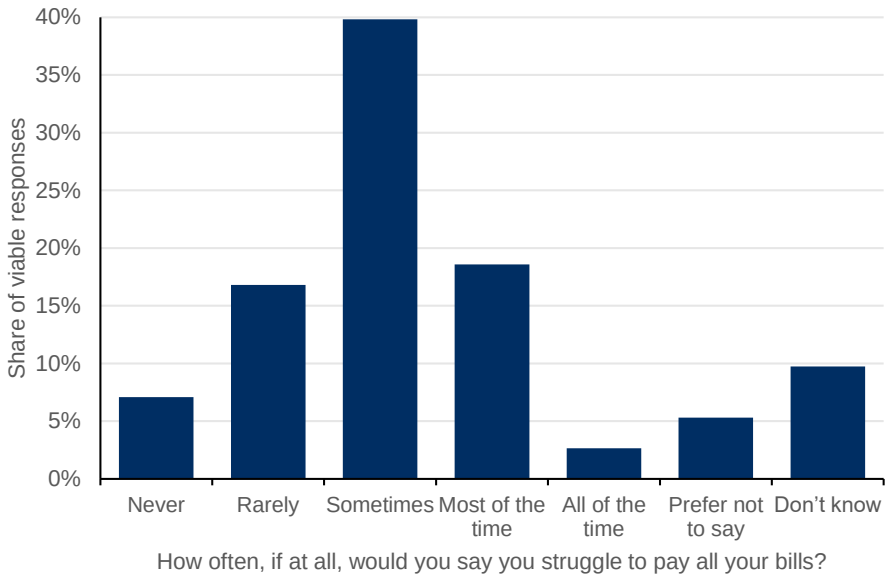
3.3.2. Financial uncertainty

As discussed in Section 3.2.2, financial uncertainty may affect customers' WTP. Among FBP customers, 24 per cent of respondents struggle "most of the time" or "all of the time" to pay all their bills (see Figure 3.6).

As for HH customers (see Section 3.2.2), there is evidence that most FBP customers are pessimistic about the future financial situation. 64 per cent of FBP respondents expect their household's financial situation will get "a little worse" or "a lot worse" over the next 12 months. Only 15 per cent expect the situation will get better (see Figure 3.7).

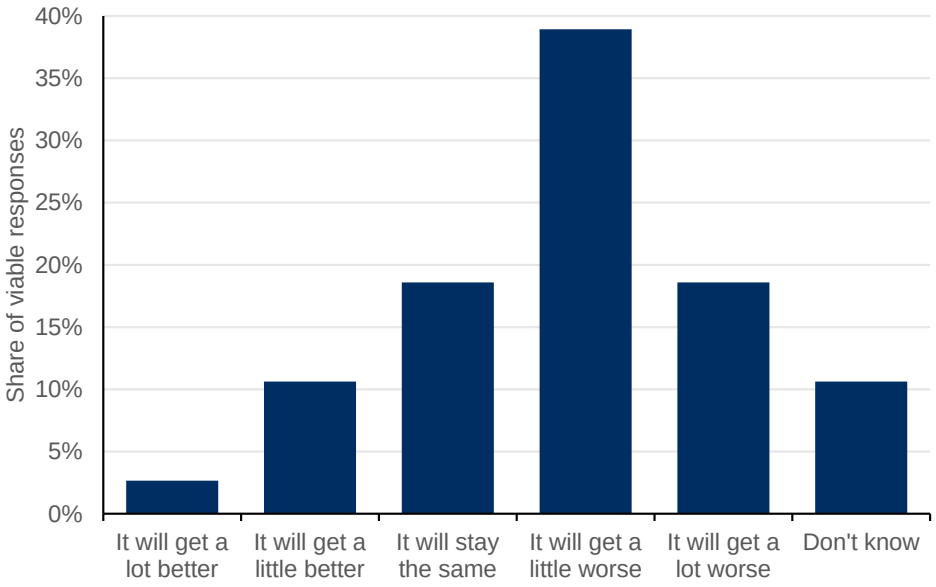
[30] North includes North Yorkshire and York; West includes Bradford, Calderdale, Kirklees, Leeds and Wakefield; South includes Barnsley, Sheffield, Chesterfield DC, Rotherham and Doncaster; and East includes East Yorkshire and Kinston upon Hull.

Figure 3.6: A Quarter of FBP Customers Struggle to Pay All Their Bills



Source: NERA analysis of WTP survey data.

Figure 3.7: More than Sixty Per Cent of FBP Customers Expect the Financial Situation of Their Household will get Worse Over the Next 12 Months



Source: NERA analysis of WTP survey data.

3.3.3. Experience of completing the survey

3.3.3.1. Ease of understanding topics and options

Figure 3.8 shows that 81 per cent of FBP respondents understood the 11 attributes "quite well" or "very well".

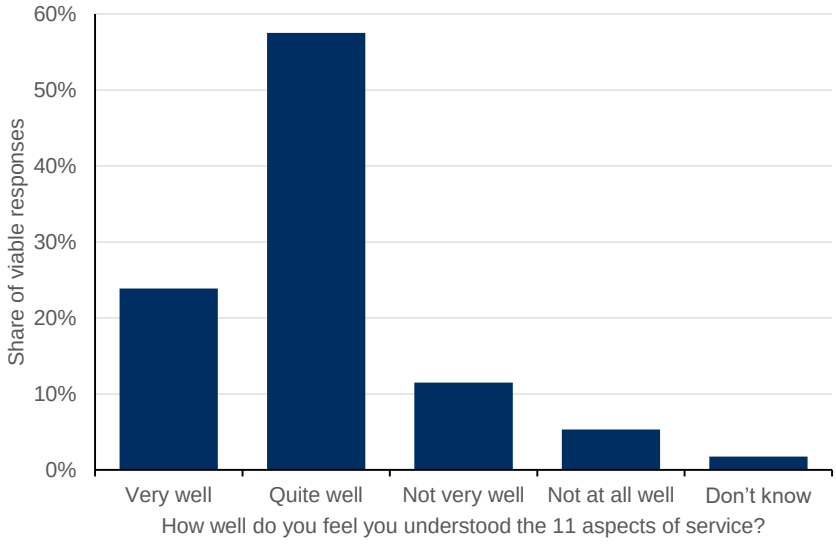
However FBP found it more difficult to work out the differences between options. On a scale of 1 to 5, with "1" being "very difficult" and "5" being "very easy", 50 per cent answered 4 or 5, meaning that they were able to work out the differences between the options they were shown without problems. However, 22 per cent answered either 1 or 2 (see Figure 3.9).

Therefore, the understanding of the survey was slightly lower for FBP than HH customers. As we discussed in Section 3.2.3, 90 per cent of HH customers understood the 11 topics "quite well" or "very well", while 59 per cent answered either 4 or 5 when asked about how easy it was to work out the differences between options ("5" being "very easy") and just 14 per cent selected options 1 or 2.

This lower level of understanding among FBP customers may be because the entire setting is more novel to FBP customers, who are not currently responsible for their water bill and so may have a more limited background understanding of what is covered by their water bill.

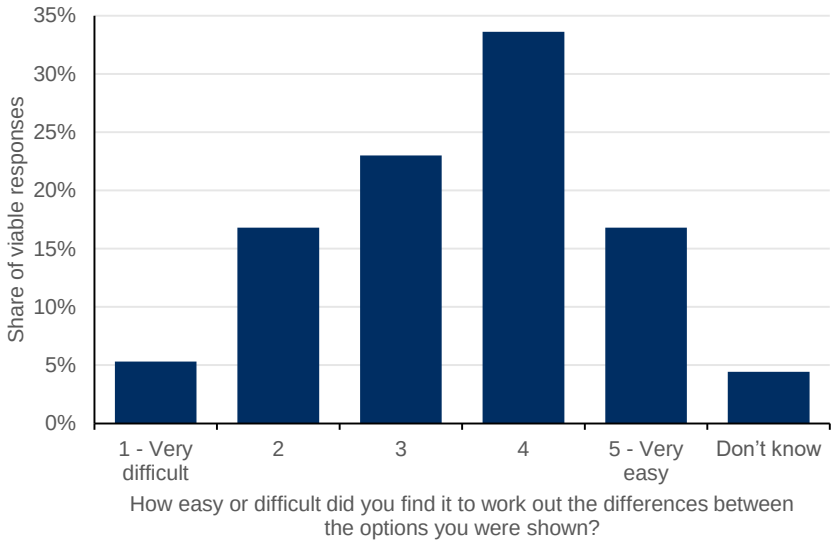
As a sensitivity check, when analysing the WTP, we run the model excluding those FBP customers that found it "difficult" or "very difficult" to work out the differences between the options and the ones that understood the 11 aspects of service "not at all well".

Figure 3.8: More than 80 Per Cent of FBP Customers Understood the Attributes Well



Source: NERA analysis of WTP survey data.

Figure 3.9: Half of FBP Customers Found it Easy to Understand the Differences Between Service Level Options



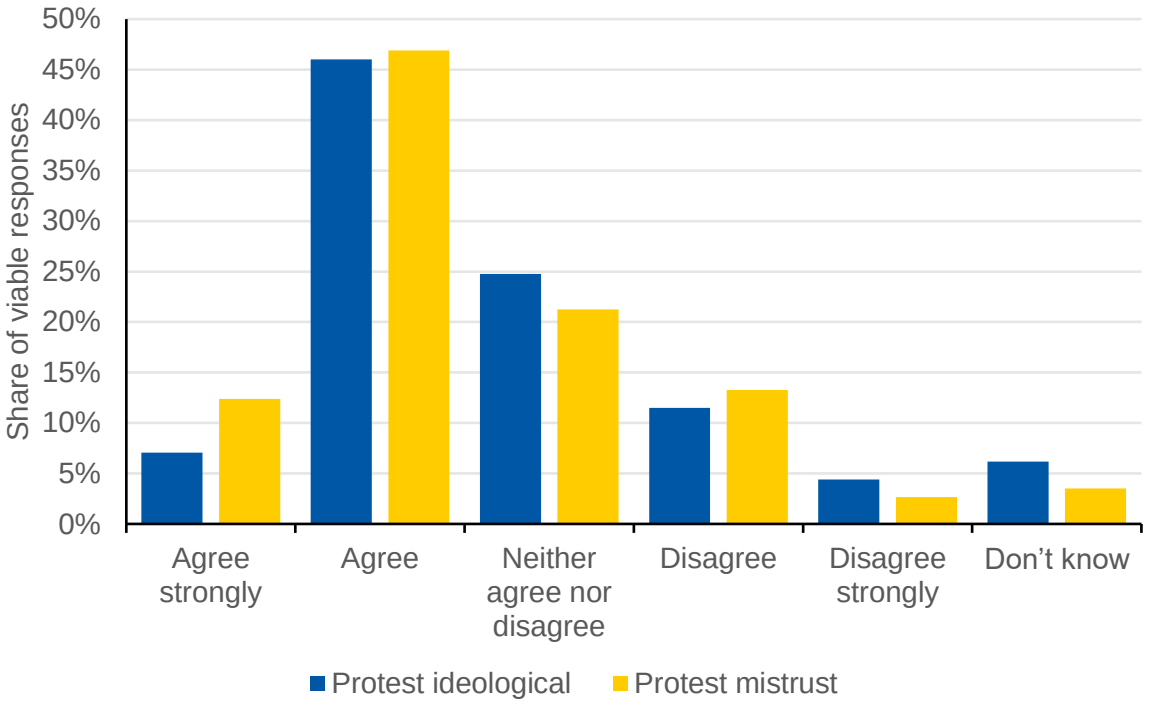
Source: NERA analysis of WTP survey data.

3.3.3.2. Protest attitudes

Among FBP respondents, 23 per cent exhibit at least one protest attitude, which is lower than the proportion we find for HH customers (among HH customers, 30 per cent exhibit at least one protest attitude, as discussed in Section 3.2.3.2). Specifically, 16 per cent exhibit a protest ideological attitude, and 16 per cent exhibit a protest mistrust attitude (see Figure 3.10).

During the WTP analysis, we examine how the results are affected by excluding the respondents with protest attitudes (see Appendix A.2).

Figure 3.10: Twenty-three per cent of FBP Customers Exhibit Protest Attitudes



Source: NERA analysis of WTP survey data.

3.3.3.3. Respondents changing decisions

After FBP respondents had answered all survey questions, they had the option to review the total impact of their combined decisions on their bill and make changes, as explained in Section 2.4.1. Among FBP respondents, 31 per cent of FBP respondents opted to change at least one choice.[31] This number is higher than for HH customers, where 17 per cent changed at least one option.

3.4. Summary of Data Collected from Non-Household Customers

We have 193 surveys from NHH customers completed via an online panel. All panel respondents are senior decision-makers within their organisations. We omit four completed surveys from our analysis because they report an implausibly high annual water bill.[32] Therefore, we perform the main stage analysis on a sample of 189 responses.

Section 3.4.1 describes the characteristics of the NHH customers. Section 3.4.2 describes the financial situation that these customers are facing. Finally, Section 3.4.3 presents the respondents' experience with the survey.

[31] We analysed the characteristics of the FBP respondents that changed at least one option and identified that the propensity to change at least one option is not higher for specific groups.

[32] In particular, we omitted four observations of small firms that reported annual bills higher than the maximum bill reported by medium-sized firms. Those bill amounts are over £500,000 even when the maximum amount reported by a medium-sized firm is £180,000. After dropping these four responses, the highest bill for small firms is £11,340.

3.4.1. Non-household customers' characteristics

For NHH, we did not set quota targets for the sample. The response rate for NHH customers is typically low, and we therefore did not want to exclude potential respondents. There was concern that the panel provider may have struggled to meet quotas, due to the limited number of suitable respondents in the panel and the typically low response rate for NHH customers.

Table 3.3 shows that in the final achieved sample, micro-enterprises are underrepresented relative to the population of firms in the UK (and all other sizes are overrepresented, particularly large firms). Also, some Standard Industrial Classification of economic activities (SIC) are overrepresented, such as Manufacturing, and Financial and Insurance Activities, and others are underrepresented such as Agriculture, Forestry and Fishing, and Construction.

It is unclear whether the underrepresentation of micro-enterprises relative to the UK statistics reflects a difference between the composition of the population of businesses in the YW operational area and the UK as a whole. Even if micro-enterprises are underrepresented relative to the YW operational area population, it is difficult to know whether this would introduce any bias to our results, as it is unclear whether micro-enterprises would have different WTP than larger firms. It is possible that they may have lower WTP due to being more vulnerable to economic shocks, so that our results may slightly overstate NHH WTP.

The differences between the UK population of businesses and our sample in terms of SIC are, overall, relatively minor.

