

# Appendix 5d: Understanding Customer Values: Data Triangulation Report

# PR19 Understanding Customer Values: Data Triangulation

Prepared for Yorkshire Water



## Acknowledgements

AECOM, DJS Research, London Economics, and University of Exeter Consulting Ltd. would like to thank Professor Michael Ward (Monash University), Professor Mike Christie (Aberystwyth University), and Professor Nicholas Hanley (University of St. Andrews) for providing peer review of the individual work packages undertaken for this project.

## Quality information

| Document name                         | Prepared for    | Prepared by         | Date     | Approved by  |
|---------------------------------------|-----------------|---------------------|----------|--|
| Data Triangulation Draft Report       | Yorkshire Water | Chris White (AECOM) | 01/11/17 | Adrian Rees (AECOM)<br>Paul Middleton (AECOM)  |
| Data Triangulation Final Draft Report | Yorkshire Water | Chris White (AECOM) | 30/11/17 | Petrina Rowcroft (AECOM)<br>Brett Day (University of Exeter Consulting Ltd.)<br>James Suter (London Economics)<br>Ali Sims (DJS Research)<br>Paul Murphy (AECOM) |
| Data Triangulation Final Report       | Yorkshire Water | Petrina Rowcroft    | 20/12/17 | Paul Middleton (AECOM)   |
| Data Triangulation Final Report       | Yorkshire Water | Petrina Rowcroft    | 01/05/18 | Paul Middleton (AECOM)   |

AECOM Infrastructure & Environment UK Limited (AECOM) has prepared this Report for the sole use of Yorkshire Water ("Client") in accordance with the terms and conditions of appointment. No other warranty, expressed or implied, is made as to the professional advice included in this Report or any other services provided by AECOM. This Report may not be relied upon by any other party without the prior and express written agreement of AECOM. Where any conclusions and recommendations contained in this Report are based upon information provided by others, it has been assumed that all relevant information has been provided by those parties and that such information is accurate. Any such information obtained by AECOM has not been independently verified by AECOM, unless otherwise stated in the Report.

# Contents

|   |           |
|---|-----------|
| Contents .....                              | 2         |
| <b>Data Triangulation.....</b>              | <b>3</b>  |
| Context .....                               | 3         |
| Aims.....                                   | 3         |
| Method.....                                 | 6         |
| Results.....                                | 8         |
| Implications.....                           | 12        |
| <b>Appendix 1: Data Triangulation .....</b> | <b>13</b> |
| Context .....                               | 13        |
| Methodology .....                           | 20        |
| High level findings.....                    | 23        |

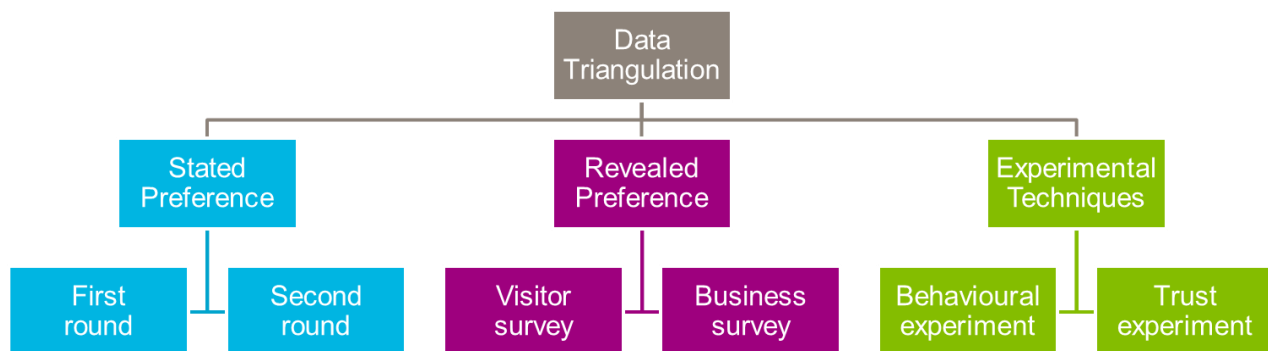
# Data Triangulation

## Context

The aim of this project is to undertake primary research to ascertain the values that Yorkshire Water (YWS) customers place on changes in service measures such as supply interruptions or drinking water failures. These values will then be used to populate the Decision Making Framework (DMF) in order to inform the investment planning process and support the wider Outcome Delivery Incentives (ODI) work stream.

In light of Ofwat's recommendations for improving the approach to understanding customer's values in PR19, the project includes six work packages (see Figure 1) which draw on a range of data to allow methodological triangulation; whereby data of different types are used to cumulatively refine and validate research outputs.

**Figure 1. Overview of the six work packages**



Each of these six work packages adopts an innovative, new approach to understanding customer's values which, together, provide a comprehensive picture of YWS customers' priorities. A summary of the key aspects of each work package is set out in Table 1.

## Aims

The aim of this report is to draw together the results of the six work packages and triangulate the different data sources in order to provide a set of recommended values that can be used by YWS for the following thirteen service measures:

- Unplanned Interruptions
- Poor Pressure
- Drinking Water Quality (Biological/Chemical)
- Drinking Water Quality (Aesthetic)
- Leakage
- Water Restrictions
- Internal Sewer Flooding
- External Sewer Flooding
- Bathing Water Quality
- River Water Quality
- Pollution Incidents
- Odour
- Land Improved

**Table 1. Overview of work packages**

| Work Package 1. First Round Stated Preference (customer sample size = 1,500)   |  |   |
|--|--|---|
| <p><u>Aims:</u><br/>Estimate customer values for 13 service measures (e.g. drinking water quality, internal sewer flood events, and pollution incidents)</p>   | <p><u>Innovations:</u></p> <ul style="list-style-type: none"> <li>– New approach to understanding the difference between ‘use’ and ‘non-use’ values for environmental measures (e.g. river water quality)</li> <li>– Use of imagery and more sophisticated presentation of comparative information to allow better understanding of customers’ values</li> </ul>           | <p><u>Outputs:</u><br/>£ estimates for a unit change in each of the service measures for household and business customers at base level severity</p>                    |
| Work Package 2. Second Round Stated Preference (customer sample size = 1,200)  |  |   |
| <p><u>Aims:</u><br/>Estimate customer values for different severity levels across 10 service measures (e.g. 3-6 vs. 24-48 hour supply interruptions)</p>   | <p><u>Innovations:</u></p> <ul style="list-style-type: none"> <li>– Use of imagery and more sophisticated presentation of comparative information to allow better understanding of customers’ values</li> </ul>  | <p><u>Outputs:</u><br/>Odds ratios to be applied to base level values to estimate £ values for different severity levels</p>  |
| Work Package 3. Revealed Preference Visitor Survey (customer sample size = 2,000)  |  |   |
| <p><u>Aims:</u><br/>Develop an economic model for quantifying the benefits of improving river water quality across different areas in Yorkshire</p>  | <p><u>Innovations:</u></p> <ul style="list-style-type: none"> <li>– Understanding of use and non-use values that draws on Revealed (i.e. visitor numbers) and Stated Preference (i.e. survey preferences) data</li> <li>– Ground breaking approach to accounting for how a change in one part of a river affects customers’ values for every river in Yorkshire</li> </ul> | <p><u>Outputs:</u><br/>£ estimates for a unit change in river water quality and a model for undertaking cost-benefit analysis of river water quality schemes</p>        |
| Work Package 4. Revealed Preference Business Survey (customer sample size = 1,000)   |  |   |
| <p><u>Aims:</u><br/>Understand the actual expenditure of businesses in Yorkshire on water service related devices e.g. pumps, filters, and back-up supplies to alleviate water services failures</p> | <p><u>Innovations:</u></p> <ul style="list-style-type: none"> <li>– One of the first times data for actual expenditure on service quality/reliability has been analysed for the water sector</li> <li>– First time this approach has been used in investment planning</li> </ul>   | <p><u>Outputs:</u><br/>£ estimates of expenditure on the 13 service measures and calibration of the Stated Preference values with expenditure data</p>                  |
| Work Package 5. Behavioural Experiment (customer sample size = 2,000)  |  |   |
| <p><u>Aims:</u><br/>Pilot a new approach to understanding customer values and explore the impacts of different ways of framing questions</p>   | <p><u>Innovations:</u></p> <ul style="list-style-type: none"> <li>– Surveys allow customers to select their preferred level of each service instead of being presented fixed options</li> <li>– Use of treatment groups to test how framing the questions in different ways impacts customer values</li> </ul>   | <p><u>Outputs:</u><br/>£ estimates for each of the service measures, broader understanding of customer decision making, and calibration of Stated Preference values</p> |
| Work Package 6. Trust Experiment (customer sample size = 62,000)   |  |   |
| <p><u>Aims:</u><br/>Explore whether there is a quantifiable relationship between levels of customer trust in YWS and costs of customer debt</p>  | <p><u>Innovations:</u></p> <ul style="list-style-type: none"> <li>– Area of research which has never been explored</li> <li>– Making a contribution to the growing understanding of the importance of ‘social capital’</li> </ul>  | <p><u>Outputs:</u><br/>£ estimate of the value of ‘trust’ to Yorkshire Water</p>  |



## Method

The results from each work package were brought together in this report for comparison and triangulation in order to establish the most appropriate set of values to be included within the DMF. In addition to the value estimates derived through each of the six work packages, the triangulation process also included data from PR14 and PR09, as well as the Benefits Transfer exercise undertaken as part of the DMF work stream.<sup>1</sup>

The framework set out in UKWIR (2016)<sup>2</sup> was used to triangulate the values from the different data sources (see Table 2).

**Table 2. Framework for triangulation of values set out in UKWIR (2016)<sup>3</sup>**

| Factor                                     | Value 1<br>Stated Preference<br>£10.25   | Value 2<br>Revealed Preference<br>£2.00                                      | Value 3<br>Experimental Approach<br>£7.50                                       |
|--|--|--|---|
| Statistical robustness                     | High – statistically significant sample  | Medium – not clear how widely substitute good is used                        | High – statistically significant sample   |
| Psychological robustness                   | Low – answers likely to be affected by loss aversion, social norms             | High – substitute purchase   | High – observed choices in “real life” situation rather than Stated Preferences |
| Consistency of track record or time series | Available within £9-11   | Reasonably constant over time  | Unknown   |
| Correlation with qualitative evidence      | Qualitative evidence may suggest lower priority than attributes with lower WTP | Aligned with qualitative evidence  | Aligned with qualitative evidence   |
| Implication of using this value            | Would lead to CBA and ODI results consistent with previous price control       | Would lead to lower target and incentive rate than in previous price control |   |
| Completeness of value                      | Likely to include some altruistic valuation                                    | Focused on one aspect of service, and the direct impact, may not be complete | Focused on one aspect of service, and the direct impact, may not be complete    |
| <b>Recommended value</b>                   | <b>Choose a weighted value based on the pros and cons of each source</b>       |  |   |

This approach therefore used a multi-criteria decision analysis to compare values on the basis of factors such as statistical validity, cognitive validity, track record, relationship with qualitative evidence, and completeness. A view was then taken of the pros and cons of each method and a recommended value was selected.

The combination of methods and findings presented in this report represent a new approach to understanding customer values. While the work has advanced practice in this area, it has also identified where further work is needed. The report is accompanied by an Excel workbook which documents the data and calculations used to derive each of the estimates.

Given that this is a new and emerging area with little precedent for setting out the most appropriate techniques to use in practice, it was agreed with YWS that the approach to triangulation would be to include as broad a range of values as possible from across the data sources, even if there were significant variances between the results and significant differences in the methodologies used across work packages. There are other potential approaches to triangulation of values which would provide different results.

---

<sup>1</sup> AECOM (2017) Integrating natural social and human capital into the SMF - Valuation Methodology V0.22

<sup>2</sup> UKWIR (2016) Setting performance commitments and incentives to deliver best value for money, UKWIR Report Ref No 16/RG/07/39

<sup>3</sup> UKWIR (2016) Setting performance commitments and incentives to deliver best value for money, UKWIR Report Ref No 16/RG/07/39

The results of this project are therefore a ‘first step’ in the triangulation exercise, using a simple and transparent process for selecting a suitable range of values for use in the DMF. Further triangulation exercises could be undertaken to refine these results further.

## Results

A summary of the recommended aggregate values for each of the 13 service measures is set out in Table 3.

**Table 3. Summary of recommended aggregate values for 13 service measures**

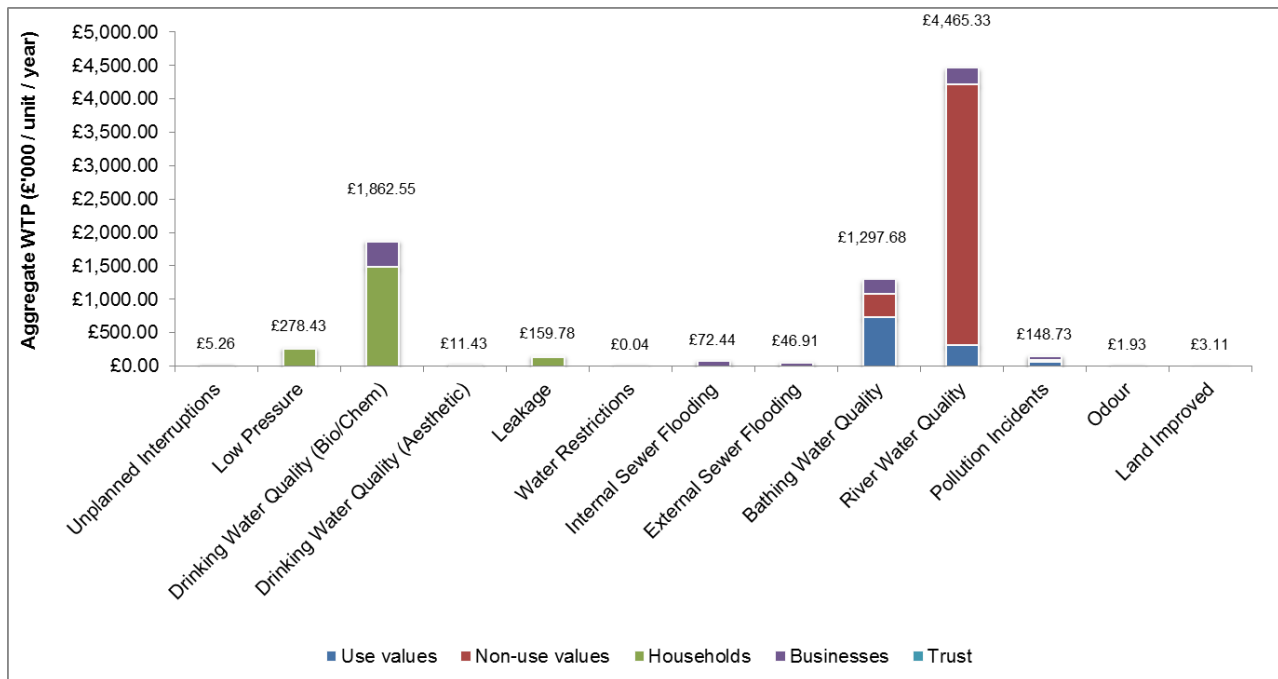
| Service measure                    | Severity level  | Units        | Use values | Non-use | Households    | Businesses    | Trust   | Total                |
|------------------------------------|---|--------------|------------|---------|---------------|---------------|---------|----------------------|
| Unplanned Interruptions            | Supply interruption of less than 3 hours                        | £ / property | -          | -       | £195.27       | £2,566.35     | £58.00  | <b>£2,819.62</b>     |
|                                    | Supply interruption of 3-6 hours                                | £ / property | -          | -       | £367.73       | £4,833.05     | £58.00  | <b>£5,258.78</b>     |
|                                    | Supply interruption of 6-12 hours                               | £ / property | -          | -       | £451.57       | £5,934.99     | £58.00  | <b>£6,444.56</b>     |
|                                    | Supply interruption of 12-24 hours                              | £ / property | -          | -       | £464.08       | £6,099.31     | £58.00  | <b>£6,621.39</b>     |
|                                    | Supply interruption of over 24 hours and up to 48 hours         | £ / property | -          | -       | £523.65       | £6,882.27     | £58.00  | <b>£7,463.92</b>     |
| Planned interruptions              | Supply interruption for < 3 hours which is announced in advance | £ / property | -          | -       | £223.21       | £2,933.66     | £58.00  | <b>£3,214.88</b>     |
|                                    | Supply interruption for 3-6 hours which is announced in advance | £ / property | -          | -       | £223.21       | £2,933.66     | £58.00  | <b>£3,214.88</b>     |
| Low Pressure                       | Properties experiencing low pressure                            | £ / property | -          | -       | £256,444.29   | £21,984.10    | -       | <b>£278,428.39</b>   |
| Drinking Water Quality (Bio/Chem)  | Drinking water sample failure (no health impact)                | £ / sample   | -          | -       | £1,490,280.00 | £372,038.92   | £234.00 | <b>£1,862,552.92</b> |
|                                    | Drinking water sample failure (public health impact)            | £ / sample   | -          | -       | £5,275,591.20 | £1,317,017.77 | £234.00 | <b>£6,592,842.97</b> |
|                                    | Drinking water sample failure (boil order notice)               | £ / sample   | -          | -       | £3,831,509.88 | £956,512.06   | £234.00 | <b>£4,788,255.94</b> |
| Drinking Water Quality (Aesthetic) | Drinking water the colour of weak tea                           | £ / contact  | -          | -       | £10,285.19    | £1,012.41     | £133.00 | <b>£11,430.60</b>    |
|                                    | Water with a taste or smell of disinfectant                     | £ / contact  | -          | -       | £11,817.68    | £1,163.26     | £133.00 | <b>£13,113.95</b>    |
|                                    | Cloudy water  | £ / contact  | -          | -       | £10,120.63    | £996.22       | £133.00 | <b>£11,249.84</b>    |
| Leakage                            | MI lost per day   | £ / MI       | £1.08      | -       | £133,410.17   | £26,364.97    | -       | <b>£159,776.22</b>   |
| Water Restrictions                 | Reduction in supply with no impact on customers                 | £ / property | -          | -       | £21.12        | £3.05         | -       | <b>£24.17</b>        |
|                                    | Voluntary restriction   | £ / property | -          | -       | £30.83        | £4.45         | -       | <b>£35.29</b>        |
|                                    | Compulsory restriction (hose pipe ban)                          | £ / property | -          | -       | £31.95        | £4.61         | -       | <b>£36.57</b>        |

| Service measure         | Severity level   | Units             | Use values  | Non-use       | Households | Businesses  | Trust   | Total                |
|-------------------------|--|-------------------|-------------|---------------|------------|-------------|---------|----------------------|
|                         | Emergency restriction                                    | £ / property      | -           | -             | £56.27     | £8.13       | -       | <b>£64.39</b>        |
| Internal Sewer Flooding | Flooding of cellar                                       | £ / property      | -           | -             | £1,537.25  | £3,444.18   | £243.00 | <b>£5,224.42</b>     |
|                         | Flooding of habitable area                               | £ / property      | -           | -             | £22,278.93 | £49,915.62  | £243.00 | <b>£72,437.55</b>    |
| External Sewer Flooding | Flooding of minor roads                                  | £ / property      | -           | -             | £2,273.86  | £61,607.89  | £182.00 | <b>£63,881.74</b>    |
|                         | Flooding of major roads                                  | £ / property      | -           | -             | £2,099.20  | £56,875.75  | £182.00 | <b>£58,974.95</b>    |
|                         | Flooding within property boundary not inhibiting access  | £ / property      | -           | -             | £1,470.44  | £39,840.07  | £182.00 | <b>£41,310.51</b>    |
|                         | Flooding within property boundary inhibiting access      | £ / property      | -           | -             | £1,663.39  | £45,067.95  | £182.00 | <b>£46,731.34</b>    |
|                         | Flooding causing societal disruption                     | £ / property      | -           | -             | £6,615.32  | £179,235.23 | £182.00 | <b>£185,850.55</b>   |
| Bathing Water Quality   | Water quality sample failure at a bathing water          | £ / bathing water | £361,609.67 | £167,890.20   | -          | £108,961.13 | -       | <b>£638,461.01</b>   |
|                         | Deterioration in classification                          | £ / bathing water | £734,979.00 | £341,240.25   | -          | £221,465.72 | -       | <b>£1,297,684.97</b> |
|                         | Loss of Blue Flag status                                 | £ / bathing water | £754,823.43 | £350,453.74   | -          | £227,445.29 | -       | <b>£1,332,722.46</b> |
| River Water Quality     | Length of river water improved                           | £ / %             | £319,252.76 | £3,899,296.51 | -          | £246,776.09 | -       | <b>£4,465,325.36</b> |
| Pollution Incidents     | Category 1 pollution incidents                           | £ / %             | £211,600.94 | £94,663.58    | -          | £162,577.79 | £28.00  | <b>£468,870.30</b>   |
|                         | Category 2 pollution incidents                           | £ / %             | £139,121.07 | £62,238.37    | -          | £106,889.87 | £28.00  | <b>£308,277.32</b>   |
|                         | Category 3 pollution incidents                           | £ / incident      | £67,110.99  | £30,023.34    | -          | £51,562.89  | £28.00  | <b>£148,725.21</b>   |
|                         | Category 4 pollution incidents                           | £ / incident      | £28,455.06  | £12,729.89    | -          | £21,862.66  | £28.00  | <b>£63,075.62</b>    |
| Odour                   | Complaints about chronic intolerable odour               | £ / complaint     | -           | -             | £1,613.51  | £313.37     | -       | <b>£1,926.88</b>     |
|                         | Complaints about transient odour                         | £ / complaint     | -           | -             | £1,140.29  | £221.47     | -       | <b>£1,361.76</b>     |
| Land Improved           | Area of land conserved or improved (general)             | £ / ha            | £3,110.74   | -             | -          | -           | -       | <b>£3,110.74</b>     |
|                         | Area of land conserved or improved (coniferous woodland) | £ / ha            | £2,817.33   | -             | -          | -           | -       | <b>£2,817.33</b>     |

| Service measure | Severity level   | Units  | Use values | Non-use | Households | Businesses | Trust | Total            |
|-----------------|--|--------|------------|---------|------------|------------|-------|------------------|
|                 | Area of land conserved or improved (broadleaf woodland)            | £ / ha | £3,397.70  | -       | -          | -          | -     | <b>£3,397.70</b> |
|                 | Area of land conserved or improved (semi-natural grassland)        | £ / ha | £1,085.49  | -       | -          | -          | -     | <b>£1,085.49</b> |
|                 | Area of land conserved or improved (farmland)                      | £ / ha | £1,634.94  | -       | -          | -          | -     | <b>£1,634.94</b> |
|                 | Area of land conserved or improved (wetlands & floodplains)        | £ / ha | £4,254.34  | -       | -          | -          | -     | <b>£4,254.34</b> |
|                 | Area of land conserved or improved (mountains, moorlands & heaths) | £ / ha | £1,228.78  | -       | -          | -          | -     | <b>£1,228.78</b> |
|                 | Area of land conserved or improved (coastal margins)               | £ / ha | £1,619.47  | -       | -          | -          | -     | <b>£1,619.47</b> |
|                 | Area of land conserved or improved (green space)                   | £ / ha | £8,847.84  | -       | -          | -          | -     | <b>£8,847.84</b> |

The aggregate baseline (or anchor) values for each of use, non-use, household, business and trust values and the total value for each service measure are displayed graphically in Figure 2.

**Figure 2. Summary of recommended aggregate baseline values for 13 service measures**



## Implications

A summary of some of the high level findings is set out in the bullet points below:

- Despite the methodological differences in the approaches used, there was generally a very close alignment between the results from Work Package 1 and Work Package 5 suggesting the results are robust. In most instances an average value from these two work packages was recommended.
- Willingness-to-pay (WTP) estimates were typically higher for business customers than for household customers. This concurs with the findings from previous price reviews.
- The Revealed Preference results for business customers were typically higher than the Stated Preference results. This is contrary to expectations and may be due to methodological/definitional differences between the two approaches.
- It was challenging to make detailed comparisons with the results from PR14 and PR09 due to differences in approaches and definitions used. There may be many reasons why results would change over time (e.g. shifts in environmental conditions such as changing frequency of flood events, changes in the economy, and changes in the level of performance provided by YWS). In order to undertake a more robust comparison of changes over time surveys would have to be replicated at regular intervals using a common approach to definitions and metrics.
- In some cases the estimates of customer values reported from the Stated Preference surveys may

underestimate some of the wider benefits. In such cases, alternative data sources are recommended.

---

# Appendix 1: Data Triangulation

---

## Context

Every five years the economic regulator for the water and sewerage industry, Ofwat, sets price limits that enable water companies to finance services in line with industry standards and requirements. Part of Ofwat's price review process is an assessment of the amount companies need to spend in order to deliver their planned investments and services, and whether these could be delivered more efficiently. Developing these investment plans requires a programme of customer engagement to help shape priorities, targets, and outcomes.

The next price review – PR19 – covers the period running from 2020 to 2025. For PR19, Ofwat<sup>4</sup> is expecting the industry to demonstrate improvements in the methodologies used to understand customers' values and represent them in investment plans through the following measures:

- A move towards methodological triangulation, where data of different types (e.g. Stated and Revealed Preference, customer contacts) can cumulatively refine or validate research outputs.
- A growing recognition of the role of behavioural economics in customer preference surveying, and improving understanding of the factors (e.g. context, framing, design) that influence the behaviour of survey respondents.
- A movement towards greater bilateral engagement with customers and efforts to better consciously integrate them into the decision making and priority setting processes.

In addition, Ofwat's vision for water and wastewater services in England and Wales emphasises that, "*new ways of working and new approaches are required to address the challenges facing the [water and wastewater services] sector and enable innovation and better ways of using scarce resources, which include customers' money, investment capital, and **natural capital***".<sup>5</sup>

Defra has also emphasised that, "*the Government looks to water companies as leaders of the natural environment... You should demonstrate how you value nature in your decisions. We want to see better informed decisions that reflect the value of the environment, using **natural capital** as a currency to aid understanding about how to manage our environment. We expect you to **thoroughly investigate and report on***

---

<sup>4</sup> Ofwat (2016), Ofwat's customer engagement policy statement and expectations for PR19

<sup>5</sup> Ofwat (2016). Water 2020: our regulatory approach for water and wastewater services in England and Wales



***environmental and social costs and benefits***.<sup>6</sup>

This last point is reiterated in the consultation draft of the Government's strategic priorities and objectives for Ofwat<sup>7</sup> which includes a specific objective for Ofwat to "**encourage the sustainable use of natural capital by water companies** – that is, our natural assets such as rivers and groundwater – by encouraging water companies to have appropriate regard to the **wider costs and benefits to the economy, society, and the environment**".

In light of this guidance Yorkshire Water (YWS) is developing an approach for incorporating social and environmental costs into its investment planning process through its Decision Making Framework (DMF). The DMF allows the impacts of investment decisions across a range of service measures (e.g. sewer flooding incidents, water supply interruptions, changes in bathing water quality) to be evaluated using a capitals approach. The capitals approach is an economic framework which quantifies and values the costs and benefits of changes in service measures in terms of the impact on natural, social, human, intellectual, financial, and manufactured capital.

The aim of this project is to undertake primary research using a variety of techniques to ascertain the values that YWS customers place on changes in the service measures included within the DMF. These values will then be used to populate the DMF and, ultimately, will inform the investment planning process. In addition, the values will be used to support the wider Outcome Delivery Incentives (ODI) work stream.

In light of Ofwat's recommendations for improving the approach to understanding customer's values in PR19, the research involved six separate work packages which employ different valuation techniques and draw on a

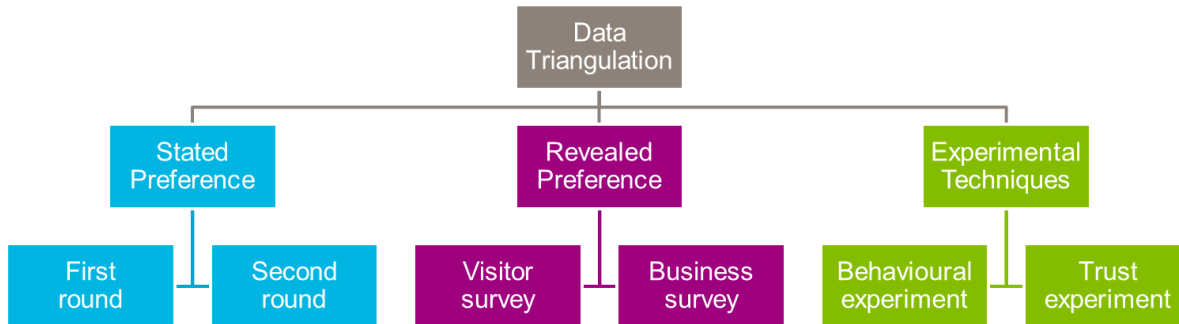
---

<sup>6</sup> Defra (2016). Guiding principles for water resources planning: for water companies operating wholly or mainly in England

<sup>7</sup> Defra (2017) The Government's strategic priorities and objectives for Ofwat. Draft for consultation, March 2017

range of data sources (Figure 3).

**Figure 3. Overview of work packages**



Of these six work packages, the two Stated Preference surveys, the Revealed Preference business survey, and the Behavioural Experiment each aim to estimate the monetary value of the set of attributes included within the DMF (Table 4). Generating valuation evidence from multiple sources represents an innovative approach to understanding customer preferences and provides a range of value estimates for each attribute which, through a process of methodological triangulation, can cumulatively refine or validate research outputs.

**Table 4. Service measures to be included within the primary research**

| No. | Service measure                              | First round attributes  | Second round attributes   |
|-----|--|---|---|
| 1   | Unplanned Interruptions                      | No. properties impacted by interruptions of 3-6 hours                                       | <ul style="list-style-type: none"> <li>- &lt;3 hours</li> <li>- 6-12 hours</li> <li>- 12-24 hours</li> <li>- &gt;24 hours</li> <li>- Planned interruption of 3-6 hours</li> </ul>   |
| 2   | Low Pressure                                 | No. properties where pressure is below minimum acceptable level                             | n/a   |
| 3   | Drinking Water Quality (Biological/Chemical) | No. water quality parameter samples exceeding PCV – without a health impact                 | <ul style="list-style-type: none"> <li>- Water quality parameter samples exceeding PCV – with a public health impact</li> <li>- Properties impacted by boil water notices</li> </ul>  |
| 4   | Drinking Water Quality (Aesthetic)           | No. contacts from properties impacted by discoloured water (colour of weak tea)             | <ul style="list-style-type: none"> <li>- Taste and smell</li> <li>- Acceptability – milky / cloudy / particles</li> </ul>   |
| 5   | Leakage                                      | MI/day of water lost  | n/a   |
| 6   | Water Restrictions                           | No. properties affected by a compulsory restriction (incl. hose pipe ban)                   | <ul style="list-style-type: none"> <li>- Loss of resource yield / distribution input</li> <li>- Voluntary restriction</li> <li>- Emergency restriction</li> </ul>   |
| 7   | Internal Sewer Flooding                      | No. properties affected by internal flooding of habitable area                              | <ul style="list-style-type: none"> <li>- Internal flooding of a cellar</li> </ul>   |
| 8   | External Sewer Flooding                      | No. properties affected by external flooding within the property boundary inhibiting access | <ul style="list-style-type: none"> <li>- Flooding of minor roads</li> <li>- Flooding of major roads</li> <li>- External flooding within property boundary not inhibiting access</li> <li>- External flooding causing societal disruption</li> </ul> |
| 9   | Bathing Water Quality                        | No. bathing waters experiencing a deterioration in classification                           | <ul style="list-style-type: none"> <li>- Compliance failure</li> <li>- Loss of Blue Flag status</li> </ul>  |
| 10  | River Water Quality                          | Length of river water improved (%)  | n/a   |
| 11  | Pollution Incidents                          | No. Category 3 pollution incidents  | <ul style="list-style-type: none"> <li>- Category 1 pollution incident</li> <li>- Category 2 pollution incident</li> <li>- Category 4 pollution incident</li> </ul>   |
| 12  | Odour  | No. complaints from properties subjected to chronic intolerable odour                       | <ul style="list-style-type: none"> <li>- Properties subjected to transient intolerable odour</li> </ul>   |
| 13  | Land Improved                                | Area of land conserved or improved (ha)   | <ul style="list-style-type: none"> <li>- Area of coniferous woodland / broadleaved woodland / semi-natural grassland / farmland / wetlands and floodplains / mountains, moors, and heaths / coastal margins / greenspace</li> </ul>                 |

In addition to the work packages aimed at estimating values for the full set of attributes set out in the DMF, the visitor survey work package provides a more in-depth look at the value of river water quality in Yorkshire in order to cross check the estimates of value from the other work packages and to inform the development of a freshwater investment portfolio; while the Trust Experiment focuses on developing a more informed understanding of the relationship between levels of trust and refusal to pay water bills to explore how the value of trust can be included within the DMF.

Each of these six work packages adopts an innovative approach to understanding customer's values which, together, provide a more sophisticated and comprehensive picture of YWS customers' priorities. A summary of the key aspects of each work package is set out in Table 5.

**Table 5. Overview of work packages**

| Work Package 1. First Round Stated Preference (customer sample size = 1,500)   |  |   |
|--|--|---|
| <p><u>Aims:</u><br/>Estimate customer values for 13 service measures (e.g. drinking water quality, internal sewer flood events, and pollution incidents)</p>   | <p><u>Innovations:</u></p> <ul style="list-style-type: none"> <li>– New approach to understanding the difference between ‘use’ and ‘non-use’ values for environmental measures (e.g. river water quality)</li> <li>– Use of imagery and more sophisticated presentation of comparative information to allow better understanding of customers’ values</li> </ul>           | <p><u>Outputs:</u><br/>£ estimates for a unit change in each of the service measures for household and business customers at base level severity</p>                    |
| Work Package 2. Second Round Stated Preference (customer sample size = 1,200)  |  |   |
| <p><u>Aims:</u><br/>Estimate customer values for different severity levels across 10 service measures (e.g. 3-6 vs. 24-48 hour supply interruptions)</p>   | <p><u>Innovations:</u></p> <ul style="list-style-type: none"> <li>– Use of imagery and more sophisticated presentation of comparative information to allow better understanding of customers’ values</li> </ul>  | <p><u>Outputs:</u><br/>Odds ratios to be applied to base level values to estimate £ values for different severity levels</p>  |
| Work Package 3. Revealed Preference Visitor Survey (customer sample size = 2,000)  |  |   |
| <p><u>Aims:</u><br/>Develop an economic model for quantifying the benefits of improving river water quality across different areas in Yorkshire</p>  | <p><u>Innovations:</u></p> <ul style="list-style-type: none"> <li>– Understanding of use and non-use values that draws on Revealed (i.e. visitor numbers) and Stated Preference (i.e. survey preferences) data</li> <li>– Ground breaking approach to accounting for how a change in one part of a river affects customers’ values for every river in Yorkshire</li> </ul> | <p><u>Outputs:</u><br/>£ estimates for a unit change in river water quality and a model for undertaking cost-benefit analysis of river water quality schemes</p>        |
| Work Package 4. Revealed Preference Business Survey (customer sample size = 1,000)   |  |   |
| <p><u>Aims:</u><br/>Understand the actual expenditure of businesses in Yorkshire on water service related devices e.g. pumps, filters, and back-up supplies to alleviate water services failures</p> | <p><u>Innovations:</u></p> <ul style="list-style-type: none"> <li>– One of the first times data for actual expenditure on service quality/reliability has been analysed for the water sector</li> <li>– First time this approach has been used in investment planning</li> </ul>   | <p><u>Outputs:</u><br/>£ estimates of expenditure on the 13 service measures and calibration of the Stated Preference values with expenditure data</p>                  |
| Work Package 5. Behavioural Experiment (customer sample size = 2,000)  |  |   |
| <p><u>Aims:</u><br/>Pilot a new approach to understanding customer values and explore the impacts of different ways of framing questions</p>   | <p><u>Innovations:</u></p> <ul style="list-style-type: none"> <li>– Surveys allow customers to select their preferred level of each service instead of being presented fixed options</li> <li>– Use of treatment groups to test how framing the questions in different ways impacts customer values</li> </ul>   | <p><u>Outputs:</u><br/>£ estimates for each of the service measures, broader understanding of customer decision making, and calibration of Stated Preference values</p> |
| Work Package 6. Trust Experiment (customer sample size = 62,000)   |  |   |
| <p><u>Aims:</u><br/>Explore whether there is a quantifiable relationship between levels of customer trust in YWS and costs of customer debt</p>  | <p><u>Innovations:</u></p> <ul style="list-style-type: none"> <li>– Area of research which has never been explored</li> <li>– Making a contribution to the growing understanding of the importance of ‘social capital’</li> </ul>  | <p><u>Outputs:</u><br/>£ estimate of the value of ‘trust’ to Yorkshire Water</p>  |

# Methodology

The results from each work package have been brought together in this report for comparison and triangulation in order to establish the most appropriate set of values to be included within the DMF. In addition to the value estimates derived through each of the six work packages, the triangulation process also included data from PR14 and PR09, as well as the Benefits Transfer exercise undertaken as part of the DMF work stream.<sup>8</sup>

The framework set out in UKWIR (2016)<sup>9</sup> was used to triangulate the values from the different data sources (see Table 6).

