Private Water Supplies: Technical Manual

Private Water Supplies

Contents

ISBN: 0-7559-5151-4

Scottish Executive
St Andrew's House
Edinburgh
EH1 3DG

Produced for the Scottish Executive by Astron B47350 06/06

Published by the Scottish Executive, June, 2006

Further copies are available from
Blackwell's Bookshop
53 South Bridge
Edinburgh
EH1 1YS

The text pages of this document are printed on recycled paper and are 100% recyclable

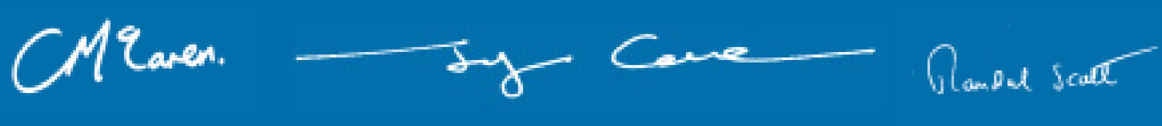
FOREWORD

The information in this Manual is intended to assist professionals regulating and maintaining private water supplies by providing an up to date and accessible reference document that brings together earlier guidance such as that contained in the Manual for Small Supplies published by the Drinking Water Inspectorate and the Technical Manual for Private Water Supplies: Operation and Regulation published by the Royal Environmental Health Institute of Scotland. As can be seen from the acknowledgements this Manual is the result of collaboration between many individuals and organisations, each striving to bring their own expertise and experience to bear on the issues affecting the quality of drinking water in private water supplies. While local authorities (with the exception of Northern Ireland) are responsible for the enforcement of the private water supplies regulations, we as water quality regulators, have a role in assisting and supporting colleagues regulating private water supplies – a role that we embrace wholeheartedly. We commend the Manual to you and hope that you find it helpful and informative.

Colin McLaren
Drinking Water Quality
Regulator for Scotland

Prof. Jeni Colbourne MBE
Chief Inspector of
Drinking Water

Randal Scott
Principal Drinking
Water Inspector for
Northern Ireland



ACKNOWLEDGEMENTS

With thanks to:

British Water
Dr Ian H Pallett, Technical Director
John Murphy, Marshall Pump Systems Ltd

Centre for Research into Environment and Health (CREH)
Prof. David Kay

Chartered Institute of Environmental Health (CIEH)
Howard Price
David Clapham, City of Bradford Metropolitan District Council

Department of Environment, Food and Rural Affairs (DEFRA)
Peter Jiggins
Martin MacDonald

Drinking Water Inspectorate (DWI)
David Drury
Tracey Viney

Drinking Water Quality Regulator for Scotland (DWQR)
Colin McLaren
Dr Donald Reid

Environment and Heritage Service, Department of Environment, Northern Ireland
David O'Neill

Health Protection Agency (HPA)
Dr Gordon Nichols, Deputy Director, Environmental & Enteric Diseases Department,
Communicable Disease Surveillance Centre

Health Protection Scotland (HPS)
Dr Colin N Ramsay, Consultant Epidemiologist

The Macaulay Institute
Dr Allan Lilly
Moira McMaster

Royal Environmental Health Institute of Scotland (REHIS)
Tom Brydon, Perth and Kinross Council
David Cooper, Aberdeenshire Council
Angus Hogg, Highland Council
Ken Jones, Scottish Borders Council
Alan Morrison, Argyll and Bute Council
Kirsty Steven, Perth and Kinross Council

Scottish Executive (SE)
Janet Brunton
Tim Hooton
Paul Neison
Kirsty Stevens
David Williamson

Scottish and Northern Ireland Plumbing Employers Federation
Alan Wilson

University of Lincoln
Prof Brian A McGaw

Welsh Assembly Government
Environment Protection and Quality Division

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

CREH
Centre for Research into Environment and Health

SNIPEF
Scottish and Northern Ireland Plumbing Employers Federation

BRITISH WATER
expertise worldwide

Health Protection Agency

THE MACAULAY INSTITUTE

dwqr

Health Protection Scotland

The Royal Environmental Health Institute of Scotland

UNIVERSITY OF LINCOLN

Environment & Heritage Service
www.ehsni.gov.uk

dwi
guardians of drinking water quality

SECTION 1

INTRODUCTION

Section Contents

This page is intentionally blank

1 INTRODUCTION

1.1 Background

Water is essential to sustain life and an adequate supply of good-quality drinking water should be available to consumers. International guidelines on drinking water quality are published by the World Health Organization[1]. Within the European Union drinking water is subject to specific quality standards set out in the EC Directive on the Quality of Water Intended for Human Consumption (98/83/EC[2], the 'Drinking Water Directive') which takes into account the WHO guidelines.

The water quality standards laid down in the drinking water Directive apply to all public and private water supplies intended for drinking, cooking, food preparation and other domestic purposes. Member States had to introduce legislation implementing the requirements of the Directive by the end of 2000 and have to comply with most of the standards in the Directive by the end of 2003.

[1] WHO (2004). *Guidelines for drinking water quality*. Third Edition Volume 1, Recommendations. World Health Organization, Geneva.

1.2 Private supplies

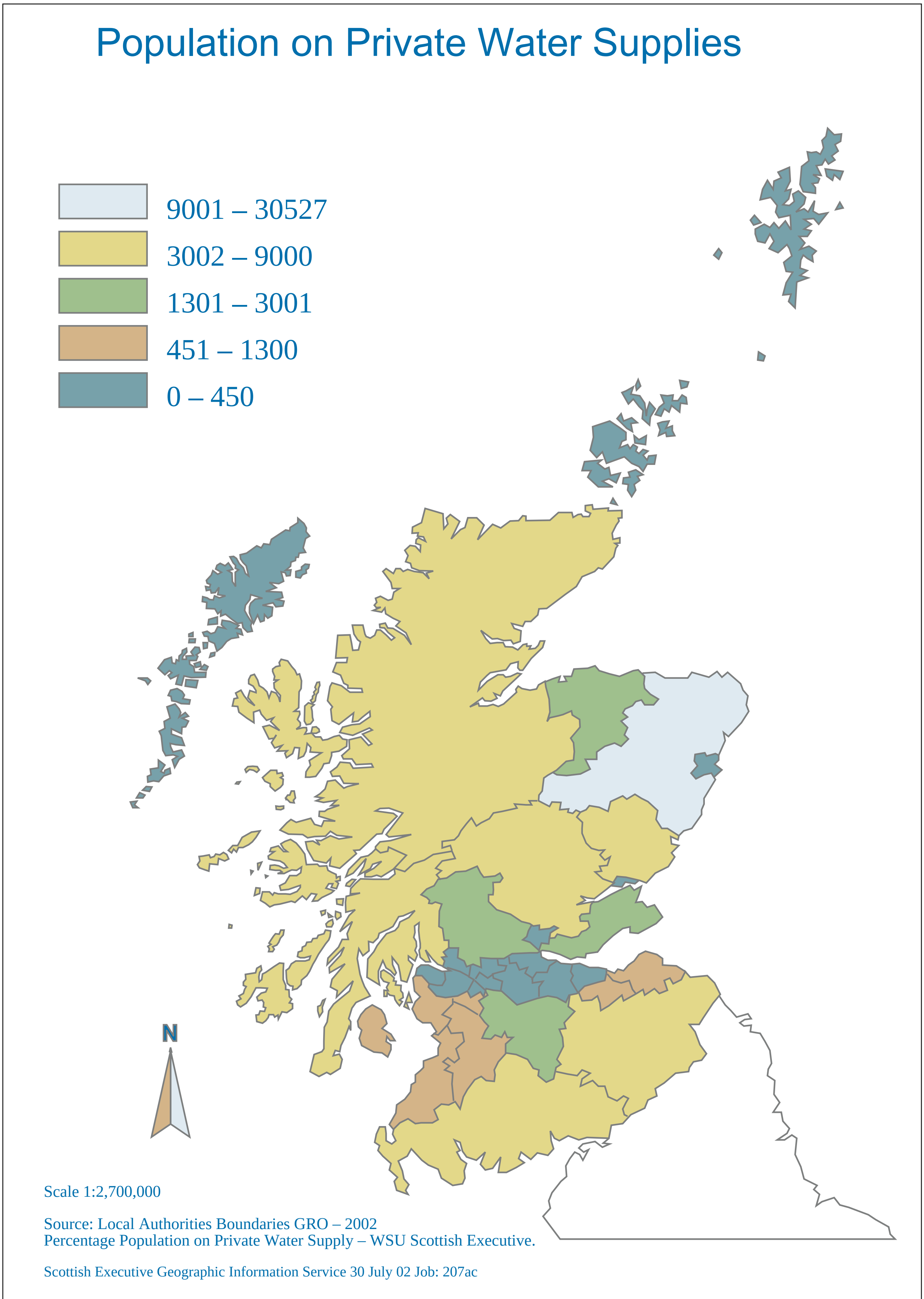
A private water supply may be defined as any water supply that is not provided by a statutory water undertaker and where the responsibility for its maintenance and repair lies with the owner or person who uses it. A private water supply can serve a single household and provide less than one cubic metre of water per day or it can serve many properties or commercial or industrial premises and provide 1000 m3/d or more. The water source could be a borehole, well, spring, lake, stream or river.

The monitoring requirements of the Drinking Water Directive vary according to the size of the supply. In addition to the volume of water produced (or population served), private water supplies should also be classified according to the nature of the supply taking account of whether the supply serves:

- single dwelling domestic use;
- is for domestic use for persons normally residing on the premises; or
- is supplying premises used for commercial food production or with changing populations.

This page is intentionally blank

1.3(S) Individual Country Data on Private Water Supplies – Scotland



This page is intentionally blank

1.4 Construction products and chemicals in contact with drinking water

Chemicals used in water treatment and construction products used in water supply systems can adversely affect water quality. Potential effects include the addition of potentially toxic contaminants as well as aesthetic aspects such as taste and appearance. This source of potential contamination is best addressed through controls on the quality of chemicals and construction products used in water supply systems, from the point of collection to the point of use.

Currently there is no internationally recognised scheme for the regulation or approval of construction products and chemicals although some countries have guidelines, standards, regulations or approval systems. The Drinking Water Directive[2] requires Member States to ensure that substances and materials (including associated impurities) used in water treatment and distribution, do not cause a risk to public health. However, the implementation of schemes to control product quality is currently left to Member States.

A wide range of European standards for drinking water treatment chemicals has been published. There is also a European Union initiative to develop a European Acceptance Scheme for construction products in contact with drinking water. Operators of private water supplies are advised to use chemicals that conform to a European standard and to observe the dosing recommendations contained in the standard. Construction products should be approved under an appropriate national approval scheme such as that provided by The Committee on Products and Processes for Use in Public Water Supply[3].

Outside Europe, particularly in North America, relevant standards for treatment chemicals and construction materials are NSF Standards 60[4] and 61[5] respectively.

[2] EC (1998). Council Directive of 3 November 1998 on the quality of water intended for human consumption. *Official Journal of the European Communities*, No L330, 5th December 1998, pp 32-52 (98/83/EC).

[3] www.scotland.gov.uk/library/environment/cppw.pdf

[4] ANSI/NSF 60 Drinking water treatment chemicals – Health effects.

[5] ANSI/NSF 61 Drinking water system components – Health effects.

This page is intentionally blank

SECTION 2

PROPERTIES AND CONTAMINANTS OF WATER

Section Contents

Private Water Supplies

2.3 Micro-organisms

In the UK a high proportion of outbreaks of **waterborne disease** have been associated with private supplies. *Campylobacter, Cryptosporidium and Giardia* are the most common pathogens associated with private supplies.

Campylobacter: Found in high numbers in the faeces of infected pigs and poultry, and the infective dose in contaminated water is relatively low.

Disinfection through chlorine, ozone and UV at the levels normally applied should ensure no viable *Campylobacter* organisms enter the supply, but waters must first be conditioned adequately by the removal of dissolved organic material and particulates, particularly where UV disinfection is being used.

Cryptosporidium: Cattle, sheep and human sewage are the main sources of contamination of private water supplies. A combination of catchment control, physical barriers and disinfection is required to provide protection from the organism.

Private supplies derived from surface waters and springs will be vulnerable to contamination, particularly in agricultural catchments. Filtration (through coagulation, sedimentation and filtration) is advised to remove *Cryptosporidium*, with disinfection aimed at inactivating any remaining viruses and bacteria.

Giardia: Private supplies should be regarded as being at greater risk if the catchment is prone to contamination by the faeces of animals, if there is a rapid route for recharge to reach the raw water intake and if there are inadequate treatment barriers. Normal coagulation, sedimentation and filtration processes, if operated correctly, should achieve at least a 3-log (99.9%) removal of *giardia* cysts.

E. coli: Many types of *E. coli* bacteria are harmless. The infectious dose of the harmful strain *E. coli* O157 appears to be very low. *E. coli* is used as faecal indicator for other pathogens.

2.4 Chemical Contaminants

Aluminium in raw water can be removed by coagulation and filtration. The national standard is **200 µg/l** and is based on avoiding problems of cloudiness and discolouration rather than being health-based.

Iron and manganese suspensions can reduce the efficiency of chlorine disinfection. Filtration after coagulation, sedimentation and oxidation may be required for when supplies contain more than 1 mg/l of either.

Lead. The current standard is 25 µg/l. By 2013 a new standard of 10 µg/l is to be met. For small water supply systems the best approach is the replacement of lead-containing materials with non-leaded alternatives. If water has been standing in lead pipes overnight, the tap should be run for 60 seconds before taking water for drinking or cooking.

Arsenic. The standard for arsenic is 10 µg/l. Arsenic (V) can be removed effectively by iron or aluminium coagulation. Arsenic (III) requires pre-oxidation (e.g. using chlorine). Other potential removal techniques include ferric oxide, activated alumina, ion-exchange and reverse osmosis.

Ammonia. Even small amounts of **ammonia** (e.g. above 0.05 mg/l NH_4) in groundwater normally warrant further investigations. Ammonia can be removed by aeration (after increasing pH to 11), ion-exchange, biological denitrification and breakpoint chlorination. Chlorine capacity must be sufficient to produce a free chlorine residual. However, only chlorination is likely to be applicable to small supplies.

Pesticides commonly reported include atrazine, simazine dieldrin, isoproturon, mecoprop and chlorotoluron. UK drinking water quality regulations specify standards of 0.1 µg/l for individual pesticides and 0.5 µg/l for total pesticides, though there is no toxicological basis for this. Ozonation, activated carbon adsorption and oxidation processes can reduce pesticide levels, but for small supplies with significant concentrations, an alternative water supply may be necessary.

Chlorinated solvents. The UK standards are 3 µg/l for 1,2-dichloroethane and 10 µg/l for the total of tetrachloroethene and trichloroethene. Solvent concentrations can be reduced by aeration or activated carbon adsorption, the latter being the likely choice for small water supplies, though an alternative supply may prove more economical. Water contaminated by chlorinated solvents can travel large distances, making it difficult to pinpoint the source of pollution.

Trihalomethanes (THMs) are formed as a result of reactions between chlorine and some organic substances present in raw waters. These precursors can be removed to some extent by adsorption on activated carbon, or an alternative to chlorine may be considered. The UK standard is 100 µg/l for the total of THMs present.

Bromate is formed by oxidation of bromide if water is ozonated. It is difficult to remove but its formation can be minimised by limiting the ozonation.

2.5 Physical and Chemical Properties

pH value. UK standards specify a minimum of pH 6.5 and a maximum of pH 10.0. The pH value can be changed by aeration, alkali or acid dosing or contact with alkaline material in contact beds.

Hardness. No UK standards are specified for hardness, calcium or magnesium but the Department of Health has stated that "it remains prudent not to undertake softening of drinking water supplies". Where water is softened by base exchange softening, it is important to provide an unsoftened outlet for potable purposes. Installation of a softener just before the hot water tank or boiler is a more economical way of preventing limescale than softening the whole supply.

Colour is removed for aesthetic reasons but the contaminants causing a high colour can also impair disinfection processes, cause high concentrations of trihalomethanes and foul reverse osmosis membranes.

Colour is expressed in mg/l on the platinum-cobalt (Pt-Co) scale, which is equivalent to Hazen units (˚H). The UK standard is 20 mg/l Pt-Co, but the colour must also be "Acceptable to consumers and [with] no abnormal change".

Colour removal at a water treatment works is usually achieved by coagulation followed by sedimentation or flotation and filtration, though filtration is usually inefficient for small supplies.

Turbidity is removed because it can impair the efficiency of disinfection, and for aesthetic reasons. The UK standards are 1 NTU in water leaving treatment works and 4 NTU at consumers' taps. It must also be "Acceptable to consumers and with no abnormal change".

Rapid sand filtration or microstraining can remove coarse turbidity and some species of algae. Fine turbidity and many species of algae can be removed by slow sand filtration or by coagulation followed by sedimentation or flotation and filtration.

Taste and odour. The intensity of taste and odour is expressed as Dilution Number and the UK standards for both are 3 dilution number at 25 ˚C, with the standard requirement "Acceptable to consumers and with no abnormal change".

Taste and odour are removed principally for aesthetic reasons. They can be reduced or removed by aeration, ozonation or adsorption on activated carbon or, where chlorination is the source, by control of the disinfection process.

Private Water Supplies

This page is intentionally blank

2 PROPERTIES AND CONTAMINANTS OF WATER

2.1 Introduction

Methods used for the treatment of a raw water will depend on the properties of the water and the presence and concentrations of any contaminants. Groundwaters usually have low levels of colour and turbidity and consistent microbiological quality, although water from shallow wells and some springs may be more variable. Particular problems may include high or low pH value and alkalinity and high concentrations of iron, manganese, nitrate, chlorinated solvents or pesticides. Surface waters may have high levels of colour and turbidity and exhibit poor microbiological quality. Quality may be variable and deteriorate following periods of heavy rainfall. Other problems may include low pH value and alkalinity and high concentrations of aluminium, iron, manganese, nitrate or pesticides.

2.2 Microbiological parameters – general

Water used as a source for a small supply of drinking water may be of unknown origin and come from a catchment prone to consistent or intermittent contamination by faecal material from domestic and farm animals, wildlife or sanitation systems such as septic tanks. As a consequence, there is a high probability of pathogenic micro-organisms being present in the source water, and adequate treatment must be applied before the water is used for domestic purposes. Because no single treatment can be expected to remove all types of pathogenic agents, a multiple barrier approach in the form of two or more sequential treatment processes is recommended.

The microbiological quality of drinking water has traditionally been assessed by monitoring for bacteria called faecal indicator organisms (coliforms, *E. coli*, and enterococci). The presence of these organisms is indicative of past faecal contamination and hence the possible presence of enteric pathogens. Although indicator organisms are generally adequate for monitoring purposes they cannot completely be relied on to indicate the absence of pathogens. This is especially true where a pathogen is environmentally more robust, or can survive treatment better than the indicators. In these circumstances the indicator may be absent even though low numbers of pathogens still remain.

An example of a pathogen with which such a discrepancy can occur is the protozoan parasite *Cryptosporidium*. This micro-organism is very much more tolerant of the action of disinfectants than faecal indicators such as *E. coli* because it forms resistant spore-like bodies called oocysts. If disinfection is the sole treatment process used, the numbers of *Cryptosporidium* oocysts will remain unchanged whereas the numbers of *E. coli* may be reduced to undetectable levels.

The use of filtration before disinfection is more effective in that an appropriate physical treatment process will remove oocysts. In addition filtration will remove much of the particulate material present which could otherwise reduce the effectiveness of disinfection by creating an oxidant demand and/or shielding microbes from the effects of the disinfectant. This is a good example of why a multiple rather than a single barrier approach is preferred. In addition the use of multiple barriers will allow some protection to remain even if one process fails.

Despite the possible shortcomings in the use of faecal indicators as a measure of the microbiological safety of a water supply, monitoring for coliforms and *E. coli* is still recommended and standards of quality are expressed in terms of these organisms. The reason for this is that monitoring for the pathogens themselves remains rather uncertain because methods of analysis are relatively insensitive and costly compared to those for faecal indicators. Additionally the absence of one pathogen will not guarantee the absence of others. Therefore *E. coli* and coliforms remain the best and most sensitive general measure of water quality.

Monitoring needs and treatment requirements should however be the subject of regular review and if a need is identified, through say an outbreak due to a specific pathogen, treatment strategies and monitoring requirements may need to be changed.

Blue-Green Algal Bloom

Crown Office copyright

2.2 Microbiological parameters – general (continued)

Growth of algae can be a problem in some surface water sources and in uncovered water storage reservoirs. Algae are naturally present in all inland waters and concentrations can increase and decrease rapidly depending on climatic factors and the availability of essential nutrients. Algae can cause taste and odour in water. Some blue-green algae release toxins that may prejudice the recreational use of water. Although algal toxins have not been identified in drinking water supplies at concentrations that would affect health, it would be prudent to avoid the use of water sources that exhibit high concentrations of algae.

With the consent of the relevant environmental authorities, it may be possible in some circumstances to adopt measures to minimise the development of excessive algal blooms. The addition of iron salts to precipitate the nutrient phosphate is one measure, although it may not represent a long-term answer to the problem. In the past, dosing of copper sulphate has been used to reduce growth of algae in reservoirs but its efficacy is questionable. The forced circulation of reservoirs to keep water mixed is another measure. Blooms of algae occur mainly at the surface of reservoirs whereas water is abstracted at depth. Some forms of water treatment, including ozonation, activated carbon adsorption and addition of potassium permanganate can be effective in removing algal toxins. Algae are normally removed as particulate matter during water treatment but some algae can pass through filters or reduce the efficiency of filtration or sedimentation systems.

In 2002 the Scottish Executive Health Department published revised guidance complied relating to all aspects of Cyanobacteria. The document "Blue-Green Algae (Cyanobacteria) in Inland Waters: Assessment and Control of Risks to Public Health"[1] should be consulted for further information on this topic.

[1] www.scotland.gov.uk/library5/environment/bgac.pdf

2.3 Micro-organisms associated with outbreaks and private supplies

2.3.1 Review of outbreaks

Fewtrell *et al*[2]. tested samples from 91 private supplies in the UK, and found the microbiological quality of the water in small supplies to be generally poor, with almost 50% of the supplies failing to meet the required quality standards on at least one occasion. They concluded that, given the high level of sanitary failures, there was the possibility that harmful micro-organisms could be present, and that a significant risk to health could not be discounted.

Poor microbiological quality of groundwater systems has caused many disease outbreaks in the USA. Between 1971 and 1994, 58% of U.S. waterborne disease outbreaks (356 in number) were caused by contaminated groundwater systems – 70% of these outbreaks were considered to be due to contamination of the groundwater source as opposed to the distribution system[3]. Being generally smaller and less well-equipped than public supplies, and being subject to less stringent surveillance and regulatory requirements, private supplies by their very nature are more likely to suffer water quality failures. In the UK 18 outbreaks of waterborne disease were associated with private water supplies between 1970-94 in which over 1,388 people were affected in England and Wales[4]. The figure is almost certainly an underestimate as no data from 1987-93 were available and because of inherent under-reporting problems. In Scotland, private supplies caused 21 out of 57 waterborne disease outbreaks between 1945 and 1987 (37%)[5]. These 21 outbreaks gave rise to at least 9,362 cases[6].

Furtado *et al*[7]. have reviewed outbreaks of disease associated with both public and private water supplies in England and Wales between 1992 and 1995. In this period ten outbreaks were associated with public supplies, and nine with private supplies. The pathogen responsible for all ten outbreaks from public supplies was *Cryptosporidium*. In contrast, the most common pathogen associated with private supplies was *Campylobacter*, along with *Cryptosporidium* and *Giardia*. In one outbreak the causal agent was not identified.

[2] Fewtrell, L., Kay, D. and Godfree, A. (1998). The microbiological quality of private water supplies. *Journal of the Chartered Institution of Water and Environmental Management* **12** (1), 45-47.

[3] Craun, G.F. and Calderon, R.L. (1997). Microbial risks in groundwater systems: epidemiology of waterborne outbreaks. In: *Under the microscope. Examining microbes in groundwater.* American Water Works Association Research Foundation, Denver Colorado.

[4] Fewtrell, L. and Kay, D. (1996). *Health risks from private water supplies.* CREH report EPG 1/9/79, University of Leeds, Leeds.

[5] Benton, C., Forbes, G.I., Paterson, G.M., Sharp, J.C.M. and Wilson, T.S. (1989). The incidence of waterborne and water-associated disease in Scotland from 1945-1987. *Water Science and Technology* **21**, 125-129.

[6] Lamb, A.J., Reid, D.C., Lilly, A., Gauld, J.H., McGaw, B.A. and Curnow, J. (1998). *Improved source protection for private water supplies: report on the development of a microbiological risk assessment approach.* School of Applied Sciences, Robert Gordon University, Aberdeen, 86pp.

[7] Furtado, C., Adak, G.K., Stuart, J.M., Wall, P.G., Evans, H.S. and Casemore, D.P. (1998). Outbreaks of waterborne infectious intestinal disease in England and Wales, 1992-5. *Epidemiology and Infection* **121**, 109-119.

2.3.1 Review of outbreaks (continued)

This difference is striking, and is most likely to reflect the differences in treatment strategies between public and private supplies. Public supplies usually employ a multiple barrier treatment strategy, normally with chlorination or possibly some other form of disinfection as a final stage. Any disease-causing organism which may have survived or broken through the conventional water treatment processes is therefore exposed to disinfection as a final barrier to prevent its entry into the distribution system. Provided that it is susceptible to the disinfectant, it will cause no problems. However, *Cryptosporidium* oocysts are highly resistant to chlorination at the levels applied in water treatment, and consequently this organism appears to be the most troublesome in public water supplies.

With private supplies a variety of treatment strategies are used, but often there is no treatment at all, and disinfection is both much less prevalent and can suffer from problems of unreliability. This allows the possibility for outbreaks to be caused by organisms that could easily be inactivated if some form of disinfection was employed. *Campylobacter* is such an organism. It is more susceptible to chlorine, ozone and ultraviolet (UV) irradiation than indicator organisms such as coliforms and *Escherichia coli*, but if there is no disinfection it can still cause outbreaks of disease, as has been observed with private supplies.

Table 2.1 summarises the outbreaks associated with private water supplies in the UK over the 25-year period from 1970 to 1995. This is not to say that these were the only outbreaks, but they are the ones that have been documented and have been subject to epidemiological investigation.

The following sections give a more detailed description of the micro-organisms that have been responsible for the outbreaks shown in Table 2.1.

2.3.2 Campylobacter species

The genus *Campylobacter* includes fourteen species with the most important human pathogens being the thermophilic species: *C. jejuni, C. coli* and *C. upsaliensis. Campylobacter jejuni* is a major cause of gastrointestinal illness and is common in the faeces of a wide variety of wild and domesticated animals. In England, Campylobacters are the main causes of food-related gastroenteritis. *C. jejuni* may adopt a dormant state with modified metabolism known as 'viable but non-culturable'. The stimulus for the adoption of this state is stress, which includes the starvation conditions found in water.