Table 3.3: The NHH Sample is Not Fully Representative of the UK Business Profile

	UK Business Profile		Final Achieved Sample	
Size of Business	**n**	**%**	**n**	**%**
Micro (1 to 9)	163,555	89%	39	20%
Small (10 to 49)	17,305	9%	42	22%
Medium-sized (50 to 249)	3,060	2%	51	26%
Large (250+)	765	<1%	61	32%
SIC	**n**	**%**	**n**	**%**
Accommodation and Food Service Activities	13,940	8%	13	7%
Administrative and Support Service Activities	13,870	8%	4	2%
Agriculture, Forestry and Fishing	10,165	6%	1	1%
Arts, Entertainment and Recreation	3,925	2%	3	2%
Construction	23,420	13%	13	7%
Education	2,990	2%	13	7%
Electricity, Gas, Steam and Air Conditioning Supply	275	<1%	1	1%
Financial and Insurance Activities	3,650	2%	17	9%
Human Health and Social Work Activities	7,570	4%	6	3%
Information and Communication	9,450	5%	9	5%
Manufacturing	12,165	7%	25	13%
Mining and Quarrying	85	<1%	1	1%
Other Service Activities	7,485	4%	7	4%
Professional, Scientific and Technical Activities	24,925	14%	10	5%
Public Administration and Defence; Compulsory Social Security	565	<1%	3	2%
Real Estate Activities	6,815	4%	7	4%
Transportation and Storage	12,465	7%	10	5%
Water Supply; Sewerage, Waste Management and Remediation Activities	685	<1%	5	3%
Wholesale and retail trade; repair of motor vehicles and motorcycles	29,930	16%	35	18%
Don't know	-	-	10	5%

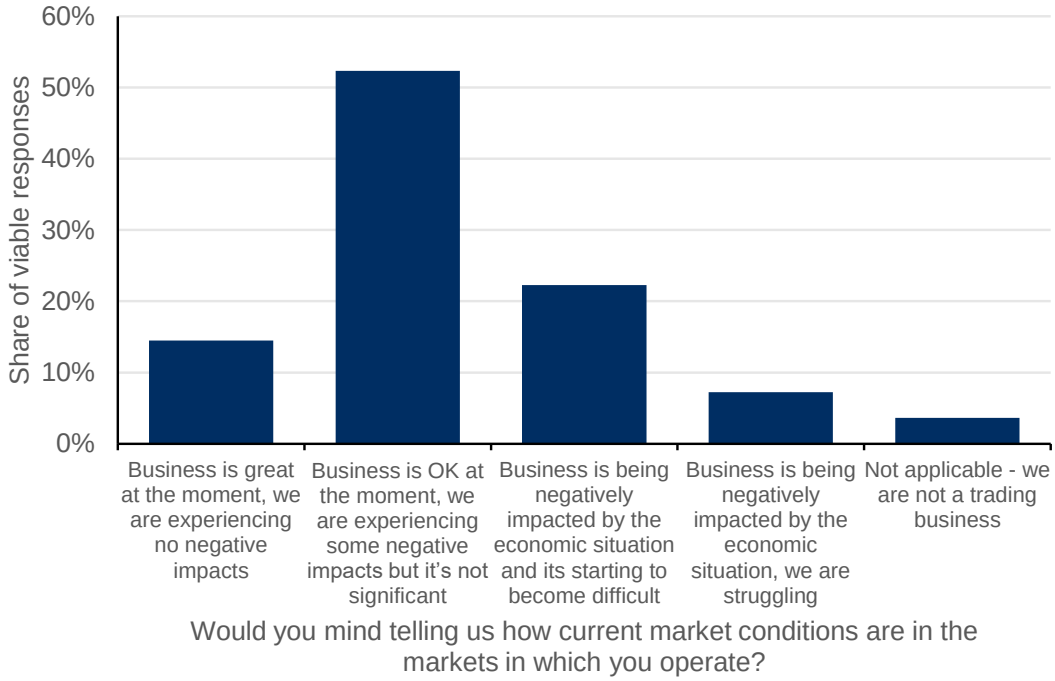
Source: Qa and NERA analysis of WTP survey data.

3.4.2. Financial uncertainty

As discussed in Section 3.2.2, financial uncertainty may affect customers' WTP. When asked, "Given the economic situation in the UK at the moment, would you mind telling us how current market conditions are in the markets in which you operate?", 82 per cent of NHH respondents said that their business was experiencing negative impacts from the current economic situation. Although 52 per cent described the impact as "not significant", 22 per cent argue that the situation is starting to become difficult, and 7 per cent that it is already struggling (see Figure 3.11).

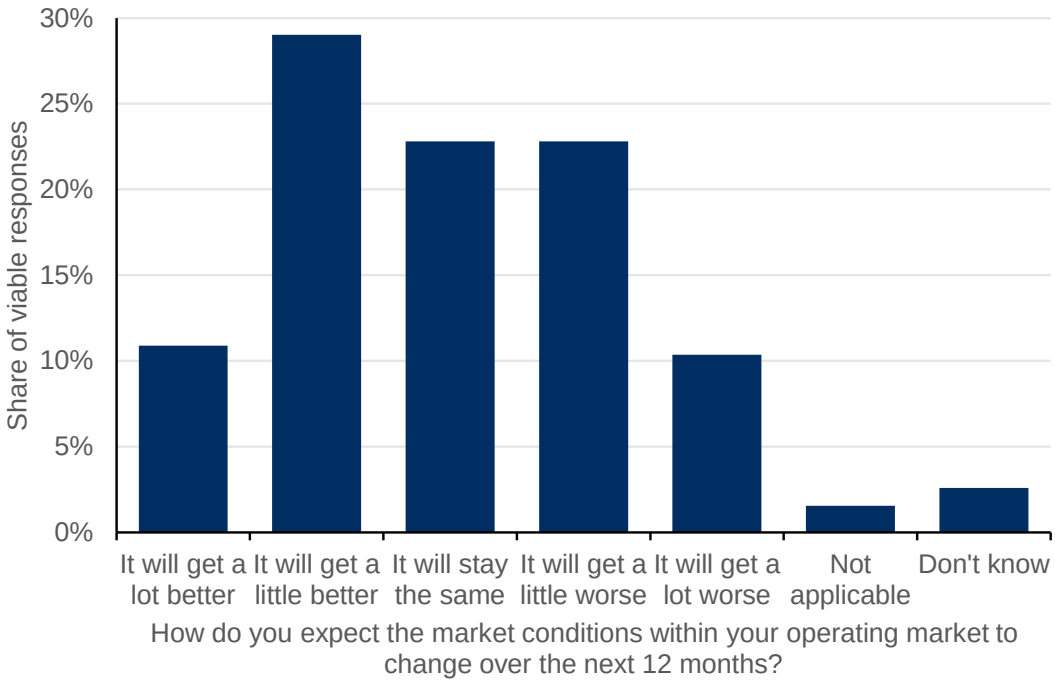
When asked about market conditions within their operating markets, 35 per cent of those NHH customers that responded expect that it will get "a little worse" or "a lot worse", and 42 per cent that it will get "a little better" or "a lot better" (see Figure 3.12).

Figure 3.11: 31 Per Cent of NHH Customers are Significantly Negatively Affected by the Economic Situation



Source: NERA analysis of WTP survey data.

Figure 3.12: One Third of NHH Customers Expect That Market Conditions Will Get Worse



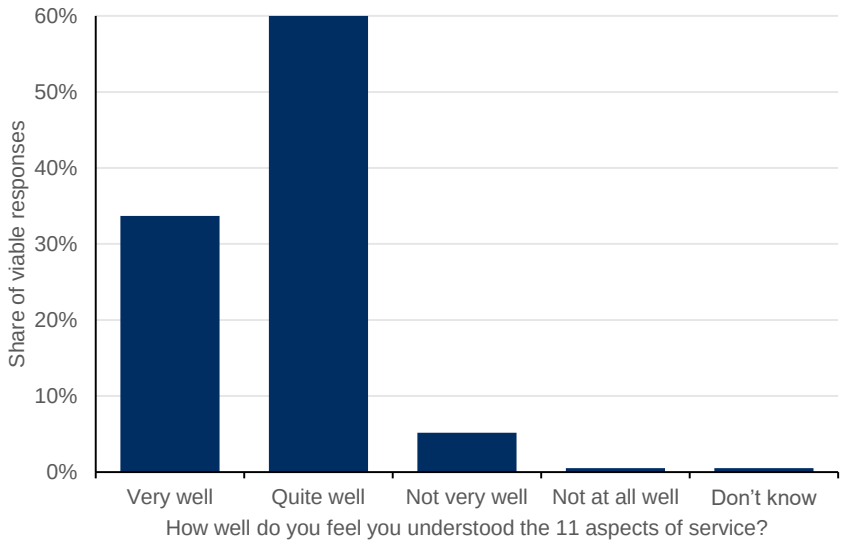
Source: NERA analysis of WTP survey data.

3.4.3. Experience of completing the survey

3.4.3.1. Ease of understanding topics and options

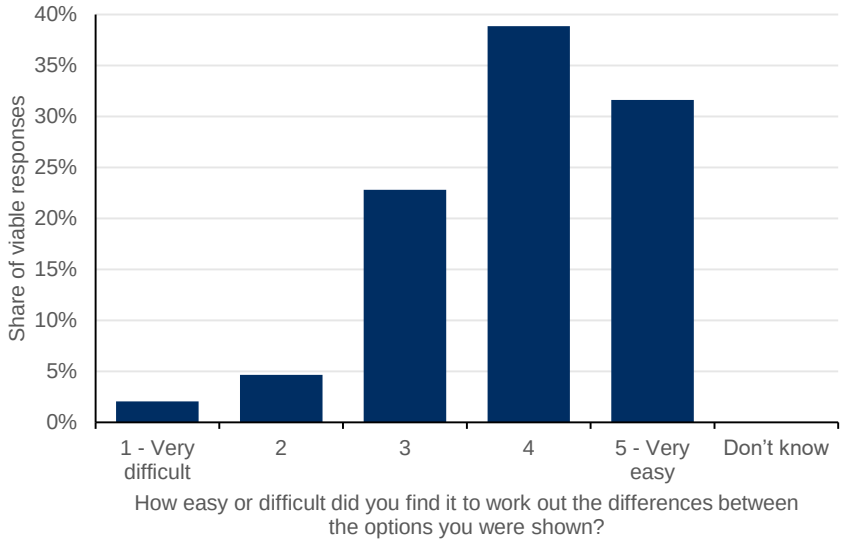
Most NHH customers found the survey easy to understand. From the sample, 94 per cent understood the 11 topics "very well" or "quite well" (see Figure 3.13), and 70 per cent found it “easy” or “very easy” to understand the differences between options (see Figure 3.14). Therefore, the responses obtained should represent the preferences of NHH customers.

Figure 3.13: Ninety-four Per Cent of NHH Respondents Understood the Attributes Well



Source: NERA analysis of WTP survey data.

Figure 3.14: Seventy Per Cent of NHH Customers Found it Easy to Understand the Differences Between Options



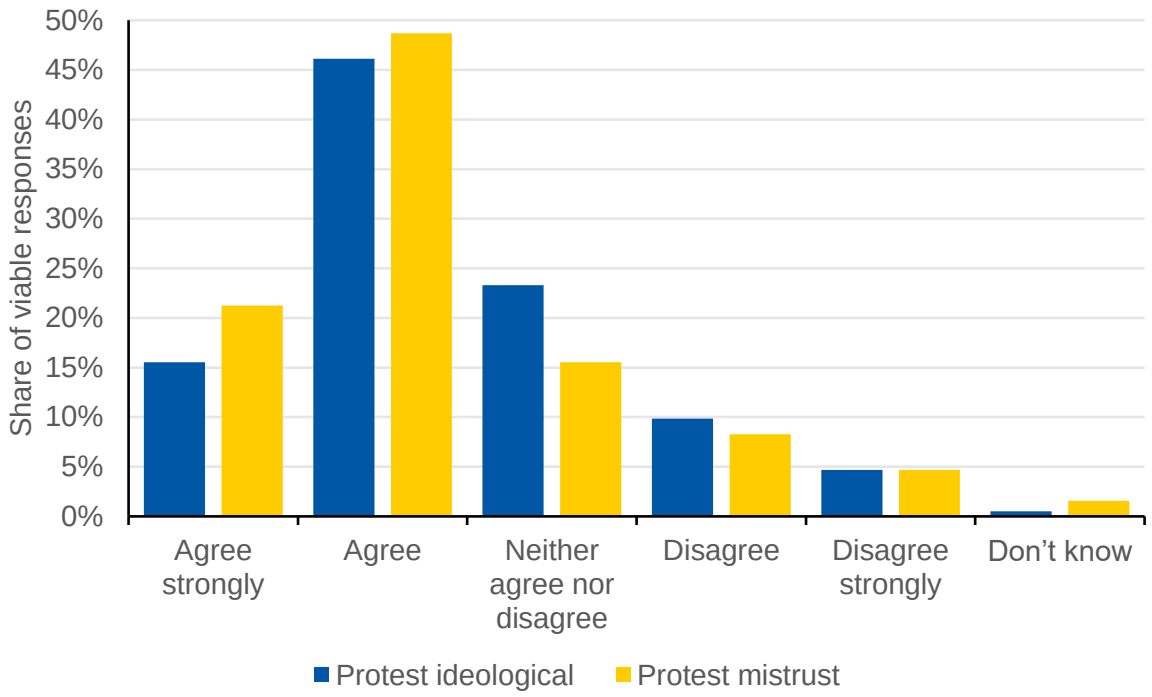
Source: NERA analysis of WTP survey data.

3.4.3.2. Protest attitudes

NHH customers are less likely to exhibit protest attitudes than HH customers. In our sample, 20 per cent of NHH respondents exhibit at least one protest attitude. In particular, 15 per cent exhibit a protest ideological attitude, and 13 per cent exhibit a protest mistrust attitude (see Figure 3.15). Among HH customers, these numbers are 22 per cent and 21 per cent, respectively (see Section 3.2.3.2).

In Appendix A.3.1 we show how the results of the WTP analysis change when excluding respondents with protest attitudes.

Figure 3.15: Twenty Per Cent of NHH Customers Exhibit Protest Attitudes



Source: NERA analysis of WTP survey data.

3.4.3.3. Respondents changing decisions

Among NHH respondents, 42 per cent of respondents changed at least one choice after reviewing the total impact of their combined decisions in their bill. This number is larger than for HH customers (17 per cent of HH changed options, see Section 3.2.3.3), suggesting that NHH customers are more sensitive to their total water bill than are HH customers.[33]

3.5. Conclusions on Survey Performance

Overall, the survey appears to have been effective in collecting information about customers' preferences that YW can reasonably rely on in its business planning.

[33] We analysed the characteristics of the NHH respondents that changed at least one option and identified that the propensity to change at least one option is not higher for specific groups.

First, we have obtained a sample size in line with targets. The collected HH sample is also in line with quotas set on demographic and billing characteristics, so that it is representative of the YW customer base. We did not set quotas for the FBP and NHH samples, but both samples contain a reasonable cross-section of YW customer types. For FBP, we have responses from all regions, both ABC1 and C2DE socio-economic groups, both metered and unmetered customers, and both men and women (although as discussed in Section 3.3.1, women are likely over-represented). For NHH, we have responses from firms of all sizes and all SICs.

Second, the evidence on customers' experience of completing the survey suggests that customers were able to understand and engage with the survey, so that the collected data is likely to fairly reflect their actual preferences over options within the choice exercise.[34] In particular, across all three customer groups (HH, FBP, and NHH):

- Most customers understood both the attributes and the options presented to them. The customer group that had the most difficulty understanding the survey was the FBP group, of whom 22 per cent report that they found it difficult to understand the differences between service level options. We run a sensitivity to investigate whether WTP results for FBP customers who report difficulty in understanding the survey are different to WTP results for other customers, and find that there are no material differences.
- Less than one-quarter of the sample report protest attitudes. This indicates that the majority of respondents accept the premise of the survey, i.e. that for service levels to increase bills must increase, and vice versa. This gives us confidence that these customers have expressed genuine preferences relating to these trade-offs. We run a sensitivity to investigate whether WTP results differ when we exclude respondents who report protest attitudes from the analysis.