**Table 6. Framework for triangulation of values set out in UKWIR (2016)<sup>10</sup>**

| Factor                                     | Value 1<br>Stated Preference   | Value 2<br>Revealed Preference   | Value 3<br>Experimental Approach   |
|--|--|--|--|
| Value                                      | £10.25 per hh  | £2.00 per hh   | £7.50 per hh   |
| Statistical robustness                     | <b>High</b> – statistically significant sample                                 | <b>Medium</b> – not clear how widely substitute good is used                 | <b>High</b> – statistically significant sample   |
| Psychological robustness                   | <b>Low</b> – answers likely to be affected by loss aversion, social norms      | <b>High</b> – substitute purchase  | <b>High</b> – observed choices in “real life” situation rather than Stated Preferences |
| Consistency of track record or time series | Available within £9-11   | Reasonably constant over time  | Unknown  |
| Correlation with qualitative evidence      | Qualitative evidence may suggest lower priority than attributes with lower WTP | Aligned with qualitative evidence  | Aligned with qualitative evidence  |
| Implication of using this value            | Would lead to CBA and ODI results consistent with previous price control       | Would lead to lower target and incentive rate than in previous price control |  |
| Completeness of value                      | Likely to include some altruistic valuation                                    | Focused on one aspect of service, and the direct impact, may not be complete | Focused on one aspect of service, and the direct impact, may not be complete           |
| <b>Recommended value</b>                   | <i>Choose a weighted value based on the pros and cons of each source</i>       |  |  |

This UKWIR framework uses a multi-criteria decision analysis to compare values on the basis of factors such as statistical validity, cognitive validity, track record, relationship with qualitative evidence, and completeness. For the purposes of this triangulation exercise, the framework was completed as follows:

- **Step 1.** Convert all data from across the six work packages to comparable units of measurement. Note this process was relatively straightforward for the work packages using a similar methodology (i.e. 1, 3 & 5) but more complex for Work Packages 4 & 6 and the Benefits Transfer work.
- **Step 2.** Select the values from each Work Package for triangulation. The approach drew on the recommended values provided in each of the work package reports although there are a much wider

<sup>8</sup> AECOM (2017) Integrating natural social and human capital into the SMF - Valuation Methodology V0.22

<sup>9</sup> UKWIR (2016) Setting performance commitments and incentives to deliver best value for money, UKWIR Report Ref No 16/RG/07/39

<sup>10</sup> UKWIR (2016) Setting performance commitments and incentives to deliver best value for money, UKWIR Report Ref No 16/RG/07/39

range of values in the detailed appendices that could potentially be included.

- **Step 3.** Assess statistical robustness based on method used and sample size. In general Work Packages 3 & 5 were awarded a score of 'very high'; Work Package 1 was considered 'high', Work Package 4 'medium', Work Package 6 'low', and the Benefits Transfer estimates varied across the data sources.
- **Step 4.** Assess psychological robustness based on method used. In general the Revealed Preference approaches were considered to be 'high' (i.e. Work Packages 3, 4 & 6); the Stated Preference approaches were 'medium' (i.e. Work Packages 1 & 5); and the Benefits Transfer estimates were not scored against this criteria.
- **Step 5.** Assess completeness of value based on method used. In general the results from Work Package 1 (linear values), 3 & 5 were considered 'high'; Work Package 1 (non-linear) 'medium'; and Work Packages 4 'low'; although these scores varied when Benefits Transfer and Work Package 6 estimates were included.
- **Step 6.** Assess consistency with PR14/09. This proved a complex exercise given differences in methodologies, definitions, and units used in previous price reviews. As a result of the differences there were a wide range of results across PR19/14/09 and a simple rule was used for undertaking the comparison: if the difference was between 0-10% it was scored 'very high'; 10-100% 'high'; 100-1,000% 'medium'; 1,000-10,000% 'low'; and 10,000-100,000% 'very low'.
- **Step 7.** Assess consistency with qualitative evidence. The data sources were scored as 'very high' if both the work package result and the qualitative work undertaken by YWS<sup>11</sup> identified the service measure as either the most or least important service measure; 'high' if both identified the measure in the same tertile; 'medium' if they were one tertile apart; 'low' if two tertiles apart; and 'very low' if one source identified the service measure as most important and the other as least important.
- **Step 8.** Assess implication of using the value. This section involved a short qualitative summary of the above points in terms of robustness and relation to PR14/09 and qualitative results.
- **Step 9.** Recommend value. This involved a qualitative discussion of the most suitable approach. The UKWIR report recommends that a view is taken of the pros and cons of each method and a recommended value is selected as follows:
  - A single value may be selected if the pros of this value significantly outweigh the other valuations.
  - A simple average may be used if there are various pros and cons for different values.
  - A weighted average may be used if some of the evidence is stronger but all estimates have some validity.
  - Some values may be ignored and a simple or weighted average of a subset of values may be used if there are significant cons associated with particular values.

In practice, the general approach was to use a simple average of all values which were not deemed to be significant outliers.

- **Step 10.** Undertake any required calculations. This step involved averaging the values across the selected data sources and applying the odds ratios from Work Package 2 to estimate values for each of the severity levels in the DMF. Note, Work Package 2 only estimated odd ratios for household customers. As such, in order to provide estimates for the different severity levels for business

---

<sup>11</sup> Creative Research (2017), 'Understanding Customer Aspirations for Performance (PR19): Key findings'.



customers, the odds ratios from household customers were applied to the baseline values estimated for the business customers.

This report provides an overview of the triangulation process used to arrive at a recommended set of values for inclusion within the DMF for each of the service measures. The findings are summarised in the following section. Appendix 1 then provides a more detailed exposition of the triangulation process for each service measure, including an overview of the data sources available for triangulation, the value estimates derived from each data source, and the process of weighting the evidence to select the appropriate values to be used in the DMF. This report is accompanied by six individual reports for each of the work packages which provide a summary of the research as well as detailed technical appendices.

The combination of methods and findings presented in this report represent a new approach to understanding customer values. While the work has advanced practice in this area, it has also identified where further work is needed. The report is accompanied by an Excel workbook which clearly documents the data sources and calculations used to derive each of the estimates. This is intended not only to support interpretation and understanding of the values presented in this report but also to provide the foundation for future enhancements.

Given that this is a new and emerging area with little precedent for setting out the most appropriate techniques to use in practice, it was agreed with YWS that the approach to triangulation would be to include as broad a range of values as possible from across the data sources, even if there were significant variances between the results and significant differences in the methodologies used across work packages. There are other potential approaches to triangulation of values which would provide different results. Some of these include:

- Using a weighted average for the various sources of data to apply greater weight to those that are more statistically robust. This may be useful since some of values (notably those from Work Package 6) are likely to have lower robustness than those of the other work packages. This approach was not used as it necessarily involves a degree of subjective judgement and, as such, may be better done with the involvement of a wider range of stakeholders).
- Selecting a range of values for use in different scenarios within the DMF (e.g. minimum set, median set, and maximum set across all data sources).
- Using a different approach to triangulation of values which could include more complex statistical analysis rather than simple qualitative scoring criteria. There are a number of alternative approaches which have been suggested in the literature and could be explored e.g. ICF (2017).<sup>12</sup>

The results of this project are therefore a 'first step' in the triangulation exercise, using a simple and transparent process for selecting a suitable range of values for use in the DMF. Further triangulation exercises could be undertaken to refine these results further.

---

<sup>12</sup> ICF (2017), 'Defining and applying 'triangulation' in the water sector How water companies can use different sources of customer evidence in business planning'

## High level findings

A summary of some of the high level findings is set out in the bullet points below:

- Despite the methodological differences in the approaches used, there was generally a very close alignment between the results from Work Package 1 and Work Package 5 suggesting the results are robust. In most instances an average value from these two work packages was recommended.
- WTP estimates were typically higher for business customers than for household customers, a finding which is line with previous price reviews.
- The Revealed Preference results for business customers were typically higher than the Stated Preference results. This is contrary to expectations and may be due to methodological/definitional differences between the two approaches.
- It was challenging to make detailed comparisons with the results from PR14 and PR09 due to differences in approaches and definitions used. There may be many reasons why results would change over time (e.g. shifts in environmental conditions such as changing frequency of flood events, changes in the economy, and changes in the level of performance provided by YWS). In order to undertake a more robust comparison of changes over time surveys would have to be replicated at regular intervals using a common approach to definitions and metrics.
- In some cases the estimates of customer values reported from the Stated Preference surveys may underestimate some of the wider benefits. In such cases, alternative data sources are recommended.

A summary of the recommended aggregate values for each of the 13 service measures is set out in Table 7. The total weighted value<sup>13</sup> for each of the baseline (or anchor) values and the relative contribution of each of the household, business, use, non-use and trust values to the total is displayed graphically in Figure 2.

---

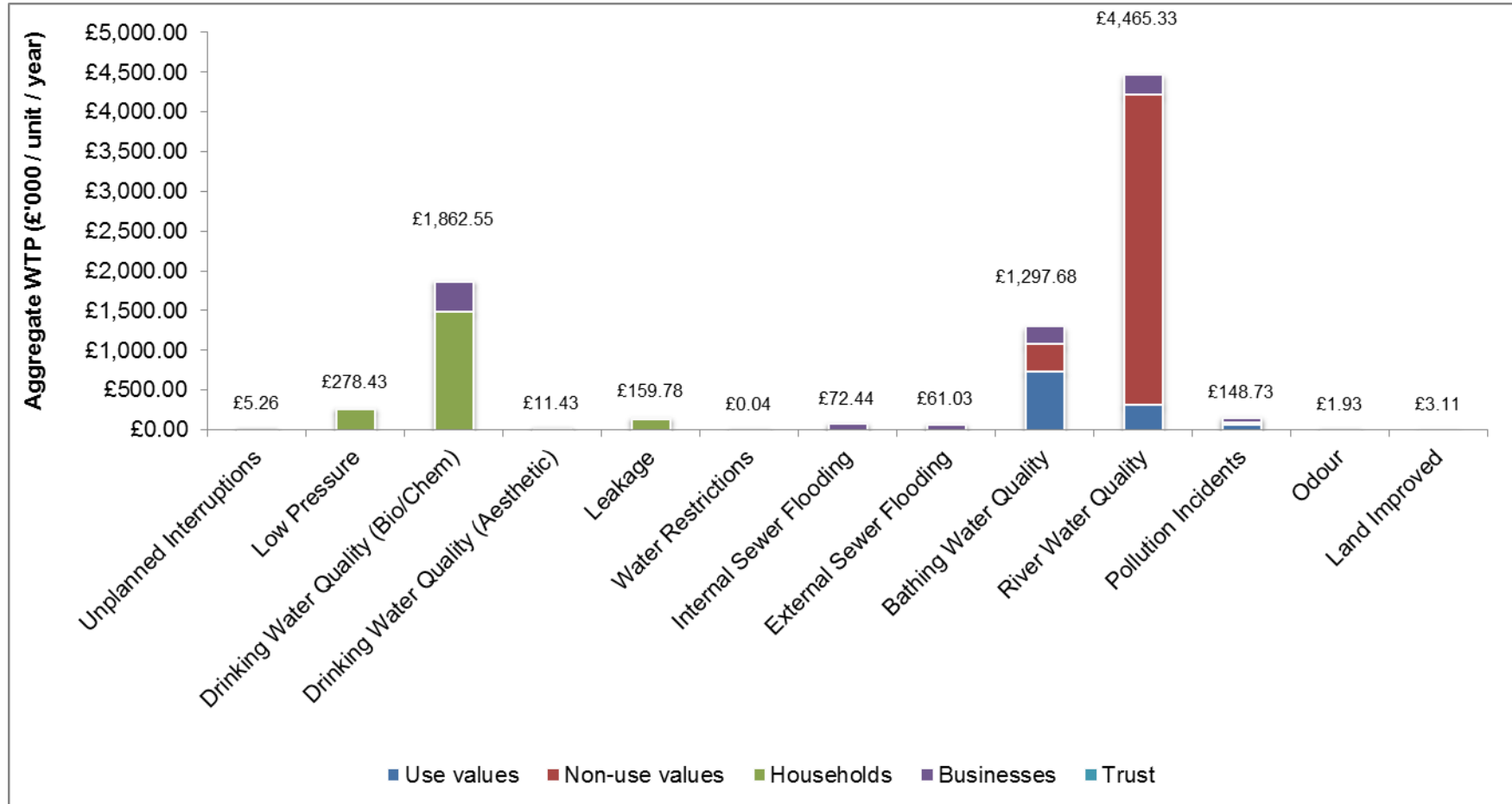
<sup>13</sup> The total value is the sum of the individual household, business, use, non-use and trust values weighted by the relative proportion of each of household and business customers in the total customer base.

**Table 7. Summary of recommended aggregate values for 13 service measures**

| Service measure                    | Severity level  | Units        | Use values | Non-use | Households    | Businesses    | Trust   | Total (including Trust) | Total (excluding Trust) |
|------------------------------------|---|--------------|------------|---------|---------------|---------------|---------|-------------------------|-------------------------|
| Unplanned Interruptions            | Supply interruption of less than 3 hours                        | £ / property | -          | -       | £195.27       | £2,566.35     | £58.00  | <b>£2,819.62</b>        | £2,761.62               |
|                                    | Supply interruption of 3-6 hours                                | £ / property | -          | -       | £367.73       | £4,833.05     | £58.00  | <b>£5,258.78</b>        | £5,200.78               |
|                                    | Supply interruption of 6–12 hours                               | £ / property | -          | -       | £451.57       | £5,934.99     | £58.00  | <b>£6,444.56</b>        | £6,386.56               |
|                                    | Supply interruption of 12–24 hours                              | £ / property | -          | -       | £464.08       | £6,099.31     | £58.00  | <b>£6,621.39</b>        | £6,563.39               |
|                                    | Supply interruption of over 24 hours and up to 48 hours         | £ / property | -          | -       | £523.65       | £6,882.27     | £58.00  | <b>£7,463.92</b>        | £7,405.92               |
| Planned interruptions              | Supply interruption for < 3 hours which is announced in advance | £ / property | -          | -       | £223.21       | £2,933.66     | £58.00  | <b>£3,214.88</b>        | £3,156.88               |
|                                    | Supply interruption for 3-6 hours which is announced in advance | £ / property | -          | -       | £223.21       | £2,933.66     | £58.00  | <b>£3,214.88</b>        | £3,156.88               |
| Low Pressure                       | Properties experiencing low pressure                            | £ / property | -          | -       | £256,444.29   | £21,984.10    | -       | <b>£278,428.39</b>      | £278,428.39             |
| Drinking Water Quality (Bio/Chem)  | Drinking water sample failure (no health impact)                | £ / sample   | -          | -       | £1,490,280.00 | £372,038.92   | £234.00 | <b>£1,862,552.92</b>    | £1,862,318.92           |
|                                    | Drinking water sample failure (public health impact)            | £ / sample   | -          | -       | £5,275,591.20 | £1,317,017.77 | £234.00 | <b>£6,592,842.97</b>    | £6,592,608.97           |
|                                    | Drinking water sample failure (boil order notice)               | £ / sample   | -          | -       | £3,831,509.88 | £956,512.06   | £234.00 | <b>£4,788,255.94</b>    | £4,788,021.94           |
| Drinking Water Quality (Aesthetic) | Drinking water the colour of weak tea                           | £ / contact  | -          | -       | £10,285.19    | £1,012.41     | £133.00 | <b>£11,430.60</b>       | £11,297.60              |
|                                    | Water with a taste or smell of disinfectant                     | £ / contact  | -          | -       | £11,817.68    | £1,163.26     | £133.00 | <b>£13,113.95</b>       | £12,980.95              |
|                                    | Cloudy water  | £ / contact  | -          | -       | £10,120.63    | £996.22       | £133.00 | <b>£11,249.84</b>       | £11,116.84              |
| Leakage                            | MI lost per day   | £ / MI       | £1.08      | -       | £133,410.17   | £26,364.97    | -       | <b>£159,776.22</b>      | £159,776.22             |
| Water Restrictions                 | Reduction in supply with no impact on customers                 | £ / property | -          | -       | £21.12        | £3.05         | -       | <b>£24.17</b>           | £24.17                  |
|                                    | Voluntary restriction   | £ / property | -          | -       | £30.83        | £4.45         | -       | <b>£35.29</b>           | £35.29                  |
|                                    | Compulsory restriction (hose pipe ban)                          | £ / property | -          | -       | £31.95        | £4.61         | -       | <b>£36.57</b>           | £36.57                  |
|                                    | Emergency restriction   | £ / property | -          | -       | £56.27        | £8.13         | -       | <b>£64.39</b>           | £64.39                  |
| Internal Sewer Flooding            | Flooding of cellar  | £ / property | -          | -       | £1,537.25     | £3,444.18     | £243.00 | <b>£5,224.42</b>        | £4,981.42               |
|                                    | Flooding of habitable area                                      | £ / property | -          | -       | £22,278.93    | £49,915.62    | £243.00 | <b>£72,437.55</b>       | £72,194.55              |
| External Sewer Flooding            | Flooding of minor roads   | £ / property | -          | -       | £21,565.65    | £61,607.89    | £182.00 | <b>£83,355.53</b>       | £83,173.53              |
|                                    | Flooding of major roads   | £ / property | -          | -       | £19,909.18    | £56,875.75    | £182.00 | <b>£76,966.93</b>       | £76,784.93              |
|                                    | Flooding within property boundary not inhibiting access         | £ / property | -          | -       | £13,945.89    | £39,840.07    | £182.00 | <b>£53,967.96</b>       | £53,785.96              |
|                                    | Flooding within property boundary inhibiting access             | £ / property | -          | -       | £15,775.89    | £45,067.95    | £182.00 | <b>£61,025.84</b>       | £60,843.84              |

| Service measure       | Severity level   | Units             | Use values  | Non-use       | Households | Businesses  | Trust   | Total (including Trust) | Total (excluding Trust) |
|-----------------------|--|-------------------|-------------|---------------|------------|-------------|---------|-------------------------|-------------------------|
|                       | Flooding causing societal disruption                               | £ / property      | -           | -             | £62,740.73 | £179,235.23 | £182.00 | <b>£242,157.96</b>      | £241,975.96             |
| Bathing Water Quality | Water quality sample failure at a bathing water                    | £ / bathing water | £361,609.67 | £167,890.20   | -          | £108,961.13 | -       | <b>£638,461.01</b>      | £638,461.01             |
|                       | Deterioration in classification                                    | £ / bathing water | £734,979.00 | £341,240.25   | -          | £221,465.72 | -       | <b>£1,297,684.97</b>    | £1,297,684.97           |
|                       | Loss of Blue Flag status   | £ / bathing water | £754,823.43 | £350,453.74   | -          | £227,445.29 | -       | <b>£1,332,722.46</b>    | £1,332,722.46           |
| River Water Quality   | Length of river water improved                                     | £ / %             | £319,252.76 | £3,899,296.51 | -          | £246,776.09 | -       | <b>£4,465,325.36</b>    | £4,465,325.36           |
| Pollution Incidents   | Category 1 pollution incidents                                     | £ / %             | £211,600.94 | £94,663.58    | -          | £162,577.79 | £28.00  | <b>£468,870.30</b>      | £468,842.30             |
|                       | Category 2 pollution incidents                                     | £ / %             | £139,121.07 | £62,238.37    | -          | £106,889.87 | £28.00  | <b>£308,277.32</b>      | £308,249.32             |
|                       | Category 3 pollution incidents                                     | £ / incident      | £67,110.99  | £30,023.34    | -          | £51,562.89  | £28.00  | <b>£148,725.21</b>      | £148,697.21             |
|                       | Category 4 pollution incidents                                     | £ / incident      | £28,455.06  | £12,729.89    | -          | £21,862.66  | £28.00  | <b>£63,075.62</b>       | £63,047.62              |
| Odour                 | Complaints about chronic intolerable odour                         | £ / complaint     | -           | -             | £1,613.51  | £313.37     | -       | <b>£1,926.88</b>        | £1,926.88               |
|                       | Complaints about transient odour                                   | £ / complaint     | -           | -             | £1,140.29  | £221.47     | -       | <b>£1,361.76</b>        | £1,361.76               |
| Land Improved         | Area of land conserved or improved (general)                       | £ / ha            | £3,110.74   | -             | -          | -           | -       | <b>£3,110.74</b>        | £3,110.74               |
|                       | Area of land conserved or improved (coniferous woodland)           | £ / ha            | £2,817.33   | -             | -          | -           | -       | <b>£2,817.33</b>        | £2,817.33               |
|                       | Area of land conserved or improved (broadleaf woodland)            | £ / ha            | £3,397.70   | -             | -          | -           | -       | <b>£3,397.70</b>        | £3,397.70               |
|                       | Area of land conserved or improved (semi-natural grassland)        | £ / ha            | £1,085.49   | -             | -          | -           | -       | <b>£1,085.49</b>        | £1,085.49               |
|                       | Area of land conserved or improved (farmland)                      | £ / ha            | £1,634.94   | -             | -          | -           | -       | <b>£1,634.94</b>        | £1,634.94               |
|                       | Area of land conserved or improved (wetlands & floodplains)        | £ / ha            | £4,254.34   | -             | -          | -           | -       | <b>£4,254.34</b>        | £4,254.34               |
|                       | Area of land conserved or improved (mountains, moorlands & heaths) | £ / ha            | £1,228.78   | -             | -          | -           | -       | <b>£1,228.78</b>        | £1,228.78               |
|                       | Area of land conserved or improved (coastal margins)               | £ / ha            | £1,619.47   | -             | -          | -           | -       | <b>£1,619.47</b>        | £1,619.47               |
|                       | Area of land conserved or improved (green space)                   | £ / ha            | £8,847.84   | -             | -          | -           | -       | <b>£8,847.84</b>        | £8,847.84               |

Figure 4. Summary of recommended baseline values for 13 service measures



# No 1. Unplanned Interruptions

## Data sources

Estimates of the value YWS customers place on reducing the number of properties affected by unplanned interruptions to water supply were obtained from the methods and data sources set out in Table 8.

**Table 8. Data sources available for unplanned interruptions**

| 1 <sup>st</sup> Round Stated Preference | 2 <sup>nd</sup> Round Stated Preference | Revealed Preference Visitor | Revealed Preference Business | Behavioural Experiment | Trust Experiment | PR14 Values | PR09 Values | Benefits Transfer |
|---|---|-----------------------------|------------------------------|------------------------|------------------|-------------|-------------|-------------------|
| ✓                                       | ✓                                       | ✗                           | ✓                            | ✓                      | ✓                | ✓           | ✓           | ✗                 |

## Results

On the basis of the linear model (i.e. where willingness-to-pay (WTP) for a defined level of improvement in service delivery is assumed to be equivalent to willingness-to-accept (WTA) the same incremental deterioration in service delivery), the results of the First Round Stated Preference (SP) survey in Work Package 1 suggest that YWS household customers are willing to pay £0.00012 per year to reduce the number of properties affected by an unexpected supply interruption of 3-6 hours by one property, while business customers are willing to pay £0.00037 per year.

By contrast, the non-linear model (i.e. where WTP and WTA estimates for the same incremental change - improvement or deterioration - in service delivery are not equivalent) estimated that household customers are willing to pay £0.000029 per property and business customers £0.00017 for a one unit improvement.

The results of the Second Round SP survey suggest that, in terms of severity levels, the WTP for household and business customers for a one unit improvement in unplanned interruptions are as follows (note this work package estimated odds ratios which were then applied to the linear model results from Work Package 1):

- Less than 3 hours = £0.000061 and £0.00019 per property
- 3-6 hours = £0.00012 and £0.00037 per property
- 6-12 hours = £0.00014 and £0.00045 per property
- 12-24 hours = £0.00015 and £0.00046 per property<sup>14</sup>
- Over 24 hours and up to 48 hours = £0.00016 and £0.00052 per property
- Planned interruption of 3-6 hours = £0.000070 and £0.00022 per property

The Revealed Preference (RP) Business Survey estimated that YWS business customers spend a median value of £7.88 per business per year to deal with supply interruptions with a range of £4.32 to £7.97. The survey recorded an average number of 121 supply interruptions reported each year by respondents giving a median value of £0.065 per business impacted, with a range of £0.036 to £0.066. Given the small sample size of businesses actually engaging in avertive behaviour and the impact of outliers on the results it is considered the median value is more appropriate for use than the mean.

The Behavioural Experiment estimated that YWS household customers are willing to increase their annual water bills by £0.00021 for every property no longer affected by unexpected supply interruptions of 3-6 hours.

The Trust Experiment estimated that the average cost incurred in terms of reduced bill payments following a supply interruption is £58.00 per customer affected. Note that this estimate is not directly equivalent to those obtained from the SP and RP surveys or the Behavioural Experiment as it represents a direct cost to YWS which reflects a cost, or loss of welfare, incurred by the customer. Dividing by the total customer base to provide a comparison against the other value sets gives a value of £0.000026 per customer. However, the estimate from the Trust Experiment needs to be treated with caution as there may be a number of other confounding factors (not explored in this project) that affect customers' propensity to pay, as well as changes in this value over time (i.e. it may not be that the propensity to refuse to pay continues over time).

The SP surveys undertaken for PR14 estimated the amount YWS households and businesses would be willing to pay to reduce the chance of being impacted by an unexpected supply interruption at £0.0017 and £0.0063 respectively. Note, the units used in PR14 are not directly comparable with those used in PR19.

The SP surveys undertaken for PR09 estimated the amount YWS households and businesses would be willing to pay to reduce the chance of being impacted by an unexpected supply interruption at £0.0030 and £0.011 respectively. Note, the units used in PR09 are not directly comparable with those used in PR19.

A comparison of these values is set out in Figure 5 and Figure 6. Note that, due to differences in units across data sources the figures are illustrative of the range of values. Also note that, the values for Work Package 2 are presented alongside the other values, these demonstrate the range in WTP estimates for different severity levels within the same service measure and so are not directly comparable to the other estimates.

## Triangulation

The data from the work packages were then compared using the triangulation method set out in Table 6. Note that the values from Work Package 2 were not included in the triangulation process as the outputs from this work package were odds ratios rather than value estimates. Instead, the outputs from Work Package 2 were applied to the final value selected through the triangulation exercise to estimate the values for each of the severity levels. The values for PR14 and PR09 were included for comparative purposes only, rather than as values to be put forward for use in the DMF.

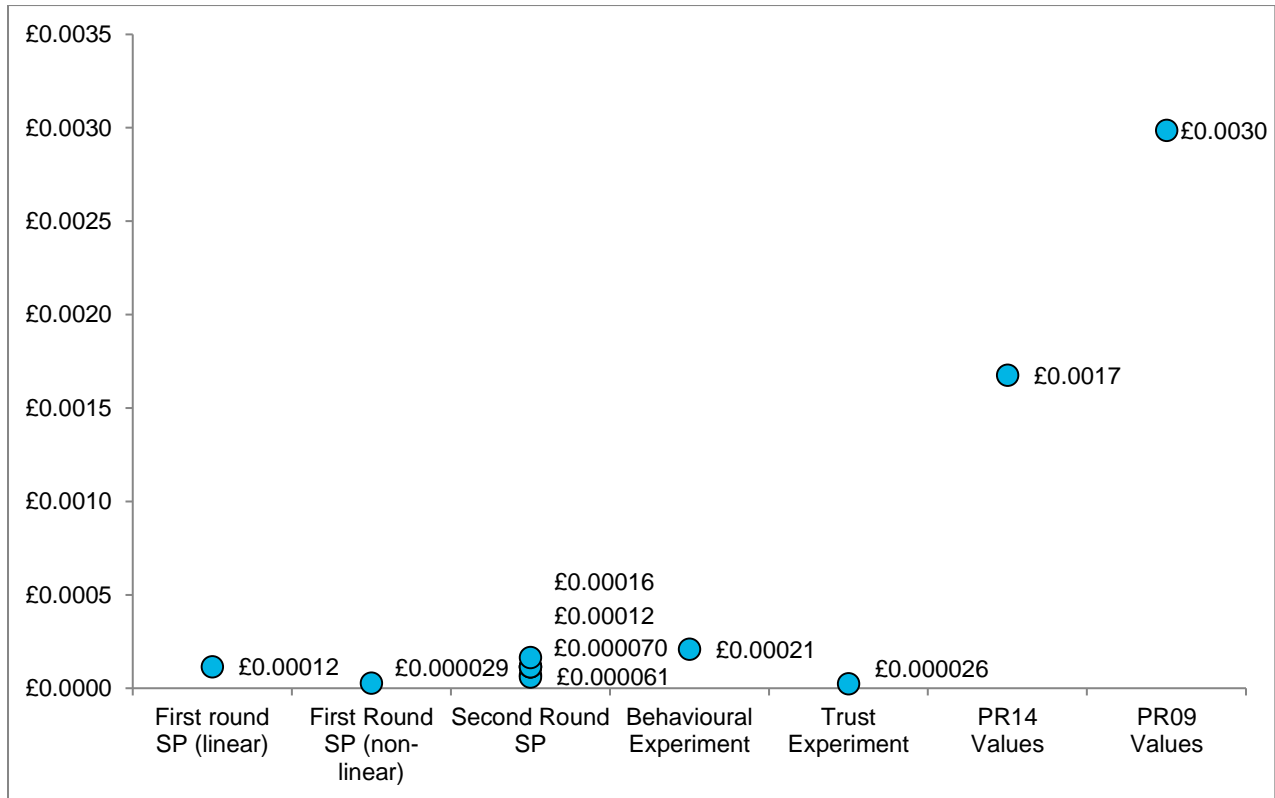
The results of the triangulation process are set out in Table 9 and Table 10.

---

<sup>14</sup> Note, these results suggest that customer WTP is indifferent between a water supply interruption which lasts 3-6, 6-12, or 12-24 hours. This could be a genuine preference or could reflect challenges in customers' understanding of the difference in severity levels and therefore being able to make an informed choice between them. Further work could be done on the raw data to investigate this issue in more detail.

