# IMPROVING WATER QUALITY ON THE RIVER WHARFE FROM OUGHTERSHAW TO THE OUSE:

# A CITIZEN SCIENCE PROJECT

## Faecal bacteria indicator data from samples collected from recreational sites on the 23rd August 2021

# iWHARFE_21

## Improving water quality on the River Wharfe from Oughtershaw to the Ouse: a citizen science project

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**Introduction**

The iWharfe project is a citizen science project concerned with water quality in the River Wharfe. It was designed in 2020 by the Ilkley Clean River Group, Yorkshire Dales Rivers Trust (YDRT), Addingham Environment Group, Dales to Vale River Network and the Environment Agency and involved charities and other community groups from along Wharfedale working together. Funding in 2020 was provided by local councils, charities and private donations. In 2021 funding was provided by the YDRT's project WaterCog.

In 2020, the principal aim of iWharfe was to raise awareness about river water quality by showing how concentrations of faecal bacteria (of concern for human health) and nutrients (of concern for ecosystem health) varied along the river on a single day[1]. It was also designed to identify sources of faecal contamination by sampling upstream and downstream of potential pollution sources including Sewage Treatment Works (STW) and selected tributary becks.

In 2021, almost exactly one year later, on the 23rd of August, we re-surveyed the river using an identical sampling methodology. However, samples were only collected from recreational sites (Figure 1). They were analysed at the ALS Ltd laboratory in Coventry. Only *E. coli* was analysed as Covid related staffing problems in the laboratory prevented samples for intestinal enterococci (IE) analysis within the 24 hours allowed for reliable results to be obtained.

Our specific objective in 2021 was to assess the potential exposure of the general public using the river for recreation to a health risk from faecal pathogens on the day of sampling.

As faecal bacteria concentrations vary greatly from day to day depending especially on river flow[2], many samples collected over the year are needed before a bathing water status can be safely established - indeed the World Health Organisation (WHO) recommend that a location's compliance with their guidelines is based on 20 samples per annum.

In the absence of a larger data-set, and for illustrative purposes only, we indicate the status of each site on the assumption that our single sample *E. coli* value for each site equates to the geometric mean of a much larger time series.

Here we present the results and make a comparison with the *E.coli* data from the same sites sampled in 2020, analysed by the same laboratory in the same way.

## Sites

Sites selected for sampling were those identified in 2020 as recreational sites i.e., those on the main river known to be popular for swimming, paddling or other water-based recreational activity (Appendix A). In most cases samples were taken directly from the recreational site itself. In a few cases, however, nearby easier to sample proxy sites were selected.

To enable samples to be collected at approximately the same time on the same day the river was divided into five zones (Figure 1) each with its own sampling team. In contrast to 2020 river levels were low (Appendix B) although there had been significant rainfall on the previous day, Sunday the 22nd August. It is likely that the rain on the previous day, occurring after a long period of dry weather, had a significant effect on faecal bacteria, elevating concentrations in the river.

