Appendix 5j: Understanding Customer Values_ Trust Experiment Report

YorkshireWater

AECOM

PR19 Understanding Customer Values: Work Package 6 – Trust Experiment

Prepared for Yorkshire Water

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Quality information

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Contents

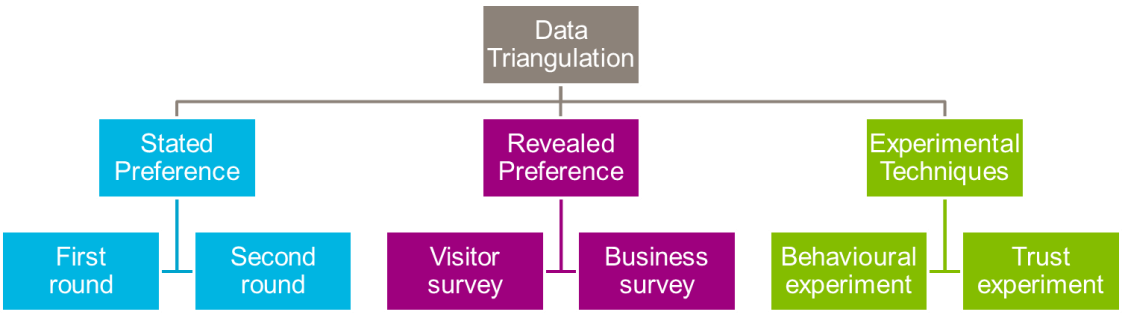
Work Package 6 – Trust Experiment

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 interruptions to supply 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



The aim of this work package is to assess the extent to which customer trust in YWS has a measurable impact on the financial performance of the business and to trial an approach (or approaches) to quantifying and valuing this. The underlying hypothesis is that service measure failures such as sewer flood events or drinking water quality failures lead to lower levels of trust in YWS amongst its customers, which in turn results in a larger number of customers refusing to pay their water bills, and thereby financial costs to YWS.

The analyses conducted here are an attempt to establish a quantifiable relationship between trust and willingness-to-pay (WTP) that will provide an important contribution to our understanding of social capital. It is nevertheless recognised that progress in this area is limited by the available data. As such, this work package is considered to be an experimental approach to understanding trust that is intended to provide a first step in developing a better understanding of trust.

Aims

The questions that this work package aims to answer are as follows: (1) What factors define trust?; (2) to what extent do different service measure failures impact levels of customer trust in YWS?; (3) Which service measures are most important in terms of determining customer trust?; (4) What impact does trust have on customers' willingness-to-pay (WTP)?; (5) Do service measure failures impact the likelihood of customers paying their water bills?; and (6) Do service measure failures mean that YWS incurs higher levels of debt?

Method

The first step in this work package was to undertake a review of the literature surrounding the measurement and valuation of trust. The main aim of the review was to identify and evaluate approaches to quantifying and valuing trust that could potentially be adapted to obtain a measure of the impact of changes in levels of customer

trust on the financial performance of YWS. The review revealed four broad potential approaches:

- Valuing trust as an attribute of customer WTP.
- Exploring trust as an incentive for customers to stay with YWS.
- Understanding trust as a factor behind decision making in a resource allocation game.
- Measuring the impact of trust on customer's payment of water bills.

The last-mentioned of these four approaches was considered to offer the most promising approach to explore as part of this work package given that: the necessary data required to undertake the analysis was likely be more readily available; the second- and third-mentioned approaches are subject to significant hypothetical bias and may not yield reliable results; and it could potentially provide useful insights beyond generating values for the use in the DMF. In particular, the approach may reveal opportunities for YWS to increase levels of trust amongst its customer base by targeted improvements in service areas, thereby improving cost recovery and reducing debt.

Figure 2 shows the assumed impact pathway (or 'logic chain') that underlies the selected methodology. This hypothesises that a service measure failure impacts on customers' trust in YWS to provide the expected level of service. This in turn impacts upon customers' propensity to pay their water bills which means that YWS is not able to recover the costs of the service provided and may incur interest charges on the debt.

Figure 2: Logic chain of assumptions underlying the methodology

YWS holds numerous datasets that were identified as being potentially useful for implementing the methodology. Based on a high-level review of these datasets, three analytical approaches were tested:

- Analysis of company-wide / aggregate data on service measure failures and payment records: the aim of this analysis was to try to establish a direct link between service measure failures and bill repayment levels (with trust assumed to be an implicit factor in customers' propensity to pay) at an aggregate or company-wide level. This analysis involved two stages: (1) establishing whether there is a link between service measure failures and the number of customers who have defaulted on payment, where defaults are assumed to be payment refusals; and (2) establishing the cost to YW as a result of customer payment refusals. The first stage comprised an analysis of YWS time series data on the number of payment refusals each year and the number service measure failures each year between 2012/13 and 2016/7. A regression analysis was then undertaken to establish if there is a quantifiable link between the two factors. The final step was then to estimate the average cost to YWS for each customer with defaulted payment status. This was done by combining information on the average water bills of customers who refuse to pay and the additional costs incurred by YWS such as interest charges on debt incurred and/or penalties and missed rewards under Ofwat's Outcome Delivery Incentive (ODI) scheme.
- Analysis of Customer Tracker survey data: the analysis described above attempts to quantify the relationship between service measure failures and the likelihood of payment refusals, where trust is considered to be an implicit factor in customer behaviour. Using YWS Customer Tracker data, it was possible to undertake an alternative analysis in which trust is explicitly accounted for as an intermediary factor in customer behaviour. This analysis took broadly the same form as that above although there was a need to first establish a relationship between service measure failures and trust, and then between levels of trust and numbers of payment refusals at a company-wide level.
- Analysis of individual customer records: in contrast to the analyses described above, the third approach that was tested investigated individual customer records on both payment history over a one-year period (2016) and the number of service measure failures experienced over the previous year(s).There was insufficient explanatory power to support a regression analysis and so a more

simple percentage attribution was undertaken to establish a link at an individual customer level.

Results

What factors define trust?

Despite emerging evidence from market research on the importance of trust in influencing customer behaviour, scholarly research on the topic is limited. Very little academic research has attempted to document empirically the factors that affect trust and where attempts have been made, this research has not systematically investigated the significance of trust in relation to other potential explanatoryfactors.

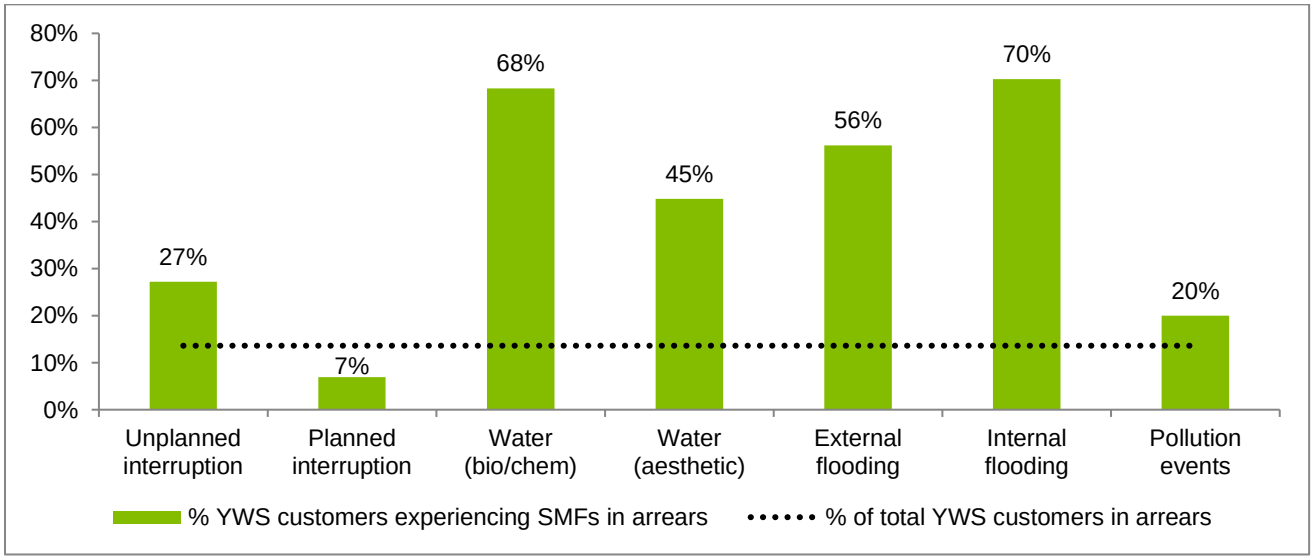
Market research conducted amongst water company customers in the UK suggests that higher levels of trust are associated with reliable water and sewerage services, value for money and customer service. Conversely, low levels of trust are associated with perceptions of poor value for money, high profits and inaffordability.

To what extent do different service measure failures impact levels of customer trust in YWS?

An analysis of 7,300 responses to the Customer Tracker survey over the period 2015-17 – in which respondents are asked the extent to which they agree or disagree with the statement *"Yorkshire Water are a company I trust"* – found that trust in YWS is typically high and that the majority (> 75%) of customers consistently 'strongly agree' with the statement. A regression analysis of this dataset found that drinking water quality, internal flooding, and odour related service measure failures all have a quantifiable negative impact on levels of trust in YWS. However, it is important to note that service measure failures only explain a very small amount of the variance in customers' levels of trust in YWS.

An analysis of the proportion of individual YWS customers who have experienced service measure failures found that customers experiencing unplanned supply interruptions, drinking water quality events, internal and external floods, and pollution incidents are more likely to be in arrears in the following year than typical YWS customers (see **Figure 3**). At least part of the explanation for the increased likelihood of being in arrears may be related to a loss of trust in YWS.

Figure 3. YWS customers in arrears



The results therefore suggest that, while there are a wide range of factors which impact on trust, there is some evidence that unplanned supply interruptions, drinking water quality events, internal and external floods, and pollution incidents may have negative impacts on trust in YWS; with the evidence being strongest for drinking water quality, internal flooding, and odour.

Which service measures are most important in terms of determining customer trust?

Analysis of the Customer Tracker survey results found that odour events have the most significant negative

impact on trust; with each customer experiencing an odour event giving, on average, a 0.63 lower score on the tracking survey. Odour was followed by internal flooding events (leading to a 0.49 lower score) and drinking water quality events (with a 0.32 lower score). The analysis of individual customer data also found that internal flooding events led to the most significant increase in likelihood of a customer going into arrears (57% more likely) followed by drinking water quality events (55% more likely). This analysis found that biological/chemical water quality incidents, as opposed to aesthetic incidents, had the greatest impact on customers going into arrears. There was no data in this analysis on odour related issues.

The results therefore suggest that odour events are the most important service measure in terms of influencing customer trust followed by internal flooding and drinking water quality events (particularly biological/chemical incidents).

What impact does trust have on customers' willingness-to-pay (WTP)?

It was not possible to explore this question with respect to Yorkshire Water within the agreed scope of the work package. Nevertheless, the academic research points clearly to a positive relationship between social capital (of which different aspects of trust are key components) and WTP. The literature review also highlighted some of the aproaches that could be considered for similar projects in future:

- Valuing trust as an attribute of WTP – one approach could be to include a series of attitudinal questions within a typical Stated Preference survey. The responses to these attitudinal questions could then be analysed to estimate the component of the overall WTP value which could be attributed to trust. This approach would be based on the assumption that customers with higher levels of trust in YWS would be likely to expect YWS to use money raised from their customers reliably, and thereby would be more likely to have a higher WTP for investing in tackling service measure failures.
- Trust as an incentive for customers to stay with YWS – an alternative approach could be to undertake a Stated Preference survey which estimates the level of monetary incentive customers would be willing to accept in order to switch from YWS to a new, untested water utility. This approach would be based on the assumption that customers with high levels of trust in YWS would be more likely to require a higher incentive to switch to an untested new provider.
- Analysing the results from Work Packages 1, 2 & 5 – as an alternative to undertaking additional primary research, the data collected as part of Work Packages 1, 2 & 5 could be used to explore this question in more depth. For example, WP1 examined the extent to which respondents' experiences of service measure failures influenced WTP and found that there was generally a positive relationship between service measure failures and WTP (i.e. those who had experienced failures exhibited a higher WTP for at least). Moreover, the information collated for each of these work packages is spatially explicit (i.e. can be attached to individual postcodes) and thus could be combined with YWS data on arrears (by postcode) to reveal whether or not stated preferences (i.e. the WTP estimates) track actual payment behaviour).

Do service measure failures impact the likelihood of customers paying their water bills?

The analysis of individual customer data found that customers who experienced service measure failures in 2016 (aside from planned supply interruptions) were more likely than the average YWS customer to be in arrears the following year. For example, in 2016-17 it was estimated that around 14% of customers were in arrears, by contrast, around double the proportion of customers experiencing unplanned supply interruptions were in arrears in 2017.

The proportion of people experiencing service measure failures in 2016 and being in arrears in 2017 was highest for internal flood events and drinking water quality (biological/chemical) events; such that 70% and 68% of all customers experiencing these service measure failures were in arrears the following year. This suggests that a large proportion of the customers who experience these service measure failures may fail to repay their bills in future.

The average water bill for defaulted customers in 2016-17 was estimated to be £405 per year, while the wider costs of bill payment refusals were estimated to be £3.976 million or around £23 per defaulting customer. The total average cost per payment refusal is thus estimated to be around £428 per year. It can be seen from **Figure**

3 that the proportion of YWS customers who have experienced a service measure failure who are in arrears is significantly higher than the proportion of total YWS customers who are in arrears. The difference between the two is taken as the proportion of additional cost that YWS bears as a result of service measure failures. By applying the percentage difference to the average total cost, one obtains an estimate of the additional costs to YWS for each type of service measure failure as follows: unplanned interruptions = £58; planned interruptions = £0; drinking water quality (bio/chem) = £0; drinking water quality (aesthetic) = £0; external flooding = £182; internal flooding = £243; and pollution incidents = £28.

However, it is important to note that there are significant levels of uncertainty associated with these numbers and that this is a high level, indicative analysis rather than an in depth estimation of value. In order to improve this analysis, a series of additional data collection exercises could be undertaken:

- Company-wide data – further time series data could be collected on the annual numbers of service measure failures, customer payment defaults, and the costs of payment defaults at a company-wide level. Further information would also be useful on the split between customers who 'can't' and 'won't' pay, as well as a more detailed breakdown of the costs to YWS from customers in arrears.
- Trust survey data – the wording of the Customer Tracker survey could be amended as follows: (1) ask customers whether YWS addressed the issue they contacted about in a satisfactory or unsatisfactory manner; (2) provide a coded response of service measure failures that respondents can select from when asked about their reason for contacting YWS; (3) ask customers whether they have refused to pay their water bills since their last contact with YWS. Note, an alternative could be to gather customer information from respondents that could be used to correlate their response with individual customer repayment records (such as post codes). Alternatively, a further option could be to issue the trust survey directly to people who have refused to pay bills (although the response rate may be low).
- Individual customer data – further data could be collected on the post codes of customers in arrears for different years, together with additional data on service measure failures experienced by those customers in previous years. This information could also be combined with spatially disaggregated information on avertive expenditure (e.g. the findings from Work Package 4) to identify where there may be overlaps between specific service measure failures, avertive expenditure, trust and customer satisfaction. A full list of the post codes of all YWS customers would also be useful for undertaking a more robust quantitative analysis and supporting the development of a more nuanced understanding of the spatial distribution of bill refusals or customers in arrears. This would help, for example, in examining the proportion of customers in arrears (e.g. per 10,000 connections) in different postcode areas or regions independent of the total size of the population.

Do service measure failures mean that YWS incurs higher levels of debt?

It was not possible to answer this question based on the data provided by YWS. The average water bill for defaulted customers in 2016-17 was estimated to be £405 per year, while the wider costs of bill payment refusals were estimated to be £3.976 million or around £23 per defaulting customer. Data was requested on a more detailed breakdown of costs for customers refusing to pay their water bills, including any impacts on debt, although this data was not available.

Implications

The outcomes of this work package provide a first step towards developing an approach to estimating the value of trust to YWS. The findings suggest that, while there are a wide range of factors which impact on trust, there is some evidence that unplanned supply interruptions, drinking water quality events, internal and external floods, and pollution incidents may have negative impacts on trust in YWS; with the evidence being strongest for drinking water quality, internal flooding, and odour.

The results also suggest that odour events are the most important service measure in terms of influencing customer trust followed by internal flooding and drinking water quality events (particularly biological/chemical incidents). The costs of each service measure in terms of loss of water bills are estimated to range from £0 per customer affected per year for planned supply interruptions to £243 for internal flooding events. However, it is

important to note that trust is complex and there are levels of uncertainty associated with these numbers.

Appendix 1: Methodology

1.1 Overview

The aim of this work package is to assess the extent to which customer trust in Yorkshire Water (YWS) has a measurable impact on the financial performance of the business and to trial an approach (or approaches) to quantifying and valuing this. While there does not appear to be an explicit definition of trust offered by water companies, Ofwat or the Consumer Council on Water (CC Water), 'trust' is understood here to be customers' belief in YWS to provide reliable, safe and affordable waste and wastewater services and to engage in honest, regular and co-operative behaviour. The underlying hypothesis is that service measure failures such as flood events or drinking water quality failures lead to lower levels of trust in YWS amongst its customers, which in turn results in a larger number of customers refusing to pay their water bills, and thereby financial costs to YWS.

The specific questions that the work package seeks to answer are as follows:

- What factors define trust?
- To what extent do different service measure failures impact upon levels of customer trust in YWS?
- Which service measures are most important in terms of determining customer trust?
- What impact does trust have on customers' willingness-to-pay (WTP)?
- Do service measure failures impact the likelihood of customers paying their water bills?
- Do service measure failures mean that YWS incurs higher levels of debt?

An enhanced understanding of the relationship between service measure failures and levels of trust in YWS may provide useful insights in terms of identifying, for example:

- Which service measures typically have the most influence on customer trust levels.
- Where YWS should prioritise investment to increase levels of trust and thereby promote cost recovery.

Establishing a quantitative link between service measure failures and the value of their impact on trust will also allow trust – as a factor that is both impacted by investment decisions and affects YWS's overall financial performance – to be incorporated into the Decision Making Framework (DMF) and YWS' wider investment planning decisions.

It is, however, recognised that there are potentially a wide range of factors that determine levels of trust (including, for example, reliability (based on past experience), communication and customer service, transparency, value-for-money, affordability, perceptions of profits, and the extent to which the business is considered a good employer)[1]. Furthermore, the available evidence on the relationship between trust and willingness to pay is relatively sparse (see Nocella et al, 2014; Vainen et al, 2017, Temperini et al, 2017, Jones et al., 2015 for some examples).

Within the water sector, the Consumer Council for Water (CCW) conducts annual surveys of household

[1] See http://utilityweek.co.uk/news/water-company-trust-issues/1158632#.WekTMWhSyUk and https://www.ofwat.gov.uk/about-us/meeting-the-challenges/

customers' views on their water and sewerage services, including their level of trust in their water company and water companies (including YWS) themselves monitor customer satisfaction and trust. These surveys do not, however, extend as far as placing a value on trust or measuring the extent to which trust is a determinant of WTP for the services received.

The analyses conducted here are an attempt to establish a quantifiable relationship between trust and WTP that will provide an important contribution to our understanding of social capital. It is nevertheless recognised that progress in this area is limited by the available data. As such, this work package is considered to be experimental and is intended to provide a first step in developing a better understanding of trust.

This Appendix provides an overview of the methodology used in this work package, the following Appendix sets out the results and implications for YWS.

1.2 Literature review

There is a substantial literature focusing on the determinants of demand (or willingness to pay, WTP) for environmental goods and services and natural resource management (see for example Mitchell and Carson, 1989; Nielsen et al., 2003; Spash, 2006; Kayaga et al., 2003; Yao et al., 2014; Breffle et al., 2015). It is only relatively recently, however, that specific attention has been devoted to understanding how social capital influences individuals' WTP (Glaeser et al., 2000; Nocella et al., 2010; Polyzou et al., 2011; Jones et al., 2015) where social capital is broadly defined as the links, shared values and understandings in society that enable individuals and groups to trust each other and to work together (Putnam, 2001; WBCSD, 2016; A4S, 2016).