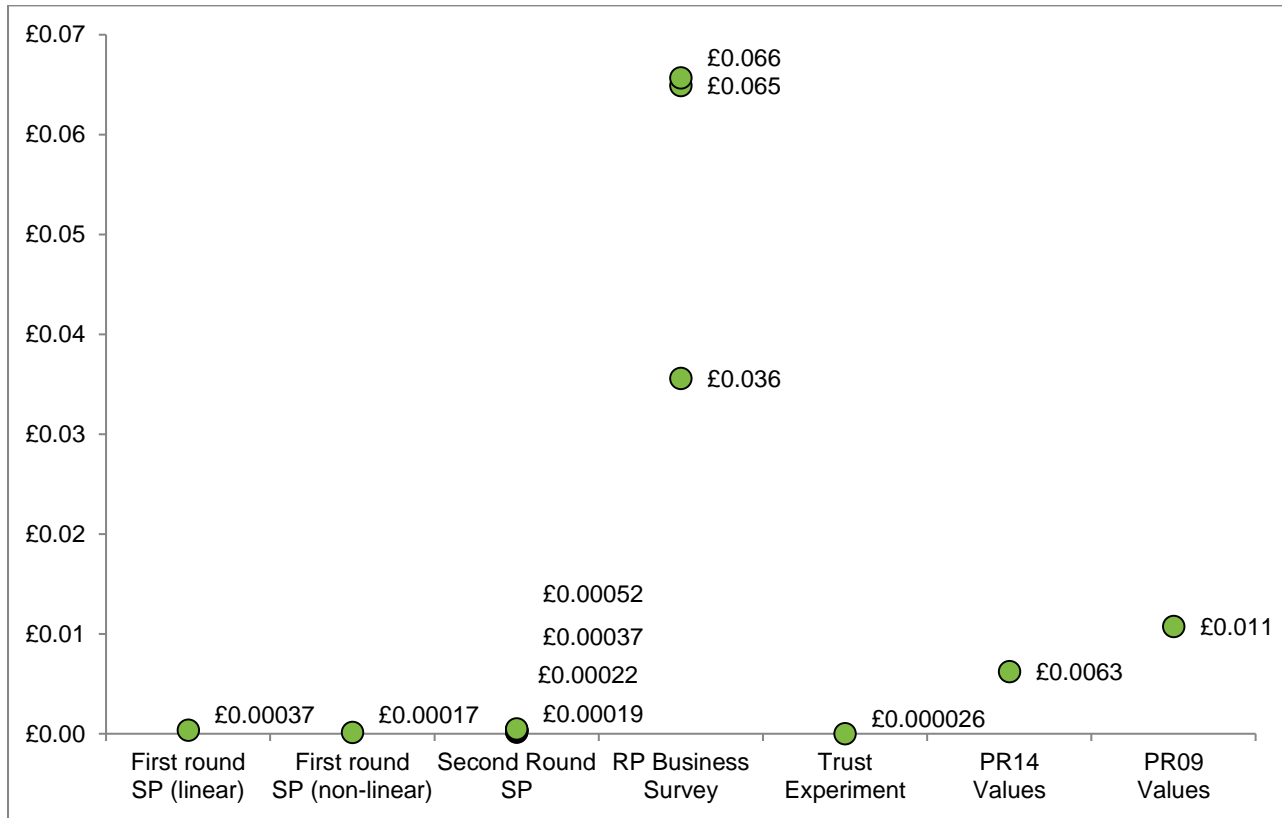


**Figure 5. Illustrative comparison of individual values for unplanned interruptions of 3-6 hours (household)**



**Figure 6. Illustrative comparison of individual values for unplanned interruptions of 3-6 hours**

(business)



**Table 9. Triangulation process for unplanned interruptions of 3-6 hours (household)**

| Factor  | First Round SP (linear)  | First Round SP (non-linear +1)  | Behavioural Experiment  | Trust Experiment  |
|---|--|---|---|---|
| Individual value                                  | £0.00012 per property  | £0.000029 per property  | £0.00021 per property   | £58.00 per incident or £0.000026 per incident/customer  |
| Statistical robustness                            | <b>High</b> – based on sample of 1,000 households  | <b>High</b> – based on sample of 1,000 households   | <b>Very High</b> – based on sample of 2,000 households  | <b>Low</b> – based on sample of 62,000 customers although significant caveats on robustness of analysis                       |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.  | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>High</b> – based on observed choices in “real life” situations   |
| Completeness of value                             | <b>Medium</b> – customer value mostly captured although potentially misses out on the trust component  | <b>Low</b> – customer value mostly captured although misses difference for larger changes and potentially misses out on the trust component | <b>Medium</b> – customer value mostly captured although potentially misses out on the trust component                           | <b>Low</b> – doesn’t capture entire customer value but does capture trust component   |
| Consistency of track record or time series (PR14) | <b>High</b> – value 93% lower than PR14  | <b>High</b> – value 98% lower than PR14   | <b>High</b> – value 87% lower than PR14   | <b>High</b> – value 99% lower than PR14   |
| Consistency of track record or time series (PR09) | <b>High</b> – value 96% lower than PR09  | <b>High</b> – value 99% lower than PR09   | <b>High</b> – value 93% lower than PR09   | <b>High</b> – value 99% lower than PR09   |
| Correlation with qualitative evidence             | <b>Medium</b> – bottom third priority (11 <sup>th</sup> /13) compared to qualitative ranking in mid third (4 <sup>th</sup> /10)  | <b>Medium</b> – bottom third priority (12 <sup>th</sup> /13) compared to qualitative ranking in mid third (4 <sup>th</sup> /10)             | <b>Medium</b> – bottom third priority (11 <sup>th</sup> /13) compared to qualitative ranking in mid third (4 <sup>th</sup> /10) | <b>Medium</b> – bottom third priority (5 <sup>th</sup> /6) compared to qualitative ranking in mid third (4 <sup>th</sup> /10) |
| Implication of using this value (household)       | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14/09   | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14/09                  | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14/09      | Less robust value although captures value associated with trust unlikely to be captured in customer valuation or in PR14/09   |
| <b>Recommended value</b>                          | <i>All three of the customer values are broadly comparable and provide robust estimates, which are similar to those of PR14 and PR09. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The Trust Experiment captures an additional aspect of value that may be missing from the customer valuation estimates. It is possible that there would be some double counting by including this value alongside the customer values although the likelihood is considered to be low. The recommended approach is therefore to take an average of the First Round SP (linear) and Behavioural Experiment values plus the Trust Experiment value.</i> |   |   |   |

**Table 10. Triangulation process for unplanned interruptions of 3-6 hours (business)**

| Factor  | First Round SP (linear)  | First Round SP (non-linear +1)  | Business Survey (median)   | Trust Experiment  |
|---|--|---|--|---|
| Individual value                                  | £0.00037 per property  | £0.00017 per property   | £0.065 per business  | £58.00 per incident or £0.000026 per incident/customer  |
| Statistical robustness                            | <b>High</b> – based on sample of 500 businesses  | <b>High</b> – based on sample of 500 businesses   | <b>Medium</b> – based on sample of 1,000 businesses although only 33 involved in averted behaviour   | <b>Low</b> – based on sample of 62,000 customers although significant caveats on robustness of analysis                       |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.  | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>High</b> – based on actual expenditure decisions  | <b>High</b> – based on observed choices in “real life” situations   |
| Completeness of value                             | <b>Medium</b> – customer value mostly captured although potentially misses out on the trust component  | <b>Low</b> – customer value mostly captured although misses difference for larger changes and potentially misses out on the trust component | <b>Low</b> – focuses on actual expenditure so likely to be a lower bound value (assuming value exceeds expenditure and consumer surplus is not captured) | <b>Low</b> – doesn’t capture entire customer value but does capture trust component   |
| Consistency of track record or time series (PR14) | <b>High</b> – value 94% lower than PR14  | <b>High</b> – value 97% lower than PR14   | <b>Medium</b> – value 938% higher than PR14  | <b>High</b> – value 100% lower than PR14  |
| Consistency of track record or time series (PR09) | <b>High</b> – value 97% lower than PR09  | <b>High</b> – value 98% lower than PR09   | <b>Medium</b> – value 504% higher than PR09  | <b>High</b> – value 100% lower than PR09  |
| Correlation with qualitative evidence             | <b>Medium</b> – bottom third priority (11 <sup>th</sup> /13) compared to qualitative ranking in mid third (4 <sup>th</sup> /10)  | <b>Medium</b> – bottom third priority (11 <sup>th</sup> /13) compared to qualitative ranking in mid third (4 <sup>th</sup> /10)             | <b>Medium</b> – bottom third priority (6 <sup>th</sup> /7) compared to qualitative ranking in mid third (4 <sup>th</sup> /10)                            | <b>Medium</b> – bottom third priority (5 <sup>th</sup> /6) compared to qualitative ranking in mid third (4 <sup>th</sup> /10) |
| Implication of using this value (household)       | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14/09   | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14/09                  | Medium robustness, somewhat aligned with qualitative preferences would lead to somewhat higher results than PR14/09                                      | Less robust value although captures value associated with trust unlikely to be captured in customer valuation or in PR14/09   |
| <b>Recommended value</b>                          | <p><i>All three of the customer values are broadly comparable and provide reasonably robust estimates which are similar to those of PR14 and PR09. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The Business Survey value is interesting in that the estimate is higher than both the SP survey and the PR14/09 values when it is expected that this would produce a lower bound estimate. This may be due to methodological/definitional issues or it may reflect the fact that some averted costs are likely to be assumed to have to be made anyway, regardless of a marginal change in service provision (capturing an average rather than a marginal cost). The Trust Experiment captures an additional aspect of value that may be missing from the customer valuation estimates. It is possible that there would be some double counting by including this value alongside the customer values although the likelihood is considered to be low. The recommended approach is therefore to take an average of the First Round SP (linear) and Business Survey (median) values plus the Trust Experiment value.</i></p> |   |  |   |

## Recommended values

A summary of the recommended values is set out in Table 11. Note, in order to estimate the values for different severities of planned and unplanned interruptions (i.e. < 3, 6-12, 12-24 hours), the corresponding unadjusted

odds ratios from Work Package 2 were applied to the base (or anchor) values (3-6 hours). Odds ratios<sup>15</sup> were only estimated for planned interruptions of 3-6 hours which was applied to the base value for unplanned interruptions. The resulting value was also applied to unplanned interruptions of less than 3 hours but was not applied to planned interruptions of more than 6 hours on the assumption that the duration of any planned interruption would not exceed 6 hours.

The aggregate total is the sum of the aggregate values for each of Households, Businesses and Trust where the aggregate values are the individual values multiplied by either the total number of YWS household or business customers. The aggregate Trust values were calculated using the total number of household customers as it was not possible to distinguish between household and business customers in the underlying analysis.

**Table 11. Recommended individual and aggregate total values for unplanned (and planned) interruptions**

| Service measure                | Unit                | Households | Businesses | Trust     | Aggregate Total  |
|--------------------------------|---------------------|------------|------------|-----------|------------------|
| <b>Unplanned interruptions</b> |                     |            |            |           |                  |
| Interruption <3 hours          | £/property/customer | £0.000086  | £0.017340  | £0.000026 | <b>£2,819.62</b> |
| Interruption 3-6 hours         | £/property/customer | £0.000163  | £0.032656  | £0.000026 | <b>£5,258.78</b> |
| Interruption 6-12 hours        | £/property/customer | £0.00020   | £0.040101  | £0.000026 | <b>£6,444.56</b> |
| Interruption 12-24 hours       | £/property/customer | £0.000206  | £0.041212  | £0.000026 | <b>£6,621.39</b> |
| Interruption >24 hours         | £/property/customer | £0.000232  | £0.046502  | £0.000026 | <b>£7,463.92</b> |
| <b>Planned interruptions</b>   |                     |            |            |           |                  |
| Interruption <3 hours          | £/property/customer | £0.000099  | £0.019822  | £0.000026 | <b>£3,214.88</b> |
| Interruption 3-6 hours         | £/property/customer | £0.000099  | £0.019822  | £0.000026 | <b>£3,214.88</b> |
| Interruption 6-12 hours        | £/property/customer | -          | -          | -         | -                |
| Interruption 12-24 hours       | £/property/customer | -          | -          | -         | -                |

<sup>15</sup> Note that the unadjusted odds ratios from the Work Package 2 Report Technical Appendix were used.

## No 2. Low Pressure

### Data sources

Estimates of the value YWS customers place on reducing the number of properties affected by low pressure were obtained from the methods and data sources set out in Table 12.

**Table 12. Data sources available for low pressure**

| 1 <sup>st</sup> Round Stated Preference | 2 <sup>nd</sup> Round Stated Preference | Revealed Preference Visitor | Revealed Preference Business | Behavioural Experiment | Trust Experiment | PR14 Values | PR09 Values | Benefits Transfer |
|---|---|-----------------------------|------------------------------|------------------------|------------------|-------------|-------------|-------------------|
| ✓                                       | ✗                                       | ✗                           | ✓                            | ✓                      | ✗                | ✓           | ✓           | ✗                 |

### Results

On the basis of the linear model, the results of the First Round Stated Preference (SP) survey in Work Package 1 suggest that YWS household customers are willing to pay £0.11 per year to reduce the number of properties affected by low pressure by one property, while business customers are willing to pay £0.27.

By contrast, the non-linear model estimated that household customers are willing to pay £0.069 per property and business customers £0.31 for a one unit improvement.

The Revealed Preference (RP) Business Survey estimated that YWS business customers spend a median value of £1.89 per business per year to deal with low pressure with a range of £0.54 to £2.07. The survey recorded an average number of 85 low pressure incidents reported each year by respondents giving a median value of £0.022 per business impacted, with a range of £0.0064 to £0.024. Given the small sample size of businesses actually engaging in avertive behaviour and the impact of outliers on the results it is considered the median value is more appropriate for use than the mean.

The Behavioural Experiment estimated that YWS household customers are willing to increase their annual water bills by £0.12 for every property no longer affected by low pressure.

The SP surveys undertaken for PR14 estimated the amount YWS households and businesses would be willing to pay to reduce low pressure events at £0.0061 and £0.82 respectively. Note, the units used in PR14 are not directly comparable with those used in PR19.

The SP surveys undertaken for PR09 estimated the amount YWS households and businesses would be willing to pay to reduce low pressure events at £0.020 and £0.081 respectively. Note, the units used in PR09 are not directly comparable with those used in PR19.

A comparison of these values is set out in Figure 7 and Figure 8. Note that, due to differences in units across data sources the figures are illustrative of the range of values.

### Triangulation

The data from the work packages were then compared using the triangulation method set out in Table 6. The values for PR14 and PR09 were included for comparative purposes only, rather than as values to be put forward for use in the DMF.

The results of the triangulation process are set out in Table 13 and Table 14.

Figure 7. Illustrative comparison of values for low pressure (household)

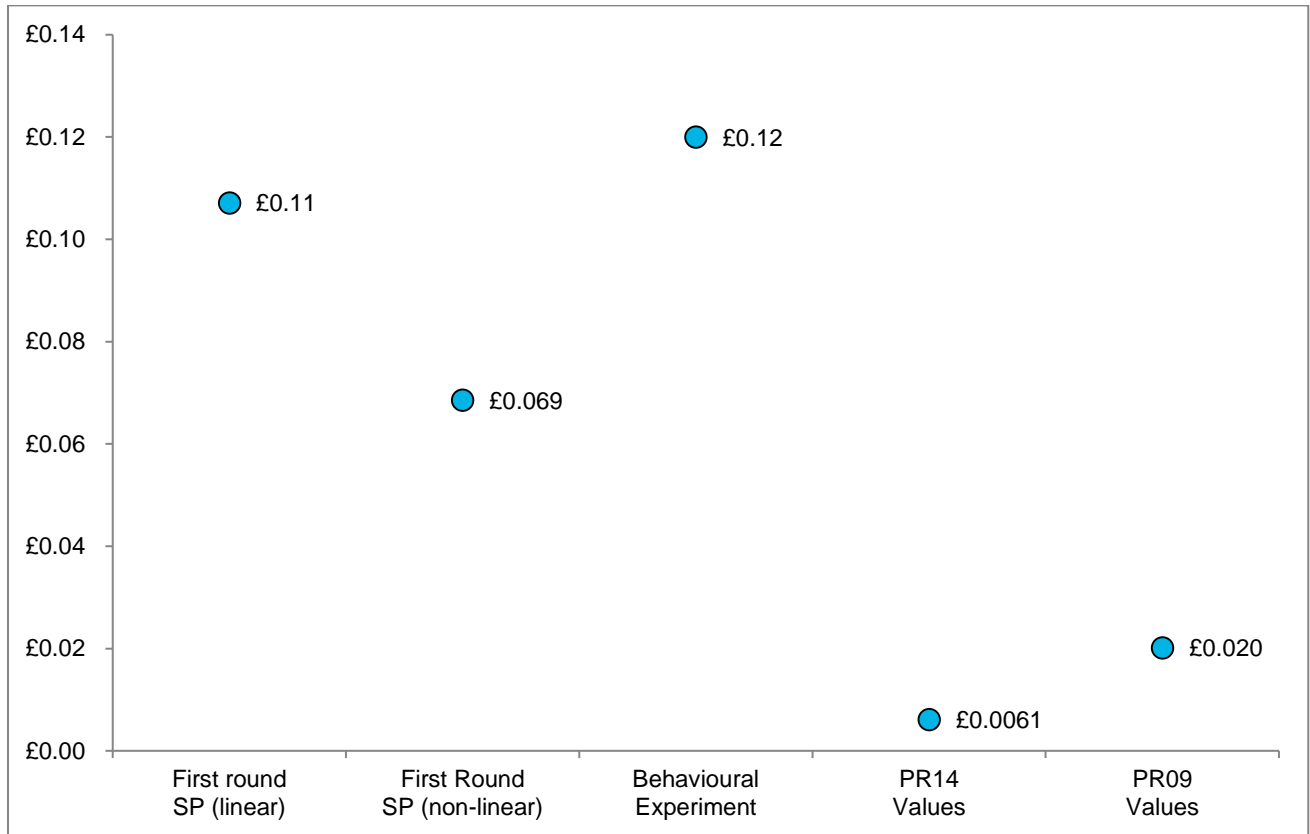
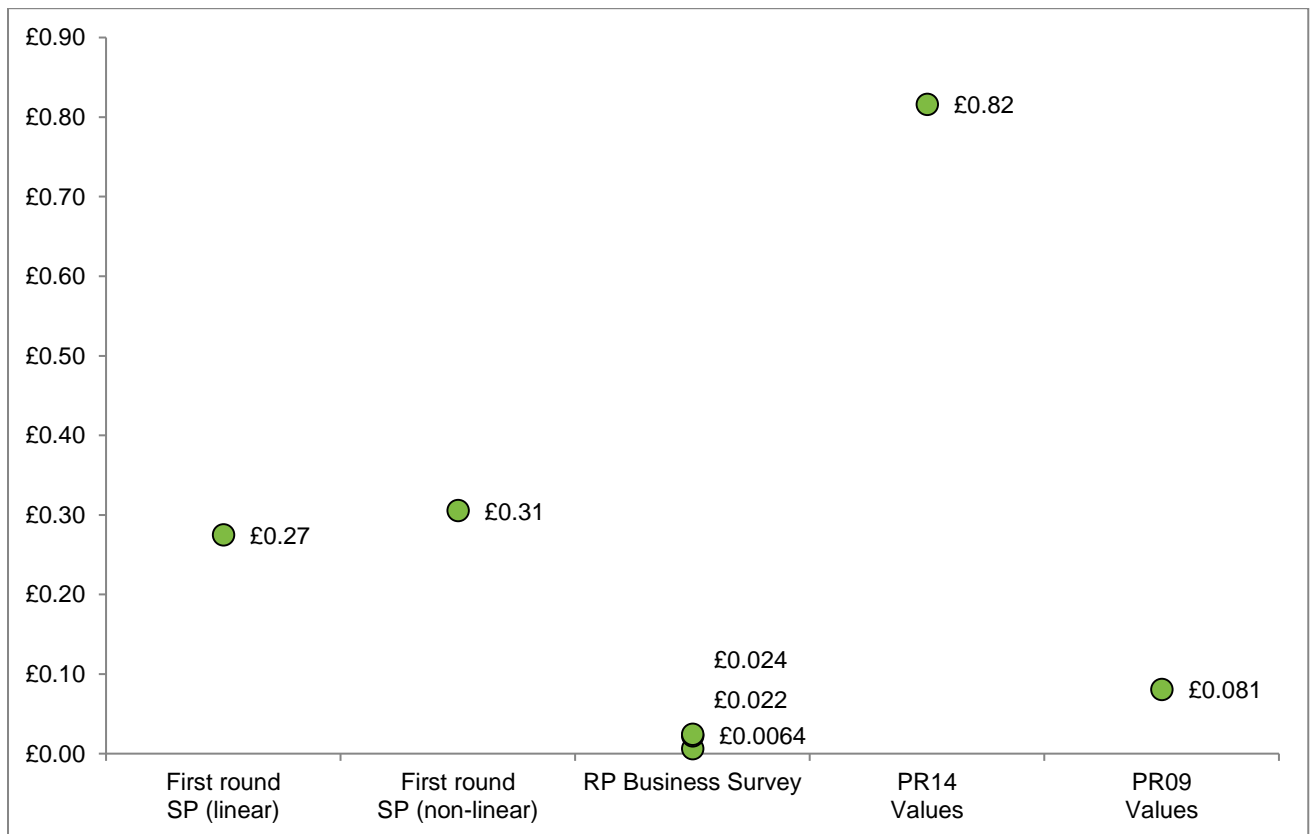


Figure 8. Illustrative comparison of values for low pressure (business)



**Table 13. Triangulation process for low pressure (household)**

| Factor  | First Round SP (linear)  | First Round SP (non-linear +1)   | Behavioural Experiment   |
|---|--|--|--|
| Value   | £0.11 per property   | £0.069 per property  | £0.12 per property   |
| Statistical robustness                            | <b>High</b> – based on sample of 1,000 households  | <b>High</b> – based on sample of 1,000 households  | <b>Very High</b> – based on sample of 2,000 households   |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.  | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.                            | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.                            |
| Completeness of value                             | <b>High</b> – customer value completely captured   | <b>Medium</b> – customer value mostly captured although misses difference for larger changes                 | <b>High</b> – customer value completely captured   |
| Consistency of track record or time series (PR14) | <b>Low</b> – value 1,644% higher than PR14   | <b>Low</b> – value 1,016% higher than PR14   | <b>Low</b> – value 1,853% higher than PR14   |
| Consistency of track record or time series (PR09) | <b>Medium</b> – value 431% higher than PR09  | <b>Medium</b> – value 240% higher than PR09  | <b>Medium</b> – value 495% higher than PR09  |
| Correlation with qualitative evidence             | <i>No qualitative data available for low pressure</i>  | <i>No qualitative data available for low pressure</i>  | <i>No qualitative data available for low pressure</i>  |
| Implication of using this value (household)       | Robust value, would lead to CBA and ODI results significantly higher than PR14 and somewhat higher than PR09   | Robust value, would lead to CBA and ODI results significantly higher than PR14 and somewhat higher than PR09 | Robust value, would lead to CBA and ODI results significantly higher than PR14 and somewhat higher than PR09 |
| <b>Recommended value</b>                          | <i>All three of the customer values are broadly comparable and provide robust estimates, although higher than both PR14 and PR09. . Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. There is a significant degree of correlation between the values for the First Round SP (linear) and the Behavioural Experiment, as such, it is recommended that an average is taken of these two values.</i> |  |  |

**Table 14. Triangulation process for low pressure (business)**



| Factor  | First Round SP (linear)  | First Round SP (non-linear +1)   | Business Survey (median)   |
|---|--|--|--|
| Value   | £0.27 per property   | £0.31 per property   | £0.022 per business  |
| Statistical robustness                            | <b>High</b> – based on sample of 500 businesses  | <b>High</b> – based on sample of 500 businesses  | <b>Medium</b> – based on sample of 1,000 businesses although only 17 involved in averted behaviour   |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.  | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.                      | <b>High</b> – based on actual expenditure decisions  |
| Completeness of value                             | <b>High</b> – customer value completely captured   | <b>Medium</b> – customer value mostly captured although misses difference for larger changes           | <b>Low</b> – focuses on actual expenditure so likely to be a lower bound value (assuming value exceeds expenditure and consumer surplus is not captured) |
| Consistency of track record or time series (PR14) | <b>High</b> – value 66% lower than PR14  | <b>High</b> – value 63% lower than PR14  | <b>High</b> – value 97% lower than PR14  |
| Consistency of track record or time series (PR09) | <b>Medium</b> – value 241% higher than PR09  | <b>Medium</b> – value 279% higher than PR09  | <b>High</b> – value 72% lower than PR09  |
| Correlation with qualitative evidence             | <i>No qualitative data available for low pressure</i>  | <i>No qualitative data available for low pressure</i>  | <i>No qualitative data available for low pressure</i>  |
| Implication of using this value (household)       | Robust value, would lead to CBA and ODI results slightly lower than PR14 and somewhat higher than PR09   | Robust value, would lead to CBA and ODI results slightly lower than PR14 and somewhat higher than PR09 | Medium robustness, would lead to slightly lower results than PR14/09   |
| <b>Recommended value</b>                          | <i>All three of the customer values are broadly comparable and provide reasonably robust estimates which are broadly similar to those of PR14 and PR09. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes (as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1, +1, +2 change from the baseline) so the linear value is recommended. With regards to the Business Survey value, the estimate sits reasonably in line with PR14/09 and, as expected, provides a lower bound estimate to contrast against the Stated Preference survey. The recommended approach is therefore to take an average of the First Round SP (linear) and Business Survey (median) values.</i> |  |  |

## Recommended values

A summary of the recommended values is set out in Table 15. The aggregate total is the sum of the aggregate values for each of Households and Businesses where the aggregate values are the individual values for Households and Businesses multiplied by the total number of YWS household and business customers respectively.

**Table 15. Recommended individual and aggregate values for low pressure**

| Service measure | Unit                | Households | Businesses | Aggregate Total    |
|-----------------|---------------------|------------|------------|--------------------|
| Low pressure    | £/property/customer | £0.11      | £0.15      | <b>£278,428.39</b> |

## No 3. Drinking Water Quality (Biological/Chemical)

### Data sources

Estimates of the value YWS customers place on reducing the number of drinking water samples failing Government standards were obtained from the methods and data sources set out in Table 16.

**Table 16. Data sources available for drinking water quality (biological/chemical)**

| 1 <sup>st</sup> Round Stated Preference | 2 <sup>nd</sup> Round Stated Preference | Revealed Preference Visitor | Revealed Preference Business | Behavioural Experiment | Trust Experiment | PR14 Values | PR09 Values | Benefits Transfer |
|---|---|-----------------------------|------------------------------|------------------------|------------------|-------------|-------------|-------------------|
| ✓                                       | ✓                                       | ✗                           | ✓                            | ✓                      | ✓                | ✓           | ✓           | ✗                 |

### Results

On the basis of the linear model, the results of the First Round Stated Preference (SP) survey in Work Package 1 suggest that YWS household customers are willing to pay £0.66 per year to reduce the number of samples failing Government standards by one sample, while business customers are willing to pay £2.14.

By contrast, the non-linear model estimated that household customers are willing to pay £0.49 per sample and business customers £2.78 for a one unit improvement.

The results of the Second Round SP survey suggest that, in terms of severity levels, the WTP for household and business customers respectively for a reduction in the number of samples failing Government standards are as follows (note this work package estimated odds ratios which were then applied to the linear model results from Work Package 1):

- Sample failure with no health impact = £0.66 and £2.14 per sample
- Sample failure with public health impact = £2.34 and £7.57 per sample
- Sample failure requiring boil order notice = £1.70 and 5.50 per sample<sup>16</sup>

The Revealed Preference (RP) Business Survey estimated that YWS business customers spend a median value of £393.02 per business per year to deal with drinking water quality failures with a range of £108.42 to £393.03. The survey recorded an average number of 136 drinking water quality issues reported each year by respondents giving a median value of £2.89 per business impacted, with a range of £0.80 to £2.89. Given the small sample size of businesses actually engaging in avertive behaviour and the impact of outliers on the results it is considered the median value is more appropriate for use than the mean.

Note that the definitions used for the service measures varied between the Business Survey and the Stated Preference surveys in Work Packages 1 & 5. In the Stated Preference surveys customers were asked to state their WTP for a change in the number of samples which fail Government standards but do not cause a health impact, while in the Revealed Preference survey customers were asked to report any expenditure related to incidents where their water supply was affected by poor quality for biological reasons (coliforms/ecoli) and hardness. As such the estimates are not directly comparable. It is also noted that these estimates are distorted by the monitoring costs provided by two companies of £5,000 and £100,000; excluding these two respondents from the sample provides a median estimate of £0.0015 per drinking water quality event with a range of £0.00029 to £0.0017.

The Behavioural Experiment estimated that YWS household customers are willing to increase their annual water bills by £4.74 for each reduction in the number of samples failing Government standards.

The Trust Experiment estimated that the average cost incurred in terms of reduced bill payments following a drinking water quality incident is £234.00 per customer affected. Note that this estimate is not directly equivalent to those obtained from the SP and RP surveys or the Behavioural Experiment as it represents a direct cost to YWS which reflects a cost, or loss of welfare, incurred by the customer. Dividing by the total customer base to provide a comparison against the other value sets gives a value of £0.00010 per customer. However, the estimate from the Trust Experiment needs to be treated with caution as there may be a number of other confounding factors (not explored in this project) that affect customers' propensity to pay, as well as changes in this value over time (i.e. it may not be that the propensity to refuse to pay continues over time).

The SP surveys undertaken for PR14 estimated the amount YWS households and businesses would be willing to pay to reduce the number of samples failing at £0.021 and £0.13 respectively. Note, the units used in PR14 are not directly comparable with those used in PR19.

The SP surveys undertaken for PR09 estimated the amount YWS households and businesses would be willing to pay to reduce the number of samples failing at £0.033 and £0.10 respectively. Note, the units used in PR09 are not directly comparable with those used in PR19.

A comparison of these values is set out in Figure 9 and Figure 10. Note that, due to differences in units across data sources the figures are illustrative of the range of values. Also note that, the values for Work Package 2 are presented alongside the other values, these demonstrate the range in WTP estimates for different severity levels within the same service measure and so are not directly comparable to the other estimates.

## Triangulation

The data from the work packages were then compared using the triangulation method set out in Table 6. Note that the values from Work Package 2 were not included in the triangulation process as the outputs from this work package were odds ratios rather than value estimates. Instead, the outputs from Work Package 2 were applied to the final value selected through the triangulation exercise to estimate the values for each of the severity levels. The values for PR14 and PR09 were included for comparative purposes only, rather than as values to be put forward for use in the DMF.

The results of the triangulation process are set out in Table 17 and Table 18.

---

<sup>16</sup> Note, these results suggest that customer WTP is higher for a sample failure with a public health impact than a boil order notice. This could be a genuine preference or could reflect challenges in customers' understanding of the difference in severity levels and therefore being able to make an informed choice between them. Further work could be done on the raw data to investigate this issue in more detail.

Figure 9. Illustrative comparison of values for drinking water quality (biological/chemical) (household)

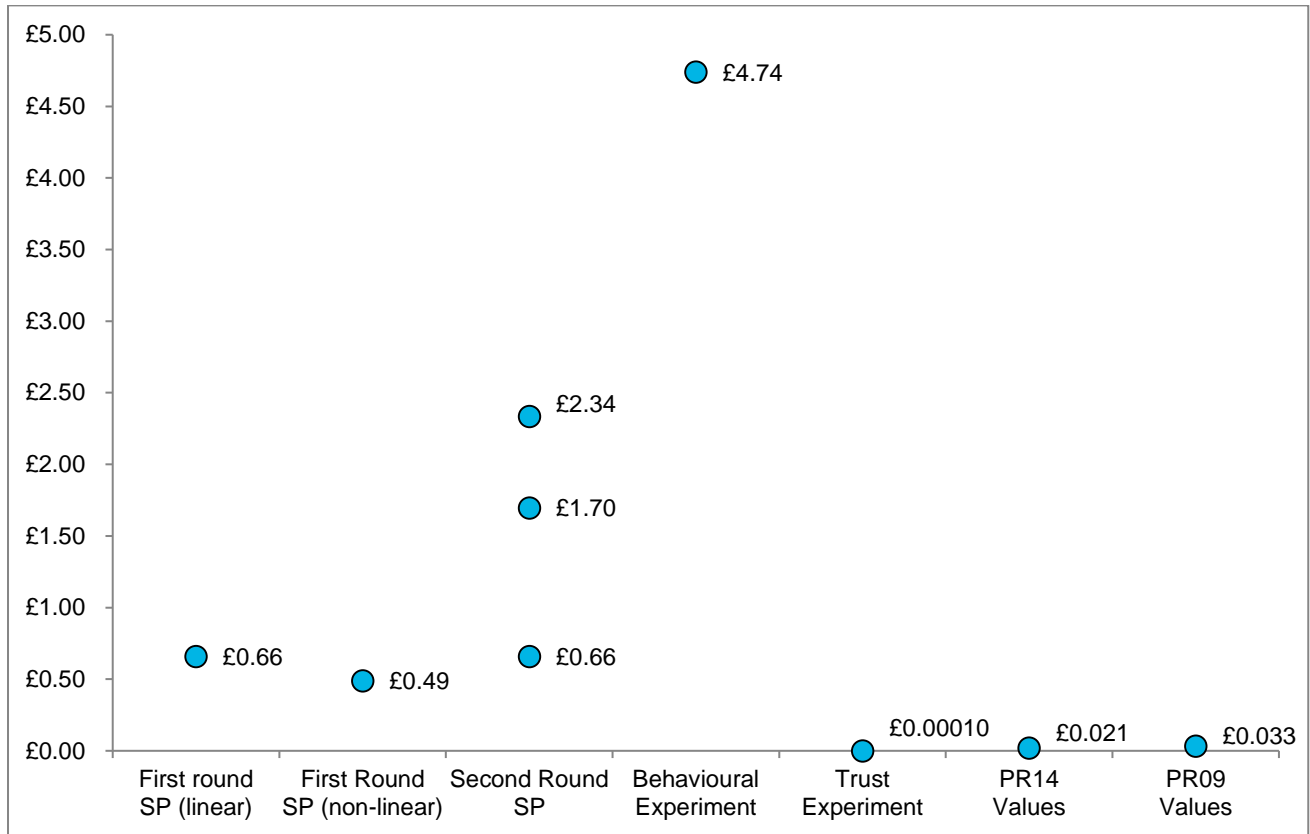
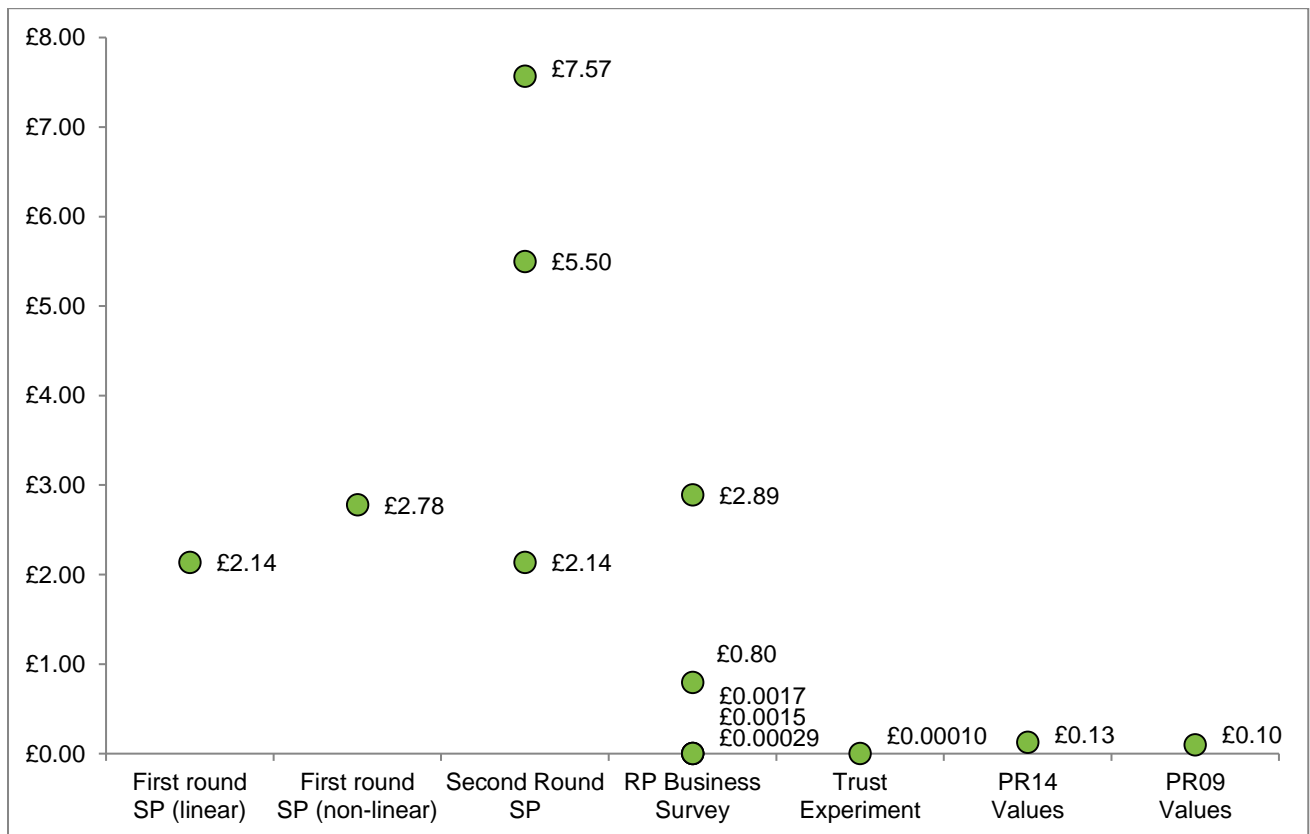


Figure 10. Illustrative comparison of values for drinking water quality (biological/chemical) (business)



**Table 17. Triangulation process for drinking water quality (biological/chemical) (household)**

| Factor  | First Round SP (linear)  | First Round SP (non-linear +1)  | Behavioural Experiment  | Trust Experiment  |
|---|--|---|---|---|
| Value   | £0.66 per sample   | £0.49 per sample  | £4.74 per sample  | £234.00 per incident or £0.00010 per incident/customer  |
| Statistical robustness                            | <b>High</b> – based on sample of 1,000 households  | <b>High</b> – based on sample of 1,000 households   | <b>Very High</b> – based on sample of 2,000 households  | <b>Low</b> – based on sample of 62,000 customers although significant caveats on robustness of analysis                     |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.  | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>High</b> – based on observed choices in “real life” situations   |
| Completeness of value                             | <b>Medium</b> – customer value mostly captured although potentially misses out on the trust component  | <b>Low</b> – customer value mostly captured although misses difference for larger changes and potentially misses out on the trust component | <b>Medium</b> – customer value mostly captured although potentially misses out on the trust component                         | <b>Low</b> – doesn’t capture entire customer value but does capture trust component   |
| Consistency of track record or time series (PR14) | <b>Low</b> – value 3,093% higher than PR14   | <b>Low</b> – value 2,271% higher than PR14  | <b>Very Low</b> – value 22,834% higher than PR14  | <b>High</b> – value 100% lower than PR14  |
| Consistency of track record or time series (PR09) | <b>Low</b> – value 1,874% higher than PR09   | <b>Low</b> – value 1,365% higher than PR09  | <b>Very Low</b> – value 14,074% higher than PR09  | <b>High</b> – value 100% lower than PR09  |
| Correlation with qualitative evidence             | <b>Very High</b> – top priority (1 <sup>st</sup> /13) compared to qualitative ranking as top priority (1 <sup>st</sup> /10)  | <b>Very High</b> – top priority (1 <sup>st</sup> /13) compared to qualitative ranking as top priority (1 <sup>st</sup> /10)                 | <b>Very High</b> – top priority (1 <sup>st</sup> /13) compared to qualitative ranking as top priority (1 <sup>st</sup> /10)   | <b>High</b> – top third priority (2 <sup>nd</sup> /6) compared to qualitative ranking in top priority (1 <sup>st</sup> /10) |
| Implication of using this value (household)       | Robust value, aligned with qualitative preferences, would lead to CBA and ODI results significantly higher than PR14/09  | Robust value, aligned with qualitative preferences, would lead to CBA and ODI results significantly higher than PR14/09                     | Robust value, aligned with qualitative preferences, would lead to CBA and ODI results orders of magnitude higher than PR14/09 | Less robust value although captures value associated with trust unlikely to be captured in customer valuation or in PR14/09 |
| <b>Recommended value</b>                          | <p><i>The Behavioural Experiment value appears to be an outlier – with an estimate significantly higher than the other data sources. All of the remaining customer values are broadly comparable and provide robust estimates, although they are higher than PR14 and PR09. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The Trust Experiment captures an additional aspect of value that may be missing from the customer valuation estimates. It is possible that there would be some double counting by including this value alongside the customer values although the likelihood is considered to be low. The recommended approach is therefore to use the First Round SP (linear) – split by use and non-use value - plus the Trust Experiment value.</i></p> |   |   |   |

