

Delivering Healthy Water:

building the science – policy interface to protect bathing water quality

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HEALTHY
WATER



Delivering Healthy Water is a project funded by the Natural Environment Research Council (NERC) that promotes the exchange of knowledge and information between science providers, science users and the public with regard to advantages and limitations of different tools for compliance monitoring of bathing waters and other regulated waters.

The aim of the project is to develop a shared understanding of the science evidence base underpinning current and emerging microbial quantification techniques.



Image courtesy of SAS



Briefing paper 2 of 2

Economics and stakeholder information

May 2013

The quality of UK [bathing waters](#) is assessed by enumerating bacteria known as [faecal indicator organisms \(FIOs\)](#) throughout the bathing season. From 2015, the number of designated bathing waters of poor microbiological status is set to rise because of the introduction of more stringent standards associated with the [regulated water](#)

Parallel debates over the suitability of traditional versus novel quantification methods for quantifying FIOs add an extra layer of complexity for regulators. [New molecular analytical techniques](#) are beginning to offer a means of characterising microbial pollution that challenge traditional [culture-based](#) reference methods.

Existing policy frameworks for microbial water quality standards around the world are centered on the culture-based approaches that are underpinned by rigorous science, reproducibility of results and an epidemiological evidence-base. However, the United States Environmental Protection Agency (USEPA) has already started to use molecular-based enumeration tools as an alternative to culture-based methods. This may increase pressure in the UK to consider a method shift as well. The difficulty lies in how to translate technological innovations into up-to-date regulation based on a firm and accepted policy evidence-base.

This is the second Briefing Paper from the Delivering Healthy Water (DHW) project. Briefing Paper 1 focused on the scientific, regulatory and policy questions surrounding a potential move to using molecular methods for compliance monitoring of bathing waters and other [regulated waters](#). Briefing Paper 2 turns to the economic implications of such a move and the complexities of providing appropriate and timely public information on bathing water quality. Any change in a standard methodology and the tools and techniques used to inform regulatory standards requires careful consideration of the social and economic implications of such a transition in addition to the scientific challenges and uncertainties.

While there are many potential uses for a variety of molecular techniques being developed, the emphasis here is placed on a transition to quantitative polymerase chain reaction ([qPCR](#)) for regulatory monitoring rather than use of molecular methods for microbial source tracking ([MST](#)).

The briefing paper is divided into two main parts:

- First it addresses the direct cost implications of method change.
- The second part deals with the subtleties of trying to place a value on non-market goods such as the concept of a day at the beach and information relating to bathing water quality. It identifies gaps in our knowledge and understanding and poses the questions that need to be explored by the research community. For it is only when we can accurately value these goods that it will be possible to measure the consequences of any change in the: method of analysis; perceived health risk, or dissemination of information.



Signposts a case study or general information.



Indicates a question or research gap



Denotes a point at which information is linked to the decision making framework document.



1. Direct Costs

The economic implications of shifting from tried and tested culture based approaches to molecular methods are wide-ranging. For those involved in the day-to-day management of bathing water quality the direct cost implications are significant. Molecular methods are more expensive than culture-based approaches to microbial enumeration. There are immediate costs associated with capital outlay for new technology, more expensive consumables and costs associated with training staff for the specialized skills

required. There are important questions surrounding the change in infrastructure that may be needed to support any transition in methodologies in order to reduce logistical issues linked to sample transit times. We do not yet know whether this could or would be feasible in the UK and wider EU. Automation and economies of scale could possibly reduce costs in the future, but this would not apply to single samples collected as part of pollution incident investigations.

A period of transition



Beyond the immediate direct cost implications there needs to be an appreciation that any proposed method transition would not equate to a clean and quick switch from culture to molecular-based methods. It would be essential to use both methods for a period of time sufficient to facilitate a robust cross-comparison between data (see Oliver et al., 2010¹). This means that the economic implication is not simply a move from a less expensive to more expensive method but a transition period during which costs would reflect the sum of both methods. While costly, it is only by underpinning the output from emerging qPCR applications to bathing waters with current tried-and-tested methods that

there can be a comprehensive and validated baseline database against which we can test and evaluate emerging molecular characterization of FIOs in the bathing zone. Thus, the emergence of cross-validation literature marks the beginning of what should be a continued and iterative approach to cross-comparison.