Trust as an indicator of social capital and WTP

Despite the importance of trust, scholarly research on the topic is limited. Very little academic research has attempted to document empirically the factors that affect trust and where attempts have been made (e.g., Crosby et al., 1990), this research has not systematically distinguished trust from related factors.

Putnam (1995) identifies trust as a key measure of social capital, defining it as *"features of social organization such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit"* (Putnam, 1995: 67). Jones et al. (2015) and Polyzou et al. (2011) identify four components of social capital that are of particular relevance to WTP:

- **Social trust**, which refers to trust towards people in general or to specific social groups (Uslaner and Conley, 2003). Halkos and Jones (2012) and Polyzou et al (2011) posited that social trust is likely to have a positive influence on individuals' WTP as individuals with higher levels of social trust will view more positively the principle of paying for an improvement in an environmental good or service due to their belief that other community members will also act collectively, and will similarly be prepared in practice to contribute towards the cost of the proposed intervention.

- **Institutional trust**, referring to trust in the institutions that operate within a community (e.g. Government, local authorities, non-governmental organisations) (e.g. Paxton, 1999). Previous studies have shown that both the intention and WTP of individuals are significantly determined by the level of trust in the proposed management body, or the public authority to use moneys prudently and appropriately (Krystallis and Chryssohoidis, 2005; Meyerhoff and Liebe, 2006; Whitehead and Cherry, 2007; Anderson, 2017; Habivov et al., 2017). Distrust towards the management actor, is regarded as one of the main reasons for protest responses and reluctance or refusal to pay (Jones et al., 2008; Yoo et al., 2001; Whitehead and Cherry, 2007).

- **Social networks and civic participation**, relating to the involvement of individuals in formal and informal networks and also their interest for collective issues of their community (Putnam, 2000). Recent studies (Yao et al., 2014) have shown, for example, that people who are members of environmental NGOs are also more willing to pay for natural resource management measures. This is because

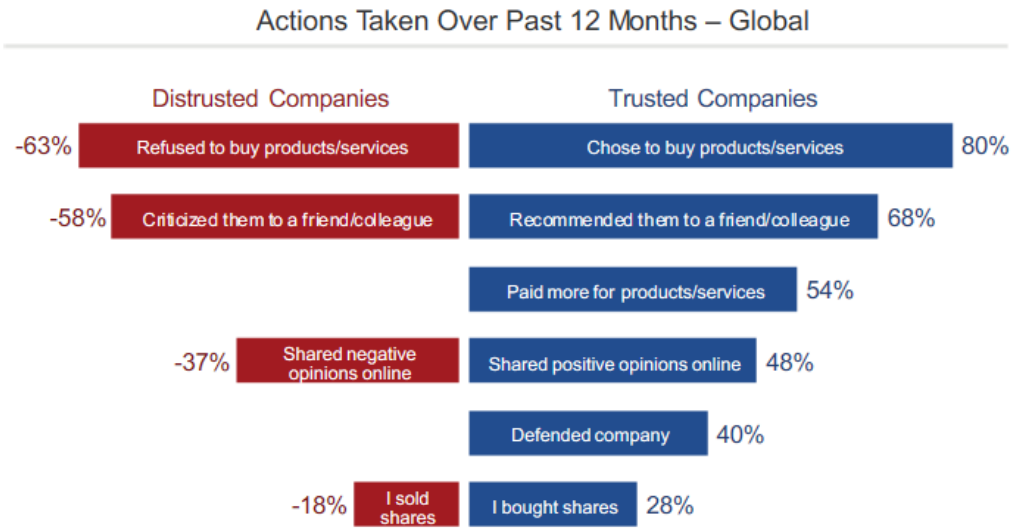
environmental NGOs tend to raise awareness of headline issues, such as climate change impacts, and this increased environmental awareness can lead to a higher WTP contribution (Polyzou et al., 2011).

- **Compliance with social norms**, and specifically the tendency of individuals to comply with formal or informal community rules aimed at protecting the interests of their community (van Oorschot et al., 2006), including contributing money for environmental protection and improvement. Alló and Loureiro (2014), for example, performed a meta-analysis of data from a large number of empirical studies on the willingness to pay for climate change mitigation to explain the social and cultural determinants of the cross-country differences that they observe in the sample. They found that countries with a high propensity to conform to social norms are associated with willingness to pay for climate change mitigation.

There are a number of studies that have tried to identify the impact of social capital by using attitudinal measures of trust from survey questionnaires. Knack and Keefer (1997), for example, show that an increase of one standard deviation in country-level trust predicts an increase in economic growth of more than one-half of a standard deviation. More recently, however, the focus has shifted to examining specific behaviours using experiments (Glaeser et al., 2000) or empirical data Polyzou et al., 2011; Jones et al., 2015). This follows from research by Glaeser al., (2000) which found that responses to attitudinal questions were weak predictors of trust in that the responses did not necessarily correspond to actual trusting behaviours. They found that past trusting behaviour was better than the abstract attitudinal questions in predicting subjects' experimental choices. This suggests that other elements of social capital (e.g. compliance with social norms, participation in social networks, etc may be just as important in determining behaviour.

The findings of the Edelman Trust Barometer, an annual global trust and credibility survey involving some 33,000 respondents across 28 countries, reveal that trust carries important implications for future business success. Respondents indicated that trust or lack of trust in a particular company has influenced their behaviors in the previous 12 months. In the 2015 survey, 80 percent of respondents said that they chose to buy a particular product or service because they trusted the company behind it. Sixty-three percent said they refused to purchase a product or service because they distrusted a particular company (see Figure 4).

Figure 4. Behaviours based on trust (Edelman Trust Barometer, 2015)



Several studies have examined the extent to which social capital, and specifically levels of social and institutional trust and participation in social networks, influences WTP for goods and services across a range of

sectors. These cover a range of sectors including energy, water, flood protection and biodiversity.

Wiser (2007) estimated WTP for 1,574 individual households to determine their preferences between public and private supplies of renewable energy technologies. The findings suggested that households were willing to pay more if the money was to be paid to the private suppliers (the agent of trust) than to the government (the agent of mistrust).

Haile and Slangen (2009) used stated preference surveys (contingent valuation methodology) to evaluate the willingness to pay for the benefits of Agri-Environmental Schemes (AES) by households living in Winterswijk, the Netherlands. Households in the sample were asked to state their WTP values for land use benefits within the AES which is provided by farmers. The findings suggest that WTP depends positively on the level of trust as well as the extent to which households are members of or support environmental organisations.

Oh and Hong (2012) sought to investigate the extent to which trust determines citizens' WTP for public projects in Korea. Using the Hicksian compensating variation method and citizen's subjective views on the trustworthiness of government, the authors were able to establish a positive association between citizens' trust in government and their WTP.

Using a contingent valuation survey, Polyzou et al., (2011) examined the influence of social capital parameters on individuals' WTP for improvements in tap water quality within a community in Greece, and specifically the relationship between social capital and zero and protest responses. The survey was designed to capture information on environmental practices (including the frequency with which individuals drink tap water), demography and social capital. Social and institutional trust were measured using a Likert scale, where zero represented the lowest level of trust and 10 the highest. Institutional trust was examined in relation to the institutions responsible for water management – the Government, the Ministry of Environment and the Municipality. The study found that higher levels of social capital were associated with higher bids for the improvement of water quality. Moreover, 60% of the respondents refused to pay as they felt that they already paid enough through state taxes, that the management by local government actors was inefficient and that financing the improvements was the responsibility of the state.

Closer to home, Jones et al. (2015) investigated the WTP of residents in rapidly eroding coastal zones in south-east England to contribute towards the costs of constructing and maintaining hard engineered coastal defences and explored, using the same approach as Polyzou et al. (2011), the influence of social capital parameters (social trust, institutional trust, social reciprocity and social networks) on respondents' WTP. They found that three out of the four social capital parameters measured had a statistically significant impact on WTP. In particular, both institutional and social trust had a positive influence, suggesting that respondents who tend to trust their fellow citizens and also trust coastal management agencies are more willing to pay for defence works. The unexpectedly high level of protest responses (refusals to pay) were attributed to low levels of instititutional trust.

Social networks, however, were found to have a largely negative impact on WTP, contradicting the assumptions that participation in social networks increases monetary contributions (Polyzou et al., 2011; Veronesi et al., 2014). This may, at least in part, be explained by the existing networks in the area that help sustain the idea that construction and maintenance of coastal defences should be the responsibility of institutions (in this case the Environment Agency) and that local communities should not be burdened with their funding.

Customer satisfaction, trust and WTP

Prior research in the marketing field has shown that trust and satisfaction are positively correlated (Crosby et al., 1990; Yoon, 2002). Evidence outlined by Kennedy et al. (2001) shows that customer satisfaction is an antecedent of trust in the service provider. However, meta-analytical studies on satisfaction (Szymanski and Henard, 2001) and trust (Geyskens et al., 1998) have shown that while satisfaction and trust are closely related, they are conceptually different.

Ranaweera and Prabhu (2003) note, for example, that while successful service delivery may satisfy the

customer, it may not be possible to erase all the negative feelings associated with the initial service failure, especially where the failure is noted and the recovery process is initiated by the customer. Customers may be entirely satisfied with the response and recovery process, but they may not necessarily forget the incident and trust the service provider not to make similar mistakes in the future. Trust has therefore been shown to be an important factor in customer loyalty.

Research supports the notion that there is a positive relationship between customer satisfaction and financial performance (e.g., Anderson, Fornell, and Rust 1997; Rust and Zahorik 1993; Homburg et al., 2005). Anderson et al. (1994) analysed data obtained from the Swedish Customer Satisfaction Index and found that "firms that actually achieve high customer satisfaction also enjoy superior economic returns (p. 63)." Similarly, through two experimental studies, Homburg et al. (2005) revealed the existence of a strong positive impact of customer satisfaction on willingness to pay.

Trust in the provision of water and wastewater services

Customer satisfaction with their service and their ability to pay bills underpins trust and confidence in water and wastewater services (Ofwat, 2017). The most recent household satisfaction survey (Water Matters)[2] conducted on behalf of the Consumer Council for Water (CCWater) revealed that:

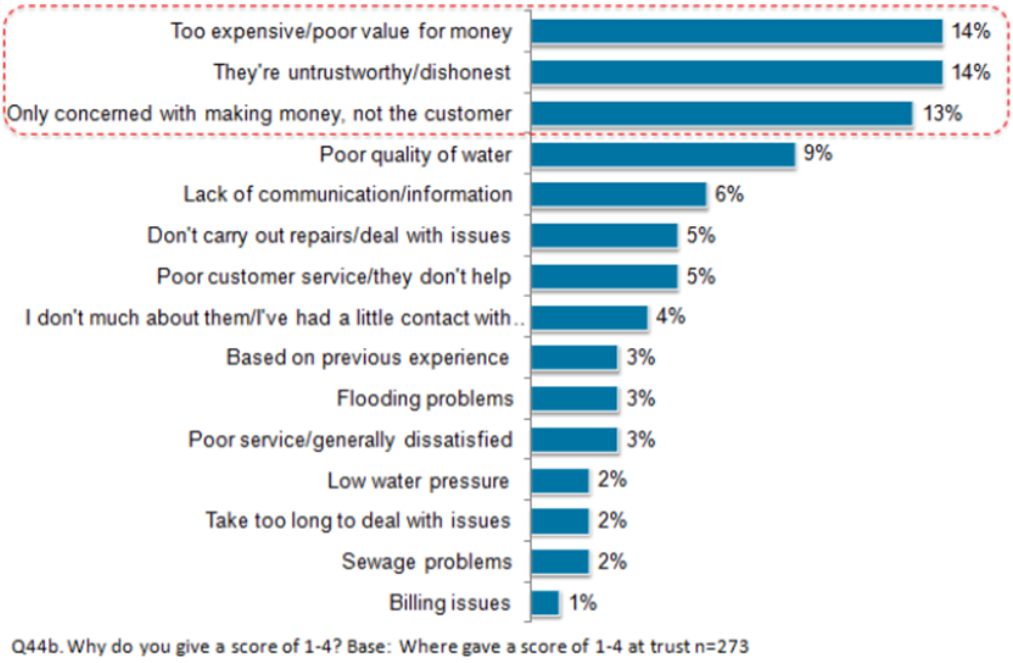
- The level of trust in the industry has fallen significantly since 2015 across both England and Wales (7.59 vs. 7.75 in 2015)[3] although the overall five-year trend remains stable.
- Amongst the water and sewerage companies (WaSCs), Yorkshire Water ranked fourth in terms of its five-year rolling average trust score and has a higher rolling average than the collective industry and WaSC average.
- Trust was found to be highest amongst customers who are retired (7.83 vs 7.46 for those who are not retired), without children in the household (7.68 of those earning less than £10,000 and 7.72 of those earning between £10,000 and £19,999 compared to the average), and those living in rural areas (7.73 vs 7.58 for urban customers and 7.49 for suburban customers).
- Households are significantly less likely to trust their water company in cases where they have contacted their water company in the past 12 months compared to those who have not (7.36 vs 7.63), where they disagree that their bill is clear about how much needs to be paid and when (6.03 vs 7.82 who agree their bill is clear), where they are dissatisfied with the value for money of water services (5.94 vs 7.98 satisfied with value for money), and where they disagree that their water company cares about the service it provides (4.98 vs 8.25 who agree that their water company cares).
- The main reasons for distrust are the feeling that water companies are too expensive or poor value for money and that they are generally untrustworthy / dishonest (14% each). These reasons were closely followed by the perception that water companies are more concerned with making money than they are

[2] Water Matters is the annual household satisfaction tracking survey commissioned by the Consumer Council for Water. Commissioned first in 2006, Water Matters aims to identify household customers' views of water and sewerage services across England and Wales and monitors changes in these views over time. The 2016 survey consisted of 5,420 telephone interviews with household water bill payers between 10th October 2016 and 15th January 2017. A minimum of 200 interviews were carried out with each Water and Sewerage Company (WaSC) and a minimum of 150 with each Water only Company (WoC).

[3] Customers were asked to what extent they trust their water company on a scale of 1 – 10 with 1 being 'do not trust them at all' and 10 being 'trust them completely'.

about their customers (see Figure 6).

Figure 5. Reasons for lack of trust in water companies (bmg research for CC Water, 2016)



In a 2015 survey of 1,000 households in England and Wales, DJS Research looked into why customers trust or don't trust their water company. In line with the CCWater findings, it found that the majority of customers (64 per cent) trust their water company. The main reason why customers trust their water company is because their water and sewerage services are reliable. Two-thirds (67 per cent) of those who trust their supplier picked this as one of the top three reasons why, with this figure increasing to 87 per cent among those aged 65+.

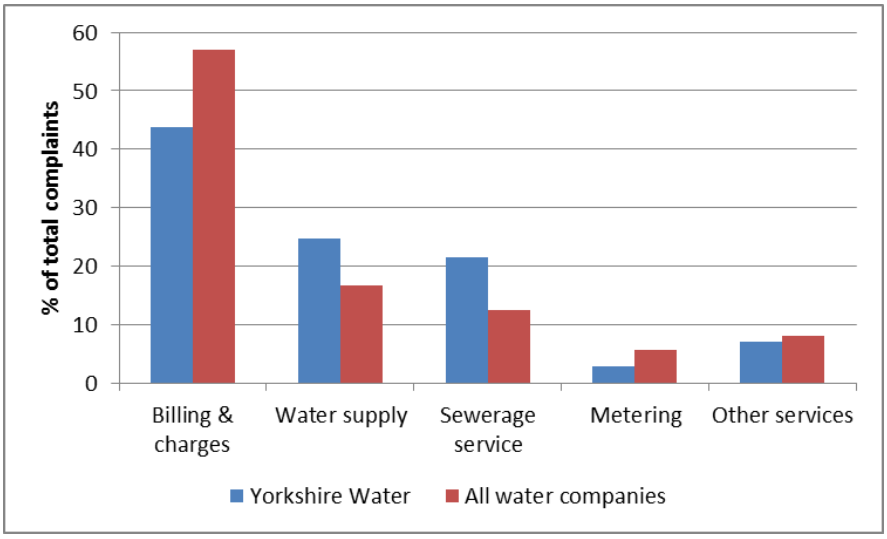
Second to reliability comes value for money and customer service, with 41 per cent saying that their bills are good value and 39 per cent saying they have had good customer service from their water company. In London and the South East, having an affordable bill (45 per cent and 43 per cent respectively) is the next most selected reason for trust, whereas in the North East, South West, Wales and East Midlands a good customer service experience is chosen ahead of affordability (41 per cent, 35 per cent, 38 per cent and 40 per cent).

Where customers expressed distrust in their water supplier, this tended to be based on views about charges and principles rather than service, which again accords with the CCWater findings. The research revealed that one in ten customers does not trust their supplier and this is most likely to be because they see their water bills as poor value for money (42 per cent), or as unaffordable (20 per cent). Perceptions of water company profits are also important, with 46 per cent choosing this as one of their reasons to distrust. Some customers (25 per cent) feel fairly neutral about trust. When asked what their water company could do to help them form a more trusting view, almost two-thirds (62 per cent) said that reducing their bill or giving less money to shareholders (31 per cent) would help.

These findings accord with the complaints data compiled by CCWater (2017) which shows that in the 2016/17 period, just under half (43.8%) of the written complaints received by Yorkshire Water were related to billing and

charges (see Figure 6).

Figure 6. Written customer complaints to water companies by category (CCWater, 2017)



Conclusions

While there is a small but growing body of evidence that demonstrates the positive relationship between customer satisfaction, trust and individuals' willingness to pay (WTP), empirical identification of the effect of trust, and social capital more generally, on firm performance in general, and against specific metrics in particular, is challenging and its measurement and valuation is not straightforward.

The research that has been undertaken as part of Work Package 6 and that is presented below is unprecedented; it is, we believe, the first time that information on customer satisfaction, trust and actual payment data has been combined and analysed in order to establish the extent to which customer trust in an organisation (in this case Yorkshire Water) affects actual payment levels.

1.3 Scoping potential approaches

The literature review pointed to a number of potential approaches that could be considered and applied to quantifying the value of trust to YWS. These included:

- **Valuing trust as a determinant of WTP.** Following the lead of Jones et al (2015)[4], one approach identified was to include a series of attitudinal questions within the Stated Preference surveys carried out in Work Packages 1 and 2. The responses to these attitudinal questions could then be analysed to estimate the proportion of the total WTP value which could be attributed to trust, similar to the way in which use and non-use values are being differentiated in Work Packages 1 and 2. This approach is based on the assumption that those customers with higher levels of trust in YWS are those that perceive YWS to reinvest money raised from their customers reliably, and are therefore also more likely to have a higher WTP for investing in tackling service measure failures. A potential limitation with this approach

[4] Jones et al. (2015) 'Social capital and willingness-to-pay for coastal defences in south-east England', Ecological Economics, vol. 119, pp. 74-82.

is that it would not generate a separate or standalone value for trust within the DMF, but instead would support an analysis of the relative contribution of the constituent components of total WTP.

- **Trust as an incentive for customers to stay with YWS** – an alternative approach could be to undertake a separate Stated Preference survey in order to estimate the level of monetary incentive required for customers to switch from YWS to a new, untested water utility. This approach would be based on the assumption that customers with high levels of trust in YWS would be more likely to require a higher incentive to switch to an untested new provider. Unlike the previous approach, this would generate a standalone value for trust in the DMF but it is subject to hypothetical bias as respondents would be asked about their preferences for a service provider that does not exist (notwithstanding opening up of retail competition for household customers). Respondents would also need to consider the transaction costs associated with a switch to an alternative provider.