[34] As with any stated preference study, there remains some risk of hypothetical bias, i.e. that customers' preferences over options within the choice exercise may not perfectly reflect their preferences in reality because they are based on hypothetical choices (even though customers are informed that their choices may influence their bills).

4. Willingness-to-Pay Analysis

This section sets out the details and results of our WTP analysis. Section 4.1 describes the methodological approach, while Sections 4.2 to 4.4 present the results for each of the HH, FBP, and NHH customer groups.

4.1. Methodological Approach

The data collected from the stated preference exercise allows us to estimate the extent to which customers would be willing to pay a specified amount for the specific package of service levels across attributes that they selected. However, this individual data is of limited utility to YW.

From a business planning perspective, YW needs to know how much a representative average customer would be willing to pay for a change to the level of service for each attribute individually. The focus on the average customer reflects the fact that YW cannot typically target service changes only on subsets of its customer base, and the service changes it does implement affect the bills paid by the generality of its customer base. We estimate this willingness to pay (WTP) using the conceptual framework of utility functions estimated using an econometric tool called the "conditional logit" model.

4.1.1. Utility functions

A utility function is a conceptual framework used in economics to think about customers' general wellbeing. We assume that each customer's utility, or well-being, depends on the quality of water services they receive and on the bill for water services, among other things. We also assume that customers' utility improves as the quality of the service received from the water company improves and falls as the bill increases.[35] We can use this trade-off inherent in the utility function to derive a value for WTP.

Consider a simple example with one service attribute, where we represent the utility of a single customer i as an equation:

$$U_{il} = aQ_l - bB_l + e_{il}$$

Here U_{il} is the utility person i derives from service level l; Q_l is the quality of service at service level l; B_l is the bill associated with service level l; and e_{il} captures the factors that affect utility other than Q_l and B_l but are not known to the researcher.[36] The terms a and b are referred to as the "parameters" of the utility function.

We can use this utility function to derive WTP for a change in service as follows. Consider that, all else equal, a customer should be willing to change their bill for the sake of a change

[35] As researchers, we do not observe customers' utility, nor do we observe their utility functions. The assumptions we make here are more precisely described as assumptions about the *representative utility* of the customer, which is a mathematical function specified by us as the researchers to relate observable factors (i.e. the water services received and the water bill) to the customer's underlying and unobservable utility. See Train, K. (2009), *Discrete Choice Methods with Simulation*, Chapter 2: Properties of Discrete Choice Models.

[36] More precisely, e_{il} captures the factors that affect customers' utility but that either (a) are excluded by our assumed mathematical function for representative utility, e.g. customer-specific sensitivities to water service levels or (b) are unobserved by the researcher. This term e_{il} is therefore defined by the assumptions imposed by the researcher, rather than a fundamental feature of customers' true (unobservable) utility.

in service up to the point that the customer's utility is the same with or without the change: that is, the change in utility associated with the change in service and bill is zero. We can write this in terms of the utility function, using Δ to represent changes, as follows:[37]

$$\Delta U_l = a\Delta Q_l - b\Delta B_l$$

$$0 = a\Delta Q_l - b\Delta B_l$$

The WTP is simply the extent to which a customer is willing to change their bill for a given change in service, i.e., the ΔB such that the change in utility from the change in service and bill is zero. Therefore, we derive the WTP by solving the above equation for ΔB:

$$\text{WTP} = \Delta B = \frac{a}{b}\Delta Q$$

4.1.2. Conditional logit model

We do not have data on customers' utility, and so we cannot directly apply the calculations above to estimate WTP. We do have data on customers' choices made in response to our survey questions. By understanding how choices relate to utility, we can use the data we do have to get estimates of WTP.

Customers will choose one combination of service levels and bill payments, l, over another combination, m, if the utility they derive from l is higher than the utility they derive from m. That is, customer i will choose combination l over m if:

$$U_l > U_m$$

$$aQ_l - bB_l + e_{il} > aQ_m - bB_m + e_{im}$$

$$a(Q_l - Q_m) - b(B_l - B_m) + e_{il} - e_{im} > 0$$

If we make certain assumptions about e_{il} and e_{im}, and we have data on what customers choose when presented with l and m as options, then we can estimate what the values of a and b must be so that the equation above holds true when we observe customers choose l over m. Once we have estimates of the utility function parameters a and b, then we have estimates of WTP.

The conditional logit model refers to the standard set of assumptions that economists make about e_{il} and e_{im}. Applying this model allows us to derive estimates for a and b and thus derive estimates of WTP.

[37] We omit the term e_{il} here because we are considering the trade-off under the assumption that all else is equal, i.e. that e_{il} is unchanged (so $\Delta e_{il} = 0$).

4.1.3. Model development

The example described in Sections 4.1.1 and 4.1.2 is highly simplified. There is only one service attribute, and customers have only two options to choose between. We do not include other factors, such as demographic characteristics, that might influence utility.[38]

In practice, the conceptual framework of the utility function and the econometric technique of the conditional logit model can handle far more complexity than this simple example. The utility function can be extended to include multiple service attributes and account for the influence of other factors. The conditional logit model can be used to derive estimates for this more complex utility function, given data on choices over a range of options.

In the stated preference exercise at hand, there are many different ways in which the utility function could be extended. We have data on multiple service factors and a range of variables reflecting demographic characteristics, billing characteristics, and the respondents' interactions with the survey, as set out in Sections 3.2 to 3.4. We can choose which additional control variables, such as demographic characteristics, to include in the equation that is the utility function; and how the relationship between those variables, water services, and utility should be expressed mathematically.

We refer to each of the different possible extensions of the utility function as a different "model" for the utility function.[39] We can use different models to answer different questions about customers' WTP. For example, our main model includes only twelve parameters (one for each of the attributes, plus one for cost); but we also estimate a sensitivity that includes all of these parameters plus a further eleven parameters (one for each attribute) to assess whether customers place additional value on the status quo service level for each attribute.

4.1.4. Derivation of WTP estimates from conditional logit model estimates

The main model that we estimate assumes that customers have the same WTP for improvements in service across the full range of possible service levels for each attribute. Specifically, we assume that the utility that customer i obtains from a specific combination of service levels and associated bill impacts l can be expressed as:

$$U_{il} = a_1 Q_{1,l} + a_2 Q_{2,l} + \cdots + a_{11} Q_{11,l} + b B_{il}$$

In this model, we have:

- Eleven observable factors of the form $Q_{j,l}$. Each of these captures the service level of attribute j that appears in the specific combination of service levels and associated bill impacts l. The service levels are defined in terms of unit improvements relative to the status quo service level (see Appendix C for further details);

[38] To be precise, we do not include these factors in the *representative utility* function, which is the mathematical function that we as researchers have adopted to represent the observable component of customers' utility.

[39] Note that the models we refer to here are models for the *utility function*, that is, different specifications of the right-hand side of the utility function (statistically speaking, different models for the linear predictor). The statistical model we use to link observed choice data to the right-hand side of the utility function is always the same conditional logit model (rather than e.g. multinomial logit, probit, or another statistical model).

- Eleven parameters of the form a_j, which capture the marginal utility derived from an unit improvement in service level of attribute j;[40]
- The observable factor B_{il} which is the total change in the customer's bill, relative to their current bill, implied by combination l;
- The parameter b, which captures the marginal utility of having a lower bill.

We describe how we estimate the parameters of this model using the collected survey data in Section 4.1.5. Once we have estimated the parameters, we calculate the incremental WTP for service level l of attribute j as $\frac{a_j}{b} \times \Delta Q_{jl}$, using our estimated values of a_j and b and letting ΔQ_{jl} be the change in service of attribute j between level 1 and level l. This is line with the expression for WTP derived in Section 4.1.1.

In some cases, the above approach may yield negative WTP for incremental improvements in service for some attributes. This happens if the statistical analysis shows that respondents are more likely, on average, to choose packages with lower service levels for those attributes than packages with higher service levels, even when the total cost of the package is controlled for; so a_j is negative. However, there is a subtle difference between this pattern of choice behaviour and a true negative WTP for incremental improvements.

A true negative WTP for incremental improvements would imply that respondents want to be compensated for incremental improvements in service. This is fundamentally implausible and also not a preference that any individual survey respondent has actually expressed; it was impossible for respondents to express such a preference because the survey was constructed so that the improved service level always increased the customer's bill. Therefore, when the model produces a negative WTP for incremental improvements we instead assume a zero WTP for incremental improvements.

4.1.5. Sample used for estimation

If we were to approach our analysis using standard WTP techniques, we would face significant computer processing challenges. The standard WTP technique is to build a single dataset containing a row for each possible option that each respondent could have chosen.

The standard technique works well when using stated preference exercises that ask respondents to choose between two pre-defined packages, as described in Section 2.4.2. Each respondent has only two options per round, and so the number of rows in the dataset is equal to the 2 × the number of rounds × the number of respondents. With say twelve rounds and a sample size in the thousands, this would generate a dataset on the order of a few hundred thousand rows, which modern statistical software can easily handle.

The standard technique runs into problems when using our new stated preference exercise that allows respondents to build their own preferred package. In this setting, each respondent

[40] For attributes where service levels are numerically defined, the incremental improvement is a unit improvement. For example, the service levels of attribute B are defined in terms of test failures; therefore a_B captures the marginal utility the average customer gets from one fewer test failure.

faces, in principle, 12,500,000 possible options.[41] Therefore, if we were to build a dataset to use in our WTP analysis of all possible options for each respondent, we would have a dataset of several billion rows. This is too large for standard statistical software to process in a time-efficient manner.

We avoid these problems by using a reduced dataset that contains, for each respondent, the option that the respondent did select as well as a random selection of the options that the respondent did not select. This approach was initially proposed by econometricians in the 1970s in the context of studying the choice of housing, where the set of possible options is near limitless.[42] As long as we include a sufficient number of the non-selected options, and do this in a random way, this approach produces results that closely approximate the results that we would obtain using the standard complete dataset.

We report the results of models estimated using c. 50,000 non-selected options per respondent, for HH, and 125,000 non-selected options for NHH and FBP. These are 0.4 per cent and 1 per cent of the total set of non-selected options, respectively. In previous applications of this method we have found that using between 0.5 per cent and 1 per cent of the sample produces similar results to using 5 or 10 per cent of the sample. For this project, we tested with up to 5 per cent of the HH sample (i.e. 500,000 non-selected options per respondent) and found that the estimated WTP was very similar to that obtained using 50,000 non-selected options per respondent.[43]

To produce this reduced dataset, we use the following approach:

1. For each respondent, we start with a dataset containing the single option that the respondent actually selected.
2. We then extend the respondent-specific dataset by randomly generating a fixed number of draws from the set of possible options that the respondent could have selected (50,000 draws for HH and 125,000 for NHH and FBP).[44] We drop any duplicates so that for each respondent, any given option appears in the dataset only once.
3. We combine the respondent-specific datasets into a single dataset for our WTP analysis.

Due to the randomisation, the number of duplicate draws differs across respondents and so the final number of rows differs across respondents. This does not create a problem for our analysis: it is not necessary to have an equal number of observations for each respondent as long as the ex ante probability of any single non-selected option appearing in the final dataset is equal across non-selected options and across respondents.

When using random sampling techniques, it is standard practice to account for the possibility that results could be sensitive to the particular random sample of non-selected options used

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41 There are eleven attributes with between 2 and 5 choices for each attribute (depending on the attribute). This leads to a total of $5^8 \times 4^2 \times 2^1 = 12{,}500{,}000$ possible combinations of choices.

42 McFadden, D. (1977), Modelling the Choice of Residential Location, Cowles Foundation Discussion Paper No. 477

43 The difference between the estimated WTP using 50,000 and 500,000 observations is always less than 0.50% of the estimated value of WTP. The average difference between the WTP for the 11 attributes is 0.23% of the initial value.

44 To implement this, we select from a uniform distribution over integers representing the available service levels. For the eight attributes where all five service levels are available, this draw is between 1 and 5 inclusive; for attributes with fewer service levels, it is over the relevant integers. Each integer is then the level chosen for that attribute. This generates one of the 12,500,000 possible combination options, with each combination option equally probable.

(referred to as testing sensitivity to the random seed). We do this by estimating each model using four different random seeds. We find that the estimates are very similar across all of the random seeds.[45] Our final reported estimates are the average of the estimated WTP across all four models.

4.2. Results for Household Customers

In this section, we examine household customers' WTP for service changes. We examine WTP estimates from a linear model, to evaluate whether there is willingness to pay for incremental improvements in service for the different attributes.

We also consider the sensitivity of our results to different modelling choices. We discuss how the estimates are affected by restricting the analysis to certain sub-groups of the sample. We also discuss the results from the alternative "Deteriorations Model". Details of the models estimated on sub-samples as well as the "Deteriorations Model" are presented on Appendix A.1.

4.2.1. Descriptive statistics on household customer choices

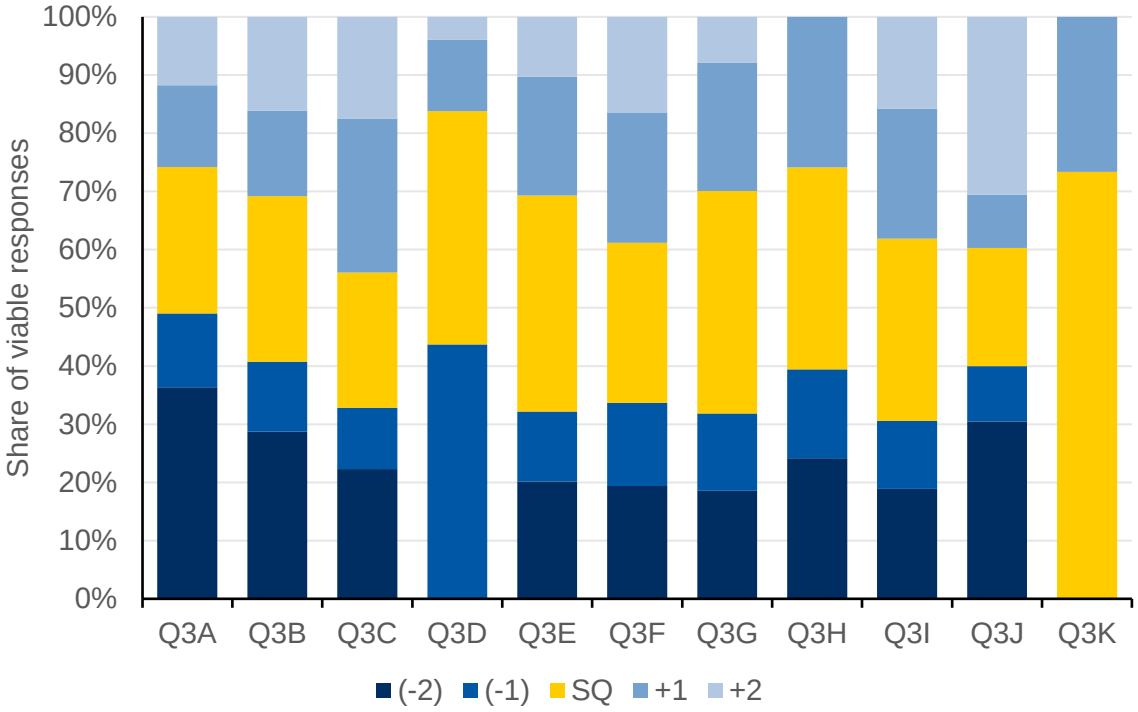
In this section, we present an analysis of the final choices made by customers for each attribute. Figure 4.1 shows customers' final choices for question 3, i.e. after they have seen the summary screen of their initial decisions in question 2 (and the total impact of those choices on their bill) and had the opportunity to revise their choices.