¹ Oliver, D. M., Heathwaite, A. L., and Haygarth, P. M. (2010). A 'culture' change in catchment microbiology? *Hydrological Processes*, 24, 2973-2976

Costs to develop an epidemiological evidence base

New methods that do not measure the same targets as culture based approaches would require the derivation of equivalent bathing water standards at a cost linked to either a comprehensive cross-comparison of the new target with values of traditional culture-based values, or a series of epidemiological studies across EU waters. The need for parallel epidemiological studies to compare culture and qPCR is discussed in [Briefing Paper 1](#).

More sensitive qPCR methods will need to reassess bathing water standards for microbial water quality to determine an equivalent regulatory standard based on molecular detection which in itself may raise new and interesting debates. Briefing paper 1 in this series advocated the need for parallel epidemiological studies in the EU that couple health outcomes with both culture and qPCR data.



Case study

Direct costs of improving bathing waters in England

Since 2000 an estimated £2bn have already been spent by the water industry on investigations into the causes of bathing water failures, and improvements of assets. This investment has seen a significant increase in bathing waters passing the highest (guideline) standard of the 1976 Bathing Waters Directive.

Improvements to water company infrastructure are carried out in line with the National Environment Plan, which sets priorities for each 5 year spending period. The costs to the Water Companies agreed in these plans are funded by increases to household water bills – the national average bill in 2013 was £388 with the highest bills in the South West at over £500 per household.

Many improvements to bathing waters have also been driven by other legislative requirements, chiefly the Urban Waste Water Directive. It is estimated that £200bn has been spent on meeting those requirements in England since implementation.

Costs for tackling diffuse agricultural pollution are generally met by the landowner. A 2011 ADAS report ¹ explores the costs of a range of ways to reduce diffuse pollution and put the cost of fencing off streams and rivers from livestock at £5 – 15 per hectare or at £2,000 per year per dairy farm.

Costs are based on provision of standard fencing and water troughs and are amortised.

Total cost for farm system (£/farm)	Dairy	Grazing LFA*	Grazing Lowland	Mixed
Annual	2,000	1,000	1,300	2,000

*LFA = Less favoured areas

²An Inventory of Mitigation Methods and Guide to their Effects on Diffuse Water Pollution, Greenhouse Gas Emissions and Ammonia Emissions from Agriculture – Dec 2011 -Prepared as part of Defra Project WQ0106 – ADAS and North Wyke Research.

2. Wider economic implications

Valuing coastal recreation linked to changes in water quality

A shift from culture-based to molecular methods for determining bathing water quality *could* lead to more beaches failing to meet the required [standards](#) under the rBWD. Using molecular methods bathing waters currently categorised as EXCELLENT may become GOOD (lower class). This is because molecular capability may introduce higher sensitivity but does not necessarily mean poorer water quality.

Such a move would need to carry with it a means to evaluate how this could change the

value of a day at the beach. There may also be positive economic impacts from shifting technologies.

New beach users may be attracted if water quality information were to be provided in a more appropriate and timely fashion. However it must be remembered that there are logistical challenges associated with the routine use of qPCR as a compliance tool and predictive models may offer a more economical and effective way forward.

Valuing changes in health risk relating to bathing water quality

It is necessary to balance the costs and benefits of technology transition against other national priorities and competing demands on limited funds. Valuing changes in health risk that may arise from technology transition is an important factor in assigning it the appropriate level of priority.

There is currently little information linked to the vulnerability of different user groups with respect to health risks from bathing waters. Neither is much known about the willingness to pay (WTP) of different user groups with regard to reducing these health risks.

