Report of the Drinking Water Inspectorate's Investigation into the Cryptosporidium Contamination of Franklaw Treatment Works in August 2015

25 October 2017

Table of Contents

Foreword

This report sets out the investigation, findings and subsequent outcome of the prosecution of United Utilities Water Ltd, (the company), by the Drinking Water Inspectorate (DWI), following the incident which was notified on 6 August 2015 and which directly affected 712,000 residents and consumers in North Lancashire. The DWI has powers to carry out investigations for the purpose of ascertaining whether any duty imposed upon the water undertaker has contravened the relevant sections of the Water Industry Act 1991, (WIA 1991), and to make such reports of investigations to the Secretary of State.

Information contained in this report was provided in response to the duty of the water undertaker under the WIA 1991 to provide all such information to the DWI, and is further complemented by investigations by the DWI on site and through correspondence and interviews with relevant persons, and information from other sources and organisations who were either directly or indirectly involved in the event such as Public Health England, (PHE).

Proceedings for an offence in relation to the quality and sufficiency of water supplied using a water undertaker's supply system, as specified in the Water Act 2003, are carried out by the Chief Inspector of Drinking Water. Proceedings are governed by criminal law including all the rights of the water undertaker as a defendant. Any information prior to the completion of the legal process will not have been derived from the investigation described in this report.

The assessment of information, the investigation, proceedings to the Crown Court and the authorship of this report was undertaken by a small team of technical assessors and Inspectors appointed by the Chief Inspector under his powers. All the Inspectors involved in this investigation have worked in the water industry or allied industries and water quality regulation with a cumulative experience of over 150 years.

The obligations on the water undertaker under the WIA 1991 are to provide water that is wholesome. This means that water must not contain any parasite at a concentration or value which would constitute a potential danger to human health. United Utilities advised consumers to boil their tap water before using it for drinking and food preparation in response to the detection of the protozoan parasite, *Cryptosporidium*, in water supplied from Franklaw treatment works at a level not seen before from this works. This report identifies the multiple potential routes of contamination, the reason why contamination occurred and the conclusion that if the company had followed the code of practice and recommendations set out in the Report of the Group of Experts on *Cryptosporidium* in Water Supplies chaired by Sir John Badenoch (published in 1990), this event could well have been avoided.

This report notes the requirements imposed on the company by Notices and Undertakings since August 2015 as part of a wider transformation programme to secure that water supplied by the company is fit for human consumption, is wholesome and that steps are taken to prevent a recurrence of this event. These requirements include the installation of treatment, wider programmes of work and organisational changes to effect outcomes for the public benefit.

The prosecution of the company was taken forward by the Chief Inspector on the basis of evidence gathered by the DWI and in recognition of the strong public interest in the case. My conclusion was that the company supplied water that was unwholesome as a direct result of actions and decisions made by the company, and that if a consumer were aware of the presence of the parasite they would have rejected it for consumption.

The company pleaded guilty to supplying water unfit for human consumption at Preston Magistrates' Court on 19 July 2017. The Honorary Recorder for Preston, Judge Mark Brown, concluded at the sentencing hearing on 10 October 2017, that the event had a major impact on the day to day consumption of water in Lancashire causing widespread inconvenience and anxiety. Although there was not an outbreak, there was significant disruption and inconvenience to members of the public. Contaminated water should never have been introduced into Franklaw. A proper risk assessment should have taken place at Franklaw. There was also a failure to carry out a risk assessment at Barnacre service reservoir, which was especially notable given the risks associated with its structural defects and situation in the wider environment. It would have been an elementary precaution to undertake risk assessments before the operational changes were implemented at Franklaw[(i)].

This report is available to all water companies, interested parties and in the public domain for wider learning. I make particular note in respect of the reports of experts on *Cryptosporidium* in Water Supplies which remain relevant and should be followed by water companies.

Marcus Rink

Chief Inspector of Drinking Water

[(i)]His Honour Judge Mark Brown (The Honorary Recorder of Preston), Regina v United Utilities Water Ltd, Observations in Passing Sentence, Preston Crown Court, 10 October 2017

1. Introduction to the report

1.1 Purpose

1.1.1 In August and September 2015 a major drinking water quality emergency occurred in north Lancashire, affecting more than 700,000 consumers inhabiting the major towns of Preston and Blackpool, the Fylde Coast and the area south of Preston. The incident began when United Utilities Water Ltd, the water undertaker responsible for supplying drinking water to consumers in the North-West of England, identified the presence of *Cryptosporidium* in water supplied from the company's Franklaw water treatment works. *Cryptosporidium* is a type of parasitic protozoa, some species of which cause gastric illness in humans. In response, United Utilities advised all consumers supplied with water from Franklaw to boil their tap water before using it for drinking and food preparation.

1.1.2 This was the largest incident of its kind in Britain since 1989, when the water industry in England and Wales was privatised and the Drinking Water Inspectorate (the Inspectorate, or DWI) was established to regulate drinking water quality in England and Wales. The Chief Inspector of Drinking Water acts on behalf of the Secretary of State for the Department of the Environment, Food and Rural Affairs in England, and on behalf of Welsh Ministers in Wales.

1.1.3 On 19 July 2017 at Preston Magistrates' Courts, United Utilities pleaded guilty to the charge of supplying water unfit for human consumption between 30 July and 18 August 2015, brought by the Chief Inspector of Drinking Water under section 70 of the Water Industry Act 1991.

1.1.4 This document is the report of the Inspectorate's investigation into this event. It covers only those aspects relating to drinking water quality that fall within the responsibilities of the Inspectorate as the independent regulator. It does not consider matters relating to performance commitments agreed with the economic regulator (Ofwat) or financial losses suffered by businesses and matters relating to financial compensation. The Consumer Council for Water represented United Utilities' customers on these matters.

1.2 Executive summary

1.2.1 On 6 August 2015, 712,000 consumers resident in North Lancashire were advised by their water company, United Utilities, to boil their tap water before using it for drinking and food preparation. This was in response to the detection of the protozoan parasite, *Cryptosporidium*, in water supplied from

Franklaw treatment works, which was the sole source of supply to the affected consumers. The area covered by this advice included the major towns of Blackpool and Preston.

1.2.2 The DWI, as regulator of drinking water quality in England and Wales, was notified of the event during the morning of 6 August 2015, and responded immediately by despatching Inspectors to Franklaw and United Utilities' control centre in Warrington where the company's incident management team was based. The Inspectorate's investigation began at this time.

1.2.3 The company became aware of the highly unusual presence of *Cryptosporidium* in Franklaw's final water on 5 August 2015. The treatment works was taken out of supply later that day for planned maintenance, unconnected with this detection. The second positive result was reported to the company during the morning of 6 August. Two consecutive results of oocysts at the concentrations detected was very unusual for Franklaw works and indicative of a potential risk to public health. The company continued with its plans to return the works to supply in the knowledge of the presence of *Cryptosporidium* and before issuing the advice to consumers to boil their tap water. Not to do so would have resulted in the loss of supply because quantities of treated water stored in the network were becoming low.

1.2.4 The event developed into a major water supply emergency. United Utilities complied with its duties as a category 2 responder under the Civil Contingencies Act and contacted the Lancashire Constabulary who mobilised the Lancashire Resilience Forum plans and established a multi-agency Strategic Coordination Group (SCG) to manage the incident. Other multi-agency teams reporting to the SCG were established to deal with specific activities. Public Health England (PHE), the National *Cryptosporidium* Reference Unit, local authorities in Lancashire, Defra and Cabinet Office were all involved, and represented on the various incident teams, as appropriate to those organisations' responsibilities and duties.

1.2.5 The Inspectorate was closely involved throughout and was represented on the Scientific and Technical Advisory Cell which was responsible for advising on aspects of the company's response and the criteria for lifting the boil advice. The DWI also maintained continual contact with Defra and other government departments, and provided updates and media briefings during the course of the emergency.

1.2.6 The advice to boil was in place for up to a month for some consumers, and caused significant concern to the consumers and businesses affected. Some areas supplied by Franklaw were rezoned to receive water from other treatment works, which meant that these consumers did not need to boil their

water, but this number of consumers was a small proportion of the total population supplied by Franklaw.

1.2.7 The presence of *Cryptosporidium* in treated water supplied by Franklaw continued throughout this period, and whilst the company was carrying out extensive investigations into the source of the contamination, it was unable to identify the source early on. Species of *Cryptosporidium* known to be pathogenic to humans were subsequently found in the supply system. Without being able to rectify the root cause of the contamination, there was a risk that the company would have to keep the boil water advice in place for an indefinite period. Therefore the DWI issued a legal Notice[11] requiring United Utilities to take immediate action to restore a wholesome water supply from Franklaw works.

1.2.8 The company decided to install ultra violet disinfection at most of the service reservoirs in the Franklaw supply system which would ensure that *Cryptosporidium* present in the system would be rendered harmless. Other service reservoirs were reconfigured to be supplied from a different supply system. This was a major task for the company, involving significant financial outlay with procurement and engineering challenges, and completing the work in less than four weeks was a commendable achievement. As the work progressed, and contaminated water was removed from the distribution network, the boil advice was lifted in phases, until 6 September when it was lifted for all consumers.

1.2.9 The company's investigations into the cause of the contamination continued long after the boil advice was lifted. A definitive cause was not established, but in December 2015 the company determined that the most likely cause was direct contamination of treated water stored in Barnacre service reservoir – one of the major reservoirs in the Franklaw system. Immediately before the first positive *Cryptosporidium* result on 4 August 2015, the company had used water from Barnacre reservoir to supply the service water system at Franklaw works. Service water is used to make up treatment chemicals and provides motive water for chlorine dosing. This, crucially, meant that contaminated water was introduced into the treatment process at Franklaw after the treatment stages that are important for removal of *Cryptosporidium*.

1.2.10 The Inspectorate's investigation of the incident continued for a number of months after the boil water advice was lifted. Our primary concern was to review the company's response to the incident, its investigations into the cause and to ensure that United Utilities took appropriate action to prevent a recurrence of the incident at Franklaw and at any other of the company's water treatment works. The Inspectorate also considered whether United Utilities may have committed offences under the Water Supply (Water Quality)

Regulations 2000 (as amended), and the Water Industry Act 1991. United Utilities provided a number of reports on the incident to the Inspectorate between August 2015 and December 2016, in accordance with its duties under the Water Industry Act 1991.

1.2.11 The Inspectorate concluded that the incident was caused by a number of significant failings in the operation of Franklaw works and inadequate risk assessment of major operational changes that took place at Franklaw immediately before *Cryptosporidium* was detected in the supply. The Inspectorate used its powers of enforcement to ensure that the company implemented appropriate remedial actions at Franklaw and at other water supply sites operated by the company.

1.2.12 The company has installed permanent ultra violet disinfection at Franklaw, which inactivates *Cryptosporidium* rendering the organism harmless to humans, and which will prevent a repeat of this event at Franklaw.

1.2.13 Public Health England has reported that there were no identified cases of cryptosporidiosis illness in the community that are likely to be associated with the water supply.

1.2.14 The Inspectorate is continuing to work with United Utilities to facilitate delivery of major programmes of work to upgrade the company's assets and to implement cultural and management changes to ensure that an incident of such magnitude and seriousness does not happen again.

1.2.15 The event highlighted some important lessons for United Utilities and the water industry as a whole in England and Wales. In particular water suppliers must have resilience built into supply systems where the supply to a large population of consumers has no alternative supply arrangements. This may be by connectivity, redundancy of assets or robust protection systems to ensure that continuous supplies of wholesome water can be maintained.

1.2.16 Water suppliers also need to ensure that emergency contingency plans are appropriate for the size of their supply systems, such as restrictive advice to consumers which can be disseminated quickly and effectively to the affected population. Plans for rezoning supply areas, providing alternative supplies such as bottled water and water in tankers and bowsers, and obtaining mutual aid, also need to be ready for mobilisation within a short space of time to minimise the impact on consumers.

1.3 Summary of the Inspectorate's recommendations

The detail of the Inspectorate's conclusions and main findings arising from its investigation into the circumstances of the event, including where the company failed to comply with its statutory duties under the Act and the Water Supply (Water Quality) Regulations, is covered in section 8 of this report. Our principal findings and recommendations are in section 8.5, and the recommendations are reproduced here, along with the relevant paragraph/recommendation number:

8.5.1 On the company's decision to advise consumers to boil their tap water:

It is recommended that United Utilities reviews its emergency plans for issuing protective advice to consumers to ensure that these plans adequately cater for the number of consumers supplied by its treatment works (including non-residential consumers) to ensure effective communication with all affected consumers with the objective of issuing written advice to all households and other premises within 24 hours of the decision to issue the advice.

8.5.2 On the company's decision to re-start Franklaw works on 6 August and its plans to rezone areas supplied by Franklaw with water from other treatment works:

It is recommended that United Utilities reviews its supply systems to identify measures required to improve the resilience of all of its networks, such that in a drinking water quality emergency, alternative sources of supply can be introduced, to reduce the population who might thereby be issued with protective advice, and to reduce the duration that any such advice might be in place.

8.5.3 On the company's programme to install Ultra Violet disinfection on the outlets of service reservoirs in the Franklaw supply system:

It is recommended that in its review of the emergency and contingency plans for all of its supply systems, United Utilities considers whether provision of temporary treatment should form part of these plans, and, if so, what and where it might be needed, and how it would be procured.

8.5.4 On the company's immediate response to the emergency, the emergency incident teams and communications with key stakeholders:

It is recommended that United Utilities publishes a report on this event and works together with water companies through Water UK, and other stakeholders to ensure that they are aware of their roles and responsibilities within the current national guidelines for responding to an emergency.

8.5.5 On the company's immediate response to the emergency, the emergency incident teams and communications with key stakeholders:

It is recommended that United Utilities works together with other water companies through WaterUK and PHE, the National *Cryptosporidium* Reference Unit and other stakeholders to review how advice is publicised, the information given to consumers and organisations and to develop appropriate wording for water suppliers to use when issuing protective advice to consumers. Any learning should be communicated to the DWI who will consider and incorporate any necessary updates to the DWI/HPA document *Drinking Water Safety – Guidance to Health and Water Professionals*[9].

8.5.6 On the company's investigational sampling response:

It is recommended that the company reviews its emergency sampling response to ensure that at the onset of a *Cryptosporidium* emergency it has a sufficient quantity of portable high volume sampling equipment available to enable immediate meaningful sampling investigations of raw water quality, in-process quality and quality in the distribution network to comply with the requirements of Regulations 10 and 17 to investigate the cause and extent of the failure.

8.5.7 On the company's investigations into the source of the oocysts:

It is recommended that:

(i) United Utilities implements a full programme of work to ensure that all of its treated water-retaining tanks and reservoirs are properly maintained and secured to prevent the possibility of ingress of surface water.

(ii) United Utilities implements a full programme of work to ensure that all of its trunk and distribution mains are properly maintained and secured to prevent the possibility of ingress of surface water.

(iii) United Utilities ensures that all assets on treatment works that are integral to the treatment process are properly maintained and protected from damage and the risk of ingress, including service water supply arrangements.

(iv) United Utilities reviews its procedures for emptying washwater tanks and sludge holding vessels, and ensure that hose union taps and standpipes used on all of its water supply assets comply with the requirements of the Water Supply (Water Fittings) Regulations 1999 and are fitted with integral back-flow protection.

(v) United Utilities ensures that all clean water supply systems (used for domestic and other purposes) on water supply sites comply fully with the requirements of the Fittings Regulations.

(vi) United Utilities reviews the recommendations made in the three reports of the Groups of Experts on *Cryptosporidium* in Water Supplies and ensure that it is

complying with recognised and current good practice with respect to its operation and maintenance of water treatment works, including recycling of recovered wash water and monitoring the quality of recycled water, continuous turbidity monitoring of filtered water and the protection of service reservoirs and other assets from livestock and potential faecal contamination.

(vii) United Utilities reviews its progress with the measures required by Regulation 28 Notice UUT 3574 (issued by the Inspectorate in October 2016) which covers the recycling of backwash water at all of the company's treatment works, to ensure that any work required at Franklaw to address the failings identified in this report are given due priority.

(viii) United Utilities takes steps to divert septic tank drainage away from water supply sites.

(ix) United Utilities implements measures to enable all of its service reservoirs to be rapidly removed from supply to allow inspection and cleaning. These actions are covered by a Regulation 28 Notice issued by the Inspectorate in October 2016 (reference number UUT 3563), due for completion in 2020, with the work to be phased on a prioritised basis. The company should review its high priority sites to ensure that reservoirs in areas served by large single sources of supply, such as Franklaw, are given appropriate priority.

8.5.8 On the company's planned operation to repair a leak on the coast aqueduct:

(i) It is recommended that United Utilities reviews all of its water treatment works sites for disused mains and other decommissioned assets and disconnects them from live assets to prevent any future risks of contamination from decommissioned assets entering a treated water supply system.

(ii) It is recommended that United Utilities ensures that its records of underground assets and the status of valves are kept fully up to date.

8.5.9 On the company's risk assessment prior to the planned operation to repair a leak on the coast aqueduct

It is recommended that United Utilities reviews its approach to risk assessing major operational changes to ensure that all relevant factors are taken into account, enabling the company to fully comply with its statutory duties under section 68 of the Water Industry Act 1991, to maintain a supply of wholesome water and to prevent deterioration in the quality of water supplied.

2. Background

2.1 Drinking water quality legislation in England and the role of the Drinking Water Inspectorate

2.1.1 The quality of drinking water in England and Wales is governed by the Water Supply (Water Quality) Regulations, which transpose the requirements of the (European) Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption. In 2015, public water supplies in England were covered by the Water Supply (Water Quality) Regulations 2000[1] as amended (referred to throughout as the Regulations). The Drinking Water Inspectorate is responsible for enforcing the requirements of these Regulations in England.

2.1.2 Regulation 4 of the Regulations requires that water supplied to consumers for domestic purposes, which includes drinking, washing and food preparation, must be wholesome. This means that the water supply must not contain any micro-organism or parasite at a concentration or value that would constitute a potential danger to human health. Furthermore, the Regulations require that where a water company has reasonable grounds for believing that any organism or substance is present such that the water supply is likely to be unwholesome, the company must investigate the cause and take sufficient samples of the water supply to support its investigation.

2.1.3 Regulation 26 requires water companies to ensure that water supplied to consumers has been adequately treated and disinfected. Disinfection is a treatment process used to ensure that water supplies are safe to drink by rendering harmless any micro-organisms that may be present that could cause a risk to human health. The Regulations make it an offence if a water company does not comply with this requirement and is unable to demonstrate a defence that it exercised due diligence to prevent the event. Additionally, section 70 of the Water Industry Act 1991[2] (WIA 1991) creates an offence of supplying water that is unfit for human consumption. Again, demonstration of due diligence to prevent the event or reduce the impact can be a defence for companies.

2.1.4 Water companies are required by Regulation 27 to carry out a risk assessment of all their water supply systems and to identify any potential risks to health which require additional control measures, and take remedial action accordingly. A water company must report these risks to the Inspectorate, who has a duty under Regulation 28 to issue a formal Notice or Notices to the company requiring it to take remedial action to address the identified risks.

[1] The Water Supply (Water Quality) Regulations 2000, SI 2000/3184 – amended in 2001, 2002, 2005, 2007 and 2010.

[2] The Water Industry Act 1991 as amended by the Water Act 2003 and the Water Act 2014.

2.1.5 Regulation 35 requires water companies to notify the Inspectorate of any event which gives rise, or is likely to give rise, to a significant risk to human health. The Inspectorate then has a duty to investigate the event and, amongst other things, to establish whether any offences may have been committed under either the Regulations and/or the Water Industry Act. The Inspectorate also makes an assessment of the appropriateness of steps taken to protect public health, and, where necessary, uses its powers of enforcement to ensure that the company takes steps to prevent a recurrence. Companies are also required to notify health professionals in Public Health England (PHE) and local authorities within the affected area.