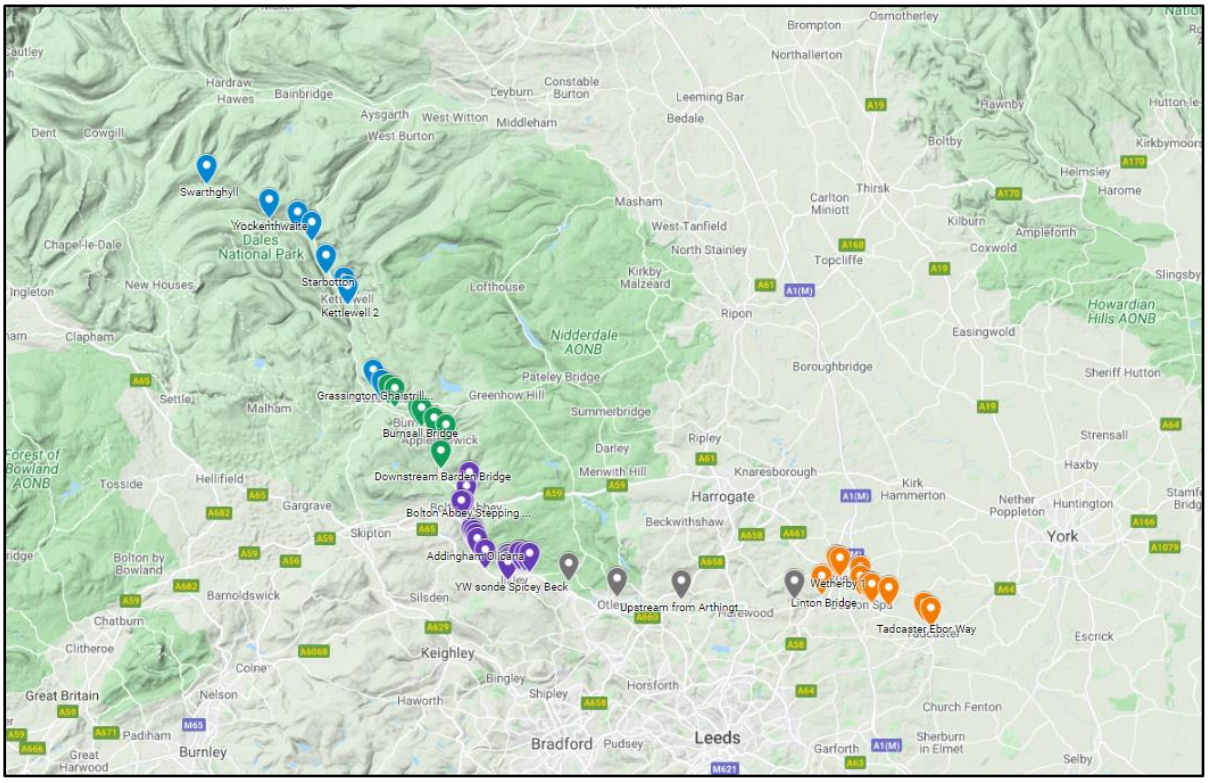



*Figure 1. iWharfe sample sites showing five zones from the headwaters in Langstrothsdale in the northwest to the confluence with the River Ouse at Cawood in the southeast. The five zones are shown by different coloured markers. Sites on tributary streams referred to in the text are not shown.*

## Methods

### *Field sampling*

The five field teams were provided with identical equipment including sterile sample bottles and cool bags. Bags of crushed ice were used to keep the temperature of the samples between 2 and 8° C. Samples were collected by hand or by using a simple throw bottle on a lead-weighted rope (Appendix C). Sampling began in the early morning and was completed in each zone by early afternoon.

*Laboratory analysis*

The samples were collected and taken to ALS Ltd in Wakefield on the afternoon of the 23rd August and then delivered to ALS Coventry for microbiological analysis which took place within 24 hours of collection. Samples were diluted x100 to allow colonies to be counted after incubation giving a detection limit of 100 cfu/100 ml.

*Visitor numbers*

In 2020, we assessed the relative popularity of the different recreational sites along the river by counting visitor numbers at each site on the Sunday prior to water sampling on the Monday. It was our intention to conduct visitor counts again in the same way in 2021 but weather conditions on the Sunday were very poor and few visitors were present. Consequently, in Appendix A we only show data for 2020 as a guide to likely popularity in 2021.

## Results

*E. coli concentrations 2021 and 2020*

Figure 2 shows the results of the *E. coli* analyses for the 32 samples taken in August 2021 ranging from Swarthghyll close to the source of Oughtershaw Beck, the main headwater of the Wharfe, down to Cawood where the Wharfe meets the Ouse, south of York. Figure 3 shows the same data but presented in comparison to *E. coli* data from the same sites in 2020 when river levels were much higher (Appendix B).