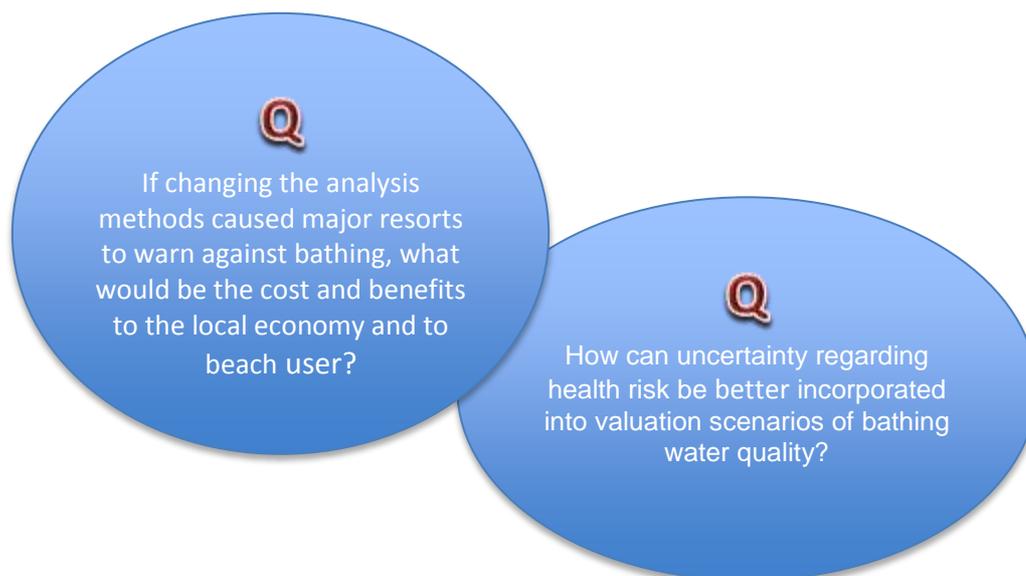


Figure 1 Key questions relating to potential impacts of changing the way bathing water quality is assessed.



Valuing risk information

In order for signs to be effective in shaping beach use it is necessary to understand the value that beach users place on risk information.

We also need to know how a transition to new methods such as qPCR may be used to provide a more meaningful statement of risk to beach users. The posting of risk information may have impacts on local economies as well as the water users and there is a need to explore how these impacts could take shape at large beach resorts and smaller designated bathing waters.

We must consider how best to communicate and interpret complex water quality results and deliver them to the public in an appropriate form. We need to know what type of information beach users require, how quickly they want it, how best it is distributed and whether a transition in methods helps meet these needs. Ultimately, better public information should benefit beach users.



Bathing water quality classification symbols

The rBWD brings in new requirements for displaying public information on bathing water quality. For example bathing water controllers must display one of these symbols showing the classification that their bathing waters will receive after the 2015 bathing season



Figure 2 Bathing water quality signs required by the EU to be displayed following the 2015 bathing season.

The potential benefit of qPCR to provide faster information needs to be balanced against the argument that water quality can change over the course of day and thus qPCR is only useful to those people using a beach within a particular window of time.

Traditional beach signage systems and real water quality data are always out of date, in the sense that there is always a sample turn-around time whatever methodology is used. This emphasises the potential of predictive tools to have more value to beach users than 'real' water quality data. New beach users may be attracted if water quality information were to be provided in a more appropriate and timely fashion.



Case study

Surfers Against Sewage (SAS) text messaging

The SAS Sewage Alert Service has over 2,000 users signed up for free real time information across 200 bathing waters around the UK. There are also a further 500 users signed up to receive email updates.

The Sewage Alert Service works by:

- The Water Company telemetry system recognises a spill at an asset and sends an email to the Water Company.
- The Water Company forwards this message to SAS.
- SAS's Sewage Alert Service receives emails to a designated email address, verifies the message is genuine and automatically forwards the information to people signed up to receive the information via free SMS or email and then updates the GIS map on www.sas.org.uk

The average user gets information at 3 beaches. The most popular beaches are in the south west with several beaches having over 700 unique users receiving free text messages when a water company asset discharges.

Since the Sewage Alert Service's inception SAS has sent out over 250,000 free text messages. In 2012 alone SAS sent out over 130,000. In a recent survey 78% of respondents (n= 1332) obtained water quality data from SAS via text alert, 31% from the SAS website, 2% from Water Company websites and 9% from lifeguards. 92% of people who received a warning changed their behaviour. The majority went to another beach within the Sewage Alert Service.