**Table 18. Triangulation process for drinking water quality (biological/chemical) (business)**

| Factor  | First Round SP (linear)   | First Round SP (non-linear +1)  | Business Survey (median)   | Business Survey (median ex. outliers)  | Trust Experiment  |
|---|---|---|--|--|---|
| Value   | £2.14 per sample  | £2.78 per sample  | £2.89 per business   | £0.0015 per business   | £234.00 per incident or £0.00010 per incident/customer  |
| Statistical robustness                            | <b>High</b> – based on sample of 500 businesses   | <b>High</b> – based on sample of 500 businesses   | <b>Medium</b> – based on sample of 1,000 businesses although only 13 involved in avertive behaviour  | <b>Medium</b> – based on sample of 1,000 businesses although only 13 involved in avertive behaviour and 2 excluded                                       | <b>Low</b> – based on sample of 62,000 customers although significant caveats on robustness of analysis                     |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>High</b> – based on actual expenditure decisions  | <b>High</b> – based on actual expenditure decisions  | <b>High</b> – based on observed choices in “real life” situations   |
| Completeness of value                             | <b>Medium</b> – customer value mostly captured although potentially misses out on the trust component   | <b>Low</b> – customer value mostly captured although misses difference for larger changes and potentially misses out on the trust component | <b>Low</b> – focuses on actual expenditure so likely to be a lower bound value (assuming value exceeds expenditure and consumer surplus is not captured) | <b>Low</b> – focuses on actual expenditure so likely to be a lower bound value (assuming value exceeds expenditure and consumer surplus is not captured) | <b>Low</b> – doesn’t capture entire customer value but does capture trust component   |
| Consistency of track record or time series (PR14) | <b>Low</b> – value 1,577% higher than PR14  | <b>Low</b> – value 2,080% higher than PR14  | <b>Low</b> – value 2,167% higher than PR14   | <b>High</b> – value 99% lower than PR14  | <b>High</b> – value 100% lower than PR14  |
| Consistency of track record or time series (PR09) | <b>Low</b> – value 2,089% higher than PR09  | <b>Low</b> – value 2,746% higher than PR09  | <b>Low</b> – value 2,860% higher than PR09   | <b>High</b> – value 98% lower than PR09  | <b>High</b> – value 100% lower than PR09  |
| Correlation with qualitative evidence             | <b>Very High</b> – top priority (1 <sup>st</sup> /13) compared to qualitative ranking as top priority (1 <sup>st</sup> /10)   | <b>Very High</b> – top priority (1 <sup>st</sup> /13) compared to qualitative ranking as top priority (1 <sup>st</sup> /10)                 | <b>Very High</b> – top priority (1 <sup>st</sup> /7) compared to qualitative ranking as top priority (1 <sup>st</sup> /10)                               | <b>Very Low</b> – lowest priority (7 <sup>th</sup> /7) compared to qualitative ranking as top priority (1 <sup>st</sup> /10)                             | <b>High</b> – top third priority (2 <sup>nd</sup> /6) compared to qualitative ranking in top priority (1 <sup>st</sup> /10) |
| Implication of using this value (household)       | Robust value, aligned with qualitative preferences, would lead to CBA and ODI results significantly higher than PR14/09   | Robust value, aligned with qualitative preferences, would lead to CBA and ODI results significantly higher than PR14/09                     | Medium robustness, aligned with qualitative preferences, would lead to somewhat higher results than PR14/09  | Medium robustness, poorly aligned with qualitative preferences, would lead to slightly lower results than PR14/09  | Less robust value although captures value associated with trust unlikely to be captured in customer valuation or in PR14/09 |
| <b>Recommended value</b>                          | <p><i>The Business Survey value using the full sample is more closely aligned with the SP survey estimates and qualitative preferences although, contrary to expectations, would not provide a lower bound estimate to the SP surveys. This may be due to methodological/definitional issues or it may reflect the fact that some avertive costs are likely to be assumed to have to be made anyway, regardless of a marginal change in service provision (capturing an average rather than a marginal cost). All of the remaining customer values are broadly comparable and provide reasonably robust estimates although they are lower than those of PR14 and PR09. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The Trust Experiment captures an additional aspect of value that may be missing from the customer valuation estimates. It is possible that there would be some double counting by including this value alongside the customer values although the likelihood is considered to be low. The recommended approach is therefore to take an average of the First Round SP (linear) and Business Survey (median) values plus the Trust Experiment value.</i></p> |   |  |  |   |



## Recommended values

A summary of the recommended values is set out in **Error! Reference source not found.** The aggregate total is the sum of the aggregate values for each of Households, Businesses and Trust where the aggregate values are the individual values multiplied by either the total number of YWS household or business customers. The aggregate Trust values were calculated using the total number of household customers as it was not possible to distinguish between household and business customers in the underlying analysis.

| Service measure                                | Unit              | Households | Businesses | Trust    | Aggregate Total      |
|--|-------------------|------------|------------|----------|----------------------|
| Sample failure (no health impact)              | £/sample/customer | £0.66      | £2.51      | £0.00010 | <b>£1,862,552.92</b> |
| Sample failure leading to public health impact | £/sample/customer | £2.34      | £8.90      | £0.00010 | <b>£6,592,842.97</b> |
| Sample failure requiring boil order notice     | £/sample/customer | £1.70      | £6.46      | £0.00010 | <b>£4,788,255.94</b> |



# No 4. Drinking Water Quality (Aesthetic)

## Data sources

Estimates of the value YWS customers place on reducing the number of customer contacts about aesthetic drinking water quality issues were obtained from the methods and data sources set out in Table 19.

**Table 19. Data sources available for drinking water quality (aesthetic)**

| 1 <sup>st</sup> Round Stated Preference | 2 <sup>nd</sup> Round Stated Preference | Revealed Preference Visitor | Revealed Preference Business | Behavioural Experiment | Trust Experiment | PR14 Values | PR09 Values | Benefits Transfer |
|---|---|-----------------------------|------------------------------|------------------------|------------------|-------------|-------------|-------------------|
| ✓                                       | ✓                                       | ✗                           | ✓                            | ✓                      | ✓                | ✓           | ✓           | ✗                 |

## Results

On the basis of the linear model, the results of the First Round Stated Preference (SP) survey in Work Package 1 suggest that YWS household customers are willing to pay £0.0022 per year to reduce the number of contacts about aesthetic drinking water issues by one contact, while business customers are willing to pay £0.0068.

By contrast, the non-linear model estimated that household customers are willing to pay £0.0021 per property and business customers £0.0061 for a one unit improvement.

The results of the Second Round SP survey suggest that, in terms of severity levels, the WTP for household and business customers for a one unit improvement in aesthetic drinking water quality are as follows (note this work package estimated odds ratios which were then applied to the linear model results from Work Package 1):

- Water with a taste or smell of disinfectant = £0.0025 and £0.0079 per contact
- Discoloured water the colour of weak tea = £0.0022 and £0.0068 per contact
- Cloudy water = £0.0021 and £0.0067 per contact

The Revealed Preference (RP) Business Survey estimated that YWS business customers spend a median value of £100.20 per business per year to deal with water taste, odour, or discolouration issues with a range of £45.20 to £116.59. While the survey did not directly record the number of issues reported by businesses, it did record the frequency of issues. Assuming that ‘infrequent’ corresponds to around one incident a year, ‘sometimes’ corresponds to twice a year, and ‘frequent’ corresponds to three times a year, there were an average of 750 taste, odour, or discolouration incidents a year giving a median value of £0.13 per business and a range of £0.060 to £0.16. There are, however, uncertainties around this estimate of the number of incidents and it should be taken as a broadly indicative figure.

The Behavioural Experiment estimated that YWS household customers are willing to increase annual water bills by £0.0069 for every one unit reduction in the number of contacts about aesthetic drinking water issues.

The Trust Experiment estimated that the average cost incurred in terms of reduced bill payments following a drinking water quality incident is £133.00 per customer. Note that this estimate is not directly equivalent to those obtained from the SP and RP surveys or the Behavioural Experiment as it represents a direct cost to YWS which reflects a cost, or loss of welfare, incurred by the customer. Dividing by the total customer base to provide a comparison against the other value sets gives a value of £0.000059 per customer. However, the estimate from the Trust Experiment needs to be treated with caution as there may be a number of other confounding factors (not explored in this project) that affect customers’ propensity to pay, as well as changes in this value over time (i.e. it may not be that the propensity to refuse to pay continues over time).

The SP surveys undertaken for PR14 estimated the amount YWS households and businesses would be willing to pay to reduce the number of aesthetic drinking water quality incidents at £0.0016 and £0.013 respectively. Note, the units used in PR14 are not directly comparable with those used in PR19.

The SP surveys undertaken for PR09 estimated the amount YWS households and businesses would be willing to pay to reduce the number of aesthetic drinking water quality incidents at £0.0010 and £0.0048 respectively. Note, the units used in PR09 are not directly comparable with those used in PR19.

A comparison of these values is set out in Figure 11 and Figure 12. Note that, due to differences in units across data sources the figures are illustrative of the range of values. Also note that, the values for Work Package 2 are presented alongside the other values, these demonstrate the range in WTP estimates for different severity levels within the same service measure and so are not directly comparable to the other estimates.

## Triangulation

The data from the work packages were then compared using the triangulation method set out in Table 6. Note that the values from Work Package 2 were not included in the triangulation process as the outputs from this work package were odds ratios rather than value estimates. Instead, the outputs from Work Package 2 were applied to the final value selected through the triangulation exercise to estimate the values for each of the severity levels. The values for PR14 and PR09 were included for comparative purposes only, rather than as values to be put forward for use in the DMF.

The results of the triangulation process are set out in Table 20 and Table 21.

Figure 11. Illustrative comparison of values for drinking water quality (aesthetic) (household)

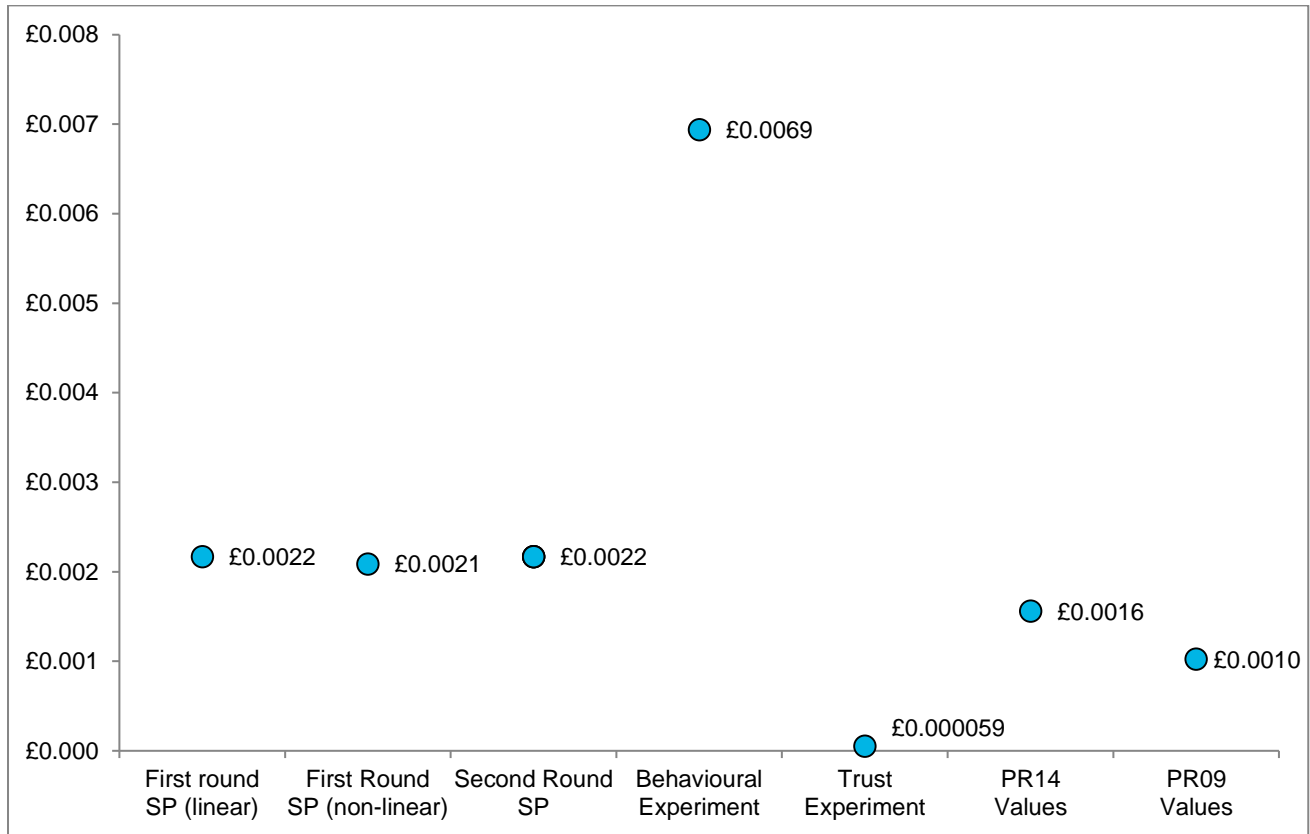
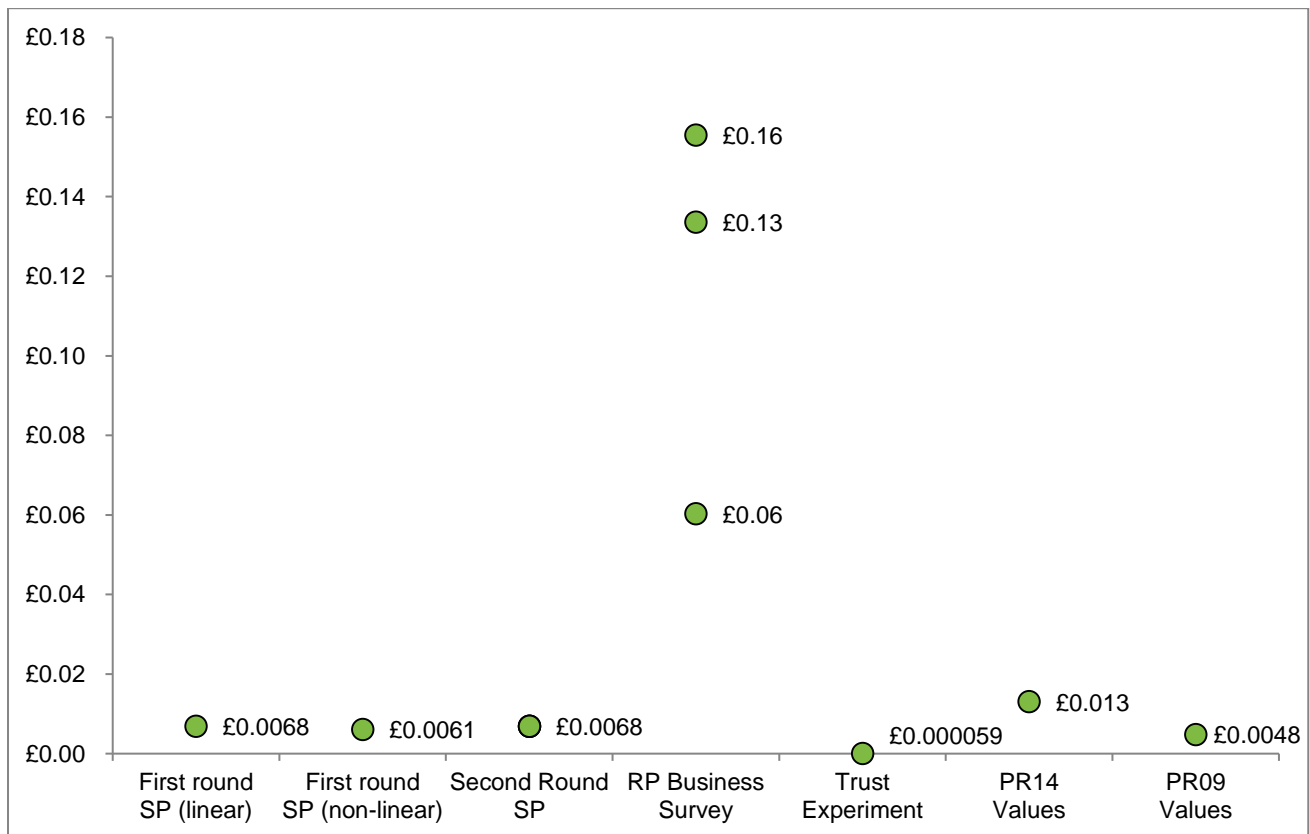


Figure 12. Illustrative comparison of values for drinking water quality (aesthetic) (business)



**Table 20. Triangulation process for drinking water quality (aesthetic) (household)**

| Factor  | First Round SP (linear)  | First Round SP (non-linear +1)  | Behavioural Experiment   | Trust Experiment  |
|---|--|---|--|---|
| Value   | £0.0022 per contact  | £0.0021 per contact   | £0.0069 per contact  | £133.00 per incident or £0.000059 per incident/customer   |
| Statistical robustness                            | <b>High</b> – based on sample of 1,000 households  | <b>High</b> – based on sample of 1,000 households   | <b>Very High</b> – based on sample of 2,000 households   | <b>Low</b> – based on sample of 62,000 customers although significant caveats on robustness of analysis                       |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.  | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.  | <b>High</b> – based on observed choices in “real life” situations   |
| Completeness of value                             | <b>Medium</b> – customer value mostly captured although potentially misses out on the trust component  | <b>Low</b> – customer value mostly captured although misses difference for larger changes and potentially misses out on the trust component               | <b>Medium</b> – customer value mostly captured although potentially misses out on the trust component                          | <b>Low</b> – doesn’t capture entire customer value but does capture trust component   |
| Consistency of track record or time series (PR14) | <b>High</b> – value 39% higher than PR14   | <b>High</b> – value 34% higher than PR14  | <b>Medium</b> – value 344% lower than PR14   | <b>High</b> – value 96% lower than PR14   |
| Consistency of track record or time series (PR09) | <b>Medium</b> – value 111% higher than PR09  | <b>Medium</b> – value 103% higher than PR09   | <b>Medium</b> – value 575% higher than PR09  | <b>High</b> – value 95% lower than PR09   |
| Correlation with qualitative evidence             | <b>Medium</b> – mid third priority (8 <sup>th</sup> /13) compared to qualitative ranking in bottom third (9 <sup>th</sup> /10)   | <b>Medium</b> – mid third priority (8 <sup>th</sup> /13) compared to qualitative ranking in bottom third (9 <sup>th</sup> /10)                            | <b>Medium</b> – mid third priority (8 <sup>th</sup> /13) compared to qualitative ranking in bottom third (9 <sup>th</sup> /10) | <b>Medium</b> – mid third priority (4 <sup>th</sup> /7) compared to qualitative ranking in bottom third (9 <sup>th</sup> /10) |
| Implication of using this value (household)       | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly higher than PR14 and somewhat higher than PR09   | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly higher than PR14/09 and somewhat higher than PR09 | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results somewhat higher than PR14/09    | Less robust value although captures value associated with trust unlikely to be captured in customer valuation or in PR14/09   |
| <b>Recommended value</b>                          | <i>All three of the customer values are broadly comparable and provide robust estimates, which are similar to those of PR14 and PR09. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The Trust Experiment captures an additional aspect of value that may be missing from the customer valuation estimates. It is possible that there would be some double counting by including this value alongside the customer values although the likelihood is considered to be low. The recommended approach is therefore to take an average of the First Round SP (linear) and Behavioural Experiment values plus the Trust Experiment value.</i> |   |  |   |

**Table 21. Triangulation process for drinking water quality (aesthetic) (business)**

| Factor  | First Round SP (linear)   | First Round SP (non-linear +1)  | Business Survey (median)   | Trust Experiment  |
|---|---|---|--|---|
| Value   | £0.0068 per contact   | £0.0061 per contact   | £0.13 per business   | £133.00 per incident or £0.000059 per incident/customer   |
| Statistical robustness                            | <b>High</b> – based on sample of 500 businesses   | <b>High</b> – based on sample of 500 businesses   | <b>Low</b> – based on sample of 1,000 businesses, of which 500 involved in avertive behaviour although uncertainty over number of incidents                      | <b>Low</b> – based on sample of 62,000 customers although significant caveats on robustness of analysis                       |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>High</b> – based on actual expenditure decisions  | <b>High</b> – based on observed choices in “real life” situations   |
| Completeness of value                             | <b>Medium</b> – customer value mostly captured although potentially misses out on the trust component   | <b>Low</b> – customer value mostly captured although misses difference for larger changes and potentially misses out on the trust component           | <b>Low</b> – focuses on actual expenditure so likely to be a lower bound value (assuming value exceeds expenditure and consumer surplus is not captured)         | <b>Low</b> – doesn’t capture entire customer value but does capture trust component   |
| Consistency of track record or time series (PR14) | <b>High</b> – value 48% lower than PR14   | <b>High</b> – value 53% lower than PR14   | <b>Medium</b> – value 922% higher than PR14  | <b>High</b> – value 100% lower than PR14  |
| Consistency of track record or time series (PR09) | <b>High</b> – value 43% higher than PR09  | <b>High</b> – value 27% higher than PR09  | <b>Low</b> – value 2,687% higher than PR09   | <b>High</b> – value 99% lower than PR09   |
| Correlation with qualitative evidence             | <b>Medium</b> – mid third priority (8 <sup>th</sup> /13) compared to qualitative ranking in bottom third (9 <sup>th</sup> /10)  | <b>Medium</b> – mid third priority (8 <sup>th</sup> /13) compared to qualitative ranking in bottom third (9 <sup>th</sup> /10)                        | <b>Medium</b> – mid third priority (5 <sup>th</sup> /7) compared to qualitative ranking in bottom third (9 <sup>th</sup> /10)                                    | <b>Medium</b> – mid third priority (4 <sup>th</sup> /6) compared to qualitative ranking in bottom third (9 <sup>th</sup> /10) |
| Implication of using this value (household)       | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14 and slightly higher than PR09   | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14 and slightly higher than PR09 | Less robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results somewhat higher than PR14 and significantly higher than PR09 | Less robust value although captures value associated with trust unlikely to be captured in customer valuation or in PR14/09   |
| <b>Recommended value</b>                          | <p><i>The Business Survey estimate has uncertainties over the robustness of the approach due to the uncertainty over definitions of incident numbers. The result is also significantly different from the other data sources (particularly relative to PR09). The two remaining customer values are broadly comparable and provide reasonably robust estimates which are similar to those of PR14 and PR09. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The Trust Experiment captures an additional aspect of value that may be missing from the customer valuation estimates. It is possible that there would be some double counting by including this value alongside the customer values although the likelihood is considered to be low. The recommended approach is therefore to use the First Round SP (linear) value plus the Trust Experiment value.</i></p> |   |  |   |

## Recommended values

A summary of the recommended values is set out in Table 22. The aggregate total is the sum of the aggregate

values for each of Households, Businesses and Trust where the aggregate values are the individual values multiplied by either the total number of YWS household or business customers. The aggregate Trust values were calculated using the total number of household customers as it was not possible to distinguish between household and business customers in the underlying analysis.

**Table 22. Recommended individual and aggregate values for drinking water quality (aesthetic)**

| Service measure                | Unit               | Households | Businesses | Trust     | Aggregate Total   |
|--------------------------------|--------------------|------------|------------|-----------|-------------------|
| Taste or smell of disinfectant | £/contact/customer | £0.005234  | £0.007860  | £0.000059 | <b>£13,113.95</b> |
| Colour of weak tea             | £/contact/customer | £0.004555  | £0.006841  | £0.000059 | <b>£11,430.60</b> |
| Cloudy                         | £/contact/customer | £0.004482  | £0.006731  | £0.000059 | <b>£11,249.84</b> |

## No 5. Leakage

### Data sources

Estimates of the value YWS customers place on reducing the level of leakage were obtained from the methods and data sources set out in Table 8.

**Table 23. Data sources available for leakage**

| 1 <sup>st</sup> Round Stated Preference | 2 <sup>nd</sup> Round Stated Preference | Revealed Preference Visitor | Revealed Preference Business | Behavioural Experiment | Trust Experiment | PR14 Values | PR09 Values | Benefits Transfer |
|---|---|-----------------------------|------------------------------|------------------------|------------------|-------------|-------------|-------------------|
| ✓                                       | ✗                                       | ✗                           | ✗                            | ✓                      | ✗                | ✓           | ✓           | ✓                 |

### Results

On the basis of the linear model the results of the First Round Stated Preference (SP) survey in Work Package 1 suggest that YWS household customers are willing to pay £0.064 per year to reduce the number of MI of water lost through leakage each day by one MI, while business customers are willing to pay £0.18.

By contrast, the non-linear model estimated that household customers are willing to pay £0.037 per ML and business customers £0.12 for a one unit improvement.

The Behavioural Experiment estimated that YWS household customers are willing to increase their annual water bills by £0.054 for reduction in the number of MI of water lost.

The SP surveys undertaken for PR14 estimated the amount YWS households and businesses would be willing to pay to reduce the amount of leakage at £0.041 and £0.33 respectively. Note, the units used in PR14 are not directly comparable with those used in PR19.

The SP surveys undertaken for PR09 estimated the amount YWS households and businesses would be willing to pay to reduce the amount of leakage at £0.92 and £5.56 respectively. Note, the units used in PR09 are not directly comparable with those used in PR19.

The Benefits Transfer exercise estimated that each unit of water lost through leakage led to a cost of £1.08 in terms of the associated greenhouse gas (GHG) emissions, which equates to around £0.00000048 per customer.

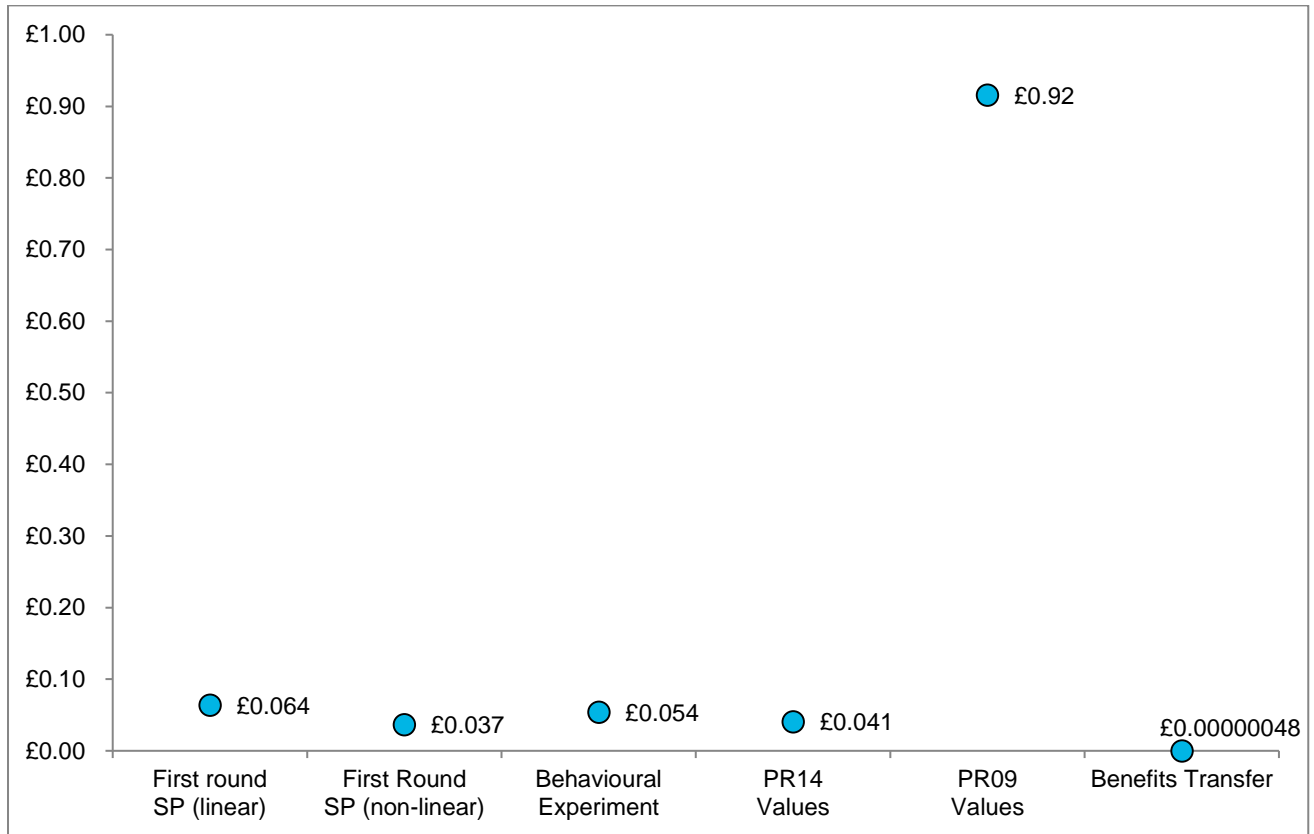
A comparison of these values is set out in Figure 13 and Figure 14. Note that, due to differences in units across data sources the figures are illustrative of the range of values.

### Triangulation

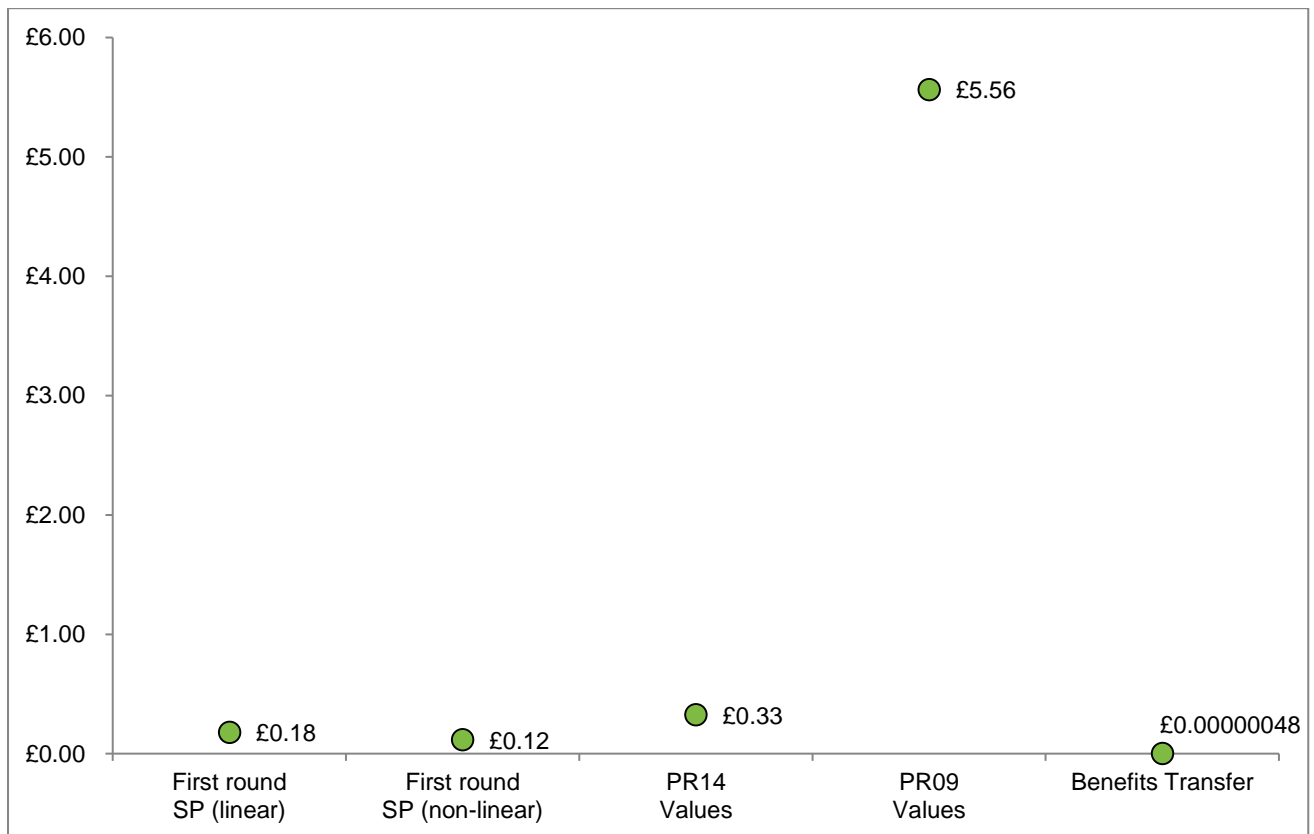
The data from the work packages, together with Benefits Transfer estimates derived from the current version of the DMF, were then compared using the triangulation method set out in Table 6.

The results of the triangulation process are set out in Table 24 and Table 25.