2.1.6 Since August 2015, when United Utilities first notified the Inspectorate of the presence of *Cryptosporidium* in the water supplied from Franklaw treatment works, the Regulations have been updated[3]. However the requirements referred to in paragraphs 2.1.2, 2.1.3 and 2.1.5 have not changed.

2.2 Cryptosporidium

2.2.1 *Cryptosporidium* is a type of protozoan parasite found in humans and many other species of animals, including cattle and sheep, other mammals, birds, fish and reptiles. Some species cause gastric illness, known as cryptosporidiosis, in humans. Its presence in raw water supplies is most frequently associated with sewage contamination or run-off from farmyards and farmland used for grazing livestock. It occurs in the environment in the form of tiny resistant bodies called oocysts, which are excreted by infected humans and animals. In the United Kingdom, the first recorded outbreak of waterborne human cryptosporidiosis occurred in Ayrshire in 1988[4].

2.2.2 There is a background level of human illness in most communities associated with sources other than drinking water, for example, swimming pools and direct contact with farm animals. The incubation period may be anything from two days to three weeks[5].

2.2.3 Oocysts can be present in raw water used for drinking water supplies and water companies must have in place treatment processes designed to reduce the concentration to a sufficiently low level, and/or to inactivate them, so that they are not harmful to health. Well-operated and well-monitored treatment processes that are designed to remove particulate material from raw water

[3] The Water Supply (Water Quality) Regulations 2016 SI 2016/614.

[4] An outbreak of waterborne cryptosporidiosis caused by post-treatment contamination, H. V. Smith et al, J of Epidemiology and Infection, vol. 103, 1989

[5] Cryptosporidium in Water Supplies, Report of the Group of Experts, Chairman Sir John Badenoch, July 1990.

are usually effective at reducing concentrations of oocysts to very low levels that are not a risk to human health.

2.2.4 In the UK, water is normally disinfected with chlorine before being supplied to consumers, to ensure that microbial pathogens are inactivated. Chlorine is not an effective disinfectant against *Cryptosporidium* and, in England and Wales, many water supplies are treated with ultra violet (UV) light as a safeguard against *Cryptosporidium*, since UV light is known to be effective for the inactivation of oocysts.

2.2.5 Not all species of *Cryptosporidium* are pathogenic to humans. The most commonly found species that are known to be harmful to humans are *C.hominis*, *C.parvum* and *C.ubiquitum*. The last of these is not as virulent (infectious) in humans as the first two.

2.2.6 *Cryptosporidium* has been associated with waterborne outbreaks of human illness, and there have been a number of cases in England and Wales which have been investigated by the Inspectorate. There is no recognised safe limit for the concentration of oocysts in water supplies and there is no regulatory limit for Cryptosporidium oocysts in drinking water. The following two examples relate to separate Cryptosporidium incidents investigated by the Inspectorate:

- Following the detection of *Cryptosporidium* in supplies to Northamptonshire from Pitsford works in 2008, there were 22 confirmed cases of cryptosporidiosis in a population served of approximately 258,000 consumers. *C.cuniculus* (not previously identified as a human pathogen in the UK as it is normally associated with rabbits) was identified in the water supplied to consumers. The concentration of oocysts observed in the water supply averaged around 2 oocysts per 10 litres (10L) at the start of the incident, with a maximum concentration of 17 oocysts/10L. The species of *Cryptosporidium* identified was not known to be a human pathogen, but these high concentrations caused cases of illness.

- In 2013, an outbreak of cryptosporidiosis in the community was linked to water supplies from Alderney works, near Bournemouth. There were 29 confirmed cases of cryptosporidiosis in a population of approximately 237,000 people served by this treatment works. C.hominis was detected in the water supplies. The observed concentration of oocysts leaving the works averaged 0.01 oocysts/10L, with a maximum detected concentration of 0.024 oocysts/10L.

2.2.7 The variable levels of oocysts detected in the water supplies that caused these outbreaks of illness illustrate the difficulties involved with establishing a safe limit for *Cryptosporidium* in drinking water. Water companies have a duty to ensure that water supplied to consumers is wholesome at all times and, therefore, should ensure that the Regulation 27 risk assessments for their supply systems are sufficiently thorough to identify all possible sources of *Cryptosporidium* in their supply systems, and to ensure that water treatment processes and protection of water supply assets from contamination are sufficient to effectively mitigate the risks to human health. Any unusual or unexpected occurrence of oocysts at any point in a supply system, whether it be in raw water, in water leaving a treatment works or water in the supply network, should prompt an immediate investigation by the water company with appropriate precautionary measures implemented to protect public health.

2.2.8 If *Cryptosporidium* is present in water supplies because of contamination or a breakdown in treatment, then alongside taking steps to restore wholesome water supplies as quickly as possible, a water company's emergency response is likely to include advising consumers to boil the water before using it for drinking and food preparation, because boiling is an effective means of inactivating oocysts.

2.2.9 The standard laboratory method used to identify *Cryptosporidium* in water will indicate whether *Cryptosporidium* is present or absent. In order to identify the species of *Cryptosporidium* present, water companies must arrange for further tests to be carried out at a specialist laboratory. Therefore until these additional tests are carried out, it is prudent for a water company to assume that any oocysts present might be pathogenic to humans and take appropriate precautionary measures to protect public health. Moreover, even where the species of *Cryptosporidium* identified is not subsequently identified to be a human pathogen, the presence of any oocysts could indicate a potential risk to health because in most circumstances the unidentified presence of a pathogenic species cannot be ruled out. The Pitsford event cited in 2.2.6 is a good example of this.

2.2.10 There is no known reliable laboratory test for the viability of oocysts. This means that when oocysts are detected and speciated, experts are unable to say whether the oocysts are infective or not.

2.2.11 In 1989, a group of experts on *Cryptosporidium* in water supplies, chaired initially by Sir John Badenoch and later by Professor Ian Bouchier, was established in response to a waterborne outbreak of cryptosporidiosis in

Swindon and Oxfordshire. This expert group published three reports in 1990[5], 1995[6] and 1998[7]. The purpose of these reports was to set out what is known about the organism, its occurrence in the environment and its importance as a human pathogen. These reports made recommendations covering water treatment, catchment protection, asset protection, management of outbreaks, responding to the presence of oocysts in water supplies, emergency planning, sampling and laboratory analysis. These recommendations remain the bench mark of good practice for managing risks associated with *Cryptosporidium* in water supplies, and since 1990 the water industry in England and Wales has invested heavily in improvements to water treatment works in response to recommendations made in these reports.

2.3 The start of the incident

2.3.1 On 6 August 2015, the Inspectorate was contacted by United Utilities reporting that unusually high levels of *Cryptosporidium* had been identified in two consecutive samples of water leaving Franklaw water treatment works (WTW). The company had agreed with PHE that consumers supplied by the works should be advised to boil their tap water before consumption because of the potential risk to human health from the presence of this organism in the water supply.

2.3.2 At the time, the company had in place continuous sampling for *Cryptosporidium* on the outlet of Franklaw works. This entailed a continuous filtration unit containing a replaceable compressed foam pad filter designed to entrap any oocysts present, installed at a dedicated sampling point on the outlet of Franklaw works. This was maintained in continuous operation and the filter was replaced on a regular basis, approximately three times per week. Filters are analysed at the company's laboratory where an extraction process is carried out in accordance with the standard published laboratory method[8], followed by microscopic examination of the concentrated extract to confirm the presence of *Cryptosporidium* oocysts.

2.3.3 On 4 August 2015, a filter which had been in place since 31 July 2015 was removed and sent to the laboratory for analysis. On 5 August the laboratory reported that a number of oocysts had been detected in the filter at a level equivalent to a concentration of 0.031 oocysts per 10 litres (10L) in Franklaw final water. The filter that was put in place on 4 August was then removed for

[6] *Cryptosporidium* in Water Supplies, Second Report of the Group of Experts, Chairman Sir John Badenoch, October 1995.

[7] *Cryptosporidium* in Water Supplies, Third Report of the Group of Experts, Chairman Professor Ian Bouchier, November 1998.

[8] The Microbiology of Drinking Water (2010) - Part 14 - Methods for the isolation, identification and enumeration of *Cryptosporidium* oocysts and *Giardia* cysts, Standing Committee of Analysts.

fast-track analysis, and on 6 August the laboratory confirmed that oocysts were also present in this filter equivalent to a concentration of 0.119 per 10L. These results were exceptionally unusual for Franklaw works, which in recent years had not had any *Cryptosporidium* oocysts detected in the final water.

2.3.4 Subsequently United Utilities sought advice from PHE and the *Cryptosporidium* Reference Unit in Swansea, and decided to advise 712,000 consumers supplied by Franklaw works to boil their tap water before consumption. The company started this process by issuing information on its website, social media and press releases to local radio, television stations and newspapers. It was followed up with the delivery of written advice notices to all affected properties, beginning on 7 August with notices delivered to all properties by 11 August.

2.3.5 In the meantime the company scaled up its investigations into the source of the *Cryptosporidium* by escalating its response to the level of a major incident, extending its investigational sampling to cover the raw waters supplying Franklaw, the treatment process and the distribution network supplied by Franklaw. The company also established various teams to investigate possible sources of the *Cryptosporidium*.

2.3.6 A major emergency response was instigated. A Scientific and Technical Advisory Cell (STAC) was established, led by PHE, which the Inspectorate was represented on. The company established a process of regular updates to the Inspectorate and other external stakeholders, including Defra's press office.

2.3.7 Following the initial notification to the Inspectorate on 6 August 2015, the Inspectorate's investigation began with the immediate deployment of Inspectors at Franklaw works and the company's incident control centre in Warrington. This was followed up with further technical audits of Franklaw treatment works and its associated supply system, visits to the company's incident control centre, representation on the STAC and assessment of the reports and updates subsequently submitted by the company to the Inspectorate during the course of the event.

2.3.8 More detail about the Franklaw supply system and the event is provided in the sections following.

3. Franklaw Water Treatment Works and its supply system

3.1 Franklaw Water Treatment Works

3.1.1 Franklaw Water Treatment Works (WTW) is a large water treatment works, supplying water to approximately 712,000 consumers inhabiting an area of some 830 square kilometres in north Lancashire, including the major towns of Blackpool and Preston, the Fylde coast and the area south of Preston including Chorley. The works itself is situated near Garstang in Lancashire and is owned and operated by United Utilities Water Ltd. The works is considered to be strategically important because it is the sole source of supply for the majority of consumers in its supply system. See Figure 1 on page 21.

3.1.2 Franklaw works was built in 1980, but the current design of the plant dates to 2004, when the works was upgraded to address *Cryptosporidium* and manganese risks in raw water sources supplying the works. Since 2004 the works has treated water from a variety of surface waters: The River Wyre, River Lune, the Thirlmere aqueduct, Barnacre impounding reservoir and the Alston impounding reservoirs; and two groundwater sources - Franklaw and Broughton boreholes. Raw water quality can vary throughout the year and flow from each source can be stopped or adjusted as required. At the time of the event, the river abstractions were not being used.

3.1.3 The maximum flow from the works is 220 million litres per day (ML/d), enough water to fill 88 Olympic-size swimming pools. The normal operating range is between 70 and 150 ML/d. At the time of the event the company reported that the works' output was between 75 and 125 ML/d, which is significantly below its designed maximum capacity.

3.1.4 Franklaw works has three key treatment stages to prepare the raw water for final disinfection by removing particulate material, consisting of chemical coagulation followed by clarification using super-pulsators, rapid gravity filtration and second stage filtration for manganese removal. The super pulsators help to bring small particles together to form a layer of sludge which is removed from the process. Particles escaping this process are removed by 12 rapid gravity filters, which at Franklaw works each consist of a bed of granular activated carbon. These two stages of the treatment process are important for the removal of *Cryptosporidium*, and, when operated well, should effectively address the *Cryptosporidium* challenge from the untreated water supplying the works.

3.1.5 Manganese is present naturally in many waters and needs to be removed to meet the standard of 50 micrograms per litre (µg/l). At Franklaw works, a bespoke treatment stage is in place to ensure this occurs. Chlorine is injected

into the water downstream of the rapid gravity filters to oxidise the manganese present and transform it into an insoluble state, which is then removed on one of five second stage filters (also known as manganese contactors).

3.1.6 Following the manganese removal on the second stage filters, the water is dosed with phosphoric acid to help prevent the dissolution of lead from domestic plumbing materials.

3.1.7 The final treatment stage is disinfection using chlorine, which is injected into the outlet main from the second stage filters from where it enters one of two contact tanks which provide time for the chlorine to disinfect the water. Chlorine is very effective for killing bacteria and viruses, but is ineffective against *Cryptosporidium* at the concentrations used. This is why the particle removal stages are important for removing *Cryptosporidium.*

3.1.8 Waste sludge from the clarifiers and water that has been used for backwashing filters is treated to remove particulate material by chemical coagulation and settlement in lamellar separators. The settled sludge is further treated prior to disposal off site. The supernatant from the separators is returned (recycled) to the works inlet. Continuous turbidity monitoring of the supernatant allows for water above a pre-set turbidity limit of 10 nephelometric turbidity units (NTU) to be returned to the lamellar separators for further treatment before recycling. At the time of the onset of the event, however, this turbidity monitor was not working.

3.1.9 A simplified schematic diagram of the treatment works is shown in Figure 2 on page 22.

Figure 1: The area supplied by Franklaw Water Treatment Works, with post codes shown. Consumers living inside the area marked with a red border were advised to boil water. Map provided by United Utilities.

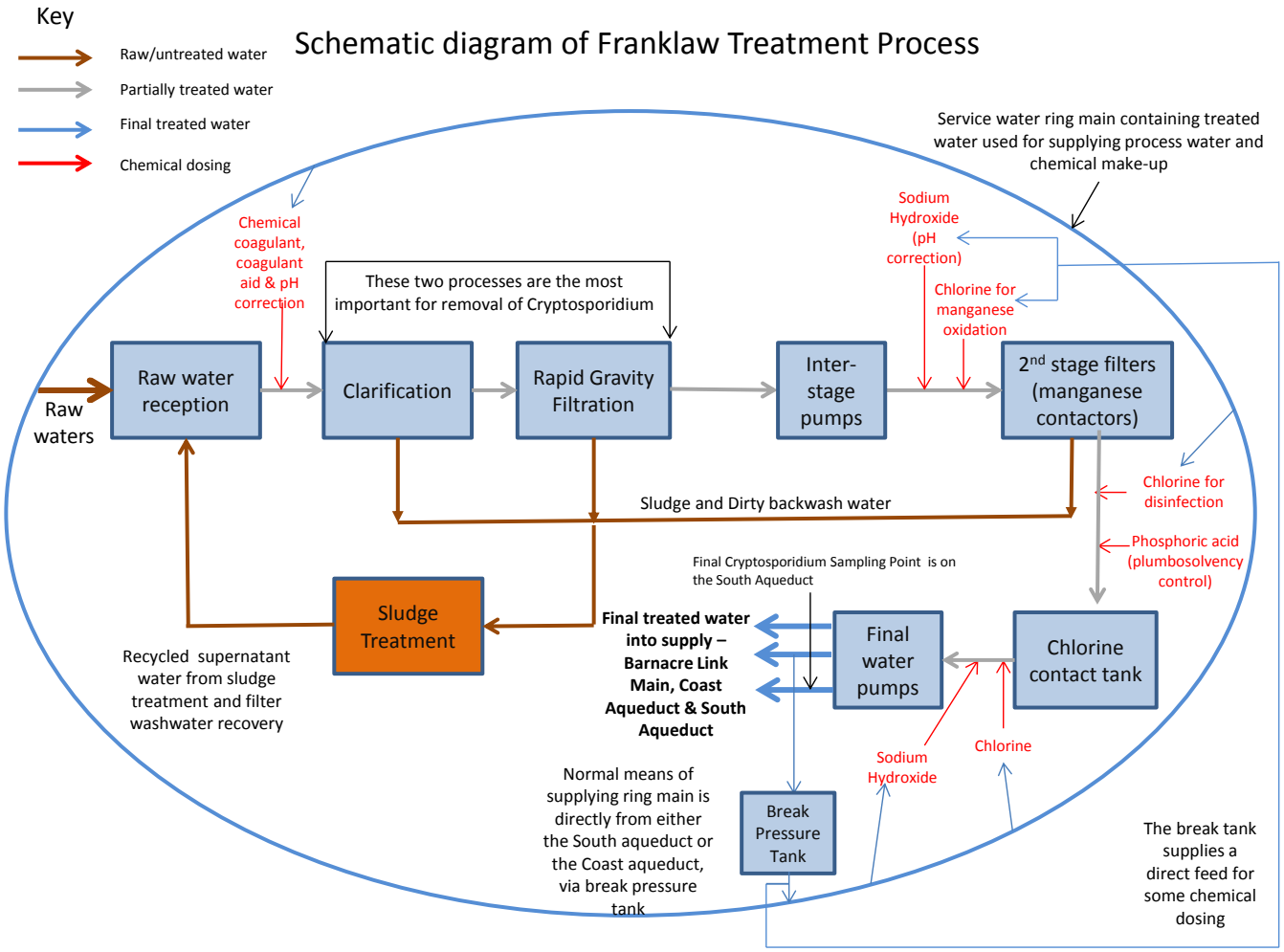

Figure 2: A simplified schematic diagram of the treatment process at Franklaw Works

3.2 Franklaw's distribution network

3.2.1 The treatment works supplies water to more than 700,000 consumers through a complex network of aqueducts and water mains, consisting of more than 2,500 miles of pipes. It takes several days for water leaving Franklaw works to reach the ends of the network. The water is stored in 15 service reservoirs and water towers across the supply area. Some of the service reservoirs are large in size and store large volumes of water, for example, Westby Service Reservoir has a maximum capacity of 164 million litres (megalitres), whilst others are very small in comparison, with maximum capacities of only one or two megalitres; others having a range of sizes in between.

3.2.2 The water is pumped from the treatment works by large pumps, into three large-diameter trunk mains (LDTMs, also known as aqueducts). The majority of the water is then transported to one of a number of service reservoirs to be stored before being supplied to consumers.

3.2.3 The South Aqueduct supplies the service reservoirs for Preston and South Ribble including Barnacre service reservoir near Garstang, and Hoghton and Whitebull service reservoirs near Preston. The Coast Aqueduct supplies the service reservoirs on the Fylde coast, including key supplies to Blackpool and the surrounding area via the strategic service reservoirs Weeton, Westby and Warbreck. The Barnacre Link Main supplies communities directly from Franklaw works to the east of the River Wyre. A number of smaller service reservoirs and water towers are supplied from Franklaw works, either directly or via the larger strategic service reservoirs outlined above. The network configuration is complex, but all these areas are supplied from Franklaw works. Parts of the system can be supported in the event of a problem at Franklaw by providing supplies from Hodder works, near Clitheroe, or Rivington works near Horwich. It is important to note, however, that these alternative supplies are not sufficient to provide water for all of the consumers normally fed by Franklaw works.

3.2.4 The diagram in Figure 3 on page 26 is a schematic representation of Franklaw works' distribution system as it was configured at the start of the event.

3.3 Risk management

3.3.1 Paragraph 2.1.4 explains the regulatory requirement that water companies must carry out risk assessments of their supply systems, under the requirements of Regulation 27. If a company identifies a risk to public health anywhere within a supply system, the company must ensure that measures are in place to protect consumers from being supplied water that could be

unwholesome or present a risk to human health. For a surface water treatment works such as Franklaw where there may be a risk of *Cryptosporidium* being present in the raw water, these measures should include treatment barriers such as coagulation and clarification and rapid gravity filtration, that are designed to deal with the volume and quality of raw water presented for treatment, and which are well-operated and well-monitored. The company must also ensure that assets such as final water tanks, service reservoirs and water mains are protected from ingress of surface water and groundwater.