The natural habitat of *Campylobacter* species is the intestinal tract of warm-blooded animals, particularly pigs and poultry. Faeces from infected animals will contain extremely high numbers of *Campylobacter* (several million per gram). Contamination of water sources should therefore be regarded with concern since the infective dose is relatively low, and 500 organisms have been shown to initiate infection. Most infections are relatively mild and resolve within a few days without medical intervention. However, serious complications can occur, particularly in the old or very young.

Although *Campylobacter* does not multiply readily outside its natural habitat, survival in water can be protracted. They are more sensitive than *E. coli* to chlorine, ozone and UV at the levels normally applied as part of water treatment, so any viable organisms passing through the earlier stages of water treatment should not enter the supply. However, the action of disinfectants can be hindered if the water has not been conditioned adequately by the removal of dissolved organic material and particulates. The latter can have a shielding effect particularly where UV disinfection is being used.

Compliance with the normal standard of 0 *E. coli* in 100 ml should provide adequate protection. However between 1981 and 1994 there were nine recorded outbreaks involving nearly 700 cases associated with private water supplies.

Table 2.1 Summary of outbreaks of disease associated with consumption of water from private supplies over the period 1970 to 1995

Pathogen	Number of outbreaks	Total cases
Campylobacter species	8	>647
Cryptosporidium	2	15
Cryptosporidium and *Campylobacter*	1	43
Escherichia coli serotype O157	1	4
Giardia	1	31
Paratyphoid fever	1	6
Streptobacillary fever	1	304
Viral gastroenteritis	3	>998
Unknown	1	51
Total:	**19**	**>2,099**

Compiled from:

Fewtrell, L. and Kay, D. (1996). *Health risks from private water supplies*. Report No. EPG 1/9/79. Centre for Research into Environment and Health, University of Leeds.

Furtado, C., Adak, G.K., Stuart, J.M., Wall, P.G., Evans, H.S. and Casemore, D.P. (1998). Outbreaks of waterborne infectious intestinal disease in England and Wales, 1992-5. *Epidemiology and Infection* **121**, 109-119.

Galbraith, N.S., Barrett, N.J. and Stanwell-Smith, R. (1987). Water and disease after Croydon: A review of water-borne and water-associated disease in the UK 1937-86. *Journal Institution of Water and Environmental Management* **1**, 7-21.

2.3.3 *Cryptosporidium* species

Cryptosporidia are unicellular protozoan parasites. Although many species are currently recognised, infecting a wide range of animals, *C. parvum* is thought to be the only species to cause the diarrhoeal disease cryptosporidiosis in humans. The incubation period (from infection to onset of symptoms) is 7 to 10 days. Person to person spread does occur. Infection is initiated by ingestion of the transmission stage which is a small (5 µm), round, resistant structure called an oocyst. Infected humans can excrete 10[8] oocysts per day and calves and lambs can excrete 10[9] oocysts per day. The broad range of hosts, high outputs from infected individuals and environmental resistance ensure a high level of contamination in the environment. Cattle, sheep and human sewage are the main sources of contamination of private water supplies.

Cryptosporidium oocysts have been detected in river, canal, lake and reservoir waters, filter back wash waters, sewage effluents and in some groundwaters. The concentrations fluctuate considerably. 'Spikes' may occur in river waters after periods of heavy rainfall. Oocyst concentrations between 7 and 48,400 per 100 litres have been reported in raw surface water sources in the USA. Higher loadings have been reported in water receiving agricultural drainage.

In sporadic cases (as distinct from outbreaks) the number of *C. parvum* infections is highest in children under five years of age. Most infections are reported during the spring and early autumn, the former probably coincidental with the lambing and calving season, and the latter with increased rainfall.

Physical treatment processes (coagulation, sedimentation and filtration) can provide an effective barrier to the parasite. Removal efficiencies of 99.8% for *C. parvum* oocysts by coagulation, clarification and sand filtration have been reported for efficiently operated systems. Membrane filters with sufficiently small pore sizes will effectively remove oocysts. Chlorination at the concentrations used in water supply does not inactivate oocysts. Disinfectants used in combination or sequentially may enhance disinfection activity against *C. parvum* and certain forms of UV treatment may be successful. However, very few published disinfection studies have been performed under conditions that are representative of actual high-risk conditions. A combination of catchment control, physical barriers and disinfection is required to provide protection from the organism.

Private supplies derived from surface waters and from some springs will be vulnerable to contamination with oocysts particularly in agricultural catchments. Here the use of a filtration stage in treatment is advisable to physically remove oocysts of *Cryptosporidium*, with disinfection aimed at inactivating any remaining viruses and bacteria.

8 CREH (2001). Report on the incidence of *Cryptosporidium* in water, Research Contract DWI 70/2/129.

9 Hancock, C., Rose, J.B. and Callahan, M. (1997). The prevalence of *Cryptosporidium* and Giardia in US groundwaters. *Proceedings International Symposium* on Waterborne *Cryptosporidium*, Ed Fricker, C.R., Clancy J.L. and Rochelle P.A. American Water Works Association, Denver, CO, 147-152.

2.3.3 *Cryptosporidium* species (continued)

Clapham reported that *Cryptosporidium* oocysts were found at one time or another in 60% of 15 private water supplies in the Bradford area, which had been monitored over roughly a 3-month period[10]. Oocysts were detected in 21 of a total of 150 samples taken (14%). These supplies were monitored after rainfall events (when the likelihood of oocysts entering supplies is thought to be increased) during the winter season (December to February not usually a peak time for *Cryptosporidium* infections). This study clearly demonstrated that *Cryptosporidium* oocysts (and also *Giardia* cysts) can enter high-risk private supplies when conditions permit.

A more recent study[8] monitored seven private water supplies in the UK for a range of micro-organisms including *Cryptosporidium* and *Giardia*. A monitoring cabinet was installed at each site and daily samples of 1,000 litres were taken. Each site was monitored daily for six weeks in two phases, May to June 2000 and October and November 2000. The results are summarised in Table 2.2. Microbiological water quality deteriorated following heavy rainfall. At Site 7, filtration and electrochlorination were installed between Phases 1 and 2 but cysts were still found during extreme weather conditions.

Contamination of groundwater by *Cryptosporidium* and *Giardia* was reported in 12% of 199 groundwater sites in the USA, with the majority of positive detections in springs, infiltration galleries and horizontal (collector) wells[9]. Reports of *Cryptosporidium* and *Giardia* in groundwater in the UK are sparse, in part because high cost and difficult analytical procedures have made sampling very sporadic in public and private supplies alike.

In the Third Report of the Group of Experts' report on *Cryptosporidium* in Water Supplies[11] further advice on private water supplies is given in Chapter 10 of that Report. The advice contained in the Report is implicit in the guidance given throughout this manual and the reference to the Report is provided for completeness.

[10] Clapham, D. (1997). *Cryptosporidium incidence in private water supplies and correlatory indicators*. Directorate of Housing and Environmental Protection, Bradford Metropolitan District Council.

[11] *Cryptosporidium in Water Supplies*. Third Report of the Group of Experts to Department of the Environment, Transport and the Regions & Department of Health. (1998) HMSO ISBN 1 85112 131 5

Table 2.2 Cryptosporidium and Giardia in seven private supplies in the UK

Site		Samples found to contain cysts (%)			
		Cryptosporidium		*Giardia*	
		Phase 1	Phase 2	Phase 1	Phase 2
1	SW England	2.4	0.0	2.4	0.0
2	Scotland	75.0	60.0	50.0	42.5
3	S Wales	2.4	2.4	56.6	50.0
4	N Ireland	0.0	0.0	2.4	12.1
5	Scotland	33.3	15.4	56.0	65.9
6	S Wales	0.0	0.0	10.0	29.0
7	Yorkshire	52.2	57.7	91.0	84.4

2.3.4 *Giardia* species

Giardia are a group of flagellate protozoans which grow in the intestinal tracts of both vertebrates and invertebrates. *G.duodenalis* infects more than 40 species of vertebrates, including humans. It causes a diarrhoeal disease in humans and between 4,000 and 7,000 cases are reported in England and Wales each year. The disease can be transmitted by direct contact with infected animals and humans, or by consumption of water, food or beverages contaminated by the faeces of infected humans or animals. *Giardia* forms cysts that are infectious and these survive well in aqueous environments. The cysts are oval in shape and 9 to 12 µm in length. A large number of animals (including humans) are potential carriers of *Giardia* infectious to humans. In the UK, the organism is endemic in sheep, cattle, rodents, cats and dogs. Birds have also been suggested to be a potential reservoir of *Giardia* infectious to humans.

The cysts survive well in aqueous environments and show greater resistance to UV, chlorine, and ozone than bacteria and viruses, but they are less resistant than *Cryptosporidium* oocysts. *Giardia* cysts are inactivated by boiling or pasteurisation. Normal coagulation, sedimentation and filtration processes, if operated correctly, should achieve at least a 3-log (99.9%) removal of cysts.

Outbreaks associated with drinking water can occur where human or animal faeces contaminate the supply and there is inadequate treatment, filtration or chlorination. In the UK the threat to public supplies is regarded as being minimal due to the use of multiple treatment barriers. Post treatment contamination, such as could occur after repairs to mains that are not adequately cleaned and disinfected before recommissioning, could still be a particular risk.

Private supplies should be regarded as being at greater risk if the catchment is prone to contamination by the faeces of animals, if there is a rapid route for recharge to reach the raw water intake and if there are inadequate treatment barriers. Table 2.2 in Section 2.3.3 shows the results of sampling seven private water supplies in the UK for *Giardia*.

2.3.5 *Escherichia coli* serotype O157

Escherichia coli (*E. coli*) is a bacterium, most strains of which live harmlessly in the gastro-intestinal tracts of people and animals. However, a few types have acquired virulence factors. These organisms are often harmful to people and can cause severe disease. Particularly important factors are toxins. One group of toxins was originally recognised by their ability to kill cultured Vero cells, (African green monkey kidney cells) hence the name Verocytotoxins (VTs). The toxin-carrying *E. coli* therefore became known as Verocytotoxin-producing *E. coli* (VTEC).

In the laboratory *E. coli* of all kinds are classified by identifying the antigenic (antibody producing) structure of two different molecules on their surface, O and H. There are more than 170 O serogroups. These can be subdivided into H serotypes. In the UK the overwhelming majority of VTECs causing human disease fall into serotype O157:H7, although other serotypes are not looked for in most laboratories. In addition to VTEC belonging to serogroup *E. coli* O157, other groups such as O111, O26, O103 and O145 have been identified as emerging pathogens throughout Europe.

Although verocytotoxin genes are necessary to cause serious disease, they alone are not sufficient. Indeed, many other *E. coli* strains have these genes but are not particularly pathogenic. Additional virulence factors are needed. In *E. coli* O157, the best studied example, some are coded by genes on a length of DNA in the bacterial chromosome called a pathogenicity island; they include proteins that help the organisms to adhere to the large bowel wall. Others are coded by genes on a plasmid (which facilitates the exchange of genetic material between bacteria). The most common kind of severe disease caused by these organisms is haemorrhagic colitis and so as a group they have been called enterohaemorrhagic *E. coli* or EHECs.

On an evolutionary time scale *E. coli* O157 (and other VTEC) are brand new, the first outbreaks caused by them occurring less than twenty years ago. It was first identified as a cause of human illness in 1982 in the USA, and there have since been numerous reports world-wide of infection with the organism.

The infectious dose (the number of bacteria necessary to produce an infection) of *E. coli* O157 appears to be very low, probably less than 100 organisms and possibly as low as 10. People can become infected through contact with the faeces of infected animals, by passing the organism from person to person, or by the consumption of contaminated foods or water.

2.3.6 *Streptobacillus* species

One outbreak of Streptobacillary fever has been associated with a private water supply. Over 300 people were affected and the illness was thought to be due to contamination of a spring source by rats.

Streptobacillary fever is a rare infection in the UK, and is caused by a bacterium called *Streptobacillus moniliformis*. This organism is normally associated with rat bites causing an illness termed rat-bite fever. However the bites of infected mice, squirrels, weasels, dogs and cats have also been recorded as causes of the illness. *Streptobacillus moniliformis* occurs in animals as a commensal inhabitant of the nasopharynx, but can occasionally be excreted in urine.

Haverhill fever is a form of Streptobacillary fever that is normally connected with direct contact with animals. It was named after the first recorded epidemic of the disease in Haverhill (Massachusetts, USA) caused by consumption of raw milk and milk products. An outbreak in the UK occurred at a boarding school in Essex in 1983. Although this was at first thought to be caused by the school's supply of unpasteurised milk, further case-controlled studies gave a strong association with the school's private water supply. This was a spring source where there was evidence of rat infestation. This source was used for the hot water supply in the school, but engineering investigations showed the possibility of cross-connection with the potable supply.

Streptobacillus moniliformis is a Gram negative bacterium, which generally occurs as short coccobacillary forms or rods (0.5 μm in length). Its small size may allow passage through water treatment filters particularly if there has not been a coagulation stage. The organism is pleomorphic and so should be susceptible to disinfectants. It can however occur in chains of filaments, which may increase its tolerance of disinfection.

2.3.7 Paratyphoid fever

Notifications of paratyphoid fever in the UK decreased about four-fold from the late 1930s to the 1980s[12]. Information collected since the early 1970s has shown that roughly half the cases of paratyphoid fever in the UK were caused by *Salmonella paratyphi A*, 95% of these being contracted abroad, and half were caused by *S. paratyphi B*, with over 70% of these being infected abroad. There have been no reported cases or outbreaks of water-borne disease due to *S. paratyphi A.*

Paratyphoid B fever is usually food-borne, but two water-borne outbreaks have been recorded since 1970, consisting of 96 cases, with no deaths. One of these outbreaks involved a private water supply. This was an unpublished PHLS report of six cases in Herefordshire in 1975. These resulted from consumption of well water that was contaminated by leakage of sewage from a domestic drain close to the well.

Salmonellae would be expected to respond to water treatment processes in a similar way to coliform organisms and *E. coli*, and would have a similar susceptibility to chlorination or other disinfection processes. A well-maintained multiple barrier system would therefore give good protection. As salmonellae, if present in raw water at all, would be less numerous than coliforms and *E. coli*, the absence of these indicator organisms should give a good assurance of the absence of this particular pathogen.

2.3.8 Enteric viruses

There are several types of viruses, which can be present in faeces that can cause viral enteritis, notably, the rotaviruses, the Noroviruses, and members of the enterovirus group. There have been several relatively large outbreaks (each of more than 100 cases) of viral enteritis associated with private water supplies derived from surface water. In each of these there was evidence of faecal contamination of the supply which had either been inadequately chlorinated, or not disinfected at all. Birds also carry viruses and can contaminate reservoirs and open cisterns.

Although filtration will remove viruses to some degree the primary treatment barrier is disinfection, either by chlorine or UV irradiation. As stated earlier, for these to be most effective waters must be conditioned by filtration (to remove particulates and aggregates of viruses) before disinfection. Where disinfection is the only treatment being employed, it must be maintained and its performance monitored regularly to optimise disinfectant activity for the prevailing water conditions.

[12] Galbraith, N.S., Barrett, N.J. and Stanwell-Smith, R. (1987). Water and disease after Croydon: A review of water-borne and water-associated disease in the UK 1937-86. *Journal of Institution of Water and Environmental Management* **1**, 7-21.

2.3.9 Blue-green algae (Cyanobacteria)

Blue-green algae can occur in quantity in lochs, lakes, ponds, canals and reservoirs. While usually green or blue-green in colour, they may be blue, black, dark brown or red.

When present in high concentrations, colonies of blue-green algae can often be seen with the naked eye; they may resemble fine grass cuttings or take the form of small irregular clumps or pinhead-sized spheres. Blue-green algae in high concentrations in the water column form "blooms" and, when blown on to a downwind shore, form scums which may be centimetres thick. Scums may also be seen in slow-flowing rivers and streams downstream from lochs or lakes.

Blue-green algae may also grow on the bottom of shallow water bodies and on shoreline rocks. They occasionally form thick gelatinous mats which may be exposed as the water level falls or may detach from the bottom and reach the shoreline. These mats are usually very dark in colour (black, dark brown or green) and cohesive and are sometimes mistaken for sewage.

Some types of algae, for example filamentous algae, occasionally form surface scums and growths of some water plants, particularly duckweed, might be mistaken for blue-green algae.

Surveys in different parts of the world have found that between 45% and 90% of blooms of blue-green algae produce toxins. These toxins are largely retained within the blue-green algal cells during their development and growth phases and are released, in the main, on cell death.

Blue-green algae of several genera can produce a range of toxins including neuro- and hepatatoxins and lipopolysaccharides. An algal bloom may contain more than one species, each producing different toxins. In addition, the toxicity of one species might change over time to a pattern that night vary for different places on a particular water body. Evidence of toxicity comes from reports of the effects of exposure of people and of animals to algal blooms and from laboratory investigations of algal blooms.

Algal blooms are inherently complex and assessment of the associated risks to public health is not straightforward. Such assessments should therefore take account of specialist advice such as that identified in "Blue-Green Algae (Cyanobacteria) in Inland Waters: Assessment and Control of Risks to Public Health"[1].

2.4 Chemical contaminants

2.4.1 Metals

2.4.1.1 Aluminium

Aluminium is a natural constituent of many raw waters, particularly acidic surface waters derived from upland catchments particularly in conifer afforested catchments and its presence is highly episodic related to precipitation. Aluminium compounds may also be introduced into treated water as the result of its use as a coagulant to remove colour and turbidity. Aluminium can deposit within the distribution system and give rise to aesthetic problems. The UK drinking water quality regulations include a national standard for aluminium of 200 µg/l. The standard for aluminium is based on avoiding problems of cloudiness and discolouration rather than being health-based. Aluminium in raw water can be removed by coagulation and filtration. The use of aluminium sulphate as a coagulant in water treatment should normally result in a residual concentration of no more than 50 to 100 µg/l Al. Aluminium in small water supplies can be removed by use of filtration or membrane techniques.

2.4.1.2 Iron and manganese

Iron and manganese derived from minerals and sediments can be present in particulate or dissolved form in groundwaters and surface waters. Iron and manganese concentrations in surface waters are usually less than 1 mg/l but much higher concentrations (up to 50 mg/l Fe and 30 mg/l Mn) can be encountered in groundwaters.

Iron and manganese deposit in treatment and distribution systems and can also interfere with the efficiency of UV disinfection by coating treatment units. Iron and manganese suspensions cause aesthetic problems including metallic taste and discolouration of water fittings and laundry. High dissolved iron and manganese concentrations can also increase chlorine demand and thus reduce the efficiency of chlorine disinfection. The UK drinking water quality regulations include national standards for iron and manganese of 200 µg/l and 50 µg/l, respectively. Iron and manganese can be removed by filtration although oxidation, coagulation and sedimentation may be required for high concentrations particularly if the metals are in dissolved form. An oxidation (aeration) process is invariably required when groundwaters contain more than 1 mg/l of dissolved iron or manganese.

2.4.1.3 Lead

The concentration of lead in raw waters rarely exceeds 20 µg/l but higher concentrations do occur in water drawn from strata containing galena or other lead ores. High levels of lead in drinking waters are usually caused by the dissolution of lead (plumbosolvency) from lead pipework, tank linings or use of leaded alloys in water fittings. Traces of lead may also be derived from lead solder and from PVC pipes containing lead-based stabilisers. The UK drinking water quality regulations specify a standard for lead of 10 µg/l to be met by 2013. For small water supply systems the best approach is the replacement of lead-containing materials with non-leaded alternatives. Treatment methods are available to reduce plumbosolvency – see Section 6.10.2. Water that has been standing in lead pipes for long periods, for example overnight, should not be drunk. In these circumstances, the tap should be run for 30 to 60 seconds to clear the pipes before taking water for drinking or cooking.

2.4.1.4 Arsenic

Arsenic is introduced into water through the dissolution of minerals and ores, from industrial effluents, and from atmospheric deposition; concentrations in groundwater in some areas are sometimes elevated as a result of water-rock interaction in the aquifer. The most prevalent species of arsenic in water are inorganic. The predominant form is either arsenic (V) (arsenate), which predominates in oxidising conditions, or arsenic (III) (arsenite), which is present in reducing conditions.

Inorganic arsenic is a documented human carcinogen. A relatively high incidence of skin cancer and possibly other cancers that increase with dose and age has been observed in populations ingesting water containing high concentrations of arsenic. The standard for arsenic is 10 µg/l.

Arsenic (V) can be removed effectively by iron or aluminium coagulation. If present as arsenic (III) then pre-oxidation (e.g. using chlorine) is required. Other potential removal techniques include ferric oxide, activated alumina, ion-exchange and reverse osmosis.

2.4.2 Nitrate

Nitrate (NO_3^-) occurs naturally in water as a result of the oxidation of ammonia, which is released during mineralisation of organic nitrogen. In some areas agriculture is the major source of nitrate in surface waters and groundwaters. The discharge of nitrate-containing effluents from sewage treatment works contributes to the concentration of nitrate in some surface waters.

Ion-exchange, biological de-nitrification and certain membrane processes can reduce nitrate concentrations. Of these, only ion-exchange and membrane processes are likely to be practicable for small water supplies. It may be appropriate to consider controls over agricultural activities within catchment areas as a long term means of reducing the leaching of nitrate into water supplies, if these are the source.

2.4.3 Ammonia

Most natural waters contain traces of ammonia or ammonium compounds. The ammonia found in water may occur naturally or it may indicate that recent pollution has taken place. Certain anoxic groundwaters may contain elevated concentrations of ammonia (greater than 1 mg/l as NH_4) resulting from natural ammonification and denitrification processes. Ammonia may also be derived from the decay of organic material in the soil resulting in small concentrations in water; unpolluted river waters rarely contain more than 0.05 mg/l NH_4. On the other hand, the presence of ammonia could indicate contamination from human or animal sources. Elevated concentrations in water should be investigated to ascertain the cause.

The UK drinking water quality regulations set an indicator parameter value for ammonia of 0.5 mg/l NH_4. However, the appearance of even small amounts of ammonia (e.g. above 0.05 mg/l NH_4) in a groundwater which is normally free from ammonia warrants further investigations.

Ammonia can be removed from water by aeration (after increasing pH to 11), ion-exchange, biological denitrification and breakpoint chlorination. Of these, only chlorination is likely to be applicable to small supplies. Chlorination converts ammonia to chloramines (see Section 6.9.3) which are less potent disinfectants than chlorine itself and can give rise to taste and odour complaints. Therefore, when designing chlorination systems for ammonia-containing waters, the chlorine capacity must be sufficient to produce a free chlorine residual.

2.4.4 Pesticides

The use of pesticides for agricultural and non-agricultural purposes is widespread and there are approximately 450 different active ingredients in pesticides licensed for use in the UK. In surveys of UK surface and groundwater sources, the most commonly reported pesticides are atrazine, simazine and dieldrin. In the past, atrazine was used almost entirely for non-agricultural control of weeds on roadside verges and railways and much of the use of simazine was attributable to non-agricultural uses. Controls on agricultural uses and withdrawal of approvals for non-agricultural uses of these pesticides were introduced in the UK in 1992. Other pesticides commonly reported in water sources used for public supplies include isoproturon, mecoprop and chlorotoluron. The UK drinking water quality regulations specify standards of 0.1 µg/l for individual pesticides and 0.5 µg/l for total pesticides. These standards do not have any toxicological basis. Some pesticides, e.g. atrazine and simazine, have been found in water sources used for drinking water supplies at levels exceeding 0.1 µg/l. Peaks in pesticide concentrations have been observed in surface waters following heavy rainfall.

Careless or improper use or storage of pesticides can contaminate water sources. Pesticides must not be used near wells. Sheep dip chemicals (organophosphates and synthetic pyrethroids) present a particular risk to water sources. Sheep dip chemicals should be handled carefully, used sheep dip should be disposed of properly (i.e. not to a soakaway), and freshly dipped sheep should be kept away from water supplies.

Several ‘advanced’ water treatment processes have been investigated for the removal of pesticides including ozonation, activated carbon adsorption and oxidation processes using combinations of oxidants. Concentrations of individual pesticides found in typical surface waters can be reduced to less than 0.1 µg/l by adsorption on granular activated carbon (GAC) with an empty bed contact time of typically 15 to 30 minutes, depending on the pesticide, its concentration, GAC type and system design. Ozonation will also reduce pesticide concentrations to varying degrees. It is unlikely that treatment to remove pesticides from small supplies will be practicable and where significant concentrations are detected it will be necessary to consider provision of an alternative supply.

2.4.5 Chlorinated solvents

Contamination of groundwaters by chlorinated solvents can result from accidental spillage of chemicals, leakage from underground storage tanks, leakage from disposal sites and deliberate discharges to soakaways. The rate of transport of the solvents through the aquifer is dependent on the properties of the aquifer; rapid transport can occur if the overlying material is highly porous or fissured. Contaminated water can travel large distances, making it difficult to pinpoint the source of pollution.

The UK drinking water quality regulations specify standards of 3 µg/l for 1,2-dichloroethane and 10 µg/l for the sum of the detected concentrations of tetrachloroethene and trichloroethene. Solvent concentrations can be reduced by aeration or activated carbon adsorption. Activated carbon adsorption is likely to be the method of choice for small water supplies although provision of an alternative supply may be an economic consideration.

2.4.6 Disinfection by-products

2.4.6.1 Trihalomethanes

Trihalomethanes (THMs) are formed as a result of reactions between chlorine and some organic substances present in raw waters. Highly coloured surface waters which contain humic and fulvic acids are particularly prone to THM formation. The UK drinking water quality regulations specify a standard for Total THMs of 100 µg/l for the sum of the detected concentrations of four specified THMs (trichloromethane, dichlorobromo-methane, dibromochloromethane and tribromomethane).

THM formation can be controlled by reduction of the organic content of the water before disinfection, modification of the disinfection practice or the use of disinfectants other than chlorine, such as ultraviolet radiation or ozone but ozone may cause other problems by reacting with organic matter. THMs precursors can be removed to some extent by adsorption on activated carbon.

2.4.6.2 Bromate

Bromate is not present in source waters but is formed by oxidation of bromide if ozonation is used for water treatment. Elevated bromide concentrations occur where saline intrusion occurs into fresh aquifers in coastal areas, increasing the potential for bromate formation during ozonation. Bromate is also a potential impurity in sodium hypochlorite, a commonly-used disinfectant. The UK drinking water quality regulations specify a standard for bromate of 10 µg/l.