The attributes for which the improvement options were more frequently chosen than the deterioration and status quo options are C (Water Lost Through Leaks), F (Sewage flooding outside properties), and I (Pollution of watercourses).

When asked about their preferences in the abstract, the majority of HH customers indicated they want to see improvements, even if their bills increase, for six of the 11 attributes: C (Water Lost Through Leaks), E (Sewage flooding inside properties), F (Sewage flooding outside properties), G (River Water Quality), H (Sea Water Quality at Yorkshire's Beaches), and I (Pollution of watercourses) (see Figure 4.2). This result is borne out in the stated preference choice exercise, where we identified a positive willingness to pay for these six attributes.

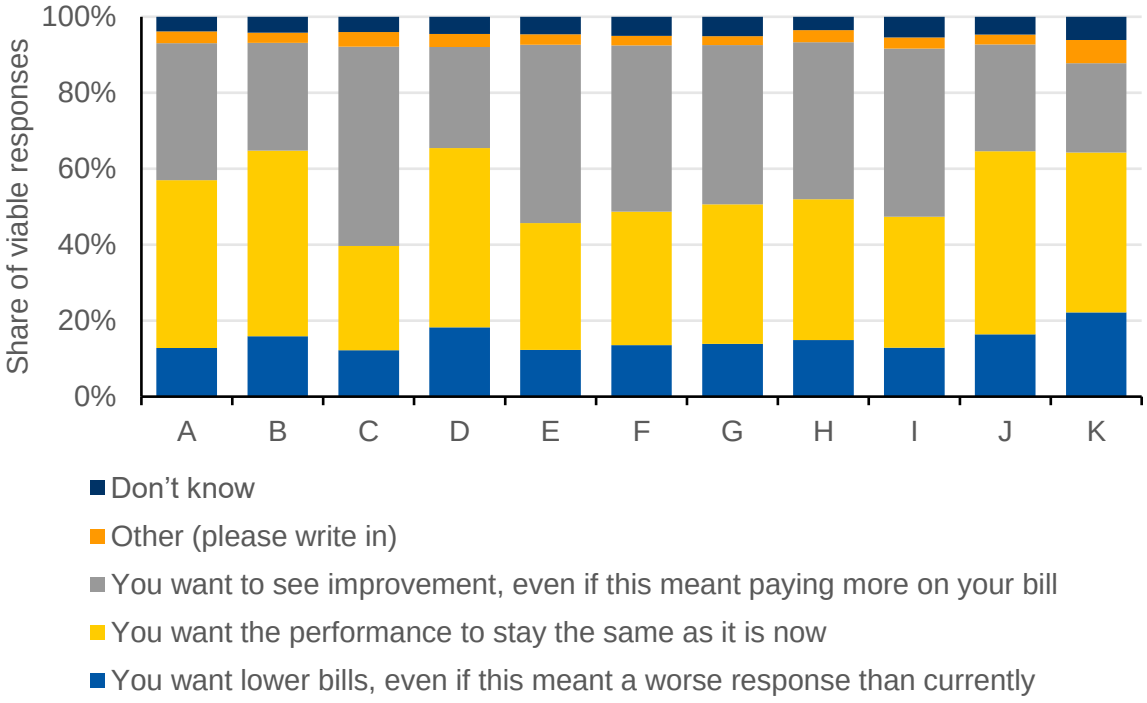
[45] Among the 11 attributes, the average difference between the maximum and minimum estimate for the four seeds is 0.51 per cent of the average WTP estimate for each attribute. This difference is lower than 0.80 per cent for all attributes with WTP significant at the 5 per cent level. Two attributes are not significant at the 5 per cent significance level (attributes G and J). The difference between the maximum and minimum estimate across all four seeds (as a percentage of the average across all four seeds) is 1.14 per cent for attribute G and 0.95 per cent for attiribute J.

Figure 4.1: More HH Customers Prefer Improvements Than Prefer Deteriorations or the Status Quo for Attributes C, F, and I



Source: NERA analysis of WTP survey data.

Figure 4.2: HH Customers Want Improvements in Six Attributes: C, E, F, G, H, and I



Source: NERA analysis of WTP survey data.

4.2.2. Summary of willingness to pay results

HH customers are WTP for incremental improvements in areas which have recently received media attention, relate to protecting the environment, or reduce the risk of service failures that would have particularly unpleasant consequences. Specifically, we identify positive and significant WTP for five attributes:

- C (Water lost through leaks)
- E (Sewage flooding inside properties)
- F (Sewage flooding outside properties)
- H (Sea water quality at Yorkshire's beaches)
- I (Pollution of watercourses)

When restricting the analysis to specific sub-groups of HH customers we identify the following (see Appendix A.1):

- After excluding respondents with protest attitudes, the positive WTP for attribute G (River water quality) becomes significant, and attribute J (Low water pressure) acquires a positive WTP.
- We observe that WTP for service improvements differs between men and women, but not in a way that is systematically consistent across multiple attributes. Women are WTP more than men for some attributes, while men are WTP more than women for others.[46]
- Customers that practice water recreation activities have positive WTP for attributes related to water quality, while those who do not participate in this type of activity are not willing to pay for incremental improvements in those attributes.[47]
- WTP for incremental improvements is higher for the socioeconomic group ABC1 than C2DE.[48]
- Finally, customers that are worried about not being able to afford their water bills or already are struggling with them do not present positive WTP for any attribute.[49]

Looking at the "Deteriorations Model", we estimate a positive WTP for every attribute, indicating that HH customers are averse to deterioration in service for all attributes.

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[46] The only attribute where men have negative WTP and women positive WTP is attribute J (Low water pressure), but the last is not significant at the 5 per cent level.

[47] WTP for attributes G (River water quality), H (Sea water quality at Yorkshire's beaches), and I (Pollution of watercourses) is positive and significant at the 5 per cent level for customers who practice water activities; and negative but not significant for those who do not.

[48] The attributes where ABC1 have positive WTP and C2DE negative WTP are attributes C (Water lost through leaks), F (Sewage flooding outside properties), G (River water quality), and J (Low water pressure). Only for attribute C are both estimates significant at the 5 per cent level.

[49] Include respondents that "strongly agree" or "agree" with the statements: (i) "I worry about not being able to afford my water bill" or (ii) "I already can't afford my water bill".

4.2.3. Estimated values of WTP for main model

We run a conditional logit model explaining customers' choices as a function of the incremental improvement in service of each attribute within the package and the overall cost of each package.[50, 51]

The WTP for the different attributes is reported in Table 4.1 and Table 4.2. The column "Incremental WTP to switch from SQ (£)" shows how customers' WTP changes as service improves or deteriorates from the status quo. Looking, for instance, at attribute E ("Sewerage flooding inside properties"), the interpretation of the figures shown in the table is as follows:

- The estimate of 5.54 WTP for service level 4 (550 properties flooded) means that, on average, customers would be willing to pay £5.54 for a reduction in the number of properties flooded from the status quo service level of 660 to 550 (i.e. an improvement).
- The estimate of -6.05 WTP for service level 2 (780 properties) means that, on average, customers would need to be compensated £6.05 for a reduction in service from 660 properties flooded to 780 properties flooded.

The results can be summarized as follows:

- Customers are WTP for incremental improvements in five attributes. Here we only consider attributes where the estimated WTP is positive and significant at the 5 per cent significance level:
  - C (Water lost through leaks)
  - E (Sewage flooding inside properties)
  - F (Sewage flooding outside properties)
  - H (Sea water quality at Yorkshire's beaches)
  - I (Pollution of watercourses)
- For attribute G (River water quality), we identify a WTP that is positive but not significant at the 5 per cent significance level.[52]
- Customers are not WTP for incremental improvements in five attributes:[53]
  - A (Drinking water colour, taste and smell)
  - B (Unplanned interruptions to the water supply)

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50 Under this specification, we consider a c. 0.4 per cent randomly selected subset of the non-selected options (c. 50,000 non-selected options per respondent). We used four different randomly selected samples (four seeds), all of which yielded similar results; the results reported here are the simple average of those four.

51 The number of observations we have from the HH survey was 1,666. After excluding respondents that reported implausible bill values (annual bill over £ 1,000), we have 1,620 observations.

52 The p-value is 0.102.

53 As we already discussed, when the model produces a negative WTP for incremental improvements we instead assume a zero WTP for incremental improvements.

- D (Using less water)
- J (Low water pressure)
- K (Creating a River Wharfe safe for swimming)

Overall, it appears that customers are willing to pay for improvements in areas which have recently received media attention (leaks, pollution, quality of the water in the natural environment). In the text responses, we observe many respondents express a desire to protect the environment or in some cases even refer to a *"need to protect the environment"*. Customers are also willing to pay to reduce the risk of service failures that would have particularly unpleasant consequences, such as sewage flooding, about which one customer wrote that they *"would not want to experience this or for others to experience it"*.

It appears that customers may be less willing to pay for improvements in service where the impact of service failure is low (altered water colour/taste/smell, short unplanned interruptions, and low water pressure). For these three attributes many respondents express a view that these are not what one respondent refers to as *"major issues"*.

Customers are also not willing to pay to reduce water use or create a River Wharfe safe for swimming; this could be because they see these as non-essential or because they do not think these improvements would benefit them. Regarding the attribute on reducing water use, several respondents argue that they use the water they need and should not pay for others to reduce their water use. With respect to creating River Wharfe safe for swimming, a large number of respondents express a view that this is not a priority and that they should not pay for it because it will benefit only a small number of people.

Table 4.1: WTP Estimates for Attributes A-F (HH Linear Model)

Attribute		Service Level	Incremental WTP to switch from SQ (£)
A	Drinking water colour, taste and smell	13 contacts per 10,000 customers	0.00
		12 contacts per 10,000 customers	0.00
		11 contacts per 10,000 customers	
		10 contacts per 10,000 customers	0.00
		9 contacts per 10,000 customers	0.00
B	Unplanned interruptions to the water supply	55,000 properties interrupted	0.00
		50,000 properties interrupted	0.00
		46,000 properties interrupted	
		41,000 properties interrupted	0.00
		36,000 properties interrupted	0.00
C	Water lost through leaks	315 million litres per day (26.3% of water supplied)	-5.65
		290 million litres per day (24.2% of water supplied)	-1.24
		283 million litres per day (23.6% of water supplied)	
		268 million litres per day (22.3% of water supplied)	2.65
		239 million litres per day (19.9% of water supplied)	7.77
D	Using less water		
		133 litres per person per day	0.00
		132 litres per person per day	
		125 litres per person per day	0.00
		117 litres per person per day	0.00
E	Sewage flooding inside properties	1,120 properties flooded	-23.18
		780 properties flooded	-6.05
		660 properties flooded	
		550 properties flooded	5.54
		310 properties flooded	17.64
F	Sewage flooding outside properties	7,100 properties flooded	-13.03
		5,000 properties flooded	-2.09
		4,600 properties flooded	
		4,400 properties flooded	1.04
		3,700 properties flooded	4.69

Source: NERA analysis of WTP survey data.

Table 4.2: WTP Estimates for Attributes G-K (HH Linear Model)

Attribute		Service Level	Incremental WTP to switch from SQ (£)
G	River water quality	0km of 742km	-3.28
		25km of 742km	-1.64
		50km of 742km	
		70km of 742km	1.31
		150km of 742km	6.55
H	Sea water quality at Yorkshire's beaches	12 of 18	-20.75
		14 of 18	-10.38
		16 of 18	
		18 of 18	10.38
I	Pollution of watercourses	175 incidents	-14.23
		165 incidents	-11.38
		125 incidents	
		100 incidents	7.12
		85 incidents	11.38
J	Low water pressure	14 properties affected	0.00
		9 properties affected	0.00
		4 properties affected	
		2 properties affected	0.00
		0 properties affected	0.00
K	Creating a river wharfe safe for swimming		
		No – do not make this investment	
		Yes – do make this investment	0.00

Source: NERA analysis of WTP survey data.

4.3. Results for Future Bill Payers

In this section, we examine FBP customers' WTP for service changes. As for HH and NHH costumers, we examine WTP estimates from a linear model, to evaluate whether there is willingness to pay for incremental improvements in service for the different attributes.

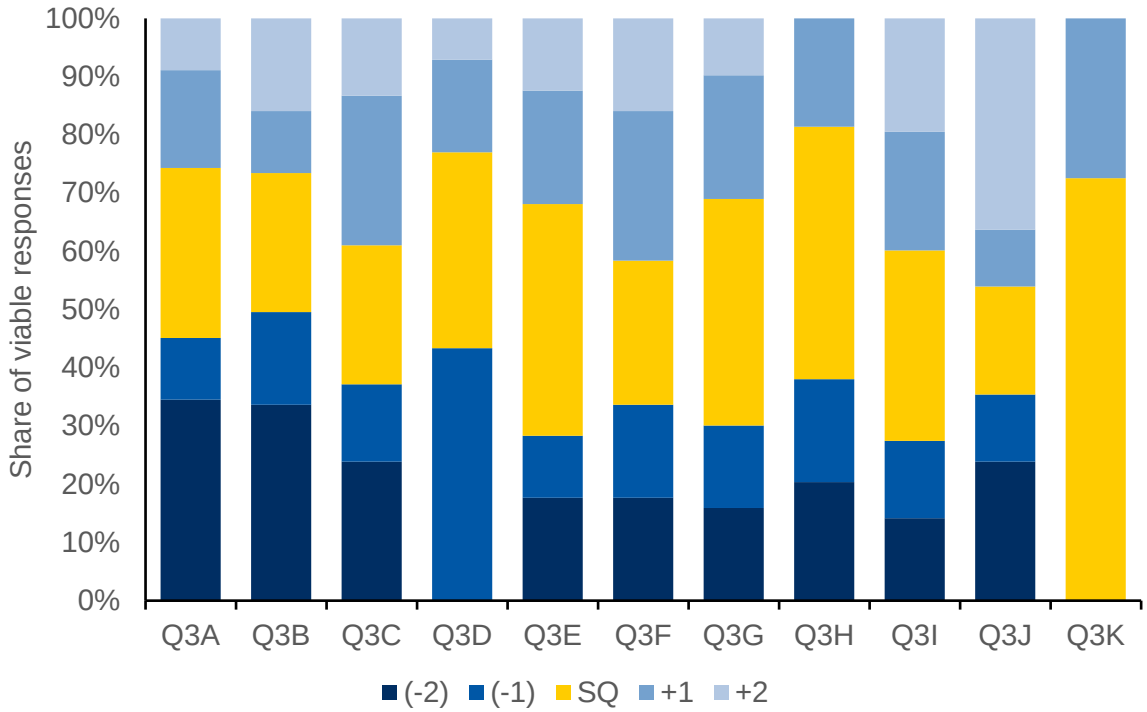
We also examine how the results are affected by excluding respondents with protest attitudes, or excluding respondents who lacked understanding of the attributes or service level options. We examine the latter model for FBP customers only, because of the relatively high proportion of customers in this group who report a lack of understanding. Finally, we examine the implications of the "Deteriorations Model".