3.3.2 If a company identifies any risks that cannot be effectively controlled with existing operational and asset-protection measures, then it should identify the risks in reports to the Inspectorate, which the company must provide under the requirements of Regulation 28. United Utilities provided a Regulation 28 report for the Fylde Demand Monitoring Zone, which includes Franklaw works, in December 2014.

3.3.3 As explained previously in paragraph 3.1.4, Franklaw works includes coagulation, clarification and rapid gravity filtration, because there is a risk of *Cryptosporidium* being present in the raw surface water sources that supply the works. In 2004, some improvements were made to the works, including the installation of continuous monitoring for *Cryptosporidium*. The company also installed treatment for recycled washwater at this time, which was recommended in the second report of the Group of Experts on *Cryptosporidium* in Water Supplies[6].

3.3.4 The Regulation 28 report submitted to the Inspectorate in December 2014 confirms that the process at Franklaw works provides a robust barrier for *Cryptosporidium* oocyst-sized particles and is consistent with the recommendations of the aforementioned report, and the Expert Group's first and third reports published in 1990[5] and 1998[7].

3.3.5 Companies are required to keep their risk assessments under continuous review, and if a new risk is identified which cannot be adequately controlled with existing measures, the company should inform the Inspectorate and submit a revised Regulation 28 report. In August 2015, at the start of the *Cryptosporidium* event, the company had not revised its risk assessment for Franklaw works since it was submitted to the Inspectorate in December 2014.

3.3.6 The Inspectorate recognises that in a complex water supply system, with large strategic treatment works such as Franklaw supplying an extensive distribution system via a large number of service reservoirs, the level of risk to water quality and sufficiency is constantly changing. The company should therefore have in place procedures and protocols which enable these changing risks to be managed as a matter of routine, with the resources

available to the company. Therefore there is no requirement for companies to send continuously updated risk assessment reports to the Inspectorate. This should only happen when a new risk is identified which requires new or improved permanent control measures.

3.3.7 Companies should have in place procedures requiring a risk assessment for all operational changes, for example when there is a change to a treatment process, and if work is to be carried out on an asset to temporarily remove it from supply to enable repair work to be carried out. All water companies deal with these types of situations on a daily basis, and should manage the risks involved to prevent anything going wrong that could cause unwholesome drinking water or a loss of supply to consumers. Companies are not required to inform the Inspectorate every time major work is carried out. But they are required to inform the Inspectorate if something goes wrong and there is a loss of supply or an increased risk of consumers being supplied with unwholesome water.

3.3.8 Companies should also have in place emergency plans to mitigate the consequences of major incidents, to ensure that continuous supplies of wholesome water can be maintained during major unplanned emergencies. These emergency plans should include the steps required to supply consumers from alternative parts of the company's network, procurement of equipment, and, if supplies are lost, plans for deployment of temporary supplies using vehicle tankers, bowsers and bottled water. These plans should ensure that any impact on consumers is managed, that steps are taken to protect public health if water quality is affected, that advice to consumers is effectively communicated and that the steps required to restore normal wholesome supplies as soon as possible are enacted and properly documented.

3.3.9 United Utilities had in place a contingency plan for Franklaw works entitled 'Process Loss Contingency Plan', dated April 2014. This plan considered the impact of a reduction in output from Franklaw works, and/or a total loss of the works, for a range of potential causes, including breakdown of a treatment process and failure of final disinfection. The plan did not cover the actions required, including measures to protect public health, during a major water quality emergency where it was not possible to shut down the treatment works without causing an interruption to the water supply to thousands of consumers. This is discussed in more detail in section 8.

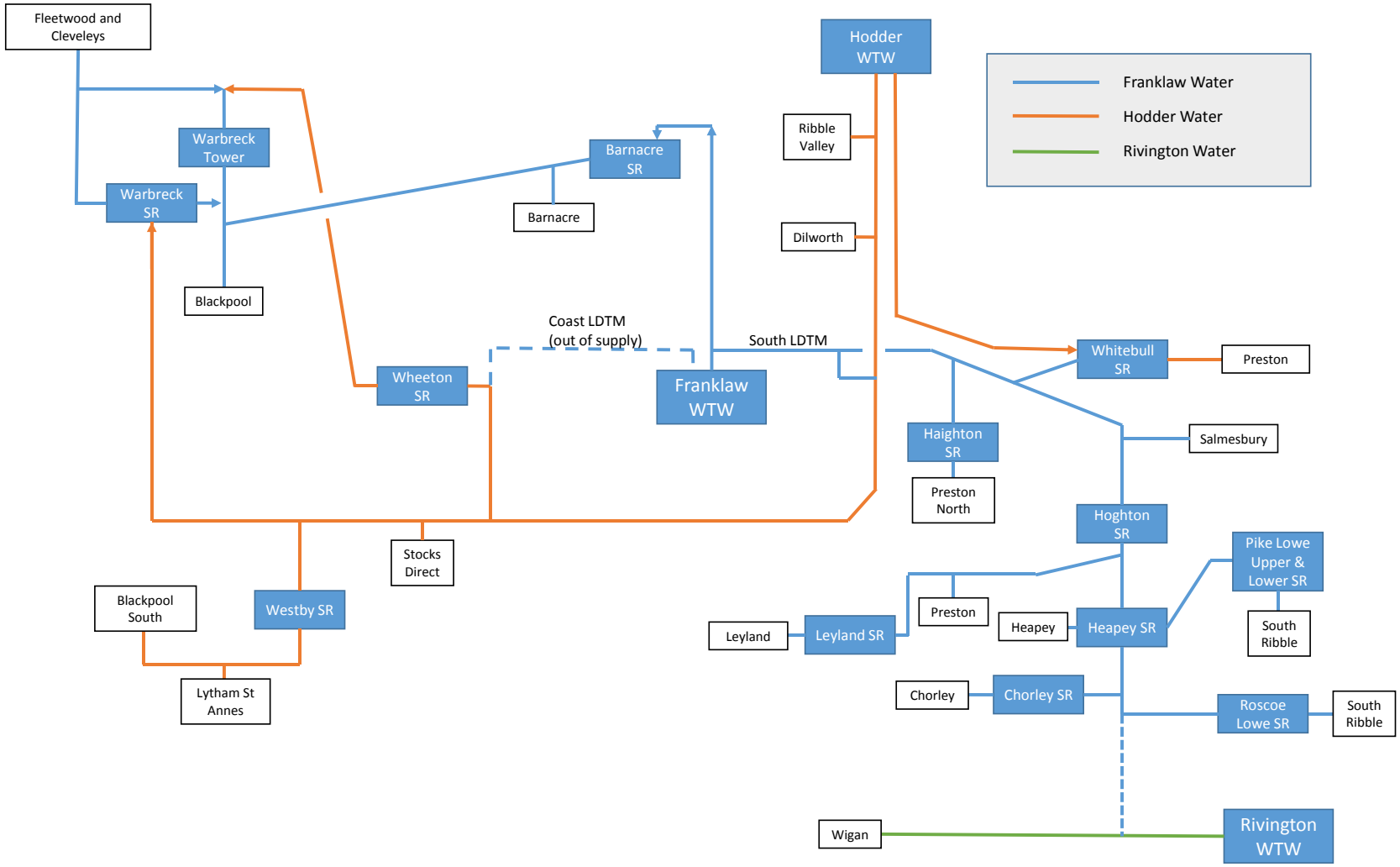

Figure 3: The normal configuration of Franklaw's supply system (Fylde, Preston and South Ribble Demand Monitoring Zone) at the start of the event, provided by United Utilities

(Key to acronyms: LDTM-Large Diameter Trunk Main; SR-Service Reservoir; WTW-Water Treatment Works)

4 The incident

4.1 Sequence of events

4.1.1 This section of the report sets out the sequence of events involving Franklaw works that led to United Utilities declaring a major incident on 6 August 2015 and advising the 712,000 residents in the area supplied with water from Franklaw to boil their tap water before consumption or using it for food preparation. This event developed into the largest ever incident of its kind in the UK, because of the strategic significance of Franklaw works as the sole supply to more than 700,000 consumers. The number of consumers affected was swollen because the incident occurred during the peak of the holiday season in August, with a large number of holiday visitors present in Blackpool and on the Fylde coast.

4.1.2 The start of the incident is described in section 2.3 of this report. It involved United Utilities identifying unusually high levels of *Cryptosporidium* in two consecutive samples of water leaving Franklaw Water Treatment Works. The company recognised that this was exceptionally unusual for Franklaw works, and contacted Public Health England (PHE) for advice. It was agreed that consumers supplied by the works should be advised to boil their tap water before consumption because of the potential risk to human health from the presence of this organism in the water supply.

4.1.3 There was a sequence of events preceding the issuing of boil water advice that started much earlier than 6 August. On 1 July 2015, United Utilities identified a leak on the Coast Aqueduct, on the Franklaw site. Operations to isolate the Aqueduct and repair the leak began on 25 July, which involved switching the supply of water to the works' service water system from the Coast Aqueduct to a different main, fed from Barnacre service reservoir which is off-site. This introduced a planned change to the treatment process, because service water is used for chemical dosing, amongst other purposes, and is therefore an integral part of the treatment process. Problems were encountered with the work to repair the leak, and the ring main which transports service water around the site depressurised a number of times between 25 July and 3 August. This sequence of events is outlined in more detail in Appendix 1, and is considered to be a key factor in the subsequent contamination of the treatment process with *Cryptosporidium* oocysts.

4.1.4 On 5 August 2015 the company became aware of the presence of *Cryptosporidium* in Franklaw final water. Sixteen oocysts were identified in a filter that had been in place for four days, from 31 July to 4 August, with approximately 5,100 litres of water passing through the filter over this period. This was exceptionally unusual for Franklaw, and the company contacted

PHE for advice. The *Cryptosporidium* filter that had been in place since 4 August was removed early for laboratory analysis. Franklaw works was removed from supply later on 5 August, for planned maintenance work that was unrelated to the detection of oocysts. On 6 August, the filter removed the previous day was found to contain 16 oocysts – the volume of water sampled this time was only around 1,340 litres, making the result even more exceptional. The company started work to return Franklaw works to supply during the morning of 6 August, in the knowledge of the exceptionally unusual presence of *Cryptosporidium* oocysts in two consecutive samples.

4.1.5 Once the company had made the decision to return Franklaw works to supply after the planned maintenance work, the decision to issue boil water advice to consumers was made and the company immediately notified the Drinking Water Inspectorate as required by Regulation 35 of the Regulations. The Inspectorate responded by sending Inspectors to Franklaw works and to the company's incident control centre to begin investigating the cause of the contamination, to ensure that the company was taking appropriate steps to protect public health, and had in place a strategy for restoring wholesome supplies as quickly as possible. The advice that consumers should boil water before using it for drinking and food preparation was publicly issued at around 15.00hrs on 6 August.

4.1.6 As required by Water Industry (Suppliers' Information) Direction 2012 which supplements the requirements of Regulation 35, the company provided a number of written reports to the Inspectorate about the event including draft, interim and final reports, the outcome of the company's investigations into the root cause, or causes, the steps the company has taken to prevent a recurrence and a re-assessment report on the event, the last of which arrived on 10 December 2016. The company also provided regular updates during and after the event of ongoing sampling results and the continuous sampling for *Cryptosporidium* on Franklaw works' outlet. The Inspectorate has investigated the event through reviewing data and information provided by the company and through carrying out technical audits of the treatment works and the supply network.

4.1.7 Having reviewed the report submitted on 17 November 2015, entitled by the company as the 'Final (Twenty-Day) Report', the Inspectorate responded with a request for more than 100 items of additional information required to enable completion of the investigation. This process involved numerous exchanges of emails, and the provision of follow-up information by United Utilities. The timeline in Appendix 1 is a compiled record of key events which the Inspectorate considers to be important, that took place in the period leading up to 6 August 2015, and subsequently during the event. This record is compiled from the company's reports, the Inspectorate's own investigations

and a range of other sources and records. There are some significant factors that emerge when the sequence of events is reviewed as a whole, and a number of questions to be answered. These include:

i. The significance of the initial detections of *Cryptosporidium* oocysts in Franklaw final water and the appropriateness of the company's decision to advise consumers to boil water.

ii. The efficiency and timeliness with which this advice was issued to consumers, and its effectiveness.

iii. The company's immediate investigation into the cause and extent of the *Cryptosporidium* contamination, including its investigational sampling response.

iv. The appropriateness and timeliness of steps taken by the company to restore wholesome supplies, including the reasons for deciding to install UV treatment at service reservoir outlets in the Franklaw supply system.

v. The company's communications with public health experts, the Inspectorate, Defra's Chemical, Biological, Radiological and Nuclear (CBRN) team (qv paragraph 4.3.4) team, local authority environmental health departments, Members of Parliament, local councillors and other key stakeholders.

vi. The outcome of the company's investigations into the root cause, or root causes, of the presence of *Cryptosporidium* in Franklaw final water.

vii. Lessons learned for the company and steps it has taken to prevent a recurrence.

viii. Lessons learned for the water industry.

ix. The extent to which the company failed to comply with the requirements of the drinking water quality Regulations.

x. Whether the company committed an offence under Section 70 of the Water Industry Act 1991, and/or Regulation 26 of the Water Supply (Water Quality) Regulations 2000.

4.1.8 The following sections of this report consider these points.

4.2 The significance of the presence of *Cryptosporidium* in Franklaw final water

4.2.1 On 5 August 2015, United Utilities detected 16 *Cryptosporidium* oocysts at a concentration of 0.031 oocysts per 10 litres (10L) in a sample taken the previous day from the final water at Franklaw water treatment works. This was unusual in that detections of oocysts in the final water are rare and the number detected was significantly higher in this sample than any experienced in the past five years. In fact, no more than one *Cryptosporidium* oocyst was found in any other sample in this period with a maximum concentration of 0.005 oocysts per 10L. PHE and the local authorities affected were notified as required by Regulation 35 of the Regulations.

4.2.2 The company immediately took steps to investigate this occurrence and arranged for the subsequent sample to be prioritised for urgent analysis and investigations into possible causes of the contamination commenced. The second sample also contained *Cryptosporidium*, at a level of 0.119/10L.

4.2.3 *Cryptosporidium* has been detected in water supplies in England and Wales before. Infrequent detections of low concentrations in treated water from properly operated works are considered to pose a low risk to public health[5]. However, in this case United Utilities appropriately identified that this was an unusual situation and whilst the concentrations of oocysts in these first samples were relatively low, they may have represented a risk to public health.

4.2.4 Section 2.2 of this report provides some basic information about the organism *Cryptosporidium*, and two examples of waterborne outbreaks of cryptosporidiosis are outlined in paragraph 2.2.6. The initial concentrations of oocysts detected in the two consecutive samples of Franklaw final water, of 0.031/10L and 0.119/10L respectively, were similar to levels detected in the water supply during the Alderney incident which affected consumers in Bournemouth, when the maximum level detected was 0.024/10L. Furthermore, positive results in two consecutive samples was unprecedented for Franklaw, which had a recent history of no oocysts being detected in its final water, and very low levels in its raw waters.

4.2.5 The first Badenoch report[5] confirms that should mains water become contaminated with oocysts, cases of illness could occur in the area of supply, and therefore action is needed to protect public health. The company considered whether Franklaw works could be shut down. The timeline in Appendix 1 shows that Franklaw works had in fact been shut down on 5 August, at approximately 22.00 hours, for planned maintenance that was unconnected with the presence of oocysts in the final water. However, by the early hours of 6 August, levels of stored water in the Franklaw system were

running low and there was an immediate risk of supplies being lost to the areas supplied. The company took the decision that supplies needed to be maintained and operations to restart Franklaw works began at approximately 08.00 hours on 6 August.

4.2.6 The second positive result reported on 6 August confirmed the presence of oocysts in Franklaw water. Furthermore, the water had been contaminated with oocysts at least since 4 August, and possibly earlier since the filter removed on 4 August had been in place since 31 July. Franklaw's supply system is large and complex, as described in sections 3.1 and 3.2, incorporating some 15 service reservoirs and 2,500 miles of strategic trunk mains and distribution mains. Therefore, water containing oocysts was already in the system, and would remain in the system for several more days.

4.2.7 The only option open to the company, therefore, having returned Franklaw to supply, was to advise consumers to boil the water before consumption. The first Badenoch report confirms that cryptosporidial oocysts are destroyed by high temperature and therefore this advice is appropriate in situations where it is necessary to maintain supplies to consumers. It is not a decision that any water company takes lightly, particularly where the population supplied is as large as the population supplied by Franklaw. There is also the associated risk that not all consumers will be cognisant of the advice, and some consumers will choose to ignore it.

4.2.8 In the case of Franklaw, the logistical difficulties involved with implementing boil water advice (BWA) on such a large scale were immense. The event was escalated to an emergency under the requirements of the Civil Contingencies Act 2004, defined in section 1.(1).(a) as an event or situation which threatens serious damage to human welfare due to the disruption of a supply of water.

4.3 Management of the incident and communications with key stakeholders

4.3.1 In an incident where there is a risk to public health, a number of organisations are involved in the response and in the recovery strategy. In this case, decisions directly related to water quality and water supply remained the responsibility of the incumbent water company, United Utilities. The company's decisions were informed by multi-agency groups and responsible authorities who had responsibility for directing the management of the incident and maintaining contact with the company to monitor progress and develop the strategy for recovery.

4.3.2 Under the terms of the Civil Contingencies Act, water undertakers are Category 2 Responders within the context of the Act, and have duties under its requirements. Incident management teams were established following

emergency plans developed by the Lancashire Resilience Forum. The incident was managed at a strategic level by the Strategic Coordination Group (SCG) which was a multi-agency group led initially by the Lancashire Police, then subsequently by United Utilities and then the Director of Public Health for Lancashire County Council. Its membership included representatives from the local authorities, PHE, NHS England and the Inspectorate. The SCG established sub-groups to deal with communications, vulnerable consumers and the recovery plan. Policy managers and local consumer advocates from the Consumer Council for Water were involved with some of these groups.

4.3.3 A Scientific and Technical Advisory Cell (STAC) was established, chaired by PHE with representatives from United Utilities, Greater Manchester Health Protection Unit, the National *Cryptosporidium* Reference Unit and the DWI. The role of this group was to provide technical advice to the SCG and other teams, to agree on the interpretation of the company's sample results, the ongoing measures required to protect public health and the criteria for lifting the boil water advice.

4.3.4 The Chief Inspector of Drinking Water, the Consumer Council for Water, Defra's CBRN team, the Secretary of State's (SoS) private office, Defra's press office and Ofwat were kept updated of developments throughout the duration of the incident.

4.3.5 United Utilities retained primary responsibility for communicating with its affected customers.

4.3.6 PHE, through its public health doctors and other public health experts has responsibility for identifying risks to public health and advising on measures necessary to protect human health. In emergency situations affecting drinking water quality, the organisation will advise the water company on the risk to human health in a given circumstance, and aid the company's decisions on steps required to protect public health.

4.3.7 Local authorities have a duty under section 77 of the WIA 1991 to keep themselves informed about the wholesomeness and sufficiency of water supplies in their area. The Act also gives the SoS the power to require a local authority to take samples of water supplied to the public, if it is deemed necessary, to support this duty. The SoS did not exercise these powers during this incident. Furthermore, local authorities have responsibilities under the Food Safety Act 1990 for protecting public health in establishments that provide food and drink for consumption by members of the public, including premises where food is manufactured and/or sold, premises such as cafes, hotels and restaurants and premises where food and drink is prepared and/or provided for consumption by members of the public for example schools, hospitals, care homes and prisons.