- The 2021 sample at Swarthghyll (not shown in Figure 2) recorded a zero value, an expected value for water running off the local moors (unpublished personal observation).
- Except for the low value at Yockenthwaite and the high value at Starbotton, *E. coli* concentrations along the whole of Upper Wharfedale and downstream as far as Ilkley varied between 600 and 2,500 cfu/100 ml indicating a constant input of *E. coli* from both sewage treatment works and agricultural land along the river.
- The high value in 2021 at Starbotton stands out. It was probably caused by discharge from Starbotton STW slightly upstream from the recreational site. In contrast values at other Upper Wharfedale sites are significantly lower than in 2020.
- Some of the lowest values in both 2020 and 2021 occur along the Bolton Abbey stretch of the river from the Cavendish Pavilion down to the Bolton Road bridge. Such low values are probably due to relatively low local inputs in relation to the volume of water in the river and to the reduced influence of upstream sources due to die-off along the Strid Wood stretch of the river[1].

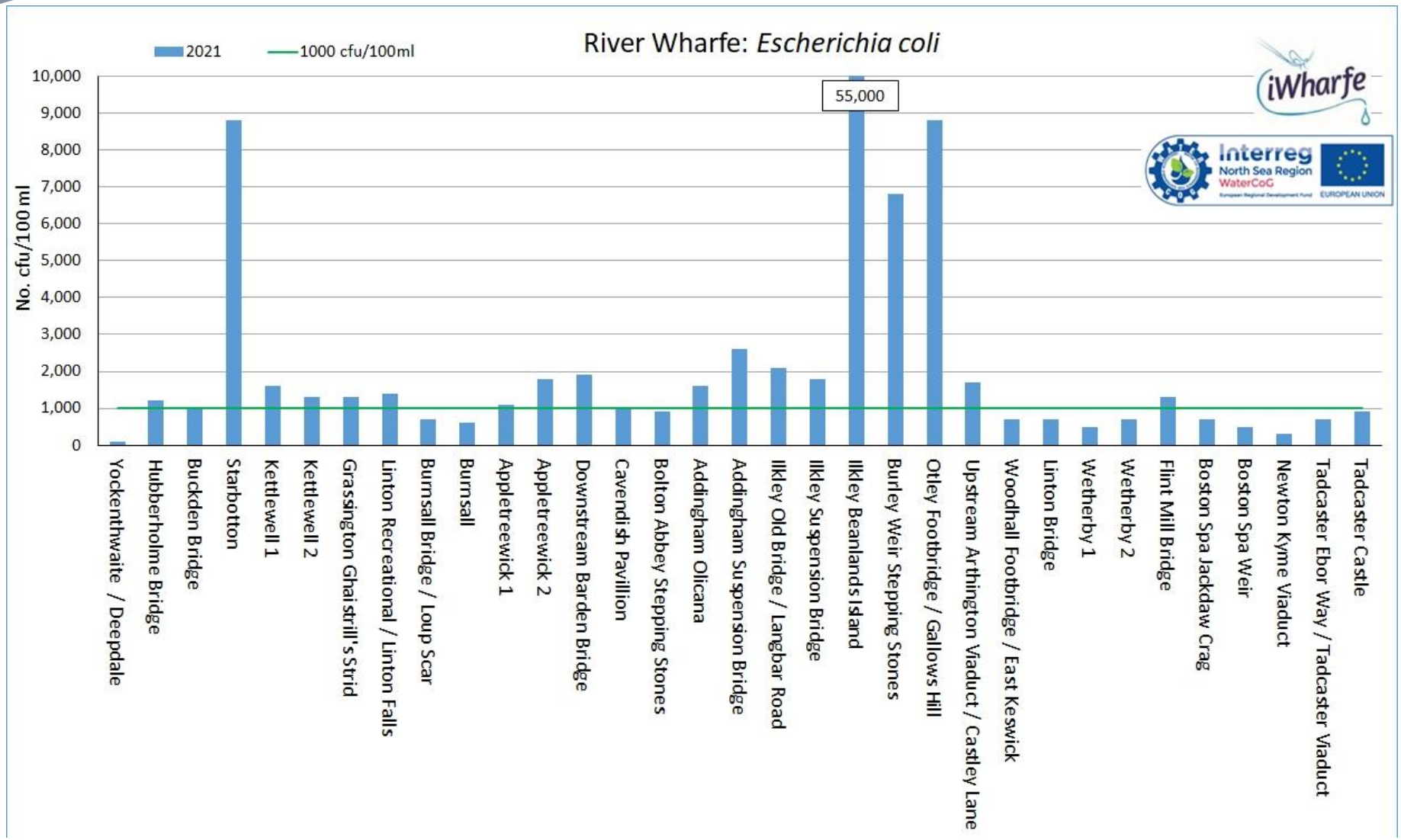



*Figure 2. E. coli concentrations for recreational sites (or closeby proxy site) on August 23rd, 2021. The horizontal green line represents the upper boundary (1000 cfu/100 ml) for a good quality bathing water were this value to be the 95 percentile of a series of samples taken across the bathing water season*