The formation of bromate during ozonation depends on several factors including concentrations of bromide and ozone and the pH. It is not practicable to remove bromide from the raw water and it is difficult to remove bromate once formed, although granular activated carbon filtration has been reported to be effective under certain circumstances. Bromate formation can be minimised by using lower ozone dose, shorter contact time and a lower residual ozone concentration.

2.5 Physical and chemical properties

2.5.1 pH value

The pH value of water is a measure of acidity or alkalinity. Pure water is very slightly ionised into positively charged hydrogen ions (H^+) and negatively charged hydroxide ions (OH^-). Water is neutral when the numbers of hydrogen ions and hydroxide ions are equal. When the concentration of hydrogen ions exceeds that of hydroxide ions, the water is acidic and has a pH value less than 7. Conversely, when the concentration of hydroxide ions exceeds that of hydrogen ions, the water is alkaline and has a pH value greater than 7. The pH scale is logarithmic, therefore a change in pH value of one unit represents a tenfold change in the concentrations of hydrogen and hydroxide ions.

Acidity in raw waters can result from the dissolution of carbon dioxide to produce weak carbonic acid. Groundwaters and surface waters may also contain organic acids produced during the decomposition of vegetation. A surface water derived from a peaty moorland catchment may have a pH value as low as 4. Alkaline waters result almost entirely from the dissolution of the bicarbonate, carbonate and hydroxide salts of calcium, magnesium, sodium and potassium. Soft acidic waters can cause corrosion of pipework and the dissolution of metals such as copper, zinc and lead. Hard, alkaline waters can cause problems associated with scale formation. Some hard waters may also be plumbosolvent.

The UK drinking water quality regulations include pH as an indicator parameter and specify a minimum pH of 6.5 and a maximum pH of 10.0. In water treatment, the pH value can be changed by aeration, alkali or acid dosing or contact with alkaline material in contact beds.

2.5.2 Hardness

Water hardness is caused by dissolved salts of calcium and magnesium. Total hardness consists of temporary and permanent hardness. Temporary hardness is caused almost entirely by the carbonates and bicarbonates of calcium and magnesium. Temporary hardness is precipitated by evaporation and boiling. Permanent hardness is caused almost entirely by the sulphates and chlorides of calcium and magnesium. Permanent hardness is not precipitated by boiling.

The hardness of waters, expressed in mg/l $CaCO_3$ (calcium carbonate), can be classified as shown below:

Water	Hardness (mg/l $CaCO_3$)
soft	up to 50
moderately soft	50 – 100
slightly hard	100 – 150
moderately hard	150 – 200
hard	200 – 300
very hard	over 300

The drinking water Directive and the UK drinking water quality regulations do not specify standards for hardness, calcium or magnesium. Water softening may be applied at water treatment works[13]. This can be achieved by lime-soda softening – the addition of lime ($Ca(OH)_2$) and sodium carbonate (Na_2CO_3) to the water which causes the hardness compounds to precipitate. An alternative method, common in domestic water softeners, is ion-exchange (base exchange), whereby the calcium and magnesium ions in the water are replaced by sodium ions. Where water is softened by base exchange softening it is important to provide an unsoftened outlet for potable purposes. Installation of a softener just before the hot water tank or boiler is a more economical method for preventing precipitation of hardness salts (limescale) than softening the whole supply.

[13] The UK Department of Health has stated that “in view of the consistency of the [epidemiological] evidence [of a weak inverse association between natural water hardness and cardiovascular disease mortality], it remains prudent not to undertake softening of drinking water supplies ... it appears sensible to avoid regular consumption of softened water where there is an alternative”.

2.5.3 Colour

Water can be coloured by humic and fulvic materials leaching from peat or other decaying vegetation and by naturally occurring salts of iron or manganese. Surface waters derived from peaty moorland catchments may be strongly coloured. The characteristic brown colour of these waters is variable and often shows a strong seasonal effect, with concentrations being greatest in late autumn and winter. Waters derived from lowland rivers can similarly show a seasonal increase in colour following autumn leaf fall.

A water may appear coloured because of material in suspension and true colour can only be determined after filtration. Colour is expressed in mg/l on the platinum-cobalt (Pt-Co) scale, which is equivalent to measurements expressed in Hazen units (°H). The removal of colour from water is necessary not only for aesthetic reasons but also because chlorination of highly coloured waters can give rise to high concentrations of trihalomethanes (see Section 2.4.6). High colour also reduces the efficiency of disinfection by UV irradiation, chlorination and ozonation. Colour will also cause fouling of reverse osmosis membranes.

The drinking water Directive includes colour as an indicator parameter without a numeric standard but with the requirement “Acceptable to consumers and no abnormal change”. The UK water quality regulations specify a standard of 20 mg/l Pt-Co.

Colour removal at a water treatment works is usually achieved by coagulation followed by sedimentation or flotation and filtration. Filtration techniques may be applied to small supplies but the efficiency of colour removal is usually relatively poor.

2.5.4 Turbidity

Turbidity is caused principally by inorganic matter in suspension including mineral sediments and oxides of iron or manganese but organic matter including algae can also cause significant turbidity. Most surface waters show particularly high turbidity following periods of heavy rainfall. Groundwaters generally show low to very low turbidity and variations, following heavy rainfall for example, may indicate rapid recharge bringing in contaminants from the surface.

Turbidity measurement gives a quantitative indication of the clarity of a water and analysis is carried out using a nephelometer. Nephelometers measure the intensity of light scattered in one particular direction, usually perpendicular to the incident light and are relatively unaffected by dissolved colour. Nephelometers are calibrated against turbidity standards prepared from a suspension of formazin and the standard unit of turbidity is the nephelometric turbidity unit or NTU.

Turbidity is removed for aesthetic reasons and because high turbidity can impair the efficiency of disinfection. The drinking water Directive includes turbidity as an indicator parameter without a numeric standard but with the requirement "Acceptable to consumers and no abnormal change". It also states that for treated surface waters the value should not exceed 1 NTU.

The UK water quality regulations specify a standard of 4 NTU at consumers' taps with an indicator parameter value of 1 NTU in water leaving treatment works.

Rapid sand filtration or microstraining can remove coarse turbidity and some species of algae. Fine turbidity and many species of algae that may penetrate rapid filters can be removed by slow sand filtration or by coagulation followed by sedimentation or flotation and filtration. A variety of filtration techniques can be successfully applied to small supplies.

2.5.5 Taste and odour

Sources of taste and odour in water include decaying vegetation, algae, moulds and actinomycetes. Taste and odour are usually associated with the presence of specific organic compounds released by the source agent which give rise to 'earthy' or 'musty' taste or odour. Chlorine and the by-products of chlorination can also cause complaints of taste or odour. Relatively high concentrations of iron, manganese and some other metals can impart an unpleasant metallic taste.

The drinking water Directive includes taste and odour as indicator parameters without numeric standards but with the requirement "Acceptable to consumers and no abnormal change". The intensity of odour and taste is expressed as Dilution Number – the dilution of the sample with odour or taste free water at which the odour or taste is undetectable. The UK water quality regulations specify standards for both odour and taste of 3 dilution number at 25 ˚C.

Taste and odour are removed principally for aesthetic reasons. Taste and odour can be reduced or removed by aeration, ozonation or adsorption on activated carbon or, where chlorination is the source of taste or odour, by control of the disinfection process.

2.6 Radioactivity

All waters contain traces of naturally occurring radionuclides, the concentrations depending on the origin of the water. The natural radionuclides of most relevance are radon (Rn) and uranium (U). Radon is volatile and as a result it can be released from water as a gas. This is of concern if the release occurs within a confined space with insufficient ventilation.

Radon and uranium are only found in significant concentrations in groundwater in certain parts of the UK, depending on the type of geology. Further advice is available from local authorities and the National Radiological Protection Board (NRPB). These substances are not significant for any surface water sources in the UK.

The concentration of radioactive elements in water is expressed in terms of their activity, in Bequerels per litre (Bq/l). There is currently no official recommended level of radon in drinking water in the UK. There is a draft European Commission recommendation on radon in drinking water supplies of 100 Bq/l for public supplies and an action level of 1000 Bq/l for non-commercial private supplies. The EU level of 1000 Bq/l is consistent with recent advice from the NRPB. Uranium limits were proposed to be in the range 20 to 100 µg/l. The uranium guideline is currently 20 Bq/l (equivalent to a concentration of approximately 2 mg/l).

Treatment for radon removal cannot use point of use systems fitted to the tap because, being volatile, it is released into the atmosphere whenever water is used. Under-sink treatment using an activated carbon filter is also inadvisable because the filter would become radioactive. Radon removal treatment therefore has to be installed before entry of water into a building. Aeration is the preferred treatment technique but other methods are feasible. Treatment is discussed further in Section 7.

Uranium removal is best achieved by point of use systems, as discussed in Section 7.

SECTION 3

SOURCE SELECTION, PROTECTION AND MONITORING

Section Contents

3.3 Source selection

Sources of private supplies are mainly springs, wells and boreholes. Whatever the source, it must consistently yield enough water for the user.

Streams and rivers – offer more reliable yields but may be susceptible to pollution and may exhibit variable quality, and so are normally used only where a groundwater source is unavailable. Treatment systems should be designed for the worst expected raw water quality. A small reservoir or tank installed at the source can help, but this will require regular inspection and cleaning.

Springs – the quantity of water available from a spring depends on its source, with those from deep-seated aquifers being the most reliable. Treatment is usually simpler than for surface waters because spring water is likely to contain less suspended matter.

Some 'spring' sources are in fact artificial land drains and should be regarded as effectively surface waters, with their associated variable quality.

Wells and boreholes – normally a properly designed and constructed borehole will be able to supply water sufficient for at least a single household.

Groundwaters are usually of good quality and treatment may consist of disinfection only. However, some contain high concentrations of iron, manganese, nitrate, pesticides and/or chlorinated solvents.

3.4 Source protection

Streams and rivers – water may be pumped directly from the stream or river or it may be collected from the ground in the immediate vicinity.

Intakes should not be situated on bends in the stream or river or at places where sudden changes in level occur. Most commonly, they are situated in the stream or river, protected by a strainer. The inlet pipe feeds a settlement tank built of a material that will not impair water quality but will keep out vermin and debris. The tank outlet is fitted with a strainer and is situated above the floor of the tank to prevent contamination by sediment.

Springs – A small chamber built over the spring will protect it from pollution, provide storage and serve as a tank. The tank should have a lockable watertight access cover, an overflow and an outlet pipe with a strainer. It should be built of a material that will not impair water quality but will keep out vermin and debris. It should also be fenced off, with a small ditch upslope for run-off.

Wells and boreholes – even shallow wells and boreholes may provide good quality water if built and sited correctly.

The upper section of the well shaft must be lined and sealed against the surrounding material, and the lining must not affect water quality.

Where boreholes are drilled through a perched aquifer, this area should be sealed to maintain water quality. A gravel packing may be necessary if the borehole penetrates unconsolidated sand or sand and gravel.

At ground level, the well or borehole should be covered by a lockable, watertight chamber, and have a sloped concrete apron to drain surface water. All wells and boreholes should be sited up-hill of and well away from potential sources of pollution.

3.5 Monitoring

Sampling frequency increases with the size of the supply in accordance with the requirements of the new Private Water Supplies Regulations.

Larger supplies should be sampled for all parameters specified in the drinking water Directive. Smaller supplies could be sampled for a reduced list, but those used for food production should be sampled more frequently than purely domestic ones.

E. coli and coliforms are still the most commonly used indicator organisms, while testing for enterococci (faecal streptococci) might be useful in identifying faecal pollution as being of human or animal origin. Also, the presence of *Clostridium perfringens* in the absence of *E. coli* and enterococci can be taken to indicate a historic pollution event.

Appropriate monitoring is generally impractical for small water supplies, however, and therefore a risk assessment of the catchment should be carried out, and protection measures taken. If there is a high risk of faecal contamination, alternative sources of supply will need to be considered. If there is no alternative supply, treatment barriers must be strengthened and assessed against microbial predictions, and contingency plans should be in place for a boil water regime if necessary.

Private Water Supplies

This page is intentionally blank

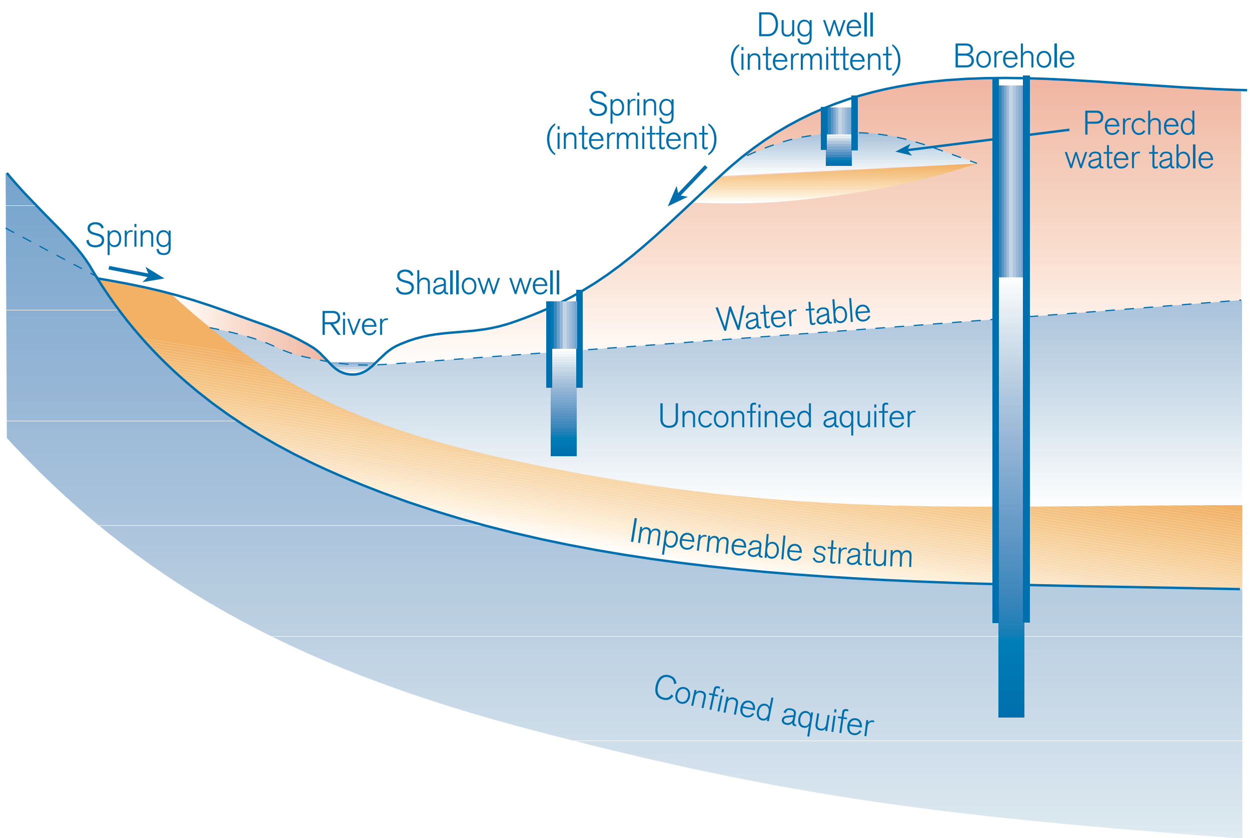
3 SOURCE SELECTION, PROTECTION AND MONITORING

3.1 Introduction

Water in oceans, lakes or lochs, rivers and the ground, as well as snow and ice, constitutes the hydrosphere. Water in the hydrosphere is involved in the hydrological cycle, which covers movement of water between the hydrosphere and the atmosphere. Precipitation and evaporation are the principal agents of this movement.

Water which flows in streams and rivers or which is contained in lakes or lochs is called surface water whilst water which percolates into the ground and reaches the water table is called groundwater. The general features of geological formations associated with surface water and groundwater sources are shown in Figure 3.1.

Figure 3.1 Groundwater and surface water sources



3.2 The hydrological cycle

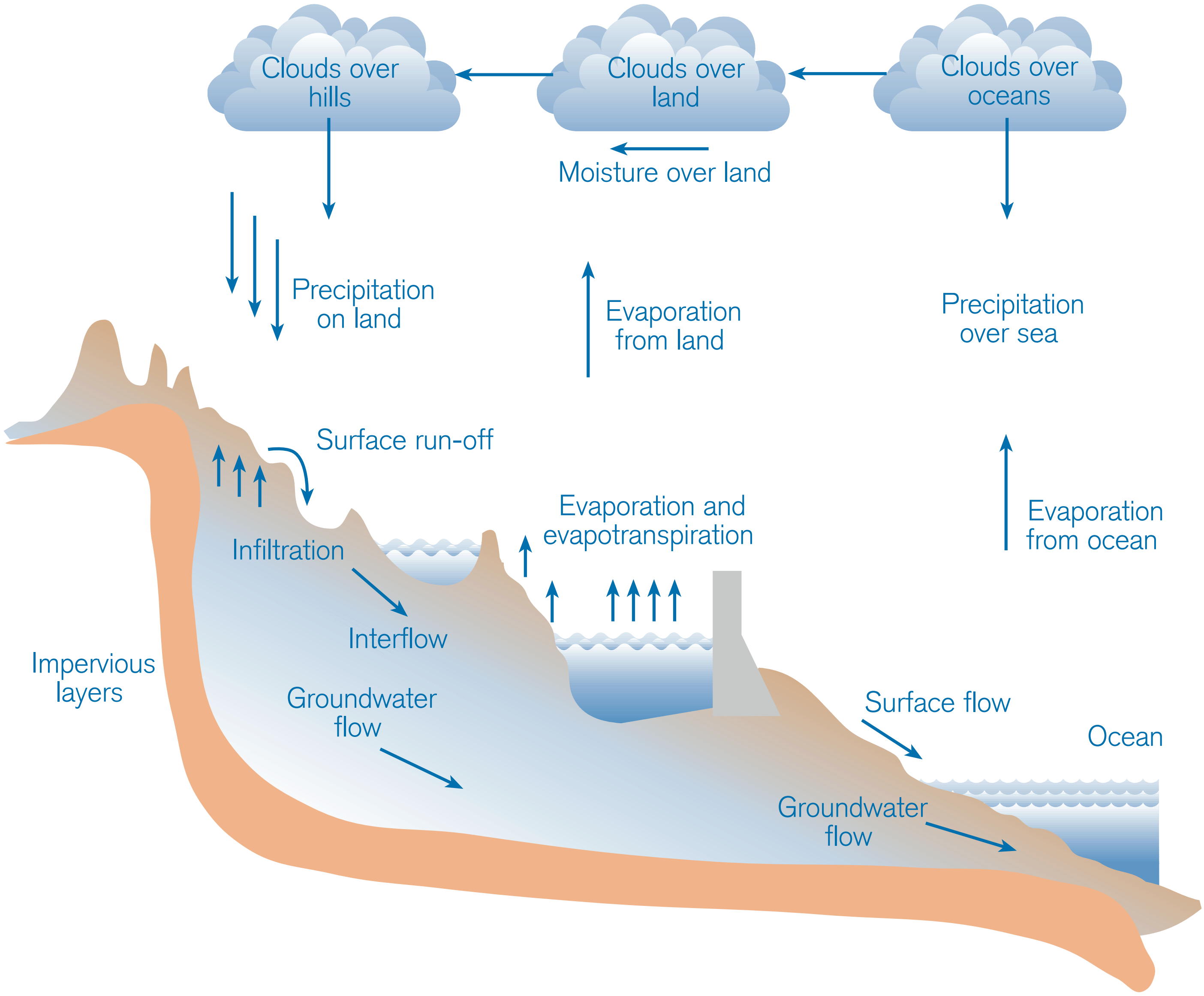
Evaporation from the oceans produces water vapour, which rises and condenses to form clouds; these clouds move with atmospheric circulation until they lose thermal energy and the condensed water vapour is released as precipitation. The precipitation introduces water into the terrestrial environment where it may percolate into the ground, run-off as rivers and streams, or be returned to the atmosphere through evapotranspiration. Eventually such moisture returns to the oceans or the clouds and the cycle begins again (Figure 3.2).

Within this cycle raw water may be obtained from rivers or streams, from lakes and reservoirs, or from groundwater. Of these sources, groundwater is the most abundant. World-wide groundwater constitutes around 95% of the available freshwater reserves. Precipitation falling on to a soil will wet the soil surface and then infiltrate below ground level where it adheres to the soil particles by a combination of surface tension and molecular attraction to form pellicular water. Such pellicular water escapes the forces of gravity as the attractive forces of surface tension and molecular attraction are such that only evapotranspiration can remove this bound water. Thus precipitation will only penetrate deeper once the soil reaches its field capacity when the force of gravity exceeds the attractive forces binding water to soil particles and allows the water to drain downwards. In this region of the soil the voids present in the soil or rock are not completely filled with water and so this region of the subsurface is known as the unsaturated zone. As gravity pulls the water down to greater depths the voids become completely filled with liquid and this is termed the saturated zone. Water in this saturated zone is termed groundwater and the boundary between the unsaturated and saturated zone is termed the water table. This separation is not clear-cut and the transition phase between the unsaturated and saturated zone is called the capillary zone or capillary fringe.

If these zones are viewed in terms of pressure then it is found that the unsaturated and saturated zones have different characteristics. The pressure gradient in the unsaturated zone is less than atmospheric pressure, i.e. atmospheric minus capillary pressure, whereas in the saturated zone the voids are completely filled with water at a pressure above atmospheric pressure. Thus the water table may be defined in terms of pressure as the level in the subsurface where atmospheric pressure occurs. These pressure differentials mean that if a well or borehole is excavated into the saturated zone, water will flow from the ground into the well. Water will then rise to a level in the well where the pressures equilibrate. Groundwater can be broadly defined as that water located below the water table, i.e. in the geomatrix (soil, rock or other geological material) where the void area, the space between the constituents of the geomatrix, is approximately 100% occupied by water. These voids or pores can be used to classify groundwater-bearing rocks into two broadly exclusive groups:

- reservoirs - geomatrix containing voids that allows liquid to penetrate into the main body of the material;
- non-reservoirs - geomatrix lacking any void space and therefore unable to harbour any liquid.

Figure 3.2 Hydrological cycle



3.2 The hydrological cycle (continued)

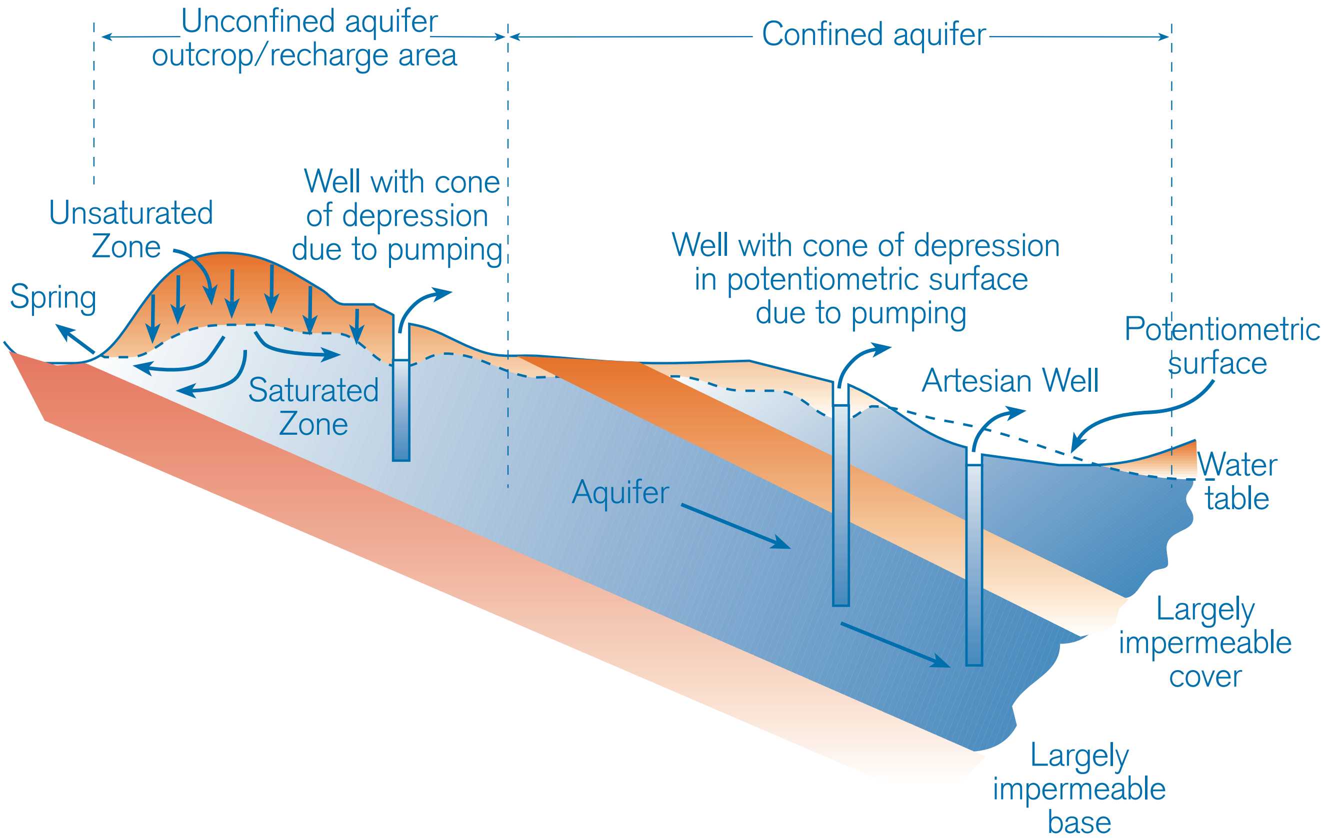
Reservoirs vary in the degree to which stored water will be released as some may not easily release their stored water, e.g. clays are reservoirs but do not release their stored water. This feature of reservoirs requires a further division into permeable and impermeable reservoirs.

Another feature is that groundwater is dynamic, being constantly in motion through the geomatrix. The ease with which water can pass through particular rock strata depends on a combination of the size of the pores and the degree to which they are interconnected resulting from the degree to which the rock is permeable. An aquifer is any rock which contains interconnected pores or fissures which can hold and transfer water (Figure 3.3) and may be defined as a water-bearing rock formation that contains water in sufficient amount to be exploited and brought to the surface by wells.

Geomatrix materials that can serve as aquifers include gravel, sand and sandstone, alluvium, cavernous limestone, vesicular basalt and jointed slate. The different components that combine to produce an aquifer system are shown in Figure 3.3. It is apparent that there are two distinct types of aquifers: confined or unconfined. In an unconfined aquifer the water table is unrestricted and can thus move up or down through the geomatrix. By contrast a confined aquifer is restrained by an upper layer of impermeable rock, termed an aquiclude, which prevents water moving upwards. As discussed above, the pressure in a confined aquifer will be above atmospheric pressure and this pressure difference will cause water to rise in a well shaft that penetrates the aquiclude. Such wells are termed artesian wells. An imaginary line joining the water surface in many wells in a confined aquifer is called the potentiometric surface (Figure 3.3).