4.3.1. Descriptive statistics on future bill payers' choices

Figure 4.3 shows the final choices of FBP customers after they have seen the summary screen of their initial decisions and the total impact of those choices on their bill, and had the opportunity to revise their choices.

The attributes for which the improvement options were more frequently chosen than the deterioration and status quo options are C (Water Lost Through Leaks), F (Sewage flooding outside properties), I (Pollution of watercourses) and J (Low Water Pressure). However, the proportion of FBP choosing the improvement options never reaches 50 per cent.

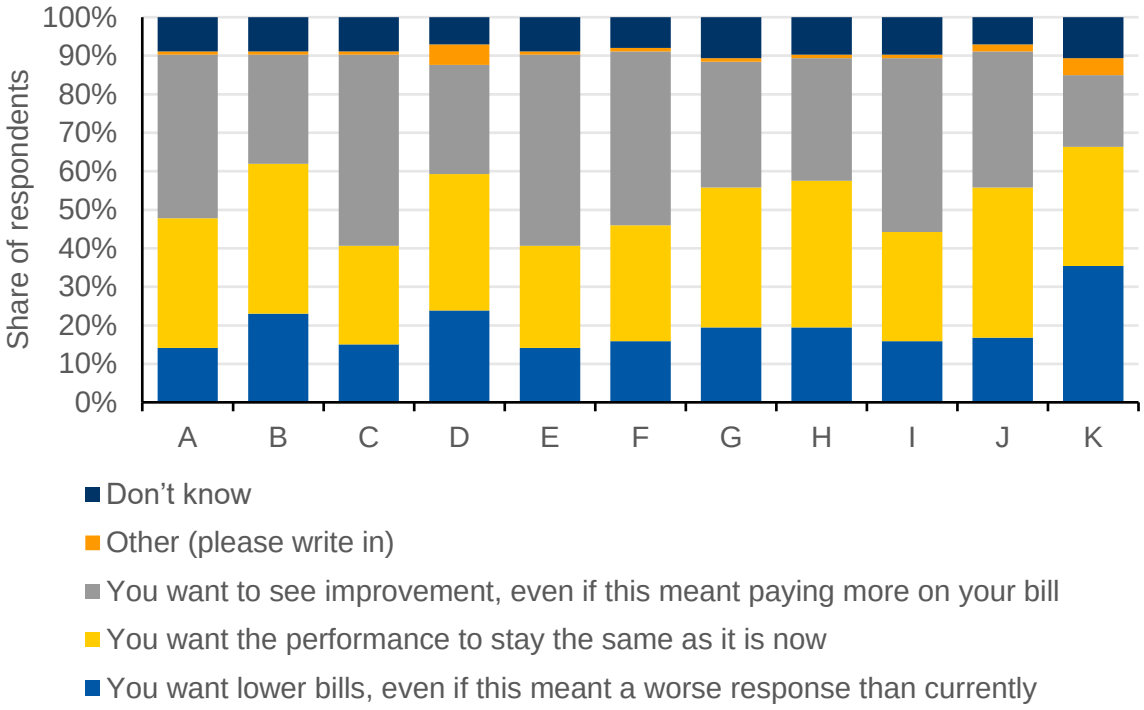
Figure 4.3: More FBP Customers Prefer Improvements Than Prefer Deteriorations or the Status Quo for Attributes C, F, I, and J



Source: NERA analysis of WTP survey data.

When asked about their preferences in the abstract, most FBP customers indicated they want to see improvements, even if their bills increase, or want the service to stay the same. In particular, as can be seen in Figure 4.4, a majority of FBP customers said they want to see improvements for five attributes: A (Drinking Water Colour, Taste and Smell), C (Water Lost Through Leaks), E (Sewage flooding inside properties), F (Sewage flooding outside properties), and I (Pollution of watercourses).

Figure 4.4: FBP Customers Want Improvements in Attributes A, C, E, F, and I



Source: NERA analysis of WTP survey data.

4.3.2. Summary of willingness to pay results

FBP are willing to pay for incremental improvements in service for attributes related to the environment and to reduce the risk of service failures that would have particularly unpleasant consequences. In particular, we find positive WTP for improvements, at the level of 5 per cent significance, in three attributes:

- E (Sewage flooding inside properties)
- G (River Water Quality)
- I (Pollution of watercourses)

We also identify positive WTP for improvements in two more attributes, at the level of 10 per cent significance:

- F (Sewage flooding outside properties)
- H (Sea Water Quality at Yorkshire's Beaches)

Looking at the "Deteriorations Model", we estimate a positive WTP for every attribute, indicating that HH customers are averse to deterioration in service for all attributes. Looking at the results of the model excluding respondents with protest attitudes, we find evidence of willingness to pay for the same attributes listed above as well as for attributes C (Water lost through leaks) and J (low water pressure). We discuss the results of these models further in Appendix A.2.

We also run the model excluding the FBP that found it "difficult" or "very difficult" to work out the differences between the options and the ones that understood the 11 aspects of service "not at all well" (see Section 3.3.3.1).[54] The results do not change materially: the same attributes have positive WTP as for the full sample of FBP customers. The only attribute that has a positive WTP in the restricted sample but does not in the full sample is attribute C (Water Lost Through Leaks), but it is not significant at the level of 5 per cent significance.[55]

4.3.3. Estimated values of WTP for main model

We run the same conditional logit model as for HH customers to explain the choices made by FBP customers as a function of the incremental improvements in service of each attribute of the package and the overall cost of the package.[56]

The WTP estimates for the different service levels of the attributes are reported in Table 4.5 and Table 4.6. As for the HH customers, the column "Incremental WTP to switch from SQ (£)" shows how future bill payers' WTP changes as service improves or deteriorates from the status quo. So, for instance, the estimate of 9.88 for service level 4 of attribute I (Pollution of watercourses) can be interpreted as FBP being willing to pay, on average, £9.88 for reducing the pollution incidents in Yorkshire caused by YW from 125 to 100 incidents.

The results can be summarized as follows:

- At the 5 per cent significance level, the FBP are WTP for improvements in three attributes:
  - E (Sewage flooding inside properties)
  - G (River Water Quality)
  - I (Pollution of watercourses)
- We also identify positive WTP for three more attributes, although this is not significant at the 5 per cent level:
  - F (Sewage flooding outside properties)
  - H (Sea Water Quality at Yorkshire's Beaches)
  - J (Low Water Pressure)

  The positive estimates for attributes F and H are significant at a 10 per cent level of significance.[57]

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54 The sample size is 81 respondents after excluding the those FBP.

55 The p-value is 0.86.

56 Under this specification, we consider a c. 1 per cent randomly selected subset of the non-selected options (c. 125,000 non-selected options per respondent). We used four different randomly selected samples (four seeds), all of which yielded similar results; the results reported here are the simple average of those four. The number of observations we have from the FBP survey was 113. After excluding respondents that reported implausible bill values (annual bill over £ 1,000), we have 108 observations.

57 The p-values for attributes F and H are 0.09 and 0.08, respectively. On the other hand, the p-value for attribute J is 0.37.

- FBP are not WTP for incremental improvements in five attributes:
  - A (Drinking Water Colour, Taste and Smell)
  - B (Unplanned Interruptions to the Water Supply)
  - C (Water Lost Through Leaks)
  - D (Using Less Water)
  - K (Creating a River Wharfe safe for swimming)

It seems that FBP customers value improvement in attributes related to the environment such as improving river water quality, avoiding pollution of watercourses, and improving seawater quality. Like HH customers, FBP customers are also WTP to reduce the risk of service failures that would have particularly unpleasant consequences (sewage flooding).

It appears that FBP customers may be less willing to pay for improvements in service where the impact of service failure is low (altered water colour/taste/smell, low water pressure, and short unplanned interruptions).

FBP are also not willing to pay to reduce water lost through leaks, using less water or creating River Wharfe safe for swimming. Regarding the last two attributes, we identified some customer comments that suggest, for example, that *"customers should be encouraged to save water (…) but this shouldn't be reflected by raising the bills of everyone*" and *"it doesm't impact me"*, respectively.

The main differences in the results between FBP and HH customers are the following:

- The positive WTP for attribute G (River Water Quality) is now significant at 5 per cent of significance, even when the sample is considerably smaller. This result suggests that FBP customers have a stronger preference for incremental improvements in this attribute.
- FBP customers are not WTP for reducing the water lost through leaks.

Table 4.3: WTP Estimates for Attributes A-F (FBP Linear Model)

Attribute		Service Level	Incremental WTP to Switch from SQ (£)
A	Drinking Water Colour, Taste and Smell	13 contacts per 10,000 customers	0.00
		12 contacts per 10,000 customers	0.00
		11 contacts per 10,000 customers	
		10 contacts per 10,000 customers	0.00
		9 contacts per 10,000 customers	0.00
B	Unplanned Interruptions to the Water Supply	55,000 properties interrupted	0.00
		50,000 properties interrupted	0.00
		46,000 properties interrupted	
		41,000 properties interrupted	0.00
		36,000 properties interrupted	0.00
C	Water Lost Through Leaks	315 million litres per day (26.3% of water supplied)	0.00
		290 million litres per day (24.2% of water supplied)	0.00
		283 million litres per day (23.6% of water supplied)	
		268 million litres per day (22.3% of water supplied)	0.00
		239 million litres per day (19.9% of water supplied)	0.00
D	Using Less Water		
		133 litres per person per day	0.00
		132 litres per person per day	
		125 litres per person per day	0.00
		117 litres per person per day	0.00
E	Sewage flooding inside properties	1,120 properties flooded	-41.00
		780 properties flooded	-10.70
		660 properties flooded	
		550 properties flooded	9.81
		310 properties flooded	31.20
F	Sewage flooding outside properties	7,100 properties flooded	-23.54
		5,000 properties flooded	-3.77
		4,600 properties flooded	
		4,400 properties flooded	1.88
		3,700 properties flooded	8.48

Source: NERA analysis of WTP survey data.

Table 4.4: WTP Estimates for Attributes G-K (FBP Linear Model)

Attribute		Service Level	Incremental WTP to Switch from SQ (£)
G	River Water Quality	0km of 742km	-13.48
		25km of 742km	-6.74
		50km of 742km	
		70km of 742km	5.39
		150km of 742km	26.95
H	Sea Water Quality at Yorkshire's Beaches	12 of 18	-18.18
		14 of 18	-9.09
		16 of 18	
		18 of 18	9.09
I	Pollution of watercourses	175 incidents	-19.76
		165 incidents	-15.81
		125 incidents	
		100 incidents	9.88
		85 incidents	15.81
J	Low Water Pressure	14 properties affected	-12.85
		9 properties affected	-6.43
		4 properties affected	
		2 properties affected	2.57
		0 properties affected	5.14
K	Creating a River Wharfe safe for swimming		
		No – do not make this investment	
		Yes – do make this investment	0.00

Source: NERA analysis of WTP survey data.

4.4. Results for Non-Household Customers

In this section, we examine NHH customers' WTP for service changes. As for HH costumers, we examine WTP estimates from a linear model, to evaluate whether there is willingness to pay for incremental improvements in service for the different attributes.

We also consider the implications of the "Deteriorations Model", and of the model excluding respondents with protest attitudes.

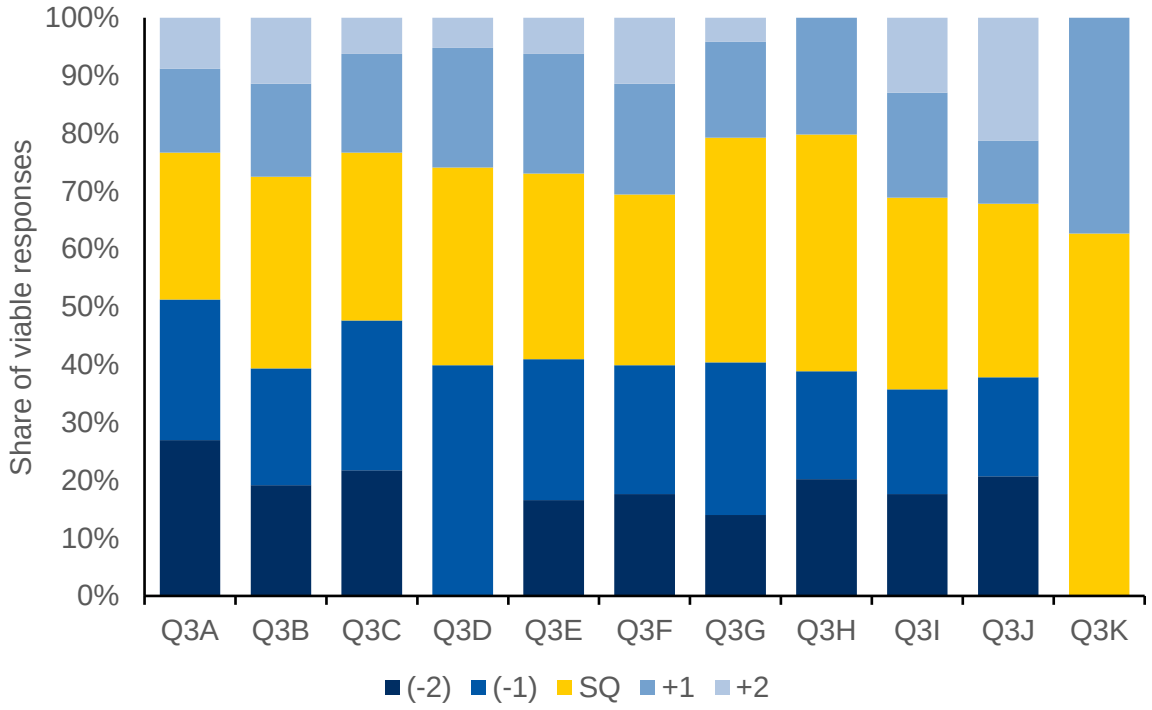
4.4.1. Descriptive statistics on non-household customer choices

In this section we explore the choices made by NHH customers for each attribute.

Figure 4.5 shows that NHH customers do not exhibit clear preferences for improvements for any attribute; there is no attribute for which most NHH customers chose the improvement options (options 4 and 5). Moreover, except for attribute K (Creating a River Wharfe safe for swimming), which has only two alternatives, the improvement options were never selected by more than one-third of the respondents.