- **Understanding trust as a factor behind decision making in a resource allocation game** – a third approach could be to ask YWS customers to play the role of an investor who needs to decide where and how much to invest in different hypothetical water companies with different levels of trust and rates of service measure failures. The results could then be used to explore trade-offs between money allocated and trust in terms of the players' expectations that the investment would be used to deliver services that customers want and can afford, in an equitable and environmentally responsible way. This approach would rest on the assumption that participants in the game would be more likely to invest in utilities with higher levels of trust. A challenge with this approach would lie in the potential complexity of designing this game to generate a reliable value of trust given that trust may be only one amongst a number of factors governing an investor's propensity to invest.

- **Measuring the impact of trust on customer's payment of water bills** – a final approach identified for valuing the impact of trust would be to look at data collected by YWS in terms of service measure failures and numbers of customers refusing to pay water bills in order to try to establish whether there is a quantifiable link between the two factors. This approach would be based on the assumption that customers experiencing service measure failures would be more likely to have lower levels of trust in YWS and thereby a greater likelihood of refusing to pay their water bills. This approach does, however, rely on the availability of relevant time-series data that is collected on a regular and consistent basis.

Following discussions with YWS, it was agreed that the last-mentioned of these four approaches was considered to offer the most promising approach to explore as part of this Work Package given that:

- the necessary data required to undertake the analysis was likely be more readily available;

- the second- and third-mentioned approaches are subject to significant hypothetical bias and may not yield reliable results; and

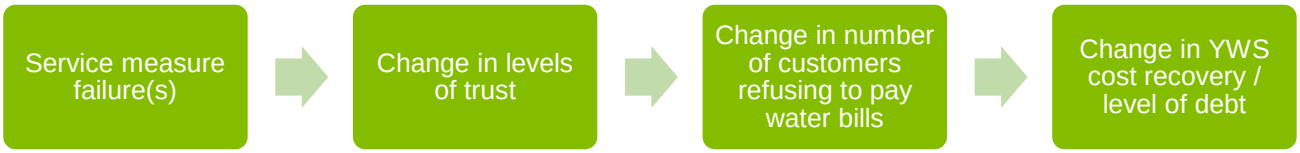
- it could potentially provide useful insights beyond generating values for the use in the DMF. In particular, the approach may reveal opportunities for YWS to increase levels of trust amongst its customer base by targeted improvements in service areas, thereby improving cost recovery and reducing debt.

1.4 Developing a methodology

Figure 6 shows the assumed impact pathway (or 'logic chain') that underlies the selected methodology. This hypothesises that a service measure failure impacts on customers' trust in YWS to provide the expected level of service. This in turn impacts upon customers' propensity to pay their water bills which means that YWS is not

able to recover the costs of the service provided and may incur interest charges on the debt.

Figure 7. Logic chain of assumptions underlying the methodology



YWS holds numerous datasets that were identified as being potentially useful for implementing the methodology. Based on a high-level review of these datasets, three alternative analytical approaches were tested:

i. **Analysis of company-wide / aggregate data on service measure failures and payment data:** the aim of this analysis was to try to establish a direct link between service measure failures and bill repayment levels (with trust assumed to be an implicit factor in customers' propensity to pay) at an aggregate or company-wide level. This analysis involved two stages: (1) establishing whether there is a link between service measure failures and the number of customers who have defaulted on payment, where defaults are assumed to be payment refusals ; and (2) establishing the cost to YW as a result of customer payment refusals.

   The first stage comprised an analysis of YWS time series data on the number of payment refusals each year and the number service measure failures each year between 2012/13 and 2016/7. A regression analysis was then undertaken to establish if there is a quantifiable link between the two factors. The final step was then to estimate the average cost to YWS for each customer with defaulted payment status. This was done by combining information on the average water bills of customers who refuse to pay and the additional costs incurred by YWS such as interest charges on debt incurred and/or penalties and missed rewards under Ofwat's Outcome Delivery Incentive (ODI) scheme.

ii. **Analysis of Customer Tracker survey data:** the analysis described above attempts to quantify the relationship between service measure failures and the likelihood of payment refusals, where trust is considered to be an implicit factor in customer behaviour. Using YWS Customer Tracker data, it was possible to undertake an alternative analysis in which trust is explicitly accounted for as an intermediary factor in customer behaviour. This analysis took broadly the same form as that above although there was a need to first establish a relationship between service measure failures and levels of trust, and then between levels of trust and numbers of payment refusals at a company-wide level.

iii. **Analysis of individual customer records:** in contrast to the analyses described above, the third approach that was tested investigated individual customer records on both payment history over a one-year period (2016) and the number of service measure failures experienced over the previous year(s).There was insufficient explanatory power to support a regression analysis and so a more simple percentage percentage attribution was undertaken to establish a link between the two variables at an individual customer level.

Given the experimental nature of this work package it was decided that each of these three analyses should be attempted in order to ascertain which offers the most promising approach for deriving a value for trust.

The following sections in this Appendix describe the data requirements that were identified, the data that was

available from YWS, the methods used for analysing the data as well as any underlying assumptions.

1.5 Company-wide / aggregate analysis of service measure failure and payment data

The aim of this analysis was to establish whether there is a quantifiable link between the number of service measure failures each year and the costs incurred by YWS from refusals to pay water bills at a company-wide level. This assumes that customers who have experienced a service measure failures will implicitly have a lower degree of trust in YWS and that this in turn adversely affects their propensity to pay. In order to undertake the analysis a request was sent to YWS for the following datasets:

- Customer payment status by year i.e. annual payment data and specifically information on the number of customers who refuse to pay their bills each year at a company-wide level.
- Service measure failures by year i.e. the number and type of service measure failures each year at a company-wide level.
- Costs of payment refusals i.e. the monetary cost to YWS associated with customers who refuse to pay their bills each year.

1.5.1 Customer payment status by year

YWS supplied annual data on the number of customers failing to pay their bills at a company-wide level over the period 2012-13 to 2016-17.[5] Bill payers were classified into nine categories depending on their payment status (see Table 1).

It is recognised that there is likely to be a difference between customers who 'can't' pay their bills versus customers who 'won't' pay their bills; although it was not possible to distinguish between these two categories on the basis of the available data. As such, it was assumed that all customers in the 'defaulted' category refused to pay their water bills. This analysis, therefore, represents an oversimplification of a complex issue asthose who cannot pay their bills could be more sensitive to service measure failures in cases where they may have fewer coping mechanisms and are therefore less resilient. Furthermore, given that affordability was identified by CCWater as one of the key drivers of stated levels of trust (see Section 1.2), it is possible that those who cannot pay and who have experiened a service outage would have significantly lower levels of trust (and would be even less likely to pay) than whose who simply refuse to pay. Further information on the proportion of customers who can't pay their bills relative to those who won't pay would be needed to extend the analysis. This should include multi-dimensional, time-series data that will allow for other factors that may contribute to non-

[5] YWS (2017) 'Trust data overview V3.xls'

payment over the course of a year (e.g. proximity to Christmas, start of school terms, etc).

Table 1. Summary of customer payment status by year

No. customers by payment status	2012-13	2013-14	2014-15	2015-16	2016-17
Up to date with payments (% of total customer base)	1,899,780 (91.16)	2,109,662 (89.75)	2,130,183 (88.16)	2,158,866 (88.10)	2,191,738 (86.39)
1 Month down	21,769	38,751	21,308	21,132	26,809
2 Months down	31,441	34,224	44,044	38,739	89,342
3 Months down	22,871	24,603	33,760	22,818	12,786
4 Months down (paying on special arrangement)	6,167	5,706	11,447	7,897	4,418
5 Months down (paying on special arrangement)	16,729	13,511	13,499	10,459	1,977
6 Months down (paying on special arrangement)	23,121	23,409	20,278	26,434	9,286
Defaulted (% of total customer base)	47,090 (2.26)	83,524 (3.55)	118,911 (4.92)	140,238 (5.72)	172,311 (6.79)
Under query	15,003	17,239	22,707	23,844	28,400
Total customers	**2,083,971**	**2,350,629**	**2,416,137**	**2,450,427**	**2,537,067**

1.5.2 Service measure failures by year

YWS provided information on the number service failures per year for a range of service measures over the period 2007-08 to 2016-17. There were some limitations with the data insofar as it:

- Was not available for each measure consistently across this period
- Did not use the same classification system as the DMF, and therefore necessitated a number of assumptions in order to align the information provided with the DMF service measure categories as far

as possible.

The way in which the datasets were aligned with the DMF service measure categories is set out in Table 2.

Table 2. Overlap between service measure failures data provided by YWS and DMF categories

DMF Service Measure	DMF Impact Category	Corresponding Dataset	Categorisation in Dataset
Unplanned Interruption to Supply	< 3hrs	Table 02.xls Interruptions and Low Pressure	-
	3 - 6hrs	Table 02.xls Interruptions and Low Pressure	(i) Unplanned interruptions - 3 hours exactly + (iii) Interruptions caused by third parties - 3 hours exactly + (iv) Unplanned interruptions (overruns of planned interruptions) - 3 hours exactly + (i) Unplanned interruptions – More than 3 hours + (iii) Interruptions caused by third parties – More than 3 hours
	6 - 12hrs	Table 02.xls Interruptions and Low Pressure	(i) Unplanned interruptions – more than 6 hours + (iii) Interruptions caused by third parties – More than 6 hours + (iv) Unplanned interruptions (overruns of planned interruptions) – More than 6 hours
	12 - 24hrs	Table 02.xls Interruptions and Low Pressure	(i) Unplanned interruptions – more than 12 hours + (iii) Interruptions caused by third parties – More than 12 hours + (iv) Unplanned interruptions (overruns of planned interruptions) – More than 12 hours
	>24hrs	Table 02.xls Interruptions and Low Pressure	(i) Unplanned interruptions – more than 24 hours + (iii) Interruptions caused by third parties – More than 24 hours + (iv) Unplanned interruptions (overruns of planned interruptions) – More than 24 hours
Planned Interruption to Supply	< 3hrs	Table 02.xls Interruptions and Low Pressure	-
	3 -6hrs	Table 02.xls Interruptions and Low Pressure	(ii) Planned and warned interruptions - 3 hours exactly + (ii) Planned and warned interruptions – More than 3 hours
	6 - 12hrs	Table 02.xls Interruptions and Low Pressure	(ii) Planned and warned interruptions – More than 6 hours
	12 - 24hrs	Table 02.xls Interruptions and Low Pressure	(ii) Planned and warned interruptions – More than 12 hours
Poor Pressure	Pressure below minimum acceptable level	Table 02.xls Interruptions and Low Pressure	Properties below reference level at end of year
Leakage	Leakage	Table 10	Total leakage
Drinking Water Quality (Biological & Chemical)	Trivial/ threshold sample failure	Table 11a APR17 Final	Water Quality (Overall Compliance)
	WQ parameter sample exceeds PCV at WTW - no health impact	Table 11a APR17 Final	
	WQ parameter sample exceeds PCV at WTW - health impact	Table 11a APR17 Final	

DMF Service Measure	DMF Impact Category	Corresponding Dataset	Categorisation in Dataset
	WQ parameter sample exceeds PCV at SRE - no health impact	Table 11a APR17 Final	
	WQ parameter sample exceeds PCV at SRE - health impact	Table 11a APR17 Final	
	WQ parameter sample exceeds PCV at Customer Property - no health impact	Table 11a APR17 Final	
	WQ parameter sample exceeds PCV at Customer Property - health impact	Table 11a APR17 Final	
	Protective advice required / Health impact due to PCV exceedence	Table 11a APR17 Final	
Drinking Water Quality (Aesthetic)	Taste and Smell	Table 11a APR17 Final	Consumer Contacts - Discoloration (per 1000 population)
	Discolouration	Table 11a APR17 Final	
	Acceptability - Milky / Cloudy / Particles	Table 11a APR17 Final	
Internal Property Sewer Flooding (Hydraulic and Other Causes)	Internal flooding of a cellar (Other Causes)	Table 03. Internal Sewer Flooding	Properties where flooding limited to uninhabited cellars only (other causes)
	Internal flooding of habitable area (Other Causes)	Table 03. Internal Sewer Flooding	Properties flooded in the year (other causes)
	Internal flooding of a cellar (Hydraulic)	Table 03. Internal Sewer Flooding	Properties where flooding limited to uninhabited cellars only (o/loaded sewers)
	Internal flooding of habitable area (Hydraulic)	Table 03. Internal Sewer Flooding	Properties flooded in the year (overloaded sewers) + Properties flooded in the year (Stability & Reliability)
External Sewer Flooding (Hydraulic and Other Causes)	Flooding of minor roads (Other Causes)	Table 03a External Sewer Flooding	Flooding incidents (other causes - equipment failure) + Flooding incidents (other causes - blockages) + Flooding incidents (other causes - collapses)
	Flooding of major roads (Oher Causes)	Table 03a External Sewer Flooding	
	External flooding within the property boundary not inhibiting access (Other Causes)	Table 03a External Sewer Flooding	
	External flooding within the property boundary inhibiting access. (Other Causes)	Table 03a External Sewer Flooding	
	External flooding causing societal disruption i.e. impact on Schools, Hospitals, Sensitive properties etc. (Other Causes)	Table 03a External Sewer Flooding	
	Flooding of minor roads (Hydraulic)	Table 03a External Sewer Flooding	Total flooding incidents (overloaded sewers)

DMF Service Measure	DMF Impact Category	Corresponding Dataset	Categorisation in Dataset
	Flooding of major roads (Hydraulic)	Table 03a External Sewer Flooding	
	External flooding within the property boundary not inhibiting access (Hydraulic)	Table 03a External Sewer Flooding	
	External flooding within the property boundary inhibiting access. (Hydraulic)	Table 03a External Sewer Flooding	
	External flooding causing societal disruption i.e. impact on Schools, Hospitals, Sensitive properties etc. (Hydraulic)	Table 03a External Sewer Flooding	
Pollution Incidents	Category 1 pollution incident	Table 44 Pollution	Cat 1 Pollution Incidents - Legacy Network + Cat 1 Pollution Incidents
	Category 2 pollution incident	Table 44 Pollution	Cat 2 Pollution Incidents - Legacy Network + Cat 2 Pollution Incidents
	Category 3 pollution incident	Table 44 Pollution	Cat 3 Pollution Incidents - Legacy Network + Cat 3 Pollution Incidents
	Category 4 pollution incident	Table 44 Pollution	-

1.5.3 Costs of bill payment refusals

YWS provided data on the average bills of defaulted customers in 2016-17 (more historical and detailed data was not available) which was estimated to be £405 per year.[6] Data was also requested on the wider costs of bill payment refusals to YWS. For the 2016-17 period this was estimated to be £3.976 million[7] or around £23 per defaulting customer. Adding these togethersuggests a total cost per payment refusal of £428 per year.

1.5.4 Analysis

Table 3 provides a summary overview of the collated dataset. A regression analysis was then run in order to establish whether there is a quantifiable link between the number of customers defaulting each year and the

[6] Yorkshire Water (2017), 'Data actions no of contacts & debt.xslx'.
[7] Yorkshire Water (2017), 'Data actions no of contacts & debt.xslx'.

number of service measure failures each year at a company-wide level.

Table 3. Data collated for regression analysis

Dependent Variable	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
Defaulted (no.)	-	-	-	-	-	47,090	83,524	118,911	140,238	172,311

Independent Variables	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
Unplanned Interruptions (no.)	**21,484**	**35,893**	**69,842**	**129,219**	**102,621**	**72,278**	**89,349**	**63,488**	**88,879**	**76,014**
< 3hrs (no.)	-	-	-	-	-	-	-	-	-	-
3 - 6hrs (no.)	17,662	30,268	59,474	79,721	79,633	57,420	70,854	47,424	62,677	62,020
6 - 12hrs (no.)	2,929	4,480	9,009	33,281	22,565	14,496	18,384	15,735	21,347	13,807
12 - 24hrs (no.)	784	1,110	1,334	14,327	412	258	107	297	3,430	181
>24hrs (no.)	109	35	25	1,890	11	104	4	32	1,425	6
Planned Interruptions (no.)	**101,674**	**53,326**	**8,991**	**15,179**	**54,569**	**13,207**	**9,385**	**22,091**	**21,738**	**15,617**
< 3hrs (no.)	-	-	-	-	-	-	-	-	-	-
3 - 6hrs (no.)	60,868	36,260	7,473	10,623	42,006	11,080	7,927	19,670	17,886	12,203
6 - 12hrs (no.)	40,806	17,066	1,518	4,556	12,563	2,127	1,458	2,421	3,852	3,414
12 - 24hrs (no.)	0	0	0	0	0	0	0	0	0	0
Poor Pressure (no.)	**102**	**86**	**115**	**11**	**4**	**10**	**14**	**9**	**11**	**8**
No. props. at start of year (no.)	102	86	115	11	4	10	14	9	11	8
Leakage (Ml/d)	**293.63**	**295.02**	**294.70**	**325.40**	**273.84**	**264.62**	**282.27**	**288.42**	**285.12**	**295.16**
Total leakage (Ml/d)	293.63	295.02	294.70	325.40	273.84	264.62	282.27	288.42	285.12	295.16
Drinking Water Quality (Biological/Chemical) (%)	**-**	**-**	**-**	**-**	**99.95**	**99.93**	**99.96**	**99.94**	**99.96**	**99.97**
Trivial/ threshold sample failure (%)	-	-	-	-	99.95	99.93	99.96	99.94	99.96	99.97
Exceeds PCV at WTW - no health impact (%)	-	-	-	-	-	-	-	-	-	-
Exceeds PCV at WTW - health impact (%)	-	-	-	-	-	-	-	-	-	-
Exceeds PCV at SRE - no health impact (%)	-	-	-	-	-	-	-	-	-	-
Exceeds PCV at SRE - health impact (%)	-	-	-	-	-	-	-	-	-	-
Exceeds PCV at Customer Property - no health impact(%)	-	-	-	-	-	-	-	-	-	-
Exceeds PCV at Customer Property - health impact (%)	-	-	-	-	-	-	-	-	-	-
Protective advice required / Health impact (%)	-	-	-	-	-	-	-	-	-	-
Drinking Water Quality (Aesthetic) (no./1,000 pop.)	**-**	**-**	**-**	**1.61**	**1.26**	**1.16**	**1.33**	**1.20**	**1.03**	**0.97**
Taste and Smell (no./1,000 pop.)	-	-	-	1.61	1.26	1.16	1.33	1.20	1.03	0.97
Discolouration (no./1,000 pop.)	-	-	-	-	-	-	-	-	-	-
Acceptability - Milky / Cloudy / Particles (no./1,000 pop.)	-	-	-	-	-	-	-	-	-	-
Internal Sewer Flooding (no.)	**811**	**840**	**708**	**682**	**700**	**1005**	**680**	**821**	**731**	**724**
Internal flooding of a cellar (Other Causes) (no.)	180	305	244	254	255	289	219	201	243	260
Internal flooding of habitable area (Other Causes) (no.)	374	443	355	340	363	420	319	292	346	372
Internal flooding of a cellar (Hydraulic) (no.)	71	16	29	19	14	68	30	61	23	15
Internal flooding of habitable area (Hydraulic) (no.)	186	76	80	69	68	228	112	267	119	77
External Sewer Flooding (no.)	**1,581**	**2,832**	**3,215**	**2,896**	**3,554**	**5,532**	**3,794**	**3,928**	**3,987**	**3,809**
Flooding of minor roads (Other Causes) (no.)	1,231	2,472	2,876	2,635	3,399	4,608	3,535	3,495	3,635	3,668

Independent Variables	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
Flooding of major roads (Oher Causes) (no.)	-	-	-	-	-	-	-	-	-	-
Ext. flooding not inhibiting access (Other Causes) (no.)	-	-	-	-	-	-	-	-	-	-
Ext. flooding inhibiting access (Other Causes) (no.)	-	-	-	-	-	-	-	-	-	-
Societal disruption (Other Causes) (no.)	-	-	-	-	-	-	-	-	-	-
Flooding of minor roads (Hydraulic) (no.)	350	360	339	261	155	924	259	433	352	141
Flooding of major roads (Hydraulic) (no.)	-	-	-	-	-	-	-	-	-	-
Ext. flooding not inhibiting access (Hydraulic) (no.)	-	-	-	-	-	-	-	-	-	-
Ext. flooding inhibiting access (Hydraulic) (no.)	-	-	-	-	-	-	-	-	-	-
Societal disruption (Hydraulic) (no.)	-	-	-	-	-	-	-	-	-	-
Pollution Incidents (no.)	**-**	**-**	**-**	**335**	**311**	**263**	**255**	**195**	**239**	**259**
Cat 1 (no.)	-	-	-	0	0	0	3	0	0	1
Cat 2 (no.)	-	-	-	13	15	6	8	4	7	6
Cat 3 (no.)	-	-	-	322	296	257	244	191	232	252
Cat 4 (no.)	-	-	-	0	0	0	0	0	0	0

1.6 Analysis of Customer Tracker survey data

The aim of this analysis is to establish whether there is a quantifiable link between: (1) the number of service measure failures each year and the level of trust in YWS; and (2) the level of trust in YWS and the costs incurred by YWS from refusals to pay water bills. The analysis was performed using YWS data on:

- Levels of trust by year i.e. average consumer trust scores for YWS customers.
- Customer payment status by year i.e. annual payment data and specifically information on the number of customers who refuse to pay their bills each year at a company-wide level.
- Costs of bill payment refusals i.e. the monetary cost to YWS associated with customers who refuse to pay their bills each year.