**Figure 13. Illustrative comparison of values for leakage (household)**



**Figure 14. Illustrative comparison of values for leakage (business)**





**Table 24. Triangulation process for leakage (household)**

| Factor  | First Round SP (linear)   | First Round SP (non-linear +1)   | Behavioural Experiment  | Benefits Transfer  |
|---|---|--|---|--|
| Value   | £0.064 per ML/customer  | £0.037 per ML/customer   | £0.054 per ML/customer  | £1.08 per ML or £0.00000048 per ML/customer  |
| Statistical robustness                            | <b>High</b> – based on sample of 1,000 households   | <b>High</b> – based on sample of 1,000 households  | <b>Very High</b> – based on sample of 2,000 households  | <b>Medium</b> – based on estimates calculated through the GHG workbook   |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.  | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | n/a  |
| Completeness of value                             | <b>Medium</b> – customer value captured although potentially misses out on the wider environmental costs of leakage associated with GHG emissions   | <b>Low</b> – customer value mostly captured although misses difference for larger changes and potentially misses out on the wider environmental costs of leakage associated with GHG emissions | <b>Medium</b> – customer value captured although potentially misses out on the wider environmental costs of leakage associated with GHG emissions | <b>Low</b> – captures GHG impacts of leakage although does not capture customer values   |
| Consistency of track record or time series (PR14) | <b>High</b> – value 57% higher than PR14  | <b>High</b> – value 10% lower than PR14  | <b>High</b> – value 32% higher than PR14  | <b>High</b> – value 100% lower than PR14   |
| Consistency of track record or time series (PR09) | <b>High</b> – value 93% lower than PR09   | <b>High</b> – value 96% lower than PR09  | <b>High</b> – value 94% lower than PR09   | <b>High</b> – value 100% lower than PR09   |
| Correlation with qualitative evidence             | <b>High</b> – mid third priority (5 <sup>th</sup> /13) compared to qualitative ranking in mid third (6 <sup>th</sup> /10)   | <b>High</b> – mid third priority (5 <sup>th</sup> /13) compared to qualitative ranking in mid third (6 <sup>th</sup> /10)  | <b>High</b> – mid third priority (5 <sup>th</sup> /13) compared to qualitative ranking in mid third (6 <sup>th</sup> /10)                         | n/a  |
| Implication of using this value (household)       | Robust value, aligned with qualitative preferences, would lead to CBA and ODI results slightly higher than PR14 and slightly lower than PR09  | Robust value, aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14/09  | Robust value, aligned with qualitative preferences, would lead to CBA and ODI results slightly higher than PR14 and slightly lower than PR09      | Reasonably robust value, captures additional value associated with leakage unlikely to be captured in customer valuation or in PR14/09 |
| <b>Recommended value</b>                          | <i>All three of the customer values are broadly similar and provide robust estimates, which are similar to those of PR14 and PR09. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The Benefits Transfer value captures an additional aspect of value that may be missing from the customer valuation estimates. It is possible that there would be some double counting by including this value alongside the customer values although the likelihood is considered to be low. The recommended approach is therefore to take an average of the First Round SP (linear) and Behavioural Experiment values plus the Benefits Transfer value.</i> |  |   |  |

**Table 25. Triangulation process for leakage (business)**

| Factor  | First Round SP (linear)  | First Round SP (non-linear +1)   | Benefits Transfer  |
|---|--|--|--|
| Value   | £0.18 per ML/customer  | £0.12 per ML/customer  | £1.08 per ML or £0.00000048 per ML/customer  |
| Statistical robustness                            | <b>High</b> – based on sample of 500 businesses  | <b>High</b> – based on sample of 500 businesses  | <b>Medium</b> – based on estimates calculated through the GHG workbook   |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.  | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.  | n/a  |
| Completeness of value                             | <b>Medium</b> – customer value captured although potentially misses out on the wider environmental costs of leakage associated with GHG emissions  | <b>Low</b> – customer value mostly captured although misses difference for larger changes and potentially misses out on the wider environmental costs of leakage associated with GHG emissions | <b>Low</b> – captures GHG impacts of leakage although does not capture customer values                                   |
| Consistency of track record or time series (PR14) | <b>High</b> – value 45% lower than PR14  | <b>High</b> – value 64% lower than PR14  | <b>High</b> – value 100% lower than PR14   |
| Consistency of track record or time series (PR09) | <b>High</b> – value 97% lower than PR09  | <b>High</b> – value 98% lower than PR09  | <b>High</b> – value 100% lower than PR09   |
| Correlation with qualitative evidence             | <b>High</b> – mid third priority (6 <sup>th</sup> /13) compared to qualitative ranking in mid third (6 <sup>th</sup> /10)  | <b>High</b> – mid third priority (6 <sup>th</sup> /13) compared to qualitative ranking in mid third (6 <sup>th</sup> /10)  | n/a  |
| Implication of using this value (household)       | Robust value, aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14/09  | Robust value, aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14/09  | Reasonably robust value, captures additional value associated with leakage unlikely to be captured in customer valuation |
| <b>Recommended value</b>                          | <i>The Stated Preference values are broadly similar and provide robust estimates, which are similar to those of PR14 and PR09. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The Benefits Transfer value captures an additional aspect of value that may be missing from the customer valuation estimates. It is possible that there would be some double counting by including this value alongside the customer values although the likelihood is considered to be low. The recommended approach is therefore to use the First Round SP (linear) value plus the Benefits Transfer value.</i> |  |  |

## Recommended values

A summary of the recommended values is set out in The aggregate total is the sum of the aggregate values for each of Households, Businesses and Use values where the aggregate values are the individual values multiplied by either the total number of YWS household or business customers. The aggregate use values were calculated using the total number of household customers as it was not possible to distinguish between household and business customers in the underlying analysis.

Table 26. The aggregate total is the sum of the aggregate values for each of Households, Businesses and Use values where the aggregate values are the individual values multiplied by either the total number of YWS household or business customers. The aggregate use values were calculated using the total number of household customers as it was not possible to distinguish between household and business customers in the

underlying analysis.

**Table 26. Recommended individual and aggregate values for leakage**

| Service measure | Unit          | Households | Businesses | Use values (GHG emissions) | Aggregate Total    |
|-----------------|---------------|------------|------------|----------------------------|--------------------|
| Leakage         | £/Ml/customer | £0.059     | £0.18      | £0.00000048                | <b>£159,776.22</b> |

## No 6. Water Restrictions

### Data sources

Estimates of the value YWS customers place on reducing the number of properties affected by water restrictions (e.g. hosepipe bans) were obtained from the methods and data sources set out in Table 27.

**Table 27. Data sources available for water restrictions**

| 1 <sup>st</sup> Round Stated Preference | 2 <sup>nd</sup> Round Stated Preference | Revealed Preference Visitor | Revealed Preference Business | Behavioural Experiment | Trust Experiment | PR14 Values | PR09 Values | Benefits Transfer |
|---|---|-----------------------------|------------------------------|------------------------|------------------|-------------|-------------|-------------------|
| ✓                                       | ✓                                       | ✗                           | ✗                            | ✓                      | ✗                | ✓           | ✗           | ✗                 |

### Results

On the basis of the linear model, the results of the First Round Stated Preference (SP) survey in Work Package 1 suggest that YWS household customers are willing to pay £0.000011 per year to reduce the number of properties affected by a five month water restriction by one property, while business customers are willing to pay £0.000031.

By contrast, the non-linear model estimated that household customers are willing to pay £0.0000095 per property and business customers £0.000031 for a one unit improvement.

The results of the Second Round SP survey suggest that, in terms of severity levels, the WTP for household and business customers for a one unit improvement in water restrictions are as follows (note this work package estimated odds ratios which were then applied to the linear model results from Work Package 1):

- Reduction in supply with no impact on customers = £0.0000075 and £0.000021 per property
- Voluntary restriction = £0.000011 and £0.000030 per property
- Compulsory restriction (e.g. hosepipe ban) = £0.000011 and £0.000031 per property
- Emergency restriction = £0.000020 and £0.000055 per property

The Behavioural Experiment estimated that YWS household customers are willing to increase their annual water bills by £0.000017 for every property no longer affected by water restrictions.

The SP surveys undertaken for PR14 estimated the amount YWS households and businesses would be willing to pay to reduce the chance of being impacted by a water restriction at £0.041 and £0.33 respectively. Note, the units used in PR14 are not directly comparable with those used in PR19.

A comparison of these values is set out in Figure 15 and Figure 16. Note that, due to differences in units across data sources the figures are illustrative of the range of values. Also note that, the values for Work Package 2 are presented alongside the other values, these demonstrate the range in WTP estimates for different severity levels within the same service measure and so are not directly comparable to the other estimates.

## Triangulation

The data from the work packages were then compared using the triangulation method set out in Table 6. Note that the values from Work Package 2 were not included in the triangulation process as the outputs from this work package were odds ratios rather than value estimates. Instead, the outputs from Work Package 2 were applied to the final value selected through the triangulation exercise to estimate the values for each of the severity levels. The values for PR14 were included for comparative purposes only, rather than as values to be put forward for use in the DMF.

The results of the triangulation process are set out in Table 28 and Table 29.

Figure 15. Illustrative comparison of values for water restrictions (household)

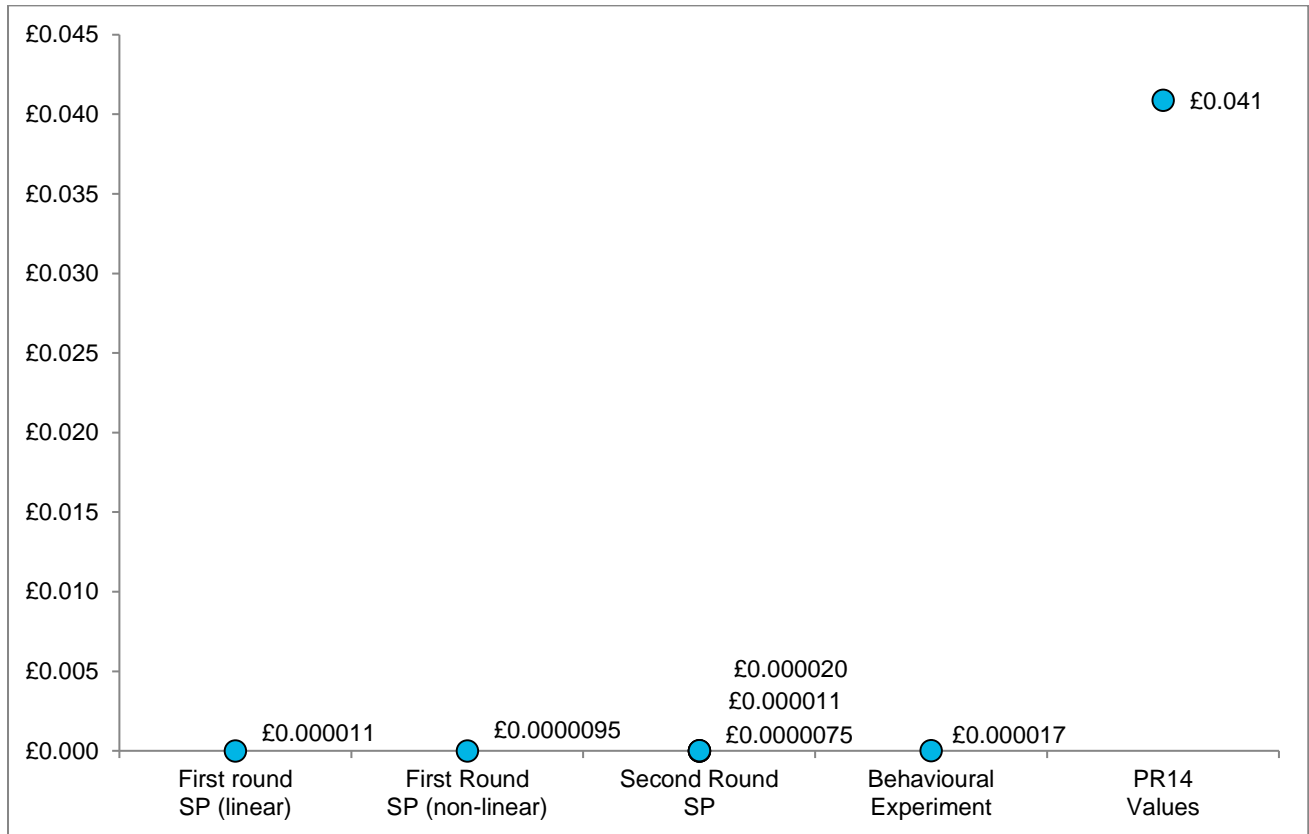
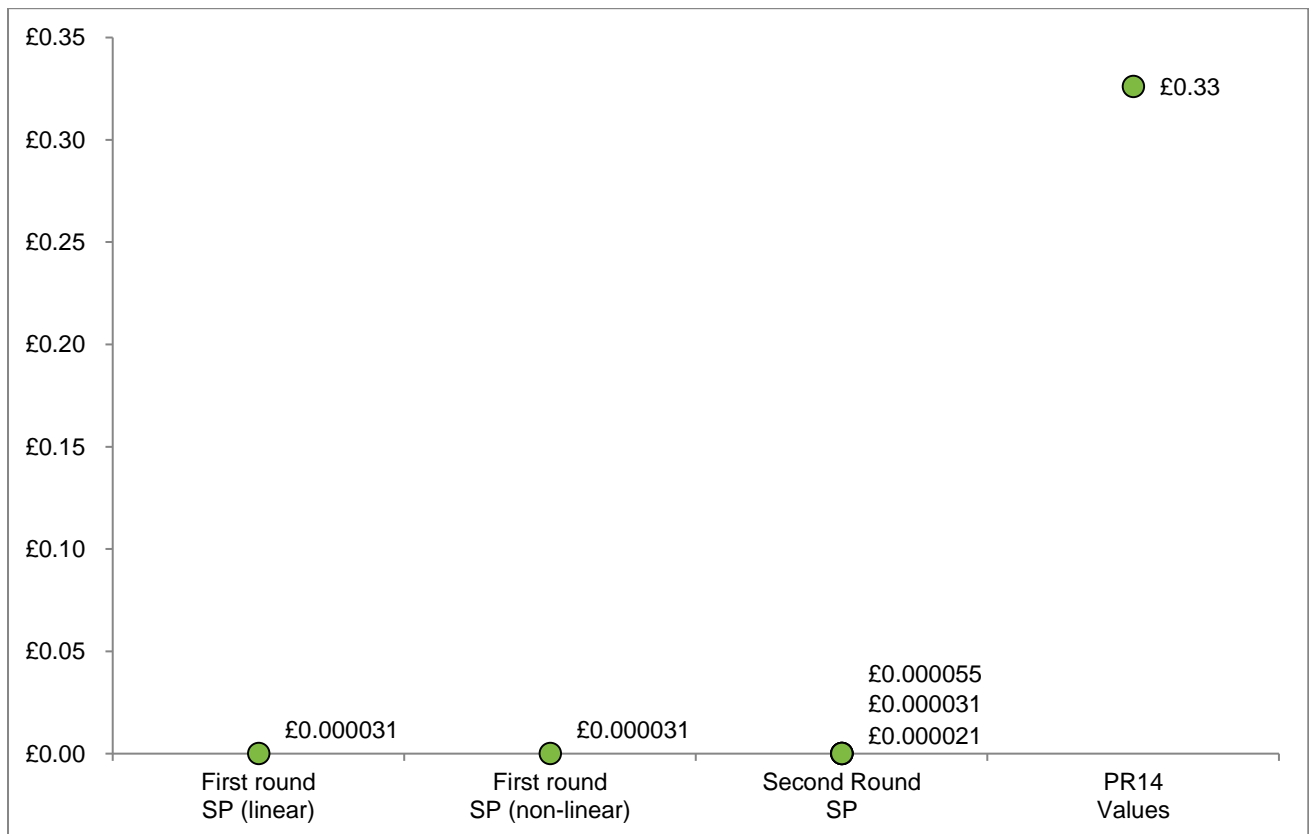


Figure 16. Illustrative comparison of values for water restrictions (business)



**Table 28. Triangulation process for water restrictions (household)**

| Factor  | First Round SP (linear)  | First Round SP (non-linear +1)   | Behavioural Experiment  |
|---|--|--|---|
| Value   | £0.000011 per property   | £0.0000095 per property  | £0.000017 per property  |
| Statistical robustness                            | <b>High</b> – based on sample of 1,000 households  | <b>High</b> – based on sample of 1,000 households  | <b>Very High</b> – based on sample of 2,000 households                            |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.  | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.            | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc. |
| Completeness of value                             | <b>High</b> – customer value completely captured   | <b>Medium</b> – customer value mostly captured although misses difference for larger changes | <b>High</b> – customer value completely captured                                  |
| Consistency of track record or time series (PR14) | <b>High</b> – value 100% lower than PR14   | <b>High</b> – value 100% lower than PR14   | <b>High</b> – value 100% lower than PR14  |
| Consistency of track record or time series (PR09) | <i>No PR09 data available for water restrictions</i>   | <i>No PR09 data available for water restrictions</i>   | <i>No PR09 data available for water restrictions</i>                              |
| Correlation with qualitative evidence             | <i>No qualitative data available for water restrictions</i>  | <i>No qualitative data available for water restrictions</i>                                  | <i>No qualitative data available for water restrictions</i>                       |
| Implication of using this value (household)       | Robust value, would lead to CBA and ODI results slightly lower than PR14/09  | Robust value, would lead to CBA and ODI results slightly lower than PR14/09                  | Robust value, would lead to CBA and ODI results slightly lower than PR14/09       |
| <b>Recommended value</b>                          | <i>All three customer value estimates are broadly similar and provide robust estimates, although lower than PR14. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The recommended approach is therefore to take an average of the First Round SP (linear) and Behavioural Experiment values.</i> |  |   |

**Table 29. Triangulation process for water restrictions (business)**

| Factor  | First Round SP (linear)   | First Round SP (non-linear +1)   |
|---|---|--|
| Value   | £0.000031 per property  | £0.000031 per property   |
| Statistical robustness                            | <b>High</b> – based on sample of 500 businesses   | <b>High</b> – based on sample of 500 businesses  |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.            |
| Completeness of value                             | <b>High</b> – customer value completely captured  | <b>Medium</b> – customer value mostly captured although misses difference for larger changes |
| Consistency of track record or time series (PR14) | <b>High</b> – value 100% lower than PR14  | <b>High</b> – value 100% lower than PR14   |
| Consistency of track record or time series (PR09) | <i>No PR09 data available for water restrictions</i>  | <i>No PR09 data available for water restrictions</i>   |
| Correlation with qualitative evidence             | <i>No qualitative data available for water restrictions</i>   | <i>No qualitative data available for water restrictions</i>                                  |
| Implication of using this value (household)       | Robust value, would lead to CBA and ODI results slightly lower than PR14/09   | Robust value, would lead to CBA and ODI results slightly lower than PR14/09                  |
| <b>Recommended value</b>                          | <i>The two customer value estimates are the same and provide a robust estimate, although it is lower than PR14. The recommended approach is therefore to use this single value.</i> |  |

## Recommended values

A summary of the recommended values is set out in Table 30. The aggregate total is the sum of the aggregate values for each of Households and Businesses where the aggregate values are the individual values for Households and Businesses multiplied by the total number of YWS household and business customers respectively.

**Table 30. Recommended individual and aggregate values for water restrictions**

| Service measure        | Unit                | Households | Businesses | Aggregate Total |
|------------------------|---------------------|------------|------------|-----------------|
| Reduced supply         | £/property/customer | £0.000009  | £0.000021  | £24.17          |
| Voluntary restriction  | £/property/customer | £0.000014  | £0.000030  | £35.29          |
| Compulsory restriction | £/property/customer | £0.000014  | £0.000031  | £36.57          |
| Emergency restriction  | £/property/customer | £0.000025  | £0.000055  | £64.39          |

## No 7. Internal Sewer Flooding

### Data sources

Estimates of the value YWS customers place on reducing the number of properties affected by internal floods were obtained from the methods and data sources set out in Table 31.

**Table 31. Data sources available for internal sewer flooding**

| 1 <sup>st</sup> Round Stated Preference | 2 <sup>nd</sup> Round Stated Preference | Revealed Preference Visitor | Revealed Preference Business | Behavioural Experiment | Trust Experiment | PR14 Values | PR09 Values | Benefits Transfer |
|---|---|-----------------------------|------------------------------|------------------------|------------------|-------------|-------------|-------------------|
| ✓                                       | ✓                                       | ✗                           | ✓                            | ✓                      | ✓                | ✓           | ✓           | ✗                 |

### Results

On the basis of the linear model, the results of the First Round Stated Preference (SP) survey in Work Package 1 suggest that YWS household customers are willing to pay £0.0061 per year to reduce the number of properties affected by internal flooding by one property, while business customers are willing to pay £0.021.

By contrast, the non-linear model estimated that household customers are willing to pay £0.0038 per property and business customers £0.0086 for a one unit improvement.

The results of the Second Round SP survey suggest that, in terms of severity levels, the WTP for household and business customers for a one unit improvement in internal flood incidents are as follows (note this work package estimated odds ratios which were then applied to the linear model results from Work Package 1):

- Flooding of a cellar = £0.00042 and £0.0014 per property
- Flooding of a habitable area = £0.0061 and £0.021 per property

The Revealed Preference (RP) Business Survey estimated that YWS business customers spend a median value of £20.27 per business per year to deal with internal flooding with a range of £6.16 to £21.17 (assuming a 50:50 split in expenditure between internal and external floods).<sup>17</sup> The survey recorded an average number of 31 internal flood events reported each year by respondents giving a median value of £0.65 per business impacted, with a range of £0.20 to £0.68. Given the small sample size of businesses actually engaging in avertive behaviour and the impact of outliers on the results it is considered the median value is more appropriate for use than the mean.

The Behavioural Experiment estimated that YWS household customers are willing to increase their annual water bills by £0.014 to reduce the number of properties affected by internal flood events by one.

The Trust Experiment estimated that the average cost incurred in terms of reduced bill payments following an internal flood is £243 per customer affected each year. Note that this estimate is not directly equivalent to those obtained from the SP and RP surveys or the Behavioural Experiment as it represents a direct cost to YWS which reflects a cost, or loss of welfare, incurred by the customer. Dividing by the total customer base to provide a comparison against the other value sets gives a value of £0.00011 per customer. However, the estimate from the Trust Experiment needs to be treated with caution as there may be a number of other confounding factors (not explored in this project) that affect customers' propensity to pay, as well as changes in this value over time (i.e. it may not be that the propensity to refuse to pay continues over time).

The SP surveys undertaken for PR14 estimated the amount YWS households and businesses would be willing to pay to reduce the number of internal flood incidents at £0.062 and £0.29 respectively. Note, the units used in PR14 are not directly comparable with those used in PR19.



The SP surveys undertaken for PR09 estimated the amount YWS households and businesses would be willing to pay to reduce the number of internal flood incidents at £0.034 and £0.12 respectively. Note, the units used in PR09 are not directly comparable with those used in PR19.

A comparison of these values is set out in Figure 17 and Figure 18. Note that, due to differences in units across data sources the figures are illustrative of the range of values. Also note that, the values for Work Package 2 are presented alongside the other values, these demonstrate the range in WTP estimates for different severity levels within the same service measure and so are not directly comparable to the other estimates.

### **Triangulation**

The data from the work packages were then compared using the triangulation method set out in Table 6. Note that the values from Work Package 2 were not included in the triangulation process as the outputs from this work package were odds ratios rather than value estimates. Instead, the outputs from Work Package 2 were applied to the final value selected through the triangulation exercise to estimate the values for each of the severity levels. The values for PR14 and PR09 were included for comparative purposes only, rather than as values to be put forward for use in the DMF.

The results of the triangulation process are set out in Table 32 and Table 33.

Figure 17. Illustrative comparison of values for internal sewer flooding (household)

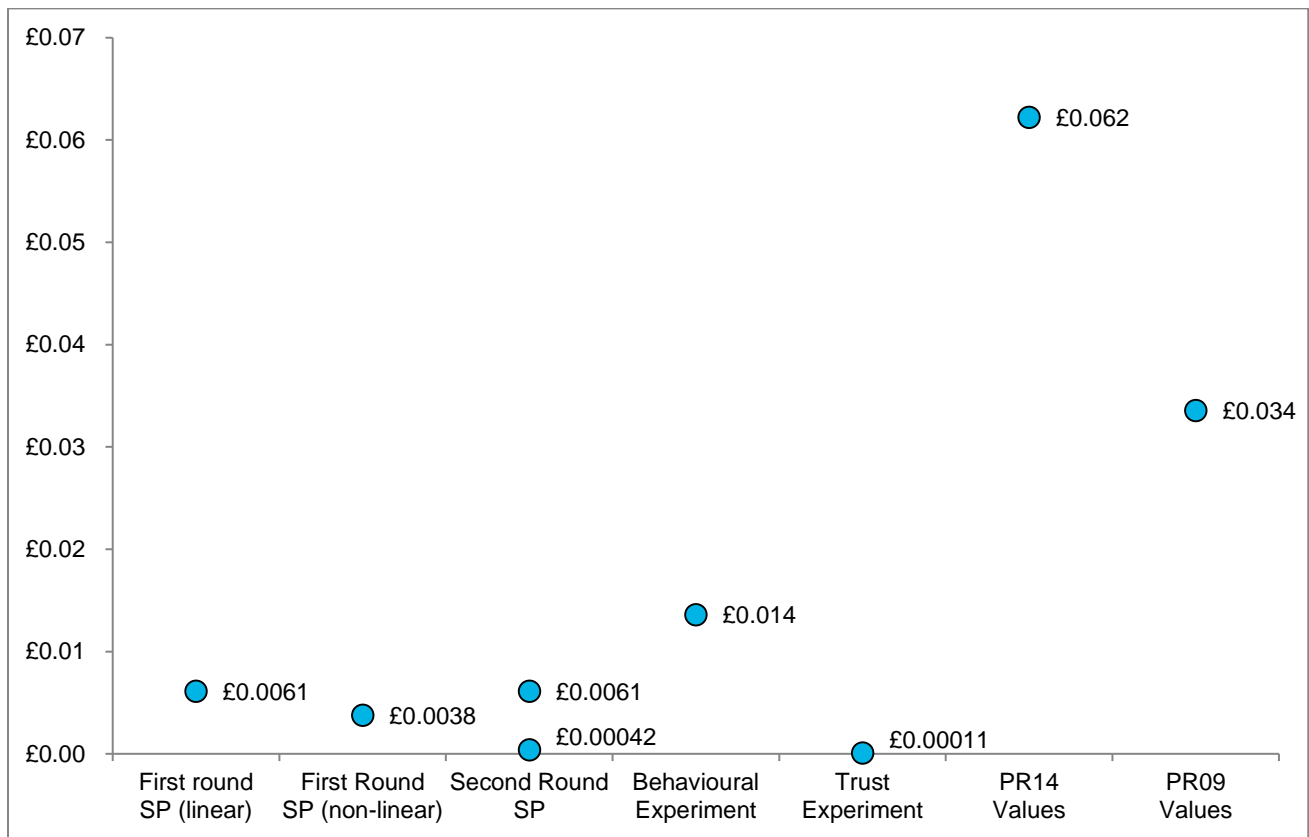
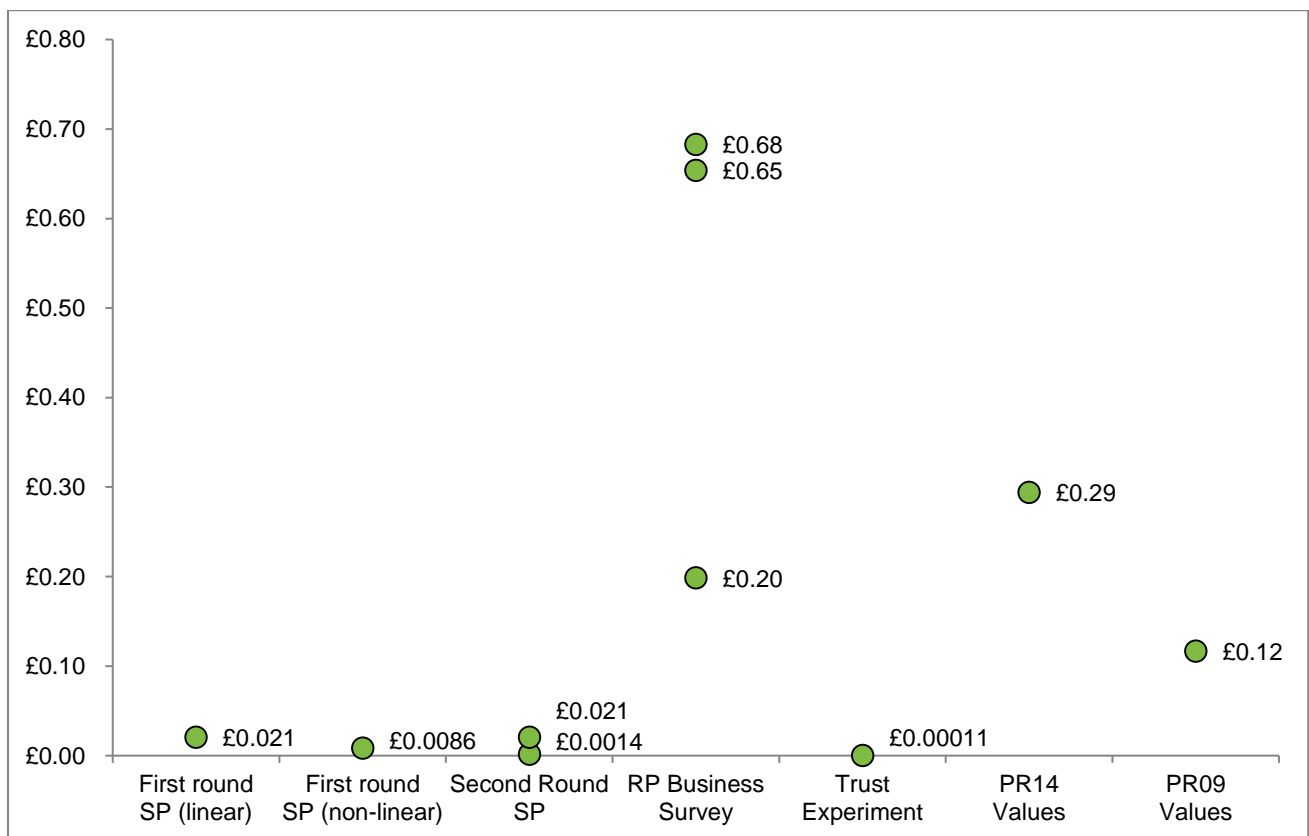


Figure 18. Illustrative comparison of values for internal sewer flooding (business)



**Table 32. Triangulation process for internal sewer flooding (household)**

| Factor  | First Round SP (linear)  | First Round SP (non-linear +1)  | Behavioural Experiment  | Trust Experiment  |
|---|--|---|---|---|
| Value   | £0.0061 per property   | £0.0038 per property  | £0.014 per property   | £243.00 per incident or £0.00011 per incident/customer  |
| Statistical robustness                            | <b>High</b> – based on sample of 1,000 households  | <b>High</b> – based on sample of 1,000 households   | <b>Very High</b> – based on sample of 2,000 households  | <b>Low</b> – based on sample of 62,000 customers although significant caveats on robustness of analysis                     |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.  | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>High</b> – based on observed choices in “real life” situations   |
| Completeness of value                             | <b>Medium</b> – customer value mostly captured although potentially misses out on the trust component  | <b>Low</b> – customer value mostly captured although misses difference for larger changes and potentially misses out on the trust component | <b>Medium</b> – customer value mostly captured although potentially misses out on the trust component                       | <b>Low</b> – doesn’t capture entire customer value but does capture trust component   |
| Consistency of track record or time series (PR14) | <b>High</b> – value 90% lower than PR14  | <b>High</b> – value 94% lower than PR14   | <b>High</b> – value 78% lower than PR14   | <b>High</b> – value 100% lower than PR14  |
| Consistency of track record or time series (PR09) | <b>High</b> – value 82% lower than PR09  | <b>High</b> – value 89% lower than PR09   | <b>High</b> – value 60% lower than PR09   | <b>High</b> – value 100% lower than PR09  |
| Correlation with qualitative evidence             | <b>Medium</b> – mid third priority (7 <sup>th</sup> /13) compared to qualitative ranking in top third (2 <sup>nd</sup> /10)  | <b>Medium</b> – mid third priority (7 <sup>th</sup> /13) compared to qualitative ranking in top third (2 <sup>nd</sup> /10)                 | <b>Medium</b> – mid third priority (7 <sup>th</sup> /13) compared to qualitative ranking in top third (2 <sup>nd</sup> /10) | <b>High</b> – top priority (1 <sup>st</sup> /6) compared to qualitative ranking in top third (2 <sup>nd</sup> /10)          |
| Implication of using this value (household)       | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14/09   | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14/09                  | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14/09  | Less robust value although captures value associated with trust unlikely to be captured in customer valuation or in PR14/09 |
| <b>Recommended value</b>                          | <i>All three of the customer values are broadly comparable and provide robust estimates, which are similar to those of PR14 and PR09. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The Trust Experiment captures an additional aspect of value that may be missing from the customer valuation estimates. It is possible that there would be some double counting by including this value alongside the customer values although the likelihood is considered to be low. The recommended approach is therefore to take an average of the First Round SP (linear) and Behavioural Experiment values plus the Trust Experiment value.</i> |   |   |   |

**Table 33. Triangulation process for internal sewer flooding (business)**

| Factor  | First Round SP (linear)   | First Round SP (non-linear +1)  | Business Survey (median)   | Trust Experiment  |
|---|---|---|--|---|
| Value   | £0.021 per property   | £0.0086 per property  | £0.65 per business   | £243.00 per incident or £0.00011 per incident/customer  |
| Statistical robustness                            | <b>High</b> – based on sample of 500 businesses   | <b>High</b> – based on sample of 500 businesses   | <b>Medium</b> – based on sample of 1,000 businesses although only 13 involved in avertive behaviour  | <b>Low</b> – based on sample of 62,000 customers although significant caveats on robustness of analysis                     |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>High</b> – based on actual expenditure decisions  | <b>High</b> – based on observed choices in “real life” situations   |
| Completeness of value                             | <b>Medium</b> – customer value mostly captured although potentially misses out on the trust component   | <b>Low</b> – customer value mostly captured although misses difference for larger changes and potentially misses out on the trust component | <b>Low</b> – focuses on actual expenditure so likely to be a lower bound value (assuming value exceeds expenditure and consumer surplus is not captured) | <b>Low</b> – doesn’t capture entire customer value but does capture trust component   |
| Consistency of track record or time series (PR14) | <b>High</b> – value 93% lower than PR14   | <b>High</b> – value 97% lower than PR14   | <b>Medium</b> – value 122% higher than PR14  | <b>High</b> – value 100% lower than PR14  |
| Consistency of track record or time series (PR09) | <b>High</b> – value 82% lower than PR09   | <b>High</b> – value 93% lower than PR09   | <b>Medium</b> – value 459% higher than PR09  | <b>High</b> – value 100% lower than PR09  |
| Correlation with qualitative evidence             | <b>Medium</b> – mid third priority (7 <sup>th</sup> /13) compared to qualitative ranking in top third (2 <sup>nd</sup> /10)   | <b>Medium</b> – mid third priority (7 <sup>th</sup> /13) compared to qualitative ranking in top third (2 <sup>nd</sup> /10)                 | <b>High</b> – top third priority (2 <sup>nd</sup> /7) compared to qualitative ranking in top third (2 <sup>nd</sup> /10)                                 | <b>High</b> – top priority (1 <sup>st</sup> /6) compared to qualitative ranking in top third (2 <sup>nd</sup> /10)          |
| Implication of using this value (household)       | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14/09  | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14/09                  | Medium robustness, aligned with qualitative preferences although would lead to somewhat higher results than PR14/09                                      | Less robust value although captures value associated with trust unlikely to be captured in customer valuation or in PR14/09 |
| <b>Recommended value</b>                          | <p><i>All three of the customer values are broadly comparable and provide reasonably robust estimates which are similar to those of PR14 and PR09. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The Business Survey value is interesting in that the estimate is higher than both the SP survey and the PR14/09 values when it is expected that this would produce a lower bound estimate. This may be due to methodological/definitional issues or it may reflect the fact that some avertive costs are likely to be assumed to have to be made anyway, regardless of a marginal change in service provision (capturing an average rather than a marginal cost). The Trust Experiment captures an additional aspect of value that may be missing from the customer valuation estimates. It is possible that there would be some double counting by including this value alongside the customer values although the likelihood is considered to be low. The recommended approach is therefore to take an average of the First Round SP (linear) and Business Survey (median) values plus the Trust Experiment value.</i></p> |   |  |   |

## Recommended values

A summary of the recommended values is set out in Table 34. The aggregate total is the sum of the aggregate values for each of Households, Businesses and Trust where the aggregate values are the individual values multiplied by either the total number of YWS household or business customers. The aggregate Trust values

were calculated using the total number of household customers as it was not possible to distinguish between household and business customers in the underlying analysis. .

**Table 34. Recommended individual and aggregated values for internal sewer flooding**

| Service measure                       | Unit                | Households | Businesses | Trust     | Aggregate Total   |
|---------------------------------------|---------------------|------------|------------|-----------|-------------------|
| Internal flooding of a cellar         | £/property/customer | £0.000681  | £0.023271  | £0.000108 | <b>£5,224.42</b>  |
| Internal flooding of a habitable area | £/property/customer | £0.009867  | £0.337268  | £0.000108 | <b>£72,437.55</b> |

# No 8. External Sewer Flooding

## Data sources

Estimates of the value YWS customers place on reducing the number of properties affected by external flooding were obtained from the methods and data sources set out in Table 35.