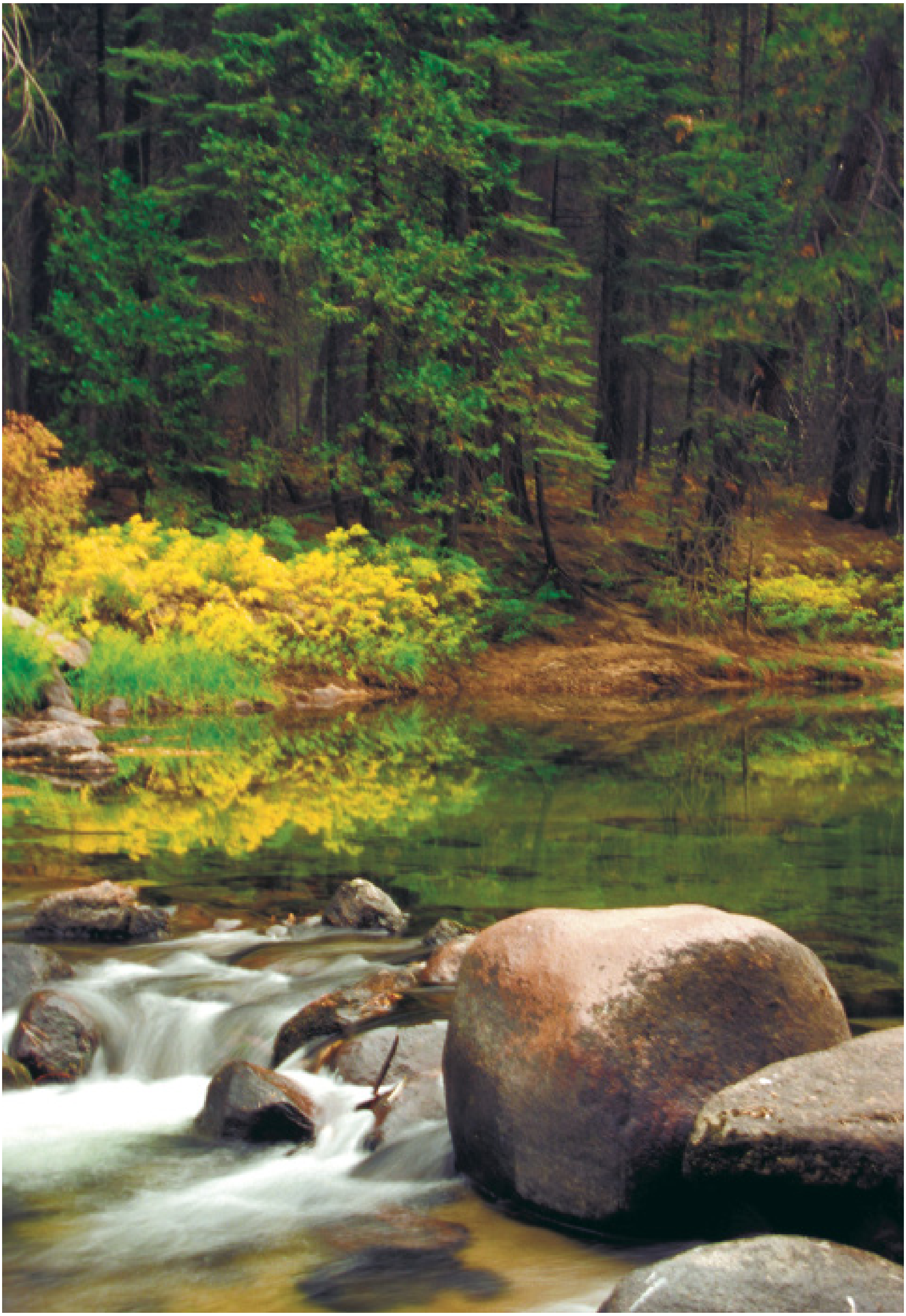
To complete the hydrological cycle within the groundwater area, all freshwater found underground must have a source of recharge such as rainfall or leakage from surface drainage such as rivers, lakes or canals. It should be borne in mind that groundwater systems are dynamic with water continuously moving from areas of recharge to areas of discharge with transit times of many years.

Figure 3.3 Confined and unconfined aquifers



3.3 Source selection

The principal sources of private supplies are springs, wells and boreholes. Streams and rivers are also used but to a lesser extent because of the more variable quality of surface waters compared to groundwaters. Whatever the source, it must consistently yield a quantity of water sufficient to satisfy the requirements of the user.



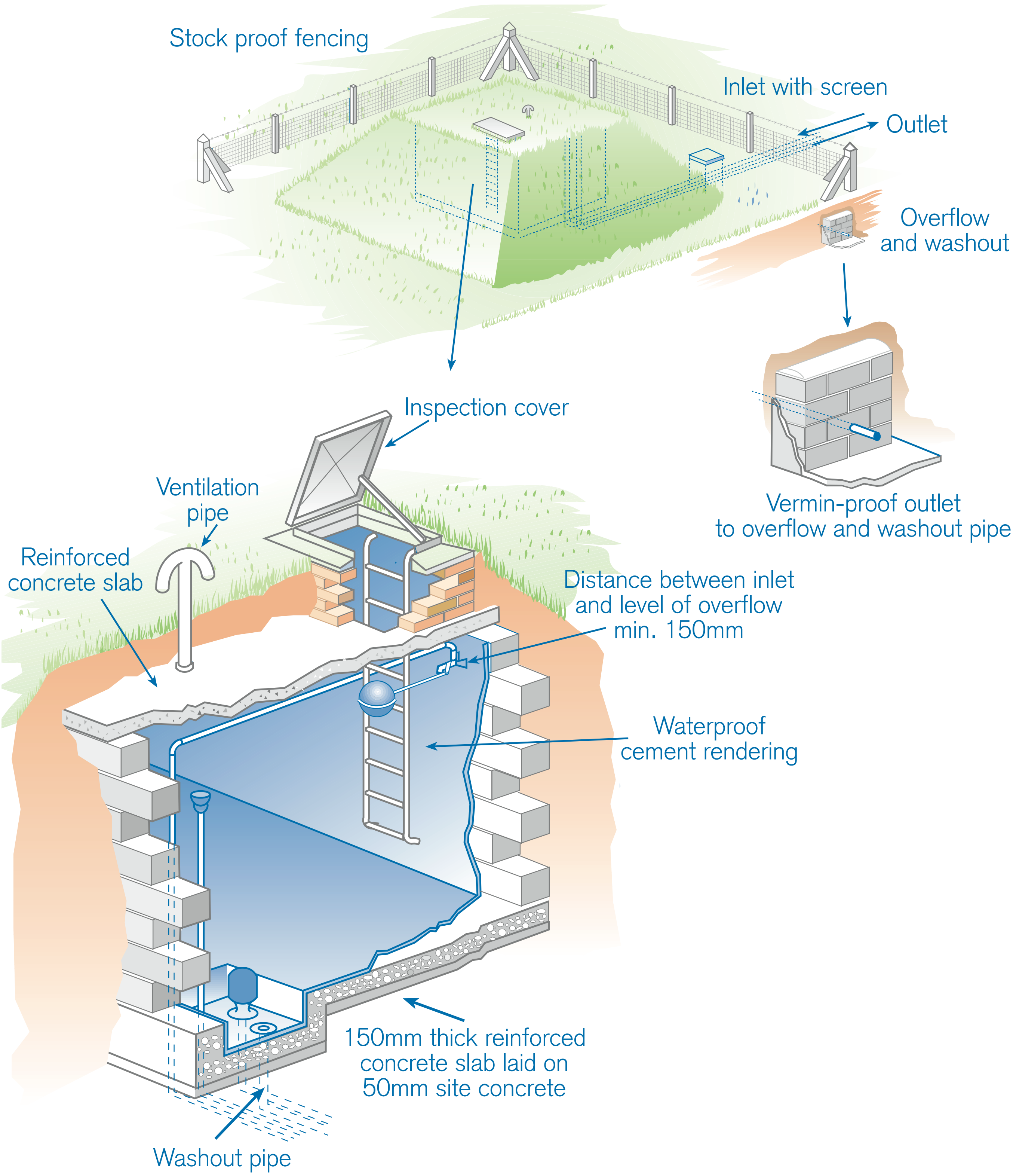
3.3.1 Streams and rivers

Streams and rivers offer more reliable yields but may be susceptible to pollution and may exhibit variable quality. The risk and extent of pollution depends on the catchment and the activities being undertaken on it. Waters derived from upland catchments that are not unduly peaty and not used for agricultural purposes are usually of good chemical quality. However, soft acidic upland waters derived from peaty moorland catchments may be corrosive and contain relatively high concentrations of dissolved metals. Small streams often exhibit variable quality because of the activities of man and animals within the catchment and will have high levels of colour from humic and fulvic acids.

Lowland surface waters are likely to be of poorer quality. The quality of surface waters may show a strong seasonal variability. Colour may be highest in late autumn and winter. Turbidity and microbiological contamination may be highest following periods of heavy rainfall.

Because of these potential problems, a surface water source is normally only considered for use as a drinking water supply where a groundwater source is unavailable. Water treatment will require a minimum of filtration and disinfection and should be designed for the worst expected raw water quality which is likely to be experienced for short periods during and after rainfall (and snow melt) events. A small reservoir or tank installed at the source can provide a period of settlement and reduce the variability in water quality. This tank will require regular inspection and cleaning. Figure 3.4 shows the construction of brick or concrete reservoirs; pre-cast concrete reservoirs can also be used.

Figure 3.4 Brick or concrete reservoirs



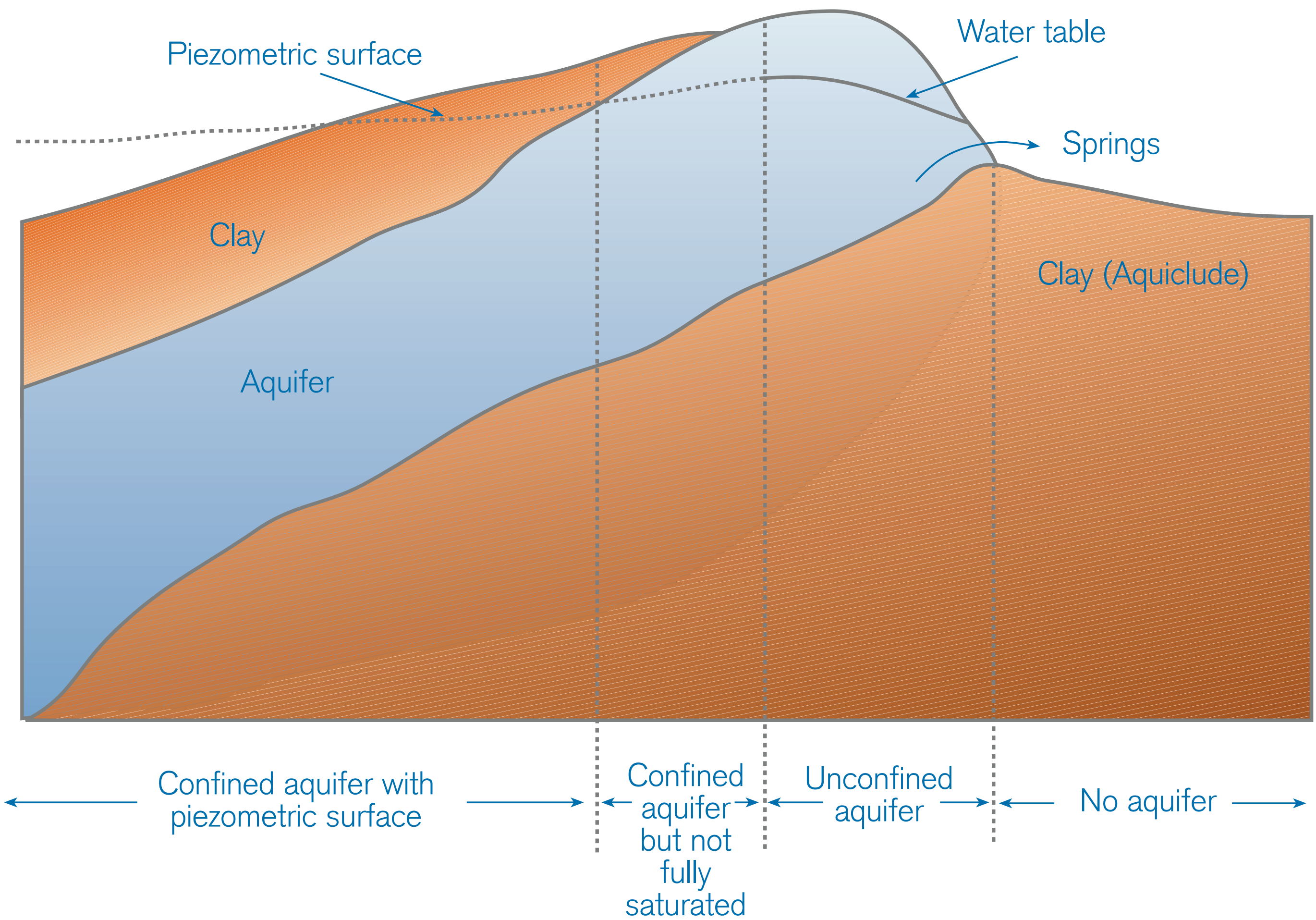
3.3.2 Springs

Where the water table intersects the surface, a springline is formed. The presence of fissuring can determine where the principal springs occur. The quantity of water available from a spring depends on its source. Most reliable are springs issuing from deep-seated aquifers whereas those from perched water tables or supported by flow from fissured limestone or granite aquifers may dry up after a short period without rain. Spring sources can be of good chemical and microbiological quality although springs from shallow strata (where there is a relatively high water table) or fractured strata may be of variable quality because of surface contamination. The treatment of spring waters is usually simpler than for surface waters because spring water is likely to contain less suspended matter.

Some ‘spring’ sources used for small water supplies are in fact artificial land drains. If the whole drainage system is properly maintained, the quantity and quality of water may be acceptable for a drinking water supply but for assessing treatment needs, a land drain should be regarded as effectively a surface water. If maintenance is poor, the water quality and flow may decrease. The probability of agricultural pollution must be considered carefully.

Much shallow throughflow is soil water which can be mistaken for a spring source. The quality of soil throughflow is likly to be unacceptable.

Figure 3.5 A Spring



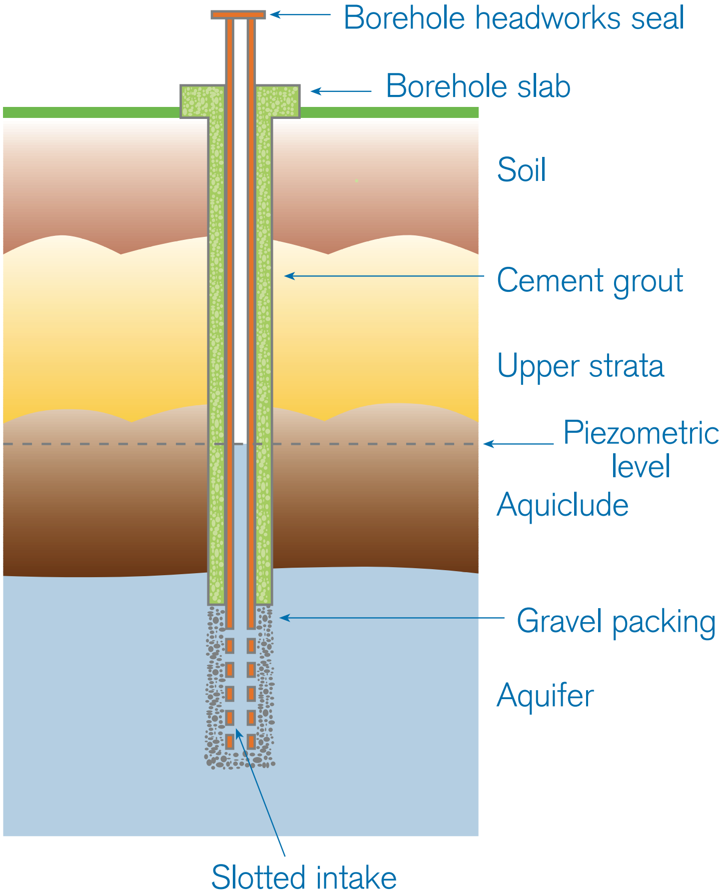
3.3.3 Wells and boreholes

Many small drinking water supplies are derived from wells and boreholes. Wells are usually of large diameter, not less than about one metre, and dug by hand or, more rarely, by a mechanical excavator. Boreholes are of smaller diameter, variable depth and are drilled by a specialist contractor using percussion or rotary drilling.

The quantity of water available will depend on the characteristics of the aquifer and can be determined by test pumping after construction. A well or borehole that penetrates an extensive aquifer will be the most reliable. A well or borehole sunk into a perched aquifer may dry up after a short period without rain. Normally, a properly designed and constructed borehole will be able to supply water sufficient for at least a single household. Water is usually pumped from a well or borehole by a surface mounted or submersible pump.

Water abstracted from deep wells and boreholes may have originated from catchments several miles away. If the aquifer is a porous stratum, such as sand or gravel, the water will have undergone thorough filtration. Such water will usually be of very good quality. Some aquifers, such as limestone or granite strata, may be fissured and the filtration of the water will not have been so thorough. Groundwaters abstracted from shallow wells and boreholes may be prone to local pollution unless adequate precautions are taken. Groundwaters are usually of good quality and treatment may consist of disinfection only. However, some groundwaters contain high concentrations of iron and manganese, which are usually removed by oxidation and filtration. Others may be polluted by nitrate or pesticides derived from agricultural or other activities or by chlorinated solvents from industrial sites.

Figure 3.6 Typical Borehole Construction



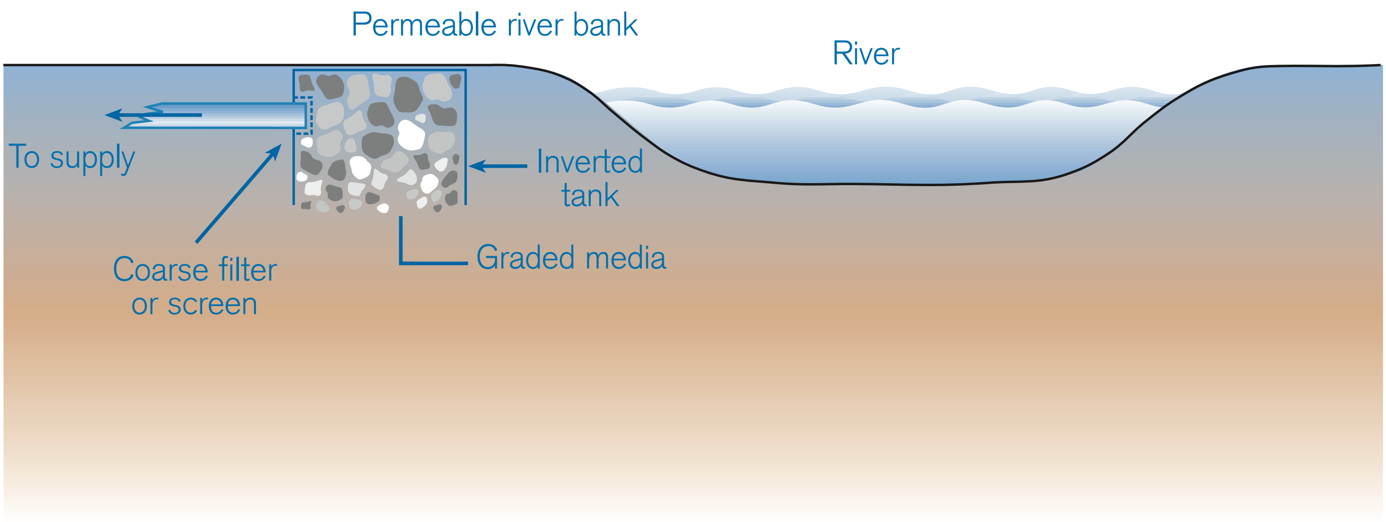
3.4 Source protection

3.4.1 Streams and rivers

Pollution and natural variations in water quality are the main problems associated with stream and river sources that need to be considered when siting and constructing an intake. Water may be pumped directly from the stream or river or it may be collected from the ground in the immediate vicinity of the stream or riverbank. The advantage of the latter is that where the strata have suitable transmissive properties, supplies taken in this way are naturally filtered and of better quality than the river water itself.

The intake should be located away from any features that might create turbulence during periods of heavy rainfall and increase the turbidity of the water. This means that intakes should not be situated on bends in the stream or river or at places where sudden changes in level occur. Most commonly, intake pipes are situated in the stream or river protected by a strainer to prevent the ingress of debris, fish and vermin. The inlet pipe feeds a settlement tank that allows particulate material to settle. The outlet of the tank, fitted with a strainer, should be situated above the floor of the tank to prevent contamination by sediment. The tank must be built of a material that will not impair water quality and designed to prevent entry of vermin and debris. An example of a slightly more sophisticated intake is shown in Figure 3.7. The inlet pipe is situated in a small gravel-filled tank buried upside down in the stream or riverbank (alternatively, the tank may be buried in the stream or river bed). The water enters the tank through a substantial thickness of riverbank material. This type of infiltration gallery will only be appropriate where the riverbank is sufficiently permeable to allow water to enter the tank at an adequate rate. The intake may suffer a gradual loss of permeability through siltation.

Figure 3.7 River source



3.4.2 Springs

Spring water can be of good quality but it must be protected from possible contamination once it has reached ground level. In particular, it is necessary to consider the possibility of pollution from septic tanks or from agricultural activities. A small chamber built over the spring, for example as shown in Figures 3.8 and 3.9, will protect it from pollution, provide storage for periods of high demand and serve as a header tank. The collection chamber should be built so that the water enters through the base or the side. The top of the chamber must be above ground level and it should be fitted with a lockable watertight access cover. An overflow must be provided appropriately sized to take the maximum flow of water from the spring. The outlet pipe should be fitted with a strainer and be situated above the floor of the chamber.

The chamber should be built of a material that will not impair water quality and be designed to prevent the entry of vermin and debris. The area of land in the immediate vicinity of the chamber should be fenced off and a small ditch dug upslope of the chamber to intercept surface run-off.

Figure 3.8 Spring source – schematic

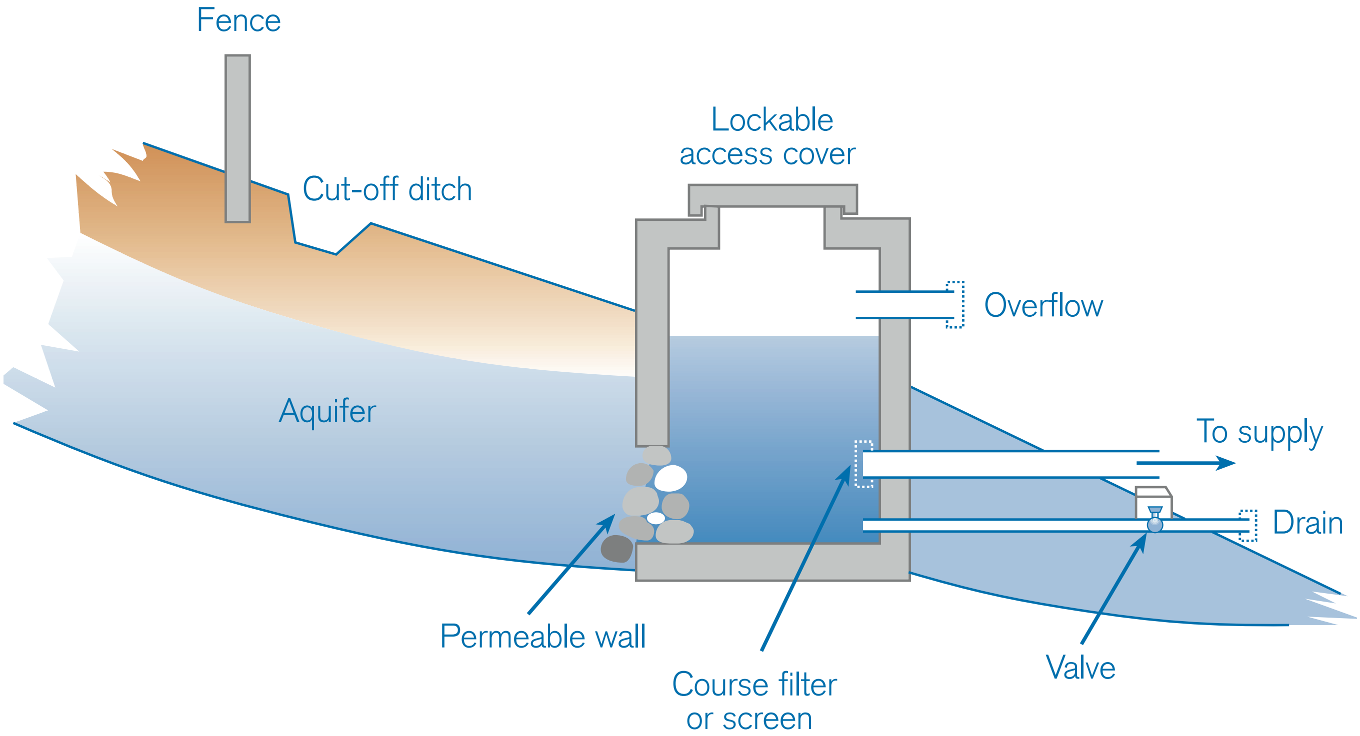
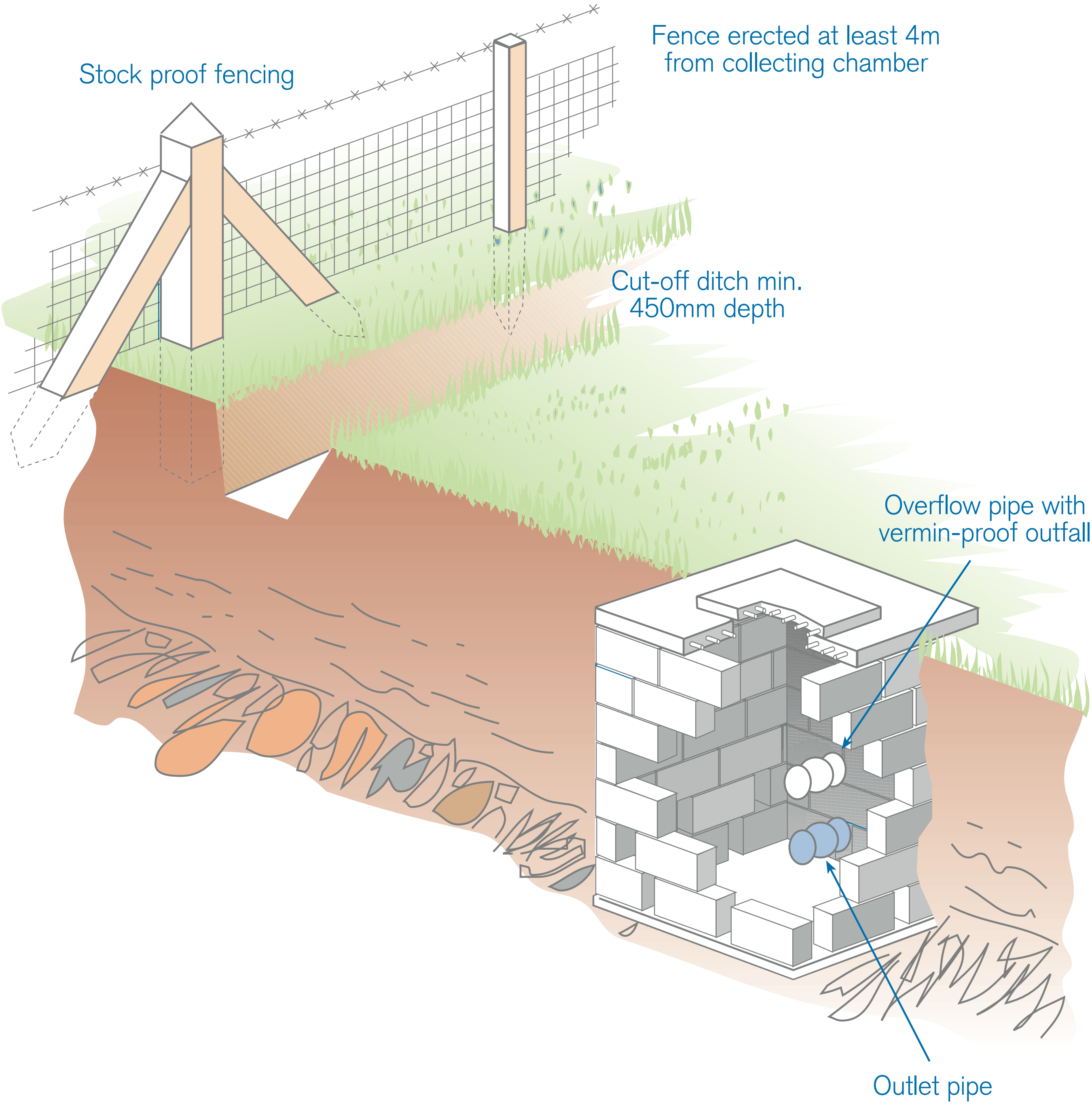


Figure 3.9 Spring collection chambers



3.4.3 Wells and boreholes

Shallow wells and boreholes are more at risk from contamination than deep wells and boreholes but if built and sited correctly, both may provide good quality water. Similar measures may be taken to protect both sources.