1.6.1 Levels of trust by year

YWS provided the results of the Customer Tracker survey over the period January 2012 to September 2017. The survey is sent to 300 respondents on a monthly basis and includes questions on both levels of trust and experiences of service measure failures by respondents.

With regards to trust, respondents are asked the extent to which they 'strongly agree', 'somewhat agree', 'neither agree nor disagree', 'somewhat disagree' or 'strongly disagree' with the statement *"Yorkshire Water are a company I trust"* (note, respondents are also able to select 'don't know' as a response). However, this question has only been included consistently in the survey design since August 2015 so the data prior to this could not be used in the analysis. Despite this, as the survey is repeated on a monthly basis, the dataset provides a relatively large sample size of measures of customer trust in YWS, with around 7,300 responses to the question.

With regards to service measure failures, respondents are asked *"When was the last time you contacted Yorkshire Water either via telephone or any other method of contact?"* followed by an open-ended question "What was the reason for this contact?" While the survey does not directly ask about service measure failures, it is possible to analyse the customer responses in terms of their broad alignment with the service measures

used in the DMF. Note, however, that the customer responses do not necessarily align with the DMF service measure categories so it was therefore necessary to match each of the responses as closely as possible with the DMF categories. The alignment is not perfect but it is expected to provide a reasonable indication of the issues that are of most concern to YWS customers.

It is also important to note that customers are not asked to provide any indication of the timeframes in which they have experienced service measure failures, how often these have occurred or how quickly they were resolved, but rather are simply asked about the last time they contacted YWS.

1.6.2 Customer payment status by year

As noted in Section 1.5.1, YWS provided data on the annual number of customers failing to pay their bills at a company-wide level over the period 2012-13 to 2016-17.[8] A longer time series dataset was requested although this was unavailable.

1.6.3 Costs of bill payment refusals

YWS also provided information on the average cost per customer refusing to pay their bills which was estimated to be around £428 per year.

1.6.4 Analysis

The information was collated and organised into a table showing the level of trust in YWS recorded for each of the customers surveyed and the reason for the last reported contact with YWS. Each of the customer responses to the question about the last contact they had with YWS was then mapped onto the one of the following service measure categories within the DMF:

- Supply interruption (note that it was not possible to distinguish between planned and unplanned interruptions so these were grouped into one category)
- Low pressure
- Drinking water quality (note that that it was not possible to distinguish between biological/chemical and aesthetic water quality issues so these were grouped into one category)
- Leakage
- Internal flooding
- External flooding
- Odour (note that while there were no mentions of pollution events in the customer contact reports, odour

[8] YWS (2017) 'Trust data overview V3.xls'

was raised as an issue for contacting YWS and so was included in the analysis)

Any responses which did not fit into these service measure categories were categorised as follows:

- Billing (and other general account related contacts)
- Water meter
- Drains (acknowledging that there be potential overlaps with flooding and odour)
- Other
- No information / contact reason provided

Aa regression analysis was then conducted to investigate whether or not there is a relationship between service measure failures and levels of trust. The dependent variable of the regression was the reported level of trust (scored on a -2 to +2 numerical scale) with the explanatory variables corresponding to the service measure categories (scored on a 1/0 scale). Those responses 'No information / contact reason provided' were excluded from the dataset.

An analysis was also attempted to establish whether there is a quantifiable relationship between trust levels and bill payment levels although there was insufficient time series data to support this (see Table 4). Further data on trust and bill payment levels would be needed to undertake this analysis. The regression outputs are shown in Table 8 in Appendix 2.

Table 4. Comparison of trust scores and bill payment levels over time

Year	2012-13	2013-14	2014-15	2015-16	2016-17
Trust score (-2 to +2)	-	-	1.39	1.39	1.37
No. customers defaulted (no.)	15,003	17,239	22,707	23,844	28,400

* Note the trust scores are collated over calendar years while the number of defaulted customers is determined for each financial year

1.7 Analysis of individual customer records

The aim of this analysis is to establish whether there is a quantifiable link between individual customers who do not pay their bills and their experience of service measure failures. The analysis was performed using data supplied by YWS on:

- Bill payment details i.e. details of individual customers who refuse to pay their water bills.
- Service measure failure details i.e. details of individual customers who have been impacted by service measure failures.
- Costs of bill payment refusals i.e. the monetary cost to YWS associated with customers who refuse to pay their bills each year.

1.7.1 Bill payment details

YWS provided data on the total number of customers in arrears (disaggregated by payment method type) as of August 2017, together with each customer's post code.[9] Any duplicate postcodes were removed from the list

[9] Yorkshire Water (2017), 'Arrears by post code Aug17.xlslx'

giving around 62,000 unique customers in arrears.

1.7.2 Service measure failure details

YWS provided data for a range of service failures over the period 2012 to 2017 and the post codes of customers who were affected, although data was not available for each measure consistently across this period and thus only 2016 data (for which data was available across all service measures) was used. The information on service failures is not classified using the service measures as defined in the DMF and thus various assumptions had

to be made in order to align the information on service failures with the DMF service measure categories. An overview of these assumptions is set out in Table 5.

Table 5. Overlap between service measure failures data provided by YWS and DMF categories

DMF Service Measure	DMF Impact Category	Corresponding Dataset	Categorisation in Dataset
Unplanned Interruption to Supply	< 3hrs	Interruptions 2010-date	Column T: Unplanned + Planned to Unplanned → Column V: 0-3 hours
	3 - 6hrs	Interruptions 2010-date	Column T: Unplanned + Planned to Unplanned → Column W: 3-6 hours
	6 - 12hrs	Interruptions 2010-date	Column T: Unplanned + Planned to Unplanned → Column X: 6-12 hours
	12 - 24hrs	Interruptions 2010-date	Column T: Unplanned + Planned to Unplanned → Column Y: 12-24 hours
	>24hrs	Interruptions 2010-date	Column T: Unplanned + Planned to Unplanned → Column Z: 24-48 hours + Column AA: >48 hours
Planned Interruption to Supply	< 3hrs	Interruptions 2010-date	Column T: Planned & Warned → Column V: 0-3 hours
	3 -6hrs	Interruptions 2010-date	Column T: Planned & Warned → Column W: 3-6 hours
	6 - 12hrs	Interruptions 2010-date	Column T: Planned & Warned → Column X: 6-12 hours
	12 - 24hrs	Interruptions 2010-date	Column T: Planned & Warned → Column Y: 12-24 hours
Drinking Water Quality (Biological & Chemical)	Trivial/ threshold sample failure	2016 -17 incident contacts for exclusion from PC & 2017 -18 incident contacts for exclusion from PC	-
	WQ parameter sample exceeds PCV at WTW - no health impact	2016 -17 incident contacts for exclusion from PC & 2017 -18 incident contacts for exclusion from PC	-
	WQ parameter sample exceeds PCV at WTW - health impact	2016 -17 incident contacts for exclusion from PC & 2017 -18 incident contacts for exclusion from PC	-
	WQ parameter sample exceeds PCV at SRE - no health impact	2016 -17 incident contacts for exclusion from PC & 2017 -18 incident contacts for exclusion from PC	-
	WQ parameter sample exceeds PCV at SRE - health impact	2016 -17 incident contacts for exclusion from PC & 2017 -18 incident contacts for exclusion from PC	-

DMF Service Measure	DMF Impact Category	Corresponding Dataset	Categorisation in Dataset
	WQ parameter sample exceeds PCV at Customer Property - no health impact	2016 -17 incident contacts for exclusion from PC & 2017 -18 incident contacts for exclusion from PC	-
	WQ parameter sample exceeds PCV at Customer Property - health impact	2016 -17 incident contacts for exclusion from PC & 2017 -18 incident contacts for exclusion from PC	Column A: Illness + Skin Irritation
	Protective advice required / Health impact due to PCV exceedence	2016 -17 incident contacts for exclusion from PC & 2017 -18 incident contacts for exclusion from PC	-
Drinking Water Quality (Aesthetic)	Taste and Smell	2016 -17 incident contacts for exclusion from PC & 2017 -18 incident contacts for exclusion from PC	Column A: Chlorine T&O + Earthy T&O + Hard Water + Other T&O + Phenolic T&O + Repeat T&O
	Discolouration	2016 -17 incident contacts for exclusion from PC & 2017 -18 incident contacts for exclusion from PC	Column A: Disc Water-Coloured + Disc Water-Historic + Disc Water-Grade 1 + Disc Water-Grade 2 + Disc Water-Grade 3 + Disc Water-Grade 4 + Disc Water-Sand
	Acceptability - Milky / Cloudy / Particles	2016 -17 incident contacts for exclusion from PC & 2017 -18 incident contacts for exclusion from PC	Column A: Biofilm + Milky/Air
Internal Property Sewer Flooding (Hydraulic and Other Causes)	Internal flooding of a cellar (Other Causes)	PR19 Sewer Flooding	Column A: INT → Column C: Other Causes → Column H: Cellar
	Internal flooding of habitable area (Other Causes)	PR19 Sewer Flooding	Column A: INT → Column C: Other Causes → Column H: BKUPFACLTY + Garden + Ground Floor + Integral/Att'd Garage + Other Internal + Under Floor
	Internal flooding of a cellar (Hydraulic)	PR19 Sewer Flooding	Column A: INT → Column C: Overloaded → Column H: Cellar
	Internal flooding of habitable area (Hydraulic)	PR19 Sewer Flooding	Column A: INT → Column C: Overloaded → Column H: BKUPFACLTY + Garden + Ground Floor + Integral/Att'd Garage + Other Internal + Under Floor
External Sewer Flooding (Hydraulic and Other Causes)	Flooding of minor roads (Other Causes)	PR19 Sewer Flooding	Column A: EXT → Column C: Other Causes
	Flooding of major roads (Oher Causes)	PR19 Sewer Flooding	

DMF Service Measure	DMF Impact Category	Corresponding Dataset	Categorisation in Dataset
	External flooding within the property boundary not inhibiting access (Other Causes)	PR19 Sewer Flooding	
	External flooding within the property boundary inhibiting access. (Other Causes)	PR19 Sewer Flooding	
	External flooding causing societal disruption i.e. impact on Schools, Hospitals, Sensitive properties etc. (Other Causes)	PR19 Sewer Flooding	
	Flooding of minor roads (Hydraulic)	PR19 Sewer Flooding	Column A: EXT → Column C: Overloaded
	Flooding of major roads (Hydraulic)	PR19 Sewer Flooding	
	External flooding within the property boundary not inhibiting access (Hydraulic)	PR19 Sewer Flooding	
	External flooding within the property boundary inhibiting access. (Hydraulic)	PR19 Sewer Flooding	
	External flooding causing societal disruption i.e. impact on Schools, Hospitals, Sensitive properties etc. (Hydraulic)	PR19 Sewer Flooding	
Pollution Incidents	Category 1 pollution incident	PR19 Pollution	Column X: 1
	Category 2 pollution incident	PR19 Pollution	Column X: 2 + 2c
	Category 3 pollution incident	PR19 Pollution	Column X: 3 + 3c + 3sw
	Category 4 pollution incident	PR19 Pollution	Column X: 4 + 4c + 4sw

1.7.3 Costs of bill payment refusals

As noted in Section 1.5.3, the average cost per bill refusal is estimated to be around £428 per year.

1.7.4 Analysis

In order to undertake the analysis, the data was collated and organised to show the year and postcode

corresponding to each service measure failure across the following categories:

- Unplanned supply interruptions
- Planned supply interruptions (note, there was no data on low pressure or leakage events)
- Drinking water (bio/chemical)
- Drinking water (aesthetic)
- Internal flooding
- External flooding
- Pollution incidents

This data was then transferred into a GIS and maps were developed for each service measure to show the spatial distribution of each event. Post code data on the number of customers in arrears was also used to map the spatial distribution of customers failing to pay their water bills. As with the previous analysis, it was not possible to distinguish between those customers who were in arrears because they could not pay (i.e. where affordability was an issue) and those that were in arrears because they would not pay. One could conceivably overlay the spatial data on arrears with the indices of multiple deprivation (on the basis that there is an established relationship between levels of deprivation and bad debt charges[10]) and thereby refine the analysis by excluding (or at least discounting) customers in arrears that are located in areas of high deprivation and who are therefore more likely to fall into the 'can't pay' rather than 'won't pay' category.

A regression analysis was then attempted to establish whether there is a quantifiable link between a customer being in arrears (the dependent variable) and whether that customer has experienced any of the service measure failures listed above (the explanatory variables). The post codes of customers in arrears were then mapped on to the service measure failure post code data for the same year (2016) to produce a dataset setting out the number of customers in arrears and the service measures they experienced in 2016. It is possible that more reliable results could be obtained by:

- analysing data in shorter (e.g. quarterly), successive time periods, .e.g. by examining the extent to which service failures in each quarter are a determinant of non-payment in that quarter or in future quarters. This follows from the finding of Ranaweera and Prabhu (2003) that while customers may be entirely satisfied with the response and recovery process following a service failure, they may not necessarily forget the incident or trust YWS not to make similar mistakes in the future.

- Controlling for other individual-level factors that may determine non-payment. For example, in the case of internal sewer flooding, customers may not be able to pay their bills due to the financial burden of uninsured flood losses. There may be seasonable factors that affect their ability to pay.

However, since there was no data available on the post codes of customers not in arrears, it was not possible to undertake the regression analysis as there was no variance in the dependent variable to be able to analyse whether or not the explanatory variables have any significance. In order to make the regression analysis possible, a full list of the post codes of all YWS customers (both customers in arrears and customers who paid on time) would be needed, together with data on whether or not they are in arrears, and any service measure failures they have experienced. A probit-type model could then be estimated on whether service failure in time *t* makes it more or less likely that a customer would not pay in period *t,* or period t+1.

As an alternative approach, the available data was analysed in order to assess what proportion of customers

[10] PWC (2017) Retail Services Efficiency benchmarking. Report for Ofwat [online] available at https://064f1d25f5a6fb0868ac-0df48efcb31bcf2ed0366d316cab9ab8.ssl.cf3.rackcdn.com/wp-content/uploads/2017/10/250717-Ofwat-Retail-Services-Efficiency-12.pdf

who experienced a service measure failure in 2016 were then recorded as being in arrears in 2017. This was then compared to the average proportion of customers in arrears across YWS in order to assess whether customers are more likely to be in arrears if they have experienced a service measure failure than if not. The results of this analysis were then combined with the average cost per customer refusing to pay their bills in order to provide a high level indication of the monetary costs of service measure failures.

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Appendix 2: Results

2.1 Overview

This Appendix provides an overview of the results for each of the three analyses undertaken as part of this work package. A final section then provides a discussion of the implications of the findings for YWS.

2.2 Company-wide / aggregate analysis of service measure failure and payment data

In order to try to establish whether there is a quantifiable relationship between service measure failures and rates of bill payment at a company-wide level a regression analysis was run on the data set out in Table 6.

Table 6. Summary of data used in the company-wide regression analysis

Dependent variable	2012-13	2013-14	2014-15	2015-16	2016-17
Defaulted customers (no.)	47,090	83,524	118,911	140,238	172,311

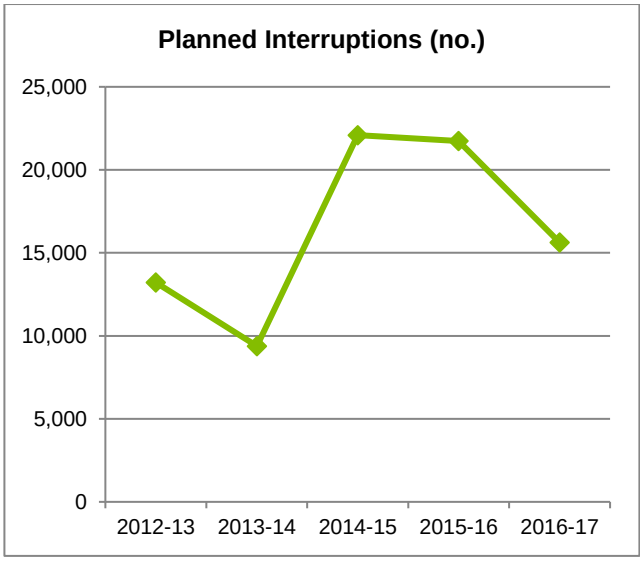
Explanatory variables	2012-13	2013-14	2014-15	2015-16	2016-17
Unplanned Interruptions (no.)	72,278	89,349	63,488	88,879	76,014
Planned Interruptions (no.)	13,207	9,385	22,091	21,738	15,617
Poor Pressure (no.)	10	14	9	11	8
Drinking Water Quality (Biological/Chemical) (%)	99.93	99.96	99.94	99.96	99.97
Drinking Water Quality (Aesthetic) (no./1,000 pop.)	1.16	1.33	1.20	1.03	0.97
Leakage (Ml/d)	264.62	282.27	288.42	285.12	295.16
Internal Sewer Flooding (no.)	1,005	680	821	731	724
External Sewer Flooding (no.)	5,532	3,794	3,928	3,987	3,809
Pollution Incidents (no.)	263	255	195	239	259

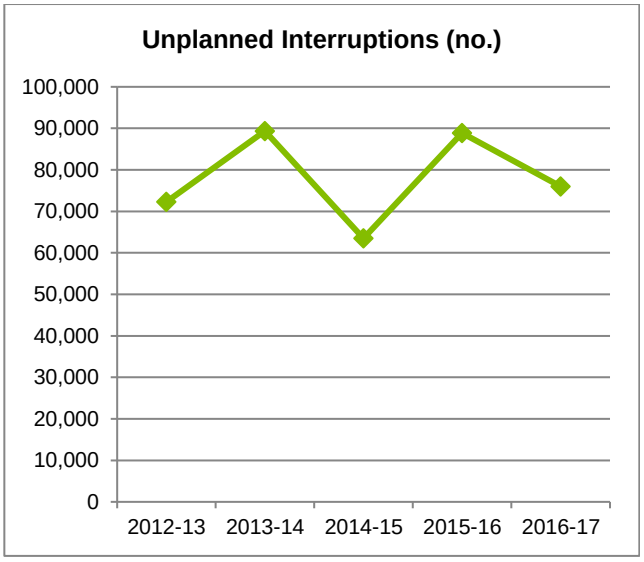
However, there were insufficient observations (given the number of explanatory variables) to identify a meaningful relationship between the dependent and explanatory variables. Graphs of the data set out above (see Figure 8) highlight that there is a high degree of correlation between some of the explanatory variables (in particular internal and external flooding, leakage and external flooding, and internal flooding and drinking water quality (biological/chemical)). A much larger dataset would therefore be required to establish whether there is a quantifiable relationship between bill payment rates and individual service measure failures at a company-wide level.