4.3.8 The Inspectorate and the Health Protection Agency (the predecessor of PHE) jointly published a guidance document for health and water professionals which sets out the structure and legal framework of the water industry in England and Wales and describes the arrangements in place for securing the quality and safety of drinking water on a day-to-day basis[9]. This document provides information about drinking water quality, risks to public health (including *Cryptosporidium*) and actions required to protect public health in the event of a water quality emergency.

4.3.9 Once the incident teams were established under the auspices of the SCG, the STAC and the company's incident management teams, communications were established with the aforementioned organisations and teams in accordance with statutory and regulatory requirements. At this point in the incident some key stakeholders with responsibility for representing consumers, in particular Members of Parliament and local councillors as well as Government stakeholders including Cabinet Office (which plays a lead role in major civil emergencies) and Ofwat, were not communicated with sufficiently early. The widespread public concern generated by this incident understandably led to anxious consumers and representatives of the press and media making direct contact with these individuals and organisations, who, at times, felt that they were not being kept appropriately updated. This has been considered further by the Inspectorate and a recommendation has been made that United Utilities works with water companies and other stakeholders to review guidance on roles and responsibilities for responsible organisations when responding to drinking water quality emergencies (recommendation 8.5.4).

4.4 Issuing the boil water advice

4.4.1 The decision to advise consumers to boil their tap water was agreed upon in consultation with the STAC, at approximately 15.00 hours on 6 August. The most effective way of providing this advice to consumers is to issue written warning notices to every property in the affected area. Franklaw works supplies more than 300,000 properties, and therefore undertaking this task was a major operation.

4.4.2 Having confirmed the post codes covering the area of supply, the process of issuing written warning cards commenced on 7 August, and was completed by 11 August. The company had arrangements in place with Royal Mail and a separate contractor to deliver Boil Water Advice, (BWA), cards, but it quickly became apparent that these organisations were unable to deal with the

[9] Drinking Water Safety – Guidance to health and water professionals, 2009, available on the Inspectorate's website.

volume of communications required, and United Utilities supplemented these arrangements by deploying its own personnel to hand-deliver notices.

4.4.3 The company recognised that delivering written advice to every property supplied by Franklaw works could not be achieved immediately, and therefore the company placed information on its website and social media, and issued briefings to local television and radio stations and local newspapers to publicise the advice as widely as possible from the start.

4.4.4 The company also provided bottled water to customers registered on United Utilities' Priority Services scheme, and to other vulnerable consumers on request.

4.4.5 The company established a dedicated web page specifically for the incident, which was kept updated throughout.

4.4.6 It is recognised that not all consumers will become aware of warning advice through publication on websites, social media and bulletins in local press, radio and television. The Inspectorate sent questionnaires to 185 consumers who were affected by the event. Of the 35 consumers who responded, all confirmed that they were unaware of the BWA either until they contacted United Utilities themselves or until the written notice was received. The question of whether the issue of written advice was carried out as quickly and efficiently as possible needs to be considered. Had the company's contingency plans for issuing a large-scale BWA adequately covered the resources required to deliver more than 300,000 notices in as short a period of time as possible, it is possible that the time required to deliver written notices to all affected properties could have been reduced. This is considered further in section 8.

4.5 The company's investigational sampling response

4.5.1 Regulation 10 of the Regulations requires the water company to take sufficient samples from the supply system as soon as it has reasonable grounds for believing that any element, organism or substance is present which may cause the water supply to be unwholesome.

4.5.2 The purpose of the company's investigational monitoring is twofold. Firstly it is important to establish the extent of the contamination, and the concentrations of oocysts in the water supplied to consumers, in order to confirm the appropriateness of the measures in place to protect public health. Secondly the company needs to establish the cause of the contamination, and the sampling strategy should be designed to support this investigation.

4.5.3 Before the start of the event the company carried out routine monitoring for *Cryptosporidium* on the raw water inlet to Franklaw works (involving 10 litre spot, or grab samples) and sampling for oocysts on the outlet of the works, which involved continuous filtering through a compressed foam pad filter which the company changed approximately three times per week. This is explained in more detail in paragraph 2.3.2. Continuous filter sampling for this organism allows very large volumes of water to be sampled – in excess of 1,000 litres can be sampled over a 24 hour period – and the results obtained from this method of sampling provide a greater level of confidence than for those obtained from 10L grab samples, from which there is a lower probability of detecting oocysts.

4.5.4 The company's risk assessment for Franklaw works did not identify a significant risk of oocysts passing through the treatment process because the three-stage treatment process involving coagulation and clarification, rapid gravity filtration and second-stage filtration were considered to provide an effective barrier. Between January 2010 and 3 August 2015 the company analysed 860 continuous filters for the presence of oocysts, and oocysts were detected very sporadically, in four of these filters, at very low levels, with no other risk indicators identified at those times.

4.5.5 As soon as the positive result was reported by the laboratory on 5 August, the company took 10L grab samples from two strategic downstream service reservoirs and consumers' taps, and fast-tracked the analysis of the continuous filter that was put in place at Franklaw on 4 August. The company maintained continuous monitoring of Franklaw final water throughout the event, replacing the filter at frequent intervals. The service reservoir samples taken on 5 August were clear of oocysts.

4.5.6 As the incident developed, the company widened its investigational sampling to include Franklaw's raw water sources, stages in the treatment process and wider sampling in the supply network at service reservoir outlets and consumers' properties. The company provided regular reports to the Inspectorate of the results of its *Cryptosporidium* monitoring.

4.5.7 As stated previously, sampling for *Cryptosporidium* requires very large volumes of sample to obtain a meaningful result, and small volume grab samples do not provide this. Negative results obtained from 10L grab samples should be treated with caution because the absence of oocysts in a 10L sample does not necessarily provide assurance that oocysts are not present in the water supply, particularly since the highest level detected from the works would on average require 100L to detect one oocyst. The company initially relied upon 10L grab samples for most of the investigational sampling.

It managed to install continuous filters at two service reservoir outlets on 7 August, and a further two by 10 August.

4.5.8 Obtaining the necessary equipment to install continuous filtration for *Cryptosporidium* on all of the service reservoirs in the Franklaw system and at other key points within the treatment process and in the network proved difficult for the company, and it was not until 25 August that continuous filters were installed at all service reservoirs. The sequence is noted in the timeline in Appendix 1. Given that the equipment required for continuous filter sampling comprises, in addition to a supply of foam pad filters, no more than a tap, a filter housing, a water meter and connecting hoses for each installation - items which should be readily available to any water company and held in sufficient numbers for emergency purposes - it is surprising that this was such a difficulty for the company.

4.5.9 Most of the samples taken on 6 August were clear of oocysts, but samples from Weeton and Heapey service reservoirs were found to contain oocysts. By 7 August oocysts were detected in Barnacre and Hoghton service reservoirs, which indicated that the *Cryptosporidium* contamination had spread deep into Franklaw's supply system. Oocysts were eventually detected in all service reservoirs supplied by Franklaw, and also in some consumers' tap samples, confirming the extent of the contamination throughout the entire system.

4.5.10 The company's investigational monitoring continued throughout the event and until well after the boil water advice was withdrawn. See section 4.6 on steps the company took to restore wholesome supplies.

4.5.11 The water samples taken by the company during the event were analysed by the company's laboratory in Warrington. The laboratory is accredited by the United Kingdom Accreditation Service (UKAS) to ISO/IEC17025:2005 and the Drinking Water Testing Specification (UKAS Lab 37 Accreditation Requirements). The laboratory's analytical method for *Cryptosporidium* is covered by its accreditation. As explained in paragraph 2.2.9, the standard laboratory method for isolating oocysts cannot determine the species of *Cryptosporidium*. Therefore United Utilities sent prepared slides with oocysts present to the *Cryptosporidium* Reference Unit in Swansea for further analysis to identify the species.

4.5.12 For the majority of samples submitted to the Reference Unit, the species of *Cryptosporidium* could not be determined. Between 4 August and 6 September when the BWA was withdrawn for all consumers, the company took 1,213 samples for *Cryptosporidium* from Franklaw and its associated supply system. Of these, the company's laboratory identified oocysts in 353 samples. Of all these 353 positive samples, five of them were positively

confirmed by the *Cryptosporidium* Reference Unit as containing a species of *Cryptosporidium*:

- Hoghton SR, 07/08 – *Cryptosporidium hominis*
- Hoghton SR, 10/08 – *Cryptosporidium ubiquitum*
- Weeton SR, 10/08 – *Cryptosporidium hominis*
- Barnacre SR 18" main at Franklaw, 10/08 – *Cryptosporidium hominis*
- Barnacre SR outlet, 11/09 – *Cryptosporidium andersoni*

C.hominis is considered to be one of the main pathogens responsible for human cryptosporidiosis (the other being *C.parvum*), but there have been reports of *C.ubiquitum* as an emerging pathogen for humans. *C.andersoni* whilst associated with illness in humans, is not considered a risk in the UK.

4.5.13 The *Cryptosporidium* Reference Unit stated that even though *Cryptosporidium* oocysts were seen on slides submitted for examination, DNA was not detected other than in the five samples listed above. There were a number of reasons given but the low number of oocysts present and degradation of the DNA were considered possible. However, when DNA is detected by this method, the test is 100% specific for *Cryptosporidium* species.

4.5.14 United Utilities' investigations into the source of the oocysts in Franklaw treated water started on 5 August following the first report of oocyst detections in the continuous filter put in place on 31 July. These investigations continued for a many months, well after the boil water advice was lifted on 6 September. This work involved extensive and complex investigations into the condition of pipes and structures at Franklaw works and in the supply system, and sampling for *Cryptosporidium* and other indicators of faecal contamination in the raw water, partially treated water in Franklaw's treatment processes and the distribution network. The company also investigated and sampled potential sources of oocysts in the environment around these assets. The work undertaken to investigate the source of *Cryptosporidium* is covered in more detail in section 5 of this report.

4.6 Restoration of wholesome supplies and the phased withdrawal of the boil water advice

4.6.1 The background to the decision to advise consumers supplied from Franklaw works to boil the tap water before consumption is discussed in section 4.2, and the process of issuing the advice is covered in section 4.4.

4.6.2 The criteria for lifting the boil water advice (BWA) was initially agreed with PHE; that there should be three sets of clear samples from Franklaw final water, each 24 hours apart.

4.6.3 The company immediately considered the feasibility of installing ultra violet irradiation (UV treatment) on the outlet of Franklaw works. UV irradiation to a recognised minimum standard is an effective treatment for the inactivation of oocysts. The option was quickly discounted, however, because of the size of the equipment required and the practical difficulties of installing it at Franklaw within a short timescale.

4.6.4 Samples from Franklaw final water taken between 9 August and 14 August were all clear of oocysts, which led the company to believe that the criteria for lifting the boil notice would be met once the entire system was free of water likely to be contaminated. But samples of Franklaw final water taken later on 14 and then 15, 16 and 17 August contained oocysts, and therefore the BWA had to continue. Thereafter positive oocyst detections continued in samples from Franklaw until well after the BWA was lifted (all of the works output was treated in the network with UV by this time, and therefore there was no ongoing risk to public health – see paragraph 4.6.10)

4.6.5 The company had already started modelling the Franklaw supply system to confirm the retention time of Franklaw water in the system, and to identify routes for alternative sources of supply that could be introduced into the network. Work to check the status of boundary valves commenced on 12 August in preparation for rezoning areas of the network which could be fed from other sources, and flushing Franklaw water out of the system. Rezoning and flushing operations on parts of the network commenced on 15 August and the first reservoir to be rezoned to an alternative supply (from Hodder treatment works) was Whitebull on 19 August, which supplies the Preston demand monitoring zone. This was nine days after the BWA was issued.

4.6.6 The company was able to rezone the Franklaw system to supply a further nine service reservoirs from alternative sources. Areas supplied by Duxon Hill, Hoghton and Clayton reservoirs were rezoned to receive water from Hodder works; areas supplied by Chorley, Roscoe Lowe and Heapey reservoirs were rezoned to receive water from Rivington WTW, and areas supplied by Pike Lowe Upper and Pike Lowe Lower reservoirs received a blend of water from Hodder and Rivington. Haighton reservoir under normal conditions was already supplied with water from Hodder works, but because of system hydraulics could also receive water from Franklaw works. An operating protocol was established to minimise the volume of Franklaw water entering this reservoir, which subsequently had UV treatment installed on its outlet

(see paragraph 4.6.10). All of this rezoning work was completed by 23 August.

4.6.7 It was also important to isolate and clean out reservoirs in the Franklaw system and to confirm the absence of oocysts before it was safe to lift the boil water advice. Isolating a strategic reservoir from supply can create a risk of loss of supplies and needs to be carefully planned. Most service reservoirs have a bypass main which allows them to be isolated from the system, and larger reservoirs generally have more than one compartment which allows one compartment to be isolated for cleaning whilst the other, or others, remain in supply. Because of operational constraints associated with the complexity of the supply system and the large sizes of some the service reservoirs, United Utilities was not able to isolate and clean out all of the reservoirs in the Franklaw system quickly enough to allow early lifting of the boil advice. This included those that had been rezoned to receive alternative sources.

4.6.8 As noted in paragraph 3.2.3, the alternative sources are not sufficient to provide water for all of the consumers normally fed by Franklaw works and the company was unable to expedite isolation and cleaning of the reservoirs that had been rezoned. Therefore in order to restore wholesome supplies to consumers who were being advised to boil their water, the company had to install treatment on reservoir outlets in the supply system. UV treatment was selected as the most practical option, and the UV task team started to make plans, and made contact with suppliers of suitable UV treatment units.

4.6.9 Initially the priority was to install UV treatment on the outlets of reservoirs that could not be rezoned to receive an alternative supply. This included Warbreck reservoir, Warbreck Tower (requiring a unit on each of two outlets), Weeton and Westby reservoirs. The company sought to procure treatment units from known suppliers of UV equipment and from other water companies through mutual aid arrangements. Obtaining off-the-shelf units that could be installed ready for use proved to be difficult, but the company was able to procure and complete the installation of these five UV treatment units between 22 August and 29 August.

4.6.10 As more UV equipment became available the company extended its strategy to install UV treatment on more reservoirs, including those that had been rezoned and which were awaiting cleaning. Thus by 6 September, 11 UV treatment units were operational on the majority of service reservoirs in the Franklaw system, 32 days after the start of the BWA. It was a significant challenge for the company to install 11 UV treatment systems by 6 September, involving considerable financial outlay with major engineering difficulties at some of the sites. The company made use of all available UV treatment units in the UK and procured a number from abroad. The average

number of days required to procure, design, build, install and commission each unit was 13.5 days. The installation at Warbreck reservoir took six days from procurement to installation, and those at Warbreck Tower took eight days. Without these UV installations the BWA would have continued for much longer, possibly for many months.

4.6.11 The Inspectorate visited a number of the UV installations to monitor progress with commissioning and to confirm that the treatment units were appropriate for the volume of water to be treated, and validated for the inactivation of oocysts under the normal operating conditions at each site. The photographs in Figure 4 illustrate the size of some of the installations and the engineering challenges involved.

Figure 4 – Photographs taken by DWI showing installation of ultraviolet treatment units at Warbreck Tower (left) and Weeton SR (right).

4.6.12 Following the installation of the UV reactors, the company implemented a flushing plan to remove water that had not been UV treated from the water supply network. The company took steps to prioritise areas for flushing once the UV reactors had been installed in order to lift the boil water advice as soon as possible for consumers in the areas supplied by UV-treated water.

4.6.13 Once UV treatment units started to be operational, the company was able, with the agreement of the STAC, to make preparations to lift the boil advice. The criteria for lifting the advice were agreed as follows:

- Installation of UV disinfection and confirmation that all water in the part of the system had received UV treatment
- Rezoning of the area of supply to an alternative source, with confirmation that all Franklaw water had been eliminated from that part of the system, and that sample results were satisfactory.

4.6.14 The area covered by the BWA was split into ten smaller areas, and a phased lifting plan was established for each area to be implemented once the criteria

had been met. This resulted in the boil water advice being lifted in three phases, which caused some anxiety amongst members of the public because some people were uncertain whether they were still required to boil water or not. The first lifting of the BWA took place on 27 August, and by 6 September had been lifted for all affected consumers. The sequence is given in the timeline in Appendix 1.

4.6.15 It has to be said that the 712,000 consumers who were asked to boil their tap water for up to 32 days suffered significant inconvenience, and a number of businesses, particularly hotels and catering businesses, reported financial losses. The incident caused significant public concern and many consumers questioned why the BWA was in place for such a long period. The Inspectorate interviewed a number of individual consumers and small businesses affected by the incident, and some of the statements made indicate the level of concern:

- *I heard about it [the boil water advice] on the radio driving home. When I got home my family knew nothing about it. We would definitely not have drunk the water if we had heard the advice earlier.*
- *My brother and sister have learning difficulties and it was hard to keep reminding them not to drink water straight from the tap.*
- *We had to carry large containers of boiled water upstairs which my elderly parents couldn't do without help.*
- *We were not impressed with United Utilities. We would not have drunk the water knowing about a potential risk to health.*
- *It was very inconvenient. In an office it is not possible to make boiled water available to everyone for drinking and I had to stock up with bottled water, which cost us about £100. As Facilities Manager for the building I am responsible for everyone's health and safety and I had to make sure that everyone was OK, which is why we bought bottled water.*
- *We first found out about the problem from our daughter in Aberdeen.*
- *The company should have found a better way of giving us advice. At the time we had visitors and we were not watching the television, listening to the radio or using the internet much at that time. We did get something through the letter box some days after we found out*
- *The girl I spoke to at United Utilities was not very helpful. She told me that everything was on the website.*

- *It was extremely inconvenient for us. We even had to use boiled water for brushing our teeth, which is not something you naturally remember to do every time.*

- *United Utilities did not offer me any bottled water even though I told them I ran a nursery. I had to buy bottled water for the children, and the £60 compensation I received did not cover the cost.*

- *I checked Facebook at 9 o'clock in the morning and there was information that the water was not safe to drink. I then phoned United Utilities who said that the water was OK and that I could carry on drinking it. In the afternoon I saw the news, and phoned United Utilities again who told me to boil the water. I was annoyed that I had asked previously and was told that the water was OK. I was pregnant at the time and I was concerned about the change of advice. I received a leaflet about 5 days later.*

- *I phoned United Utilities and they told me to boil the water for drinking. It was only later that we found out that we should also boil it for food preparation and bathing. My parents are in their nineties and my mother suffers from dementia, but the company did not provide them with bottled water. I was worried that my mother would be harmed by drinking water straight from the tap.*

4.6.16 PHE was closely involved with the event from the beginning, chaired the STAC and was represented on the SCG. PHE immediately initiated surveillance for cases of cryptosporidiosis in the community, with an onset of illness from 1 August 2015 until two weeks after the BWA was lifted. It is important to note that PHE[10] concluded from epidemiological studies that there were no laboratory reported cases of illness in the area covered by the BWA which could be confirmed to be associated with the water supply, either before, during or after the BWA. Therefore there is no evidence that the presence of *Cryptosporidium* in Franklaw water caused any cases of illness in the community. Given that some of the samples taken in the supply system contained species of *Cryptosporidium* known to be human pathogens, this is a reassuring outcome.

4.6.17 It is appropriate to consider whether United Utilities could have restored wholesome supplies and lifted the BWA earlier. As the sole source of supply to 712,000 consumers, Franklaw was strategically significant and the company's contingency plans for the works did not cover a prolonged

[10] The Potential Impact of media reporting in syndromic surveillance: an example using a possible *Cryptosporidium* exposure in North West England, August to September 2015. Elliot, Hughes, Astbury (of PHE) et al, Surveillance and Outbreak report, 15 December 2015.

contamination event. Issuing the BWA and responding to the event stretched the company's resources to its limits.