The upper section of the shaft must be lined and sealed against the surrounding material to exclude surface water ingress and, in the case of shallow wells and boreholes, water from the upper layer of the aquifer. Such sanitary seals range from 6 to 30 m in depth and must extend above ground level. Wells are often lined with masonry or concrete pipes and boreholes with steel, plastic or glass-reinforced plastic casings and sealed into the ground by a cement grout injected into the annular space between the casing and the surrounding ground. The shaft lining material should not affect water quality.

Where boreholes are drilled through a perched aquifer into lower water bearing strata, highly variable water quality may be obtained. Use of such boreholes as sources of potable water should be avoided unless the area through the perched aquifer is sealed.

The borehole lining may extend some depth into the aquifer if the bottom section requires support. Slotted or perforated linings are inserted which allow the ingress of groundwater. A gravel packing may be necessary if the borehole penetrates unconsolidated sand or sand and gravel to prevent fine material being drawn into the well during pumping.

At ground level, the well or borehole should be covered by a watertight chamber with a lockable cover. A concrete apron should slope away from the chamber to drain surface water. The well or borehole should be sited up-hill of, and at least 30 m away from, potential sources of pollution which include septic tanks, sewer pipes, cess pools and manure heaps. Typical arrangements for wells and boreholes are shown in Figures 3.10 to 3.13.

Figure 3.10 Well or borehole source – schematic

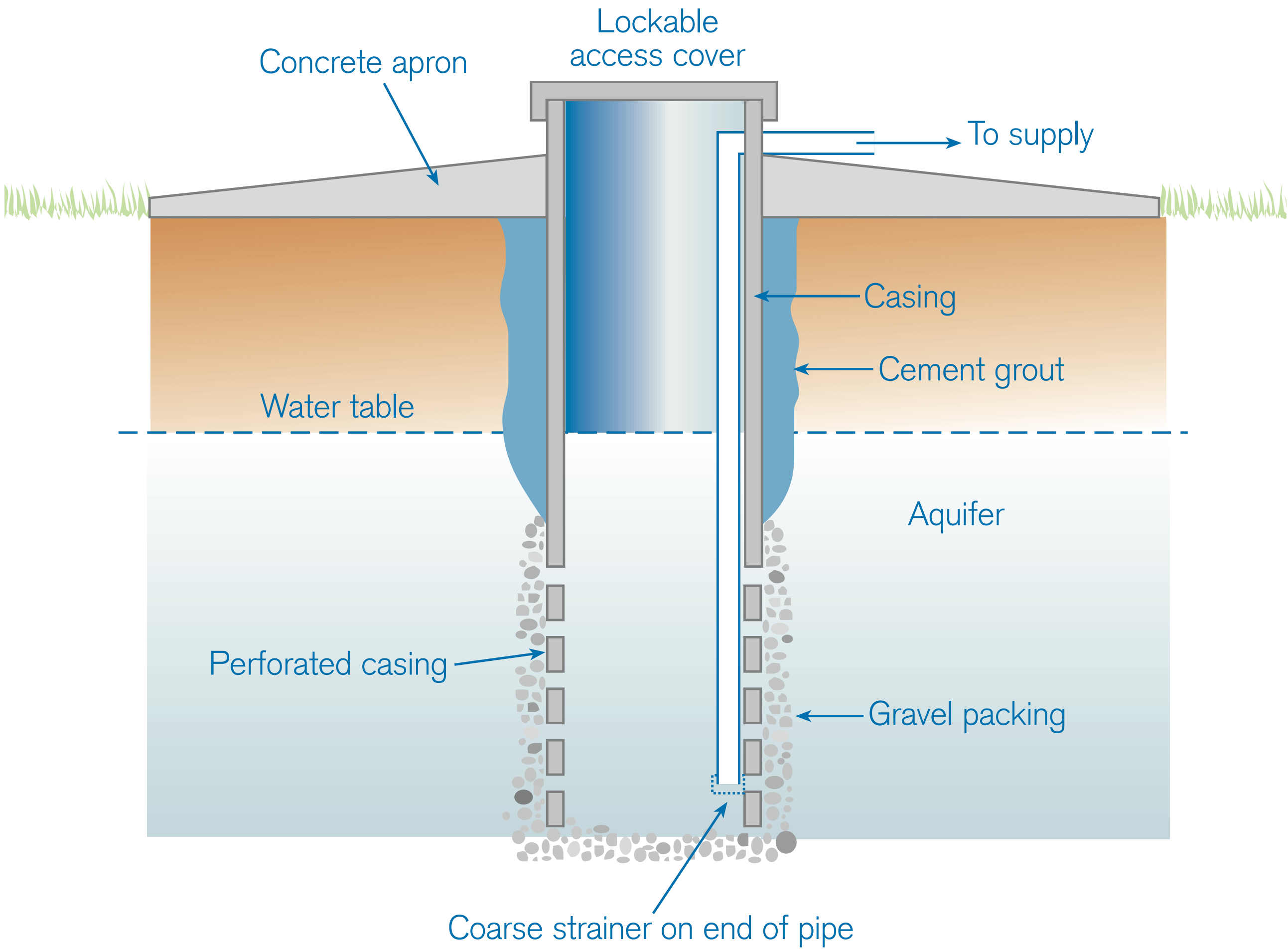


Figure 3.11 Well and submersible pump installation – typical arrangement

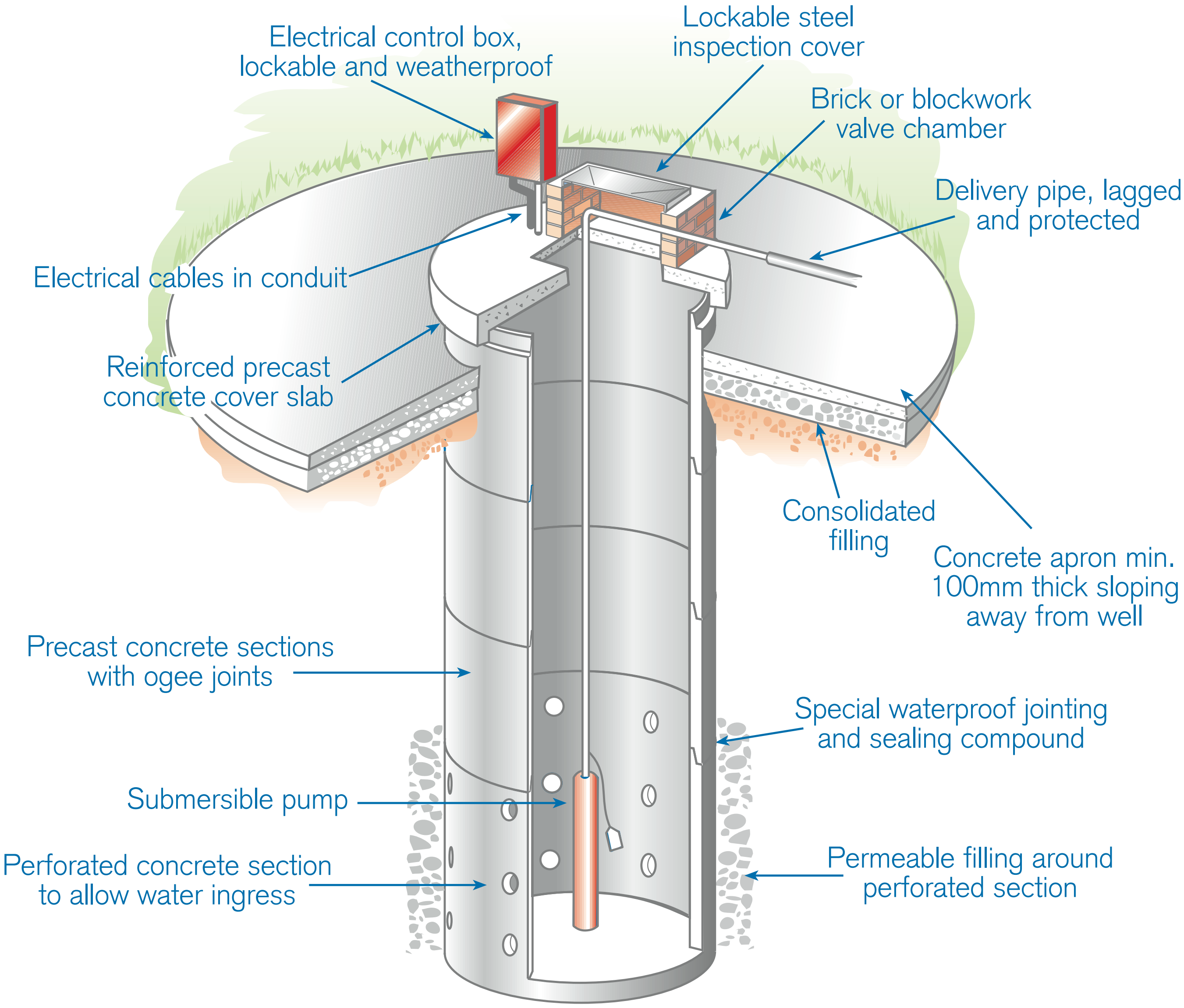


Figure 3.12 Well and pump installation – typical arrangement

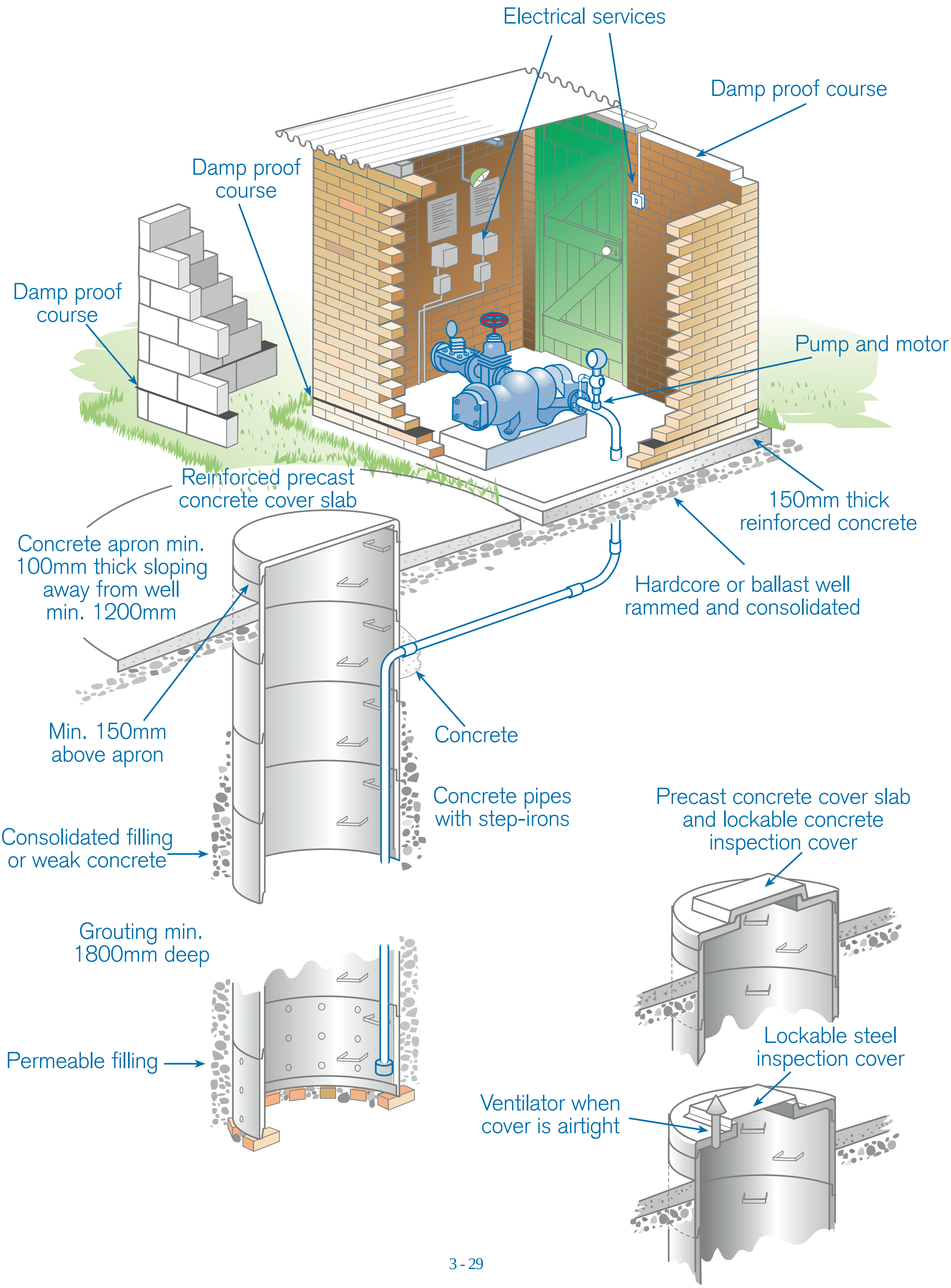


Figure 3.13 Borehole headworks

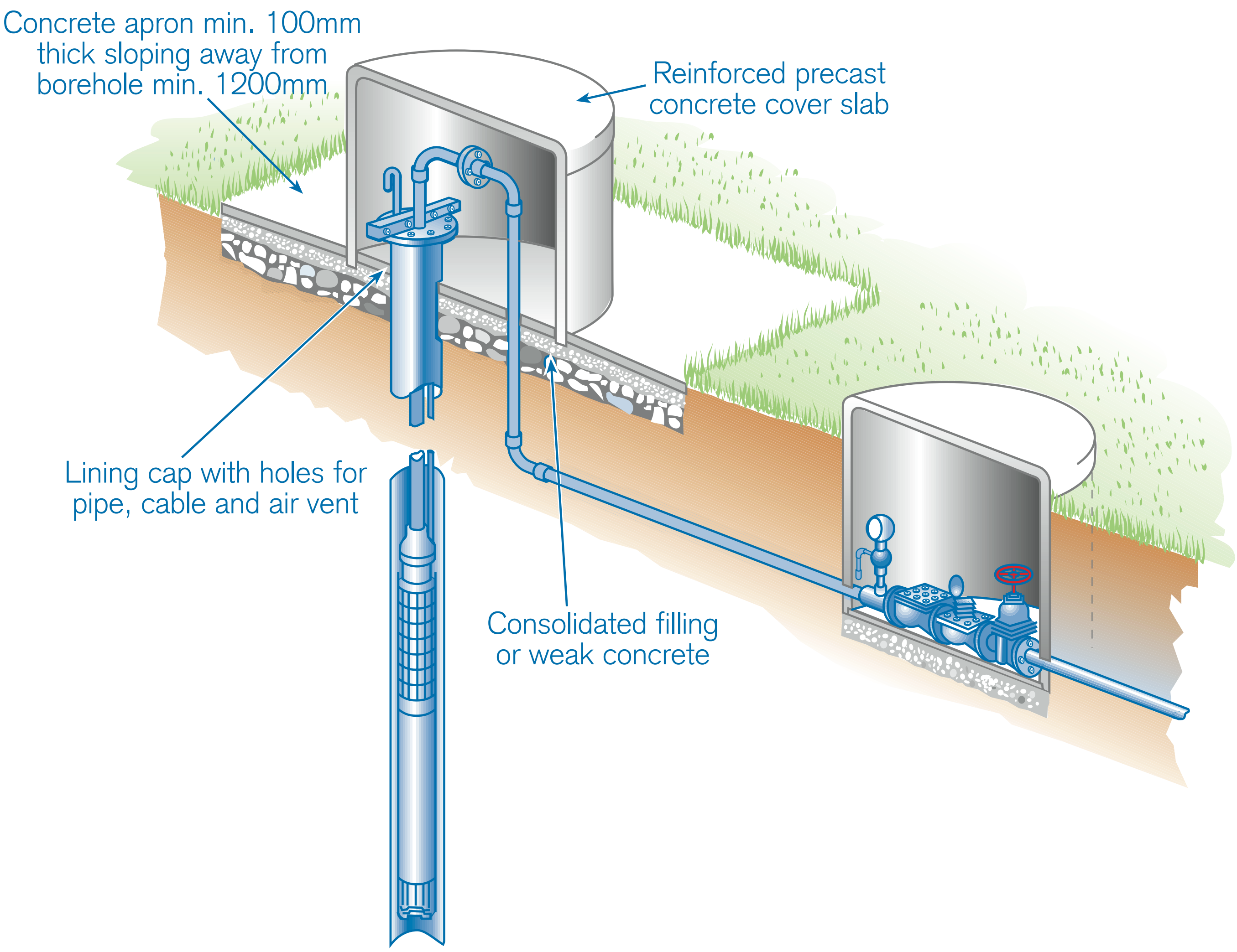
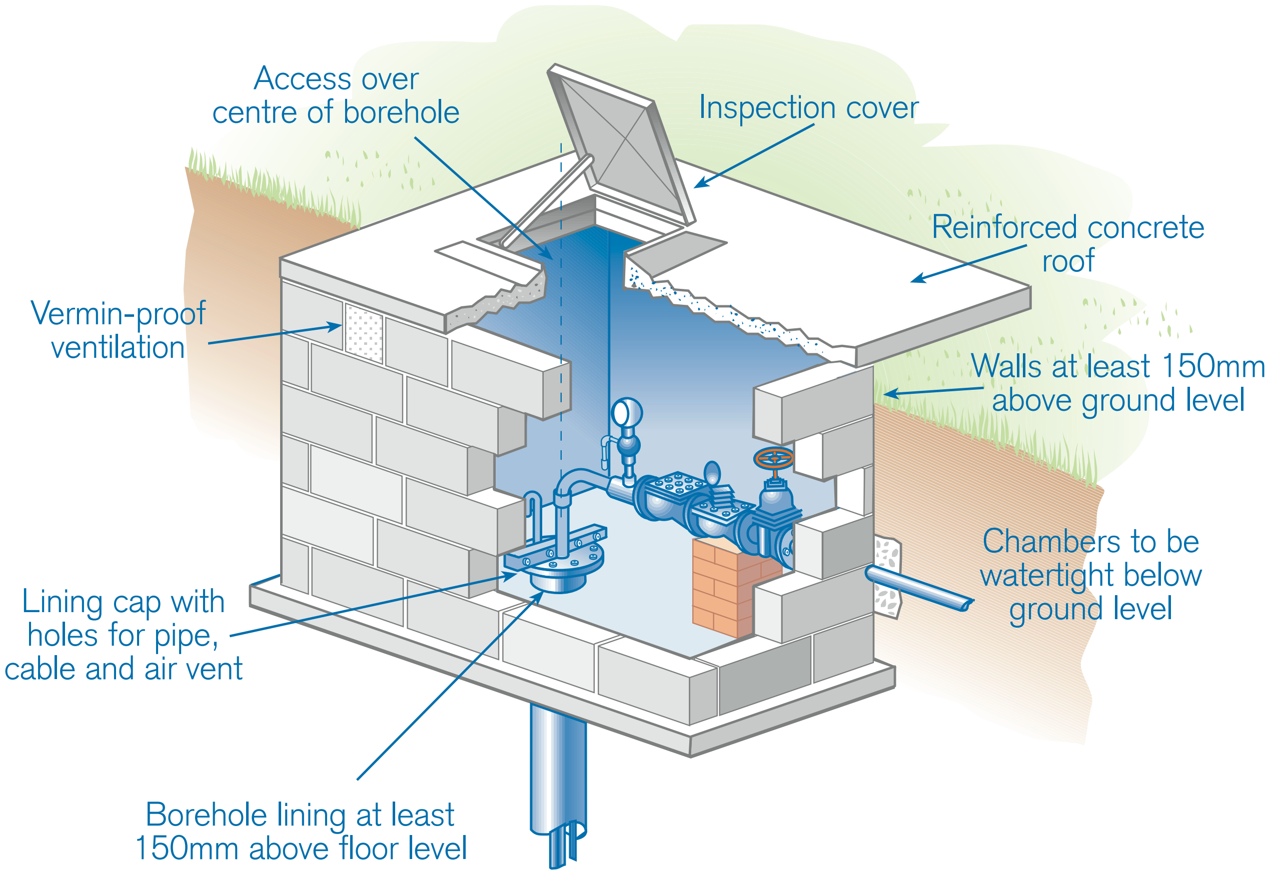


Figure 3.13 Borehole headworks (cont'd)



3.5 Monitoring

Monitoring for the presence of specific pathogenic bacteria, viruses and other agents in water is impracticable and indeed unnecessary for routine control of most small supplies. Pathogens are only shed by infected humans and animals, so will not be present all the time, and it is infeasible to examine water for every possible pathogen, which might be present. Any pathogenic micro-organisms that are present will often be so only in small numbers, and the methods for their detection are usually difficult, comparatively expensive, and time-consuming. Reliance is therefore placed on simpler and more rapid bacteriological tests for the detection of certain commensal intestinal bacteria – especially enterococci, *Escherichia coli* and other coliform organisms – because they are easier to isolate and characterise, and because they are always present in the faeces of man and warm-blooded animals (and hence also in sewage) in large numbers. The presence of such faecal indicator organisms in a sample of drinking water denotes that intestinal pathogens could be present, and that the supply is therefore potentially dangerous to health.

As discussed earlier, *E. coli* and coliforms have been and still are the most commonly used indicator organisms. *E. coli* is particularly important because it is specifically of faecal origin. It is abundant in the faeces of humans, other mammals and birds, and is rarely found in water or soil that has not been subject to faecal contamination. However, other indicators are available which could be equally relevant, or even more so, in assessing the quality of small water supplies.

Enterococci (previously referred to as faecal streptococci) are bacteria that are found exclusively in the faeces of warm-blooded animals. They are more tolerant of the aquatic environment and water treatment processes (including disinfection) than *E. coli* and coliforms, but are present in smaller numbers in human faeces. However, they are found in higher numbers than *E. coli* in the faeces of many domestic and farm animals. There is some evidence that testing for enterococci (and especially their speciation) might be useful in identifying faecal pollution as being of human or animal origin, but this has not been widely tried or accepted.

Methods of analysis for enterococci are no more expensive than those for *E. coli* and coliforms (though a longer incubation period is usually necessary), and no special sampling equipment is required.

The sulphite-reducing bacteria belonging to the genus *Clostridium* can also be useful indicators of faecal contamination. Only *Clostridium perfringens* is specific to faecal material, with other species being found in soil and other environmental materials. Clostridia can form spores that are extremely resistant to the water environment and water treatment processes. As a consequence, their presence in the absence of *E. coli* and enterococci can be taken to indicate a historic pollution event. *Cl. perfringens* is present in lower numbers than *E. coli* or enterococci in the faeces of all animals, so its value as an indicator comes from the resistance of its spores to a wide range of environments.

3.5 Monitoring (continued)

The parameter included in the drinking water Directive 98/83/EC is *"Clostridium perfringens* (including spores)" but it is also possible to test for spores alone, if necessary. In either case the method of analysis is slightly more complex than the methods for the other indicator organisms, but should be within the scope of any competent microbiology laboratory.

Because of logistic difficulties the monitoring of private water supplies is commonly infrequent. As a consequence, the value of the monitoring as an aid to protection of public health is often questioned, since contamination of the source may be sporadic and dependent on factors such as rainfall. In these circumstances the use of indicators that survive for longer periods of time than *E. coli* would be advantageous, in that they should allow historic or intermittent pollution to be detected.

Risk assessment of the catchment is better than monitoring for micro-organisms. To be of most value, monitoring for faecal indicators needs to be undertaken frequently, so that samples representative of the water quality are obtained. This is generally impractical for small water supplies and therefore a risk assessment of the catchment should be carried out, and protection measures aimed at excluding faecal contamination should be taken. If the risk assessment predicts a high risk of faecal contamination, alternative sources of supply will need to be considered.

Where total exclusion cannot be guaranteed, and no other supplies offer a viable alternative, treatment barriers must be strengthened and assessed against the microbial loading predicted to occur in the source water.

