SUMMARY

I  OBJECTIVES

The objectives of this project were to:

i. Confirm nitrogen-containing disinfection by-product (N-DBP) compounds to monitor and select analytical methods.

ii. Conduct appropriate performance testing for the selected analytes using the chosen methods.

iii. Select water treatment works with due regard to the risk factors identified in previous reports.

iv. Liaise with water companies to select and arrange access to appropriate sampling sites and locations.

v. Conduct quarterly sampling of water leaving the selected water treatment works in accordance with best practice in terms of sampling and analysis, including appropriate analytical quality control.

vi. Gather other relevant data such as water treatment performance information and water quality data to help interpret the results.

vii. Report the findings of the survey, comparing levels found with established health based standards or with occurrence data from other countries.

II  MOTIVATION

Drinking water utility surveys in the US and other countries have reported the occurrence of a large number (i.e. hundreds) of disinfection by-products (DBPs) in treated drinking waters. These include a range of nitrogen-containing disinfection by-product compounds (N-DBPs) which have been reported to occur mostly in the low to sub-microgram per litre concentration range in treated drinking water. There is some evidence from non-regulatory studies that N-DBPs are more toxic than the trihalomethanes (THMs), which are regulated as DBPs in England and Wales currently. The source water characteristics and water treatment conditions that lead to the formation of N-DBPs have been studied but there remain gaps in understanding, and at the beginning of this project there were very limited or no occurrence data for most N-DBPs in drinking waters in England and Wales. A previous project (DWI/2/243) provided a review of the occurrence and toxicological information available on N-DBPs and recommended some priority N-DBPs for sampling in England and Wales. The N-DBPs studied in this project excluded the nitrosamines, which have been considered in previous Defra-sponsored projects (DWI 70/2/210 and DWI 70/2/239).
A sampling survey of 20 water supply systems in England and Wales was conducted to measure the concentrations of N-DBPs in drinking waters. Water supply systems were selected to include treatment works that have suspected risk factors for the formation of N-DBPs, such as certain source water characteristics or treatment processes in use; several supply systems with no risk factors were also included, to give a representative indication of typical N-DBP concentrations. The measured N-DBP groups were selected haloacetonitriles (HANs), haloacetamides (HAcAms), halonitromethanes (HNMs), and cyanogen chloride. Water samples were collected in four sampling rounds over a one-year period. Quality assured sample collection, storage and analytical methods using gas chromatography mass spectrometry were used for measuring the N-DBPs. Samples were collected from the pre-disinfection and final treated water stages at the treatment works as well as three locations in the distribution networks. The results of the survey were compared against existing health-based standards for selected N-DBPs and against the N-DBP concentrations that have been reported in other countries (e.g. the US). The N-DBP concentrations were also examined alongside other raw and treated water quality parameters (e.g. total organic carbon, trihalomethanes, haloacetic acids), the source water types, and the treatment processes in order to consider potential links to N-DBP occurrence.

The N-DBPs occurred at broadly similar concentrations as have been reported in surveys in other countries, e.g. the US. As individual compounds, all the N-DBP compounds were typically only present at concentrations < 2 µg/l. HANs were detected at the highest group sum concentrations (mean = 3.2 µg/l), followed by HAcAms (mean = 1.5 µg/l), and HNMs (mean = 0.4 µg/l). All the measured N-DBPs occurred at levels below the current World Health Organisation (WHO) guidelines for dichloroacetonitrile (20 µg/l) and dibromoacetonitrile (70 µg/l). The lowland water sources that were included in this survey formed more N-DBPs than the upland and groundwater sources. The six treatment works that applied ozone were associated with higher concentrations of HANs and HAcAms than non-ozone treatment works, although this is potentially confounded because all the ozone works were treating lowland source waters which may have had higher N-DBP formation potential. The ozonated systems also produced higher cyanogen chloride concentrations, which agreed with the previous understanding of the formation of this compound. In general, supply systems applying chlorine formed slightly more HANs and HAcAms than those applying chloramines. Total chlorinated and brominated THMs were measured in rounds 1 and 4; none of the N-DBPs exhibited consistent correlations with total THMs. The nine chlorinated and brominated haloacetic acids (HAA₉) were measured in round 4 only; HANs and HAcAms exhibited better linear correlations with HAA₉ than with total THMs. However, there were no trends linking HNMs to either THMs or HAA₉. Total organic carbon alone was not a consistent predictor of N-DBP concentrations nor were there clear observed links with other individual measured water quality parameters. Possible correlations with total organic nitrogen could not be investigated because of
limitations in the sensitivity of the organic nitrogen measurement methods that were used. There were no significant consistent differences between the N-DBP concentrations measured in the different sampling rounds, nor were there consistent trends between N-DBP concentrations and water age in distribution (distance from the treatment works).