4.6.18 It is noted in paragraph 3.3.3 that the company installed treatment for recycled washwater at works in response to a Badenoch Report recommendation. At Franklaw, washwater from the rapid gravity and second stage filters is returned to the works inlet after treatment with a coagulant and settlement in lamellar separators. The turbidity of the treated washwater is continuously monitored, and if it exceeds 10 NTU, the recycled water is returned to the lamellar separators for further treatment. There is no facility to divert washwater of unsuitable quality to waste. At the time of the onset of the incident, the continuous turbidity monitor on the recycled washwater stream was not working.

4.6.19 The first Badenoch report[5] confirms that when oocysts are present in a treatment process, the situation with regard to recycling waste water is potentially dangerous. The report cites an example of learning from the Ayrshire outbreak in 1988, when run off from farmland contaminated a break pressure tank which led to post treatment contamination of the trunk main and detection of oocysts in the treatment works through backwash water contamination where the raw source water contained no oocysts.

4.6.20 There are three points of concern with these arrangements at Franklaw:

i. The company continued to recycle washwater for the duration of the event, despite knowledge of the presence of oocysts in the final water, and later in the outlet of the second stage filters. Therefore washwater potentially contaminated with oocysts was being recycled to the works inlet, with the consequential risk of the rapid gravity filters becoming contaminated with oocysts.

ii. The continuous turbidity monitor on the treated washwater was non-functional at the time when *Cryptosporidium* was first detected, and therefore the company had no information about the quality of the recycled washwater at this critical time.

iii. There was no facility to divert treated washwater to waste, so even if the company had identified that washwater of unsuitable quality was being returned to the works inlet, it would have had no option but to continue recycling it through the lamellar separators.

4.6.21 The decision to continue to recycle washwater at Franklaw despite the known presence of oocysts could have resulted in reintroduction of *Cryptosporidium* to the works. It cannot be discounted that this may have prolonged the need for the BWA. There was a period between 9 and 14 August when Franklaw final water was clear of oocysts, and it cannot be ruled out that recycling

contaminated washwater reintroduced *Cryptosporidium* to the works and led to the reappearance of oocysts in the final water after this date.

4.6.22 By the end of December 2015 all water supplied from Franklaw works was treated with UV which has created a permanent barrier against viable *Cryptosporidium* oocysts from entering the treated water supply. UV treatment remains in place at Barnacre service reservoir as a precautionary approach.

5 United Utilities' investigations into the cause of the *Cryptosporidium* contamination

5.1 From 5 August, United Utilities began to investigate the possible sources of faecal contamination that could have resulted in the presence of *Cryptosporidium* in the water supplied from Franklaw works. This led to the development of a number of working hypotheses as to how the contamination occurred – 27 in total. These hypotheses included:

- The possibility of raw water contamination.
- The loss of or compromised effectiveness of a treatment process.
- Ingress into the final water contact tank.
- Contamination of the process via the service water system.
- Contamination of a treatment chemical.
- Contamination by backsiphonage whilst cleaning out washwater tanks.
- Contamination by backsiphonage from the sludge treatment system.
- That the Coast Aqueduct was contaminated during the operation to repair the leak.
- Contamination from drains and sewers on the Franklaw site.

5.2 United Utilities had to investigate each theory, and obtain information to test each one. This investigational work continued well into 2016, and a final report was provided to the Inspectorate in December 2016.

5.3 The company was able to establish on 6 August that the early stages of treatment that are important for removal of *Cryptosporidium* - clarification and rapid gravity filtration - had been operating satisfactorily. This was the case throughout the event. The investigation also established that *Cryptosporidium* was not coming from any of the raw water sources supplying the works and there was no other indication of deterioration in raw water quality that could have compromised these treatment processes. This was confirmed by the technical audits carried out by the Inspectorate, from the Inspectorate's review of works' data and scrutiny of the company's investigational sampling results.

5.4 The company's investigations also ruled out early speculation about the contamination being linked to the presence of dead animals in treated water tanks and from a number of other sources including cross connections from sewage works. Oocysts were detected in samples across the whole of Franklaw's water supply network.

5.5 After the initial detections at the works, there was a short period between 10 and 14 August when no detections were made on the final water. Subsequently, oocysts were observed in samples taken from the final water

and continued to be detected regularly until early October 2015 when there was an observed reduction in the concentration and frequency of detections.

5.6 Similar trends have been observed across the distribution network, with regular detections being made until early October and then a reduction in the frequency and concentration of oocysts detected. Sporadic detections continued into 2016, with five detections being made at four service reservoirs (Heapey, Haighton, Barnacre and Warbreck Tower) during March 2016.

5.7 The concentration of oocysts detected at a number of service reservoir sites exceeded those observed in samples of Franklaw final water. Of particular interest were detections at Barnacre service reservoir, which had notably high concentrations of oocysts in some of its samples. Between 26 August and 7 October, 21 continuous filter samples from Barnacre reservoir outlet contained concentrations of oocysts greater than 0.119 per 10L, the maximum detected in Franklaw treated water. The highest concentration was in the filter removed on 14 September, which contained 0.548 oocysts per 10L.

5.8 Franklaw works supplies water to Barnacre reservoir via the South Aqueduct whereby, following storage in the reservoir, the water can return to the works via the Barnacre 18 inch main (shown on Figure 5). Under normal circumstances, the water in the Barnacre 18" main bypasses the works, but work carried out to repair a burst on the Coast Aqueduct immediately prior to the first reported positive sample on 4 August introduced a route for water from Barnacre to supply the service water to Franklaw works. This was a major operational change for Franklaw which should have been subject to a prior risk assessment.

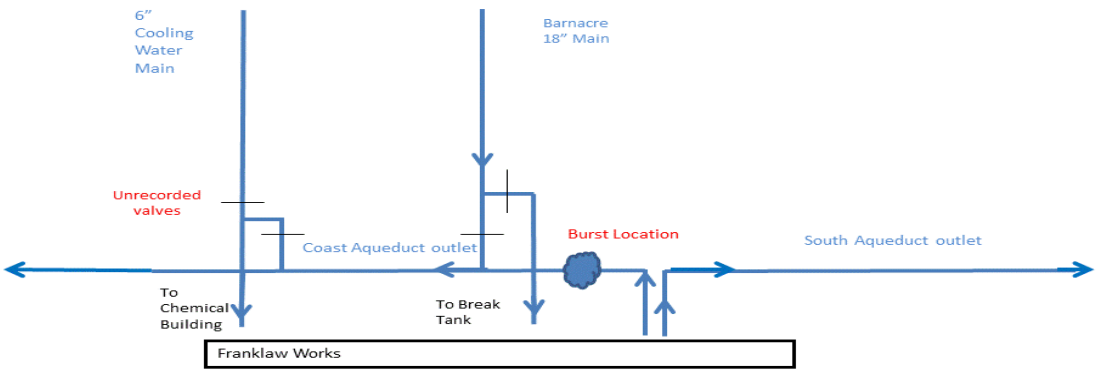

Figure 5 – Showing the configuration of the supply into Franklaw's service water system, and the location of the burst on the Coast Aqueduct. The 6" cooling water main was previously unrecorded in the company's mains records.

5.9 Investigations at Franklaw identified that *Cryptosporidium* was present in the second stage filters. Given that the upstream treatment processes were free

from *Cryptosporidium*, this evidence indicated contamination at some point between second-stage filters and treated water leaving the works. This conclusion is supported through sampling evidence, and the detection of oocysts in the break tank supplying the service water ring main (see Figure 2).

5.10 The most plausible causes of the presence of *Cryptosporidium* in the final water was either contamination of the treatment process in the vicinity of the second stage filters and/or inoculation with *Cryptosporidium* via the service water used in chemical dosing processes. A number of facts support this conclusion. Figure 6 shows a diagram of the site with the service water ring main shown:

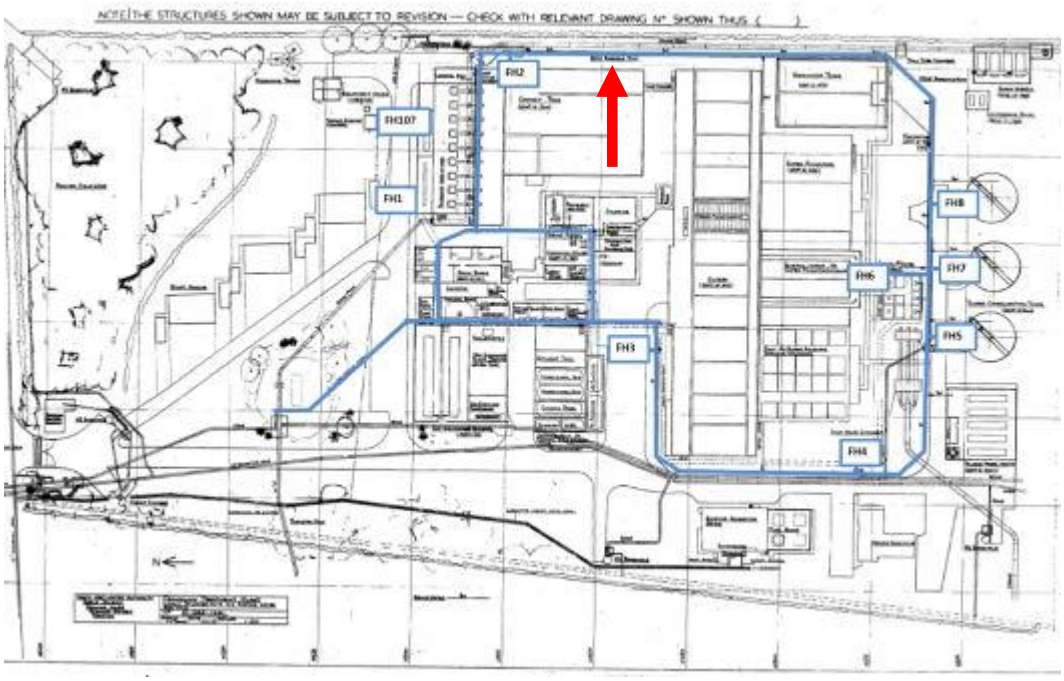

Figure 6 – Franklaw site diagram showing the service water ring main. The red arrow indicates the position of a leak identified on the ring main on 2 September. Diagram provided by United Utilities.

5.11 The timeline in Appendix 1 records that from 27 July, operations began to isolate the Coast Aqueduct to repair the leak, which had been identified on 1 July. The Coast Aqueduct was the normal source of supply for the service water system at Franklaw works, via a break pressure tank on the site and into the ring main which runs around the perimeter of the site. Service water was drawn off from a number of connections at various points on the ring main to supply the domestic facilities, to make up treatment chemicals, for motive water used for chlorine dosing and for general site cleaning.

5.12 On 27 July the service water supply was switched to be supplied from Barnacre service reservoir through the Barnacre 18” main. A number of

potential points of ingress into this main were later identified by the company whilst inspecting of the condition of the main. Additionally, the Coast Aqueduct was depressurised without being fully isolated, with an associated risk of back siphonage.

5.13 The company operated valves in error which may have caused stagnant water from a disused main (the 6” cooling water main shown in Figure 5) to enter the service water system, which may have introduced contamination. The company’s records of the mains and valves associated with Franklaw works were inaccurate. The errors made in the valving operations may also have led to uncontrolled depressurisation of the Coast Aqueduct. The company also reported difficulties with maintaining full isolation of the section of Coast Aqueduct to be repaired, with leakage of water into the isolated section.

5.14 The timeline in Appendix 1 shows that the service water system at Franklaw depressurised a number of times in the days immediately prior to the first detection of oocysts, and subsequently until the ring main system was permanently decommissioned in September 2015. A significant leak, reported to be in the region of 100 litres per minute, was identified on the service water ring main which could have caused ingress through back siphonage when the ring main depressurised. The company reported that on 3 September a septic tank discharge was identified at the point of this leak, but this was discounted as the source of the *Cryptosporidium* because samples taken from the surrounding soil were negative for oocysts.

5.15 Between 27 and 29 July, the washwater tanks were being cleaned out. A tanker previously used on sewage works was on site removing settled sludge from these tanks. At the same time the tanks were being washed down with clean water from a hose connected to the service water ring main. This could have introduced sewage contamination into the ring main during one of the depressurisations that occurred. The Inspectorate interviewed an employee involved in this operation, who could not confirm whether backflow protection was in place on the hose, or on the hydrant standpipe connecting the hose to the ring main.

5.16 The company investigated the condition of the Barnacre 18” main and found defective air valves on the main, situated in fields used for grazing livestock. This is confirmed by the Inspectorate when defects were found during a technical audit on 10 August 2015 (Figure 7).

Figure 7 – Photographs taken by DWI showing evidence of a flooded air valve chamber and defective cover on the Barnacre 18" main.

5.17 In October and December 2015 United Utilities carried out an internal inspection and a roof flood test of the two compartments of Barnacre service reservoir, which identified significant ingress into both compartments. The land hydraulically above Barnacre reservoir was used for grazing livestock. Farmyard manure and slurry stores, and a septic tank discharge were also found in the area. This confirmed potential pathways for *Cryptosporidium* contamination to enter Franklaw's treatment process, during the time when the service water was being supplied from Barnacre reservoir via the 18" main. The photographs in Figure 8 provided by United Utilities illustrate the extent of ingress into the service reservoir.

Figure 8 – Photographs showing evidence of surface water ingress into Barnacre Service Reservoir, taken by United Utilities during an internal inspection and flood test

5.18 In December 2015, the company identified significant sources of ingress in the post second stage filters common outlet chamber, from which water used

to backwash the second stage filters would have been drawn. This could also explain the presence of oocysts in the second stage filters. Under normal circumstances, *Cryptosporidium* should not be detected in second stage filters because the upstream clarification and rapid gravity filtration processes are designed to remove oocysts. There were no issues identified with these upstream processes at this time.

5.19 In July 2016 the company inspected the interstage pumping station wet wells, which were drained and flood tested. The interstage pumps are upstream of the second stage filters and ingress of contamination into the wet wells could have been a source of *Cryptosporidium*. Some points of ingress were identified (see Figure 9) but with no obvious source of oocysts.

Figure 9 – Photographs taken by United Utilities showing evidence of surface water ingress into the interstage pumping station at Franklaw works.

5.20 From the company's investigations, a number of plausible pathways for *Cryptosporidium* to enter the treatment process either via the service water or directly in the vicinity of the second stage filters has been demonstrated, but the exact root cause or causes and the exact source or sources of the *Cryptosporidium* have not been proven.

5.21 The most likely source of the contamination, supported by evidence, is Barnacre service reservoir itself. Structural defects were identified by the company which were causing significant ingress into the reservoir, and the land hydraulically above the level of the reservoir contained potential sources of *Cryptosporidium* (i.e. septic tank discharges and the presence of livestock). When the reservoir was inspected, one sample taken from the reservoir outlet was found to contain the same species of *Cryptosporidium* as that present in a neighbouring water course. Until the start of the event, the company did not routinely sample any of its service reservoirs for *Cryptosporidium*, and therefore oocysts that might have been present in water supplied from Barnacre reservoir would have gone undetected.

5.22 Companies have a duty to maintain their assets in good order. Section 68(1)(b) of the Water Industry Act 1991 requires water undertakers to ensure

that, as far as reasonably practicable, water quality is not allowed to deteriorate. This requires that assets are properly maintained. Allowing an asset used for the strategic storage of drinking water to deteriorate to the extent that significant ingress occurs is indicative of the company's failure to comply with its statutory duty to ensure no deterioration of water quality, since the routine maintenance of existing assets is entirely within the company's control, is financially provided for in charges raised to customers and cannot be deemed to be impractical.

5.23 As explained in paragraph 2.1.4, and in section 3.3, companies have a duty to carry out a risk assessment of their supply systems, and operational changes should also be risk assessed to ensure that any new risks identified as a result of the change are effectively controlled. The company's Regulation 27 risk assessment for the Franklaw supply system did not identify the poor structural condition of Barnacre service reservoir and the defects on the Barnacre 18" Main.

5.24 The risk assessment for the operational change that involved isolating the Coast Aqueduct and transferring Franklaw's service water supply to the Barnacre 18" main did not consider the potential impact on the operation of Franklaw works, and did not consider the poor structural condition of the service water ring main and the risk that flow and pressure changes might cause damage to the ring main with the consequential risk of ingress. It is documented as a lesson learned in the first Badenoch report that water supplies may be more susceptible to oocyst contamination when there has been a major planned change in a water treatment process. In addition, service reservoirs were specifically highlighted by Badenoch where leakage in of oocysts poses a particular risk to the population served by a treated water reservoir. Switching the service water supply to receive water from Barnacre reservoir was a major planned operational change for Franklaw works and a major change of risk identified by Badenoch which should have prompted a comprehensive risk assessment beforehand. This did not take place.

6 Actions taken by United Utilities and lessons learned

6.1 Key actions taken by the company

6.1.1 The most likely cause of the presence of *Cryptosporidium* in the water supplied from Franklaw is contamination introduced into the service water system when the service water supply was switched to Barnacre service reservoir. This cannot be categorically proven after the event as there were a number of other possible routes of contamination that cannot be entirely ruled out as described previously in section 5.

6.1.2 The main action that the company has taken to prevent a recurrence of this event at Franklaw works is to install permanent UV treatment on the outlet of the works. This was completed by December 2015. *Cryptosporidium* oocysts continued to occur in Franklaw final water long after the BWA was lifted and the only way that the company could ensure that there was no risk to public health from the presence of oocysts was to install UV treatment.

6.1.3 UV treatment remains in place on the outlet of Barnacre service reservoir in the Franklaw supply system to protect consumers. The company's plans to isolate and clean all of the affected reservoirs in the system are ongoing.

6.1.4 The service water ring main at Franklaw was in poor condition, and the company found holes in the ring main in more than one place. A septic tank discharge was found in the vicinity of one of the holes, but this was ruled out as a source of the oocysts because *Cryptosporidium* was not found in the surrounding soil. The company decommissioned the ring main and associated break pressure tank in August 2015 and the service water supply has since been supplied directly from the South Aqueduct.

6.1.5 The company carried out an internal survey of the condition of the Coast Aqueduct and has completed necessary repairs. The unrecorded disused main that was found during initial operations to isolate the Coast Aqueduct has been fully isolated from the system.

6.1.6 The company has carried out a full survey of the Barnacre 18" main and necessary repair works have been completed.

6.1.7 The company identified significant sources of ingress into Barnacre Reservoir when its two compartments were inspected in October and then in December 2015. These defects have been repaired and the reservoir has been returned to supply.

6.1.8 Sources of ingress into treatment stages at Franklaw have been investigated and defects have been repaired and the filter media of the first and second stage filters has been cleaned.

6.1.9 The company has carried out a thorough review of its management of the event, communications with customers and other stakeholders and its recovery plans and has identified a number of lessons learned.

6.2 Outcome of the company's internal lessons learned exercise

6.2.1 The company's internal review of the event identified lessons learned in the following areas:

- incident management (including the roles and responsibilities of the emergency teams);
- communications, including social media;
- training and exercising; and
- contingency planning.

6.2.2 The event stretched the company's resources to their limits and the contingency plan for the loss of Franklaw works did not cover the actions involved in advising all consumers supplied by the works to boil their water, as evidenced by the difficulties that the company's service providers had in coping with the volume of communications required. The plans to supply the distribution network from alternative sources did not consider the effects of a prolonged drinking water quality emergency on consumers in areas that could not be rezoned.

6.2.3 The company identified that its employees were not uniformly competent to deal with a major emergency and identified that training and regular emergency exercises are important to ensure that a company can respond rapidly in an emergency situation to identify the cause, take immediate steps to protect public health and implement actions to restore normal wholesome supplies as soon as possible.