Following installation of the treatment processes a period of validation based on microbiological monitoring should be undertaken to ensure that the strategy adopted is adequate for the protection of public health. This would usually involve relatively intensive monitoring of the source and final water quality using faecal indicator organisms, but some sampling for specific pathogens should be considered where a particular risk has been identified (e.g. high probability of contamination from farm animals, where monitoring for *Campylobacter* and *Cryptosporidium* might be appropriate). Ideally this monitoring should include periods when the risk assessment has shown that the source water is highly likely to become contaminated (e.g. following heavy rainfall).

Regulatory monitoring frequency should only be introduced once satisfactory performance from the treatment has been obtained, and a maintenance procedure has been introduced which will ensure that any shortcomings in the performance of the treatment are detected at an early stage. This procedure will include very frequent (at least daily) checks that UV or other disinfection equipment is operating properly, and observation of the performance of any filtration processes being used. This procedure should also include a contingency plan for the use of alternative supplies or the instigation of a boil water regime, when necessary, for water used for drinking.

This page is intentionally blank

SECTION 4

RISK ASSESSMENT FOR PRIVATE WATER SUPPLIES

Section Contents

Private Water Supplies

4.1 Risk Assessment and Hazard Identification – Background and development of the Approach in the UK

Even in the developed world, infectious diseases caused by pathogenic bacteria, viruses and protozoa or by parasites are the most common and widespread health risk associated with drinking water, and such waterborne infectious diseases can be fatal.

4.2 Integrated Drinking Water Management

To ensure safe drinking water, suppliers have been moving away from the limitations of compliance monitoring in favour of a more integrated approach.

Definitions vary, but here **Multiple Barrier Approach** means overlapping water treatments, so that if one layer fails there are others in place. A **Water Safety Plan** (WSP) is wider in scope, meaning everything that can prevent or reduce water contamination – including legislation, standards, training etc. as well as monitoring and treatments.

The World Health Organisation (WHO), defines a WSP as using:
supply system assessment from source to tap
control measures and effective monitoring
management plans for both normal and incident conditions

The basis of the approach is Risk Assessment, and its the aim is to protect public health.

4.3 Historical Development of Approach in the UK

In 1996-97 an outbreak of *E. coli* O157 poisoning from a private water supply in north-east Scotland prompted a scoping study and research to assess and protect private water supplies. The resulting report from The Robert Gordon University and The Macaulay Institute in 1998 concluded that any *quantitative* risk assessment would be highly complex and cumbersome.

4.4 Development of the Approach in the UK

Initial development of RGU/Macaulay Risk Assessment Protocol - the initial risk assessment was *qualitative*, based on the physical nature of the source and whether certain activities occurred within 50m and 250m catchments. Soil was recognised as a key protective component for groundwaters.

Each of the two sections – source character and catchment activities - was scored as being low, medium or high risk and the overall risk assessment taken as the highest risk scored. A revised **Manual on Treatment for Small Water Supply Systems** incorporated this risk assessment system in March 2001.

After a fatal outbreak of *E. coli* O157 traced to a butcher's shop in Wishaw in 1996, the landmark **Pennington Report** of 2000 concluded that most *other* sporadic cases of contamination were actually due to environmental sources.

In 2001, a Task Force on *E coli* O157 recommended that users and owners of private water supplies be educated on the risks of faecal contamination of supplies, and that their sources should be risk assessed and protected.

Further refinement of the Risk Assessment approach - more research was undertaken to validate the original RGU/Macaulay risk assessment approach. Of 33 sites monitored in 2002, none was free of coliform bacteria contamination. The proximity of agricultural land and the timing of rainfall were important factors.

The study suggested the need for wider sampling, but it was felt that risk assessment could help to keep drinking water safe. However, the current approach scored most supplies as High Risk, and a better system was needed.

Water Safety Plan Approach for Private Water Supplies in the UK - the validation study was used to develop a prototype *semi-quantitative* risk assessment in 2004 that included chemical and other contaminants as well as microbiological ones. This risk assessment required development but was preferable to the existing one and could be recalibrated with future data, using, and would use the WHO guidelines where possible.

The resulting index scoring system uses a hazard assessment matrix to pair take the *likelihood* of a given hazard occurring, and multiply it with against the *severity* of its consequences. Its cut-off score of 16 is not a mathematically derived figure. These numbers (1, 2, 4, 8, 16) are convenient indices though, not mathematical probabilities. The cut-off score of 16 is used to prioritise remedial action for each hazard.

4.5 Risk Assessment Guidance

There are four separate sets of guidance for risk assessing each type of supply, i.e. one set each for assessing wells, springs, bore holes and surface supplies.

For visiting and inspecting sites, the same pattern of working is suggested for all four types of supply. This requires relevant site contact details and the use of Ordnance Survey maps in all cases, as well as soil leaching potential maps and/or water sampling equipment in particular cases.

Risk Assessment Pro Formas
Each Risk Assessment requires the completion of a Pro Forma with different sections of questions relating to the supply and the site it is located in. The answers to the questions ("yes", "no" or "don't know") are combined to give an overall risk grading and a set of hazard scores for prioritising remedial actions if the overall risk is high.

The purpose of the guidance sections is to help the assessor answer these pro forma questions conclusively. Where there is uncertainty ("don't know"), the pro forma will always lead the assessor to err on the side of caution and assign a high risk.

Overlapping sections
Many of the pro forma questions (and therefore the items in the guidance sections) are identical for each type of supply, but there are marked differences too:-

Sections A to C are the same in all four risk assessments (and so Items 1 to 22, which relate to very general questions, are the same in each guidance section).

Section D(i) General Site Survey is the same in all four except for two questions that are not included for surface waters. (Items 23 and 39 of the other three.)

Section D(ii) Supply Survey varies slightly or markedly between all four types.

Only **springs and wells** have section D(iii) on **Soil Leaching**, identical in both cases.

Boreholes have additional sections Site and Supply survey sections E(i) and (ii) for Site and Supply surveys for headworks located above ground. E(i) is identical to D(i), while E(ii) is very similar to D(ii).

Overall Risk Assessment
The final section of each pro forma describes how to assign the overall risk category (low, moderate or high) from the hazard scores in the individual sections.

References for the entire section (4.1 to 4.9) are included at the end.

4.6 Well Risk Assessment guidance sections

SECTION A – Supply Details

Item 1 – Supply category.
Type A provides 10 or more cubic metres of water per day, serves 50 or more persons, or is used for commercial or public activity. Any other is Type B.

Items 2-4 concern contact details of key individuals. The 'responsible person' owns or manages the distribution system; the relevant person provides the supply or occupies the land around it. These role(s) may overlap.

Item 5 – details of premises and purposes supplied are essential for scoping the impact of any safety concerns.

SECTION B

Items 6 & 7 – diagram, description and Ordnance Survey grid reference to enable newly visiting colleagues to navigate the supply. How to give a grid reference is explained here.

Item 8 – daily volume. If not metered, estimate the volume based on 200 litres per person per day using a robust estimate of the maximum number of people supplied.

Item 9 – details of *all* water treatment processes, cross-referenced to the diagram in 6.

SECTION C

Item 10 – summary details of any temporary departures granted.

Item 11 – sample results for the last 12 months, so that, e.g. if lead failed previously, then lead sources can be investigated.

Item 12 – previous two investigations and actions, to help resolve if still ongoing.

Item 13 – enforcement notices.

Item 14 – previous risk assessment.

Items 15 & 16 – location and suitability of public notice on water quality.

Item 17 – remedial action needed if (re-)sampling indicates supply quality failure.

Item 18 – whether exempt (i.e. not drinking water or directly affecting food or drink).

Item 19 – other relevant information collated by the local authority.

Items 20-22 relate to whether there is a WSP, and its fitness for purpose.

SECTION D

This section describes how the risk assessment process assigns qualitative risk ratings (low, moderate, high) and numerical hazard assessment scores for a given risk **indicator**, e.g. animal remains being present near the supply.

Each such indicator has a severity score preassigned to it from the scale 1, 2, 4, 8, 16. Similarly, its likelihood score (how often it is thought to be present) is rated on the same scale, though this is done by the assessor, using the guidance notes.

The hazard score is the product of these two scores - severity times likelihood - and is simply an index that can be used to prioritise remedial action, if needed. It can vary from *Rare* x *Insignificant* (1x1=1) to *Almost certain* x *Catastrophic* (16x16=256).

This process is applied to each of the risk indicators (below) relevant to the supply:-

SECTION D (i) General Site Survey

Item 23 – evidence of poor drainage causing stagnant water, e.g. mud or reeds around the wellhead.

Item 24 – evidence of livestock; likely to be permanent.

Item 25 – evidence of wildlife and whether seasonal or persistent.

Item 26 – surface run-off from agriculture; deals with drains and overland flow on farmland.

Item 27 – wastewater irrigation; differs from 26 in applying materials to, as well as disrupting, the soil.

Item 28 – disposal of organic wastes to land, e.g. abattoir waste.

Item 29 – farm wastes relates to middens, bagged silage and other grounded hazards.

Item 30 – remediation of land will typically involve a higher application than in 27.

Item 31 – forestry activity; planting and harvesting can disrupt water supplies.

Item 32 – awareness by agriculture workers, who might ignore or not know of sources.lack of awareness, or consideration, of the supply by agricultural workers.

Item 33 – waste disposal sites such as scrap yards, landfill and incinerator sites can contaminate supplies.

Item 34 – disposal sites for animal remains, including human burial sites.

Item 35 – unsewered human sanitation; the condition and position of septic tanks etc. are very important in preventing leaching.

Item 36 – sewage pipes that cross the source may need special consideration.

Item 37 – sewage effluent lagoons may leach into groundwater.

Item 38 – sewage effluent discharge to adjacent watercourse; e.g. from treatment works.

Item 39 – old wells or supplies can contaminate a new well.

Item 40 – pesticides, including sheep dip.

Item 41 – industrial activity introduces hazards from chemical or pharmaceutical manufacture, mining, electroplating (solvents) etc.

SECTION D(ii) Supply Survey

Item 42 – no suitable stock proof fence (see diagram in main document).

Item 43 – no suitable barrier to prevent ingress of flooding (e.g. impermeable cut-off ditch with downslope discharge).

Item 44 – no concrete apron to prevent soil splashing into well.

Item 45 – well top too close to apron to keep out surface flows.

Item 46 – no pre-cast concrete cover slab; a well-fitting, lockable cover is essential to keep out rain, vermin and unauthorised people.

Item 47 – the well construction must itself be in a good state of repair.

Item 48 – supply network must not be liable to fracture e.g. clay or asbestos concrete.

Item 49 – adequate protection of any intermediate tanks, since the potential for contamination via intermediate points is as high as for the source itself.

Item 50 – junctions present in the supply network must have back-siphoning protection (e.g. on permanent hosepipes to provide water for animal troughs).

Item 51 – no maintenance in previous 12 months suggests inadequate care of the supply.

Item 52 – header tank does not have vermin-proof cover; particularly relevant if it feeds the main potable tap.

Item 53 – header tank not cleaned in last 12 months – slime and scum grow naturally on tank walls.

Item 54 – point of entry/use equipment not serviced correctly suggests inadequate care of the supply.

Item 55 – UV lamps not working; a common fault is for UV bulbs to stop working.

Item 56 – noticeable change in level and flow; constancy of supply relates directly to the quality of the source; consider treating as a surface-derived supply.

Item 57 – noticeable change in turbidity or colour after heavy rain or snow melt; the hazard assessment will depend on whether weather or surface influence is the cause.

SECTION D(ii) Soil Leaching Risk Survey

4.6 Background

Introduction – any groundwater can be contaminated through human activity, and there are many factors affecting groundwater vulnerability, including the overlying soil, drift deposits, solid geological strata in the unsaturated zone, groundwater depth and the contaminant itself.

Use of soil information – full assessment of groundwater vulnerability requires actual field investigation but existing environmental data can prove useful. Some **drift deposits** can hinder pollution (although reliable maps may not be available), as can less permeable **aquifers**. **Soil mapping** can be used to determine how effectively different soils attenuate pollutants, using characteristics such as permeability, wetness, porosity, clay content and parent geological material.

Soil leaching potential maps classify soils into three different leaching classes with Class 1 having the highest vulnerability or soil leaching potential, and Class 3 the lowest. Class 1 and Class 2 have further subdivisions, including an urban class that is assumed to be a worst case until proved otherwise. These maps must be used cautiously but can be helpful when used with soil inspection pits. For large catchments or uncertain source locations, **interpreted soil maps** can be used where available. Both approaches must take account of land use, as even land offering little protection will not be contaminated if no contaminants were introduced.

Other factors affecting groundwater contamination include physical disturbance of aquifers and groundwater flow (e.g. groundwater extraction, landfill and field drainage); waste disposal to land; contaminated land; discharges to underground strata (including sewage treatment); and diffuse pollution (i.e. spread over time).

In conclusion, soil can protect the shallow groundwaters used by many supplies, while for deeper groundwaters, geological factors will also need to be considered. Assessments will use either site inspection or soil maps, with past and present land use a key component.

Surface waters – soil type affects the risk of contamination for surface waters too, in regard to surface run-off and stream expansion after rainfall. Research suggests this is lower for mineral soils and those without a slowly permeable surface layer. Land use will also be a factor (e.g. forestry may reduce contamination; grazed moorland may increase it).

However, surface waters are inherently at higher risk of contamination.

SECTION D(iii) Soil Leaching Potential Survey

The soil category is read from the OS grid reference of the supply on the appropriate soil leaching potential map, and a look-up table is used to assign the hazard score.

A simplified explanation of soil leaching potential is also given.

SECTION D(iv) Overall Risk Assessment for Wells

This is the highest individual risk category present in any of the three surveys.
Hazard scores of 16 or higher indicate priority for remedial work on the supply.

Throughout the risk assessment, any uncertainty implies a high risk.

Section E applies this principle when the type of supply is not known, and **Section F** allows space for additional notes.

Well Risk Assessment Pro Forma
The sections of questions correspond to those in the guidance sections above, with hazard scores and risk characterisations built in.

4.7 Spring Supply Risk Assessment guidance section

Guidance sections A to D(i) for springs are identical to those for wells, above.

D(ii) Supply Survey is the same too, except for items 44-46 as follows:

Item 44 – overflow/washout pipe must be fitted with vermin-proof cap. Mice can get through a gap the size of a pencil diameter.

Item 45 – inlet pipe must have a filter to prevent ingress of detritus.

Item 46 – if chamber present, a lockable water-tight pre-cast cover slab is essential, which should be vermin-proof if ventilated.

Guidance section **D(iii) Soil Leaching** is also identical to that for wells, but the hazard scores in the springs pro forma (Table D1) are higher for spring water.

Section **D(iv) Overall Risk Assessment** for springs is the same as for wells too, as are sections **E and F**.

The **Springs Pro Forma** is therefore almost identical to that for wells.

4.8 Bore Hole Risk Assessment guidance sections

NB: Assessments differ between bore holes with headworks above and below ground.

Guidance sections A to D refer to *all* Bore Holes and these sections are identical to those for wells and springs (see 4.6 Wells).

D(i) General Site Survey for bore holes with headworks **below** ground is the same as that for wells and springs (see 4.6 Wells).

D(ii) Supply Survey relates to Bore Holes with headworks **below** ground, as follows:

Item 42 – below ground chamber not watertight means contaminated surface water could enter the supply.

Item 43 – casing not 150mm above floor means a risk of water entering the chamber or vermin entering the pipe.

Item 44 – a watertight lining cap is essential to seal out material, water and vermin.

Item 45 – a suitable barrier to keep out flooding is essential, e.g. an impermeable cut-off ditch..

Item 46 – chamber top must be 150mm above ground level to keep out surface flows.

(**Note**: Items 47 to 58 are almost the same as items 46-57 for wells, namely:-)

Item 47 – no pre-cast concrete cover slab; a well-fitting, lockable cover is essential to keep out rain, vermin and unauthorised people.

Item 48 – the bore hole construction must itself be in a good state of repair.

Item 49 – supply network must not be liable to fracture e.g. clay or asbestos concrete.

Item 50 – adequate protection of any intermediate tanks, since the potential for contamination via intermediate points is as high as for the source itself.

as items 42-45 for any intermediate tanks, since the potential for contamination via intermediate points is as high as for the source itself.

Item 51 – junctions present in the supply network must have back-siphoning protection (e.g. on permanent hosepipes to provide water for animal troughs).

Item 52 – no maintenance in previous 12 months suggests inadequate care of the supply.no maintenance in previous 12 months suggests inadequate care of supply.

Item 53 – header tank does not have vermin-proof cover; particularly relevant if it feeds the main potable tap.

Item 54 – header tank not cleaned in last 12 months – slime and scum grow naturally on tank walls.

Item 55 – point of entry/use equipment not serviced correctly suggests inadequate care of the supply.

Item 56 – UV lamps not working; a common fault is for UV bulbs to stop working.

Item 57 – noticeable change in level and flow; constancy of supply relates directly to the quality of the source; consider treating as a surface-derived supply.

Item 58 – noticeable change in turbidity or colour after heavy rain or snow melt; the hazard assessment will depend on whether weather or surface influence is the cause.

D(iii) Overall Risk Assessment for headworks **below** ground:
Soil leaching potential assessment is not applied to boreholes, so the overall risk is taken from the site and source surveys only.

E(i) General Site Survey for bore holes with headworks **above** ground is the same as that for wells, springs and other bore holes (see 4.6 Wells).

E(ii) Supply Survey for bore holes with headworks **above** ground is the same as for those with headworks below ground, except for the 1st and 5th items and the higher numbering:-

Item 78 – housing cover must be watertight to exclude surface water and vermin.

Item 79 – casing not 150mm above floor means a risk of water entering the chamber or vermin entering the pipe.

Item 80 – a watertight lining cap is essential to seal out material, water and vermin.

Item 81 – a suitable barrier to keep out flooding is essential, e.g. an impermeable cut-off ditch...

Item 82 – a sloping concrete apron must be provided to keep water off the casing.

Item 83 – no pre-cast concrete cover slab; a well-fitting, lockable cover is essential to keep out rain, vermin and unauthorised people.

Item 84 – the bore hole construction must itself be in a good state of repair.

Item 85 – supply network must not be liable to fracture e.g. clay or asbestos concrete.

Item 86 – as items 42-45 for adequate protection of any intermediate tanks, since the potential for contamination via intermediate points is as high as for the source itself.

Item 87 – junctions present in the supply network must have back-siphoning protection (e.g. on permanent hosepipes to provide water for animal troughs).

Item 88 – no maintenance in previous 12 months suggests inadequate care of the supply.

Item 89 – header tank does not have vermin-proof cover; particularly relevant if it feeds the main potable tap.

Item 90 – header tank not cleaned in last 12 months – slime and scum grow naturally on tank walls.

Item 91 – point of entry/use equipment not serviced correctly suggests inadequate care of the supply.

Item 92 – UV lamps not working; a common fault is for UV bulbs to stop working.

Item 93 – noticeable change in level and flow; constancy of supply relates directly to the quality of the source; consider treating as a surface-derived supply.

Item 94 – noticeable change in turbidity or colour after heavy rain or snow melt; the hazard assessment will depend on whether weather or surface influence is the cause.

E(iii) Overall Risk Assessment for headworks **above** ground:
Soil leaching potential assessment is not applied to boreholes, so the overall risk is taken from the site and source surveys only.

Throughout the risk assessment, any uncertainty implies a high risk.

Section F applies this principle when the type of supply is not known, and **Section G** allows space for additional notes.

Bore Holes Risk Assessment Pro Forma
The sections correspondThe sections of questions correspond to those in the guidance sections above, with hazard scores and risk characterisations built in.

4.9 Surface Supply Risk Assessment guidance sections

Guidance sections A to D for surface supplies are identical to those for wells, springs and bore holes (see 4.6 Wells).

D(i) General Site Survey for surface supplies is the same as for wells etc., but minus the two items concerning drainage and old wells:-

Item 23 – evidence of livestock; likely to be permanent.

Item 24 – evidence of wildlife and whether seasonal or persistent.

Item 25 – surface run-off from agriculture; deals with drains and overland flow on farmland.

Item 26 – wastewater irrigation; differs from 25 in applying materials to, as well as disrupting, the soil.

Item 27 – disposal of organic wastes to land, e.g. abattoir waste.

Item 28 – farm wastes relates to middens, bagged silage and other grounded hazards.

Item 29 – remediation of land will typically involve a higher application than in 26.

Item 30 – forestry activity; planting and harvesting can disrupt water supplies.

Item 31 – awareness by agriculture workers, who might ignore or not know of sources. Lack of awareness, or consideration, of the supply by agricultural workers.

Item 32 – waste disposal sites such as scrap yards, landfill and incinerator sites can contaminate supplies.

Item 33 – disposal sites for animal remains, including human burial sites.

Item 34 – unsewered human sanitation; the condition and position of septic tanks etc. are very important in preventing leaching to streams.

Item 35 – sewage pipes that cross the source may need special consideration.

Item 36 – sewage effluent lagoons may leach into groundwater.

Item 37 – sewage effluent discharge to adjacent watercourse; e.g. from treatment works.

Item 38 – pesticides, including sheep dip.

Item 39 – industrial activity introduces hazards from chemical or pharmaceutical manufacture, mining, electroplating (solvents) etc.

D(ii) Supply Survey

This has all but the first six items from the wells supply survey in 4.6:-

Item 40 – supply network must not be liable to fracture e.g. clay or asbestos concrete.

Item 41 – intermediate tanks should be as protected as the source, since the potential for contamination via intermediate points is as high as for the source itself.

Item 42 – junctions present in the supply network must have back-siphoning protection (e.g. permanent hosepipese.g. on permanent hosepipes to provide water for animal troughs).

Item 43 – no maintenance in previous 12 months suggests inadequate care of the supply.

Item 44 – header tank does not have vermin-proof cover; particularly relevant if it feeds the main potable tap.

Item 45 – header tank not cleaned in last 12 months – slime and scum grow naturally on tank walls.

Item 46 – point of entry/use equipment not serviced correctly suggests inadequate care of the supply.

Item 47 – UV lamps not working; a common fault is for UV bulbs to stop working.

Item 48 – noticeable change in level and flow; constancy of supply relates directly to the quality of the source; consider treating as a surface-derived supply.

Item 49 – noticeable change in turbidity or colour after heavy rain or snow melt; the hazard assessment will depend on whether weather or surface influence is the cause.

Overall Risk Assessment
Soil leaching potential assessment is not applied to surface supplies, so the overall risk is taken from the site and source surveys only.

Throughout the risk assessment, any uncertainty implies a high risk.

Surface Supply Risk Assessment Pro Forma
The sections of questions correspond to those in the guidance sections above, with hazard scores and risk characterisations built in.

Private Water Supplies

This page is intentionally blank

4. RISK ASSESSMENT FOR PRIVATE WATER SUPPLIES

4.1 Risk assessment and hazard identification – Background and development of the approach in the UK

Nowadays, most Europeans take clean drinking water for granted. However, in the WHO European region – covering Western Europe, central and eastern Europe and the countries of the former Soviet Union – there are 120 million people without a regular supply of safe water. Cleaner water and better sanitation could prevent over 30 million cases of water-related disease each year in this region alone.[1]

Infectious diseases caused by pathogenic bacteria, viruses and protozoa or by parasites are the most common and widespread health risk associated with drinking water. Waterborne infectious diseases can be fatal; globally, two million people die from diarrhoea every year; in the WHO European region alone, over ten thousand children under five die of diarrhoea. Although the problem is not as acute as in the developing world, also in the WHO European region thousands of people suffer from infectious disease caused by poor quality water, or are affected by water-related diseases. For example, a large proportion of gastrointestinal disease comes from water.[1]

4.2 Integrated drinking water management

Traditionally, drinking water suppliers have relied heavily on a process called compliance monitoring to ensure water is safe to drink. Compliance monitoring relies on sampling small amounts of water in a drinking water system and testing those samples for the presence of known and quantifiable organisms or contaminants. If those samples comply with established requirements for drinking water quality, the water is considered safe to drink. However, this approach has major limitations in its sampling and monitoring techniques and in the range of factors that affect drinking water quality that can be considered. For instance, compliance monitoring only deals with microbiological pathogens and/or contaminants for which a prescribed numerical guideline value or established method of analysis has been developed, making it nearly impossible to address the entire range of potential health concerns. Sample analysis also takes time, during which period consumers will be drinking the water. If the water is contaminated, some people may become ill before the problem is identified and resolved. In order to address these limitations, the drinking water industry has been shifting focus in recent years to using more integrated approaches to drinking water management.[3]

The concept of multiple barriers for drinking water sources has applied for over a hundred years but, unfortunately, there is no single, widely accepted definition of precisely what the term encompasses [4]. The term can mean having "defence in depth" through having layers of treatment that "overlap" by removing (or having the potential to remove) similar contaminants so that if one layer should fail the remaining processes will ensure treatment is maintained. However, the term "multiple barrier approach" can also have a wider remit encompassing source protection, treatment, distribution system, monitoring and responses to adverse conditions [4].

The multiple barrier approach has been defined as "an integrated system of procedures, processes and tools that collectively prevent or reduce the contamination of drinking water from source to tap in order to reduce risks to public health"[3]. Under this approach all potential control barriers are identified along with their limitations. The barriers can be physical, such as the installation of a filtration system in a drinking water treatment plant, or they can be processes or tools that improve the overall management of a drinking water programme. Examples of the latter include legislation and policies, guidelines and standards, staff training and education, and communications strategies that programme staff may use to communicate with the media or the public.[3]

The latter definition of multiple barrier (or multi barrier) approach is very close to the concept of "water safety plan" and it is perhaps better to use this term when describing such wide-ranging approaches to drinking water safety, and retaining the term "multiple barrier approach" to define the concept of systems back-up such that should one system fail consumers are still protected by other complementary treatment systems[5]. This leads to the question "What is a water safety plan?"

"The most effective means of consistently ensuring the safety of a drinking water supply is through the use of a comprehensive risk assessment and risk management approach that encompasses all steps in water supply from catchment to consumer."[2] The WHO Guidelines for Drinking-water Quality 3rd edition (2004) define such an approach as "water safety plans (WSPs)".