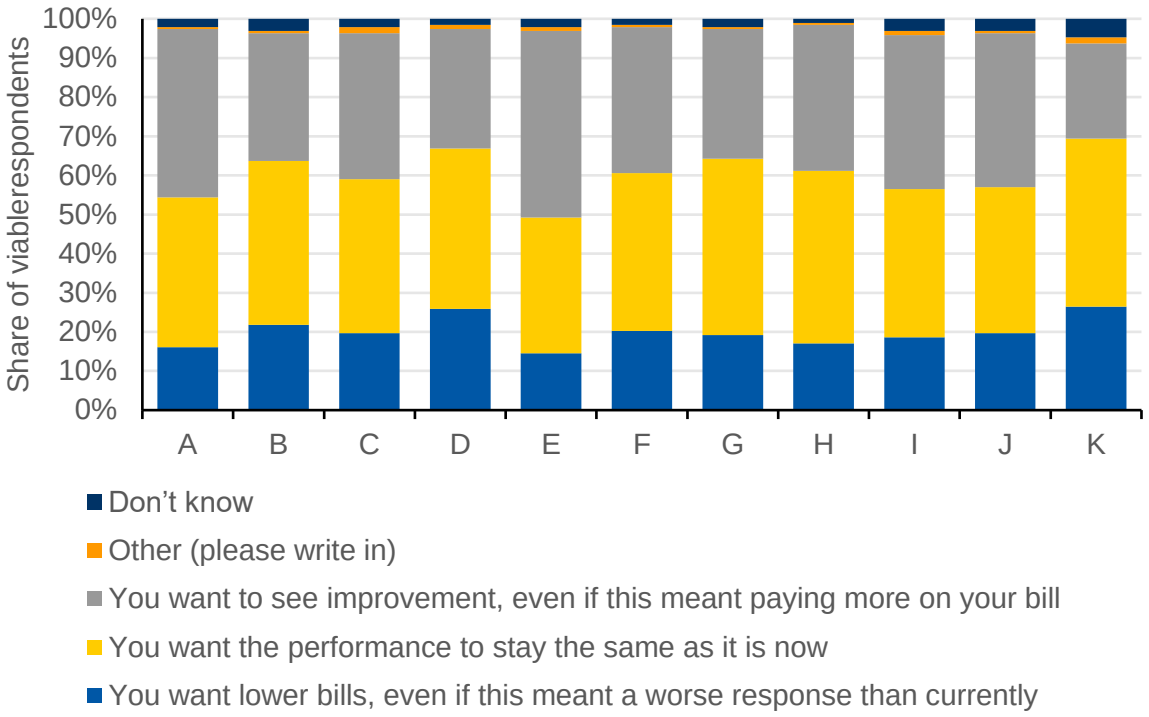
When asked about their preferences in the abstract, NHH customers most frequently chose the option "You want the performance to stay the same as it is now" for seven of the 11 attributes. For the remaining four attributes i.e. attributes A (Drinking Water Colour, Taste and Smell), E (Sewage flooding inside properties), I (Pollution of watercourses), and J (Low Water Pressure), the most chosen option was "You want to see improvement, even if this meant paying more on your bill". However, this option never reaches 50 per cent (see Figure 4.6).

Figure 4.5: The Improvement Options Are Not the Most Preferred by NHH Customers for Any of the Attributes



Source: NERA analysis of WTP survey data.

Figure 4.6: For Most Attributes, NHH Customers Want Performance to Stay the Same



Source: NERA analysis of WTP survey data.

4.4.2. Summary of willingness to pay results

For NHH customers, we only identify positive WTP for one attribute, attribute H (Sea Water Quality at Yorkshire's Beaches). However, none of our WTP estimates are significant at the 5 per cent significance level.

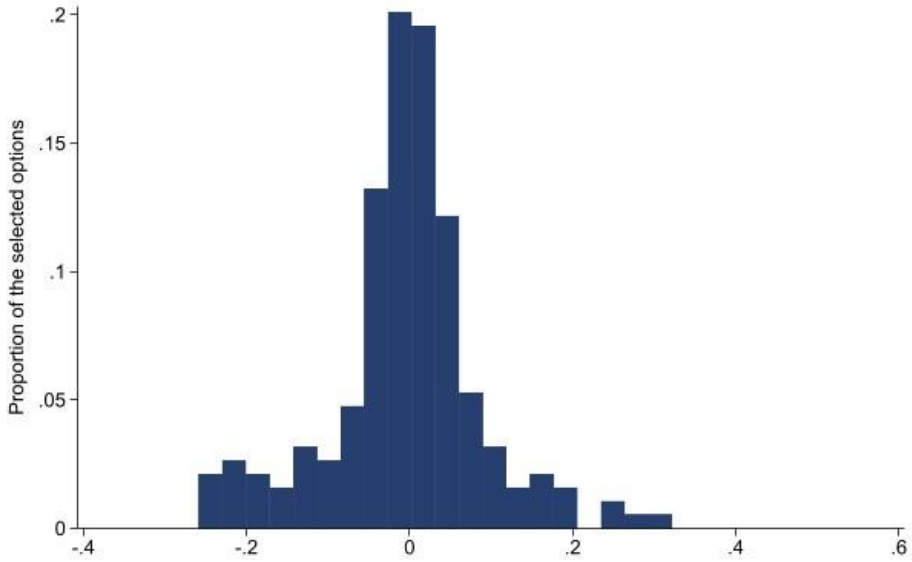
We find a similar result for the model estimated on the sample excluding those with protest attitudes, that is, positive WTP for attribute H only and a lack of statistical significance. For the "Deteriorations Model", we find positive WTP for all attributes but again an overall lack of statistical significance. We discuss these results in more detail in Appendix A.3.

The positive WTP for attribute H may, in part, be due to the fact that we are estimating a single per-unit valuation across the full range of deteriorations and improvements and so the estimated value reflects a combination of preferences to avoid deterioration and preferences for improvement. In particular for attribute H, since there is only one option for improvement that is quite similar to the status quo option, the single valuation that we estimate may be more influenced by preferences over deterioration options than preferences over improvement options. Therefore, we recommend that YW exercise caution in using this valuation alone to justify investment, and instead consider using a triangulated value that also accounts for other evidence on NHH customer preferences regarding this attribute.

The lack of statistical significance may be driven by the fact that NHH respondents do not have consistent preferences on changes in their bill across the full range of possible bill changes. They are averse to an increase in bills but also do not have a strong preference to see a reduction in the bill, as suggested by the fact that the chosen bundles have a cost centred

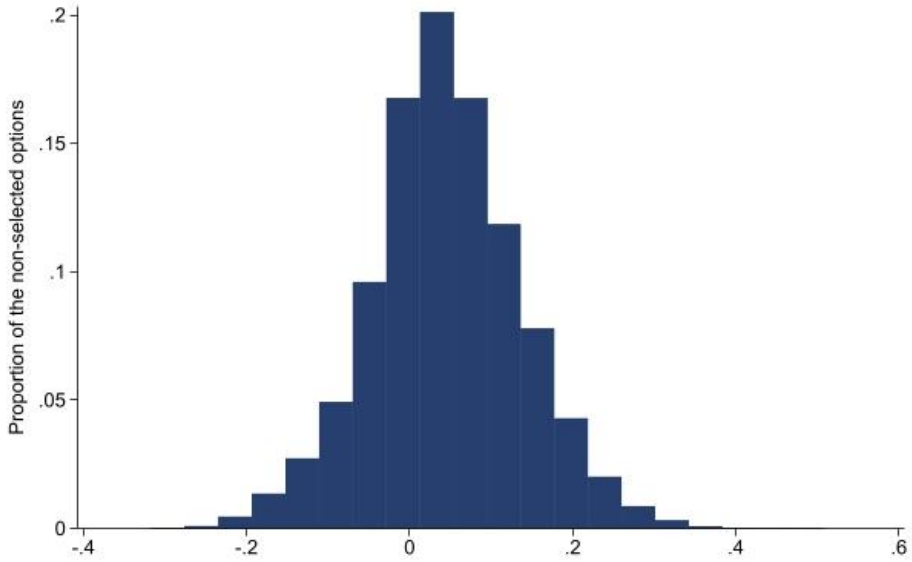
on zero (see Figure 4.7), even though the offered bundles have a cost centre at the right of zero (see Figure 4.8). If, on average, customers' highest priority was a reduction in their bill, we would expect them to select options so that the distribution of cost for selected bundles would be centered on a negative number.

Figure 4.7: NHH Customers' Selected Bundles Are Concentrated Close to Zero



Source: NERA analysis of WTP survey data.

Figure 4.8: The Bundles Presented to NHH Customers Have a Positive Mean Percent Cost Impact



Source: NERA analysis of WTP survey data.

In addition, we analyse the free text responses and find that many NHH respondents report that they *can not afford* an increase in their bills, or that due to the current economic situation they *"wouldn't choose to do anything that would unnecessarily increase the companies outgoings at this moment in time"*.

Although in general a lack of statistical significance can be a consequence of a small sample size, the sample size cannot fully explain the lack of statistical significance here. The FBP sample is smaller than the NHH sample, and yet we find significant WTP for several attributes when estimating the same model on the FBP sample, as explained in Section 4.3.

4.4.3. Estimated values of WTP for main model

There are two main differences in how we estimate the model for the NHH sample as compared to the HH sample:

- Due to the limited sample size for non-household customers (i.e. 193 surveys), we are able to use a larger number of non-selected options. We use a c. 1 per cent randomly selected subset of the non-selected options (c. 125,000 non selected options per respondent).
- Instead of using the level of the costs associated with respondents' choices, we now explain utility as a function of the cost of respondents' choices relative to their bill size (i.e. in percentage terms). Specifically, we use the percentage increase in cost relative to the reported bill amount, rather than the pound value of the change in costs. This alternative specification is required because non-household bill sizes (and thus costs associated with changes in service levels for a given attributes) vary much more across customers than household bill sizes.[58]

Because of the second point above, the interpretation of the conditional logit coefficients and WTP estimates slightly changes. Looking at column " Incremental WTP to switch from SQ (% point change in bill)" for attribute H (Sea Water Quality at Yorkshire's Beaches), for instance, the interpretation of the figures shown in the table is as follows:

- The estimate of 0.27 per cent for service level 4 (18 of 18) means that customers would be willing to pay, on average, the equivalent of 0.27 per cent of their current bill for an increase from 16 to 18 out of 18 beaches in Yorkshire with quality of the sea water rated as "excellent" or "good".
- The estimate of -0.27 per cent for service level 2 (14 of 18) means that, on average, customers would need to be compensated with the equivalent of 0.27 per cent of their current bill for a reduction in service from 16 to 14 beaches in Yorkshire with water rated as "excellent" or "good".

As we can see in Table 4.5 and Table 4.6, customers are WTP for incremental improvements for only one attribute, attribute H (Sea Water Quality at Yorkshire's Beaches). However, this positive WTP estimate is not significant at the significance level of 5 per cent.

[58] In the sample used for HH analysis, the annual bill amount varies between £50 to £1,000. On the other hand, for NHH, the annual bill amount varies between £180 and £2,600,000.

Table 4.5: WTP Estimates for Attributes A-F (NHH Linear Model)

Attribute		Service Level	Incremental WTP to switch from SQ (% point change in bill)
A	Drinking Water Colour, Taste and Smell	13 contacts per 10,000 customers	0.00
		12 contacts per 10,000 customers	0.00
		11 contacts per 10,000 customers	
		10 contacts per 10,000 customers	0.00
		9 contacts per 10,000 customers	0.00
B	Unplanned Interruptions to the Water Supply	55,000 properties interrupted	0.00
		50,000 properties interrupted	0.00
		46,000 properties interrupted	
		41,000 properties interrupted	0.00
		36,000 properties interrupted	0.00
C	Water Lost Through Leaks	315 million litres per day (26.3% of water supplied)	0.00
		290 million litres per day (24.2% of water supplied)	0.00
		283 million litres per day (23.6% of water supplied)	
		268 million litres per day (22.3% of water supplied)	0.00
		239 million litres per day (19.9% of water supplied)	0.00
D	Using Less Water		
		133 litres per person per day	0.00
		132 litres per person per day	
		125 litres per person per day	0.00
		117 litres per person per day	0.00
E	Sewage flooding inside properties	1,120 properties flooded	0.00
		780 properties flooded	0.00
		660 properties flooded	
		550 properties flooded	0.00
		310 properties flooded	0.00
F	Sewage flooding outside properties	7,100 properties flooded	0.00
		5,000 properties flooded	0.00
		4,600 properties flooded	
		4,400 properties flooded	0.00
		3,700 properties flooded	0.00

Source: NERA analysis of WTP survey data.

Table 4.6: WTP Estimates for Attributes G-K (NHH Linear Model)

Attribute		Service Level	Incremental WTP to switch from SQ (% point change in bill)
G	River Water Quality	0km of 742km	0.00
		25km of 742km	0.00
		50km of 742km	
		70km of 742km	0.00
		150km of 742km	0.00
H	Sea Water Quality at Yorkshire's Beaches	12 of 18	-0.54
		14 of 18	-0.27
		16 of 18	
		18 of 18	0.27
I	Pollution of watercourses	175 incidents	0.00
		165 incidents	0.00
		125 incidents	
		100 incidents	0.00
		85 incidents	0.00
J	Low Water Pressure	14 properties affected	0.00
		9 properties affected	0.00
		4 properties affected	
		2 properties affected	0.00
		0 properties affected	0.00
K	Creating a River Wharfe safe for swimming	No – do not make this investment	
		Yes – do make this investment	0.00

Source: NERA analysis of WTP survey data.

5. Conclusion

5.1. Conclusions on Performance of the Survey

In this stated preference study, we have adopted an innovative approach that addresses concerns raised by Ofwat and CCW at PR19 about the reliability of estimates of customer WTP from traditional stated preference studies.

Specifically:

- By asking respondents about one attribute at a time and describing the attribute at the same time that the customer is asked to make a decision, we reduce the cognitive burden on the customer. Most respondents to this survey reported that they did not find it very difficult to understand either the attributes or the options presented for each attribute.
- Because we give respondents the opportunity to construct their preferred package rather than asking them to choose between pre-defined packages, our approach actively engages with customers on the choices YW faces in developing its business plan, so the context for the questions accurately reflects the intended use of our results.
- Most respondents accept the premise of the study (i.e. that for service levels to improve, customer bills must increase) and engage effectively with the choice exercise on that basis, as demonstrated by the fact that less than one-quarter of respondents exhibit protest attitudes.

Further, we have confidence that the sample is reasonably representative of the YW customer base and consequently that YW can view the results of the study as informative about the average preferences of its customers. Our HH customer sample is in line with the target quotas we set for demographic and billing characteristics, based on information provided by YW about its customer base. We did not set quotas for the FBP and NHH customer samples, but the collected data includes a reasonable cross-section of the YW customer base on relevant demographic and billing characteristics (for FBP) or firm size and industry (for NHH).

5.2. Summary of Willingness to Pay Estimates

We identify a number of key themes from our analysis of the results of the WTP models that we estimated.

Domestic customers (i.e. HH customers and FBP customers) are, on average, WTP for improvement in service for a number of attributes. These are attributes that relate to protecting the environment, reducing the risk of service failures that would have particularly unpleasant consequences (such as sewage flooding), and reducing leakage (which has received substantial media attention).

There are some differences in preferences among household customers.

- Customers who typically engage in water-based recreational activities are willing to pay for service improvements that protect the environment and could be expected to enhance their enjoyment of these activities, whereas customers who do not engage in such activities are not willing to pay for these service improvements.

- Vulnerable customers and those who are worried about their ability to pay their water bills are less willing to pay for improvements in service than the average household customer.

Non-domestic (NHH) customers are less WTP for improvement in service than domestic customers, in the sense that we only identify a positive WTP for improvement in service among NHH customers for one attribute: attribute H (Sea Water Quality at Yorkshire's Beaches). NHH customers have a preference to avoid any changes to the level of their water bill: on average, they choose a combination of service levels that results in a total change to their water bill near zero.

Across all customer groups (i.e. domestic and non-domestic) we observe no willingness to pay for improvement in service for four attributes. Customers are not willing to pay for improvements in service for attributes where the impact of service failure is small (i.e. attribute A, Drinking water colour, taste, and smell; and attribute B, Unplanned interruptions to the water supply). Customers are also not willing to pay to reduce per capita water consumption (attribute D, Using less water) or to create a River Wharfe safe for swimming (attribute K), which may be because they see these as non-essential or because they do not think these improvements would benefit them.