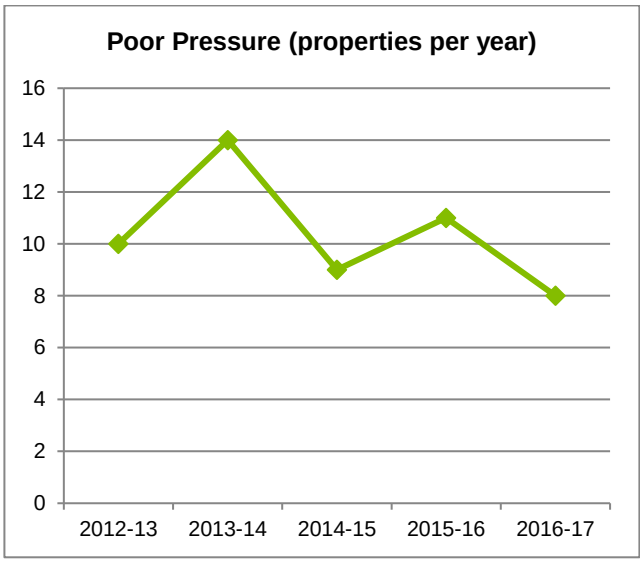
Ongoing data collection could allow this type of analysis to take place in future in order to try to establish whether there is a relationship between service measure failures and costs to YWS. Further information would also be

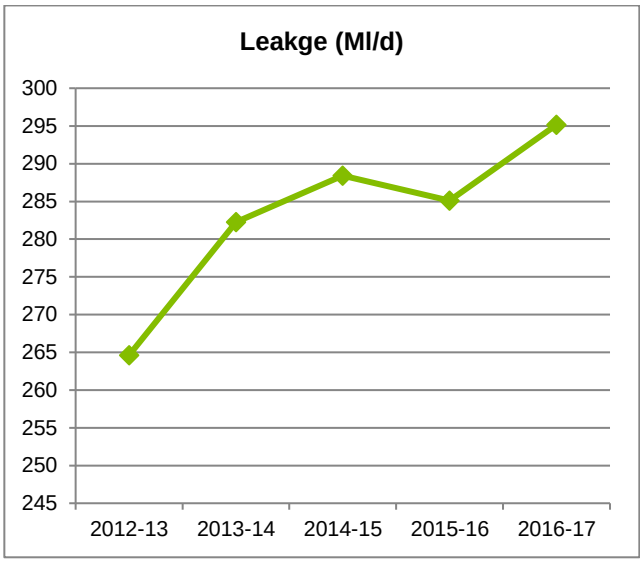
needed on the split between customers who ‘can’t’ and ‘won’t’ pay in order to establish a meaningful relationship.

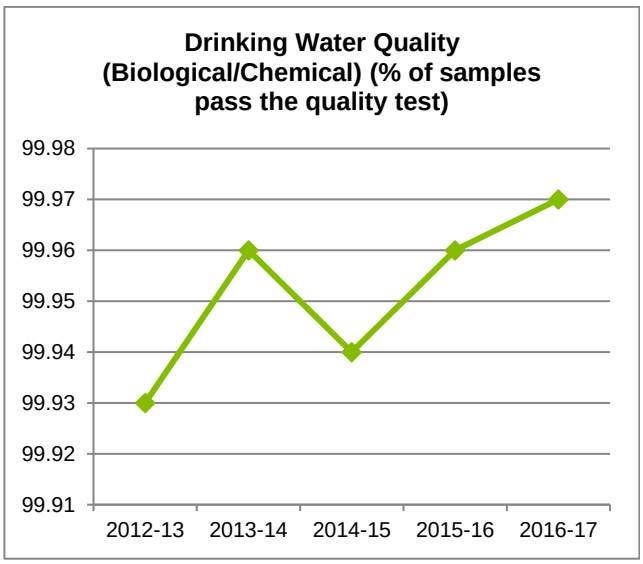
Figure 8. Graphical representation of trends in the variables analysed

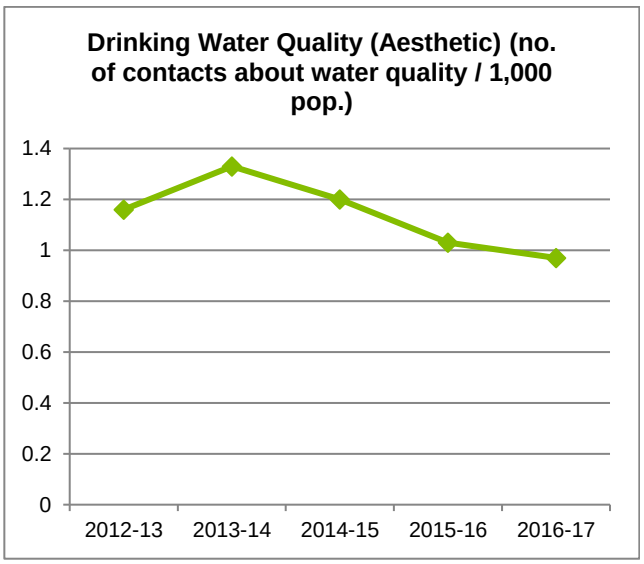

Planned Interruptions (no.)
25,000
20,000
15,000
10,000
5,000
0
2012-13
2013-14
2014-15
2015-16
2016-17

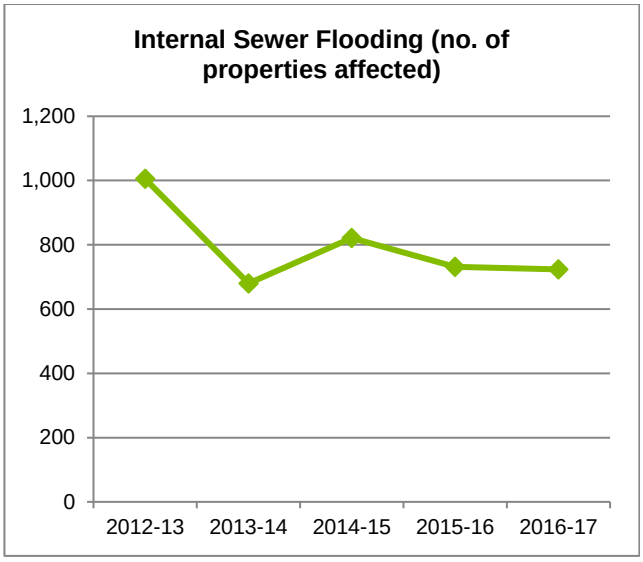

Unplanned Interruptions (no.)
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
2012-13
2013-14
2014-15
2015-16
2016-17

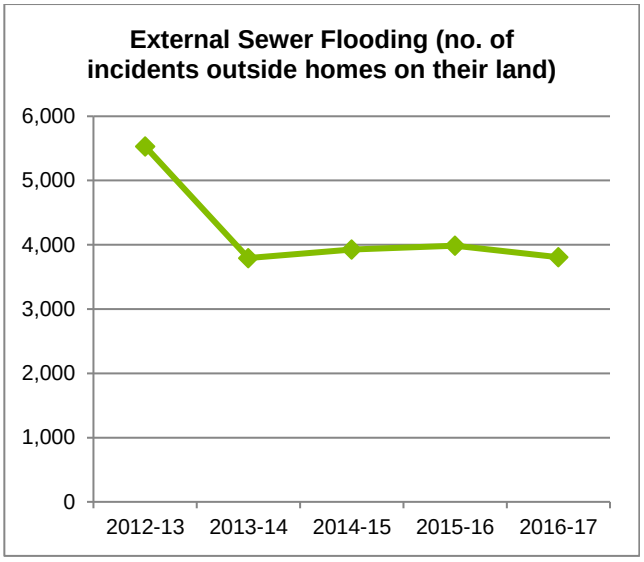

Poor Pressure (properties per year)
16
14
12
10
8
6
4
2
0
2012-13
2013-14
2014-15
2015-16
2016-17

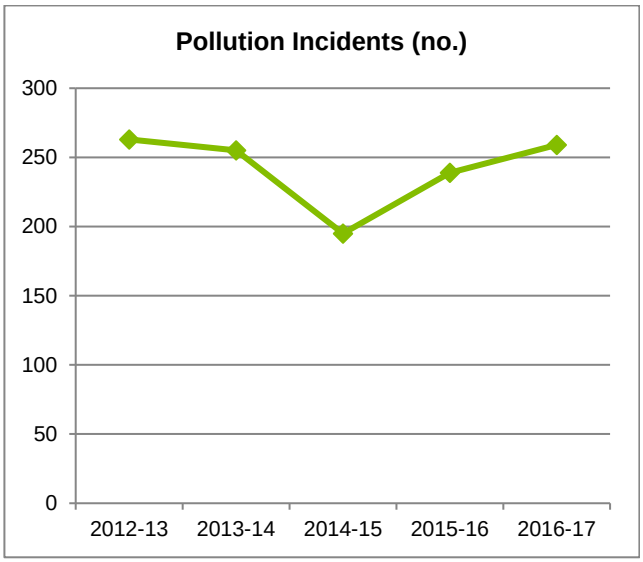

Leakge (Ml/d)
300
295
290
285
280
275
270
265
260
255
250
245
2012-13
2013-14
2014-15
2015-16
2016-17

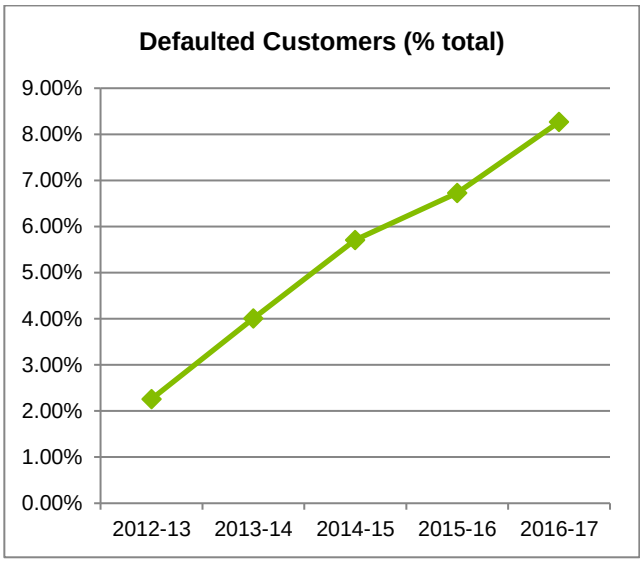

Drinking Water Quality (Biological/Chemical) (% of samples pass the quality test)
99.98
99.97
99.96
99.95
99.94
99.93
99.92
99.91
2012-13
2013-14
2014-15
2015-16
2016-17


Drinking Water Quality (Aesthetic) (no. of contacts about water quality / 1,000 pop.)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2012-13
2013-14
2014-15
2015-16
2016-17









2.3 Analysis of Customer Tracker survey data

The analysis of YWS Customer Tracker survey data suggests that trust in YWS is generally high and there is little variation on an annual basis (average score of 1.39 in 2015, 1.39 in 2016, and 1.37 in 2017) although there is a greater degree of variation on a monthly basis (see Figure 9).

Across YWS customers, half of all contacts were related to billing or other account related matters. Of the service measures, most contacts were about leakage (7%) followed by drinking water quality (3%), supply interruptions, and external flooding (3%). For many of the responses it was unclear how they should best be

categorised, particularly for flooding, leakage, and drainage issues.

The results are summarised in

Figure 10.

Figure 9. Overview of trust survey results from August 2015 to September 2017

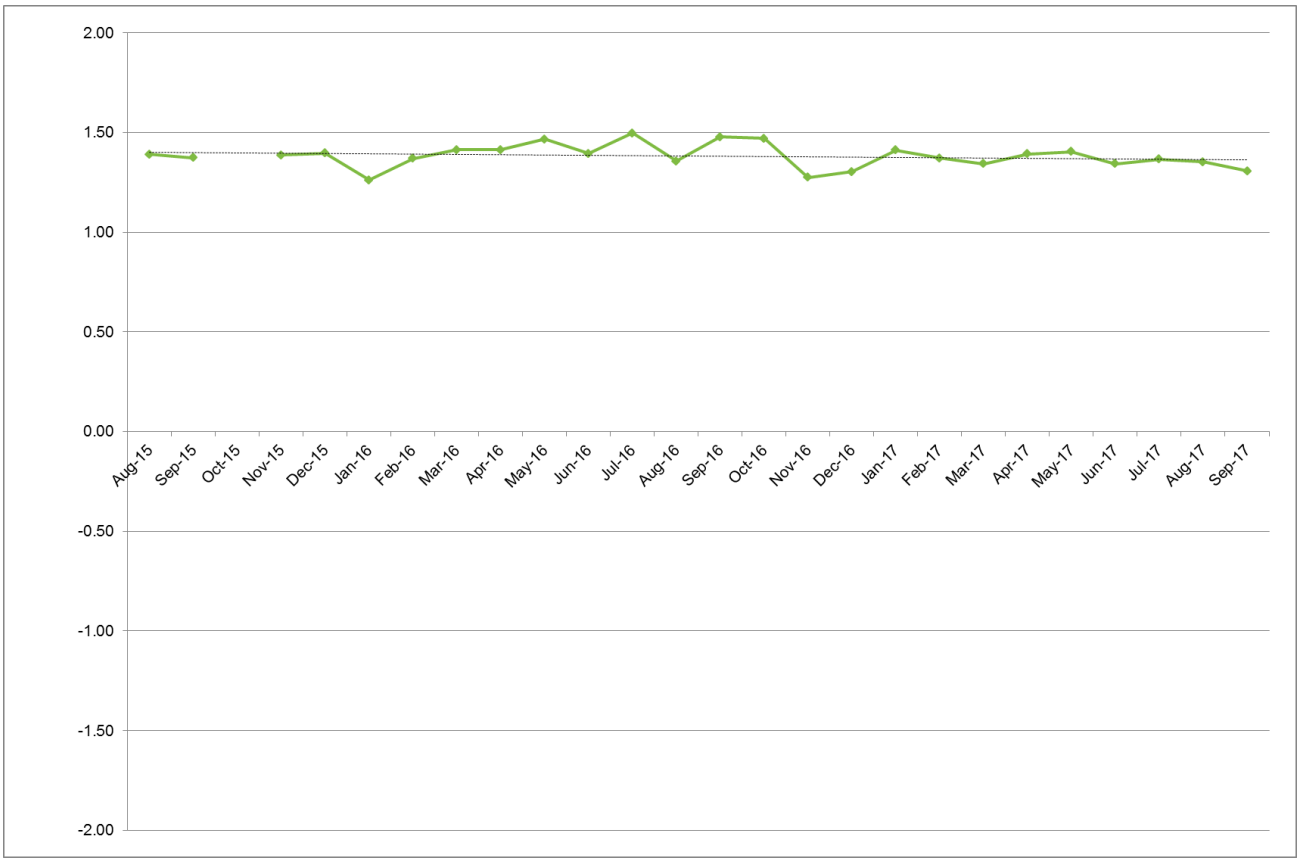
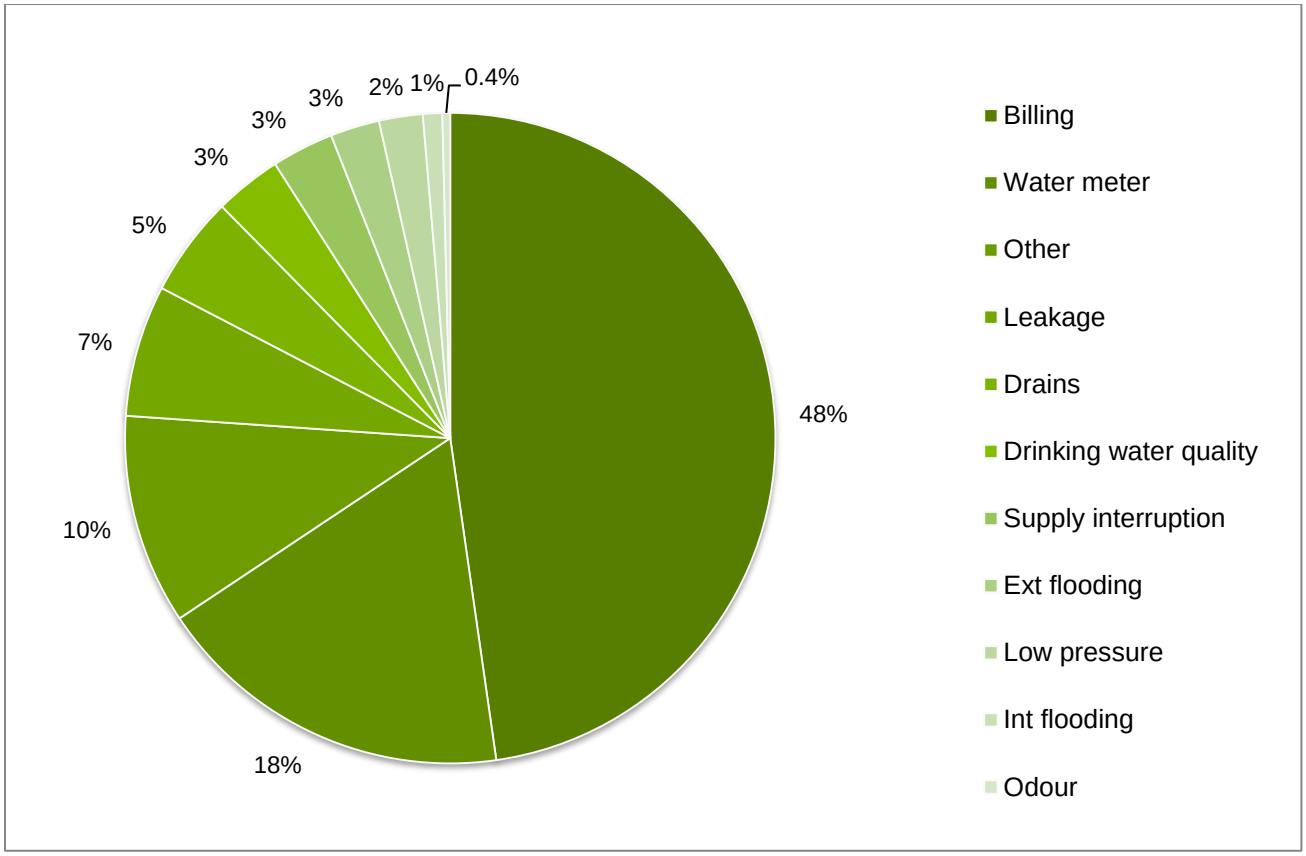


Figure 10. Breakdown of customer contacts over the period August 2015 – September 2017



In order to try to establish whether there is a quantifiable relationship between service measure failures and levels of trust a linear regression analysis was run on the data as set out in Table 7.

Table 7. Summary of data used in the trust survey regression analysis

Dependent	Explanatory						
Level of trust (-2 to +2)	**Customer contacted about leakage (0,1)**	**Customer contacted about drinking water quality (0,1)**	**Customer contacted about internal flooding (0,1)**	**Customer contacted about external flooding (0,1)**	**Customer contacted about low pressure (0,1)**	**Customer contacted about supply interruption (0,1)**	**Customer contacted about odour (0,1)**
-2	0	1	0	0	0	0	0
…	…	…	…	…	…	…	…

The results of the regression analysis are set out in Table 8 and suggest that each of the service measure failures has a negative impact on trust in YWS. However, of the explanatory variables, only that of drinking water quality, internal flooding, and odour were found to be statistically significant; of these, odour was found to have the strongest negative impact on trust. As such, the findings can be interpreted as providing some evidence that drinking water quality, internal flooding, and odour related service measure failures have a quantifiable impact on levels of trust in YWS; such that for every customer affected they are estimated to lead to a 0.32, 0.49, and 0.63 lower score on the trust survey respectively.

It is important to note that the R squared value for the regression was low – with the explanatory variables only explaining around 0.59% of the variance in trust scores. This suggests that any results should be carefully caveated with the understanding that there are numerous factors affecting trust levels in YWS and service

measure failures are only one small aspect of this.

One of the challenges with analysing the data is that it is often difficult to translate the customer's response about why they have contacted YWS to the relevant service measure categories – this is particularly the case for leakage, drainage, and flooding events.

A second issue is that the respondent's level of trust is likely to be impacted, not just by whether they have experienced a service measure failure directly, but how YWS dealt with that event. For example, if a flooding event is responded to promptly and efficiently, trust in YWS may actually increase.