The WHO state that a WSP has three key components which are guided by health-based targets and overseen through drinking-water supply surveillance. They are:

(i) system assessment to determine whether the drinking water supply chain (up to the point of consumption) as a whole can deliver water of a quality that meets health-based targets. This also includes the assessment of design criteria of new systems;
(ii) identifying control measures in a drinking water system that will collectively control identified risks and ensure that the health-based targets are met. For each control measure identified, an appropriate means of operational monitoring should be defined that will ensure that any deviation from required performance is rapidly detected in a timely manner; and
(iii) management plans describing actions to be taken during normal operation or incident conditions and documenting the system assessment (including upgrade and improvement), monitoring and communication plans and supporting programmes.[2]

The Guidelines go on to state:

"The primary objectives of a WSP in ensuring good drinking water supply practice are the minimization of contamination of source waters, the reduction or removal of contamination through treatment processes and the prevention of contamination during storage, distribution and handling of drinking water. These objectives are equally applicable to large piped drinking water supplies, small community supplies and household systems and are achieved through:

- development of an understanding of the specific system and its capability to supply water that meets health-based targets;
- identification of potential sources of contamination and how they can be controlled;
- validation of control measures employed to control hazards;
- implementation of a system for monitoring the control measures within the water system;
- timely corrective actions to ensure that safe water is consistently supplied; and
- undertaking verification of drinking water quality to ensure that the WSP is being implemented correctly and is achieving the performance required to meet relevant national, regional and local water quality standards or objectives."[2]

The aim for regulatory authorities and practitioners in the early part of the 21st century is to realise the goals set out by the WHO through incorporation of the water safety plan (WSP) approach into corporate systems as well as national (and international) water quality standards and objectives. This paper describes how the concept of risk assessment for private water supplies arose and has developed to a point where risk assessment will form the basis of the regulatory regime for private water supplies in the UK, and from their current status as embryonic WSPs how they may further develop into a mature WSP, thereby achieving the aim of incorporation of the WSP approach into national legislation to enhance the protection of public health for consumers of drinking water from private water supplies.

4.3 Historical development of approach in the UK

During the autumn of 1996 and early 1997 a spate of outbreaks of *E. coli* O157 infections resulted in the deaths of 20 elderly people in Scotland although not all outbreaks caused deaths to occur[6]. One of these non-fatal outbreaks was attributable to a private water supply at Dunecht in north-east Scotland:

> "The private water supply was provided and maintained by an estate for the use of a number of properties within its boundaries. The original supply was constructed around 1945 using water derived from a surface spring source. Asbestos-lined pipes were used to take the water to a primary tank located 250 metres away. The water was then pumped up to a header tank 500 metres from the primary tank where it was distributed to a number of houses. Over the years the spring had disappeared but the pipes continued to bring water into the supply. The distribution downstream of the header tank had also been recently modified with an additional spur constructed using piping made from modern material. The area around the primary collection tank was pasture on which cattle were frequently grazed. There was a marked gradient on the field dropping toward this tank.
>
> "Eleven properties were supplied by the main header tank and 41 people utilise the water supply. The outbreak consisted of 13 cases of enteritis with diarrhoea of varying severity. Seven of these individuals had positive stool samples for *E coli* O157. A further asymptomatic excretor was also discovered during the screening undertaken as part of the management of the incident. All had consumed water from the estate supply.
>
> "A survey of the system revealed a number of interesting points. The pump house was well maintained and the water within the tank appeared to be clear. There were no obvious areas of disrepair and no signs of water entering the tank other than through the feeder pipe. Few individuals could remember the spring as a surface feature and the exact location of the source remained unclear. Inspection of the header tank revealed it to be in need of some repair. The inspection hatch was broken and the roof area showed signs of rainwater accumulation. The structure was located in a remote spot and there was evidence of animal faecal contamination on the roof of the tank.
>
> "Water samples taken from domestic taps demonstrated the presence of faecal coliforms and a boil water notice was issued to prevent further illness. Although the header tank was a possible source of the contamination, given the results of the inspection, the geography of the system did not rule out the pump house. Indeed, a sample taken from this tank also showed the presence of faecal coliforms. An adjacent field used for grazing sloped down towards the pump house and there was ample evidence to show that cattle had been present in the field for some time.

"Laboratory studies confirmed the presence of *E. coli* O157 in water taken from the pump house and from faecal material collected from the field. The grazing cattle were also shown to be positive for the organism too. Isolates from the animals, water and environmental samples were indistinguishable from those recovered from the affected individuals. The water from the supply continued to be unsatisfactory for a considerable time in spite of the remedial action undertaken by the estate." [7]

This incident prompted the then Scottish Office to send a circular [8] to local authorities alerting them to the risk of *E. coli* O157 infection from private water supplies and suggesting an approach to managing the risk. The Scottish Office also prepared a leaflet ("Keeping It Safe") for local authorities to send to all owners and users of private water supplies, this was issued in July 1997.

The Scottish Office also commissioned a scoping study to consider the need for further research into the risk posed by *E. coli* O157 to water supplies. The work was awarded to a group from WRc and the main findings of the study were:

(i) A review of the literature revealed that because of the predominance of food associated infections and outbreaks, past and current research had focused on agricultural sources of *E. coli* O157 and how it entered the food chain – there was a marked absence of research specifically directed at studying *E. coli* O157 in water.
(ii) There was no evidence to indicate that *E. coli* O157 was more persistent in the environment or more resistant to water treatment processes than non-pathogenic *E. coli* found in the gastro-intestinal tract.
(iii) Except in the case of humans with a severe infection, the number of *E. coli* O157 in faecal material would be several orders of magnitude lower than the concentration of other *E. coli* serotypes. It was tentatively concluded that existing microbial standards for drinking water quality should be adequate. However, because the infective dose of *E. coli* O157 appeared to be low, drinking water supplies which only just achieved compliance with coliform and *E. coli* standards should be regarded as being at risk.
(iv) Private water supplies may require barriers to prevent contamination by *E. coli* O157 and other enteric pathogens and this should be achieved by better source protection, the use of point of use devices, or a combination of both.
(v) Future research must concentrate on obtaining better information on the fate of *E. coli* O157 in the environment, ensuring that it is removed by normal water treatment processes and identifying the most acceptable and cost-effective means of protecting private water supplies. [9]

The Scottish Office took the findings of the scoping study and acted on them by commissioning research projects to investigate the fate of *E. coli* O157 in the environment and to develop a methodology for improved source protection for private water supplies.

In a separate development the Drinking Water Inspectorate in England and Wales, acting also on behalf of Northern Ireland and Scotland, commissioned and published a Manual on Treatment for Small Water Supply Systems [10].

The Scottish Office commissioned the project “Improved source protection for private water supplies” in January 1998 and the final report was produced in June 1998 [7] from a consortium led by The Robert Gordon University and Macaulay Institute, both located in Aberdeen. The design of the risk assessment protocols required cognisance to be taken of the multifactorial nature of hazards that could impact upon any given source. Much of the scientific evidence regarding microbiological hazards exists without reference to the importance of such hazards in specific physical situations. There was also a lack of evidence regarding synergistic interactions between such microbiological hazards. In addition, in order to provide consistent and reliable assessments the possibility of subjectivity in a quantitative system needed to be reduced to as low a level as possible. Given the complexity of the individual situations concerning private water supplies (for example, location, size, construction and maintenance regime – if any!), any quantitative risk assessment system could have become highly complex and cumbersome and would have ceased to conform to the user-friendly requirement of the system.

4.4 Development of the approach in the UK

4.4.1 Initial development of RGU/Macaulay risk assessment protocol

The initial risk assessment was a qualitative risk assessment that identified all the specific activities that were hazardous to the maintenance of good microbiological water quality at the source. Hazards were placed into two main categories based on their proximity to the source – those within 50 metres' radius of the source and those within 250 metres of the source. Factors associated with the 50 metres radius were primarily concerned with the physical nature and construction of the source and were scored as high, medium or low risk based on a presence/absence system. The different types of sources (e.g. wells, springs, boreholes, rivers/streams) would not necessarily have the same risk factors associated with them requiring source-specific risk assessment protocols to be developed.

The importance and potential influence of soils and substrates, on private water supply systems, particularly those derived from groundwater systems, was recognised as an important component of any risk assessment system from the start of the project. The soil can offer a degree of protection to the contamination of groundwater through its ability to buffer (chemically and biologically) potential contaminants and to act as a physical barrier. These attributes can vary considerably between different soil types and between the different layers, or "horizons", within the soil. Some soils have a greater propensity for preferential flow than others, that is, contaminated water can by-pass the filtering ability of the soil matrix, and fluctuations in soil wetness can enhance transport of pathogens through the soil to shallow groundwaters. Although site inspection of the soil properties is desirable it requires considerable expertise. In recognition of this, a series of maps were produced indicating the ability of the soil to buffer pathogens and other potential contaminants.

A second group of hazards relating to activities undertaken near the source that had the potential to introduce microbiological contamination to the source water were also identified. These activities were divided between those occurring within 50 metres' radius of the source and those occurring within 250 metres' radius of the source – such radii relating to the recommended Arbitrary Fixed Radius Circle values (AFRCs) detailed by NRA at $AFRC_{50}$ and MAFF at $AFRC_{250}$ respectively [11,12].

Upon completion of the risk assessment each of the two sections was scored as being low, medium or high risk and the overall risk assessment for the source was determined by applying the highest level of risk from the individual sections.

Throughout the development of the risk assessment approach each phase of the developing assessment system was tested and evaluated in the field with the researchers and practising experts (environmental health officers). This partnership approach ensured that the final risk assessment system was practicable, user-friendly and robust.

The risk assessment protocol was launched at a series of roadshow events in Scotland in late 1998 held jointly by the Scottish Office and the Royal Environmental Health Institute for Scotland (REHIS) – the professional body representing environmental health officers in Scotland. REHIS, through the Public Health and Housing Working Group's Private Water Supplies Sub-group, were developing a "Manual of Best Practice for Environmental Health Officers and Support Staff" which was published in March 2000[13] and incorporated the elements of the RGU/Macaulay risk assessment system presented in 1998.

4.4.2 Manual on treatment for small water supply systems

During 2000 the Drinking Water Inspectorate recognised the need to update their earlier Manual to take account of developments in the area of private water supplies. The revised second edition of the Manual on Treatment for Small Water Supply Systems was published in March 2001[14] and it too incorporated the elements of the RGU/Macaulay risk assessment system.

4.4.3 Pennington Report and Task Force on *E. coli* O157

In November 1996 21 elderly people died in Wishaw, Scotland, 17 of whom were subsequently found to have been affected by *E. coli* O157. In total 496 persons were thought to have become ill after consuming meat products from a butcher's shop in Wishaw, and which were found to have been distributed widely throughout Central Scotland. The landmark Report of the group led by Prof. Hugh Pennington looked closely at procedures for preparation and sale of raw and cooked meat products, and made 32 recommendations on the management, distribution and handling of such products. The findings of the Fatal Accident Inquiry into the Central Scotland Outbreak gave added weight to the factors identified in the Pennington Report[15].

In the wake of the Pennington Report numerous research projects were commissioned and by mid-2000 much of this work on animal sources and case control studies came to a conclusion. In June 2000 the results of this research were made public at an Open Forum in Edinburgh. The significant finding overall was that the majority of sporadic cases[a] lay in environmental sources rather than in the food chain; however, the food chain retained potential to cause large numbers of cases from particular events. The Scottish Executive (the successor to the Scottish Office following devolution in 1999) together with the newly-created Food Standards Agency in Scotland (FSAS) identified a requirement to place this research output into a practical plan for action highlighting the range of sources of infection. The result was the creation of a Task Force on *E. coli* O157 which commenced its work in September 2000 and presented its final report in June 2001. The Task Force was set up with the deliberate brief to be open and consultative, to gather information widely from scientific and professional sources and from practitioners and patients. Membership of the Task Force was from throughout the UK and while it was convened under the auspices of the Scottish Executive, the recommendations were to apply to the UK through the appropriate devolved or national agencies or Government departments. The desired output from the Task Force was to be a practical action plan to improve the protection of the public from infection by *E. coli* O157.

[a] Single cases of disease apparently unrelated to other cases

As part of the work of the Task Force water supplies were considered – both public and private water supplies. Part of the evidence provided by the drinking water regulatory team in Scotland to the Task Force related to the RGU/Macaulay risk assessment approach and the Scottish Executive's desire to incorporate the approach within the revision of the Regulations covering private water supplies in Scotland. This approach was also endorsed by the drinking water regulators in the rest of the UK (England, Wales and Northern Ireland). The Task Force recommended, in relation to private water supplies, that users and owners should be educated on the risks associated with faecal contamination of private water supplies; that appropriate works should be undertaken to protect and stock proof the sources of private water supplies and that a microbiological risk assessment protocol should be applied to all private water supplies.

The Scottish Executive accepted the recommendations of the Task Force and has been adopting the recommendations. The Scottish Agricultural Pollution Group was asked to take appropriate account of the relevant recommendations as part of the planned process of reviewing and updating the Code of Good Practice – Prevention of Environmental Pollution from Agricultural Activity (PEPFAA)[16]. The leaflet "Keeping It Safe" was updated and distributed to all local authorities in Scotland in December 2001[17]. The question of risk assessment and other issues were identified in "Private Water Supply Regulation: A Consultation" which was published in November 2001[18].

4.4.4 Further refinement of the Risk Assessment approach

In 2001, prior to the publication of the consultation paper on private water supply regulation in Scotland, the Scottish Executive commissioned research from a consortium led by The Macaulay Land Use Research Institute, Aberdeen and included the Centre for Research into Environment and Health and University of Aberdeen. The research was undertaken to validate the original RGU/Macaulay risk assessment approach in order to provide additional evidence to support the incorporation of the approach into the proposed new regulatory regime. The final report was delivered in March 2003 [19].

A total of 33 sites in North-east Scotland were monitored throughout 2002. The proportion of source types in the study reflected the proportion of supplies in each of the Private Water Supply Regulations (1992) [20] categories that occur nationally and included sources on a range of land uses such as arable agriculture, grazed pastures, woodland and moorland. The type of supplies within the sampling network included wells tapping shallow groundwater; springs; surface flow to reservoirs or holding tanks; and field drainage collection systems.

No source sampled was free of coliform bacteria contamination over the 12 consecutive months of sampling. The results showed that there was a greater degree of contamination in sources surrounded by agricultural land compared with moorland or woodland despite the weak statistical relationship between the presence of domestic stock and levels of contamination, and may simply be reflecting a greater population of bacteria associated with the more fertile land.

In the study rainfall appeared to be an important driver of contamination either by inducing overland flow (which was observed in a number of instances) or by enabling the transport of bacteria to the groundwater. However, it was found that the amount of rainfall was less important than the timing of heavy or prolonged rainfall events. The heavy rainfall would be more likely to induce by-pass flow during infiltration and overland flow when the soils became saturated. The water sources associated with soils that were naturally wet were found to be at greater risk of contamination. In these soils near-saturated conditions would be reached in less time than in freely drained soils and they often occur in topographic hollows where excess overland flow could gather.

The results agreed well with other studies but concluded that the complex nature of private water supplies may mean that any validation of such an approach would not be possible without a considerable increase in the number of sources sampled. However, the authors also stated that, intuitively, the individual components of the risk assessment would seem to encompass the main factors likely to affect the quality of water supplies and so the risk assessment could be viewed as a tool to aid risk identification which would allow the integrity of supplies to be strengthened. The main concern over the approach was an apparent lack of differentiation within the resulting scores with most supplies being scored as High Risk. A greater degree of resolution was felt to be desirable in any system such that appropriate action plans could be devised and implemented in an achievable manner.

4.4.5 A Water Safety Plan approach for private water supplies in the UK

The conclusions from the validation study were carried forward and widened to encompass the other constituent parts of the UK. The data collected were used to verify other approaches to risk assessment following a workshop convened at Peebles, Scotland in early April 2003, hosted by the Scottish Executive. Key stakeholders were able to present and discuss their approaches to risk assessment as applied to private water supplies and a prototype quantitative risk assessment was developed and applied to several data sets in Wales and Scotland. The workshop delegates agreed the assessment should not limit itself to only microbiological parameters and potential sources of chemical and other contaminants should be considered also. The goal of the revised risk assessment was to achieve the greater resolution within the assessed risk for each private water supply – a weakness in the original system. It was felt that the introduction of a semi-quantitative approach would provide this desired output.

Several key data sets relating to private water supplies, their source and distribution system details and water quality details were identified and reanalysed using the semi-quantitative risk assessment system that emerged from the workshop. This work was undertaken by The Macaulay Institute and the Centre for Research into Environment and Health and the final report (Analysis of Risk Protocol Options for Private Water Supplies) was presented in March 2004[21]. The conclusions from the work were:

(i) there were doubts as to whether the data sets utilised were sufficiently comparable to justify combination into a unified data matrix. This appeared to be an artefact of the sampling strategies employed in the studies that generated the original data sets.

(ii) Although weak in many cases, the correlation with rainfall made it difficult to validate the quantified risk assessment scoring systems. The most likely reason suggested by the researchers for this was that the ‘noise’ in the data, which was produced by rainfall (a non-risk-related factor), was so great that it was masking the ‘signal’ derived from the risks indexed in the data sets.

(iii) To effect better calibration of a quantitative risk index, it is likely that additional, and greater, resolution sampling would be required, which was specifically designed to discriminate between the ‘rainfall effect’ and catchment risk factors. With such enhanced data it would be possible that more sophisticated statistical analyses would be able to identify other contributing factors.

(iv) The present regulatory regime, particularly for Category 1F supplies[b] is clearly unsatisfactory and a risk scoring system would certainly be preferable to the *status quo* even without firm empirical data to fully calibrate a set of score weights and derive a fully quantitative risk assessment.

(v) Movement towards a scoring system which could be subject to subsequent re-calibration if suitable data are acquired would be prudent. In the interim, such a system would be a valuable tool for indicating weaknesses in the supply system that can be improved.

The results of the study were circulated to the original participants of the April 2003 workshop, and another meeting of the group was convened in Edinburgh in July 2004. The results of the March 2004 report and associated developments with water safety plans and the Bonn Charter were discussed. The meeting agreed with the conclusions of the March 2004 report and that a pragmatic decision should be taken to refine the original risk assessment system with a view to reviewing the opportunity for developing a more quantitative approach once sufficient data had been acquired through the use of the risk assessment within the new Regulations governing private water supplies. It was also agreed that, wherever possible, the WHO Guidelines for Drinking Water Quality (3rd Edition)[2] guidance on water safety plans should be incorporated into the revised risk assessment protocol.

The final version of the risk assessment protocol intended for incorporation into the revised Regulations governing private water supplies was developed during autumn 2004 and circulated for final approval/organisational affiliation in December 2004. The final risk assessment form retains the original structure with a series of questions relating to different parts of the private water supply system. The original risk assessment is now termed “Risk Characterisation” and is still based on a presence/absence scoring system. In conjunction with each risk characterisation question there is also an associated “Hazard Assessment” score which has been derived from the WHO Guidelines. The risk index (Figure 1) is intended to provide the much sought-after differentiation for undertaking remedial/intervention works. The risk cut-off is proposed as being 16 – but it should be stressed that this is an index and has no implied mathematical relationship to risk, it is merely a convenient way of prioritising actions where there may be resource conflicts.

[b] Category 1F supplies are single dwellings with no commercial activity associated with them.
Private Water Supplies (Scotland) Regulations 1992 (1992 No. 575 (S.64)).
http://www.opsi.gov.uk/si/si1992/Uksi_19920575_en_1.htm

Figure 1 – Hazard assessment matrix

	Severity of consequences				
Likelihood	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	16	32	64	128	256
Likely	8	16	32	64	128
Moderately likely	4	8	16	32	64
Unlikely	2	4	8	16	32
Rare	1	2	4	8	16

4.5 Risk assessment guidance

The following sections provide detailed instructions and guidance for the completion of each of the items contained in the risk assessment forms. A separate set of guidance is presented for each of the four risk assessment forms – well, borehole, spring and surface derived supplies. While each form has some common sections, guidance for each complete form is given for ease of reference.

It is important to understand that under most circumstances it will be appropriate to combine the risk assessment investigation with some sampling in order that the quality of the water can be assessed in conjunction with the risk investigation. Such sampling will be undertaken at a domestic (potable) tap from premises served by the supply. Additional sampling may be required as part of investigative work, e.g. at source or intermediate tanks.

The following list provides a suggested pattern to follow when undertaking a risk assessment investigation.

(1) Identify the private water supply on which to undertake the risk assessment investigation.
(2) Confirm with the relevant person or persons who will be an appropriate contact person.
(3) Arrange with contact person identified from (2) a mutually agreeable date/time/location to meet and undertake the investigation. **Note that the risk assessment is principally based around the source of the supply.**
(4) Ensure that an appropriate premise will also be available for sampling and make necessary arrangements to take a sample of the drinking water.
(5) Prepare risk assessment forms prior to site investigation completing all sections that require historic or archived data.
(6) Ensure that appropriate maps (soil leaching potential and Ordnance Survey 1:50,000) for the likely area of the source are available and take to site investigation meeting.
(7) Ensure that appropriate sampling equipment and containers are available and take to site investigation meeting.
(8) Undertake site risk assessment investigation.
(9) Undertake appropriate sampling activities at location(s) identified in (4).
(10) Collate results of sampling activity into risk assessment form
(11) Complete risk assessment form including any additional information requested at time of site investigation.
(12) Record and file complete risk assessment form.
(13) Send a copy of the completed risk assessment to the relevant person(s) for their records.

4.6 Well risk assessment (see 4.6 Annex 1 for full form)

Overall Risk – this is taken from the overall risk assessment in section D(iv)(a) of the risk assessment form.

SECTION A – Supply Details

Item 1 – Supply Category

The supply category that is required to be identified is taken from The Private Water Supplies (Scotland) Regulations 2006 Part 1(2). These state:

"Type A supply" means a private water supply for human consumption purposes which

(a) on average, provides 10 or more cubic metres of water per day or serves 50 or more persons, or
(b) regardless of the volume of water provided or the number of persons served, is supplied or used as part of a commercial or public activity,

and references in this definition –

(i) to the average volume of water provided by such a supply, are references to such volume (calculated as a daily average) as may be reasonably estimated to have been distributed or, if not distributed, used or consumed from the supply during the year prior to the year in which these Regulations come into force; and that estimate may be on the assumption that five persons use one cubic metre of water per day; and
(ii) to the average number of persons served by such a supply, are references to such number of persons as may be reasonably estimated to be the maximum number served by the supply on any one day during the year prior to the year in which these Regulations come into force;

"Type B supply" means a private water supply other than a Type A supply; and "year" means a calendar year.

Item 2 – Address and telephone number of responsible person

"Responsible person" is a term used in the Regulations referring to the person who owns or otherwise is responsible for the domestic distribution system which includes the pipework, fitting and appliances which are installed between the taps that are normally used for human consumption purposes and the distribution network which is not the responsibility of a relevant person (see Item 3). Full contact details of the responsible person should be recorded here.

Item 3 – Name of person (or persons) who is relevant person in relation to the supply

The term "relevant person" refers to the person considered by the local authority to be the person providing the supply, or occupying the land from, or on, which the supply is obtained or located, and any person who exercises powers of management or control in relation to the supply.

The relevant and responsible person may be one and the same person in some instances.

In some instances there may be more than 3 relevant persons in which case additional sheets should be used to record the information and details of these additional sheets should be included in section (d) and the sheets appended to the form when completed.

Item 4 – Address of relevant person (or persons) (if different from above)

Where the responsible person and the relevant person are different then the contact details for the relevant person or persons should be recorded in this section.

In some instances there may be more than 3 relevant persons in which case additional sheets should be used to record the information and details of these additional sheets should be included in section (d) and the sheets appended to the form when completed.

Item 5 – Details of premise(s) served by the supply and purpose for which water is supplied

This item seeks to capture details of any premise that may be served by the supply and the purpose for which the water is being supplied. It is necessary to have as complete a list of properties served by a private water supply as possible in order that the true interconnectivity of the supply may be assessed and the potential population affected by any breach of the Regulations or incidence of waterborne disease outbreak can be assessed rapidly and efficiently. For larger supplies this exercise will be challenging but attention to detail will ensure that the most comprehensive and accurate records are compiled which will assist in future investigations relating to the supply.

Additional sheets (as required) should be appended to the form and a note of these made at section (d).

SECTION B

Item 6 – Diagram of the supply

This is intended to enable the investigating officer to provide a schematic sketch showing the interrelationships between the various components of the supply such as source, intermediate tanks and properties being supplied. While there is undoubtedly a balance to be struck between too much detail and insufficient detail, a guiding principle should be to provide sufficient information to enable colleagues who have not visited the site to quickly navigate around the supply.

Item 7 – Description of the source of the supply

The description provided should complement the schematic sketch provided at Item 6. The purpose of having a written description is to provide a record of the condition of the infrastructure at the time of the risk assessment. This will enable a baseline to be established against which any future developments made to the supply can be benchmarked. If the facility exists it would be appropriate to also include relevant photographic evidence of the various components so long as they are uniquely identified and cross-referenced within the risk assessment report.

A full National Grid Reference for the source (or the closest point to the source identified) should also be provided.

How to give a grid reference to nearest 100 metres

The example below is taken from Ordnance Survey Braemar to Blair Atholl Sheet 43 1:50000 Landranger Series.

100 000 metre Grid Square Identification	**Example - Altaltan**			
NN NO ^{2}00	1. Read letters identifying 100 000 metre square in which the point lies.	NO		
	2. FIRST QUOTE EASTINGS Locate first VERTICAL grid line to LEFT of point and read LARGE figures labelling the line either in the top or bottom margin or on the line itself. Estimate tenths from grid line to point.		18 4	
	3. AND THEN QUOTE NORTHINGS Locate first HORIZONTAL grid line BELOW line either in the left or right margin or on the line itself. Estimate tenths from grid line to point.			63 5
	EXAMPLE REFERENCE	NO	184	635
Ignore the smaller figures of any grid number: these are for finding the full coordinates. Use ONLY the LARGER figure of the grid number. Example: ^{2}80^{000m}				

Extract from 1:50 000 sheet 43 showing location of Altaltan

Due to OS licence conditions, you/your agent may only use this map for official business dealings with the Scottish Executive. If you wish to use the map for other uses, you must first obtain a separate licence from OS.

Item 8 – Estimated daily volume of water provided by the supply

If the volume of water is not being measured, e.g. via a water meter, then the investigating officer can make an estimate of the volume based on 200 litres of water per day per person served by the supply. While the figure will only be an estimate every effort should be made to identify the maximum number of people who are being supplied with water from the supply. It is not sufficient just to base the estimate on historical records, e.g. the classification of the supply made under previous regulatory frameworks. It is important to have a robust and defensible maximum occupancy for the supply as this may well have an impact on the sampling frequency to which the supply is subjected.

Item 9 – Details of any water treatment processes associated with the supply

While it is important to document any treatment that occurs on the supply it is not practicable to list all possible treatment types or systems that may be encountered. The risk assessment form concentrates on the provision of standard disinfection equipment/processes but all other treatment systems should be included in the description including items such as sediment traps of pH correction systems. Each of the treatment processes should be cross-referenced to those identified on the schematic provided at Item 6.