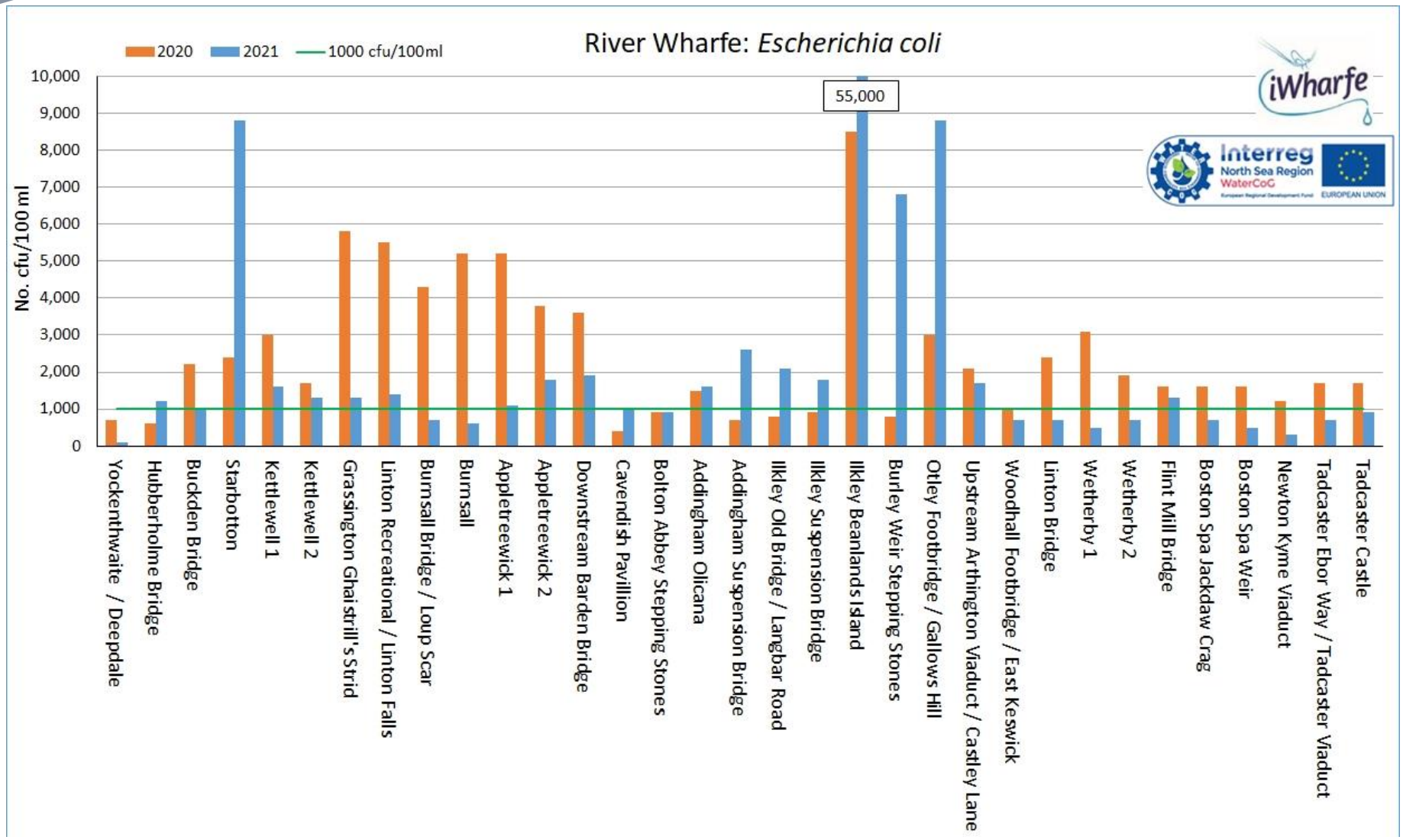



*Figure 3. E. coli concentrations for recreational sites (or their close by proxy) for August 24th 2020 (orange bars) and August 23rd 2021 (blue bars). The horizontal green line represents the upper boundary (1000 cfu/100 ml) for a good quality bathing water were this value to be the 95 percentile of a series of samples taken across the bathing water season*