A further complicating issue is that customers are responding about service measure failures experienced over different time periods as the survey does not specify a specific time period for recording responses. As such, some customers reported recent events whereas others may be referring to events – and possibly more than one event - that took place some time ago. The survey also does not pick up frequency of contacts with YWS and only captures the most recent contact.

In order to improve the analysis, the wording of the trust survey could be amended to allow a more precise analysis of this issue as follows:

- Ask customers whether YWS addressed the issue they contacted about in a satisfactory or unsatisfactory manner.
- Provide a coded response of service measure failures that respondents can select from when asked about their reason for contacting YWS (note this cold include an open response for 'other' reasons in addition to the coded list).
- Ask customers whether they have refused to pay their water bills since their last contact with YWS. An alternative approach could be to gather customer information from respondents that could be used to correlate their response with individual customer repayment records (such as post codes) although one would have to test for spatial auto-correlation (i.e. clustering effects). Alternatively, a further option could be to issue the trust survey directly to people who have refused to pay bills (although the response rate may be low).

Further data could also be collected on customer repayment rates over time to facilitate a regression analysis

of trust scores against repayment levels.

Table 8. Results of regression analysis of trust survey data

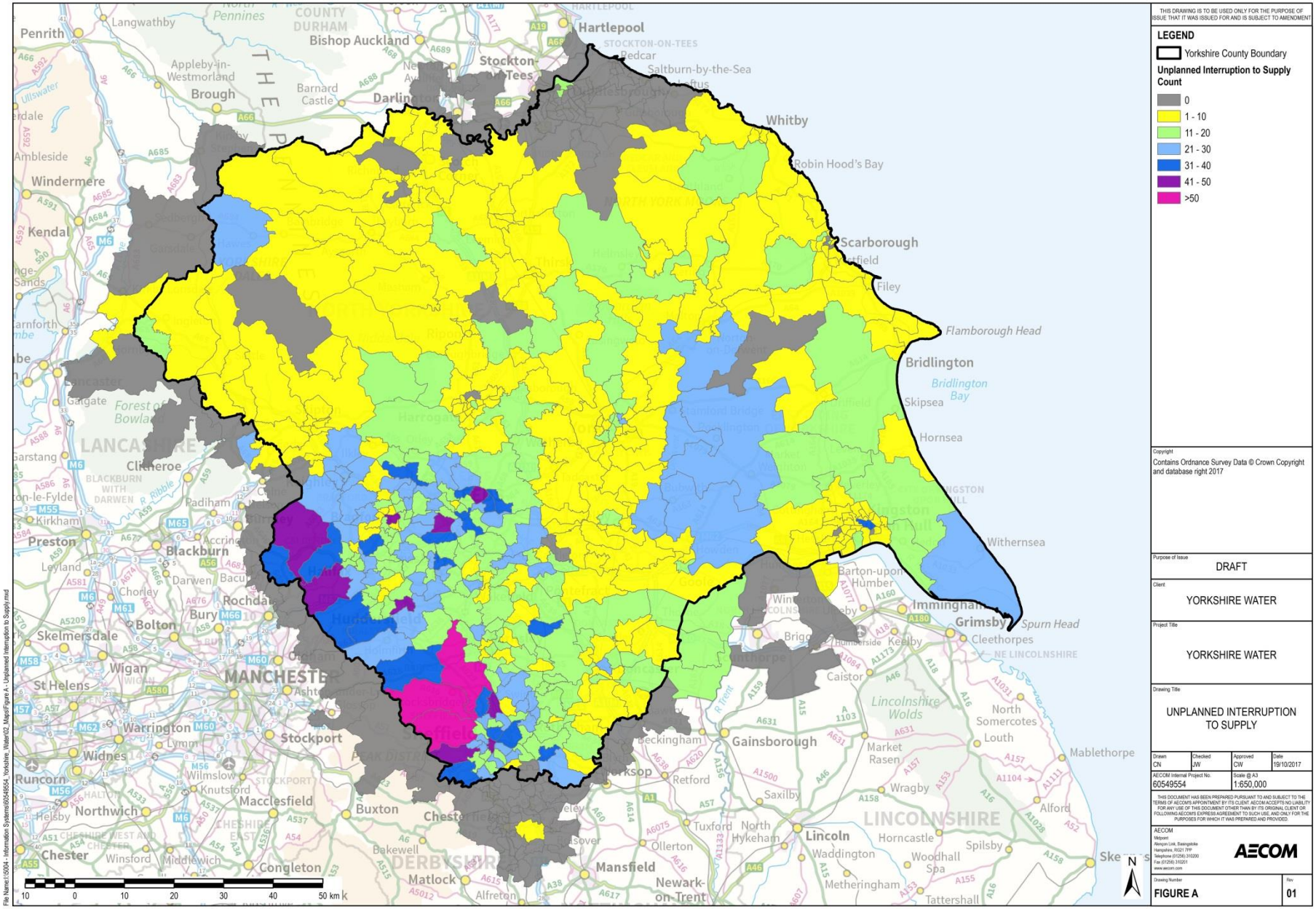
Regression Statistics	
Multiple R	0.07709446
R Square	0.005943556
Adjusted R Square	0.004977917
Standard Error	0.862999184
Observations	7,214

	df	SS	MS	F
Regression	7	32.08856696	4.584080994	6.155048959
Residual	7,206	5,366.79527	0.744767592	
Total	7,213	5,398.883837		

	Coefficients	Standard Error	t Stat	P-value
Intercept	1.393488809	0.010796772	129.0653145	0
Supply interruption	-0.080055973	0.075329525	-1.062743627	0.287933843
Low pressure	-0.056646704	0.089197697	-0.635069127	0.525403495
Leakage	-0.0320853	0.052247391	-0.614103388	0.539166396
Drinking water quality	-0.324523292	0.072476883	-4.477611066	0.000007665
Internal flooding	-0.488726904	0.133600644	-3.658117883	0.000255887
External flooding	-0.047694416	0.084124997	-0.566947022	0.570767835
Odour	-0.628782927	0.209586327	-3.000114245	0.002708015

2.2 Analysis of individual customer records

The spatial analysis (see Figures A to H) shows that, unsurprisingly, the areas with the highest concentration of customers in arrears (see Figure H) are also the areas with the highest populations (i.e. Leeds, Bradford, Doncaster, Sheffield, and Hull). With regards to the service measures, there are no obvious spatial correlations between the number of service measure failures and the location of customers in arrears.


THIS DRAWING IS TO BE USED ONLY FOR THE PURPOSE OF ISSUE THAT IT WAS ISSUED FOR AND IS SUBJECT TO AMENDMENT
LEGEND
Yorkshire County Boundary
Unplanned Interruption to Supply Count
0
1 - 10
11 - 20
21 - 30
31 - 40
41 - 50
>50
Copyright
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Purpose of Issue
DRAFT
Client
YORKSHIRE WATER
Project Title
YORKSHIRE WATER
Drawing Title
UNPLANNED INTERRUPTION TO SUPPLY
Drawn CN
Checked JW
Approved CW
Date 19/10/2017
AECOM Internal Project No. 60549554
Scale @ A3 1:650,000
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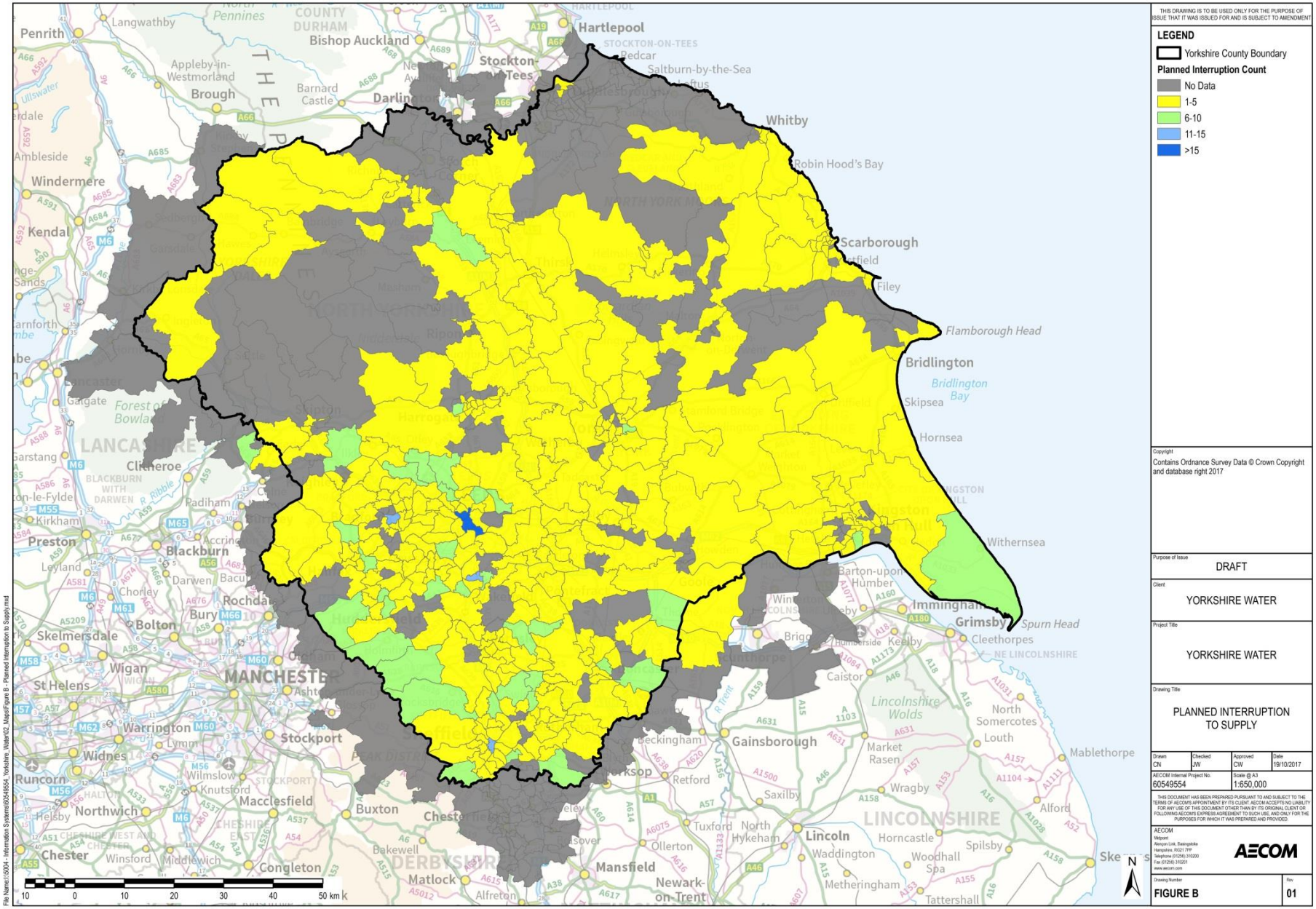
Drawing Number
FIGURE A
Rev
01
10 0 10 20 30 40 50 km
N
Hartlepool
Whitby
Robin Hood's Bay
Scarborough
Filey
Flamborough Head
Bridlington
Bridlington Bay
Skipsea
Hornsea
Withernsea
Spurn Head
Grimsby
Immingham
Cleethorpes
NE LINCOLNSHIRE
Barton-upon Humber
Caistor
Lincolnshire Wolds
Gainsborough
Market Rasen
Mablethorpe
North Somercotes
Louth
Alford
Wragby
Saxilby
Lincoln
Horncastle
Spilsby
Woodhall Spa
Waddington
Metheringham
Tattershall
LINCOLNSHIRE
Retford
Mansfield
Newark-on-Trent
Matlock
Buxton
Macclesfield
Stockport
MANCHESTER
Warrington
Wigan
St Helens
Widnes
Runcorn
Northwich
Chester
Winsford
Middlewich
Congleton
Knutsford
Wilmslow
Bolton
Bury
Rochdale
Blackburn
Preston
Skelmersdale
Leyland
Chorley
Darwen
Padiham
Clitheroe
Kirkham
Lancaster
Morecambe
Kendal
Windermere
Ambleside
Penrith
Langwathby
Appleby-in-Westmorland
Brough
Bishop Auckland
Barnard Castle
Stockton-Tees
Darlington
Saltburn-by-the-Sea
Redcar
Pennines
COUNTY DURHAM
YORKSHIRE DALES
NORTH YORK MOORS
LANCASHIRE
DERBYSHIRE
CHESHIRE EAST
CHESHIRE WEST AND CHESTER
File Name:I:\5104 - Information Systems\60549554_Yorkshire_Water\02_Maps\Figure A - Unplanned Interruption to Supply.mxd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LEGEND
Yorkshire County Boundary
Planned Interruption Count
No Data
1-5
6-10
11-15
>15
Copyright
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Purpose of Issue
DRAFT
Client
YORKSHIRE WATER
Project Title
YORKSHIRE WATER
Drawing Title
PLANNED INTERRUPTION TO SUPPLY
Drawn CN
Checked JW
Approved CW
Date 19/10/2017
AECOM Internal Project No. 60549554
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Drawing Number
FIGURE B
Rev
01
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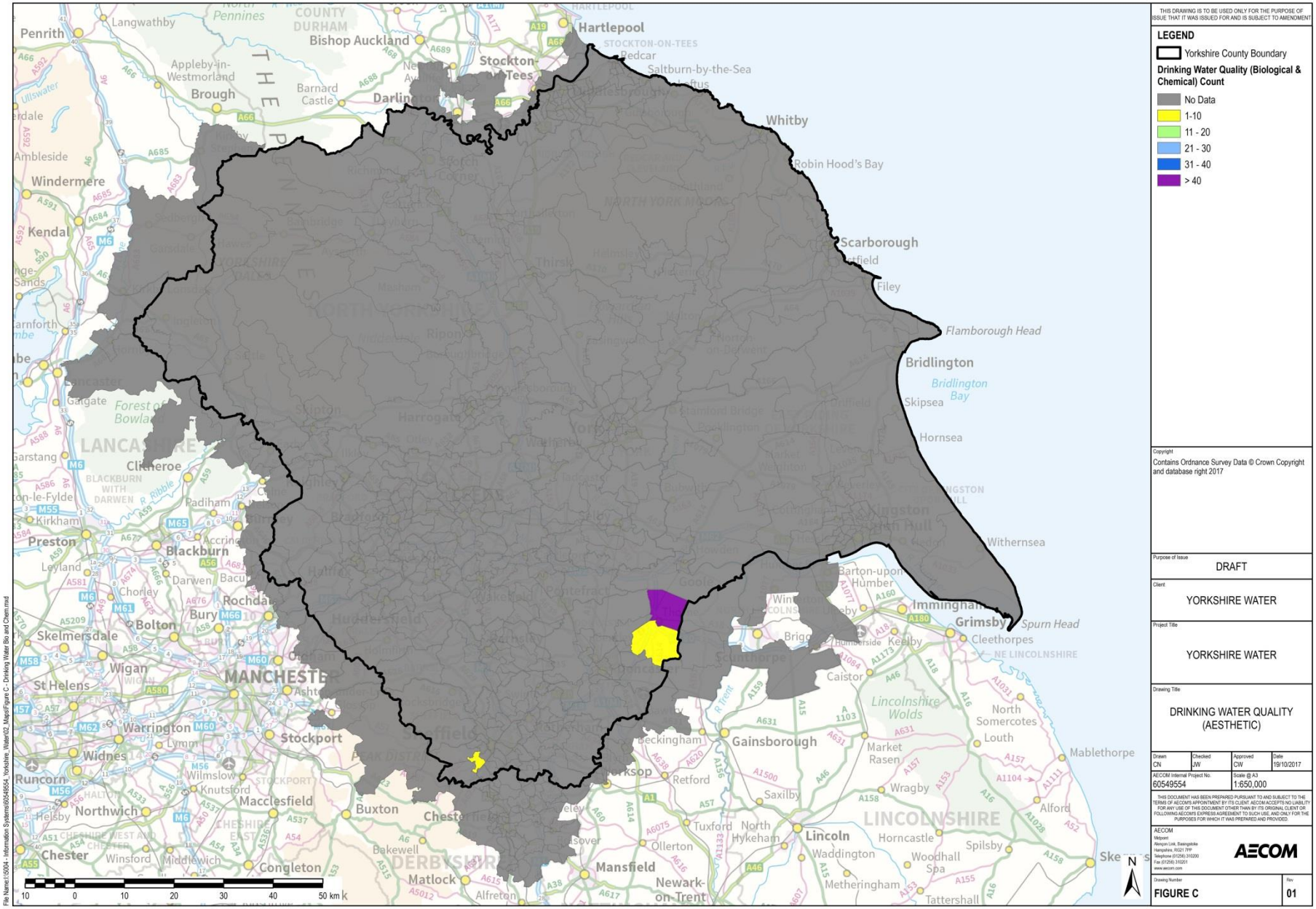
Whitby
Robin Hood's Bay
Scarborough
Filey
Flamborough Head
Bridlington
Bridlington Bay
Skipsea
Hornsea
Withernsea
Spurn Head
Grimsby
Immingham
Cleethorpes
Barton-upon Humber
Caistor
Lincolnshire Wolds
Gainsborough
Market Rasen
Mablethorpe
North Somercotes
Louth
Alford
Wragby
Saxilby
Retford
Lincoln
Horncastle
Spilsby
Woodhall Spa
Waddington
Metheringham
Tattershall
Mansfield
Newark-on-Trent
Matlock
Buxton
Macclesfield
Stockport
MANCHESTER
Warrington
Wigan
St Helens
Widnes
Runcorn
Northwich
Chester
Winsford
Middlewich
Congleton
Knutsford
Wilmslow
Preston
Blackburn
Bolton
Bury
Rochdale
Skelmersdale
Leyland
Chorley
Darwen
Padiham
Clitheroe
Kirkham
Lancaster
Morecambe
Kendal
Windermere
Ambleside
Penrith
Langwathby
Appleby-in-Westmorland
Brough
Bishop Auckland
Stockton-on-Tees
Darlington
Barnard Castle
Saltburn-by-the-Sea
Redcar
Pennines
THE PEAK DISTRICT
LANCASHIRE
CHESHIRE EAST
DERBYSHIRE
LINCOLNSHIRE
NE LINCOLNSHIRE
NORTH YORK MOORS
COUNTY DURHAM
STOCKTON-ON-TEES
HARTLEPOOL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Yorkshire County Boundary
Drinking Water Quality (Biological & Chemical) Count
No Data
1-10
11 - 20
21 - 30
31 - 40
> 40
Copyright
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Purpose of Issue
DRAFT
Client
YORKSHIRE WATER
Project Title
YORKSHIRE WATER
Drawing Title
DRINKING WATER QUALITY (AESTHETIC)
Drawn CN
Checked JW
Approved CW
Date 19/10/2017
AECOM Internal Project No. 60549554
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Drawing Number
FIGURE C
Rev
01
10 0 10 20 30 40 50 km
N
File Name:\\50\04 - Information Systems\60549554_Yorkshire_Water\02_Maps\Figure C - Drinking Water Bio and Chem.mxd