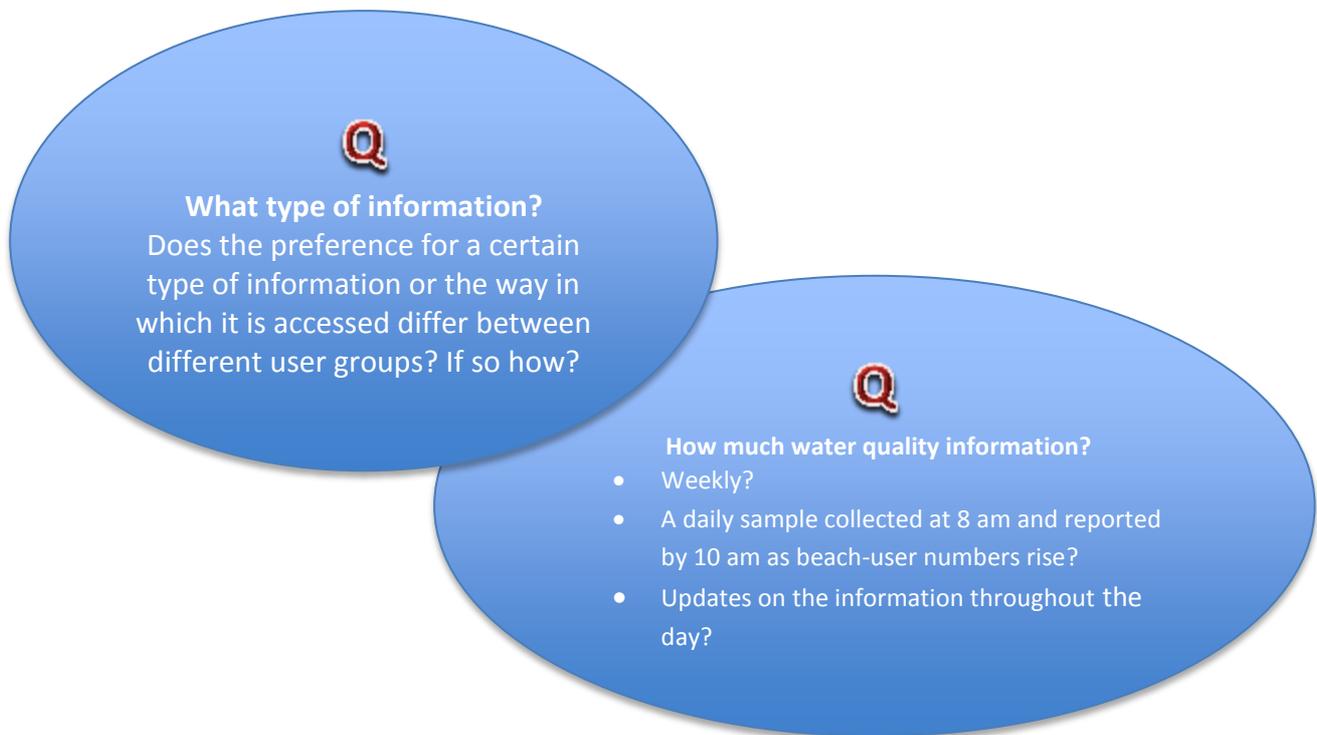


Figure 3 Key questions relating to the type and quantity of water quality information required by the public.

3. Priority question framework based on user-needs and decision-driven science

Fig 4 summarises some of the main research questions and gaps identified by participants of the third DHW workshop and respondents to the DHW online survey. Details of both these can be found in the Workshop 3 Report available from the DHW website. This model of decision making puts public stakeholders at the heart of the process and illustrates the interaction between the public, regulators, scientists and policy makers. The questions under the “Public involvement” section drive the research. Fundamental knowledge gaps

surrounding the way in which people use the beach and the nature and quantity of water quality information form the starting point. Once these are understood, specific questions concerning health risk and the economic impacts of changes to the way we evaluate bathing water quality and present information can be addressed and quantified. This understanding can then feed into broader policy making processes at local, national and international levels.