**Table 35. Data sources available for external sewer flooding**

| 1 <sup>st</sup> Round Stated Preference | 2 <sup>nd</sup> Round Stated Preference | Revealed Preference Visitor | Revealed Preference Business | Behavioural Experiment | Trust Experiment | PR14 Values | PR09 Values | Benefits Transfer |
|---|---|-----------------------------|------------------------------|------------------------|------------------|-------------|-------------|-------------------|
| ✓                                       | ✓                                       | ✗                           | ✓                            | ✓                      | ✓                | ✓           | ✗           | ✗                 |

## Results

On the basis of the linear model, the results of the First Round Stated Preference (SP) survey in Work Package 1 suggest that YWS household customers are willing to pay £0.00037 per year to reduce the number of properties affected by external flooding by one property, while business customers are willing to pay £0.00093.

By contrast, the non-linear model estimated that household customers are willing to pay £0.00019 per property and business customers £0.00086 for a one unit improvement.

The results of the Second Round SP survey suggest that, in terms of severity levels, the WTP for household and business customers for a one unit improvement in external flooding are as follows (note this work package estimated odds ratios which were then applied to the linear model results from Work Package 1):

- Minor roads = £0.00051 and £0.0013 per property
- Major roads = £0.00047 and £0.0012 per property
- Within property boundary but not inhibiting access = £0.00033 and £0.00082 per property
- Within property boundary inhibiting access = £0.00037 and £0.00093 per property
- Causing societal disruption = £0.0015 and £0.0037 per property

The Revealed Preference (RP) Business Survey estimated that YWS business customers spend a median value of £20.27 per business per year to deal with external flooding (assuming a 50:50 split with internal flooding)<sup>18</sup> with a range of £6.16 to £21.17. The survey recorded an average number of 33 external flood events reported each year by respondents giving a median value of £0.61 per business impacted, with a range of £0.18 to £0.64. Given the small sample size of businesses actually engaging in avertive behaviour and the impact of outliers on the results it is considered the median value is more appropriate for use than the mean.

The Behavioural Experiment estimated that YWS household customers are willing to increase their annual water bills by £0.0011 to reduce the number of properties affected by external flood events by one.

The Trust Experiment estimated that the average cost incurred in terms of reduced bill payments following an external flood is £182 per customer affected. Note that this estimate is not directly equivalent to those obtained from the SP and RP surveys or the Behavioural Experiment as it represents a direct cost to YWS which reflects a cost, or loss of welfare, incurred by the customer. Dividing by the total customer base to provide a comparison against the other value sets gives a value of £0.000081 per customer. However, the estimate from the Trust Experiment needs to be treated with caution as there may be a number of other confounding factors (not explored in this project) that affect customers' propensity to pay, as well as changes in this value over time (i.e. it may not be that the propensity to refuse to pay continues over time).

The SP surveys undertaken for PR14 estimated the amount YWS households and businesses would be willing to pay to reduce the number of external floods at £0.011 and £0.065 respectively. Note, the units used in PR14 are not directly comparable with those used in PR19.

A comparison of these values is set out in Figure 19 and

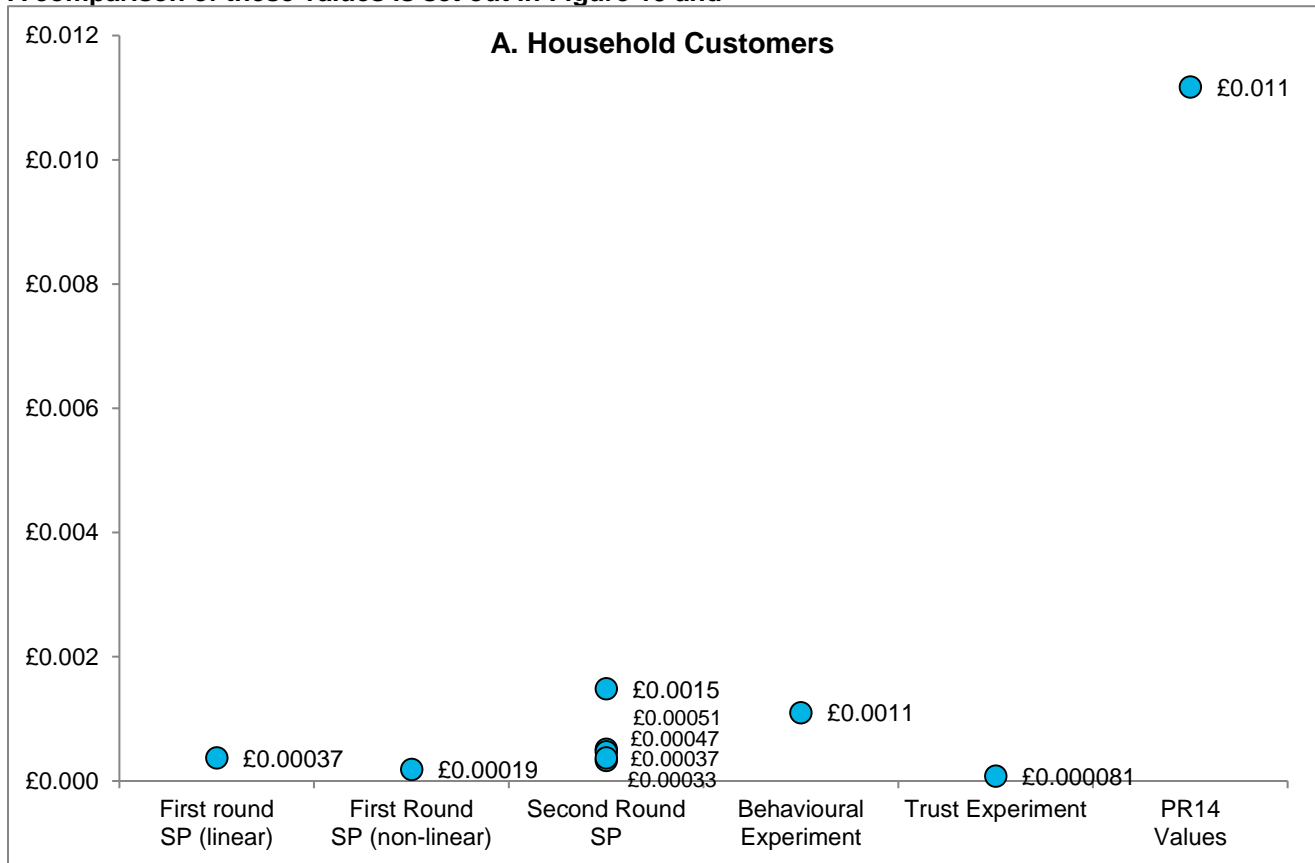


Figure 20. Note that, due to differences in units across data sources the figures are illustrative of the range of values. Also note that, the values for Work Package 2 are presented alongside the other values, these demonstrate the range in WTP estimates for different severity levels within the same service measure and so are not directly comparable to the other estimates.

### Triangulation

The data from the work packages were then compared using the triangulation method set out in Table 6. Note that the values from Work Package 2 were not included in the triangulation process as the outputs from this work package were odds ratios rather than value estimates. Instead, the outputs from Work Package 2 were applied to the final value selected through the triangulation exercise to estimate the values for each of the severity levels. The values for PR14 were included for comparative purposes only, rather than as values to be put forward for use in the DMF.

The results of the triangulation process are set out in Table 36 and Table 37.



Figure 19. Illustrative comparison of values for external sewer flooding (household)

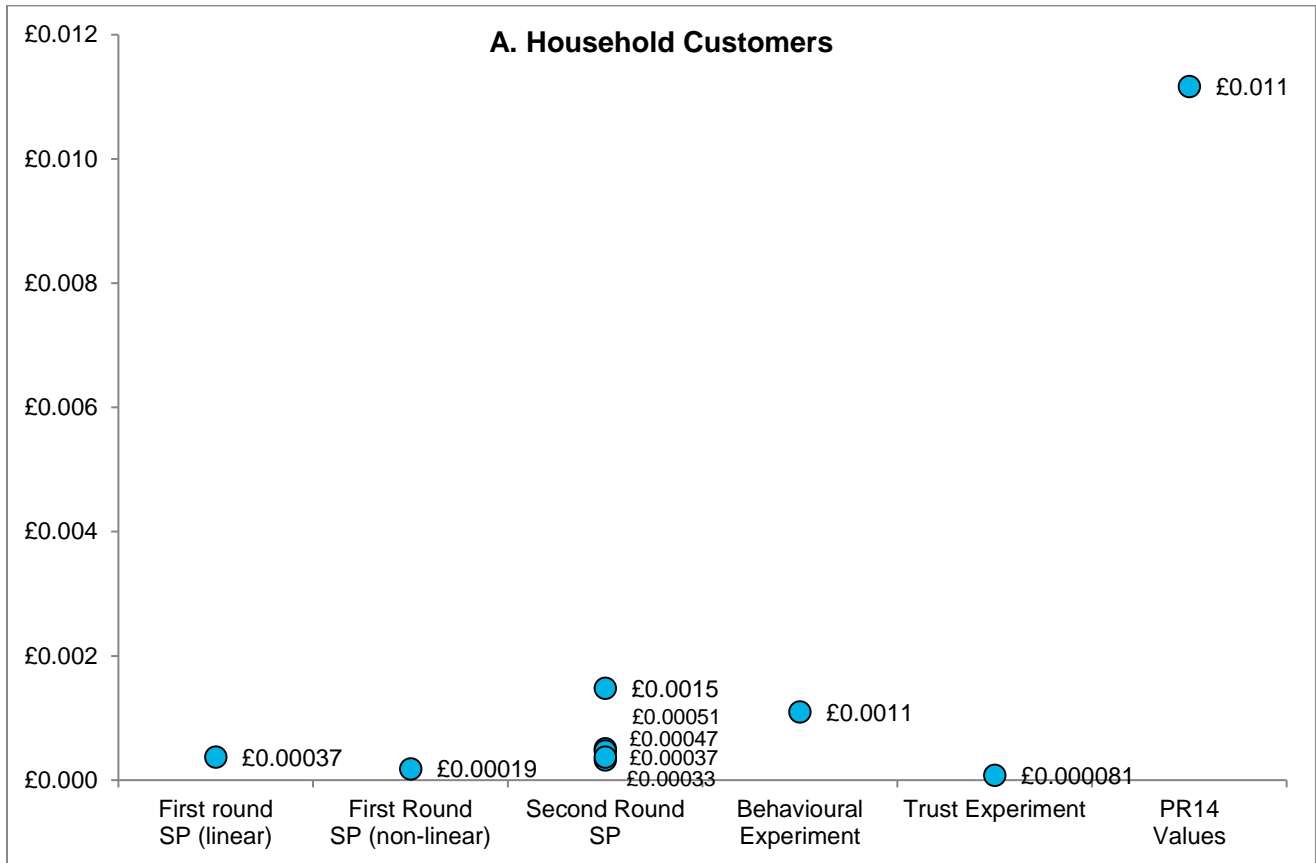
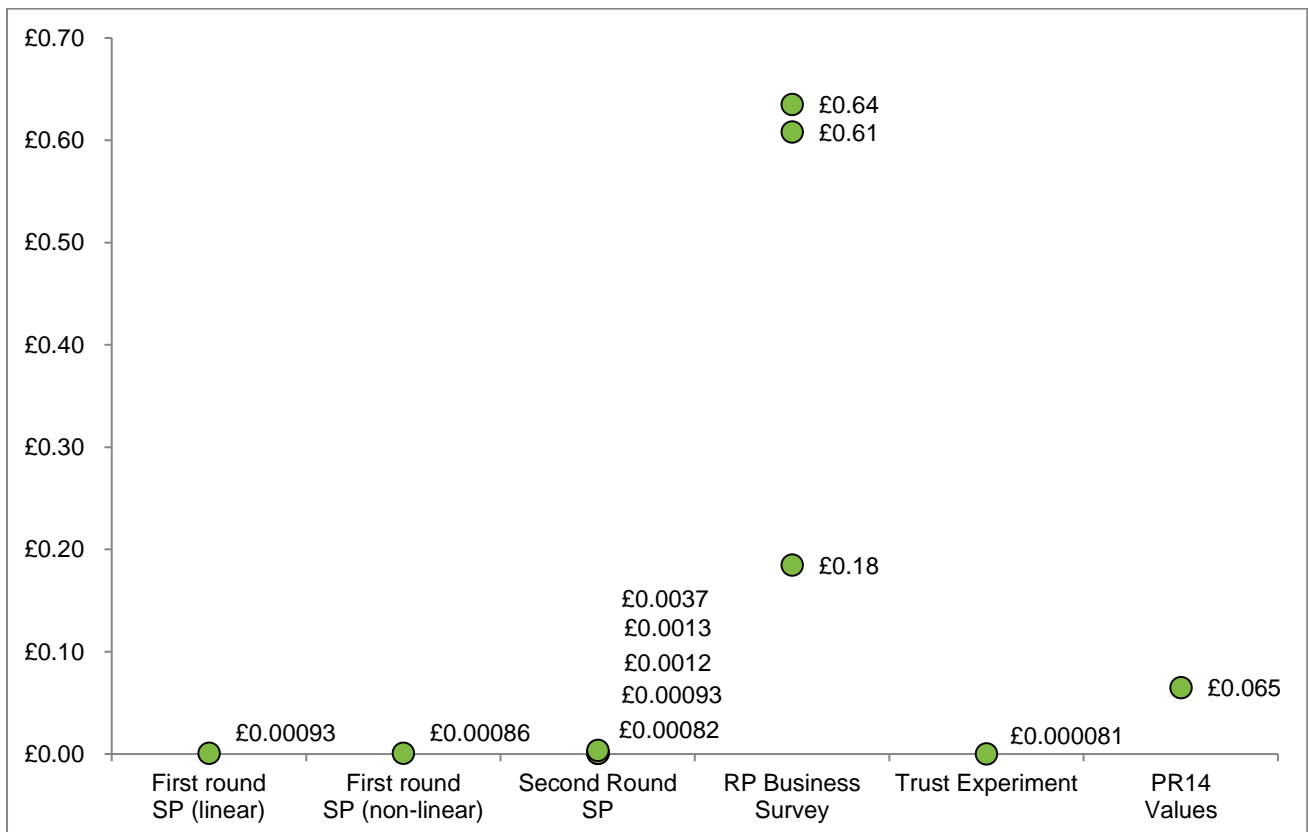


Figure 20. Illustrative comparison of values for external sewer flooding (business)



**Table 36. Triangulation process for external sewer flooding (household)**

| Factor  | First Round SP (linear)  | First Round SP (non-linear +1)  | Behavioural Experiment  | Trust Experiment  |
|---|--|---|---|---|
| Value   | £0.00037 per property  | £0.00019 per property   | £0.0011 per property  | £182.00 per incident or £0.000081 per incident/customer   |
| Statistical robustness                            | <b>High</b> – based on sample of 1,000 households  | <b>High</b> – based on sample of 1,000 households   | <b>Very High</b> – based on sample of 2,000 households  | <b>Low</b> – based on sample of 62,000 customers although significant caveats on robustness of analysis                     |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.  | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>High</b> – based on observed choices in “real life” situations   |
| Completeness of value                             | <b>Medium</b> – customer value mostly captured although potentially misses out on the trust component  | <b>Low</b> – customer value mostly captured although misses difference for larger changes and potentially misses out on the trust component | <b>Medium</b> – customer value mostly captured although potentially misses out on the trust component                       | <b>Low</b> – doesn’t capture entire customer value but does capture trust component   |
| Consistency of track record or time series (PR14) | <b>High</b> – value 97% lower than PR14  | <b>High</b> – value 98% lower than PR14   | <b>High</b> – value 90% higher than PR14  | <b>High</b> – value 99% lower than PR14   |
| Consistency of track record or time series (PR09) | <i>No PR09 data available for water restrictions</i>   | <i>No PR09 data available for water restrictions</i>  | <i>No PR09 data available for water restrictions</i>  | <i>No PR09 data available for water restrictions</i>  |
| Correlation with qualitative evidence             | <b>Low</b> – bottom third priority (10 <sup>th</sup> /13) compared to qualitative ranking in top third (3 <sup>rd</sup> /10)   | <b>Low</b> – bottom third priority (10 <sup>th</sup> /13) compared to qualitative ranking in top third (3 <sup>rd</sup> /10)                | <b>Medium</b> – mid third priority (9 <sup>th</sup> /13) compared to qualitative ranking in top third (3 <sup>rd</sup> /10) | <b>Medium</b> – mid third priority (3 <sup>rd</sup> /6) compared to qualitative ranking in top third (3 <sup>rd</sup> /10)  |
| Implication of using this value (household)       | Robust value, poorly aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14  | Robust value, poorly aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14                       | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly higher than PR14    | Less robust value although captures value associated with trust unlikely to be captured in customer valuation or in PR14/09 |
| <b>Recommended value</b>                          | <i>All three of the customer values are broadly comparable and provide robust estimates, which are similar to those of PR14 and PR09. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The Trust Experiment captures an additional aspect of value that may be missing from the customer valuation estimates. It is possible that there would be some double counting by including this value alongside the customer values although the likelihood is considered to be low. The recommended approach is therefore to take an average of the First Round SP (linear) and Behavioural Experiment values plus the Trust Experiment value.</i> |   |   |   |

**Table 37. Triangulation process for external sewer flooding (business)**

| Factor  | First Round SP (linear)   | First Round SP (non-linear +1)  | Business Survey (median)   | Trust Experiment  |
|---|---|---|--|---|
| Value   | £0.00093 per property   | £0.00086 per property   | £0.61 per business   | £182.00 per incident or £0.000081 per incident/customer   |
| Statistical robustness                            | <b>High</b> – based on sample of 500 businesses   | <b>High</b> – based on sample of 500 businesses   | <b>Medium</b> – based on sample of 1,000 businesses although only 13 involved in avertive behaviour  | <b>Low</b> – based on sample of 62,000 customers although significant caveats on robustness of analysis                     |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>High</b> – based on actual expenditure decisions  | <b>High</b> – based on observed choices in “real life” situations   |
| Completeness of value                             | <b>Medium</b> – customer value mostly captured although potentially misses out on the trust component   | <b>Low</b> – customer value mostly captured although misses difference for larger changes and potentially misses out on the trust component | <b>Low</b> – focuses on actual expenditure so likely to be a lower bound value (assuming value exceeds expenditure and consumer surplus is not captured) | <b>Low</b> – doesn’t capture entire customer value but does capture trust component   |
| Consistency of track record or time series (PR14) | <b>High</b> – value 99% lower than PR14   | <b>High</b> – value 99% lower than PR14   | <b>Medium</b> – value 835% higher than PR14  | <b>High</b> – value 100% lower than PR14  |
| Consistency of track record or time series (PR09) | <i>No PR09 data available for water restrictions</i>  | <i>No PR09 data available for water restrictions</i>  | <i>No PR09 data available for water restrictions</i>   | <i>No PR09 data available for water restrictions</i>  |
| Correlation with qualitative evidence             | <b>Low</b> – bottom third priority (10 <sup>th</sup> /13) compared to qualitative ranking in top third (3 <sup>rd</sup> /10)  | <b>Low</b> – bottom third priority (10 <sup>th</sup> /13) compared to qualitative ranking in top third (3 <sup>rd</sup> /10)                | <b>High</b> – top third priority (3 <sup>rd</sup> /7) compared to qualitative ranking in top third (3 <sup>rd</sup> /10)                                 | <b>Medium</b> – mid third priority (3 <sup>rd</sup> /6) compared to qualitative ranking in top third (3 <sup>rd</sup> /10)  |
| Implication of using this value (household)       | Robust value, poorly aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14   | Robust value, poorly aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14                       | Medium robustness, aligned with qualitative preferences although would lead to somewhat higher results than PR14   | Less robust value although captures value associated with trust unlikely to be captured in customer valuation or in PR14/09 |
| <b>Recommended value</b>                          | <p><i>All three of the customer values are broadly comparable and provide reasonably robust estimates which are similar to those of PR14 and PR09. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The Business Survey value is interesting in that the estimate is higher than both the SP survey and the PR14/09 values when it is expected that this would produce a lower bound estimate. This may be due to methodological/definitional issues or it may reflect the fact that some avertive costs are likely to be assumed to have to be made anyway, regardless of a marginal change in service provision (capturing an average rather than a marginal cost). The Trust Experiment captures an additional aspect of value that may be missing from the customer valuation estimates. It is possible that there would be some double counting by including this value alongside the customer values although the likelihood is considered to be low. The recommended approach is therefore to take an average of the First Round SP (linear) and Business Survey (median) values plus the Trust Experiment value.</i></p> |   |  |   |

## Recommended values

A summary of the recommended values is set out in Table 38. The aggregate weighted total is the weighted sum of the aggregate values for each of Households and Businesses where the aggregate values are the marginal values for Households and Businesses multiplied by the total number of YWS household and business customers respectively and weighted according to the proportion of the total YWS customer base that each of household and business customers represent.

**Table 38. Recommended values for external sewer flooding**

| Service measure                                | Unit                | Households | Businesses | Trust     | Aggregate Total    |
|--|---------------------|------------|------------|-----------|--------------------|
| Minor road                                     | £/property/customer | £0.001     | £0.42      | £0.000081 | <b>£63,881.74</b>  |
| Major road                                     | £/property/customer | £0.0009    | £0.38      | £0.000081 | <b>£58,974.95</b>  |
| Within property boundary not inhibiting access | £/property/customer | £0.0007    | £0.27      | £0.000081 | <b>£41,310.51</b>  |
| Within property boundary inhibiting access     | £/property/customer | £0.0007    | £0.30      | £0.000081 | <b>£46,731.34</b>  |
| Societal disruption                            | £/property/customer | £0.003     | £1.21      | £0.000081 | <b>£185,850.55</b> |

# No 9. Bathing Water Quality

## Data sources

Estimates of the value YWS customers place on bathing water quality were obtained from the methods and data sources set out in Table 39.

**Table 39. Data sources available for bathing water quality**

| 1 <sup>st</sup> Round Stated Preference | 2 <sup>nd</sup> Round Stated Preference | Revealed Preference Visitor | Revealed Preference Business | Behavioural Experiment | Trust Experiment | PR14 Values | PR09 Values | Benefits Transfer |
|---|---|-----------------------------|------------------------------|------------------------|------------------|-------------|-------------|-------------------|
| ✓                                       | ✓                                       | ✗                           | ✗                            | ✓                      | ✗                | ✓           | ✓           | ✓                 |

## Results

On the basis of the linear model, the results of the First Round Stated Preference (SP) survey in Work Package 1 suggest that YWS household customers are willing to pay £0.40 per year to reduce the number of bathing waters experiencing a deterioration in classification by one bathing water. This was broken down into a ‘use’ value of £0.28 (primarily related to direct use of the water environment such as through recreation although also indirect use such as by benefitting from the regulation of the global climate and option value in terms of future potential uses) and a ‘non-use’ value of £0.13 (related to bequest value e.g. so that future generations can enjoy the environment and existence value e.g. because the environment is valuable in its own right). By contrast, business customers are willing to pay £1.50.

The non-linear model estimated that household customers are willing to pay £0.32 per property and business customers £1.39 for a one unit improvement.

The results of the Second Round SP survey suggest that, in terms of severity levels, the WTP for household and business customers for a one unit improvement are as follows (note this work package estimated odds ratios which were then applied to the linear model results from Work Package 1):

- Water quality sample failure at a bathing water = £0.20 and £0.74 per bathing water
- Deterioration in bathing water classification = £0.40 and £1.50 per bathing water
- Loss of Blue Flag status = £0.41 and £1.54 per bathing water

The Behavioural Experiment estimated that YWS household customers are willing to increase their annual water bills by £0.53 to prevent a deterioration in bathing water classification.

The SP surveys undertaken for PR14 estimated the amount YWS households and businesses would be willing to pay to improve bathing water quality at £2.99 and £7.31 respectively. Note, the units used in PR14 are not directly comparable with those used in PR19.

The SP surveys undertaken for PR09 estimated the amount YWS households and businesses would be willing to pay to improve bathing water quality at £0.11 and £0.20 respectively. Note, the units used in PR09 are not directly comparable with those used in PR19.

The Benefits Transfer work undertaken as part of the DMF work stream estimated a ‘use’ value for a change in bathing water classification of £29,488 (2017 prices), this estimate was based on: recreation; wellbeing; health & safety; and local economy. On a per customer basis (given the 2.4 million YWS customers) this would suggest a use value of around £0.013 per bathing water.

The Benefits Transfer work also estimated that a loss in Blue Flag status would lead to a cost to the local economy of around £20.1 million (2017 prices), which combined with the recreation, wellbeing, and health & safety values set out above suggests a use value of around £8.91 per bathing water. Note, this encompasses direct, indirect, and induced effects so is looking much more broadly than customers' use value.

A comparison of these values is set out in Figure 21 and Figure 22. Note that, due to differences in units across data sources the figures are illustrative of the range of values. Also note that, the values for Work Package 2 are presented alongside the other values, these demonstrate the range in WTP estimates for different severity levels within the same service measure and so are not directly comparable to the other estimates.

## Triangulation

The data from the work packages, together with Benefits Transfer estimates derived from the current version of the DMF, were then compared using the triangulation method set out in Table 6. Note that the values from Work Package 2 were not included in the triangulation process as the outputs from this work package were odds ratios rather than value estimates. Instead, the outputs from Work Package 2 were applied to the final value selected through the triangulation exercise to estimate the values for each of the severity levels. The values for PR14 and PR09 were included for comparative purposes only, rather than as values to be put forward for use in the DMF.

The results of the triangulation process are set out in Table 40 and Table 41.

Figure 21. Illustrative comparison of values for bathing water quality (household)

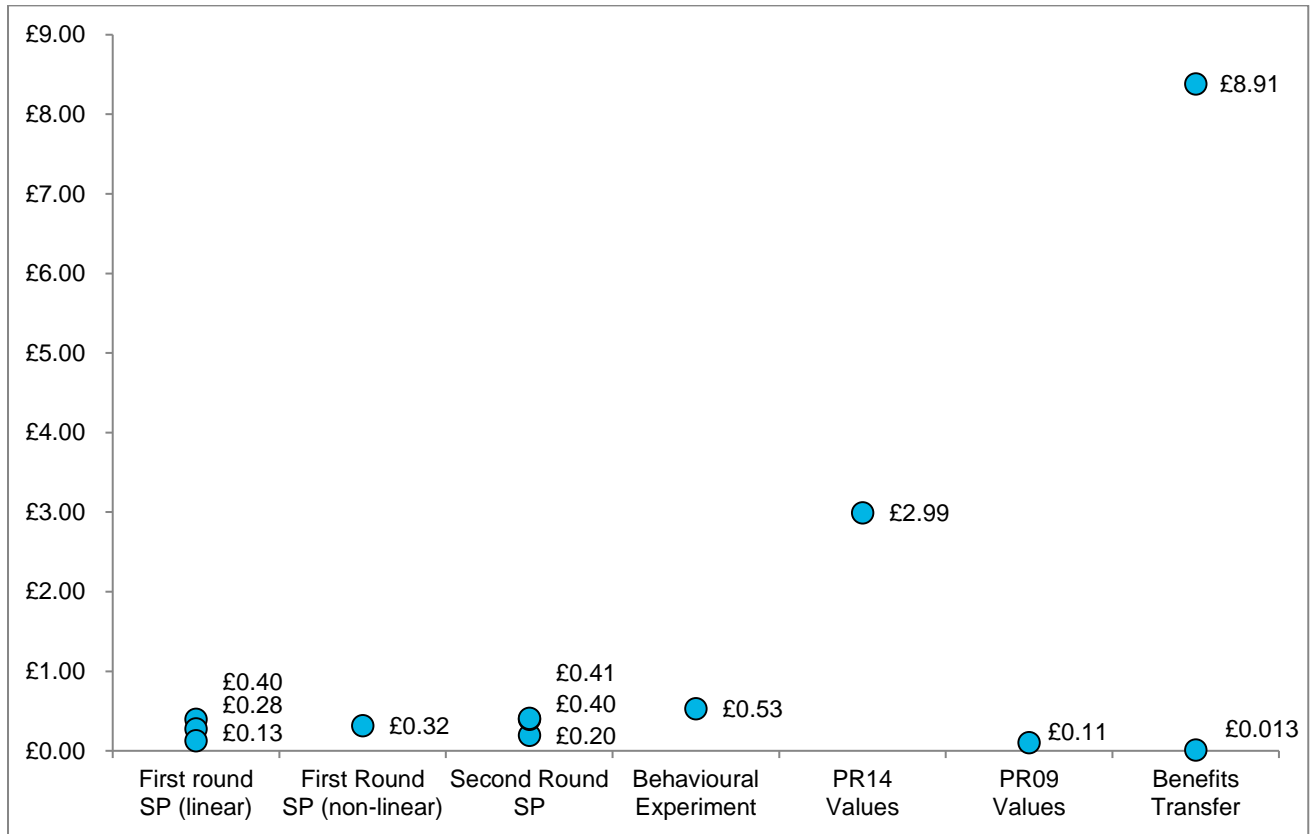
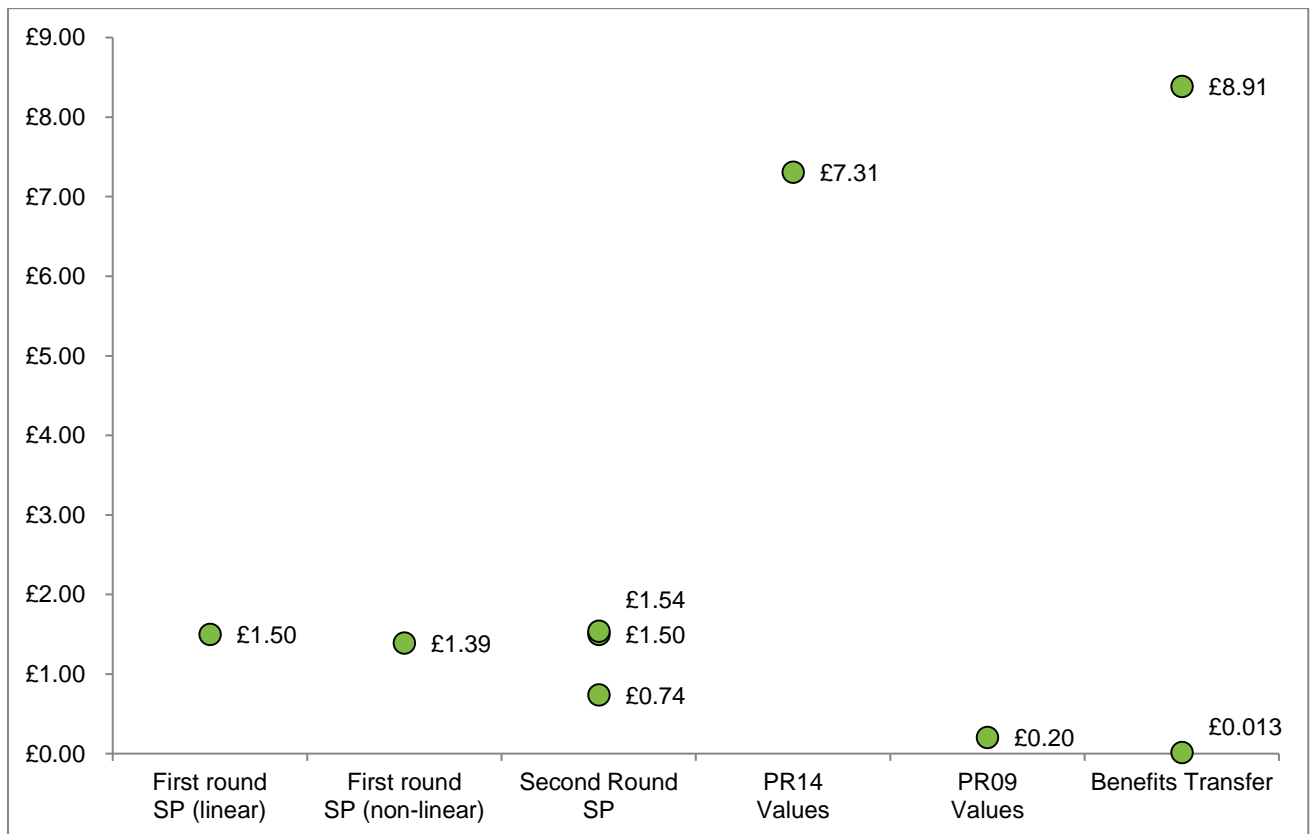


Figure 22. Illustrative comparison of values for bathing water quality (business)



**Table 40. Triangulation process for bathing water quality (household)**



| Factor  | First Round SP (linear)  | First Round SP (non-linear +1)  | Behavioural Experiment  | Benefits Transfer (classification)   | Benefits Transfer (Blue Flag)  |
|---|--|---|---|--|--|
| Value (use)                                       | £0.28 per bathing water/customer   | £0.32 per bathing water/customer  | £0.53 per bathing water/customer  | £29,488 per bathing water or £0.013 per bathing water / customer   | £20.1m per bathing water or £8.91 per bathing water / customer   |
| Value (non-use)                                   | £0.13 per bathing water/customer   |   |   | n/a  | n/a  |
| Statistical robustness                            | <b>High</b> – based on sample of 1,000 households  | <b>High</b> – based on sample of 1,000 households   | <b>Very High</b> – based on sample of 2,000 households  | <b>Low</b> – based on secondary sources from the literature  | <b>Medium</b> – based on a regression analysis in Yorkshire  |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.  | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | n/a  | n/a  |
| Completeness of value                             | <b>Medium</b> – customer value captured although potentially misses out on the wider environmental and social costs of bathing water quality changes   | <b>Low</b> – customer value mostly captured although misses difference for larger changes and potentially misses out on the wider environmental and social costs of bathing water quality changes | <b>Medium</b> – customer value captured although potentially misses out on the wider environmental and social costs of bathing water quality changes  | <b>Low</b> – captures some of the wider costs of bathing water changes although does not capture customer values   | <b>Low</b> – captures some of the wider costs of bathing water changes although does not capture customer values   |
| Consistency of track record or time series (PR14) | <b>High</b> – value 87% lower than PR14  | <b>High</b> – value 89% lower than PR14   | <b>High</b> – value 82% lower than PR14   | <b>High</b> – value 100% lower than PR14   | <b>Medium</b> – value 180% higher than PR14  |
| Consistency of track record or time series (PR09) | <b>Medium</b> – value 274% higher than PR09  | <b>Medium</b> – value 199% higher than PR09   | <b>Medium</b> – value 396% higher than PR09   | <b>High</b> – value 89% lower than PR09  | <b>Low</b> – value 7,743% higher than PR09   |
| Correlation with qualitative evidence             | <b>Medium</b> – top third priority (3 <sup>rd</sup> /13) compared to qualitative ranking in mid third (5 <sup>th</sup> /10)  | <b>Medium</b> – top third priority (3 <sup>rd</sup> /13) compared to qualitative ranking in mid third (5 <sup>th</sup> /10)   | <b>Medium</b> – top third priority (3 <sup>rd</sup> /13) compared to qualitative ranking in mid third (5 <sup>th</sup> /10)                           | n/a  | n/a  |
| Implication of using this value (household)       | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14 and somewhat higher than PR09  | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14 and somewhat higher than PR09   | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14 and somewhat higher than PR09 | Low robustness of value, could be combined with non-use value from customer research although value significantly lower than other sources and potential for double counting | Medium robustness of value, could be combined with non-use value from customer research although value significantly higher than other sources and potential for double counting |
| <b>Recommended value</b>                          | <p><i>All three of the customer values are broadly similar and provide robust estimates. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The Benefits Transfer value captures an additional aspect of value although there is significant potential for double counting and the estimates vary significantly across data sources. The recommended approach is to take an average of the First Round SP (linear) and Behavioural Experiment values and split by use and non-use values.</i></p> |   |   |  |  |

**Table 41. Triangulation process for bathing water quality (business)**

| Factor  | First Round SP (linear)   | First Round SP (non-linear +1)  | Benefits Transfer (classification)  | Benefits Transfer (Blue Flag)   |
|---|---|---|---|---|
| Value   | £1.50 per bathing water/customer  | £1.39 per bathing water/customer  | £28,605 per bathing water or £0.013 per bathing water / customer  | £19.5m per bathing water or £8.91 per bathing water / customer  |
| Statistical robustness                            | <b>High</b> – based on sample of 1,000 households   | <b>High</b> – based on sample of 1,000 households   | <b>Low</b> – based on secondary sources from the literature   | <b>Medium</b> – based on a regression analysis in Yorkshire   |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | n/a   | n/a   |
| Completeness of value                             | <b>Medium</b> – customer value captured although potentially misses out on the wider environmental and social costs of bathing water quality changes  | <b>Low</b> – customer value mostly captured although misses difference for larger changes and potentially misses out on the wider environmental and social costs of bathing water quality changes | <b>Low</b> – captures some of the wider costs of bathing water changes although does not capture customer values  | <b>Low</b> – captures some of the wider costs of bathing water changes although does not capture customer values  |
| Consistency of track record or time series (PR14) | <b>High</b> – value 80% lower than PR14   | <b>High</b> – value 81% lower than PR14   | <b>High</b> – value 100% lower than PR14  | <b>High</b> – value 15% higher than PR14  |
| Consistency of track record or time series (PR09) | <b>Medium</b> – value 635% higher than PR09   | <b>Medium</b> – value 582% higher than PR09   | <b>High</b> – value 94% lower than PR09   | <b>Low</b> – value 4,018% higher than PR09  |
| Correlation with qualitative evidence             | <b>Medium</b> – top third priority (3 <sup>rd</sup> /13) compared to qualitative ranking in mid third (5 <sup>th</sup> /10)   | <b>Medium</b> – top third priority (3 <sup>rd</sup> /13) compared to qualitative ranking in mid third (5 <sup>th</sup> /10)   | n/a   | n/a   |
| Implication of using this value (household)       | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14 and somewhat higher than PR09   | Robust value, somewhat aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14 and somewhat higher than PR09   | Low robustness of value, could be combined with non-use value estimated from customer research although value significantly lower than other data sources and potential for double counting | Medium robustness of value, could be combined with non-use value estimated from customer research although value significantly higher than other data sources and potential for double counting |
| <b>Recommended value</b>                          | <i>The customer values are broadly similar and provide robust estimates. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The Benefits Transfer value captures an additional aspect of value although there is significant potential for double counting and the estimates vary significantly across data sources. The recommended approach is to use the First Round SP (linear) value.</i> |   |   |   |

## Recommended values

A summary of the recommended values is set out in Table 42. The aggregate total is the sum of the aggregate values for each of Households, Use values and Non-use values where the aggregate values are the individual values multiplied by either the total number of YWS business or household customers. The aggregate use and non-use values were calculated using the total number of household customers.