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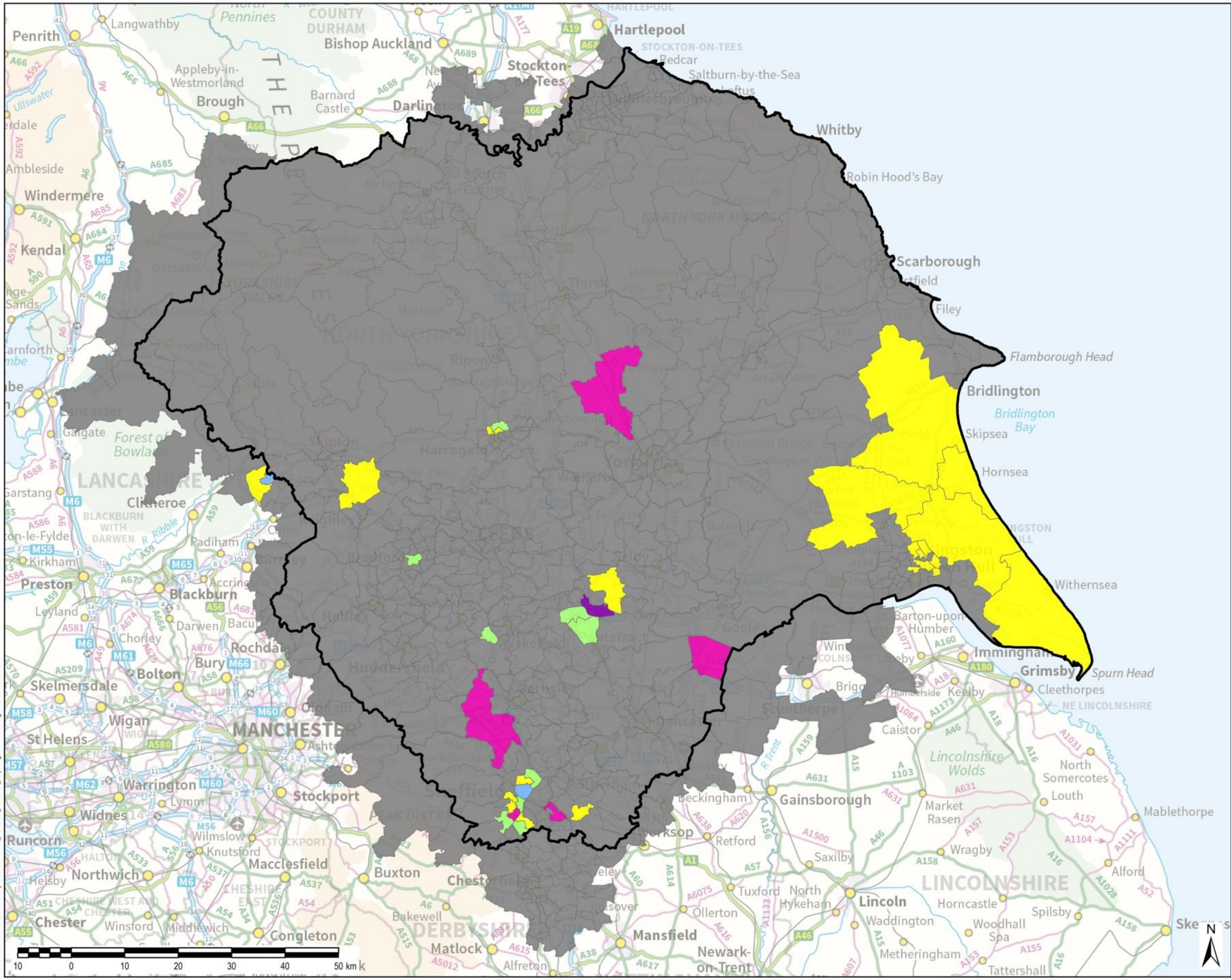

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LEGEND

- Yorkshire County Boundary

Drinking Water Quality (Aesthetic)

- No Data
- 1 - 10
- 11 - 20
- 21 - 30
- 31 - 40
- 41 - 50
- > 50

Purpose of Issue: DRAFT

Client: YORKSHIRE WATER

Project Title: YORKSHIRE WATER

Drawing Title: DRINKING WATER QUALITY (BIOLOGICAL & CHEMICAL)

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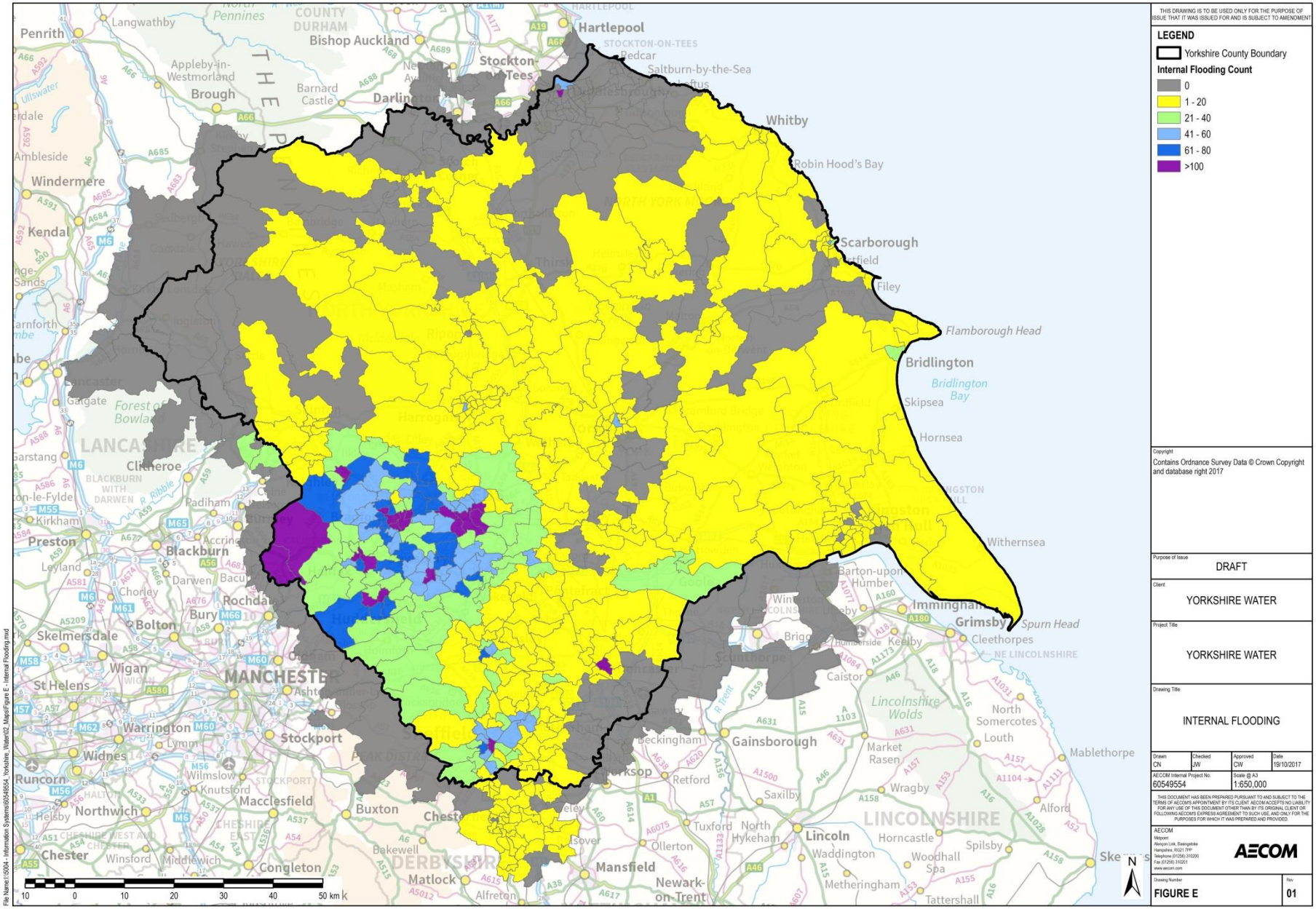
FIGURE D	01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LEGEND
Yorkshire County Boundary
Internal Flooding Count
0
1 - 20
21 - 40
41 - 60
61 - 80
>100
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Purpose of Issue
DRAFT
Client
YORKSHIRE WATER
Project Title
YORKSHIRE WATER
Drawing Title
INTERNAL FLOODING
Drawn
CN
Checked
JW
Approved
CW
Date
19/10/2017
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FIGURE E
Rev
01
10 0 10 20 30 40 50 km
N
Hartlepool
Whitby
Robin Hood's Bay
Scarborough
Filey
Flamborough Head
Bridlington
Bridlington Bay
Skipsea
Hornsea
Withernsea
Spurn Head
Grimsby
Immingham
Cleethorpes
Barton-upon Humber
Caistor
Lincolnshire Wolds
Gainsborough
Mablethorpe
Alford
Lincoln
Horncastle
Spilsby
Woodhall Spa
Waddington
Metheringham
Tattershall
Newark-on-Trent
Mansfield
Matlock
Alfreton
Chesterfield
Buxton
Macclesfield
Stockport
MANCHESTER
Warrington
Wigan
Bolton
Rochdale
Bury
Blackburn
Preston
Chorley
Skelmersdale
St Helens
Widnes
Runcorn
Northwich
Chester
Winsford
Middlewich
Congleton
Knutsford
Wilmslow
Clitheroe
Kendal
Windermere
Ambleside
Penrith
Langwathby
Appleby-in-Westmorland
Brough
Bishop Auckland
Stockton-on-Tees
Darlington
Barnard Castle
Saltburn-by-the-Sea
Redcar
Pennines
THE PEAK DISTRICT
LANCASHIRE
CHESHIRE EAST
CHESHIRE WEST AND CHESTER
DERBYSHIRE
NE LINCOLNSHIRE
LINCOLNSHIRE
NORTH YORK MOORS
COUNTY DURHAM
STOCKTON-ON-TEES
HARTLEPOOL
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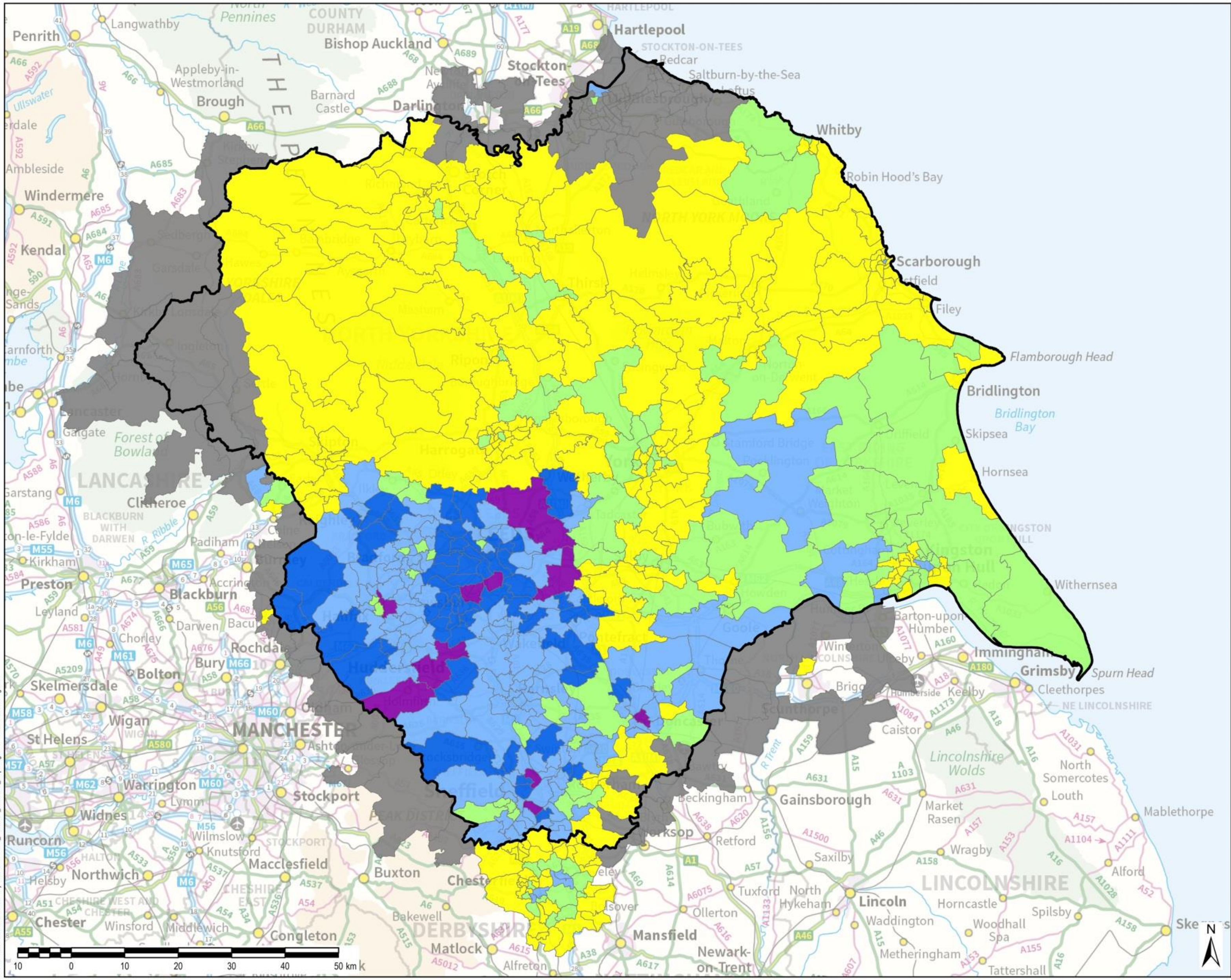

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LEGEND

Yorkshire County Boundary

External Flood Count

- No Data
- 1 - 50
- 51 - 100
- 101 - 200
- 201 - 300
- >300

Purpose of Issue: DRAFT

Client: YORKSHIRE WATER

Project Title: YORKSHIRE WATER

Drawing Title: EXTERNAL FLOODING

Drawn	Checked	Approved	Date
CN	JW	CW	19/10/2017

AECOM Internal Project No.	Scale @ A3
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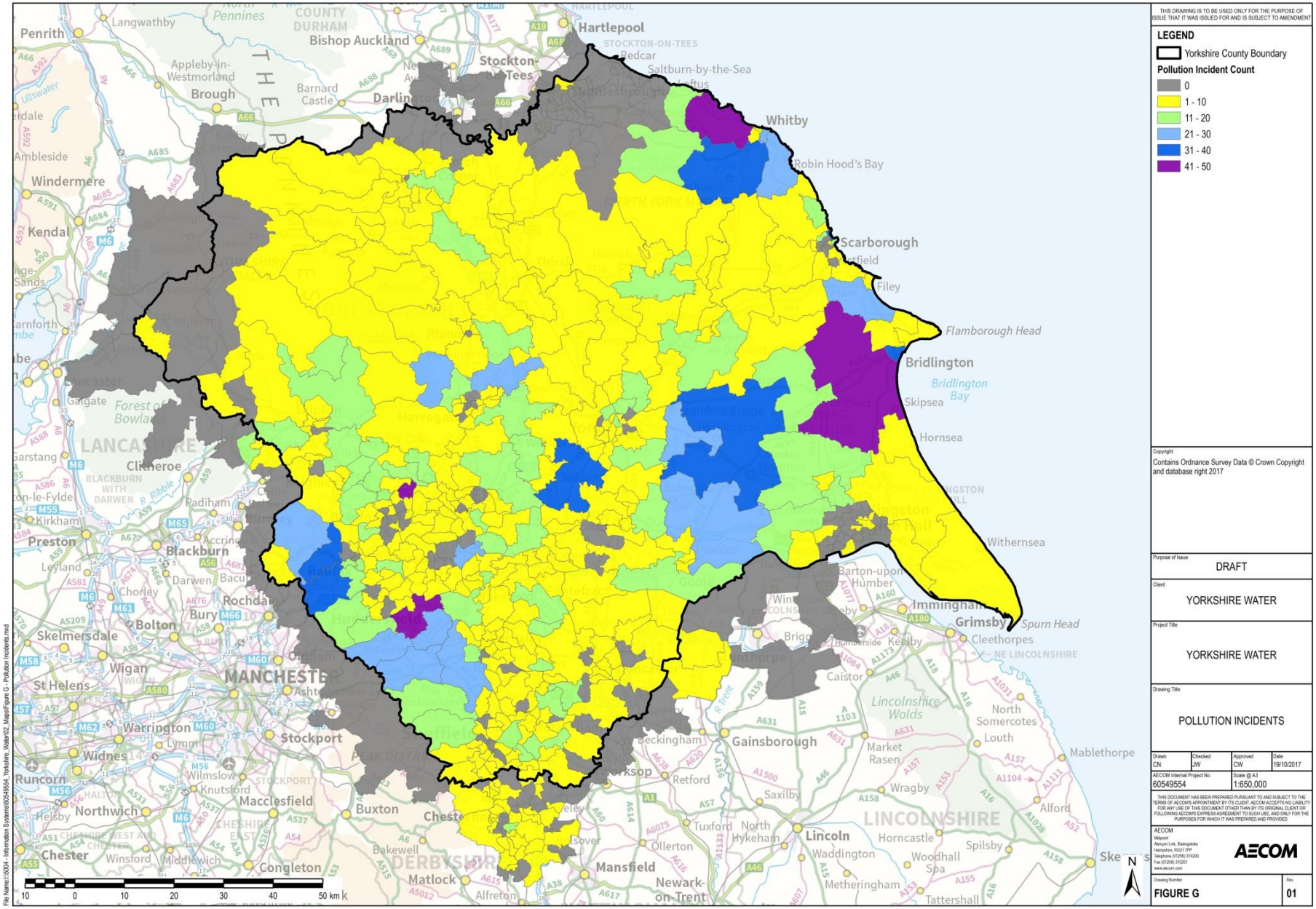
Drawing Number: **FIGURE F** | Rev: **01**