We do, however, observe that – even where customers are not willing to pay for improvement in service – they are typically averse to deterioration in service. That is, if we restrict the analysis to consider only deteriorations in service compared to the status quo (and assume all customers who chose improvements would, if restricted to choose between deteriorations and the status quo, have chosen the status quo option), we observe that customers would require compensation for deterioration in service in the form of a reduction of their bill.

The difference in preferences across customer groups suggests that, if YW were to improve service for all customers with the costs recovered from all customers, some would be made better off (i.e. would see enhanced "utility") while others would be made worse off (lower utility) as they are not willing to pay for improvements. This finding represents a challenge when selecting the improvements YW should offer as part of its business plan when providing "public goods" from which all customers benefit, especially if all customers are constrained by the tariff structure to pay the same contributions to the costs.

This could potentially be addressed through adjusting tariff structures so that the burden of paying the costs for improvements in environmental attributes does not fall on more disadvantaged customers or NHH customers. However, separate research and engagement would be required to develop the tariff mechanisms needed to achieve this. YSW would also need to consider the extent to which such tariff mechanisms are feasible given regulatory constraints.

Appendix A. Further Willingness-to-Pay Results

In this appendix, we describe additional WTP results derived from alternative models to the main specification discussed in the body of the report. We consider two alternative model specifications: a status quo model, that allows for the possibility that customers attach additional value to the status quo, and a deteriorations model, that allows for the possibility that customers are more averse to deterioration than they are willing to pay for improvement. We also consider models estimated on sub-samples of the full sample for each of HH, FBP, and NHH customers, in particular, models excluding those respondents who reported protest attitudes.

A.1. Further Willingness-to-Pay Results for Households Customers

A.1.1. Other WTP models

In addition to the main linear model described in Section 4.1.4, we estimate two other models to understand the sensitivity of the results to the choice of model. These are:

- **Status Quo Model:** The model allows for a common incremental WTP per unit (as the linear model) and an additional "status quo" preference. The additional "status quo" preference captures the value that customers attach to the status quo option over and above the value implied by their incremental preference. We identify a positive status quo preference for all attributes.[59] We identify positive and significant incremental WTP for attributes C, E, F, G, H, and I. However, the customers' status quo preference exceeds the incremental WTP for the proposed improvement options for all attributes.

- **Deterioration Model:** In this model, we limit our attention to the deterioration and status quo service level options, excluding the improvement options. We assume that anyone who chose an improvement would, if limited to choosing between deteriorations and the status quo, have chosen the status quo option. We then re-estimate the linear model considering just the deteriorations and the status quo, re-assigning any improvement choices to be status quo choices (and revising the total bill accordingly). This model allows us to understand whether customers are more averse to deteriorations in service than they are willing to pay for improvement and so serves as a useful "sense-check" in cases where we see negative willingness-to-pay estimates in the other models. For all attributes, this model produces a positive estimate of WTP that is significant at the 5 per cent level. This positive WTP is the amount of compensation that customers would require, per unit of deterioraton from the status quo, to accept that deterioration, where compensation should here be understood as reductions in the average customer's bill. The results suggest that HH customers would need to be compensated for accepting deteriorations of the service for any attribute.[60]

[59] We do not include an additional parameter for status quo preference for Attribute K (Creating a River Wharfe safe for swimming) because it has only two service levels.

[60] Attribute K (Creating a River Wharfe safe for swimming) is not included in this analysis because it only has one improvement option, in addition to the status quo.

A.1.2. Model for customer sub-groups

We estimated the linear model for the HH suample described in Section 4.2 for different sub-groups to assess whether the results change if we restrict the sample to certain sub-groups.

Table A.1, Table A.2, and Table A.3 report the results by gender (male and female) and for the sub-group of respondents who "typically" engage in (they or members of their households) water-based recreational activities.[61]

- In the models for only men and only women, we estimate positive WTP for the same attributes as we do in the model on the full sample. Additionally, women exhibit positive WTP for attribute J (low water pressure).
- We find that individuals who do not "typically" engage in water-based recreational activities exhibit positive WTP for fewer attributes than do individuals who do typically engage in such activities. We observe this difference in WTP for attributes related to water-based recreational activities (attributes G to I), but also for other attributes – attribute C (water lost through leaks), attribute F (sewage flooding outside properties) and attribute J (low water pressure).

Table A.4, Table A.5, and Table A.6 report the result for the sub-group excluding those who exhibit protest attitudes[62], by socio-economic group (ABC1 and C2DE), for the sub-group of respondents that answered the "vulnerable" survey, and for the sub-group of customers that are worried about their water bills or already can not afford them.[63]

- If we restrict our attention to those who do not exhibit protest attitudes or the ABC1 socio-economic group, we see higher WTP than we do for the full sample as reported in Section 4.2.3. We observed that the positive WTP for attribute G becomes significant, and positive (but not significant) WTP for attribute J. For those attributes where there was already positive and significant WTP, the incremental WTP per unit of improvement also increases slightly.
- Conversely, if we restrict our attention to individuals in the C2DE socio-economic group, responses collected from the "vulnerable" survey, or those who report they are worried about their water bills, we see lower WTP than we do for the full sample as reported in Section 4.2.3. Individuals who report they are worried about their water bills do not have positive WTP for any attribute. Individuals who responded through the vulnerable customer survey are only willing to pay for improvement attribute E (sewage flooding inside properties). Individuals in the C2DE socio-economic group are willing to pay for improvements in three attributes: attributes E (sewage flooding inside properties), H (sea water quality at Yorkshire's beaches), and I (pollution of watercourses).

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61 The activities included are: (i) Swim in a UK river/sea (sometimes called wild swimming) (ii) Canoe, kayak or paddle board (SUP) in a UK river/sea (iii) Go leisure boating in a UK river/sea, (iv) Go fishing in a UK river/sea, (v) Go paddling (i.e. up to you knees) in a UK river/sea, (vi) Allow your dog to swim/play in a UK river/sea, and (vii) Visit a UK river/sea for recreation or a day out/holiday.

62 The definition of protest attitudes is set out in Section 3.2.3.2

63 Include respondents that "strongly agree" or "agree" with the statements: (i) "I worry about not being able to afford my water bill" or (ii) "I already can't afford my water bill".

Table A.1: WTP Estimates for Attributes A-D (HH Linear Model, Sub-Groups for Gender and Water Recreation)

Attribute		Service Level	Full Sample		Male		Female		Water Recreation		Non- Recreation	
			WTP to switch SQ (£)	pvalue	WTP to switch SQ (£)	pvalue	WTP to switch SQ (£)	pvalue	WTP to switch SQ (£)	pvalue	WTP to switch SQ (£)	pvalue
A	Drinking water colour, taste and smell	Level 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Level 2	0.00		0.00		0.00		0.00		0.00	
		Level 3										
		Level 4	0.00		0.00		0.00		0.00		0.00	
		Level 5	0.00		0.00		0.00		0.00		0.00	
B	Unplanned interruptions to the water supply	Level 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
		Level 2	0.00		0.00		0.00		0.00		0.00	
		Level 3										
		Level 4	0.00		0.00		0.00		0.00		0.00	
		Level 5	0.00		0.00		0.00		0.00		0.00	
C	Water lost through leaks	Level 1	-5.65	0.01	-9.02	0.01	-3.02	0.32	-15.88	0.00	0.00	0.01
		Level 2	-1.24		-1.97		-0.66		-3.47		0.00	
		Level 3										
		Level 4	2.65		4.23		1.41		7.44		0.00	
		Level 5	7.77		12.41		4.15		21.83		0.00	
D	Using less water			0.00		0.00		0.00		0.00		0.00
		Level 2	0.00		0.00		0.00		0.00		0.00	
		Level 3										
		Level 4	0.00		0.00		0.00		0.00		0.00	
		Level 5	0.00		0.00		0.00		0.00		0.00	

Note: Level 1 = (-2) deterioration, Level 2 = (-1) deterioration, Level 3 = status quo, Level 4 = (+1) improvement, Level 5 = (+2) improvement
Source: NERA analysis of WTP survey data.

Table A.2: WTP Estimates for Attributes E-H (HH Linear Model, Sub-Groups for Gender and Water Recreation)

Attribute		Service Level	Full Sample		Male		Female		Water Recreation		Non-Recreation	
			WTP to switch SQ (£)	pvalue	WTP to switch SQ (£)	pvalue	WTP to switch SQ (£)	pvalue	WTP to switch SQ (£)	pvalue	WTP to switch SQ (£)	pvalue
E	Sewage flooding inside properties	Level 1	-23.18	0.00	-16.73	0.00	-28.92	0.00	-31.09	0.00	-11.79	0.03
		Level 2	-6.05		-4.36		-7.54		-8.11		-3.08	
		Level 3										
		Level 4	5.54		4.00		6.92		7.43		2.82	
		Level 5	17.64		12.73		22.00		23.66		8.97	
F	Sewage flooding outside properties	Level 1	-13.03	0.00	-7.65	0.17	-17.57	0.00	-25.16	0.00	0.00	0.30
		Level 2	-2.09		-1.22		-2.81		-4.03		0.00	
		Level 3										
		Level 4	1.04		0.61		1.41		2.01		0.00	
		Level 5	4.69		2.75		6.32		9.06		0.00	
G	River water quality	Level 1	-3.28	0.10	-4.70	0.10	-2.38	0.38	-7.80	0.00	0.00	0.44
		Level 2	-1.64		-2.35		-1.19		-3.90		0.00	
		Level 3										
		Level 4	1.31		1.88		0.95		3.12		0.00	
		Level 5	6.55		9.39		4.76		15.60		0.00	
H	Sea water quality at Yorkshire's beaches	Level 1	-20.75	0.00	-24.73	0.00	-17.64	0.00	-36.25	0.00	0.00	0.17
		Level 2	-10.38		-12.36		-8.82		-18.12		0.00	
		Level 3										
		Level 4	10.38		12.36		8.82		18.12		0.00	

Note: Level 1 = (-2) deterioration, Level 2 = (-1) deterioration, Level 3 = status quo, Level 4 = (+1) improvement, Level 5 = (+2) improvement
Source: NERA analysis of WTP survey data.

Table A.3: WTP Estimates for Attributes I-K (HH Linear Model, Sub-Groups for Gender and Water Recreation)

Attribute		Service Level	Full Sample		Male		Female		Water Recreation		Non- Recreation	
			WTP to switch SQ (£)	pvalue	WTP to switch SQ (£)	pvalue	WTP to switch SQ (£)	pvalue	WTP to switch SQ (£)	pvalue	WTP to switch SQ (£)	pvalue
I	Pollution of watercourses	Level 1	-14.23	0.00	-14.75	0.00	-13.61	0.00	-23.91	0.00	0.00	0.42
		Level 2	-11.38		-11.80		-10.89		-19.13		0.00	
		Level 3										
		Level 4	7.12		7.37		6.80		11.96		0.00	
		Level 5	11.38		11.80		10.89		19.13		0.00	
J	Low water pressure	Level 1	0.00	0.08	0.00	0.01	-1.97	0.71	-2.03	0.68	0.00	0.00
		Level 2	0.00		0.00		-0.98		-1.01		0.00	
		Level 3										
		Level 4	0.00		0.00		0.39		0.41		0.00	
		Level 5	0.00		0.00		0.79		0.81		0.00	
K	Creating a river wharf safe for swimming			0.00		0.00		0.00		0.00		0.00
		Level 3										
		Level 4	0.00		0.00		0.00		0.00		0.00	

Note: Level 1 = (-2) deterioration, Level 2 = (-1) deterioration, Level 3 = status quo, Level 4 = (+1) improvement, Level 5 = (+2) improvement
Source: NERA analysis of WTP survey data.

Table A.4: WTP Estimates for Attributes A-D (HH Linear Model, Sub-Groups for Socioeconomic Status and Vulnerability)

			Exclude Protest		ABC1		C2DE		Vulnerable		Worried Water Bills	
Attribute		**Service Level**	**WTP to switch SQ (£)**	**pvalue**	**WTP to switch SQ (£)**	**pvalue**	**WTP to switch SQ (£)**	**pvalue**	**WTP to switch SQ (£)**	**pvalue**	**WTP to switch SQ (£)**	**pvalue**
A	Drinking water colour, taste and smell	Level 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00
		Level 2	0.00		0.00		0.00		0.00		0.00	
		Level 3										
		Level 4	0.00		0.00		0.00		0.00		0.00	
		Level 5	0.00		0.00		0.00		0.00		0.00	
B	Unplanned interruptions to the water supply	Level 1	0.00	0.45	0.00	0.22	0.00	0.00	0.00	0.07	0.00	0.00
		Level 2	0.00		0.00		0.00		0.00		0.00	
		Level 3										
		Level 4	0.00		0.00		0.00		0.00		0.00	
		Level 5	0.00		0.00		0.00		0.00		0.00	
C	Water lost through leaks	Level 1	-17.12	0.00	-19.96	0.00	0.00	0.02	0.00	0.05	0.00	0.00
		Level 2	-3.74		-4.37		0.00		0.00		0.00	
		Level 3										
		Level 4	8.02		9.36		0.00		0.00		0.00	
		Level 5	23.54		27.45		0.00		0.00		0.00	
D	Using less water			0.00		0.00		0.00		0.05		0.00
		Level 2	0.00		0.00		0.00		0.00		0.00	
		Level 3										
		Level 4	0.00		0.00		0.00		0.00		0.00	
		Level 5	0.00		0.00		0.00		0.00		0.00	

Note: Level 1 = (-2) deterioration, Level 2 = (-1) deterioration, Level 3 = status quo, Level 4 = (+1) improvement, Level 5 = (+2) improvement
Source: NERA analysis of WTP survey data.

Table A.5: WTP Estimates for Attributes E-H (HH Linear Model, Sub-Groups for Socioeconomic Status and Vulnerability)

			Exclude Protest		ABC1		C2DE		Vulnerable		Worried Water Bills	
Attribute		**Service Level**	**WTP to switch SQ (£)**	**pvalue**	**WTP to switch SQ (£)**	**pvalue**	**WTP to switch SQ (£)**	**pvalue**	**WTP to switch SQ (£)**	**pvalue**	**WTP to switch SQ (£)**	**pvalue**
E	Sewage flooding inside properties	Level 1	-36.50	0.00	-35.96	0.00	-11.28	0.03	-8.54	0.50	0.00	0.31
		Level 2	-9.52		-9.38		-2.94		-2.23		0.00	
		Level 3										
		Level 4	8.73		8.60		2.70		2.04		0.00	
		Level 5	27.77		27.36		8.58		6.50		0.00	
F	Sewage flooding outside properties	Level 1	-34.20	0.00	-35.88	0.00	0.00	0.23	0.00	0.33	0.00	0.03
		Level 2	-5.47		-5.74		0.00		0.00		0.00	
		Level 3										
		Level 4	2.74		2.87		0.00		0.00		0.00	
		Level 5	12.31		12.92		0.00		0.00		0.00	
G	River water quality	Level 1	-10.10	0.00	-8.80	0.00	0.00	0.45	0.00	0.36	0.00	0.06
		Level 2	-5.05		-4.40		0.00		0.00		0.00	
		Level 3										
		Level 4	4.04		3.52		0.00		0.00		0.00	
		Level 5	20.20		17.60		0.00		0.00		0.00	
H	Sea water quality at Yorkshire's beaches	Level 1	-39.21	0.00	-40.82	0.00	-3.02	0.50	0.00	0.67	0.00	0.06
		Level 2	-19.60		-20.41		-1.51		0.00		0.00	
		Level 3										
		Level 4	19.60		20.41		1.51		0.00		0.00	

Note: Level 1 = (-2) deterioration, Level 2 = (-1) deterioration, Level 3 = status quo, Level 4 = (+1) improvement, Level 5 = (+2) improvement
Source: NERA analysis of WTP survey data.

