Summary

i Reasons

Poly and perfluorinated alkyl substances (PFASs) are a class of anthropogenic chemicals. Some PFASs have become subject to regulatory restrictions due to concerns over their potential toxicity and bioaccumulative properties. When specific PFASs become restricted, they may be substituted by alternative PFASs that may have similar environmental properties, which may conceivably increase as restrictions come into force. The European Commission (EC) has recently proposed a drinking water standard of 0.1 µg/l for any individual PFAS and 0.5 µg/l for the sum of all PFASs in drinking water under the draft Drinking Water Directive (DWD).

This project determines the likely risks of exceedance of the proposed 0.1 µg/l standard from PFASs and whether water companies will be able to adequately measure all PFASs of relevance in England and Wales to a level that can demonstrate compliance with the proposed DWD.

ii Objectives

- A literature review on the presence of PFASs in water, methods of analysis and efficacy of removal by water treatment processes.
- Summarise the existing knowledge on the different uses of PFASs, the potential routes to drinking water, the current quantities of each substance used in England and Wales.
- Estimate the likely changes in use of other PFASs in response to the restrictions on perfluorooctanoic acid (PFOA) and perfluorooctane sulphonic acid (PFOS).
- Estimate the likely concentrations of PFASs in all source waters used for public supplies and drinking water and the extent of any potential non-compliance with the proposed standard in the draft DWD.

iii Results

Objective 1

The first objective was to carry out a literature review on the presence of PFASs in water, methods of analysis and efficacy of removal by water treatment processes. Limited data were identified in the UK regarding the presence of PFASs in surface water, groundwater, drinking water, wastewater and landfill leachate. Therefore, data were supplemented with occurrence data from Europe. In general, concentrations of PFASs in surface water, groundwater and

drinking water have been reported to be present in the ng/l to 10's of ng/l range. However, at a number of locations, concentrations of several hundred ng/l have been reported.

A number of analytical techniques have been identified that can determine a range of PFASs in drinking water, including liquid chromatography-mass spectrometry/mass spectrometry (LC-MS/MS), high performance liquid chromatography (HPLC)-MS and gas chromatography (GC)-MS. All methodologies are capable of detecting PFASs at ng/l. However, the data suggest that LC-MS/MS has better recovery of analytes than HPLC-MS.

With respect to the removal of PFASs by drinking water treatment processes, the literature suggests that conventional treatment is not particularly effective at removing PFASs from water, whereas nanofiltration, absorbance to activated carbon or anion exchange with a suitable resin are effective in removing PFASs.

With respect to the removal of PFASs by wastewater treatment processes, the data are contradictory, with both removal and increase of PFASs observed in all treatment processes. No treatment process shows consistent removal of PFASs.

Objective 2

In objective two, the existing knowledge on the different uses of PFASs, the potential routes to drinking water, the current quantities of each substance used in England and Wales was sought.

A range of uses for PFASs were identified, including use as flame retardants, lubricants and heat transfer fluids, metal plating, surfactants, and in the synthesis of polymers. However, data on the volumes of use for PFASs has proven difficult to obtain. As such, REACH registration tonnage bands have been used to inform the likely release volumes of PFASs to water. Routes to water were determined via a combination of release information from REACH dossiers, infocards from the European Chemicals Agency (ECHA) and physico-chemical data. From this review, 44 PFASs were identified as having the potential to occur in water sources.

Objective 3

In objective three, data were sought to estimate the likely changes in use of PFASs in response to the restrictions on PFOA and perfluorooctane sulphonic acid (PFOS).

With respect to PFOS, the deadline for any exemptions to the restrictions has passed. Therefore, it can be assumed that any alternatives to PFOS are already being used and that the quantities of such alternatives are unlikely to significantly change.

With respect to PFOA, no alternatives for the use in the production of PTFE (Teflon) have been identified. In regards to PFOA compounds being used for the manufacture or production of

fluoropolymers, some alternatives have been identified and it can be assumed that use of these alternatives will increase in the future. However the future quantities of these alternatives cannot be estimated.

Objective 4

In objective four, a model to estimate the concentrations of PFASs in source waters and drinking water has been developed, with the ultimate aim to identify any potential non-compliance with the proposed standard.

The model compares the estimated concentration of each PFAS in drinking water against a drinking water standard, presenting these data as risk characterisation ratio (RCRs); an RCR of $\geq$1 indicates that the concentration of the chemical exceeds the drinking water standard. The model may over-estimate concentrations of PFASs in drinking water derived from surface water, but under-estimate concentrations in drinking water derived from groundwater, based on occurrence data.

In general, if using surface water as a source for drinking water, the majority of PFASs within the model are lower than the proposed drinking water standard. Those PFASs that occur at concentrations above the proposed drinking water standard usually have the largest data gaps with respect to their use volumes and environmental release. As such, conservative assumptions have been made with respect to these parameters, potentially leading to an over-estimated concentration in drinking water. If using groundwater as a source, concentrations of all PFASs are lower than the proposed drinking water standard. However, the reliability of these predictions is uncertain.

iv Conclusions

In general, the data obtained during the literature review indicate that it is unlikely that levels of any individual PFAS in drinking water will exceed 0.1 µgl (100 ng/l). This conclusion is supported by the model that has been developed. The model indicates that if a drinking water standard of 0.1 µg/l were to be adopted for any individual PFAS, the majority of PFASs would not be anticipated to exceed that standard.

v Suggestions

This project has identified a significant body of data on the use and occurrence of PFASs and their removal by treatment processes that have allowed the estimation of their concentrations in drinking water under a variety of scenarios. However, there remain significant gaps in the

data that create uncertainty in the estimations. Therefore, several suggestions are made for further work:

- Data on the removal of PFASs by wastewater treatment are inconsistent and often contradictory. Further investigation of the fate of PFASs in wastewater to determine the circumstances that do/do not favour their removal and the nature of the precursors that will increase PFAS concentrations is recommended.

- Data on the volumes of PFASs used in England and Wales and the manner in which they may be released to the environment are limited and as such, conservative assumptions have been made within this project. If information on the volumes of PFASs used in England and Wales can be obtained, more robust estimates of concentrations in drinking water can be developed.

- For several drinking water treatment processes (e.g. coagulation, rapid gravity filtration or slow sand filtration), it has been necessary to assume within the model that no removal will occur for any PFAS. Small-scale trials of the effectiveness of different treatment processes may allow a refinement of the model to provide more robust estimates of concentrations in drinking water.

- The concentration of several PFASs in drinking water have the potential to exceed the proposed drinking water standard. It may be appropriate to identify sites in England and Wales that are considered to be at 'high risk' and undertake a survey for these PFASs.