File Name: I:\5004 - Information Systems\60549554_Yorkshire_Water\02_Maps\Figure F - External Flooding.mxd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LEGEND
Yorkshire County Boundary
Pollution Incident Count
0
1 - 10
11 - 20
21 - 30
31 - 40
41 - 50
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Purpose of Issue
DRAFT
Client
YORKSHIRE WATER
Project Title
YORKSHIRE WATER
Drawing Title
POLLUTION INCIDENTS
Drawn
CN
Checked
JW
Approved
CW
Date
19/10/2017
AECOM Internal Project No.
60549554
Scale @ A3
1:650,000
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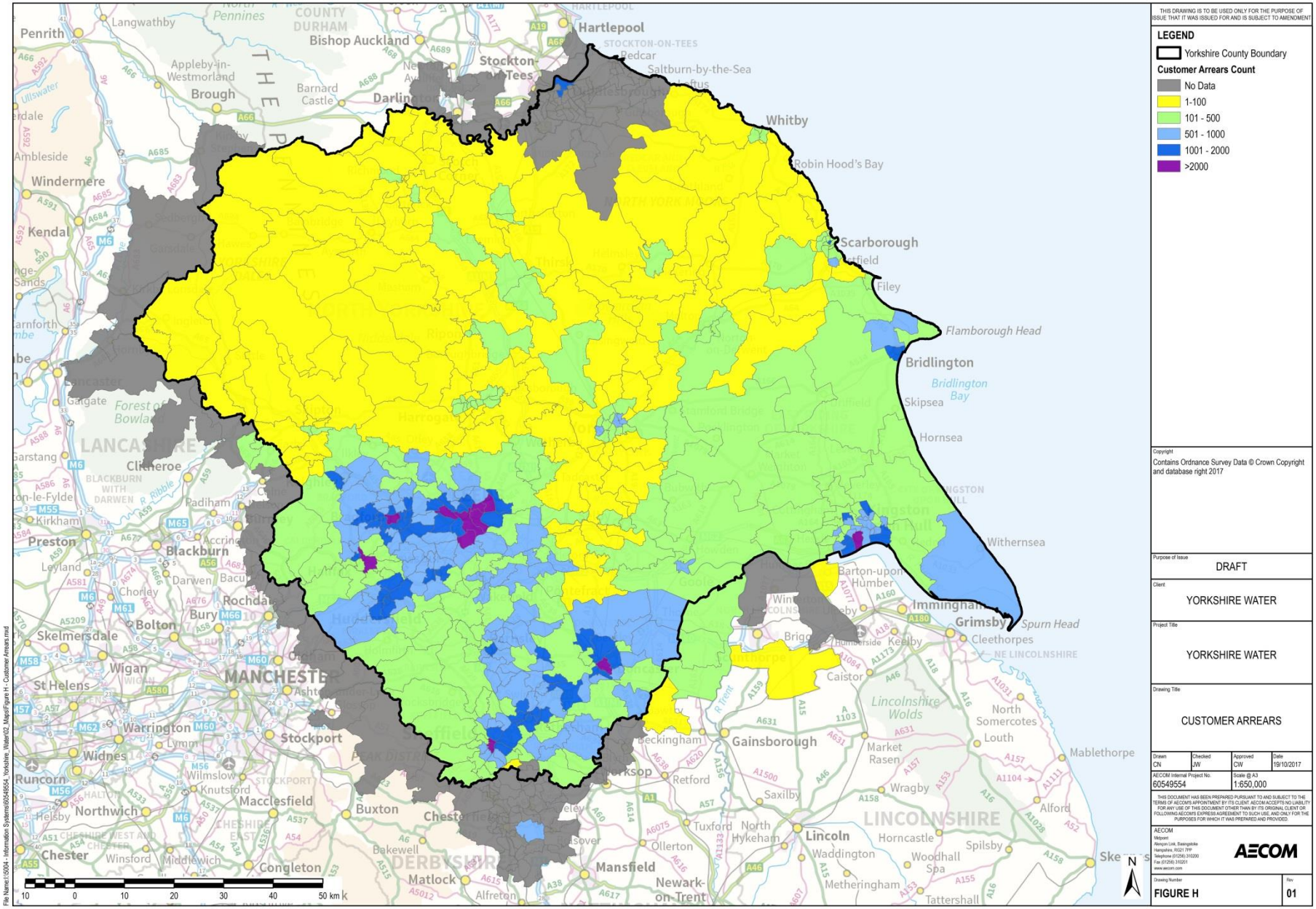
Drawing Number
FIGURE G
Rev
01
10 0 10 20 30 40 50 km
N
Hartlepool
Whitby
Robin Hood's Bay
Scarborough
Filey
Flamborough Head
Bridlington
Bridlington Bay
Skipsea
Hornsea
Withernsea
Spurn Head
Grimsby
Immingham
Cleethorpes
Barton-upon Humber
Caistor
Lincolnshire Wolds
Gainsborough
Market Rasen
Mablethorpe
Louth
North Somercotes
Alford
Wragby
Saxilby
Retford
Lincoln
Horncastle
Spilsby
Woodhall Spa
Waddington
Metheringham
Tattershall
Skegness
LINCOLNSHIRE
NE LINCOLNSHIRE
Mansfield
Newark-on-Trent
Matlock
Alfreton
Buxton
Chesterfield
Bakewell
DERBYSHIRE
Macclesfield
Stockport
MANCHESTER
Warrington
Wigan
St Helens
Widnes
Runcorn
Northwich
Chester
Winsford
Middlewich
Congleton
Knutsford
Wilmslow
Preston
Blackburn
Bolton
Bury
Rochdale
Skelmersdale
Leyland
Chorley
Darwen
Padiham
Clitheroe
Kirkham
Lancaster
Morecambe
Heysham
Kendal
Windermere
Ambleside
Penrith
Langwathby
Appleby-in-Westmorland
Brough
Barnard Castle
Bishop Auckland
Stockton-on-Tees
Darlington
Saltburn-by-the-Sea
Redcar
Pennines
COUNTY DURHAM
YORK
LANCASHIRE
File Name:I:\5104 - Information Systems\60549554_Yorkshire_Water\02_Maps\Figure G - Pollution Incidents.mxd



File Name:I:\5004 - Information Systems\60549554_Yorkshire_Water\02_Maps\Figure H - Customer Arrears.mxd

For the quantitative analysis, customers who experienced service measure failures in 2016 (aside from planned supply interruptions) were found to be more likely than the average proportion of YWS customers to be in arrears the following year. For example, in 2016-17 it was estimated that around 14%[11] of customers were in arrears; by contrast, around 27% of customers experiencing unplanned supply interruptions were in arrears in 2017. However, further work would be required to assess the extent to which service measure failures are randomly distributed across households or whether there is some factor that makes service measure failures more likely for a given household. If there is a factor that makes service measure failures more likely for any given household (i.e. where they experience repeat events), and this is also correlated with willingness to pay one's bill, then this complicates interpretation. Again, time-series data would be required to support such an analysis.

The proportion of people experiencing service measure failures in 2016 and being in arrears in 2017 was highest for internal flood events and drinking water quality (biological & chemical) events; such that 70% and 68% of all customers experiencing these service measure failures were in arrears the following year. This suggests that a large proportion of the customers who experience these service measure failures are likely to fail to repay their bills in future. These findings correlate with those of Analysis B which also identified internal flooding and drinking water quality events as having the most significant impact on trust.

Assuming that the difference in likelihood of being in arrears following a service measure failure relative to the average rate can be used as a proxy of the impact of service measure failures on bill repayment levels, and assuming an average cost per payment refusal of £428 per year (see Section 1.5.3), indicative values of the impact of service measure failures can be estimated as set out in Table 9 and Figure 11.

The results of this high level analysis suggest that the average cost per service measure failure ranges from £0 per year for planned interruptions to £243 per year for internal flood events. However, it is important to note that there are significant levels of uncertainty associated with these numbers and that this is a high level, indicative analysis rather than an in depth estimation of value.

In order to improve this analysis, the collection of time series would allow an examination of how long service measure failures persist in influencing bill repayment levels. A wider dataset would also provide context on whether this is a particularly unusual year or whether this is a regular pattern. A regression analysis of the number of customers in arrears against their experience of service measure failures would provide a more robust understanding of the link between these two factors. Further a more detailed understanding of the costs to YWS from customers in arrears would also be useful to develop a better understanding of the value of trust

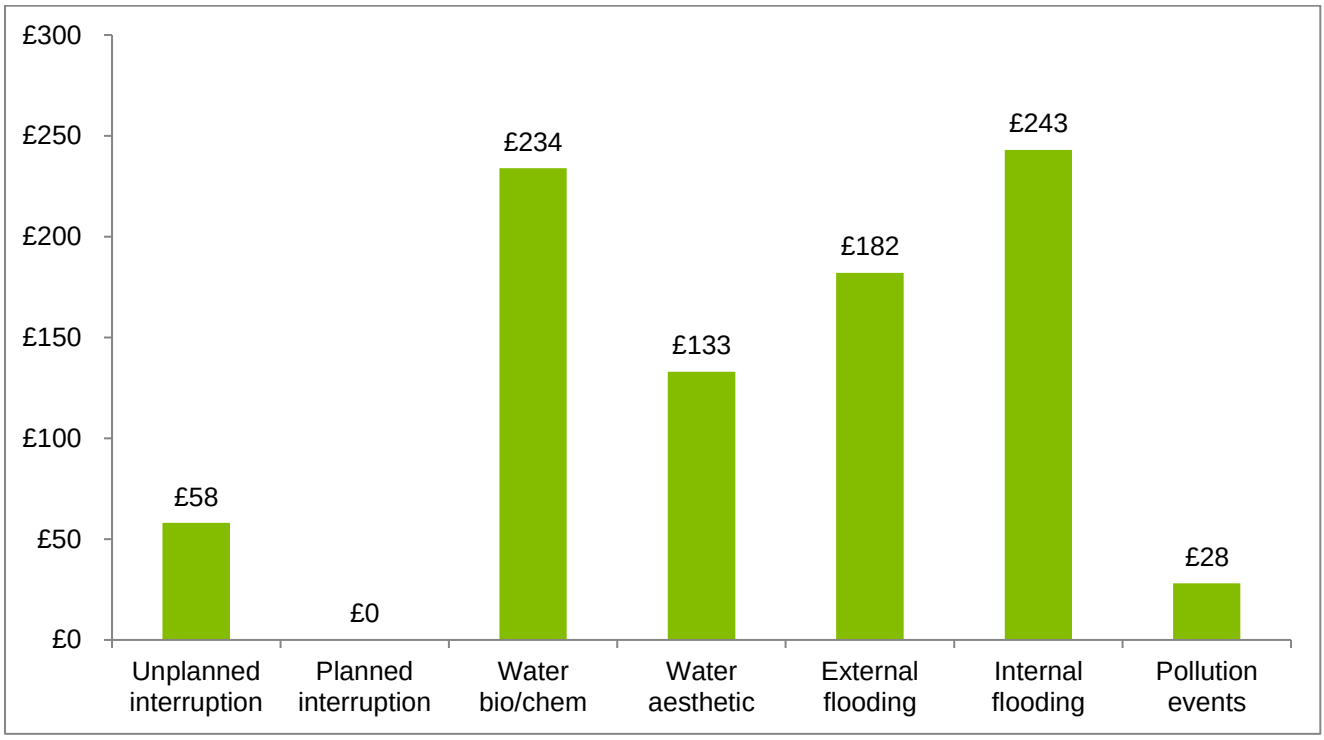
[11] Yorkshire Water (2017), 'Trust data overview V4.xslx'

to YWS.

Table 9. High level estimation of the cost of service measure failures in terms of customer repayments

Factor	Unplanned interruption	Planned interruption	Water bio/chem	Water aesthetic	External flooding	Internal flooding	Pollution events
No. experiencing service measure failures	808	434	41	288	9,171	1,867	479
No. experiencing service measure failure and in arrears	220	30	28	129	5,151	1,313	96
% in arrears of no. experiencing service measure failure	27.2%	6.9%	68.3%	44.8%	56.2%	70.3%	20.0%
% of all YWS customers in arrears	13.6%	13.6%	13.6%	13.6%	13.6%	13.6%	13.6%
Difference relative to average of % experiencing failures in arrears	+13.6%	-6.7%	+54.7%	+31.2%	+42.6%	+56.7%	+6.4%
Average cost per person in arrears each year	£428	£428	£428	£428	£428	£428	£428
Additional cost per service measure failure each year	**£58**	**-**	**£234**	**£133**	**£182**	**£243**	**£28**

Figure 11. High level comparison of the costs of service measures in terms of customer repayments



2.4 Findings

This section provides an overview of the findings for YWS based around the six overarching research questions

for this work package.

1) What factors define trust?

Despite emerging evidence from market research on the importance of trust in influencing customer behaviour, scholarly research on the topic is limited. Very little academic research has attempted to document empirically the factors that affect trust and where attempts have been made, this research has not systematically investigated the significance of trust in relation to other potential explanatoryfactors.

Market research conducted amongst water company customers in the UK suggests that higher levels of trust are associated with reliable water and sewerage services, value for money and customer service. Conversely, low levels of trust are associated with perceptions of poor value for money, high profits and inaffordability.

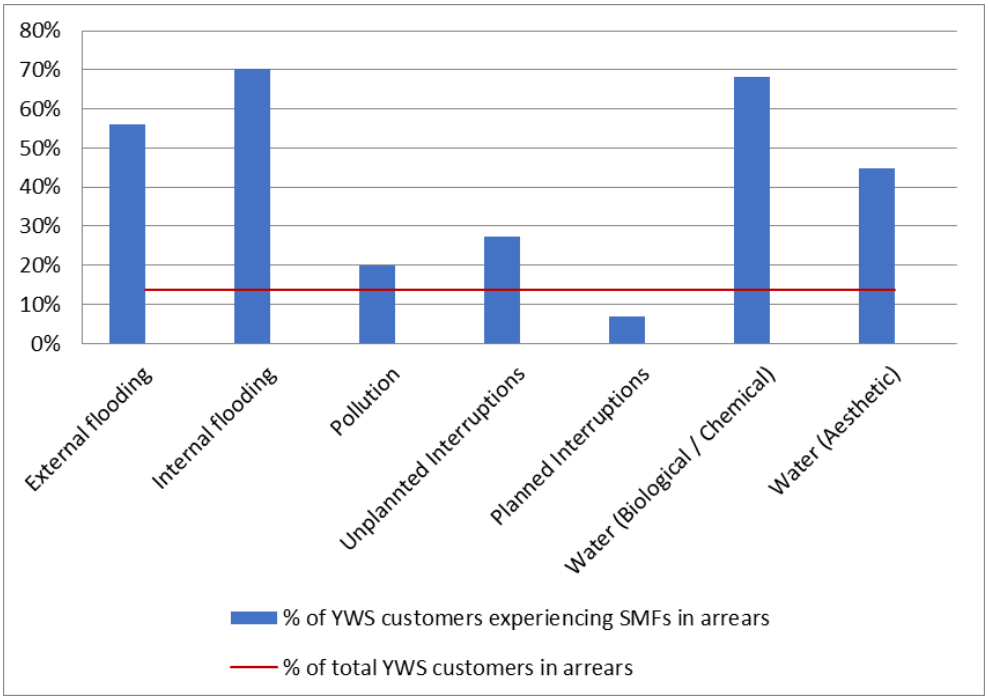
2) To what extent do different service measure failures impact upon levels of customer trust in YWS?

An analysis of 7,300 responses to the Customer Tracker survey over the period 2015-17 – in which respondents are asked the extent to which they agree or disagree with the statement *"Yorkshire Water are a company I trust"* – found that the trust in YWS is typically high and that the majority (>75%) of customers consistently 'strongly agree' with the statement. A regression analysis of this dataset found that drinking water quality, internal flooding, and odour related service measure failures all have a quantifiable negative impact on levels of trust in YWS. However, it is important to note that service measure failures only explain a very small amount of the variance in customers' levels of trust in YWS.

An analysis of the proportion of individual YWS customers who experience service measure failures found that customers experiencing unplanned supply interruptions, drinking water quality events, internal and external floods, and pollution incidents are more likely to be in arrears in the following year than typical YWS customers (see Figure 12).It is not, however, possible to say for certain whether or not this effect is due to changes in trust as there may multiple other factors that determine non-payment. As noted earlier, investigating quarterly time-step data over successive periods, controlling for other confounding factors and including trust as an explicit

determinant of payment behaviour may start to yield more reliable results.

Figure 12: YWS customers in arrears



The results therefore suggest that, while there are a wide range of factors which impact on trust, there is some evidence that unplanned supply interruptions, drinking water quality events, internal and external floods, and pollution incidents may have negative impacts on trust in YWS; with the evidence being strongest for drinking water quality, internal flooding, and odour.

3) Which service measures are most important in terms of determining customer trust?

Analysis of the Customer Tracker survey results found that odour events have the most significant negative impact on trust; with each customer experiencing an odour event giving, on average, a 0.63 lower score on the trust survey. Odour was followed by internal flooding events (leading to a 0.49 lower score) and drinking water quality events (with a 0.32 lower score).

The analysis of individual customer data also found that internal flooding events lead to the most significant increase in likelihood of a customer going into arrears (57% more likely) followed by drinking water quality events (55% more likely). This analysis found that biological/chemical water quality incidents as opposed to aesthetic incidents, had the greatest impact on customers going into arrears. There was no data in this analysis on odour related issues.

The results therefore suggest that odour events are the most important service measure in terms of influencing customer trust followed by internal flooding and drinking water quality events (particularly biological/chemical incidents).

4) What impact does trust have on customers' willingness-to-pay (WTP)?

It was not possible to explore this question with respect to Yorkshire Water within the agreed scope of the work

package. Nevertheless, the academic research points clearly to a positive relationship between social capital (of which different aspects of trust are key components) and WTP.

The literature review also highlighted some of the aproaches that could be considered for similar projects in future:

- Valuing trust as an attribute of WTP – one approach could be to include a series of attitudinal questions within a typical Stated Preference survey. The responses to these attitudinal questions could then be analysed to estimate the component of the overall WTP value which could be attributed to trust. This approach would be based on the assumption that customers with higher levels of trust in YWS would be likely to expect YWS to use money raised from their customers reliably, and thereby would be more likely to have a higher WTP for investing in tackling service measure failures.

- Trust as an incentive for customers to stay with YWS – an alternative approach could be to undertake a Stated Preference survey which estimates the level of monetary incentive customers would be willing to accept in order to switch from YWS to a new, untested water utility. This approach would be based on the assumption that customers with high levels of trust in YWS would be more likely to require a higher incentive to switch to an untested new provider.

- Analysing the results from Work Packages 1, 2 & 5 – as an alternative to undertaking additional primary research, the data collected as part of Work Packages 1, 2 & 5 could be used to explore this question in more depth. For example, WP1 examined the extent to which respondents' experiences of service measure failures influenced WTP and found that there was generally a positive relationship between service measure failures and WTP (i.e. those who had experienced failures exhibited a higher WTP for at least). Moreover, the information collated for each of these work packages is spatially explicit (i.e. can be attached to individual postcodes) and thus could be combined with YWS data on arrears (by postcode) to reveal whether or not stated preferences (i.e. the WTP estimates) track actual payment behaviour).

5) Do service measure failures impact the likelihood of customers paying their water bills?

The analysis of individual customer data found that customers who experienced service measure failures in 2016 (aside from planned supply interruptions) were more likely than the average YWS customer to be in arrears the following year. For example, in 2016-17 it was estimated that around 14% of customers were in arrears, by contrast, around double the proportion of customers experiencing unplanned supply interruptions were in arrears in 2017.

The proportion of people experiencing service measure failures in 2016 and being in arrears in 2017 was highest for internal flood events and drinking water quality (biological & chemical) events; such that 70% and 68% of all customers experiencing these service measure failures were in arrears the following year. This suggests that a large proportion of the customers who experience these service measure failures may fail to repay their bills in future.

The average water bill for defaulted customers in 2016-17 was estimated to be £405 per year, while the wider costs of bill payment refusals were estimated to be £3.976 million or around £23 per defaulting customer. The total average cost per payment refusal is thus estimated to be around £428 per year. It can be seen from **Figure 3** that the proportion of YWS customers who have experienced a service measure failure who are in arrears is significantly higher than the proportion of total YWS customers who are in arrears. The difference between the two is taken as the proportion of additional cost that YWS bears as a result of service measure failures. By applying the percentage difference to the average total cost, one obtains an estimate of the additional costs to

YWS for each type of service measure failure as follows:

- Unplanned interruption = £58 per customer affected per year
- Planned interruption = £0 per customer affected per year
- Drinking water quality (biological/chemical = £234 per customer affected per year
- Drinking water quality (aesthetic) = £133 per customer affected per year
- External flooding = £182 per customer affected per year
- Internal flooding = £243 per customer affected per year
- Pollution events = £28 per customer affected per year

However, it is important to note that there are significant levels of uncertainty associated with these numbers and that this is a high level, indicative analysis rather than an in depth estimation of value.

In order to improve this analysis, a series of additional data collection exercises could be undertaken:

- Company-wide data – further time series data could be collected on the annual numbers of service measure failures, customer payment defaults, and the costs of payment defaults at a company wider level. Further information would also be useful on the split between customers who 'can't' and 'won't' pay, as well as a more detailed breakdown of the costs to YWS from customers in arrears.
- Trust survey data – the wording of the Customer Tracker survey could be amended as follows: (1) ask customers whether YWS addressed the issue they contacted about in a satisfactory or unsatisfactory manner; (2) provide a coded response of service measure failures that respondents can select from when asked about their reason for contacting YWS; (3) ask customers whether they have refused to pay their water bills since their last contact with YWS. Note, an alternative could be to gather customer information from respondents that could be used to correlate their response with individual customer repayment records (such as post codes). Alternatively, a further option could be to issue the trust survey directly to people who have refused to pay bills (although the response rate may be low).
- Individual customer data – further data could be collected on the post codes of customers in arrears for different years, together with additional data on service measure failures experienced by those customers in previous years. This information could also be combined with spatially disaggregated information on avertive expenditure (e.g. the findings from Work Package 4) to identify where there may be overlaps between specific service measure failures, avertive expenditure, trust and customer satisfaction. A full list of the post codes of all YWS customers would also be useful for undertaking a more robust quantitative analysis and supporting the development of a more nuanced understanding of the spatial distribution of bill refusals or customers in arrears. This would help, for example, in examining the proportion of customers in arrears (e.g. per 10,000 connections) in different postcode areas or regions independent of the total size of the population.

6) Do service measure failures mean that YWS incurs higher levels of debt?

It was not possible to answer this question based on the data provided by YWS. The average water bill for defaulted customers in 2016-17 was estimated to be £405 per year, while the wider costs of bill payment refusals were estimated to be £3.976 million or around £23 per defaulting customer. Data was requested on a more detailed breakdown of costs for customers refusing to pay their water bills, including any impacts on debt, although this data was not available. For this issue to be explored more detailed data would be required on the

impact of customer payments on debt levels.

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