Table A.6: WTP Estimates for Attributes I-K (HH Linear Model, Sub-Groups for Socioeconomic Status and Vulnerability)

			Exclude Protest		ABC1		C2DE		Vulnerable		Worried Water Bills	
Attribute		**Service Level**	**WTP to switch SQ (£)**	**pvalue**	**WTP to switch SQ (£)**	**pvalue**	**WTP to switch SQ (£)**	**pvalue**	**WTP to switch SQ (£)**	**pvalue**	**WTP to switch SQ (£)**	**pvalue**
I	Pollution of watercourses	Level 1	-25.90	0.00	-24.04	0.00	-5.37	0.10	0.00	0.84	0.00	0.37
		Level 2	-20.72		-19.23		-4.30		0.00		0.00	
		Level 3										
		Level 4	12.95		12.02		2.69		0.00		0.00	
		Level 5	20.72		19.23		4.30		0.00		0.00	
J	Low water pressure	Level 1	-11.73	0.01	-0.55	0.92	0.00	0.02	0.00	0.13	0.00	0.01
		Level 2	-5.86		-0.28		0.00		0.00		0.00	
		Level 3										
		Level 4	2.35		0.11		0.00		0.00		0.00	
		Level 5	4.69		0.22		0.00		0.00		0.00	
K	Creating a river wharf safe for swimming			0.00		0.00		0.00		0.04		0.00
		Level 3										
		Level 4	0.00		0.00		0.00		0.00		0.00	

Note: Level 1 = (-2) deterioration, Level 2 = (-1) deterioration, Level 3 = status quo, Level 4 = (+1) improvement, Level 5 = (+2) improvement
Source: NERA analysis of WTP survey data.

A.2. Further Willingness-to-Pay Results for Future Bill Payers

A.2.1. Other WTP models

As for HH customers, we estimate both a status quo model and a deteriorations model.

- **Status Quo Model:** We identify a positive and significant (at the 5 per cent level) status quo preference for attributes A, E, G, H, and I. We also find positive and significant incremental WTP for attributes E, G, and I. However, the customers' status quo preference exceeds the incremental WTP for the proposed improvement options for these attributes.
- **Deterioration Model:** FBP customers have positive WTP for all attributes, which is significant at a level of 5 per cent of significance for attributes C, E, F, G, H and I. This suggests that FBP customers are averse to deterioration in service for all attributes.

A.2.2. Model excluding customers with protest attitudes

We do not estimate WTP models for sub-groups of FBP customers defined on demographic or socio-economic characteristics, as the small total sample size would make it impossible to interpret the results with any degree of certainty.

However, we do have a sufficient number of respondents who do not exhibit protest attitudes that it is feasible to estimate the model on this sub-group. We report the results of these models in Table A.7 and Table A.8. Overall, the WTP of FBP customers that do not have protest attitudes is similar to the WTP of the full FBP sample, as reported in Section 4.3. We identify WTP that is positive and significant, at 5 per cent level of significance, for only two attributes:

- E (Sewage flooding inside properties)
- G (River water quality)

We also identify positive WTP for the following attributes:

- C (Water Lost Through Leaks)
- F (Sewage flooding outside properties)
- H (Sea Water Quality at Yorkshire's Beaches)
- I (Pollution of watercourses)
- J (Low Water Pressure)

The estimates for attributes F, H, and I are significant at a level of 10 per cent of significance.[64]

[64] Their p-values are 0.06, 0.10 and 0.07, respectively.

Table A.7: WTP Estimates for Attributes A-F (FBP Linear Model, Excluding Protest Attitudes)

Attribute		Service Level	Incremental WTP to switch from SQ (£)
A	Drinking Water Colour, Taste and Smell	13 contacts per 10,000 customers	0.00
		12 contacts per 10,000 customers	0.00
		11 contacts per 10,000 customers	
		10 contacts per 10,000 customers	0.00
		9 contacts per 10,000 customers	0.00
B	Unplanned Interruptions to the Water Supply	55,000 properties interrupted	0.00
		50,000 properties interrupted	0.00
		46,000 properties interrupted	
		41,000 properties interrupted	0.00
		36,000 properties interrupted	0.00
C	Water Lost Through Leaks	315 million litres per day (26.3% of water supplied)	-0.79
		290 million litres per day (24.2% of water supplied)	-0.17
		283 million litres per day (23.6% of water supplied)	
		268 million litres per day (22.3% of water supplied)	0.37
		239 million litres per day (19.9% of water supplied)	1.08
D	Using Less Water		
		133 litres per person per day	0.00
		132 litres per person per day	
		125 litres per person per day	0.00
		117 litres per person per day	0.00
E	Sewage flooding inside properties	1,120 properties flooded	-37.35
		780 properties flooded	-9.74
		660 properties flooded	
		550 properties flooded	8.93
		310 properties flooded	28.42
F	Sewage flooding outside properties	7,100 properties flooded	-44.06
		5,000 properties flooded	-7.05
		4,600 properties flooded	
		4,400 properties flooded	3.52
		3,700 properties flooded	15.86

Source: NERA analysis of WTP survey data.

Table A.8: WTP Estimates for Attributes G-K (FBP Linear Model, Excluding Protest Attitudes)

Attribute	Service Level	Incremental WTP to

			switch from SQ (£)
G	River Water Quality	0km of 742km	-15.47
		25km of 742km	-7.73
		50km of 742km	
		70km of 742km	6.19
		150km of 742km	30.93
H	Sea Water Quality at Yorkshire's Beaches	12 of 18	-23.46
		14 of 18	-11.73
		16 of 18	
		18 of 18	11.73
I	Pollution of watercourses	175 incidents	-20.06
		165 incidents	-16.05
		125 incidents	
		100 incidents	10.03
		85 incidents	16.05
J	Low Water Pressure	14 properties affected	-13.34
		9 properties affected	-6.67
		4 properties affected	
		2 properties affected	2.67
		0 properties affected	5.34
K	Creating a River Wharfe safe for swimming	No – do not make this investment	
		Yes – do make this investment	0.00

Source: NERA analysis of WTP survey data.

A.3. Further Willingness-to-Pay Results for Non-Households Customers

A.3.1. Other WTP models

As for HH and FBP customers, we estimate both a status quo model and a deteriorations model. For both models, we do not observe statistical significance for any WTP coefficients. This is due to the fact that NHH customers do not exhibit a consistent preference regarding changes to their bill, as explained in Section 4.4.

- **Status Quo Model:** The results for the status quo model are similar to the results for the main model described in Section 4.4. We find positive incremental WTP for one attribute only, attribute H (sea water quality at Yorkshire's beaches). We observe a positive status quo preference for attribute H that exceeds the preference for improvement. For all attributes except attribute D (using less water) we observe a positive preference for the status quo. For all attributes except attribute A (drinking water colour, taste, and smell) this status quo preference is sufficient to outweigh any preference for deterioration implied by the negative incremental WTP. This suggests that customers are averse to deterioration in service for all attributes except A and D.
- **Deterioration Model:** We find that NHH customers are averse to deteriorations in service for all attributes in that we estimate positive WTP coefficients from the deteriorations model.

A.3.2. Model excluding customers with protest attitudes

We do not estimate WTP models for sub-groups of NHH customers defined on size or SIC, as the small total sample size would make it impossible to interpret the results with any degree of certainty.

However, we do have a sufficient number of respondents who do not exhibit protest attitudes that it is feasible to estimate the model on this sub-group. Excluding the respondents with protest attitudes has little impact on the NHH results. We still find positive, but not significant, WTP only for attribute H (Sea water quality at Yorkshire's beaches), as shown in Table A.9 and Table A.10.

Table A.9: WTP Estimates for Attributes A-F (NHH Linear Model, Excluding Protest Attitudes)

Attribute		Service Level	Incremental WTP to switch from SQ (% point change in bill)
A	Drinking Water Colour, Taste and Smell	13 contacts per 10,000 customers	0.00
		12 contacts per 10,000 customers	0.00
		11 contacts per 10,000 customers	
		10 contacts per 10,000 customers	0.00
		9 contacts per 10,000 customers	0.00
B	Unplanned Interruptions to the Water Supply	55,000 properties interrupted	0.00
		50,000 properties interrupted	0.00
		46,000 properties interrupted	
		41,000 properties interrupted	0.00
		36,000 properties interrupted	0.00
C	Water Lost Through Leaks	315 million litres per day (26.3% of water supplied)	0.00
		290 million litres per day (24.2% of water supplied)	0.00
		283 million litres per day (23.6% of water supplied)	
		268 million litres per day (22.3% of water supplied)	0.00
		239 million litres per day (19.9% of water supplied)	0.00
D	Using Less Water		
		133 litres per person per day	0.00
		132 litres per person per day	
		125 litres per person per day	0.00
		117 litres per person per day	0.00
E	Sewage flooding inside properties	1,120 properties flooded	0.00
		780 properties flooded	0.00
		660 properties flooded	
		550 properties flooded	0.00
		310 properties flooded	0.00
F	Sewage flooding outside properties	7,100 properties flooded	0.00
		5,000 properties flooded	0.00
		4,600 properties flooded	
		4,400 properties flooded	0.00
		3,700 properties flooded	0.00

Source: NERA analysis of WTP survey data.

Table A.10: WTP Estimates for Attributes G-K (NHH Linear Model, Excluding Protest Attitudes)

Attribute		Service Level	Incremental WTP to switch from SQ (% point change in bill)
G	River Water Quality	0km of 742km	0.00
		25km of 742km	0.00
		50km of 742km	
		70km of 742km	0.00
		150km of 742km	0.00
H	Sea Water Quality at Yorkshire's Beaches	12 of 18	-0.55
		14 of 18	-0.28
		16 of 18	
		18 of 18	0.28
I	Pollution of watercourses	175 incidents	0.00
		165 incidents	0.00
		125 incidents	
		100 incidents	0.00
		85 incidents	0.00
J	Low Water Pressure	14 properties affected	-0.16
		9 properties affected	-0.08
		4 properties affected	
		2 properties affected	0.03
		0 properties affected	0.06
K	Creating a River Wharfe safe for swimming	No – do not make this investment	
		Yes – do make this investment	0.00

Source: NERA analysis of WTP survey data.

Appendix B. Further Descriptive Statistics

We examined whether the level of understanding of the survey varied among different non-domestic customers, and in particular whether vulnerable customers had difficulty understanding the survey. We did not find evidence that vulnerable customers had more difficulty understanding the survey than other customers. Table B.1 shows that just 13 per cent of HH customers whose responses were collected through the face-to-face survey lacked understanding of the survey, in line with those whose responses were collected through the main and pilot surveys. Table B.2 shows that just 15 per cent of C2DE customers in the HH sample lacked understanding, similar to the percentage of ABC1 customers who lacked understanding. Table B.3 shows that among FBP customers, those from a higher socio-economic background (ABC1) had more difficulty understanding the survey than those from a lower socio-economic background (C2DE).

Table B.1: HH Customers' Understanding of the Survey is Similar Across Survey Types

	Lack understanding	Total	%
F2F – Vulnerable	24	184	13%
Main	185	1282	14%
Pilot	26	200	13%
Total	**235**	**1666**	**14%**

Source: NERA analysis

Table B.2: HH Customers' Understanding of the Survey is Similar Across Socio-economic Groups

	Lack understanding	Total	%
ABC1	113	880	13%
C2DE	113	758	15%
Don't know/prefer not to say	9	28	32%
Total	**235**	**1666**	**14%**

Source: NERA analysis

Table B.3: FBP Customers in the C2DE Socioeconomic Group Report Better Understanding of the Survey than Those in the ABC1 Group

	Lack understanding	Total	%
ABC1	16	59	27%
C2DE	7	46	15%
Don't know/prefer not to say	2	8	25%
Total	**25**	**113**	**22%**

Source: NERA analysis

Appendix C. Specification of Service Levels in Regression Model

In order to estimate the conditional logit models described in Section 4.1.4, we convert the service levels for each attribute set out in Table 2.3 into numeric values suitable for estimation. We adopt the following process:

1. We set the status quo as the reference service level, so the numeric value for the status quo service level is always equal to zero.

2. We define the units of the numeric values so that improvements are always positive and deteriorations are always negative. For example, for attribute D (using less water) we define the units of the numeric value to be the *reduction* in litres of water used per person per day, relative to the status quo, as shown in Table C.1 below.

Table C.1: Conversion of Attribute D Service Levels to Numeric Values for Estimation

	Larger Reduction (-2)	**Small Reduction (-1)**	**Current Level (0)**	**Small Improvement (+1)**	**Larger Improvement (+2)**
Service Levels Shown to Customers	-	133 litres per person per day	132 litres per person per day	125 litres per person per day	117 litres per person per day
Conversion to Numeric Values Used in Estimation	n/a	=132-133	=132-132	=132-125	=132-117
Numeric Values Used in Estimation	n/a	-1	0	7	15

Source: NERA analysis

3. The service levels shown to customers for different attributes can involve units on very different scales. For example, attribute B (unplanned interruptions to the water supply) is in tens of thousands of interruptions,attribute D (using less water) is in single litres. The algorithm that estimates the conditional logit model performs better when variables are on similar scales, and so we convert all the attributes to be in units on the order of 1 or 10. The final numeric values of each attribute used in estimation are shown in Table C.2 below.

When we calculate the final WTP for each of the service levels as reported in, for example, Table 2 and Table 3, we convert back from the numeric units used in estimation (shown in Table C.2) to the units used to display the service levels to customers.

Table C.2: Numeric Values for Estimation for All Attributes

Attribute		Service levels for Estimation -2	-1	Status Quo	+1	+2	units
A	Drinking Water Colour, Taste and Smell	-2	-1	0	1	2	reduction in contacts per 10k customers
B	Unplanned Interruptions to the Water Supply	-9	-4	0	5	10	reduction in interruptions (thousands of)
C	Water Lost Through Leaks	-32	-7	0	15	44	reduction in litres of water lost per day (millions of)
D	Using Less Water	n/a	-1	0	7	15	reduction in litres of water used per person per day
E	Sewage flooding inside properties	-46	-12	0	11	35	reduction in number of properties flooded (tens)
F	Sewage flooding outside properties	-25	-4	0	2	9	reduction in number of properties flooded (hundreds)
G	River Water Quality	-50	-25	0	20	100	increase in km of rivers improved
H	Sea Water Quality at Yorkshire's Beaches	-4	-2	0	2	n/a	increase in number of beaches of good quality
I	Pollution of watercourses	-50	-40	0	25	40	reduction in number of pollution incidents for watercourses
J	Low Water Pressure	-10	-5	0	2	4	reduction in number of properties affected
K	Creating a River Wharfe safe for swimming	n/a	n/a	0	1	n/a	indicator for whether the project goes ahead

Source: NERA analysis

Appendix D. List of Attachments: Findings from Qualitative Research and Pilot Survey

D.1. Report on Pre-Survey Qualitative Research

See attachment.

D.2. Report on Pilot Survey

See attachment.

Appendix E. List of Attachments: Survey Instruments

E.1. Survey of Household Customers

See attachment.

E.2. Survey of Non-Household Customers

See attachment.

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