**Table 42. Recommended individual and aggregate values for bathing water quality**

| Service measure   | Unit                      | Businesses | Use values | Non-use values | Aggregate Total      |
|---|---------------------------|------------|------------|----------------|----------------------|
| Reduction in bathing waters experiencing sample failure | £/bathing water /customer | £0.74      | £0.16      | £0.07          | <b>£638,461.01</b>   |
| Reduction in bathing waters being declassified          | £/bathing water /customer | £1.50      | £0.33      | £0.15          | <b>£1,297,684.97</b> |
| Reduction in bathing waters losing Blue Flag status     | £/bathing water /customer | £1.54      | £0.33      | £0.16          | <b>£1,332,722.46</b> |

# No 10. River Water Quality

## Data sources

Estimates of the value YWS customers place on river water quality were obtained from the methods and data sources set out in Table 43.

**Table 43. Data sources available for river water quality**

| 1 <sup>st</sup> Round Stated Preference | 2 <sup>nd</sup> Round Stated Preference | Revealed Preference Visitor | Revealed Preference Business | Behavioural Experiment | Trust Experiment | PR14 Values | PR09 Values | Benefits Transfer |
|---|---|-----------------------------|------------------------------|------------------------|------------------|-------------|-------------|-------------------|
| ✓                                       | ✗                                       | ✓                           | ✗                            | ✓                      | ✗                | ✓           | ✓           | ✓                 |

## Results

On the basis of the linear model, the results of the First Round Stated Preference (SP) survey in Work Package 1 suggest that YWS household customers are willing to pay £0.44 per year to increase the % of rivers in good condition by one percentage point. This was broken down into a ‘use’ value of £0.30 (primarily related to direct use of the water environment such as through recreation although also indirect use such as by benefitting from the regulation of the global climate and option value in terms of future potential uses) and a ‘non-use’ value of £0.14 (related to bequest value e.g. so that future generations can enjoy the environment and existence value e.g. because the environment is valuable in its own right). By contrast, business customers are willing to pay £1.67.

The non-linear model estimated that household customers are willing to pay £0.33 per % improved and business customers £1.71 for a one unit improvement.

The Revealed Preference Visitor Survey estimated a total value of improving water quality in 1% of rivers in Yorkshire of £4.2 million, of which £0.3m was use value and £3.9m was non-use value; or around £1.87 per customer of which £0.14 was use value and £1.73 non-use value. Note, there may be a difference in what respondents are valuing across work packages. The approach to the Visitor Survey looked at the value of improving a randomly assigned section of river across the Yorkshire region. This includes large stretches of river which are inaccessible and therefore have low use values. In the stated preference surveys, customers were asked to value the improvement of a general percentage change in river water quality, but may have been thinking of rivers which they actively use for recreation when responding, which could lead to higher use values relative to non-use values.

Further there may also be a difference in how respondents understand the extent of an ‘improvement’ across the work packages; with the Visitor Survey looking at a range of different changes in condition (e.g. from Bad to Good or Poor to Good), presenting the final results in terms of an average one step improvement. By contrast, responses to the stated preference surveys may have included a wider range of ideas about the extent of such an improvement.

The Behavioural Experiment estimated that YWS household customers are willing to increase their annual water bills by £1.01 for every % of river improved.

The SP surveys undertaken for PR14 estimated the amount YWS households and businesses would be willing to pay to improve river water quality at £0.049 and £0.19 respectively. Note, the units used in PR14 are not directly comparable with those used in PR19.

The SP surveys undertaken for PR09 estimated the amount YWS households and businesses would be willing to pay to improve river water quality at £0.84 and £2.31 respectively. Note, the units used in PR09 are not directly comparable with those used in PR19.

The Benefits Transfer work undertaken as part of the DMF work stream estimated a 'use' value for improvements in river water quality of £844,312, this estimate was based on: recreation, amenity, wellbeing, health & safety, and local economy. On a per customer basis (given the 2.258 million YWS customers) this would suggest a use value of around £0.37 per % improved.

A comparison of these values is set out in Figure 23 and Figure 24. Note that, due to differences in units across data sources the figures are illustrative of the range of values.

### **Triangulation**

The data from the work packages, together with Benefits Transfer estimates derived from the current version of the DMF, were then compared using the triangulation method set out in Table 6. The values for PR14 and PR09 were included for comparative purposes only, rather than as values to be put forward for use in the DMF.

The results of the triangulation process are set out in Table 44 and Table 45.

Figure 23. Illustrative comparison of values for river water quality (household)

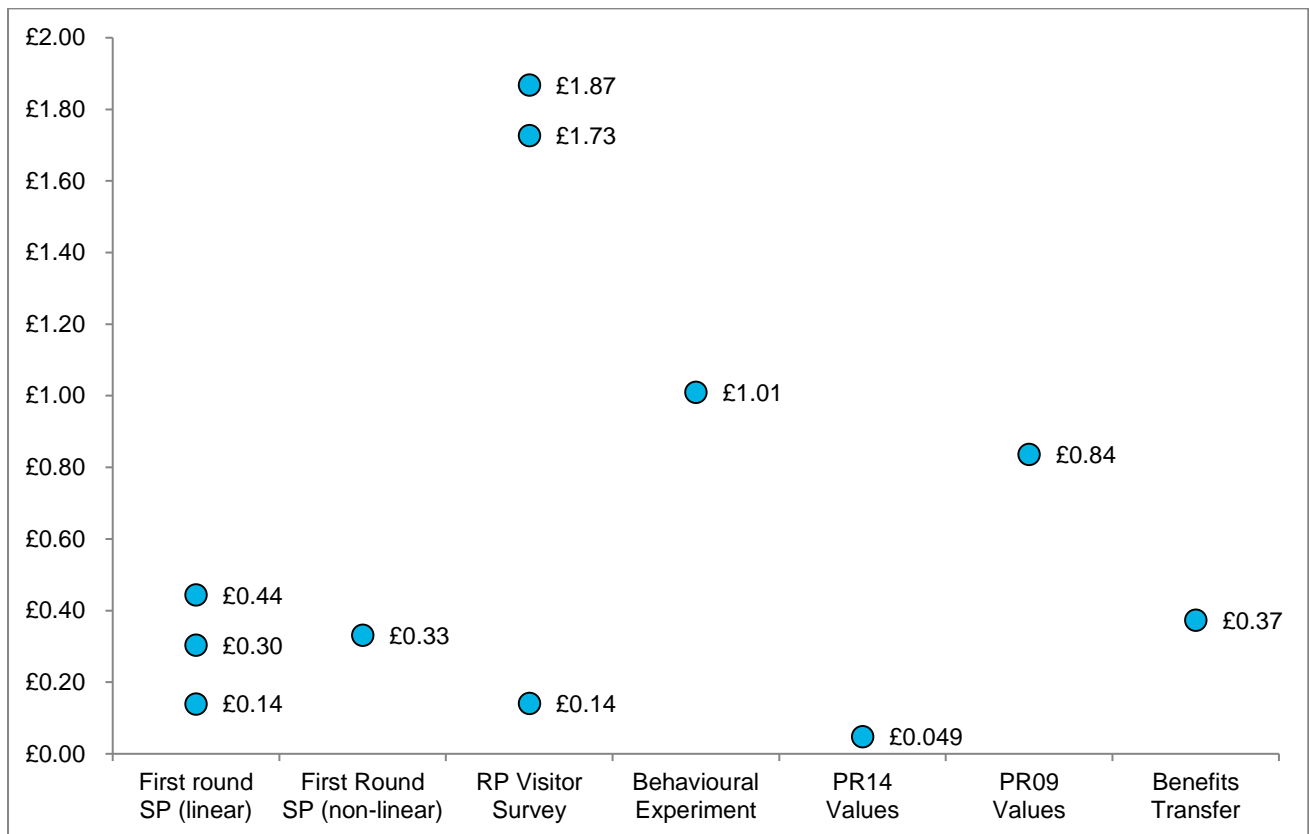
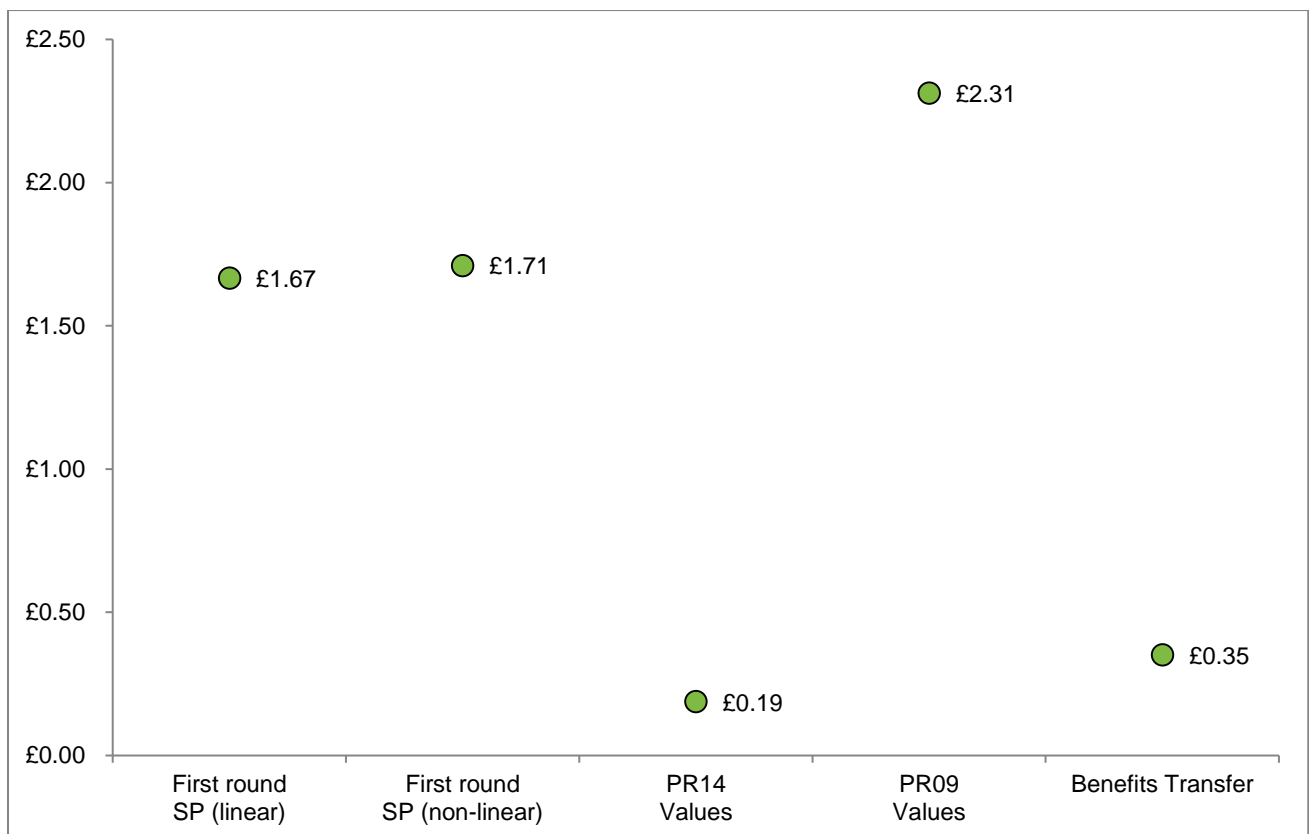


Figure 24. Illustrative comparison of values for river water quality (business)



**Table 44. Triangulation process for river water quality (household)**

| Factor  | First Round SP (linear)  | First Round SP (non-linear +1)  | RP Visitor Survey   | Behavioural Experiment   | Benefits Transfer   |
|---|--|---|---|--|---|
| Value (use)                                       | £0.14 per % / customer   | £0.33 per % / customer  | £0.3m per % or £0.14 per % / customer   | £1.01 per % / customer   | £0.8m per % or £0.35 per % / customer   |
| Value (non-use)                                   | £0.30 per % / customer   |   | £3.9m per % or £1.62 per % / customer   |  | n/a   |
| Statistical robustness                            | <b>High</b> – based on sample of 1,000 households  | <b>High</b> – based on sample of 1,000 households   | <b>Very High</b> – based on sample of 2,000 visitors  | <b>Very High</b> – based on sample of 2,000 households   | <b>Low</b> – based on secondary sources from the literature   |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.  | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>High</b> – combined stated and Revealed Preference information, including real behaviour based on visitor statistics   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.  | n/a   |
| Completeness of value                             | <b>Medium</b> – customer value captured although potentially misses out on the wider environmental and social benefits of river water quality improvements   | <b>Low</b> – customer value mostly captured although misses difference for larger changes and potentially misses out on the wider environmental and social benefits of river water quality improvements | <b>High</b> – brings together both use and non-use values although may potentially miss out on some aspects of use values | <b>Medium</b> – customer value captured although potentially misses out on the wider environmental and social benefits of river water quality improvements | <b>Low</b> – captures the wider benefits of river water quality although does not capture customer values         |
| Consistency of track record or time series (PR14) | <b>Medium</b> – value 809% higher than PR14  | <b>Medium</b> – value 580% higher than PR14   | <b>Low</b> – value 3,500% higher than PR14  | <b>Low</b> – value 1,969% higher than PR14   | <b>Medium</b> – value 621% higher than PR14   |
| Consistency of track record or time series (PR09) | <b>High</b> – value 47% lower than PR09  | <b>High</b> – value 60% lower than PR09   | <b>Medium</b> – value 110% higher than PR09   | <b>High</b> – value 21% higher than PR09   | <b>High</b> – value 58% lower than PR09   |
| Correlation with qualitative evidence             | <b>Low</b> – top third priority (2 <sup>nd</sup> /13) compared to qualitative ranking in bottom third (8 <sup>th</sup> /10)  | <b>Low</b> – top third priority (2 <sup>nd</sup> /13) compared to qualitative ranking in bottom third (8 <sup>th</sup> /10)   | n/a   | <b>Low</b> – top third priority (2 <sup>nd</sup> /13) compared to qualitative ranking in bottom third (8 <sup>th</sup> /10)                                | n/a   |
| Implication of using this value (household)       | Robust value, poorly aligned with qualitative preferences, would lead to CBA and ODI results somewhat higher than PR14 and slightly lower than PR09  | Robust value, poorly aligned with qualitative preferences, would lead to CBA and ODI results somewhat higher than PR14 and slightly lower than PR09   | Robust value, would lead to CBA and ODI results significantly higher than PR14 and somewhat higher than PR09              | Robust value, poorly aligned with qualitative preferences, would lead to CBA and ODI results significantly higher than PR14 and slightly higher than PR09  | Low robustness of value, would lead to CBA and ODI results somewhat higher than PR14 and slightly lower than PR09 |
| <b>Recommended value</b>                          | <i>There are a range of sources of data for this service measure, each of which is likely to captured different aspects of value. However, it is considered that the most robust and complete value is the one from the Visitor Survey which brings together both stated and Revealed Preference techniques to provide an estimate of the value.</i> |   |   |  |   |



**Table 45. Triangulation process for river water quality (business)**

| Factor  | First Round SP (linear)   | First Round SP (non-linear +1)  | Benefits Transfer   |
|---|---|---|---|
| Value   | £1.67 per % / customer  | £1.71 per % / customer  | £0.8m per % or £0.35 per % / customer   |
| Statistical robustness                            | <b>High</b> – based on sample of 500 businesses   | <b>High</b> – based on sample of 500 businesses   | <b>Low</b> – based on secondary sources from the literature   |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | n/a   |
| Completeness of value                             | <b>Medium</b> – customer value captured although potentially misses out on the wider environmental and social benefits of river water quality improvements  | <b>Low</b> – customer value mostly captured although misses difference for larger changes, also potentially misses out on the wider environmental and social benefits of river water quality improvements | <b>Low</b> – captures the wider benefits of river water quality although does not capture customer values         |
| Consistency of track record or time series (PR14) | <b>Medium</b> – value 787% higher than PR14   | <b>Medium</b> – value 810% higher than PR14   | <b>High</b> – value 87% higher than PR14  |
| Consistency of track record or time series (PR09) | <b>High</b> – value 28% lower than PR09   | <b>High</b> – value 26% lower than PR09   | <b>High</b> – value 85% lower than PR09   |
| Correlation with qualitative evidence             | <b>Low</b> – top third priority (2 <sup>nd</sup> /13) compared to qualitative ranking in bottom third (8 <sup>th</sup> /10)   | <b>Low</b> – top third priority (2 <sup>nd</sup> /13) compared to qualitative ranking in bottom third (8 <sup>th</sup> /10)   | n/a   |
| Implication of using this value (household)       | Robust value, poorly aligned with qualitative preferences, would lead to CBA and ODI results somewhat higher than PR14 and slightly lower than PR09   | Robust value, poorly aligned with qualitative preferences, would lead to CBA and ODI results somewhat higher than PR14 and slightly lower than PR09   | Low robustness of value, would lead to CBA and ODI results slightly higher than PR14 and slightly lower than PR09 |
| <b>Recommended value</b>                          | <i>The customer values are broadly similar and provide robust estimates. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The Benefits Transfer value captures an additional aspect of value although there is significant potential for double counting and has limited robustness. The recommended approach is to use the First Round SP (linear) value.</i> |   |   |

### Recommended values

A summary of the recommended values is set out in Table 46. The aggregate total is the sum of the aggregate values for each of Households, Use values and Non-use values where the aggregate values are the individual values multiplied by either the total number of YWS business or household customers. The aggregate use and non-use values were calculated using the total number of household customers.

**Table 46. Recommended individual and aggregate values for river water quality**

| Service measure     | Unit        | Use values | Non-use values | Businesses | Aggregate Total      |
|---------------------|-------------|------------|----------------|------------|----------------------|
| River water quality | £%/customer | £0.13      | £1.62          | £1.67      | <b>£3,987,849.73</b> |

# No 11. Pollution Incidents

## Data sources

Estimates of the value YWS customers place on reducing the number of pollution incidents were obtained from the methods and data sources set out in Table 47.

**Table 47. Data sources available for pollution incidents**

| 1 <sup>st</sup> Round Stated Preference | 2 <sup>nd</sup> Round Stated Preference | Revealed Preference Visitor | Revealed Preference Business | Behavioural Experiment | Trust Experiment | PR14 Values | PR09 Values | Benefits Transfer |
|---|---|-----------------------------|------------------------------|------------------------|------------------|-------------|-------------|-------------------|
| ✓                                       | ✓                                       | ✗                           | ✓                            | ✓                      | ✓                | ✓           | ✓           | ✗                 |

## Results

On the basis of the linear model, the results of the First Round Stated Preference (SP) survey in Work Package 1 suggest that YWS household customers are willing to pay £0.056 per year to reduce the number of Category 3 pollution incidents by one incident. This was broken down into a ‘use’ value of £0.038 (primarily related to direct use of the water environment such as through recreation although also indirect use such as by benefiting from the regulation of the global climate and option value in terms of future potential uses) and a ‘non-use’ value of £0.017 (related to bequest value e.g. so that future generations can enjoy the environment and existence value e.g. because the environment is valuable in its own right). By contrast, business customers are willing to pay £0.20.

The non-linear model estimated that household customers are willing to pay £0.033 per incident and business customers £0.18 for a one unit improvement.

The results of the Second Round SP survey suggest that, in terms of severity levels, the WTP for household and business customers for a one unit improvement in pollution incidents are as follows (note this work package estimated odds ratios which were then applied to the linear model results from Work Package 1):

- Category 1 = £0.18 and £0.64 per incident
- Category 2 = £0.12 and £0.42 per incident
- Category 3 = £0.056 and £0.20 per incident
- Category 4 = £0.024 and £0.086 per incident

The Revealed Preference (RP) Business Survey estimated that YWS business customers spend a median value of £5.76 per business per year to deal with pollution incidents (the survey did not distinguish between types of incident). The survey recorded an average number of 12 pollution incidents reported each year by respondents giving a median value of £0.49 per business impacted. However, it is also noted that these estimates are distorted by the monitoring costs provided by one company of £17,000; excluding this respondent from the sample provides a median estimate of £0.038 per business. Given the small sample size of businesses actually engaging in avertive behaviour and the impact of outliers on the results it is considered the median value is more appropriate for use than the mean.

The Behavioural Experiment estimated that YWS household customers are willing to increase their annual water bills by £0.032 for every reduction in Category 3 pollution incidents.

The Trust Experiment estimated that the average cost incurred in terms of reduced bill payments following a pollution incident is £28.00 per customer affected. Note that this estimate is not directly equivalent to those obtained from the SP and RP surveys or the Behavioural Experiment as it represents a direct cost to YWS which reflects a cost, or loss of welfare, incurred by the customer. Dividing by the total customer base to provide a comparison against the other value sets gives a value of £0.000012 per customer. However, the estimate from the Trust Experiment needs to be treated with caution as there may be a number of other confounding factors (not explored in this project) that affect customers' propensity to pay, as well as changes in this value over time (i.e. it may not be that the propensity to refuse to pay continues over time).

The SP surveys undertaken for PR14 estimated the amount YWS households and businesses would be willing to pay to reduce the number of pollution incidents at £0.13 and £0.67 respectively. Note, the units used in PR14 are not directly comparable with those used in PR19.

The SP surveys undertaken for PR09 estimated the amount YWS households and businesses would be willing to pay to reduce the number of pollution incidents at £0.039 and £0.14 respectively. Note, the units used in PR09 are not directly comparable with those used in PR19.

A comparison of these values is set out in Figure 25 and Figure 26. Note that, due to differences in units across data sources the figures are illustrative of the range of values. Also note that, the values for Work Package 2 are presented alongside the other values, these demonstrate the range in WTP estimates for different severity levels within the same service measure and so are not directly comparable to the other estimates.

## Triangulation

The data from the work packages were then compared using the triangulation method set out in Table 6. Note that the values from Work Package 2 were not included in the triangulation process as the outputs from this work package were odds ratios rather than value estimates. Instead, the outputs from Work Package 2 were applied to the final value selected through the triangulation exercise to estimate the values for each of the severity levels. The values for PR14 and PR09 were included for comparative purposes only, rather than as values to be put forward for use in the DMF.

The results of the triangulation process are set out in Table 48 and Table 49.

Figure 25. Illustrative comparison of values for pollution incidents (household)

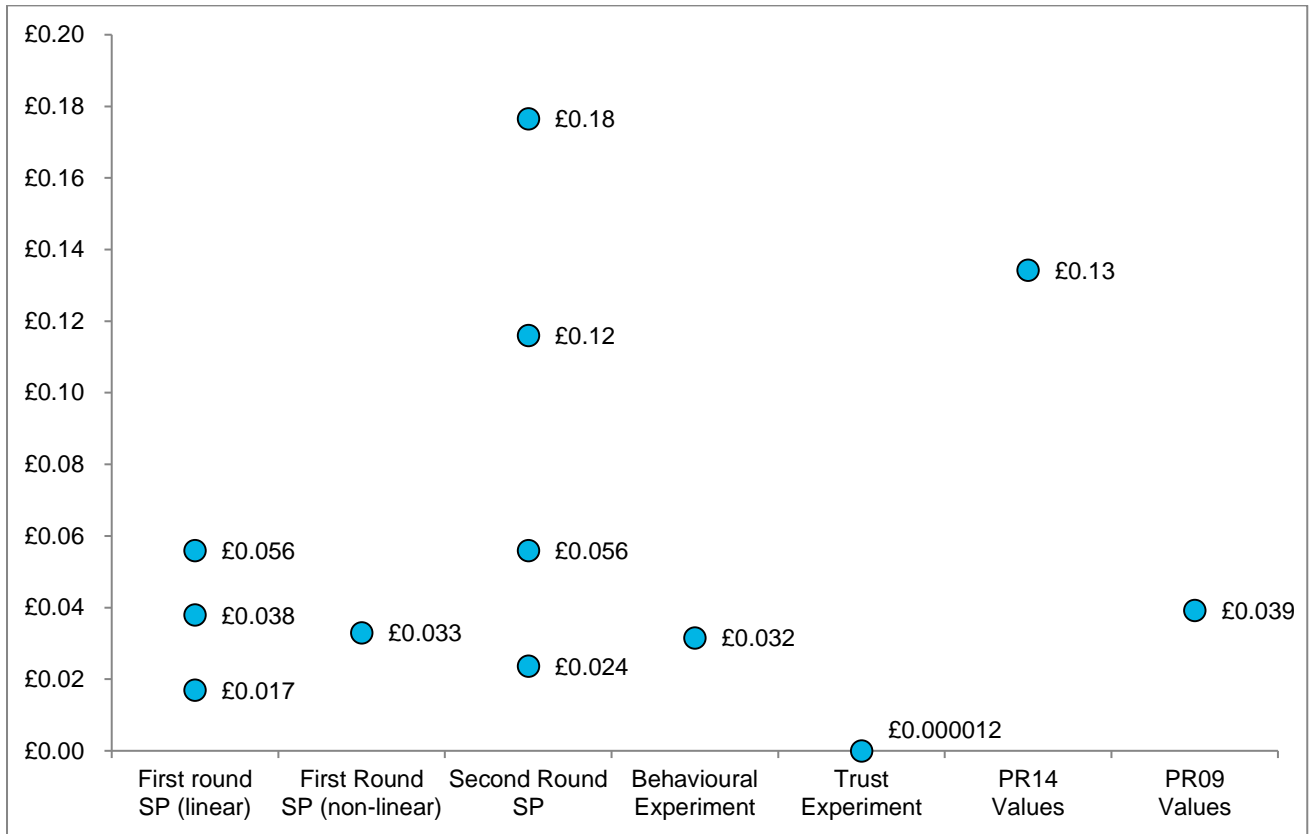
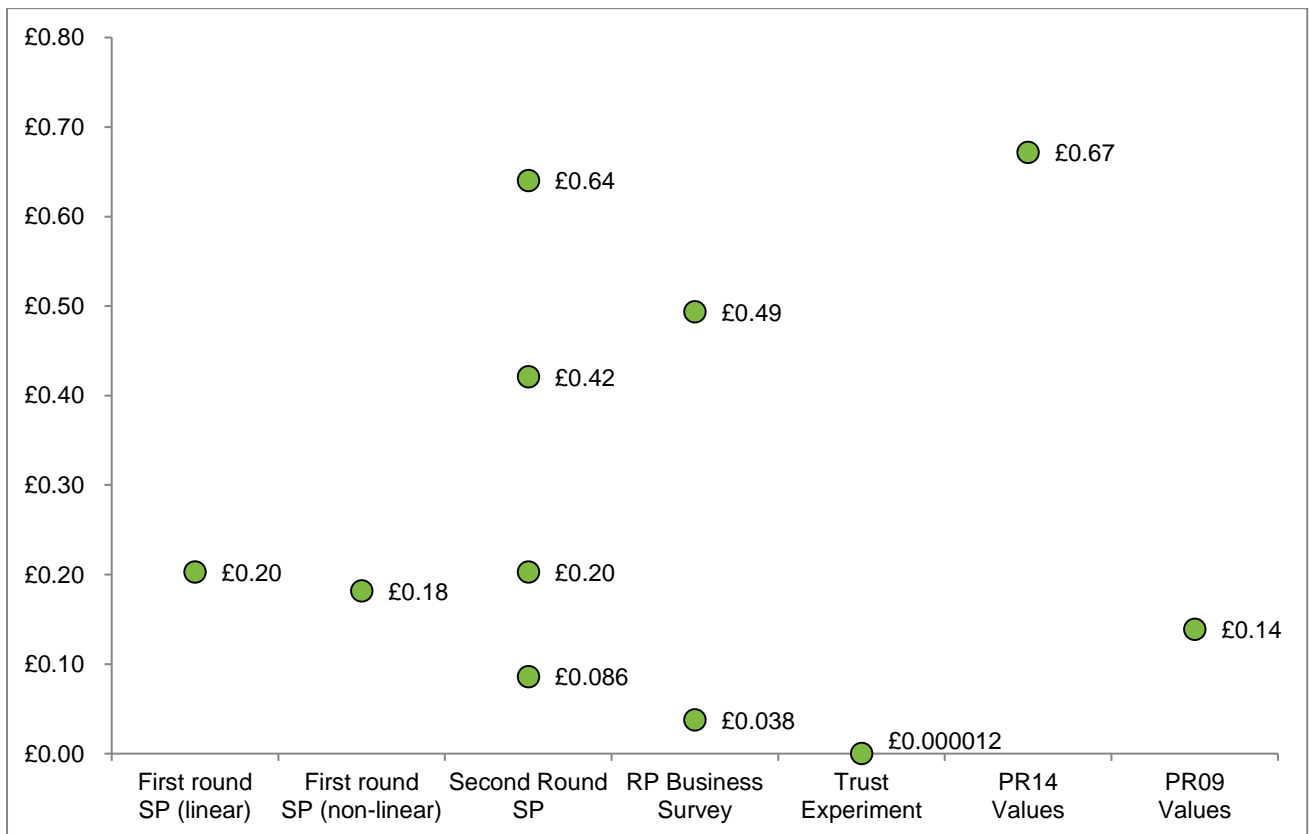


Figure 26. Illustrative comparison of values for pollution incidents (business)



**Table 48. Triangulation process for pollution incidents (household)**

| Factor  | First Round SP (linear)  | First Round SP (non-linear +1)  | Behavioural Experiment  | Trust Experiment  |
|---|--|---|---|---|
| Value (use)                                       | £0.038 per incident  | £0.033 per incident   | £0.032 per incident   | £28.00 per incident or £0.000012 per incident/customer  |
| Value (non-use)                                   | £0.017 per incident  |   |   |   |
| Statistical robustness                            | <b>High</b> – based on sample of 1,000 households  | <b>High</b> – based on sample of 1,000 households   | <b>Very High</b> – based on sample of 2,000 households  | <b>Low</b> – based on sample of 62,000 customers although significant caveats on robustness of analysis                     |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.  | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>High</b> – based on observed choices in “real life” situations   |
| Completeness of value                             | <b>Medium</b> – customer value mostly captured although potentially misses out on the trust component  | <b>Low</b> – customer value mostly captured although misses difference for larger changes and potentially misses out on the trust component | <b>Medium</b> – customer value mostly captured although potentially misses out on the trust component                     | <b>Low</b> – doesn’t capture entire customer value but does capture trust component   |
| Consistency of track record or time series (PR14) | <b>High</b> – value 58% lower than PR14  | <b>High</b> – value 75% lower than PR14   | <b>High</b> – value 76% lower than PR14   | <b>High</b> – value 100% lower than PR14  |
| Consistency of track record or time series (PR09) | <b>High</b> – value 43% higher than PR09   | <b>High</b> – value 16% lower than PR09   | <b>High</b> – value 19% lower than PR09   | <b>High</b> – value 100% lower than PR09  |
| Correlation with qualitative evidence             | <b>High</b> – mid third priority (6 <sup>th</sup> /13) compared to qualitative ranking in mid third (7 <sup>th</sup> /10)  | <b>High</b> – mid third priority (6 <sup>th</sup> /13) compared to qualitative ranking in mid third (7 <sup>th</sup> /10)                   | <b>High</b> – mid third priority (6 <sup>th</sup> /13) compared to qualitative ranking in mid third (7 <sup>th</sup> /10) | <b>Medium</b> – bottom priority (6 <sup>th</sup> /6) compared to qualitative ranking in mid third (7 <sup>th</sup> /10)     |
| Implication of using this value (household)       | Robust value, aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14 and higher than PR09  | Robust value, aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14 and PR09                     | Robust value, aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14 and PR09   | Less robust value although captures value associated with trust unlikely to be captured in customer valuation or in PR14/09 |
| <b>Recommended value</b>                          | <i>All three of the customer values are broadly comparable and provide robust estimates, which are similar to those of PR14 and PR09. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The Trust Experiment captures an additional aspect of value that may be missing from the customer valuation estimates. It is possible that there would be some double counting by including this value alongside the customer values although the likelihood is considered to be low. The recommended approach is therefore to take an average of the First Round SP (linear) and Behavioural Experiment values (split by use and non-use values) plus the Trust Experiment value.</i> |   |   |   |

**Table 49. Triangulation process for pollution incidents (business)**

| Factor  | First Round SP (linear)   | First Round SP (non-linear +1)   | Business Survey (median)   | Business Survey (median ex. outliers)  | Trust Experiment  |
|---|---|--|--|--|---|
| Value   | £0.20 per incident  | £0.18 per incident   | £0.49 per business   | £0.038 per business  | £28.00 per incident or £0.000012 per incident/customer  |
| Statistical robustness                            | <b>High</b> – based on sample of 500 businesses   | <b>High</b> – based on sample of 500 businesses  | <b>Medium</b> – based on sample of 1,000 businesses although only 3 involved in avertive behaviour   | <b>Medium</b> – based on sample of 1,000 businesses although only 3 involved in avertive behaviour and 1 excluded  | <b>Low</b> – based on sample of 62,000 customers although significant caveats on robustness of analysis                     |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.  | <b>High</b> – based on actual expenditure decisions  | <b>High</b> – based on actual expenditure decisions  | <b>High</b> – based on observed choices in “real life” situations   |
| Completeness of value                             | <b>Medium</b> – customer value mostly captured although potentially misses out on the trust component   | <b>Low</b> – customer value mostly captured although misses difference for larger changes and potentially misses out on the trust component  | <b>Low</b> – focuses on actual expenditure so likely to be a lower bound value (assuming value exceeds expenditure and consumer surplus is not captured) | <b>Low</b> – focuses on actual expenditure so likely to be a lower bound value (assuming value exceeds expenditure and consumer surplus is not captured) | <b>Low</b> – doesn’t capture entire customer value but does capture trust component   |
| Consistency of track record or time series (PR14) | <b>High</b> – value 70% lower than PR14   | <b>High</b> – value 73% lower than PR14  | <b>High</b> – value 27% lower than PR14  | <b>High</b> – value 94% lower than PR14  | <b>High</b> – value 100% lower than PR14  |
| Consistency of track record or time series (PR09) | <b>High</b> – value 46% higher than PR09  | <b>High</b> – value 31% higher than PR09   | <b>Medium</b> – value 256% higher than PR09  | <b>High</b> – value 73% lower than PR09  | <b>High</b> – value 100% lower than PR09  |
| Correlation with qualitative evidence             | <b>High</b> – mid third priority (5 <sup>th</sup> /13) compared to qualitative ranking in mid third (7 <sup>th</sup> /10)   | <b>High</b> – mid third priority (5 <sup>th</sup> /13) compared to qualitative ranking in mid third (7 <sup>th</sup> /10)                    | <b>High</b> – mid third priority (4 <sup>th</sup> /7) compared to qualitative ranking in mid third (7 <sup>th</sup> /10)                                 | <b>High</b> – mid third priority (5 <sup>th</sup> /7) compared to qualitative ranking in mid third (7 <sup>th</sup> /10)                                 | <b>Medium</b> – bottom priority (6 <sup>th</sup> /6) compared to qualitative ranking in mid third (7 <sup>th</sup> /10)     |
| Implication of using this value (household)       | Robust value, aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14 and slightly higher than PR09  | Robust value, aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14 and slightly higher than PR09 | Medium robustness, aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14 and somewhat higher than PR09        | Medium robustness, aligned with qualitative preferences, would lead to CBA and ODI results slightly lower than PR14/09                                   | Less robust value although captures value associated with trust unlikely to be captured in customer valuation or in PR14/09 |
| <b>Recommended value</b>                          | <p><i>It is difficult to determine which of the Business Survey values is most appropriate. Given the closer alignment to the PR14 and the wider sample size it is recommended that the full sample estimate is used. All of the remaining customer values are broadly comparable and provide reasonably robust estimates which are similar to those of PR14 and PR09. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The Trust Experiment captures an additional aspect of value that may be missing from the customer valuation estimates. It is possible that there would be some double counting by including this value alongside the customer values although the likelihood is considered to be low. The recommended approach is therefore to take an average of the First Round SP (linear) and Business Survey (median) values plus the Trust Experiment value.</i></p> |  |  |  |   |

## Recommended values

A summary of the recommended values is set out in Table 50. The aggregate total is the sum of the aggregate values for each of Households, Use values and Non-use values where the aggregate values are the individual values multiplied by either the total number of YWS business or household customers. The aggregate use and non-use values were calculated using the total number of household customers.