- Values from Addingham Olicana to the Ilkley Suspension Bridge are higher in the 2021 survey than for 2020. This is not due to a spill from Addingham Pumping Station as the increase in concentration occurs upstream of Low Mill. These high values instead correspond to high values in tributary becks (data not shown here), including Hambleton Beck, Winebeck, Town Beck and Lumb Beck all of which had concentrations of *E. coli* above 7,000 cfu/100 ml on the 23rd August. These becks are contaminated by *E. coli* from a range of sources including agriculture, septic tanks, small STWs and urban surface water. It is likely that the rainfall that occurred on the previous day, after a long period of dry weather was responsible for mobilising faecal bacteria from these catchment sources.
- By far the most significant features of the data from the 2021 survey are the peaks in concentration at the recreational sites downstream of Ashlands STW in Ilkley (Figure 2). These include Ilkley Beanlands Island, Burley Weir Stepping Stones and Otley Gallows Hill sites. There is little doubt that these peaks are caused by effluent discharge from Ashlands STW and other downstream STWs including Ben Rhydding and Burley/Menston.
- The steep decline in *E. coli* concentration between Otley and the Castley Lane beach can be partially explained by downstream die-off and partially by the diluting influence of cleaner water from the River Washburn that meets the Wharfe downstream of the Otley STW.
- *E. coli* concentrations at all recreational sites from East Keswick to Tadcaster were low in 2021. This is a somewhat surprising finding as impacts from the STWs serving Wetherby, Boston Spa and Tadcaster were expected. The rainfall that occurred on the previous day may have been less intense in these lower stretches of the river and/or higher river discharge volumes may have been effective in diluting point source inputs of faecal bacteria. However, the relatively high value at Flint Mill may have been due to the influence of the Wetherby STW, a short distance upstream.

*Bathing water status*

The EU Bathing Waters Directive, now taken into UK law, defines a "good" quality bathing site as one achieving a 95 percentile value of *E. coli* less than 1000 cfu/100 ml and an intestinal enterococci (IE) 95 percentile value less than 400 cfu/100 ml. A less demanding "sufficient" classification is also defined requiring 90 percentile values of *E. coli* and IE to be less than 900 and 330 respectively. Here we only have a single spot water sample from each site and no data for IE. Consequently, the results shown in Appendix A are based only on *E. coli* data and make several quite major assumptions about the relationship of our single value to a larger theoretical data-set for each site i.e. (i) that our single sample represents the geometric mean of the data-set; (ii) that the data-set is log-normally distributed; and (iii) the standard deviation of the data is 0.4 (David Kay, personal communication). The first of these assumptions is the most uncertain as both higher and lower values are likely depending on riverflow conditions.

On the basis of these data, however, only one site, Deepdale/Yockenthwaite, meets the standard to be classified as "sufficient". All other sites fail.

## Conclusions

Faecal bacteria patterns along the Wharfe in 2021 were somewhat different from those in 2020 reflecting differences in hydrological conditions between the two dates. In 2020 flow was high and *E. coli* concentrations were higher at almost all sites in that year, especially in Upper Wharfedale.

Values vary considerably along the river. Data from a single spot sample cannot be used to determine the safety of any site under the Bathing Water Directive. However, were these values to be representative of values from samples taken across the bathing water season all sites except one would fail to meet the minimum standard.

There is evidence of *E. coli* contributions from both livestock and human sources but the most striking feature of the data in both 2020 and 2021 is the very high concentration of *E. coli* at Beanlands Island immediately downstream from the Ashlands STW, a recreational site that lies within the newly designated bathing water site in Ilkley.