In summary

Regulators in the UK may have little appetite for using rapid methods in compliance monitoring (see Briefing Paper 1) but this view may not be shared by beach users who may be in favour of rapid methods being used if they provide a more meaningful statement of risk. Consideration should be given to informing and educating all parties over the advantages and disadvantages of molecular techniques.

A change in methodology carries implications for beach classifications, water quality and health risk and would need to be accompanied by a thorough programme of communication to the public about the nature of the shifts in approach and what this means for them. **The logistical issues surrounding sample turnaround time may prevent qPCR from being suitable at present in the UK.**

It is important to remember that in addition to investing in technology there is clearly a critical land based management opportunity that can be undertaken within the catchment environment to help reduce FIO loadings to the bathing zone.

Current and recent research and surveys that focus on some of the themes introduced in this briefing paper and which may address some of the gaps recognised can be found in the report from workshop 3 on the [DHW website](#)

Priority question framework based on user-needs and decision-driven science

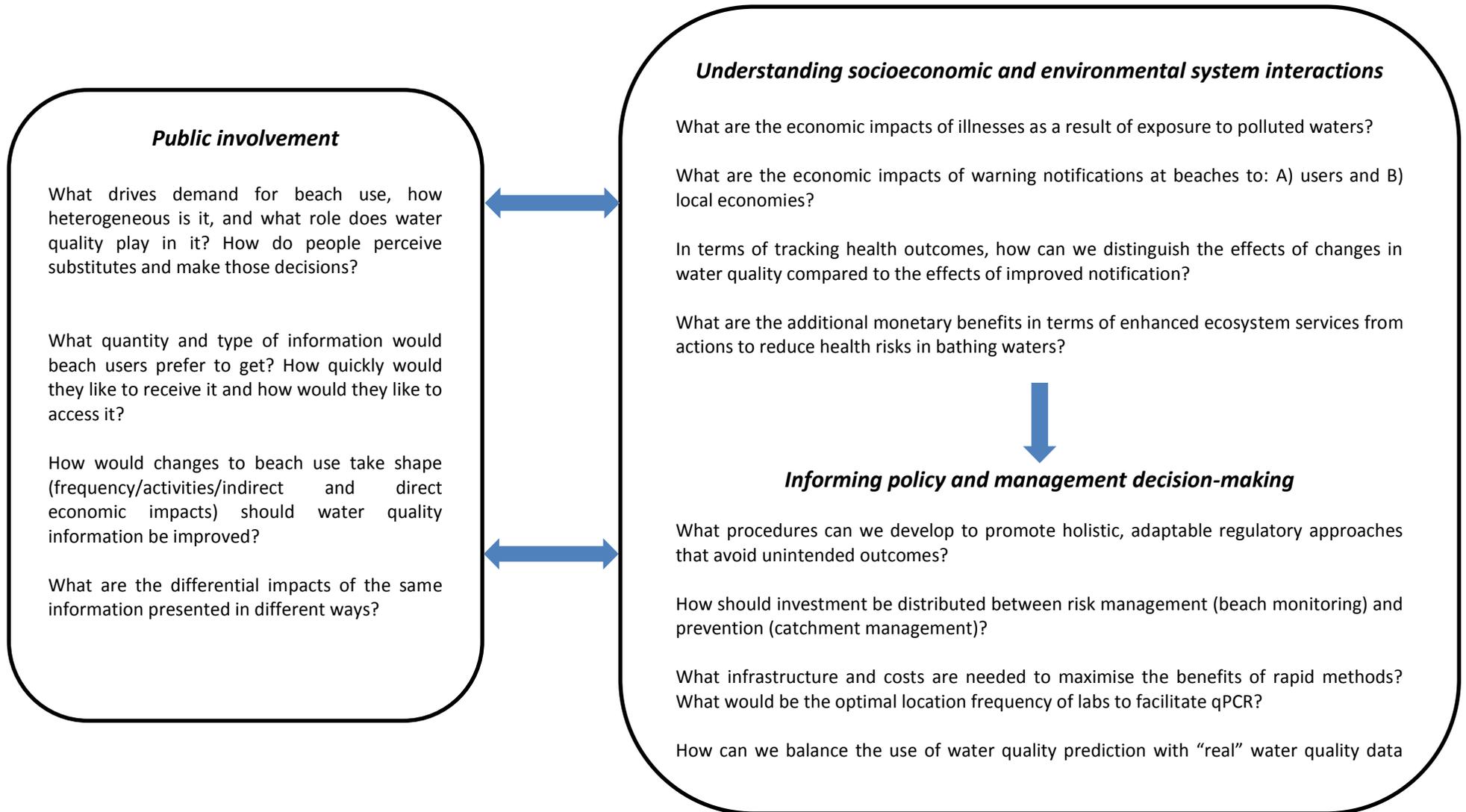


Figure 4 A model for user-driven science and policy making to address research needs and knowledge gaps in quantifying the economic impacts of changes to the methods used for monitoring bathing water quality and disseminating information

Glossary

Bathing water classification

The rBWD has four classification categories:

Excellent	approximately twice as stringent as the current Guideline standard;
Good	similar to the current Guideline;
Sufficient	approximately twice as stringent as the current Mandatory standard;
Poor	for waters which do not comply with the Directive's standards

Colony forming unit (CFU)

CFU is an estimate of bacterial numbers and is used to determine the number of viable bacterial cells in a sample per millilitre of water. Unlike direct microscopic counts where all cells, dead and living, are counted, CFU estimates viable cells. The appearance of a visible colony requires significant growth of the initial cells - and it is not possible to determine if the colony arose from one cell or 1,000 cells. Therefore, the results are given as CFU/mL (colony-forming units per millilitre) for liquids such as bathing water samples.

Compliance monitoring

The sampling and analysis of water at designated bathing waters to assess compliance with the standards set by the current Bathing Water Directive and to be used in the four year data set that will provide the first set of classifications under the rBWD in 2015.

Culture-based enumeration