**Table 50. Recommended individual and aggregate values for pollution incidents**

| Service measure | Unit                | Use values | Non-use values | Businesses | Trust     | Aggregate Total    |
|-----------------|---------------------|------------|----------------|------------|-----------|--------------------|
| Category 1      | £/incident/customer | £0.094     | £0.042         | £1.10      | £0.000012 | <b>£468,870.30</b> |
| Category 2      | £/incident/customer | £0.062     | £0.028         | £0.72      | £0.000012 | <b>£308,277.32</b> |
| Category 3      | £/incident/customer | £0.030     | £0.013         | £0.35      | £0.000012 | <b>£148,725.21</b> |
| Category 4      | £/incident/customer | £0.013     | £0.006         | £0.148     | £0.000012 | <b>£63,075.62</b>  |



## No 12. Odour

### Data sources

Estimates of the value YWS customers place on reducing the number of complaints about odour issues were obtained from the methods and data sources set out in Table 51.

**Table 51. Data sources available for odour**

| 1 <sup>st</sup> Round Stated Preference | 2 <sup>nd</sup> Round Stated Preference | Revealed Preference Visitor | Revealed Preference Business | Behavioural Experiment | Trust Experiment | PR14 Values | PR09 Values | Benefits Transfer |
|---|---|-----------------------------|------------------------------|------------------------|------------------|-------------|-------------|-------------------|
| ✓                                       | ✓                                       | ✗                           | ✗                            | ✓                      | ✗                | ✓           | ✓           | ✗                 |

### Results

On the basis of the linear model, the results of the First Round Stated Preference (SP) survey in Work Package 1 suggest that YWS household customers are willing to pay £0.00058 per year to reduce the number of complaints about odour by one complaint, while business customers are willing to pay £0.0015.

By contrast, the non-linear model estimated that household customers are willing to pay £0.00040 per property and business customers £0.0013 for a one unit improvement.

The results of the Second Round SP survey suggest that, in terms of severity levels, the WTP for household and business customers for a one unit improvement odour are as follows (note this work package estimated odds ratios which were then applied to the linear model results from Work Package 1):

- Chronic odour = £0.00058 and £0.0015 per complaint
- Transient odour = £0.00082 and £0.0021 per complaint

The Behavioural Experiment estimated that YWS household customers are willing to increase their annual water bills by £0.00043 for reduction in complaints about odour.

The SP surveys undertaken for PR14 estimated the amount YWS households and businesses would be willing to pay to reduce odour issues at £0.0025 and £0.014 respectively. Note, the units used in PR14 are not directly comparable with those used in PR19.

The SP surveys undertaken for PR09 estimated the amount YWS households and businesses would be willing to pay to reduce odour issues at £0.0012 and £0.045 respectively. Note, the units used in PR09 are not directly comparable with those used in PR19.

A comparison of these values is set out in Figure 27 and Figure 28. Note that, due to differences in units across data sources the figures are illustrative of the range of values. Also note that, the values for Work Package 2 are presented alongside the other values, these demonstrate the range in WTP estimates for different severity levels within the same service measure and so are not directly comparable to the other estimates.

## Triangulation

The data from the work packages were then compared using the triangulation method set out in Table 6. Note that the values from Work Package 2 were not included in the triangulation process as the outputs from this work package were odds ratios rather than value estimates. Instead, the outputs from Work Package 2 were applied to the final value selected through the triangulation exercise to estimate the values for each of the severity levels. The values for PR14 and PR09 were included for comparative purposes only, rather than as values to be put forward for use in the DMF.

The results of the triangulation process are set out in Table 52 and Table 53.

Figure 27. Illustrative comparison of values for odour (household)

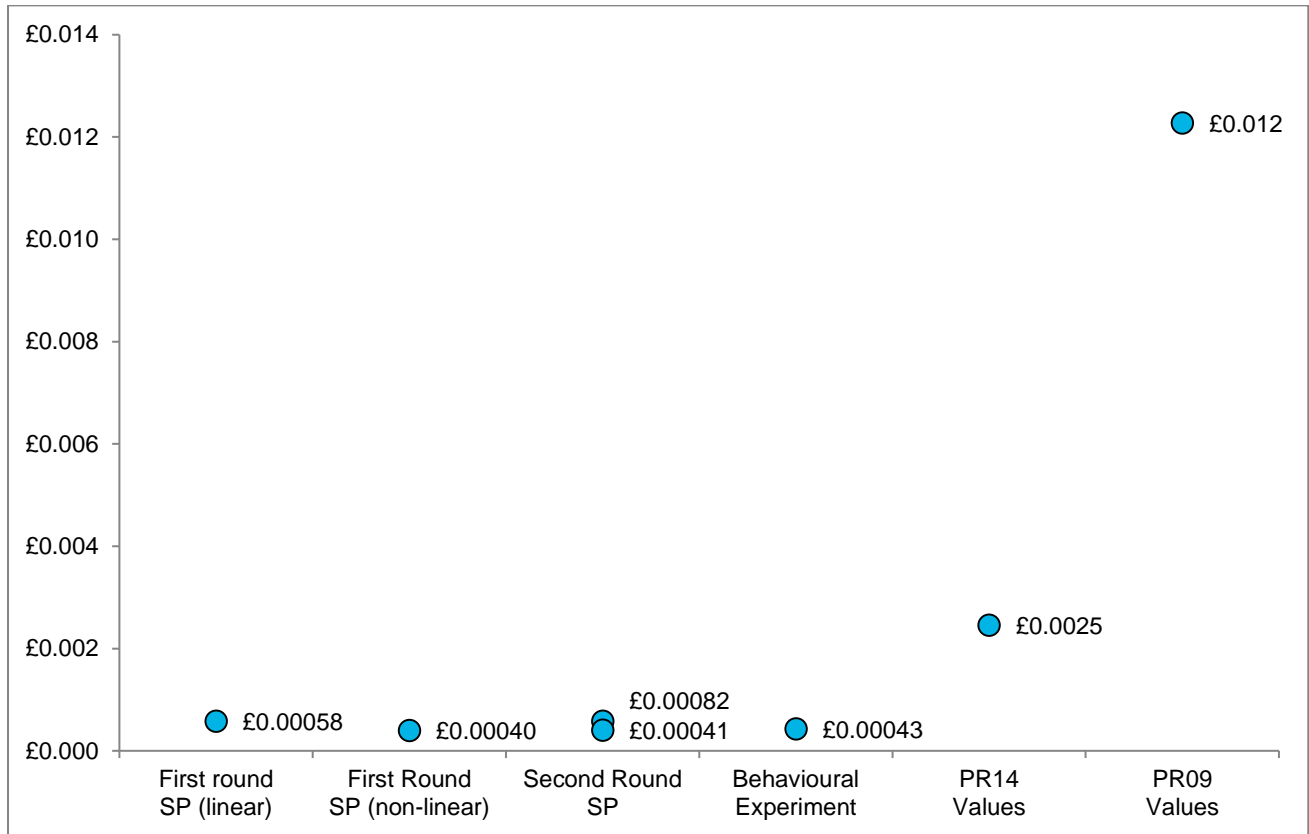
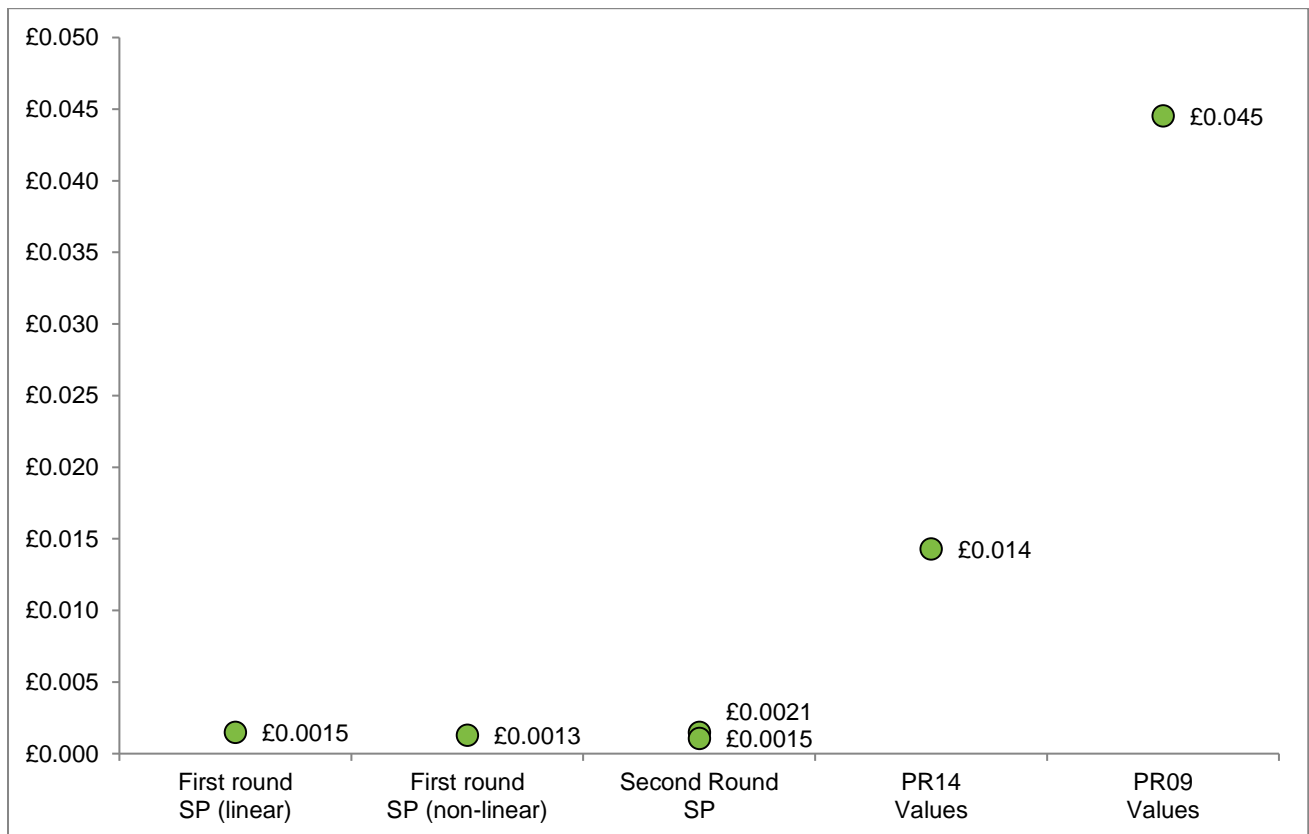


Figure 28. Illustrative comparison of values for odour (business)



**Table 52. Triangulation process for odour (household)**

| Factor  | First Round SP (linear)   | First Round SP (non-linear +1)   | Behavioural Experiment  |
|---|---|--|---|
| Value   | £0.00058 per complaint  | £0.00040 per complaint   | £0.00043 per complaint  |
| Statistical robustness                            | <b>High</b> – based on sample of 1,000 households   | <b>High</b> – based on sample of 1,000 households  | <b>Very High</b> – based on sample of 2,000 households                            |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.            | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc. |
| Completeness of value                             | <b>High</b> – customer value completely captured  | <b>Medium</b> – customer value mostly captured although misses difference for larger changes | <b>High</b> – customer value completely captured                                  |
| Consistency of track record or time series (PR14) | <b>High</b> – value 76% lower than PR14   | <b>High</b> – value 84% lower than PR14  | <b>High</b> – value 83% lower than PR14   |
| Consistency of track record or time series (PR09) | <b>High</b> – value 95% lower than PR09   | <b>High</b> – value 97% lower than PR09  | <b>High</b> – value 96% lower than PR09   |
| Correlation with qualitative evidence             | <i>No qualitative data available for odour</i>  | <i>No qualitative data available for odour</i>   | <i>No qualitative data available for odour</i>                                    |
| Implication of using this value (household)       | Robust value, would lead to CBA and ODI results slightly lower than PR14/09   | Robust value, would lead to CBA and ODI results slightly lower than PR14/09                  | Robust value, would lead to CBA and ODI results slightly lower than PR14/09       |
| <b>Recommended value</b>                          | <p><i>All three of the customer values are broadly comparable and provide robust estimates, which are similar to those of PR14 and PR09. Of the two Stated Preference estimates, the non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The recommended approach is therefore to take an average of the First Round SP (linear) and Behavioural Experiment values.</i></p> |  |   |

**Table 53. Triangulation process for odour (business)**

| Factor  | First Round SP (linear)   | First Round SP (non-linear +1)   |
|---|---|--|
| Value   | £0.0015 per complaint   | £0.0013 per complaint  |
| Statistical robustness                            | <b>High</b> – based on sample of 500 businesses   | <b>High</b> – based on sample of 500 businesses  |
| Psychological robustness                          | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.   | <b>Medium</b> – answers likely to be affected by loss aversion, social norms etc.            |
| Completeness of value                             | <b>High</b> – customer value completely captured  | <b>Medium</b> – customer value mostly captured although misses difference for larger changes |
| Consistency of track record or time series (PR14) | <b>High</b> – value 90% lower than PR14   | <b>High</b> – value 91% lower than PR14  |
| Consistency of track record or time series (PR09) | <b>High</b> – value 97% lower than PR09   | <b>High</b> – value 97% lower than PR09  |
| Correlation with qualitative evidence             | <i>No qualitative data available for odour</i>  | <i>No qualitative data available for odour</i>   |
| Implication of using this value (household)       | Robust value, would lead to CBA and ODI results slightly lower than PR14/09   | Robust value, would lead to CBA and ODI results slightly lower than PR14/09                  |
| <b>Recommended value</b>                          | <i>The two values are broadly similar and provide robust estimates, although lower than both PR14 and PR09. The non-linear value may miss out on some of the differences for larger changes as it only captures the +1 change from the baseline whereas the linear estimate captures a -2, -1,+1,+2 change from the baseline. The recommended approach is therefore to use the First Round SP (linear) value.</i> |  |

## Recommended values

A summary of the recommended values is set out in Table 54. The aggregate total is the sum of the aggregate values for each of Households and Businesses where the aggregate values are the individual values for Households and Businesses multiplied by the total number of YWS household and business customers respectively.

**Table 54. Recommended individual and aggregate values for odour**

| Service measure | Unit                 | Households | Businesses | Aggregate Total  |
|-----------------|----------------------|------------|------------|------------------|
| Chronic         | £/complaint/customer | £0.00071   | £0.00212   | <b>£1,926.88</b> |
| Transient       | £/complaint/customer | £0.00051   | £0.00150   | <b>£1,361.76</b> |

## No 13. Land Improved

### Data sources

Estimates of the value YWS customers place on land being conserved or improved by YWS were obtained from the methods and data sources set out in Table 55.

**Table 55. Data sources available for land improved**

| 1 <sup>st</sup> Round Stated Preference | 2 <sup>nd</sup> Round Stated Preference | Revealed Preference Visitor | Revealed Preference Business | Behavioural Experiment | Trust Experiment | PR14 Values | PR09 Values | Benefits Transfer |
|---|---|-----------------------------|------------------------------|------------------------|------------------|-------------|-------------|-------------------|
| ✓                                       | ✓                                       | ✗                           | ✗                            | ✓                      | ✗                | ✗           | ✗           | ✓                 |

### Results

On the basis of the linear model, the results of the First Round Stated Preference (SP) survey in Work Package 1 suggest that YWS household customers are willing to pay £0.000093 per year to increase the area of land conserved or improved by YWS by one hectare. This was broken down into a 'use' value of £0.000063 (primarily related to direct use of the water environment such as through recreation although also indirect use such as by benefitting from the regulation of the global climate and option value in terms of future potential uses) and a 'non-use' value of £0.000028 (related to bequest value e.g. so that future generations can enjoy the environment and existence value e.g. because the environment is valuable in its own right). By contrast, business customers are willing to pay £0.00018.

The non-linear model estimated that household customers are willing to pay £0.000065 per ha and business customers £0.00012 for a one unit improvement.

The results of the Second Round SP survey suggest that, in terms of severity levels, the WTP for household and business customers respectively for a one unit increase in the area of land conserved or improved are as follows (note this work package estimated odds ratios which were then applied to the linear model results from Work Package 1):

- Coniferous woodland, broadleaved woodland, semi-natural grassland, farmland, wetlands, and

moorlands = £0.0000102 and £0.00019

- Coastal margins = £0.000080 and £0.00015
- Green space = £0.000071 and £0.00014

However, it was also noted in this Work Package that care should be taken when using the odds ratios for this service measure as the findings suggested that customers found it difficult to choose between options and a validation question suggested that customers would actually prioritise improvements to coastal areas, followed by broadleaved woodland and farmland.

The Behavioural Experiment estimated that YWS household customers are willing to increase their annual water bills by £0.000050 for every hectare of land conserved or improved.

The Benefits Transfer work undertaken as part of the DMF work stream estimated a 'use' value for a hectare of land of £3,111, this estimate was based on: crops & livestock, global climate, air quality, flood regulation, water quality regulation, pollination, amenity, and employment values. On a per customer basis (given the 2.258 million YWS customers) this would suggest a use value of around £0.0014 per hectare. Given the different ecosystem services provided, the value was broken down by habitat type as follows:

- General average = £3,111 per ha or £0,0014 per ha/customer
- Coniferous woodland = £2,817 per ha or £0.0012 per ha/customer
- Broadleaved woodland = £3,398 per ha or £0.0015 per ha/customer
- Semi-natural grassland = £1,085 per ha or £0.00048 per ha/customer
- Farmland = £1,635 per ha or £0.00072 per ha/customer
- Wetlands and floodplains = £4,254 per ha or £0.0019 per ha/customer
- Mountains, moorlands, and heaths = £1,229 per ha or £0.00054 per ha/customer
- Coastal margins = £1,619 per ha or £0.00072 per ha/customer
- Green space = £8,848 per ha or £0.0039 per ha/customer<sup>19</sup>

A comparison of these values is set out in Figure 29 and Figure 30.

Note that the values obtained from secondary data sources are consistently higher than those derived from the primary research conducted in Work Packages 1, 2 & 5. This may be due to the fact that it is challenging for customers to provide a full understanding of the value of all of the ecosystem services provided by natural habitats, particularly when some of them may not be obvious (e.g. understanding the value of air quality regulation services provided by different habitats requires specialist knowledge). As such customers may tend to understate values relative to studies which have specifically aimed to quantify the value of particular ecosystem services in more detail.

## Triangulation

The data from the work packages were then compared using the triangulation method set out in Table 6. Note that the values from Work Package 2 were not included in the triangulation process as the outputs from this work package were odds ratios rather than value estimates. Instead, the outputs from Work Package 2 were applied to the final value selected through the triangulation exercise to estimate the values for each of the severity levels.

The results of the triangulation process are set out in Table 56 and Table 57.

Figure 29. Illustrative comparison of values for land improved (household)

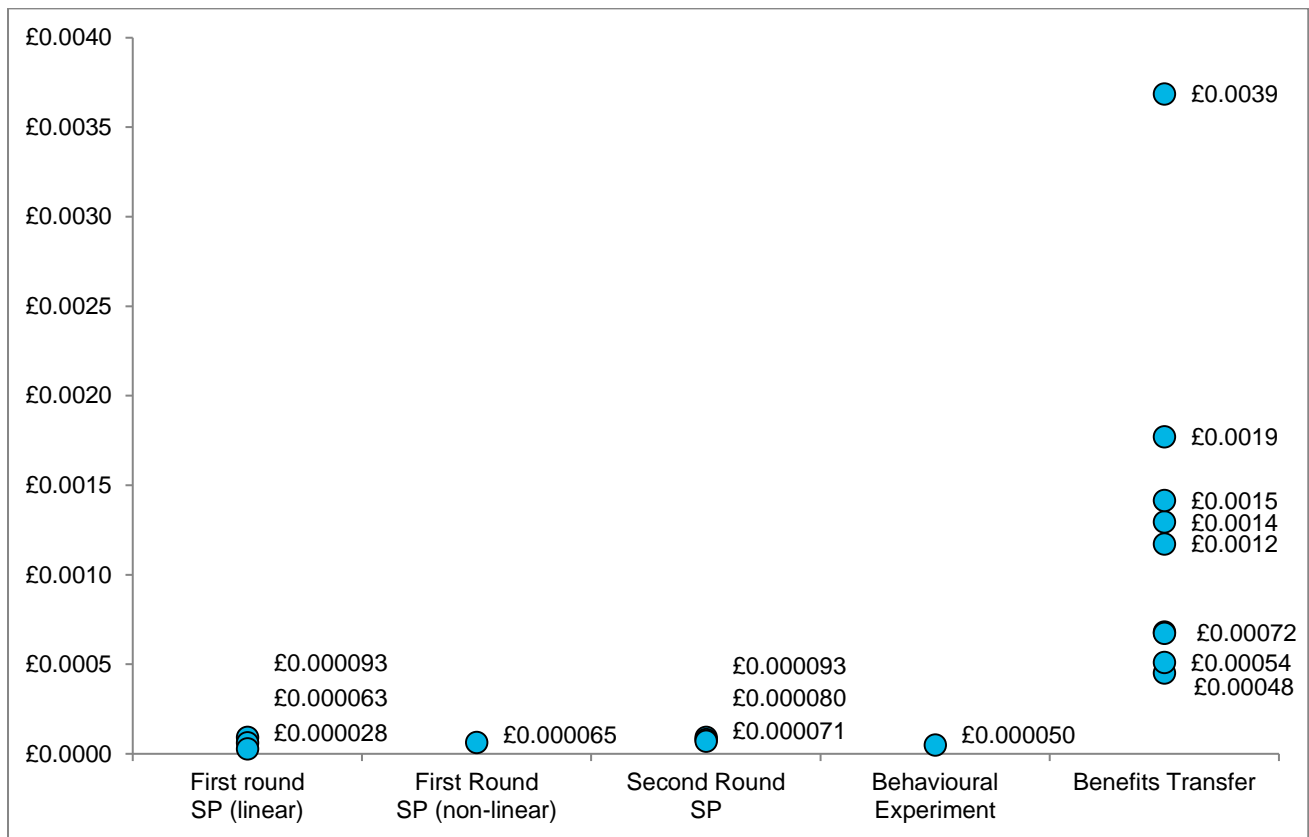
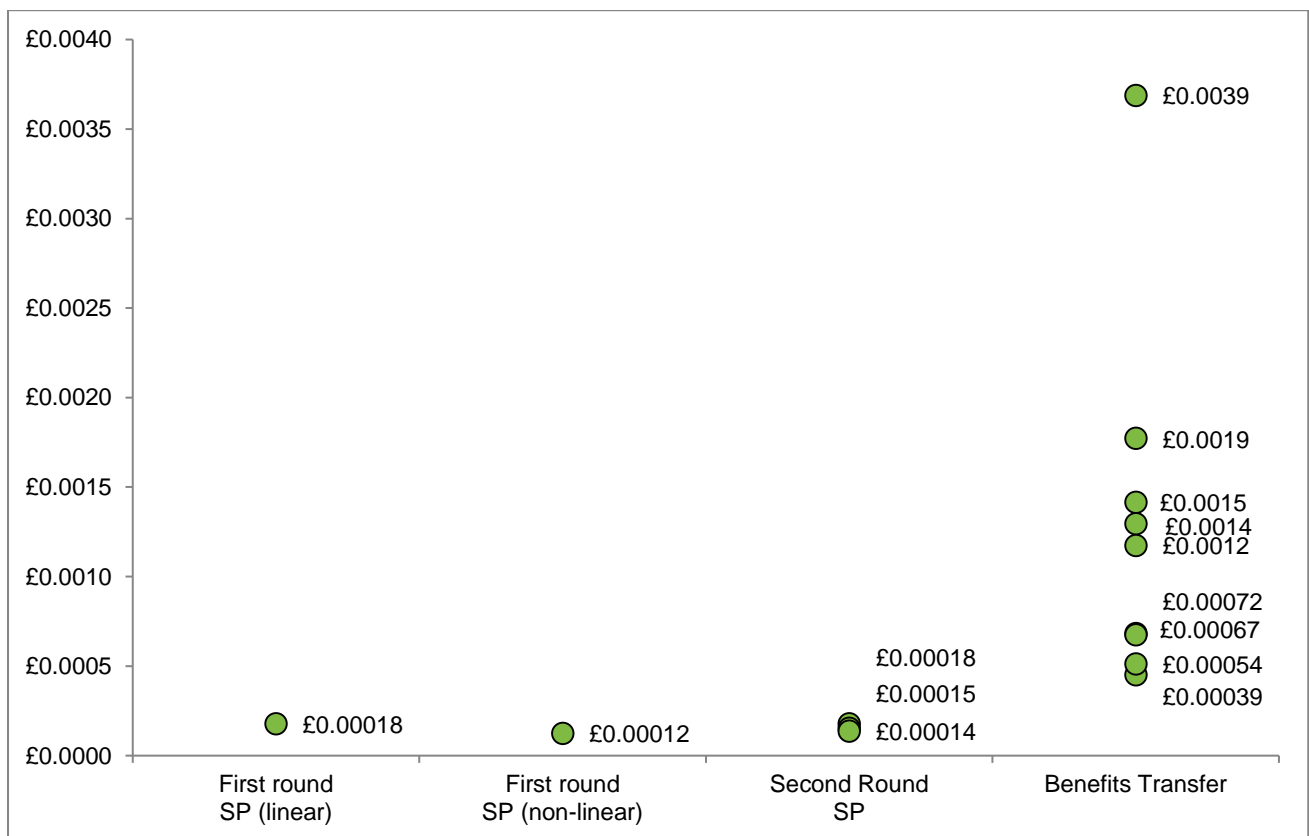


Figure 30. Illustrative comparison of values for land improved (business)





**Table 56. Triangulation process for land improved (household)**

| Factor  | First Round SP (linear)  | First Round SP (non-linear +1)   | Behavioural Experiment   | Benefits Transfer   |
|---|--|--|--|---|
| Value (use)                                       | £0.000063 per ha / customer  | £0.000065 per ha / customer  | £0.000050 per ha / customer  | £3,111 per ha or £0.0014 per ha / customer  |
| Value (non-use)                                   | £0.000028 per ha / customer  |  |  | n/a   |
| Statistical robustness                            | <b>High</b> – based on sample of 1,000 households  | <b>High</b> – based on sample of 1,000 households  | <b>Very High</b> – based on sample of 2,000 households   | <b>Medium</b> – based on well-established sources from the literature   |
| Psychological robustness                          | <b>Low</b> – answers likely to be affected by loss aversion, social norms etc., customers found it challenging to make the valuation decisions   | <b>Low</b> – answers likely to be affected by loss aversion, social norms etc., customers found it challenging to make the valuation decisions   | <b>Low</b> – answers likely to be affected by loss aversion, social norms etc., customers found it challenging to make the valuation decisions | n/a   |
| Completeness of value                             | <b>Medium</b> – customer value captured although potentially misses out on the wider environmental and social benefits of land conservation  | <b>Low</b> – customer value mostly captured although misses difference for larger changes and potentially misses out on the wider environmental and social benefits of land conservation | <b>Medium</b> – customer value captured although potentially misses out on the wider environmental and social benefits of land conservation    | <b>Medium</b> – captures the wider benefits of land conservation although may not fully capture customer values |
| Consistency of track record or time series (PR14) | <i>No PR14 data available for land improvement</i>   | <i>No PR14 data available for land improvement</i>   | <i>No PR14 data available for land improvement</i>   | <i>No PR14 data available for land improvement</i>  |
| Consistency of track record or time series (PR09) | <i>No PR09 data available for land improvement</i>   | <i>No PR09 data available for land improvement</i>   | <i>No PR09 data available for land improvement</i>   | <i>No PR09 data available for land improvement</i>  |
| Correlation with qualitative evidence             | <i>No qualitative data available for land improvement</i>  | <i>No qualitative data available for land improvement</i>  | <i>No qualitative data available for land improvement</i>  | <i>No qualitative data available for land improvement</i>   |
| Implication of using this value (household)       | <i>No qualitative or PR14/09 data to compare to</i>  | <i>No qualitative or PR14/09 data to compare to</i>  | <i>No qualitative or PR14/09 data to compare to</i>  | <i>No qualitative or PR14/09 data to compare to</i>   |
| <b>Recommended value</b>                          | <p><i>For this service measure it is difficult to explain the differences in the value estimates and there is little previous or qualitative data against which to compare the value estimates. On balance it is considered that, since customers found it challenging to value this service measure, and the Benefits Transfer data is based on well-established approaches to quantifying value, the Benefits Transfer estimates may be most appropriate. Using these values would also provide a more detailed breakdown of the particular ecosystem services impacted as well as in terms of prioritising which land to conserve or improve.</i></p> <p><i>It could be argued that the non-use component of the customer value could be added to the Benefits Transfer value (as this only captures use value) although this is not recommended due to the challenges of disaggregating value by habitat type from the customer data and the fact that the Benefits Transfer value is already considerably higher than the customer values.</i></p> <p><i>While it could be argued that this is overstating the value customers are willing to pay it is likely that it is challenging for customers to provide a full understanding of the value of all of the ecosystem services provided by natural habitats and so may tend to understate the value.</i></p> |  |  |   |

**Table 57. Triangulation process for land improved (business)**

| Factor  | First Round SP (linear)  | First Round SP (non-linear +1)   | Benefits Transfer   |
|---|--|--|---|
| Value (use)                                       | £0.00018 per ha / customer   | £0.00012 per ha / customer   | £3,111 per ha or £0.0014 per ha / customer  |
| Statistical robustness                            | <b>High</b> – based on sample of 1,000 households  | <b>High</b> – based on sample of 1,000 households  | <b>Medium</b> – based on well-established sources from the literature   |
| Psychological robustness                          | <b>Low</b> – answers likely to be affected by loss aversion, social norms etc., customers found it challenging to make the valuation decisions | <b>Low</b> – answers likely to be affected by loss aversion, social norms etc., customers found it challenging to make the valuation decisions   | n/a   |
| Completeness of value                             | <b>Medium</b> – customer value captured although potentially misses out on the wider environmental and social benefits of land conservation    | <b>Low</b> – customer value mostly captured although misses difference for larger changes, also potentially misses out on the wider environmental and social benefits of land conservation | <b>Medium</b> – captures the wider benefits of land conservation although may not fully capture customer values |
| Consistency of track record or time series (PR14) | <i>No PR14 data available for land improvement</i>   | <i>No PR14 data available for land improvement</i>   | <i>No PR14 data available for land improvement</i>  |
| Consistency of track record or time series (PR09) | <i>No PR09 data available for land improvement</i>   | <i>No PR09 data available for land improvement</i>   | <i>No PR09 data available for land improvement</i>  |
| Correlation with qualitative evidence             | <i>No qualitative data available for land improvement</i>  | <i>No qualitative data available for land improvement</i>  | <i>No qualitative data available for land improvement</i>   |
| Implication of using this value (household)       | <i>No qualitative or PR14/09 data to compare to</i>  | <i>No qualitative or PR14/09 data to compare to</i>  | <i>No qualitative or PR14/09 data to compare to</i>   |
| <b>Recommended value</b>                          | <i>As set out above, it is recommended that the Benefits Transfer estimates may be most appropriate.</i>                                       |  |   |

### Recommended values

A summary of the recommended values is set out in Table 58. The aggregate weighted total is the weighted sum of the aggregate values for each of Households and Businesses where the aggregate values are the marginal values for Households and Businesses multiplied by the total number of YWS household and business customers respectively and weighted according to the proportion of the total YWS customer base that each of household and business customers represent.

**Table 58. Recommended individual and aggregate values for land improved**

| Service measure                  | Unit          | Use values | Aggregate Total  |
|----------------------------------|---------------|------------|------------------|
| General land                     | £/ha/customer | £0.0014    | <b>£3,110.74</b> |
| Coniferous woodland              | £/ha/customer | £0.0012    | <b>£2,817.33</b> |
| Broadleaved woodland             | £/ha/customer | £0.0015    | <b>£3,397.70</b> |
| Semi-natural grassland           | £/ha/customer | £0.0005    | <b>£1,085.49</b> |
| Farmland                         | £/ha/customer | £0.0007    | <b>£1,634.94</b> |
| Wetlands and floodplains         | £/ha/customer | £0.0019    | <b>£4,254.34</b> |
| Mountains, moorlands, and heaths | £/ha/customer | £0.0005    | <b>£1,228.78</b> |
| Coastal margins                  | £/ha/customer | £0.0007    | <b>£1,619.47</b> |
| Green space                      | £/ha/customer | £0.0039    | <b>£8,847.84</b> |