We recommend that recreational sites along the Wharfe continue to be surveyed on an annual basis using this citizens science approach both to highlight the problem of faecal contamination at recreational sites and to characterize patterns of contamination under different flow conditions. More urgently the sources of faecal contamination need to be clearly identified. The role of STWs is clear as high concentrations of faecal bacteria are discharged by all STWs from both treated and untreated effluents[2]. However, it is uncertain how rapidly bacteria die off downstream under different conditions. The role of agriculture in causing elevated concentrations of faecal bacteria in the main river is also uncertain. Progress can be made by higher resolution sampling and analysis at the farm scale within tributary catchments but genetic characterization of faecal pathogens to differentiate animal livestock from human sources is also called for.

## Acknowledgements

Our thanks to the iWharfe Citizen Science community especially our teams in the field, Steve and Christine Cheetham, John Rishworth, Steve Fairbourn, Kathleen Roberts, Charlotte Simons, Karl and Charlotte Ridley, Tom and Ruth Raper, Mike Gadd, Penny Stables and Marie Taylor. We are also grateful for the help in the field of Leah Humphries and Will Hunt of Yorkshire Water and Isabel Douterelo and Cathal Berney of Sheffield University. Dave Kay's comments on an earlier version of this report and his calculations based on the EU Bathing Water Directive standards for safe bathing presented in Appendix A are much appreciated.

Funding was provided by YDRT through their WaterCog Project.

## References

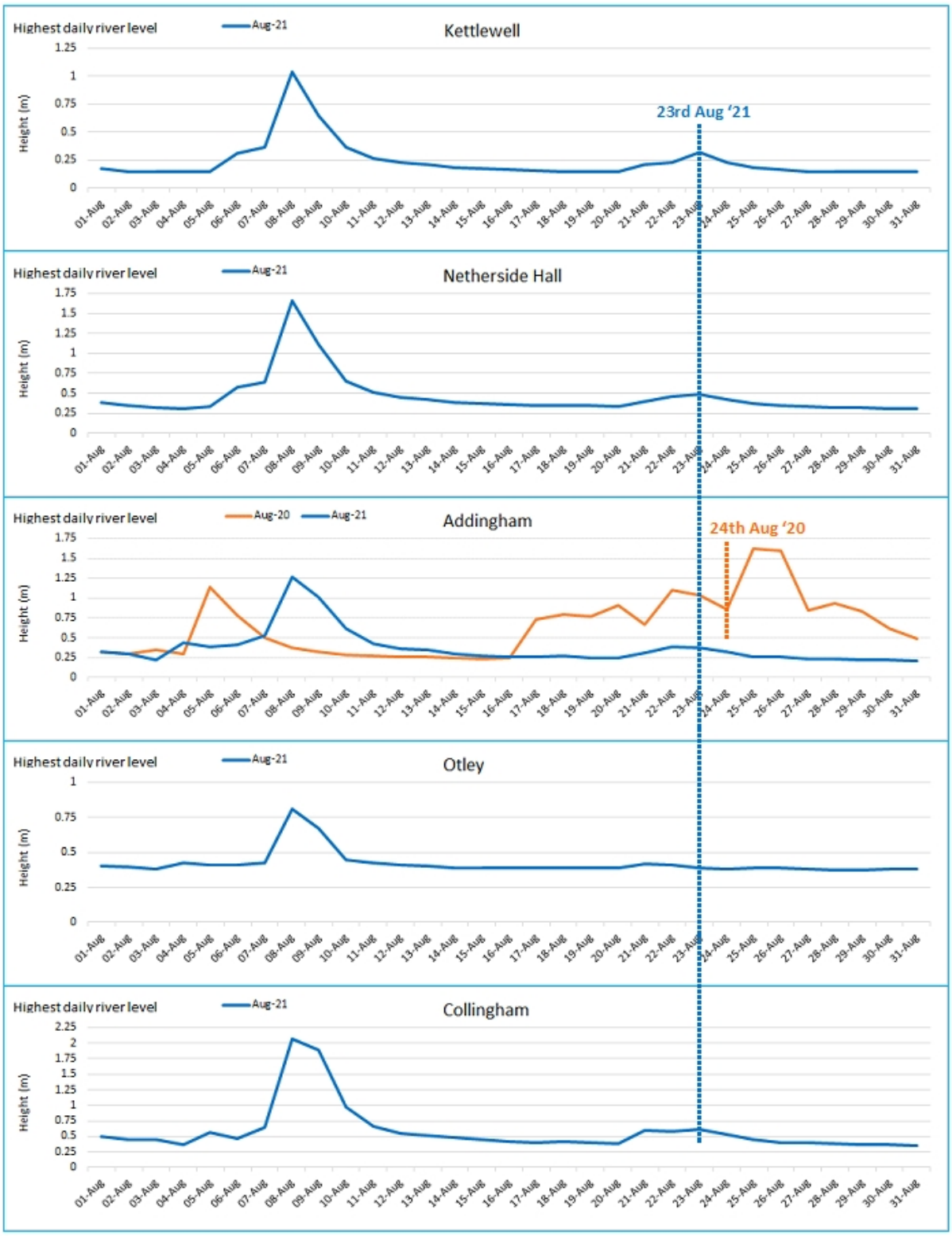
[1]Battarbee, R.W., Secrett, M., Malby, R., Shackleton, K., Taylor, M. & Simons, C. 2020. iWharfe, improving water quality on the River Wharfe from Oughtershaw to the Ouse: A Citizens Science Project. https://www.ydrt.org.uk/wp-content/uploads/2021/03/Wharfe_iWHARFE_MicrobiologyReport_Small.pdf