6.2.4 The company recognised that consumer contacts through social media channels are a key source of information and that social media communications should be brought into the company's mainstream customer communications department.

6.2.5 The Inspectorate, in conducting its investigations into this event, identified a number of areas of concern, covered in section 8.

7 The Drinking Water Inspectorate's involvement and actions undertaken

7.1 The Drinking Water Inspectorate's main statutory duties

7.1.1 The Drinking Water Inspectorate (DWI) was established by Parliament in 1990 to provide independent assurance that the privatised water industry in England and Wales delivered safe, clean drinking water to consumers. The two main strategic objectives of the Inspectorate are: that water suppliers deliver water that is safe and clean; and that consumers have confidence in their drinking water.

7.1.2 The regulatory framework for water supplies in England and Wales, including the powers and duties under which the Drinking Water Inspectorate operates and the duties of water suppliers, is established in legislation. The Chief Inspector of Drinking Water is appointed by the Secretary of State for Environment, Food and Rural Affairs, and Welsh Ministers, and acts on their behalf. Certain powers are also vested directly in the Chief Inspector which ensure clear independence in the Inspectorate's work. In addition to the Inspectorate's regulatory role, the Chief Inspector and his Inspectors are the appointed technical advisers to the Secretary of State and Welsh Ministers on all drinking water quality matters.

7.1.3 The primary legislation setting out our functions and duties is contained in the Water Industry Act 1991 (the Act) (as amended by the Water Act 2003 and the Water Act 2014)[2]. Water supply matters are also devolved to the Welsh Government by means of the Government of Wales Act 1998.

7.1.4 The Water Supply (Water Quality) Regulations 2016[3] (the Regulations) made under the WIA set out the regulatory requirements for the quality of public drinking water supplies in England. Predecessor regulations[1] were in force at the time of the Franklaw event.

7.1.5 The provisions in section 68 of the Act (concerning enforcement) have been formally delegated to the Chief Inspector by Ministers. The provisions in Section 70 of the Act (concerning proceedings against undertakers and others who supply water unfit for human consumption) are vested directly in the Chief Inspector. Responsibility for supporting Ministers in some other requirements of the Act is shared between the Inspectorate and policy officials in the Welsh Government and Defra.

7.1.6 Companies are required under the provisions of Regulation 35(6) to notify the Inspectorate of any event which is giving rise to, or is likely to give rise to, a significant risk to human health. The company must also notify every appropriate local authority and Public Health England (PHE). It was on 6

August 2015 that United Utilities notified the Inspectorate of the detection of *Cryptosporidium* oocysts in the output of Franklaw water treatment works, and its decision to advise 712,000 consumers to boil their tap water.

7.2 Actions taken by the Inspectorate

7.2.1 Inspectors are experienced professionals with strong technical, scientific or engineering backgrounds, most of whom have experience of working in the water industry in operational roles and/or as laboratory analysts. The work requires a high level of expertise in all aspects of drinking water supply, the interpretation of law, fair and proportionate enforcement of legal requirements and the provision of sound advice and guidance to all levels of industry, stakeholders and government.

7.2.2 On receipt of the notification from United Utilities on 6 August 2015, Inspectors were immediately sent to Franklaw works and to United Utilities incident control centre at the company's head office in Lingley Mere, Warrington. This on-site involvement continued throughout covering the following activities:

- technical audits of Franklaw works and associated assets including the aqueducts supplied from Franklaw and the Barnacre 18" main;
- attending the company's incident control centre at Lingley Mere;
- meetings with company representatives to discuss ongoing issues;
- interviews with employees;
- reviewing the results of the company's monitoring programme, with continual appraisal of the significance of the results and the appropriateness of the company's response; and
- audits of the UV installations to monitor progress and to confirm that the treatment units were validated for the inactivation of oocysts at the conditions under which they would be operated.

7.2.3 The Inspectorate's work also involved scrutinising the company's reports and assessing the company's hypotheses on the possible causes of the *Cryptosporidium*, reviewing the evidence and seeking further information as necessary to allow the Inspectorate to draw conclusions about the most likely cause and the appropriateness of actions taken by the company.

7.2.4 The Inspectorate was represented on, and participated in, meetings with the Strategic Coordination Group (SCG) and the Scientific and Technical Advisory Cell (STAC) – see paragraphs 4.3.2 and 4.3.3, along with representatives from PHE and Defra.

7.2.5 As soon as it became apparent that the company would not be in a position to lift the boil water advice at an early stage, the Inspectorate used its powers of enforcement to issue a legally binding Regulation 28 Notice (ref. UUT 3499[11], issued on 18 August 2015) which required the company to take immediate steps to ensure that the risk to public health was mitigated by means of disinfection and appropriate treatment at Franklaw works or at appropriate points of use; or to secure other measures to ensure that the water at the point of consumption was wholesome. The company installed UV treatment at points in Franklaw's supply system to meet the requirements of the Notice. The required completion date for the work was 21 August 2015. Because of the challenges associated with implementing this solution, covered previously in paragraphs 4.6.9 and 4.6.10, the work was completed by 6 September 2015.

7.2.6 The Notice also required permanent UV treatment at Franklaw works to be installed and commissioned by 31 March 2016. All water supplied from Franklaw was treated with UV by the end of December 2015, with the works operating on a reduced output. The company completed installing all of the UV units, enabling the works to operate at its design maximum flow, in June 2017.

7.2.7 The Inspectorate's Press Officer dealt with communications from press and media and liaised with Defra's press office and the Secretary of State's private office to ensure that media communications were consistent and appropriate. Written and verbal statements were issued from time to time in response to media requests for statements.

7.2.8 The DWI Enquiries team handled calls from concerned members of the public and other stakeholders requesting information about the event.

7.2.9 After the lifting of the boil water advice, further investigation by DWI included additional visits to Franklaw works, service reservoir sites and other locations within the supply network. Audits were carried out at Franklaw works to investigate the cause of the event and at the temporary UV installations to ensure the reactors were being operated correctly.

7.2.10 The Inspectorate's investigation continued into 2016. This involved scrutiny of data and information provided by the company to understand the cause of the incident and an assessment of how the company managed the emergency, the actions taken by the company to restore wholesome supplies of water and actions taken by the company to prevent a recurrence. In accordance with the Inspectorate's duties, consideration was given to whether the company may

[11] Available on the Inspectorate's website: http://www.dwi.gov.uk/stakeholders/improvement-programmes/uu/UUT3499.pdf

have committed any offences under the WIA 1991 and the Water Supply (Water Quality) Regulations (see section 8).

7.2.11 The Inspectorate sent questionnaires to 185 consumers who were affected by the incident to gain an understanding of consumers' knowledge of the BWA, how the company communicated with consumers, how the event affected consumers and any concerns they had about the handling of the event. Face-to-face interviews were conducted with eight consumers (see paragraph 4.6.15).

8 The Inspectorate's findings and recommendations

8.1 Contraventions of the Water Supply (Water Quality) Regulations

8.1.1 When notified of an event or incident, the Inspectorate gathers information considered to be relevant and assesses this in conjunction with information provided by the company about the circumstances of the event and any actions taken. The Inspectorate then considers the way in which the event was handled, whether the company failed to comply with the Regulations and whether offences were committed.

8.1.2 This section covers the Inspectorate's conclusions on whether the company failed to comply with any specific regulations in the Water Supply (Water Quality) Regulations 2000 (as amended) which were in force at the time of the Franklaw event, and if we found evidence that the company may have committed an offence.

8.1.3 The Inspectorate has a duty to consider whether the company has taken sufficient action to prevent a recurrence of the incident. If there remains a risk of a similar incident in the future, either at Franklaw or at any of the company's other treatment works, then the Inspectorate has a duty to consider whether enforcement is necessary.

8.1.4 **Regulation 4 – Wholesomeness**

i. Regulation 4 requires that water supplied to consumers for domestic purposes, which includes drinking, washing and food preparation, must be wholesome. This regulatory requirement is derived from section 68(1) of the Act and is, therefore, a statutory requirement. It is a condition of all water undertakers' appointment licences that they must comply with all of their statutory obligations and duties.

ii. Regulation 4(2)(i) requires that the water must not contain any micro-organism (other than a parameter) or parasite at a concentration or value which would constitute a potential danger to human health.

iii. A parameter means a property, element, organism or substance that has a prescribed concentration or value (i.e. a legal limit, which is normally a maximum concentration) specified in the Regulations. *Cryptosporidium* is a parasite which does not have a legal limit in drinking water, and therefore it is not defined as a parameter. The requirement of Regulation 4(2(i) is clear, nevertheless, that water is unwholesome if it contains micro-organisms and parasites at a concentration or value that constitutes a potential danger to human health.

iv. The significance of the presence of oocysts detected in Franklaw final water is discussed in section 4.2. of this report. The fact that the company took the

decision to advise consumers to boil water, a decision taken following advice given by public health experts, clearly indicates that the company recognised the potential risk to human health from the initial detections of oocysts, at the levels detected. Furthermore, species of *Cryptosporidium* known to be pathogenic to humans were later identified in samples taken from Franklaw's distribution system (see paragraph 4.5.12).

v. The Inspectorate concludes, therefore, that United Utilities failed to comply with the requirement to supply wholesome water from Franklaw treatment works and its associated supply system to the 712,000 consumers supplied from this works, who were advised to boil their tap water before consumption.

8.1.5 Regulation 10 – Sampling: further provisions

i. Regulation 10 requires that as soon as a water company has reasonable grounds for believing that any element, organism or substance other than a parameter may cause the supply of water in any of its supply zones to be unwholesome, that the company must take sufficient samples from water within the supply system of the zone in order to establish whether that water is wholesome.

ii. The company's investigational sampling response is discussed in section 4.5 of this report. The initial sampling response relied upon the use of 10 litre grab samples, the limitations of which are explained in paragraph 4.5.7. It was not until 18 August (12 days after the boil water advice was issued) that United Utilities managed to install continuous large volume sampling on all service reservoir outlets in the Franklaw system. It was not until 23 August that the company installed large volume sampling at sampling points within the treatment process at Franklaw works to investigate the source of the oocysts.

iii. It cannot be ruled out that, had the company reacted more quickly to install large volume sampling for *Cryptosporidium* at Franklaw works and within the distribution network, the evidence of contamination of the treatment process after the second stage filters and the links to the service water supply and Barnacre service reservoir might have been identified sooner, enabling the source of the contamination to be addressed much earlier. The boil water advice continued until 6 September.

iv. The Inspectorate has concluded that the company's investigational sampling response fell short of expectations, because United Utilities failed to include provision for large-volume sampling in the company's emergency plans. The company did not comply fully with the requirement of Regulation 10 which requires the sampling strategy to be sufficient to establish whether the water supply is wholesome. Reliance on 10 litre grab samples for *Cryptosporidium* is insufficient for this purpose.

8.1.6 **Regulation 26 – Disinfection and other treatment arrangements**

8.1.6.1 **Regulation 26(1)**

i. Regulation 26(1) requires that a water supply must be disinfected before it is supplied to consumers, and where necessary, subject to sufficient preliminary treatment to prepare it for disinfection. The latter requirement applies where a chemical disinfectant is used, such as chlorine, which was the final disinfectant used at Franklaw works at the start of the incident.

ii. Disinfection is defined in the Regulations as a process of water treatment to remove or render harmless to human health every pathogenic micro-organism and pathogenic parasite that would otherwise be present in the water.

iii. The presence of *Cryptosporidium* in water supplied from Franklaw works at a level acknowledged by the company to be a potential danger to human health demonstrates that the processes at Franklaw were not operating effectively, and, therefore, the company was failing to adequately disinfect the water before supply to consumers.

iv. Regulation 26(4) allows a company to supply inadequately disinfected water as a matter of urgency in order to prevent an unexpected interruption in the supply to consumers, provided that, before the supply is made, all necessary steps have been taken to inform consumers. United Utilities returned Franklaw works to supply following a planned shutdown in the full knowledge of the presence of atypically high levels of oocysts in the final treated water and did not take steps to inform consumers before the works was returned to supply.

v. The Inspectorate concluded, therefore, that United Utilities failed to comply with the requirements of Regulation 26(1).

8.1.6.2 **Regulation 26(3)**

i. Regulation 26(3) requires water companies to design and continuously operate an adequate treatment process for water from the source. ‘Adequate treatment process’ is defined in the Regulations, and means a process of blending or purification treatment which removes or renders harmless the concentration or value of any property of water, or organism or substance in water, so that supplies do not constitute a potential danger to human health.

ii. The company’s investigations into the source of the oocysts ruled out an increased level in any of the raw waters supplying the works. Failure of any of the treatment processes that are important for removal of

Cryptosporidium – at Franklaw works coagulation, clarification and rapid gravity filtration – was also ruled out as a cause. This conclusion was supported by the Inspectorate's investigation. The association with Franklaw's service water supply and/or ingress near the outlet of the second stage filters became the focus of the company's investigations. Again, this finding was confirmed by the Inspectorate's investigations.

iii. Regulation 26(3) clearly requires that water supplied to consumers does not constitute a potential danger to human health. The company's actions caused *Cryptosporidium* to be present in water supplied from Franklaw works. Furthermore the presence of this parasite was recognised by the company to be a potential danger to human health, and, therefore, the company was failing to continuously operate an adequate treatment process as required by Regulation 26(3).

iv. Under the provisions of Regulation 33, it is a criminal offence for a water undertaker to contravene Regulation 26(1) or 26(3). The Inspectorate has concluded that the company contravened both these regulations. The exemption provided by Regulation 26(4) that inadequately treated water may be supplied to prevent an unexpected interruption does not apply because the company did not take all necessary steps to inform consumers before the supply was made (having made the decision to issue the BWA some six to seven hours after work began to return Franklaw to supply on 6 August).

8.1.7 **Regulation 27 – Risk Assessment**

i. Regulation 27 applies to every treatment works and supply system from which water is supplied for Regulation 4(1) purposes (i.e. water supplied for drinking, washing and food preparation). Every water undertaker must carry out a risk assessment of each of its treatment works and connected supply system in order to establish whether there is a significant risk of supplying water from those works or supply system that could constitute a potential danger to human health.

ii. A supply system means untreated (raw) water as abstracted, raw water as it is presented for treatment, water at any point in the treatment process that will ultimately be supplied to consumers (including recycled water), final treated water, water at any point in the supply network and within consumers' premises.

iii. As explained in paragraph 3.3.4, United Utilities' risk assessment for Franklaw works and its connected supply system was assessed as low risk for *Cryptosporidium* on the basis that '*the process at Franklaw provides a robust barrier for Cryptosporidium oocyst-sized particles and is consistent with the*

recommendations of the aforementioned report [the first Badenoch Report[5]], *and the Expert Group's second and third reports published in 1995 and 1998'.*

iv. Additional requirements of Regulation 27 are that risk assessments must be kept under continuous review and that where a water undertaker becomes aware of any factors which make it likely that a risk assessment would establish that there is a significant risk of supplying water that would constitute a potential danger to human health, it must notify the Secretary of State (i.e. the Inspectorate) specifying the relevant factors.

v. Regulation 28 requires water companies to submit a report to the Inspectorate of the outcome of risk assessments, including whether or not the risk assessment has established a risk of supplying water that could constitute a potential danger to human health, and where there is an identified risk, whether the company has taken any action to remove the risk. If the company has not taken action to remove the risk, the necessary measures must be specified in the report and the Inspectorate has a duty to issue a formal Notice requiring the company to take necessary steps.

vi. On 6 August 2016, when the Inspectorate was first notified of the incident, the risk assessment for Franklaw works had not been revised since December 2014. Furthermore, as discussed previously in paragraphs 5.21 to 5.23, the company's risk assessment for the work that was carried out on the Coast Aqueduct immediately prior to the first positive sample was inadequate. There was a lack of knowledge in the company of the poor condition of Barnacre service reservoir, the Barnacre 18" outlet main, Franklaw's service water ring main and the presence of a disused main containing stagnant water which was not shown in the company's mains records. All of these factors rendered the company's risk assessment for the Franklaw supply system wholly inadequate.

vii. Risk assessments should also include contingency plans for unplanned drinking water quality events and emergencies, as discussed in paragraphs 3.3.8 and 3.3.9. United Utilities had in place a contingency plan for Franklaw works entitled '*Process Loss Contingency Plan*', dated April 2014. This documented contingency plan proved to be wholly unfit for purpose in this particular emergency, as evidenced by the large number of consumers advised to boil their water for a prolonged period of time, the failure of the company to identify the source of the oocysts at an early stage and the continued recycling of filter backwash water without measures in place to monitor and control the quality of recycled water.

viii. The Inspectorate concluded early on that the company had comprehensively failed to comply with the requirements of Regulation 27, and issued a Regulation 28 Notice (ref. UUT 3499)[11] on 18 August 2015 which required the company to take immediate steps to ensure that the risk to public health from

the presence of *Cryptosporidium* oocysts in water supplied from Franklaw was mitigated.

8.1.8 **Regulation 35 – Provision of Information**

i. Regulation 35(6) requires that, as soon as possible after an event which, by reason of its effect or likely effect on the water supplied, gives rise or is likely to give rise to a significant risk to human health, the company must notify, in every case:

- every appropriate local authority;
- Public Health England (PHE);
- the Consumer Council for Water; and
- the Secretary of State.

ii. The Inspectorate acts on behalf of the Secretary of State, and investigates drinking water quality events on his/her behalf.

iii. The company's report on the incident confirms that PHE was involved from 5 August when the first positive sample was confirmed, and that the Lancashire Resilience Forum plans were mobilised on 6 August. The Strategic Coordination Group (SCG) involved the Lancashire Police, Lancashire County Council and the local authorities serving the areas supplied by Franklaw works. The Scientific and Technical Advisory Cell (STAC) established on 6 August also included representatives from the county council and local authorities.

iv. The Inspectorate was notified under the requirements of this regulation on 6 August.

v. The Inspectorate concluded that the company complied with the requirements of this Regulation.

8.2 Offences

8.2.1 In paragraph 8.1.6.2 (iv) it is explained that failure to comply with the requirements of Regulations 26(1) and/or 26(3) is an offence under Regulation 33. It is a defence for the water company if it can show that it took all reasonable steps and exercised all due diligence to avoid commission of the offence.

8.2.2 The Inspectorate considers that the company may have committed offences through contravening the requirements of both of these Regulations.

8.2.3 Section 70 of the Water Industry Act creates an offence of supplying water that is unfit for human consumption. The Act allows that the offence can be committed by a person, or by a company. Unfit for human consumption is not defined in the Act, and the Inspectorate's position, based on consistent legal advice over the years, is that water unfit for human consumption is a matter for the court to decide on a case-by-case basis.

8.2.4 Again, it is a defence for the water company if it can show that it took all reasonable steps and exercised all due diligence to avoid commission of the offence.

8.2.5 A previous court judgement[12] determined that drinking water is unfit for human consumption if the quality is such that a reasonable person of sound mind would reject the water, for example if it is noticeably discoloured or has an unacceptable taste or odour. The Judge ruled that water is unfit if it would be likely to, or did, cause injury when drunk, or if its appearance and/or smell would cause a reasonable person of firm character to refuse to drink it or use it in the preparation of food.

8.2.6 In the United Kingdom, we expect clean, safe drinking water to come out of our taps. We do not expect tap water to be potentially harmful to health. In this incident, consumers became aware that their tap water was a potential risk to human health because the company advised consumers to boil the water before consumption. There were no unacceptable aesthetic characteristics that would have alerted a consumer to the potential risk. The Inspectorate is of the view that a reasonable person of sound mind, had they been aware of the risk, would have rejected the water, and the company may, therefore, be guilty of supplying water that is unfit for human consumption.