Established methods for growing or culturing FIOs for the purpose of monitoring water quality. A common method is the membrane filter technique. This consists of filtering a water sample on a sterile filter with a 0.45-mm pore size which retains bacteria, incubating this filter on a selective medium and enumerating typical colonies on the filter.

Designated bathing water

Beaches that attract a large number of visitors may be designated as bathing waters. In 2012 there were 83 designated BW sites in Scotland, 416 in England, 100 in Wales and 23 in Northern Ireland

Faecal indicator organism (FIO)

Bacteria normally present in large numbers in faeces whose presence above standard levels is viewed as a sign that levels of all bacteria from faeces are too high.

Microbial Source Tracking (MST)

The tracing of a pollution indicator organism in order to identify the host group of organisms from which it originated. This allows for the identification of the source of pollution and the potential pathways for transfer of microorganism in the environment.

Molecular technique

Molecular methods, such as quantitative polymerase chain reaction (qPCR) that have the potential for rapid analysis of samples.

Quantitative Polymerase Chain Reaction (qPCR).

A biochemical reaction in which a selected piece of DNA is copied and amplified. This then gives a copy number per unit volume allowing for the accurate quantification of the number of copies of an organism in a sample.

Regulated water

For the purposes of this document the term Regulated Water refers to any water body where the water quality is protected by legislation that sets out standards that must be achieved for the purposes of a compliance regime. This includes but is not limited to bathing waters and shellfish harvesting waters.

Revised Bathing Water Directive (rBWD) Research into bathing water and human health since the original Directive's introduction in 1976 has led to the development of the revised Bathing Water Directive (2006/7/EC), which will be implemented in stages between now and 2015, when the original Directive will be repealed. The revised Directive uses two parameters to assess water quality, *Escherichia coli* and intestinal enterococci, using a four year data set for each set of results, and sets much tighter standards than the original Directive.

<http://www.defra.gov.uk/environment/quality/water/water-quality/bathing/>

Further information and contacts

This project has been funded by the Natural Environment research Council (NERC) and led by the University of Stirling. It is supported by Lancaster University and Aberystwyth University.

The core Working Group includes a membership of representatives from UKWIR, SEPA, EA, Defra, and Surfers against Sewage but has also drawn on a breadth of knowledge and experience from across the UK and the international community as well.

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Briefing Paper 1 concerned with Science, Regulation and Policy can be viewed and downloaded from the DHW website www.deliveringhealthywater.net