[2]Stapleton, C. M., Wyer, M. D., Crowther, J., McDonald, A.T., Kay, D., Greaves, J., Wither, A., Watkins, J., Francis, C., Humphrey, N. and Bradford, M. 2008. Quantitative catchment profiling to apportion faecal indicator organism budgets for the Ribble system, the UK's sentinel drainage basin for Water Framework Directive research. *Journal of Environmental Management 87*, 535-550.

**Appendix A:** Table showing recreational sites sampled in both 2020 and 2021 with *E. coli* concentrations for both years. Visitor survey numbers are shown for 2020 for the day preceding sampling (Sunday 23rd August). No data are shown for the equivalent day in 2021 (Sunday August 22nd) as visitors were sparse due to rain all day. Numbers in italics indicate sites where samples were taken at proxy sites, close to but not exactly at the recreational site named. *Data from August 7th, 2020. **Data estimated from 2019 counts for similar weather conditions. For illustrative purposes the sites have been classified based on the EU's Bathing Water Quality Directive (2006) for the 90 percentile "poor/sufficient" standard for *E. coli* of 900 cfu per 100 ml. The values shown have been calculated on the assumption that the *E. coli* concentrations of the spot samples taken in 2020 and 2021 represent the geometric mean of a normal distribution of a population with a standard deviation of 0.4. For alternative calculations based on 95 percentile values and a standard deviation assumption of 0.8 see spreadsheet.