8.2.7 It is a defence for a water company under Regulation 33 and section 70 if it can show that it took all reasonable steps and exercised all due diligence to avoid commission of the offence. The Inspectorate has concluded that United Utilities failed to take reasonable steps and failed to exercise all due diligence for the following reasons:

i. The company contravened the requirements of section 68(1)(a) of the Act and Regulation 4 through supplying unwholesome water by virtue of water supplied from Franklaw works containing *Cryptosporidium* oocysts at concentrations that were a potential danger to human health. The company recognised this and decided to advise consumers supplied with water from Franklaw works to boil the water before consumption.

[12] The judgement of His Honour Judge Norman Jones QC, the Recorder for Leeds, R v. Yorkshire Water Services Limited [1999]

ii. Furthermore, on 6 August, the company took a positive decision to return Franklaw works to supply following the shutdown on 5 August, in the full knowledge of atypically high levels of *Cryptosporidium* oocysts in the treated water. This necessitated the issue of advice to consumers to boil the water before consumption. Regulation 26(4) provides for inadequately disinfected water to be supplied as a matter of urgency in order to prevent an unexpected interruption in the supply to consumers, but, before the supply is made, the company must take all necessary steps to inform consumers. As explained previously, the company did not take these necessary steps.

iii. The company did not instigate issuing written advice to consumers until 7 August 2015, taking five days to complete the exercise. The Inspectorate sent questionnaires to a number of consumers who were affected by the incident. 35 consumers responded to the questionnaire. Of these 35, 19 (54%) confirmed that they did not receive any advice from the company. The remainder confirmed that they received advice after the problem happened.

iv. The company failed to comply fully with the requirements of Regulation 10, because there were shortcomings in its monitoring strategy for investigating whether the water supplied was unwholesome (explained previously in 8.1.5).

v. The company continued to recycle filter backwash water to the works inlet in direct contravention of best practice recommended in the Badenoch report, without any knowledge of the quality of the recycled water. See under previous paragraphs 4.6.18 to 4.6.21. This may have prolonged the need for the boil advice.

vi. The company's risk assessment for the Franklaw supply system was wholly inadequate, as explained in 8.1.7.

vii. The Inspectorate has concluded that United Utilities failed to assess the condition of Barnacre service reservoir and associated assets to protect the water supplied from these assets from becoming unwholesome (see paragraph 5.21) prior to the reintroduction of the stored water to the works. The company failed to consider recognised and accepted expert advice and the lessons learned by the water industry from previous incidents. For example, the 1988 Ayrshire cryptosporidiosis outbreak cited in the first report of the Group of Experts[5] was caused by contaminated farm runoff entering a break pressure tank[4]. Furthermore, it is clearly stated in this report that "*good practice regarding the maintenance of service reservoirs and water towers should ensure their hygienic safety. Service reservoirs, particularly roofs, may leak inwards. Leakage in of oocysts poses a particular risk to the population served by a treated water reservoir, as there is no further barrier to the oocysts reaching consumers' taps*".

viii. In addition to the failure to maintain Barnacre service reservoir, the company failed to maintain the service water ring main at Franklaw, and did not

consider the poor condition of this main in its risk assessments for the works. The company's mains records were inaccurate and incomplete.

ix. The company's contingency and emergency plans for Franklaw works failed to consider the consequences of *Cryptosporidium* being detected in the final water, the actions necessary to minimise the impact on consumers and to restore wholesome supplies as quickly as possible.

x. Franklaw treatment works is the sole source of supply for more than 700,000 consumers, and the connectivity of the company's supply system was insufficient to maintain supplies to this large number of consumers. United Utilities should have taken steps to improve supply resilience in areas reliant on a single large source of supply such as Franklaw works.

xi. The company did not complete the delivery of written warning advice to consumers to boil their water until 11 August, which was five days after the advice was first issued on 6 August. The Inspectorate issued questionnaires to a number of affected consumers, and some of the respondents confirmed that they were unaware of the advice until United Utilities made direct contact with them. The Inspectorate concluded that the company's emergency plans were inadequate to deal with issuing advice to consumers on such a large scale, and the company did not consider this fully in the preparation of its emergency plans.

xii. There was a period between 9 and 14 August 2015 when no oocysts were detected in samples of Franklaw final water. United Utilities mistakenly thought that this showed that the contamination had passed and that the situation was recovering. There is some evidence that the company slowed its preparations for rezoning parts of the network on the basis of these results (paragraph 4.6.4) and the first service reservoir was rezoned on 19 August, which was 13 days after the boil advice was issued. The Inspectorate considers that this was a slow response which should have been expedited.

8.2.8 United Utilities submitted a report to the Inspectorate in December 2016 – '*Assessment of the 2016 Detections of Cryptosporidium Oocysts at Franklaw WTW and Re-assessment of the 2015 Event'*. During 2016, positive oocyst detections in Franklaw final water started to reappear during July and into September 2016. The company carried out an investigation into these detections, and submitted some of the slides to the National *Cryptosporidium* Reference Unit for speciation. None of them confirmed as positive for species of *Cryptosporidium* (i.e. no *Cryptosporidium* genetic material was identified). Samples were also submitted to Cardiff University for whole genome amplification and next generation sequencing (developing analytical techniques for environmental samples which are not currently widely used or accredited for water analysis), which identified the organisms as a species of algae. The company did some further work to investigate the oocysts

identified during the 2015 incident, and concluded that whilst water supplied from Franklaw between 4 and 9 August 2015 may have contained *Cryptosporidium* oocysts (originating in water from Barnacre service reservoir where a proven contamination route had been identified), the oocysts that were detected in water supplied from Franklaw after this period could have been algae, not *Cryptosporidium*. The principal reason for this conclusion is a correlation between the number of oocysts detected after 9 August and hours of sunlight and the lack of correlation with rainfall (which was noted during the first phase of detections up to 9 August).

8.2.9 The Inspectorate considers that the identification of particles of a similar size to *Cryptosporidium* at the end of a treatment process should be investigated in respect of the efficacy of the filtration process, and the site risk assessment should be re-assessed for actions to mitigate any risk these findings might pose. However, the occurrence of these findings in 2016 does not replicate the conditions of 2015 and any retrospective conclusions should be considered with caution. It is does however identify that other organisms such as algal cells and fungal spores can exhibit some of the typical features of oocysts when stained and examined using the standard laboratory method[8] for microscopic identification of *Cryptosporidium* - a known interference of the methodology.

8.2.10 The detection of oocysts in 2015, identified using the company's accredited analytical method for *Cryptosporidium,* confirmed that contamination had taken place, (subsequent DNA tests which are 100% specific for *Cryptosporidium* confirmed the potential for pathogenicity), and that there was a risk to public health which warranted advising consumers to boil water before consumption. Even where *Cryptosporidium* DNA is not subsequently detected during speciation tests, it cannot be concluded that *Cryptosporidium* is absent from the water supply. Equally if the species identified is not a human pathogen, it cannot be assumed that all the oocysts present in water supplied to consumers are harmless. There is no reliable test for viability, therefore the company must assume that if *Cryptosporidium* oocysts are identified using the standard microscopic method, that the organism is present, and that there is a risk to human health.

8.2.11 The company accepted that they advised consumers to boil their tap water before consumption because there was a risk to human health.

8.3 The Inspectorate's conclusions on actions taken by the company

8.3.1 The company has implemented permanent measures to protect consumers from *Cryptosporidium* in water supplied from Franklaw works by installing ultra

violet disinfection with built-in failsafe mechanisms to prevent any water that has not been treated by UV from leaving the works.

8.3.2 The Inspectorate has raised concerns with the company about the time taken to remove some of the larger service reservoirs from supply to inspect and clean them. The company has confirmed that three service reservoirs in the Franklaw system are still to be cleaned, and work is required at Warbreck Tower to enable this reservoir to be removed from supply before it can be inspected and cleaned. There is no longer a risk to consumers from *Cryptosporidium* in these reservoirs and UV treatment remains in place at Barnacre service reservoir as ongoing mitigation.

8.3.3 The Inspectorate raised serious concerns with the company about the management failings that led to this incident, and the ongoing risk that there could be a similar incident associated with another works operated by United Utilities. In response to these ongoing risks the Inspectorate has served the following Regulation 28 Notices on the company, which cover all of the company's treatment works and service reservoirs:

- UUT 3574 - Back wash water (to ensure that arrangements for recycling wash water at all treatment works comply with Badenoch and Bouchier recommendations)
- UUT 3571 - Chemical Dosing and Monitoring (to ensure adequate control of chemical dosing at all treatment works)
- UUT 3568 - Disinfection (to ensure adequate disinfection at all treatment works)
- UUT 3567 - Site Specific Disinfection Policies (to ensure that every treatment works has an appropriate disinfection policy that is understood by all operators)
- UUT 3563 - Treated Water Storage Tanks (at all treatment works and service reservoirs – to implement measures to allow structures to be removed from supply for inspection and cleaning)

8.3.4 The work required to be delivered under the terms of these Notices is, in the majority of cases, due for completion before March 2020. These Notices are all available on the Inspectorate's website.

8.4 Prosecution

8.4.1 The Inspectorate instigated prosecution proceedings against United Utilities Water Ltd under section 70 of the WIA 1991, for supplying water unfit for human consumption.

8.4.2 The company pleaded guilty to the offence of supplying water unfit for human consumption, at Preston Magistrates' Court on 19 July 2017.

8.5 Summary of the Inspectorate's findings with recommendations

8.5.1 **On the company's decision to advise consumers to boil their tap water**:

The Inspectorate concluded that the significantly elevated levels of *Cryptosporidium* oocysts in water supplied from Franklaw works between 31 July and 5 August 2015 justified the company's decision, to advise consumers supplied by Franklaw works to boil their tap water before using it for drinking and food preparation. The company took five days to complete delivery of written advice to all affected consumers. Some consumers interviewed by the Inspectorate confirmed that they were unaware of the advice until written notification was received. The company's contingency plan for responding to a water quality emergency whereby advice to consumers was required was wholly inadequate.

It is recommended that United Utilities reviews its emergency plans for issuing protective advice to consumers to ensure that these plans adequately cater for the number of consumers supplied by its treatment works (including non-residential consumers) to ensure effective communication with all affected consumers with the objective of issuing written advice to all households and other premises within 24 hours of the decision to issue the advice.

8.5.2 **On the company's decision to re-start Franklaw works on 6 August and its plans to rezone areas supplied by Franklaw with water from other treatment works:**

After being informed of the first positive detections of oocysts on 5 August, Franklaw works was removed from supply later that day for planned maintenance, unconnected with these detections. Part of the area normally supplied by Franklaw works was rezoned at this time to introduce water from Hodder and Rivington treatment works. However, the majority of the area supplied by Franklaw works could not be rezoned to receive water from other treatment works, and some 712,000 people were dependent on Franklaw works for a continuous supply of water. The company decided that it was essential to maintain supplies to these consumers, and that it was preferable to return Franklaw works to supply and advise consumers to boil their tap water, rather than maintaining the works out of supply for an indefinite period. The Inspectorate concluded that, in doing so, the company did not comply

with Regulation 26(3), because the company did not issue the protective advice to all of its affected consumers before returning the works to supply on 6 August.

It is recommended that United Utilities reviews its supply systems to identify measures required to improve the resilience of all of its networks, such that in a drinking water quality emergency, alternative sources of supply can be introduced, to reduce the population who might thereby be issued with protective advice, and to reduce the duration that any such advice might be in place.

8.5.3 On the company's programme to install ultra violet disinfection on the outlets of service reservoirs in the Franklaw supply system:

Additional areas were rezoned as the incident progressed, until 22 August when the operations to rezone all areas that could be rezoned were completed. Water supplied from Franklaw works was continuing to exhibit the presence of *Cryptosporidium* oocysts, and it was necessary for the company to find a way of restoring wholesome supplies as quickly as possible to consumers supplied by Franklaw works. The company was unable to remove some of the larger service reservoirs from supply to enable them to be cleaned within a short period of time, and thus expedite removal of contaminated water from the supply network. The Inspectorate issued a Regulation 28 Notice on the company requiring the necessary steps to be taken. The company responded by installing UV treatment at most of the reservoirs in the supply system. The speed with which the company responded to this, sourcing UV treatment units from around the UK and abroad, and installing them within a short space of time is commendable. Without this the boil water advice would have been in place for significantly longer.

Had the company's contingency plans for Franklaw been adequate, such a major operation, with all the expense and engineering challenges incurred, may not have been necessary.

It is recommended that in its review of the emergency and contingency plans for all of its supply systems, United Utilities considers whether provision of temporary treatment should form part of these plans, and, if so, what and where it might be needed, and how it will be procured.

8.5.4 On the company's immediate response to the emergency, the emergency incident teams and communications with key stakeholders:

The company engaged its emergency incident response on 5 August when the first positive *Cryptosporidium* result in Franklaw treated water was

reported. This involved establishing an internal incident response team that liaised with external organisations as required by Regulation 35 of the Regulations, including PHE, local authorities and the Inspectorate. As the incident escalated, strategic, tactical and operational company incident teams were formed to manage the event. As the scale of the emergency became apparent, as described in section 4.3, United Utilities as a Category 2 responder made contact with the Lancashire Constabulary and the local Lancashire Resilience Forum plans were set in motion to deal with the wider public emergency. This led to the formation of the Strategic Coordination Group (SCG) at Lancashire Police HQ and chaired initially by the Police, then by United Utilities and finally by Lancashire County Council. The Scientific and Technical Advisory Cell (STAC) was chaired by PHE. These two groups were the principal multi-agency incident teams, whose membership comprised PHE, local authorities, the DWI, the National *Cryptosporidium* Reference Unit, the Environment Agency and other organisations at times throughout the duration of the incident – for example Department of Communities and Local Government (DCLG), Defra, the Consumer Council for Water, the Food Standards Agency and local Councils.

Initially there was some consideration that the Cabinet Office and the Government should direct the management of the response, but it was clarified that this was not necessary for this particular incident because the water company was solely responsible and legally required to identify the cause of the contamination and restore wholesome supplies to consumers.

The Inspectorate sought feedback from local authorities, PHE, Members of Parliament and other key stakeholders on how the incident was managed and their experiences of communications with the company, and it is evident that, especially at first, there was some uncertainty about the roles and responsibilities of the organisations involved. Members of Parliament and some key stakeholders not directly involved with the incident, such as Ofwat, were being contacted by consumers wanting information and had not been communicated with all relevant information necessary to respond.

It is recommended that United Utilities publishes a report on this event and works together with water companies through WaterUK, and other stakeholders to ensure they are aware of their roles and responsibilities within the current national guidelines for responding to an emergency.

8.5.5 **On the company's communications with consumers and other stakeholders about the boil water advice:**

The Inspectorate interviewed a number of consumers and sought views from local Members of Parliament and other stakeholders. The feedback received confirmed that consumers were confused, not only when the advice was first

published, but also as it was lifted. Consumers also received unclear information about the likely duration of the boil water advice. Whilst the company made every effort to communicate effectively with consumers using a range of media (e.g. radio, television, the company's website, local press, text messaging, Facebook, Twitter) and written advice delivered to premises, there is a general sense that the company could have communicated better.

The following list includes examples of issues that caused uncertainty:

- When the boil advice was first issued, who it applied to.
- The reason for the boil water advice.
- The likely duration of the boil advice.
- What the advice actually meant, for example could the water be used for personal washing and teeth brushing.
- Actions being taken to restore normal wholesome supplies and managing expectations about the time it would take for those actions to be completed.
- Provision of bottled water – who would qualify, and how people could register to qualify.
- The phased lifting of the boil advice, areas covered by a lift, and areas not covered.
- Advice for schools should the boil advice still be in place at the start of the new school term.
- Advice for swimming pool operators.
- Advice for pets.
- And whilst not part of this report, information about financial compensation.

Guidance[13] has been issued in the past regarding publication of joint communications from water undertakers, health agencies and other organisations directly involved with an incident. Consideration should be given as to whether advice issued jointly from water suppliers and health agencies may need reviewing.

[13] Guide to the microbiological implications of emergencies in the water service, National Water Council, January 1981

It is recommended, therefore, that United Utilities works together with other water companies through WaterUK and PHE, the National *Cryptosporidium* Reference Unit and other stakeholders to review how water company advice to consumers is publicised, the information given to consumers and organisations and to develop appropriate wording for water suppliers to use when issuing protective advice to consumers. Any learning should be communicated to the DWI who will consider and incorporate any necessary updates to the DWI/HPA document *Drinking water Safety – Guidance to health and water professionals*[8].

The issues around financial compensation and communicating associated advice to customers are matters for United Utilities, Ofwat and the Consumer Council for Water to consider.

8.5.6 **On the company's investigational sampling response:**

The company's initial sampling response relied on the use of 10 litre grab samples to investigate the presence of *Cryptosporidium* in Franklaw's raw water supplies and in service reservoirs downstream of Franklaw works. Small-volume spot samples are recognised to be less reliable when sampling for *Cryptosporidium* than high volume samples obtained through filters[7]. It was not until 27 August that large-volume sampling equipment was installed at all of the service reservoirs supplied by Franklaw works. It also took the company some time to investigate and take appropriate samples from points within the treatment process at Franklaw. It was not until 23 August that in-process samples were taken that indicated the most likely point of contamination at the works. More comprehensive and better targeted initial sampling could have identified the most likely cause of the contamination earlier on, enabling remedial action to be taken without having to resort to installation of UV treatment at so many locations.

It is recommended, therefore, that the company reviews its emergency sampling response to ensure that at the onset of a *Cryptosporidium* emergency it has a sufficient quantity of portable high volume sampling equipment available to enable rapid meaningful sampling investigations of raw water quality, in-process quality and quality in the distribution network to comply with the requirements of Regulations 10 and 17 to investigate the cause and extent of the failure.

8.5.7 **On the company's investigations into the source of the oocysts:**

As mentioned previously, United Utilities' ability to install 11 UV treatment units by 6 September is a commendable achievement. This enabled the advice to consumers to be lifted in a phased manner by this date. The company had not, however, established the cause of *Cryptosporidium* being

present in Franklaw treated water by this time, even though it was more than four weeks after the start of the incident.

The Inspectorate is concerned about the company's investigational sampling response (see 8.5.6) and the time it took to establish the most likely cause of the contamination. The Inspectorate identified a number of potential causes of contamination in the Franklaw supply system during the technical audits carried out in August and September. These and the hypotheses developed by the company had to be investigated and tested by United Utilities. Eventually, following the isolation and inspection of Barnacre service reservoir and investigating the surrounding area for sources of oocysts completed in December 2015, the company concluded that the most likely cause of the contamination at Franklaw was ingress of water contaminated with faecal material into Barnacre Reservoir, which was used to supply the service water system at Franklaw works and thus introduced the organism into the treatment process downstream of the treatment stages that are important for removal of *Cryptosporidium.*

The Inspectorate agrees that, based on the evidence and information provided by United Utilities, this is the most likely cause, although other potential contamination routes were identified. A number of factors support this conclusion.

To summarise, the company's investigations identified a number of risk factors that are causes for concern:

- The poor structural condition of Barnacre service reservoir with sources of oocysts in the immediate environment.
- The poor condition of the Barnacre 18" main which was used to supply the service water system at Franklaw works in the period immediately prior to the first detections of oocysts.
- The poor condition of the service water ring main at Franklaw works, which had never been assessed and was not included in the company's distribution maintenance strategy.
- The lack of an adequate risk assessment when the decision was made to effect a major operational change at Franklaw works by switching the service water supply from the works' final treated water to water from Barnacre.
- The continued recycling of supernatant from the lamellar separators to the works inlet when oocysts were known to have been present.
- The broken turbidity monitor on the recycled supernatant flow.

- Washwater tanks were cleaned using a hose attached to a standpipe connected to the ring main - which depressurised a number of times around the time this work was carried out. The company was unable to confirm that the cleaning equipment connected to the ring main had back-flow protection in place.
- The valving errors made when the Coast Aqueduct was isolated for repair, and the introduction of stagnant water from a disused main into the Aqueduct.
- Drainage from local septic tanks running across the Franklaw site.
- Routes of ingress into tanks and other structures at Franklaw works (e.g. the interstage pumping station).
- The inability to remove some of the larger service reservoirs from supply to enable them to be inspected and cleaned.

In response to these identified failings it is recommended that:

i. United Utilities implements a full programme of work to ensure that all of its treated water-retaining tanks and reservoirs are properly maintained and secured to prevent the possibility of ingress of surface water.

ii. United Utilities implements a full programme of work to ensure that all of its trunk and distribution mains are properly maintained and secured to prevent the possibility of ingress of surface water.

iii. United Utilities ensures that all assets on treatment works that are integral to the treatment process are properly maintained and protected from damage and the risk of ingress, including service water supply arrangements.

iv. United Utilities reviews its procedures for emptying washwater tanks and sludge holding vessels and ensure that hose union taps and standpipes used on all of its water supply assets comply with the requirements of the Water Supply (Water Fittings) Regulations 1999[14] and are fitted with integral back-flow protection.

v. United Utilities ensures that all clean water supply systems (used for domestic and other purposes) on water supply sites comply fully with the requirements of the Fittings Regulations.

vi. United Utilities reviews the recommendations made in the three reports of the Groups of Experts on *Cryptosporidium* in Water Supplies and the company

[14] The Water Supply (Water Fittings) Regulations 1999, SI 1999/1148

should ensure that it is complying with recognised and current good practice with respect to its operation and maintenance of water treatment works, including recycling of recovered wash water and monitoring the quality of recycled water, continuous turbidity monitoring of filtered water and the protection of service reservoirs and other assets from livestock and potential faecal contamination.

vii. United Utilities reviews its progress with the measures required by Regulation 28 Notice UUT 3574 (issued by the Inspectorate in October 2016) which covers the recycling of backwash water at all of the company's treatment works. This will ensure that any work required at Franklaw to address the failings identified in this report are given due priority for completion.

viii. United Utilities takes steps to divert septic tank drainage away from water supply sites.

ix. United Utilities implements measures to enable all of its service reservoirs to be rapidly removed from supply to allow inspection and cleaning. These actions are covered by a Regulation 28 Notice issued by the Inspectorate in October 2016 (reference number UUT 3563), due for completion in 2020, with the work to be phased on a prioritised basis. The company should review its high priority sites to ensure that reservoirs in areas served by large single sources of supply, such as Franklaw, are given appropriate priority.

8.5.8 **On the company's planned operation to repair a leak on the Coast Aqueduct:**

The company made a number of unsuccessful attempts to isolate the Coast Aqueduct to repair a leak on the Franklaw site, during the week leading up to the first detection of oocysts in the continuous filter removed on 4 August. Problems were caused by valves not closing properly, and errors were made with valve operations because the company's mains records were out of date. There was no record of a disused 6 inch main connected to Franklaw's outlet mains through valves which were operated in error, introducing stagnant water into the Coast Aqueduct. The work caused the service water ring main to burst and depressurise a number of times during this period (see recommendation 8.5.7 (iii) above).

i. **It is recommended**, therefore, that the company reviews all of its water treatment works sites for disused mains and other decommissioned assets and disconnects them from live assets to prevent any future risks of contamination from decommissioned assets entering a treated water supply system.

ii. **It is recommended** that the company ensures that its records of underground assets and the status of valves are kept fully up to date.

8.5.9 On the company's risk assessment prior to the planned operation to repair a leak on the Coast Aqueduct

Whenever a major change is made to the operation of a water treatment works, companies should carry out a full risk assessment before work is commenced in order to identify all likely hazards and to implement steps to prevent serious consequences from materialising. This is a duty under Regulation 27, which requires that companies' risk assessments for their supply systems are continuously reviewed and updated.

United Utilities' risk assessment completed prior to the work undertaken to repair the Coast Aqueduct focused on maintaining supplies to consumers and avoiding discolouration caused by changes in flow to areas supplied from the 18" Barnacre outlet main. The risk assessment failed to consider the following:

- The likelihood of water from Barnacre service reservoir being contaminated because of the reservoir's poor structural condition and proximity to grazing livestock and septic tank discharges [Note: It is well documented in the Reports of the Groups of Experts and other academic sources that service reservoirs represent a risk of contamination, especially when they are close to areas used for grazing livestock.]

- The likelihood of contamination entering the 18" Barnacre outlet main because of its poor condition.

- The poor condition and consequential risk of depressurisation of the service water ring main at Franklaw works, and the likelihood of ingress of contamination – given the presence of septic tank discharges on the Franklaw site.

As a consequence of the wholly inadequate risk assessment, contingency arrangements for dealing with a water quality emergency at Franklaw works were neither considered nor implemented in the planning of this operation.

It is recommended, therefore, that United Utilities reviews its approach to risk assessing major operational changes to ensure that all relevant factors are taken into account, enabling the company to fully comply with its statutory duties under section 68 of the Water Industry Act 1991, to maintain a supply of wholesome water and to prevent deterioration in the quality of water supplied.

Appendix 1 - Incident time line – From 01/07/2015 to 21/12/2015

Date	Time (if known)	Event/action
01/07		The company identified a leak on the 33" Coast Aqueduct, on the Franklaw site.
20/07		The risk assessment for the operation to repair the Coast Aqueduct was completed.
24/07		The risk assessment for the repair of the Coast Aqueduct was signed off by a manager.
25/07		Preliminary works began to shut off the Coast Aqueduct to carry out repair.
25/07		The break pressure tank on Franklaw's service water supply suffered unplanned emptying, and the service water ring main depressurised.
27/07		The valving operations to isolate the Coast Aqueduct were completed. The service water supply was switched to 18" Barnacre main in order to repair Coast Aqueduct. Consumer contacts of discolouration received. (This was reported to the Inspectorate as a separate event ref. 5144 reported on 29/07/15). A wrong valve was operated which caused stagnant water from a disused main to enter the Coast Aqueduct.
27/07 to 29/07		The washwater recovery tanks were cleaned. [Note – at the time of the first positive *Cryptosporidium* on Franklaw final water, recovered washwater was being recycled to the works inlet, representing 5 to 8% of the inlet flow]. The on-line turbidity monitor on the returned washwater was not working between 26/07/15 and 06/08/15. During this time only one manual sample was taken on 05/08/16. Depressurisation of the service water ring main occurred more than once during this period.
28/07		Further attempts were made to empty the Coast Aqueduct. More discolouration contacts were received. The service water ring main depressurised between 21.00 and 22.00hrs.
29/07		Loss of pressure was recorded in DMA 065-09 which is supplied from Barnacre 18" main, still being used to supply Franklaw's service water ring main. The ring main depressurised.
31/07	09.15	An entry was made in the site diary log retrospectively, describing the opening of bypass valve on a pressure management valve (PMV)…. 'The effect of this operation would have drawn high pressure water in to the ring main from Barnacre SR'.
31/07		Franklaw final *Cryptosporidium* filter replaced (routine – replaced three times per week). This filter was clear of oocysts. The service water supply was switched to the South Aqueduct. The ring main depressurised again**,** and problems were identified with a Pressure Reducing Valve (PRV) on the ring main.
03/08		Further issues identified with the PRV. The ring main depressurised again and valving errors were discovered. Valve positions were corrected. A dead pheasant was reportedly found in one of the wash water tanks – later to disappear. The ring main depressurised at 22.00hrs. The supply to the ring main was switched back to

Date	Time (if known)	Event/action
		the Coast Aqueduct (the timing of this is unclear).
04/08		At 01.00hrs problems with caustic soda batching occurred, due to low availability of service water. Final water *Cryptosporidium* filter replaced at 07.38hrs.
05/08		The *Cryptosporidium* filter removed on 04/08 found to contain 16 oocysts (0.031/10L). Company incident response was triggered.
05/08		The *Cryptosporidium* filter on Franklaw final was replaced following the report of positive oocysts from the previous day. Investigational sampling began.
05/08	22.00	Franklaw WTW was removed from supply for planned maintenance (not associated with the repair to the Coast Aqueduct).
06/08	02.00	A Low level alarm from Hoghton SR in the Franklaw supply system was received at the company's operational control centre.
06/08	From approx. 08.00hrs	Work began to return Franklaw WTW to supply at about 08.00hrs, completed by 15.15hrs – the exact time is not reported.
06/08		The *Cryptosporidium* filter removed on 05/08 had 16 oocysts (0.119/10L). A 10L grab sample taken 05/08 from one of the washwater tank contained 4 oocysts/10L, which the company reported to be normal for washwater. The dead pheasant was ruled to be an unlikely cause of the presence of oocysts in the final water because the concentration of oocysts in the washwater was within expected levels. The company's investigations into the raw water and the treatment processes at Franklaw did not detect anything abnormal. This was the case throughout the incident. Ingress of *Cryptosporidium* into the final contact tank was also subsequently ruled out as a cause of the contamination.
06/08		The company escalated the incident response. Lancashire Resilience Forum plans were mobilised. The DWI was informed and attended Franklaw works and the company's incident control room at its headquarters in Lingley Mere, Warrington. The company instigated further investigational sampling.
06/08		10L grab samples taken from Weeton SR and Heapey SR on 06/08 contained oocysts (later followed with positive detections in 10L samples from Pike Lowe Upper on 08/08, Roscoe Lowe on 09/08, Bamber Bridge Water Supply zone 80 on 12/08, Westby SR on 15/08, Clayton SR on 18/08… etc.). This shows that significant quantities of oocysts were already in Franklaw's supply system by 06/08.
06/08		A 10L grab sample taken from the service water break tank contained oocysts
06/08	09.25 to 10.00	The company started to receive contacts from consumers in the Fylde asking whether the water supply to Blackpool was safe to drink – this was before the company had publicly issued any advice.
06/08	Afternoon /evening	Air valves on the 18" Barnacre main were inspected by DWI. Evidence was discovered of damaged valve chambers and flooded chambers with cattle grazing in field.
06/08	12.28	Following confirmation that water (containing oocysts) from Franklaw would be retained in the network for several days, the company advised PHE that boil advice was considered necessary. The DWI was notified.

Date	Time (if known)	Event/action
06/08	13.30	PHE confirmed that STAC would be convened, which they would head. DWI to participate. Company confirmed that number of tweets was escalating – again before any official warning advice had been issued.
06/08/15	From 15.30 onwards	Boil advice issued via the company's website and local media. Bottled water stocks were made available for vulnerable consumers. The criteria for lifting the boil advice was agreed with PHE – that there should be a minimum of three sets of clear samples from Franklaw, at least 24 hours apart.
07/08		Oocysts detected in continuous filter samples from Barnacre and Hoghton SRs.
07/08		Customer communications plan developed, including provisions for vulnerable consumers. A programme of regular internal and external meetings was established which continued for the duration. Hand delivery of boil water advice (BWA) advice cards commenced.
08/08		Carding of customers in urban areas commenced. Mobile visitor centres were established.
08/08		The company completed an inspection of the Barnacre 18" main and associated assets. An air valve (AV15) was found to be submerged in a flooded chamber. The water in the chamber was sampled and *C.ubiquitum* and another species of *Cryptosporidium* were later identified in the sample. Another air valve (AV9) was found to have a broken cover, with evidence of muck spreading in the surrounding field. *C.ubiquitum* was later identified in a sample of standing water from within this air valve chamber.
08/08 and 09/08		The company started to explore the feasibility of installing UV at Franklaw. The option was discounted because of the size of the plant required and operational logistics.
09/08		Oocysts detected in a continuous filter sample from Weeton SR.
09/08 to 14/08		No oocysts detected in Franklaw final water.
11/08		Distribution of BWA cards was completed.
11/08		Oocysts detected in continuous filter samples from Westby and Warbreck SRs
12/08	13.00hrs	The company learned that *C.hominis* had been identified in a sample from Weeton SR. The company established a root cause task team to investigate possible sources.
12/08		DMZ boundary valve checks were commenced in preparation for rezoning and flushing.
13/08		A run of clear samples from Franklaw indicated that the boil lift criteria may be met on 16/08, taking into account residence time in the network.
13/08		Oocysts detected in continuous filter sample from Grimeford SR supply system.

Date	Time (if known)	Event/action
15/08 (Sat)		The *Cryptosporidium* filter removed from Franklaw final on 14/08 reported as positive. This confirmed that the contamination was ongoing. The company took the decision to consider installing ultra violet (UV) treatment on SR outlets. A UV task team was established. Rezoning and flushing options investigated and began to implement – note this is more than a week after the second positive *Cryptosporidium* result reported on 06/08.
15/08		Oocysts detected in continuous filter sample from Whitebull SR.
16/08		Oocysts detected in continuous filter sample from Mellor Booster.
16/08		Further de-pressurisation of the service water ring main was logged.
18/08		The company completed the installation of continuous *Cryptosporidium* sampling equipment at 16 SRs in the Franklaw supply system.
18/08		Oocysts detected in continuous filter sample from Roscoe Lowe SR.
18/08		DWI issued Regulation 28 Notice UUT3499.
19/08		Whitebull SR (Preston DMZ) was rezoned to receive supply from Hodder WTW.
19/08		Oocysts detected in continuous filter samples from Pike Lowe Lower, Heapey, Warbreck Tower and Chorley SRs.
20/08		South Ribble DMZ rezoned to receive supply from Hodder WTW, via Hoghton, and Duxon Hill SRs.
20/08		Haighton SR (Fylde DMZ) operating protocol was established to prevent Franklaw supply from entering the reservoir. UV treatment was subsequently installed.
20/08		Oocysts detected in continuous filter sample from Warbreck Tower and Pike Lowe Upper SR.
21/08 – 22/08		South Ribble DMZ – Chorley, Roscoe Low and Heapey SRs – was rezoned to receive supply from Rivington WTW.
22/08		The first UV treatment unit was commissioned at Warbreck SR.
22/08		Oocysts detected in continuous filter sample from Haighton SR.
22/08 (Sat) - 23/08 (Sun)		DWI inspected ongoing UV installations.
22/08 - 23/08		Other parts of South Ribble DMZ rezoned to blend of Hodder and Rivington, via Pyke Lowe Lower and Pyke Lowe Upper SRs.
23/08		Oocysts detected in continuous filter sample from the Coast Aqueduct.
24/08		Clayton SR was bypassed and area supplied by Hodder WTW.

Date	Time (if known)	Event/action
24/08		UV commissioned at Warbreck Tower East and West outlets.
24/08		United Utilities agreed to supply bottled water to schools to enable reopening after summer break.
25/08		Oocysts detected in Franklaw service water ring main equivalent to a concentration of 5.882/10L – which is very high.
27/08		Cleaning and recommissioning of side 1 of Hoghton SR and side 1 of Chorley SR completed.
27/08		It was confirmed to DWI whilst on site that the service water ring main was leaking at a rate of 100L/min, and therefore, when under negative pressure, would draw in at the same rate.
27/08		UV commissioned at Haighton SR.
27/08		73,501 (23%) consumers released from BWA (Phase 1).
28/08		UV commissioned at Westby SR.
28/08		Oocysts detected in continuous filter sample from Duxon Hill SR.
29/08		UV commissioned at Weeton SR.
30/08		Cleaning and recommissioning of Roscoe Low SR completed.
30/08 to 02/09		138,175 (cumulative 66%) consumers released from BWA (Phase 2)
31/08		Cleaning and recommissioning of Pike Lowe Lower SR completed.
01/09		Barnacre link main was isolated at Franklaw.
02/09		Cleaning and recommissioning of Pike Lowe Upper SR completed. Defects were identified causing ingress. The UV installed on the outlet was operational by this time.
02/09		UV commissioned at Barnacre SR and Broughton BSP.
02/09		A hole was discovered in Franklaw's service water ring main.
03/09		A septic tank discharge identified at the site of the hole in the ring main. Soil samples were negative for oocysts and the company subsequently discounted the septic tank as the source of the *Cryptosporidium*.
03/09		UV commissioned at Pike Lowe Upper SR.
04/09		UV commissioned at Grimeford (upstream of Roscoe Lowe SR).
04/09 to 06/09		109,135 (cumulative 100%) consumers released from BWA (Phase 3).
05/09		UV commissioned at Hoghton SR.
06/09		UV commissioned at Whitebull SR.

Date	Time (if known)	Event/action
06/09		Cleaning, repairs and recommissioning of side 2 of Clayton SR completed, and cleaning and recommissioning of Chorley SR side 2 completed.
07/09		Media, customer and stakeholder task teams stood down. Sampling investigations, root cause investigation and plan to install UV at Franklaw continued.
08/09		Cleaning and recommissioning of side 2 of Heapey SR completed.
19/09		Cleaning and recommissioning of side 2 of Hoghton SR completed.
25/09		UV commissioned at Cuerdale Lane (contingency location on Hodder supply)
09/10		Cleaning, remedial work on roof and recommissioning of Roscoe Lowe SR completed, after a microbiological failure on 29/09.
30/10		Cleaning and recommissioning of North Tank of Barnacre SR completed. UV operational at the SR.
01/12 – 02/12		Franklaw works was shutdown for inspection. Significant ingress was identified in the outlet chamber after the second stage filters. Note that this water would have been used for backwashing the second stage filters throughout the incident.
14/12		Remedial works to common outlet chamber of second filters completed.
21/12		Cleaning and recommissioning of second compartment of Barnacre SR completed. UV operational.

Appendix 2 - List of references

1. The Water Supply (Water Quality) Regulations 2000, SI 2000/3184 – amended in 2001, 2002, 2005, 2007 and 2010.
2. The Water Industry Act 1991 as amended by the Water Act 2003 and the Water Act 2014.
3. The Water Supply (Water Quality) Regulations 2016 SI 2016/614.
4. An outbreak of waterborne cryptosporidiosis caused by post-treatment contamination, H. V. Smith et al, J of Epidemiology and Infection, vol. 103, 1989.
5. Cryptosporidium in Water Supplies, Report of the Group of Experts, Chairman Sir John Badenoch, July 1990.
6. Cryptosporidium in Water Supplies, Second Report of the Group of Experts, Chairman Sir John Badenoch, October 1995.
7. Cryptosporidium in Water Supplies, Third Report of the Group of Experts, Chairman Professor Ian Bouchier, November 1998.
8. The Microbiology of Drinking Water (2010) - Part 14 - Methods for the isolation, identification and enumeration of Cryptosporidium oocysts and Giardia cysts, Standing Committee of Analysts.
9. Drinking Water Safety – Guidance to health and water professionals, DWI and HPA, 2009.
10. Potential Impact of media reporting in syndromic surveillance: an example using a possible Cryptosporidium exposure in North West England, August to September 2015. Elliot *et al*, Surveillance and Outbreak report, 15 December 2015.
11. UUT 3499 – Notice under Regulation 28(4) of the Water Supply (Water Quality) Regulations 2000 as amended, for Franklaw Works, that the Company is required to mitigate risks associated with its duty to ensure wholesomeness at the customer's tap as defined by Regulation 4 and the other requirements of the Regulations 2000 and *Cryptosporidium*, by 31 March 2016. Issued 18 August 2015.
12. The judgement of His Honour Judge Norman Jones QC, the Recorder for Leeds, R v. Yorkshire Water Services Limited [1999].
13. Guide to the microbiological implications of emergencies in the water service, National Water Council, January 1981.

14. The Water Supply (Water Fittings) Regulations 1999, SI 1999/1148.

Version	Revision	Date
1.1	Amendment to paragraphs 2.2.6 and 4.2.4	1 December 2017
1.2	Addition of reference (i) in Foreword – Judgement of Judge Mark Brown	5 January 2018