| | *E.coli* Cfu/100ml | | Visitors | Location | 90%ile SD 0.4 EC <900/100ml | | EC Class |
|---|---|---|---|---|---|---|---|
| Sample Site Name (2021 / 2020) | 2020 | 2021 | 2020 | Lat/Long | 2020 | 2021 | 2021 |
| Yockenthwaite / Deepdale | 700 | 100 | 40 | 54.20894,-2.15260 | 2,280 | 326 | Sufficient |
| Hubberholme Bridge | *600* | *1200* | 3 | 54.19970,-2.11400 | 1,954 | 3,908 | Poor |
| Buckden Bridge | *2200* | *1000* | 0 | 54.19143,-2.09360 | 7,165 | 3,257 | Poor |
| Starbotton | *2400* | *8800* | 2 | 54.16553,-2.07556 | 7,816 | 28,660 | Poor |
| Kettlewell 1 | 3000 | 1600 | 6 | 54.14668, -2.05023 | 9,771 | 5,211 | Poor |
| Kettlewell 2 | 1700 | 1300 | 0 | 54.14369, -2.04904 | 5,537 | 4,234 | Poor |
| Grassington Ghaistrill's Strid | 5800 | 1300 | 31 | 54.07548,-2.01129 | 18,890 | 4,234 | Poor |
| Linton Recreational / Linton Falls | *5500* | *1400* | 321 | 54.06650,-2.00198 | 17,913 | 4,560 | Poor |
| Burnsall Bridge / Loup Scar | *4300* | *700* | 184 | 54.05179,-1.95656 | 14,005 | 2,280 | Poor |
| Burnsall | 5200 | 600 | 727 | 54.04476,-1.95161 | 16,936 | 1,954 | Poor |
| Appletreewick 1 | 5200 | 1100 | 60 | 54.03724,-1.93126 | 16,936 | 3,583 | Poor |
| Appletreewick 2 | 3800 | 1800 | 14 | 54.03218,-1.91488 | 12,376 | 5,862 | Poor |
| Barden Bridge | *3600* | *1900* | 222 | 54.01215,-1.92181 | 11,725 | 6,188 | Poor |
| Cavendish Pavillion | *400* | *1000* | 315 | 53.99421,-1.88372 | 1,303 | 3,257 | Poor |
| Bolton Abbey Stepping Stones | 900 | 900 | 354 | 53.98327, -1.88626 | 2,931 | 2,931 | Poor |
| Addingham Olicana | 1500 | 1600 | 25 | 53.94983,-1.87673 | 4,885 | 5,211 | Poor |
| Addingham Suspension Bridge | *700* | *2600* | 20 * | 53.94547,-1.87437 | 2,280 | 8,468 | Poor |
| Ilkley Old Bridge / Langbar Road | *800* | *2100* | 25 | 53.92950,-1.83359 | 2,605 | 6,839 | Poor |
| Ilkley Suspension Bridge | *900* | *1800* | 145 | 53.93222,-1.81539 | 2,931 | 5,862 | Poor |
| Ilkley Beanlands Island | 8500 | 55000 | 20 ** | 53.93222,-1.81539 | 27,683 | 179,128 | Poor |
| Burley Weir Stepping Stones | 800 | 6800 | 31 | 53.92267,-1.74934 | 2,605 | 22,147 | Poor |
| Otley Footbridge / Gallows Hill | *3000* | *8800* | 38 | 53.91042,-1.67891 | 9,771 | 28,660 | Poor |
| Upstream Arthington Viaduct / Castley Lane | 2100 | 1700 | 2 | 53.90925,-1.59859 | 6,839 | 5,537 | Poor |
| Woodhall Footbridge / East Keswick | *1000* | *700* | 0 | 53.91359,-1.43758 | 3,257 | 2,280 | Poor |
| Linton Bridge | *2400* | *700* | 65 | 53.91213,-1.40840 | 7,816 | 2,280 | Poor |
| Wetherby 1 | *3100* | *500* | 2 | 53.92789,-1.38983 | 10,096 | 1,628 | Poor |
| Wetherby 2 | *1900* | *700* | 40 | 53.92661,-1.38566 | 6,188 | 2,280 | Poor |
| Flint Mill Bridge | *1600* | *1300* | NR | 53.91964,-1.35839 | 5,211 | 4,234 | Poor |
| Boston Spa Jackdaw Crag | *1600* | *700* | 9 | 53.91253,-1.35773 | 5,211 | 2,280 | Poor |
| Boston Spa Weir | *1600* | *500* | 18 | 53.90767,-1.34678 | 5,211 | 1,628 | Poor |
| Newton Kyme Viaduct | *1200* | *300* | 5 | 53.90364,-1.32012 | 3,908 | 977 | Poor |
| Tadcaster Ebor Way / Tadcaster Viaduct | *1700* | *700* | 21 | 53.88858,-1.26408 | 5,537 | 2,280 | Poor |
| Tadcaster Castle | *1700* | *900* | 31 | 53.88695, -1.26336 | 5,537 | 2,931 | Poor |

**Appendix B:** River levels for August 2021 for EA monitoring sites on the River Wharfe. Data for August 2020 are also shown for Addingham to illustrate the difference in flow between the two sample years



**Appendix C:** Sampling teams (Zones 1 – 5)

http://www.yorkshiredalesriverstrust.com/projects/iwharfe/.
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