For larger systems it will not be practicable to complete Item 9 (c) and so a table should be drawn up listing the properties and the treatments associated with each property differentiating between point of entry and point of use devices, e.g.:

Responsible Person	Property address (including post code)	Point of entry device (specify)	Point of use device (specify)	Notes
Mr D Able	1 Wellside Cottage, Nethermuir, ZZ1 1AA	UV lamp	None	located in lean-to on north side of house, pre-filter bypassed
Mrs C Brown	3 Wellside Cottage, Nethermuir, ZZ1 1AA	UV lamp	None	On maintenance contact with Bloggs Plumbing, Nethermuir
Ms B Charlie	Springside House, By Nethermuir, ZZ1 2BA	None	UV lamp	Under sink in kitchen – poor access for changing bulb
Rev. A Davis	Riverbank Cottage, Nethermuir, ZZ1 1AB	None	None	

These details should be recorded as additional sheets on the form at Item 9 (d)

SECTION C

Item 10 – Details of departures authorised

Provide details of any temporary departures granted under Part IV of the Private Water Supplies (Scotland) Regulations 2006. These details should summarise the details provided in the original temporary departure and should cross-reference to the complete application. If applicable the temporary departure authorisation (Regulation 6(7) of the above Regulations) can be appended to the risk assessment. Details of this should be recorded in Section F.

Item 11 – Details of sample results for previous 12 months or last available (reference location of information, e.g. paper or electronic files, reference number, sample numbers, etc.)

The inclusion of this information is to assist the investigation officer in their investigations. Details of the previous sampling results will enable areas of concern to be highlighted and assist in focusing on areas where actual breaches of the drinking water quality standards have occurred. For example, if lead is highlighted as failing in the sample results, while lead is not specifically being looked for in the risk assessment, the investigation officer may take the opportunity of the investigation to attempt to determine whether there are any known lead pipes or tanks associated with the supply or through examination of the appropriate geological map whether lead is naturally occurring in the vicinity of the source. If lead pipes or tanks are present then appropriate advice can be provided on the need for their removal; if lead is naturally occurring at the source then discussions around locating a more acceptable alternative source for the supply can be entered into.

Item 12 – Details of previous (last two) investigations and actions taken

If there have been investigations into previous failures then the last two such investigations should be summarised here along with the actions that were taken or were understood to have been agreed to have been taken. This information will provide the investigation officer with a background to the problems that have been encountered previously along with an understanding of what actions have been attempted to improve the situation and whether these actions have proved to be successful. If they have proved to be unsuccessful then this information will allow the investigation officer to consider alternative solutions that have not been previously implemented.

Item 13 – Details of enforcement notices served

If any enforcement notices have been served that affect the supply under investigation, details of these should be provided here. If necessary additional information may be appended to the risk assessment and details of these should be provided in Section F.

Item 14 – Results of previous risk assessment (if applicable)

If the source or supply has previously been risk assessed then the details of the previous risk assessment(s) should be included with the current risk assessment. The previous risk assessments should be appended to the current form and details of these additional sheets should be recorded against this item.

Item 15 – Details of location of Notice for Type A supplies (location)

Regulation 31 of the Private Water Supplies (Scotland) Regulations 2006 requires that up-to-date information about the quality of the water provided in commercial or public premises shall be displayed in a prominent location. This notice forms part of the communication of risk to members of the public and so the location of the notice should be recorded to ensure that appropriate risk communication is being undertaken.

Item 16 – Is Notice appropriate (conforms to requirements of the Regulations)

Regulation 31 (2) details the form that the information notice must take. This item confirms that the appropriate form of the notice is being displayed as the form of the notice interlinks with additional information available to both owners/users and visitors to private water supplies making it vital that the appropriate form of the notice is utilised.

Item 17 – Details of action taken (or to be taken) by relevant persons to comply with (a) results of sampling (b) results of follow-up to sampling

If sampling results indicate that the supply fails to comply with the requirements of the Regulations, this section should be completed to identify what suggested/agreed remedial steps should be taken to prevent future failures.

Item 18 – Whether supply exempt under Regulation 2 (4)

If the supply is used solely for washing a crop after it has been harvested or during the distillation of spirits (solely in the mashing process or for washing plant but for no other purpose) and which does not affect, either directly or indirectly, the fitness for human consumption of any food or drink or, as the case may be, spirits in their finished form, then the provisions of the Private Water Supply (Scotland) Regulations 2006 do not apply to that supply with the exception of the provisions of regulation 29. If the supply is exempted under the provisions of regulation 2(4) then a full risk assessment is not required to be completed but good practice would require a partially completed form to be retained by the local authority containing the information required by regulation 29.

Item 19 – Details of other information relating to the supply collated by the local authority

If the local authority has other relevant information relating to the supply then these details should be included here or appended to the form and details of the additional sheets recorded under this item.

Item 20 – Is there a Water Safety Plan/Emergency Action Plan available for the supply

Some supplies may have a water safety plan or emergency action plan that details steps to be taken to ensure the quality of water at the source and steps to be taken in the event of a loss of constancy or quality from that supply.

Item 21 – If "Yes" to Item 20, is it fit for purpose

This item requires an assessment by the investigation officer as to whether or not the water safety plan or emergency action plan is suitable for the premises it relates to.

Item 22 – If "No" to Item 20, what deficiencies are required to be addressed (provide details)

If the assessment undertaken in Item 21 suggests there are inadequacies in the water safety plan or emergency action plan then the deficiencies should be noted against this item with suggestions, where appropriate, as to what improvements may be considered to the plan(s).

SECTION D

General introduction

In this part of the form each of the indicators being looked for, e.g. disposal sites for animal remains, will have two separate scores associated with them.

The first score will be the Risk Characterisation score.

The Risk Characterisation score has three values – High, Moderate or Low – and is based on the presence or absence of the indicator based on the evidence available to the person undertaking the risk assessment. The form is preloaded with the risk characterisation value based on the individual indicator being present or absent. If the assessor cannot determine if the indicator is present then the “Don’t know” option should be used.

The assessor should tick the appropriate response box for each indicator. If any response is identified as High Risk (H) then the Risk Characterisation Score will be **HIGH**. If no response is High Risk but there are Moderate Risks (M) identified then the Risk Characterisation Score will be **Moderate**. If no response is High Risk or Moderate Risk then the Risk Characterisation Score is **Low**.

The second score is the Hazard Assessment score.

The Hazard Assessment Score is also based on the indicator being present but this scoring allows the extent of the potential influence of the indicator to be taken into account. Thus the likelihood score is dependent on a knowledge or estimate of the time period during which the indicator may be present at the source under investigation. The table in the form provides guidance on the values to be assigned based on how frequently the indicator is known, or thought, to be present. If the indicator is present continuously, i.e. once per day or a permanent feature, then the likelihood value assigned will be 16 as the indicator is almost certainly there continuously; if the indicator is present once a week then the likelihood value assigned will be 8; if the indicator is present once a month then the value will be 4; if the indicator is present once a year then the likelihood value assigned will be 2; and if the indicator is known, or thought, to occur rarely such as once every five or more years, then the value assigned will be 1. Once the likelihood value has been assigned on the form the Hazard Assessment Score is determined by multiplying the Likelihood Value by the Severity (which is pre-loaded on the form) to give the overall Hazard Assessment Score.

The Hazard Assessment Score is an index and there is no implied mathematical relationship to risk. The Hazard Assessment Score is a convenient way of prioritising actions or interventions so that resources are effectively targeted to those areas that pose the greatest potential risk of contamination to the source under investigation.

If the Hazard Assessment Score is **16** or greater for an individual component then the issues associated with that component should be considered as a priority for remedial works to reduce the hazard experienced by the supply.

The value of 16 is considered to be appropriate when only a rare event may produce a catastrophic outcome, e.g. sewage effluent discharge to adjacent watercourse (item 38). However, the presence of sewage effluent discharge to an adjacent watercourse were to occur more frequently than once every 5 years or more then the Hazard Assessment Score would reflect this change by increasing the score, and hence flag the requirement to take appropriate action to reduce the likelihood of the occurrence.

Hazard assessment matrix

	Severity of consequences				
Likelihood	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	16	32	64	128	256
Likely	8	16	32	64	128
Moderately likely	4	8	16	32	64
Unlikely	2	4	8	16	32
Rare	1	2	4	8	16

Each of the indicators in Section D will now be considered in turn.

Section D(i) General site survey

Item 23 – Evidence or history of poor drainage causing stagnant/standing water

If standing water can be seen present around the well head area or if there is evidence of standing water having been present, e.g. mud or vegetation consistent with marshy ground such as reeds, then the hazard should be scored as being present and the risk characterisation assigned as "Yes". If there is a suggestion that the likelihood of the standing water being present (or evidence of having been present) is a long-standing occurrence then the likelihood score for the hazard assessment should reflect this.

Item 24 – History of livestock production (rearing, housing, grazing) – including poultry

Any evidence of domestic livestock production being present (either directly by the presence of animals in the vicinity of the supply) or indirectly (through presence of broken ground around the supply or the presence of animal droppings around the supply) should result in the risk characterisation being scored as "Yes". Further investigations will be required to decide on the persistence of such presence in order to allow the hazard assessment likelihood score to be accurately assigned.

Item 25 – Evidence of wildlife

Any evidence of wildlife, mammals (rabbits, deer, etc.), birds (gulls, geese, migratory birds, etc.), reptiles (newts, frogs including spawn) etc. at the source could indicate the potential for contamination of the supply either from faecal material or from carcasses falling into the supply. If evidence of wildlife is found then the risk characterisation should be scored as "Yes". Account should be taken of the likely frequency of the presence of wildlife, e.g. a rabbit warren nearby will suggest permanent presence; migratory birds will suggest a seasonal presence which will require the suggested likelihood values to be moderated to reflect this seasonal presence by raising the once per year score of 2 to 4.

Item 26 – Surface run-off from agricultural activity diverted to flow into source/supply

This indicator is intended to deal with field drains and other drainage systems employed on agricultural land which may be connected to the source or supply. The indicator also deals with instances where there is overland flow from agricultural land that ends up in a watercourse or entering the source and potentially contaminating the supply, e.g. applied slurry where there is potential for it to be washed into field drains or watercourse or similar drainage systems. If there are drainage systems or similar present in areas of agricultural activity then the risk characterisation response will be "Yes". The likelihood value will be based on the probable time the land is being subjected to agricultural applications.

Item 27 – Soil cultivation with wastewater irrigation or sludge/slurry/manure application

This indicator differs from Item 26 in that there will be active application of the materials in conjunction with the disruption of the soil itself, e.g. via ploughing or sub-soil injection. If such activities are considered to be undertaken then the risk characterisation will be "Yes". The likelihood value will be based on the probable time/duration that such activities occur at.

Item 28 – Disposal of organic wastes to land

This indicator deals with any other organic waste, e.g. abattoir wastes or "blood and guts". The scoring for this indicator will be irrespective of whether there has been disruption of the soil. If such activities are considered to be undertaken then the risk characterisation will be "Yes". The likelihood value will be based on the probable time/duration that such activities occur at.

Item 29 – Farm wastes and/or silage stored on the ground (not in tanks or containers)

If there are middens or areas where silage are being stored in polyethylene bags (or equivalent) or other farm-derived wastes where there is no bunded storage and there is the potential for spillage entering drainage systems, then this item should be scored such that the risk exists. If the storage appears to be a permanent or long-term feature then the hazard assessment should be scored as almost certain (value 16) or likely (value 8).

Item 30 – Remediation of land using sludge or slurry

In some areas brownfield sites or derelict land will be remediated using sewage-derived sludge or slurry or similar materials. The rate of application will typically be higher than those used in Item 27 and this should be borne in mind when assessing both the risk characterisation and hazard assessment parts of the risk assessment form.

Item 31 – Forestry activity

Forestry activities have the potential to cause significant disruption to water supplies to the area in which they are being undertaken. The disruption may occur when forests are being planted, when thinning activities are being carried out or when the timber is being harvested. Account should be taken of the maturity of the forest and the likelihood of activity starting or changing during the period of the risk assessment. If the risk assessment is not scheduled to be time-limited then the potential for disruption should be highlighted.

Item 32 – Awareness of the presence of drinking water supply/source by agricultural workers

If the awareness of the presence of a drinking water source is absent from those agricultural or forestry workers who may be available to be interviewed or if there is evidence of disregard for the presence of such sources, e.g. ploughing to the margins of a well or spring, then the risk characterisation will be "No" or "Don't Know" to reflect the high level of risk such a lack of knowledge may be introducing to the supply. Lack of awareness on the hazard assessment should be scored as almost certain (16) again to reflect the potential for introduction of harmful materials or disturbance of the supply.

Item 33 – Waste disposal sites (including scrap yard, car yard, rubbish and hazardous waste disposal, landfill or incinerator including on-farm incineration)

The presence of disposal sites may influence the quality of water at the source by allowing the introduction of microbiological or chemical contaminants into the supply, depending on the nature of the materials being disposed. Incineration is also included in this section as the question of both airborne material and disposal sites for ash residues need to be considered when making the overall assessment of the likely impact of this item on the water quality at the source. If any waste disposal sites are present then the risk characterisation will be "Yes" and the associated hazard assessment should reflect the permanent nature (or longevity) of such sites in terms of their potential to continue to release polluting materials for many years after their immediate use has ceased.

Item 34 – Disposal sites for animal remains

This definition includes on-farm carcass disposal, burial pits, e.g. arising from foot-and-mouth disease, and vicinity to human burial sites such as graveyards or family plots away from traditional burial sites. If any disposal sites are present then the risk characterisation will be "Yes" and the associated hazard assessment should reflect the permanent nature (or longevity) of such sites in terms of their potential to continue to release polluting materials for many years after their immediate use has ceased.

Item 35 – Unsewered human sanitation including septic tanks, pit latrines, soakaways

If unsewered human sanitation is present near the source then there is considerable potential for raw human sewage to contaminate the source of the drinking water supply. Great care must be taken when assessing the positioning of septic tanks as well as their condition (maintenance), the areas where the soakaway is positioned, the condition of any pipes leading from the septic tank to the soakaway (is there evidence of different vegetation which may indicate a leaking pipe) and the discharge point of the soakaway if this is directed towards a surface receiving water. Similarly if there are pit latrines in use, e.g. at a campsite or areas where chemical toilets are discharged, the area surround the disposal point or latrine should be considered carefully in terms of allowing contact with the source. The contact may not be visible as there may be some connectivity underground and so some thought must be given to the soil leaching potential of the site.

Item 36 – Sewage pipes, mains or domestic (e.g. leading to/from septic tank)

In addition to Item 35 consideration must be given to the path that sewers may take. If the line of the pipe intersects with the area from which the drinking water source is being recharged (the area from where the water is being drawn) then there is the potential that any failure (leak) from the sewer or similar pipe will introduce raw sewage directly into the water source. It is unlikely that the path of such pipes will be clearly visible and so some care in interpreting the area will need to be taken, e.g. areas where the vegetation/ground appears to be drier indicating that there is a pipe buried below the surface or if there is a fracture in the pipe areas that would not naturally be damp or areas where there is vegetation indicative of wet or nutrient enriched conditions such as reeds or nettles.

Item 37 – Sewage effluent lagoons

Sewage effluent lagoons bring the potential that leaking material from the lagoon may enter the soil and pass into the groundwater providing a direct route for the contamination of the source with raw sewage. Farm effluent lagoons may be viewed as being the same in terms of the risks posed to the source when assessing the scoring values to be assigned.

Item 38 – Sewage effluent discharge to adjacent watercourse (where present)

While some aspects of this item may be identified when reviewing Item 35, Item 38 draws attention to the potential for sewage effluent discharges from a variety of sources such as municipal wastewater treatment works, septic tanks, privately owned/operated sewage treatment systems or reed beds. If there is evidence of discharge to a watercourse that is adjacent to the source of the supply under investigation then the risk characterisation should reflect the circumstances and "Yes" should be recorded. Similarly, for the hazard assessment the permanent, or semi-permanent, nature of the hazard should be reflected in the likelihood value assigned which should be almost certain (value 16).

Item 39 – Supplies or wells not in current use

If there are supplies or wells not in use that are associated with the supply under investigation then the potential for material to be introduced directly into the source water exists. For example, if an older, out of use well is located adjacent to the currently operational well and the out of use well is not properly sealed then the opportunity exists for faeces or animals to enter the older well and contaminate the same source of water that the new well is drawing from.

Item 40 – Evidence of use of pesticides (including sheep dip) near source

If disposal sites for pesticides (including sheep dip) are known to be close to the source under investigation then the risk characterisation should reflect this as should the hazard assessment. If there is evidence of the area having been used for dipping sheep (with dip tanks, fanks, etc.) then this evidence should be taken into account when assessing the site.

Item 41 – Evidence of industrial activity likely to present a contamination threat

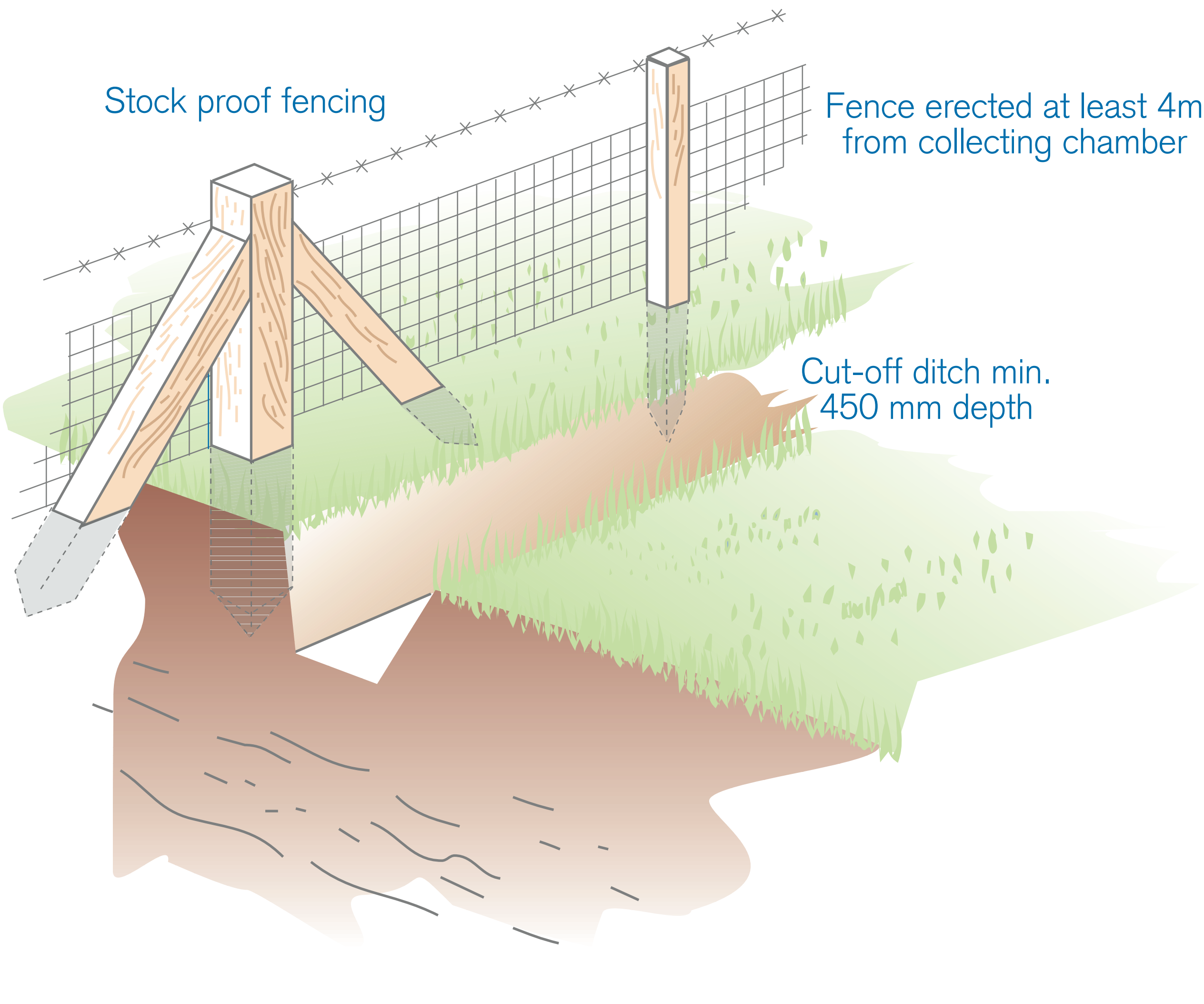
If there is evidence of the area adjacent to the source having been used for industrial activity which may pose a contamination threat then this should be recorded on the risk assessment. Such activities may include chemical or pharmaceutical production, mineral or other extraction such as coal mining, areas where old fuel tanks may have been located or may still be in place either below or above ground, or industries where solvents would have been in use and may have been disposed of on to the ground, e.g. electroplating, metal working or electronics. This list is not exhaustive and so appropriate interpretation of the previous use to which the site may have been put will be required by the investigation officer.

Section D (ii) Supply survey

Item 42 – No stock proof fence (to BS1722 or equivalent) at a minimum of four metres around the source

Figure 9.1 identifies a fence to BS1722. The fence must be erected at a minimum of four metres around the source to ensure that any animals who may frequent the area around the fence, e.g. for scratching, do not have an opportunity to contaminate the area of the source with faecal material which may be deposited. If there is no fence or the fence is deficient in terms of the distance or specification of construction (i.e. not fit for purpose) then the risk characterisation will be “Yes” and the hazard assessment will reflect the permanent nature of the deficiency.

Figure 9.1 Fence and ditch



Item 43 – No suitable barrier present to prevent ingress of surface flows into the well (e.g. cut-off ditch lined with impermeable material, steep incline/decline such as embankments, appropriate walls, etc.)

The well head areas need to be protected from the ingress of surface flows (such as flooding). This can be accomplished in a variety of ways such as having a cut-off ditch surrounding the well with an impermeable lining and a suitable discharge downslope from the well head area or conveying the water away from the immediate vicinity of the well head. Another method would be to have the well head area built up such that it protrudes above the ground level and the slopes convey surface flows away from the well head. It should be borne in mind that surface flows, while including flooding, are not restricted to flooding. In certain ground conditions the impermeable nature of the soil during periods of dry weather will produce a surface akin to concrete which will result in rainfall, such as a heavy summer downpour, running over the surface rather than percolating into the soil. Such conditions need to be protected against by use of appropriately engineered well head arrangements. If suitable arrangements are absent from the site under investigation then the risk characterisation will be scored as "Yes" with the hazard assessment reflecting the permanent nature of the deficiency by scoring the likelihood as almost certain (value 16).

Item 44 – No concrete apron, a minimum of 1200 mm, sloping away from the well and in good condition

The presence of a concrete apron is necessary to prevent soil (or faecal material present) from splashing to top of the well. If there is an unsuitable cover on the well such splashing may allow the direct entry of contaminating material into the well and hence into the drinking water supply. If suitable arrangements are absent from the site under investigation then the risk characterisation will be scored as "Yes" with the hazard assessment reflecting the permanent nature of the deficiency by scoring the likelihood as almost certain (value 16).

Item 45 – The top of the well not 150 mm above the apron described in [44]

This requirement is to ensure that in all but extreme weather conditions there will be very little opportunity for the well head to be inundated with surface flows. If suitable arrangements are absent from the site under investigation then the risk characterisation will be scored as "Yes" with the hazard assessment reflecting the permanent nature of the deficiency by scoring the likelihood as almost certain (value 16).

Item 46 – No reinforced pre-cast concrete cover slab, or equivalent, in satisfactory condition with a watertight, vermin-proof inspection cover present to BS497 (lockable steel type or equivalent) with or without ventilation

A properly constructed and well-fitting well cover is essential to maintaining the integrity of the source. The cover should be watertight to prevent ingress of rainwater; vermin-proof to prevent animals from entering the well (vermin-proof means having no holes, remember a field mouse can easily enter a space where a pencil will fit); and lockable to prevent malicious (or just curious) persons gaining access to the supply. If ventilation is present ensure that it is also vermin-proof with appropriate wire mesh in place. If suitable arrangements are absent from the site under investigation then the risk characterisation will be scored as "Yes" with the hazard assessment reflecting the permanent nature of the deficiency by scoring the likelihood as almost certain (value 16).

Item 47 – The well construction in an unsatisfactory state-of-repair

The fabric of the well itself (i.e. below ground) should be in good repair to prevent any short-circuiting with water entering from or near the soil surface. If suitable arrangements are absent from the site under investigation then the risk characterisation will be scored as "Yes" with the hazard assessment reflecting the permanent nature of the deficiency by scoring the likelihood as almost certain (value 16).

Item 48 – Supply network constructed from material liable to fracture (e.g. asbestos concrete, clay, etc.)

If the network of pipes that lead from the well are constructed of materials that are liable to deterioration or fracture, e.g. if heavy farm machinery is driven over the top of the pipeline, then the integrity of the system will be lost and potentially polluting material may enter the pipes through the fractures or the whole supply will be lost through pipe blockages. If it is considered likely that such materials have been used for all or part of the pipework being used to convey water from the source then the risk characterisation must reflect this with a "Yes" score and the hazard assessment must similarly reflect the permanent nature of the hazard by scoring as almost certain (value 16).

Item 49 – Intermediate tanks (e.g. collection chambers, holding tanks, break-pressure tanks) are not adequately protected (i.e. do not have protection described in [42] to [45])

The level of protection for all intermediate tanks or similar structures should be equivalent to that recommended for the source itself as the potential for contamination to enter the system via such intermediate points is just as high as for the source itself. If any of the intermediate tanks or similar structures are deficient in respect of the requirements provided in Items 42 to 45 then this should be reflected in the risk characterisation and hazard assessment. If there is more than one intermediate tank or similar structure, the deficient ones should be noted in section F and cross-referenced with the diagram provided in Section B (Item 6).

Item 50 – Junctions present in the supply network, particularly supplying animal water systems, have no back-siphon protection

If there are provisions made to provide water to animal watering troughs or other connections where back-siphonage may occur, e.g. from a hosepipe permanently connected, there is potential for the contents of the trough or container to be back-siphoned into the distribution pipe and for the contents of the trough or container to enter the supply. Clearly the contents of a cattle watering trough or a barrel into which the end of a hose has been dangled for some weeks will do little to improve the quality of the drinking water being provided. It is essential that where connections are made on the system prior to the first taps to be used for domestic (potable) consumption appropriate back-siphonage prevention devices are fitted. If they are not or there is no evidence to support claims that they have been fitted then the risk characterisation must reflect this with a “Yes” response. Similarly the hazard assessment should highlight the permanent nature of the situation with an almost certain (value 16) rating.

Item 51 – No maintenance (including chlorination) has been undertaken in the previous 12 months

If the system has had no maintenance undertaken in the 12 months preceding the investigation then this suggests that the level of care and attention required to ensure the system is operating as effectively as possible is lacking. If this is the case then the risk characterisation score should reflect the situation encountered and a “Yes” response entered. The hazard assessment likelihood score should also reflect the situation with an unlikely score (value = 2).

Item 52 – If present, header tank within the property(s) does not have a vermin-proof cover

Many properties served by a private supply, particularly those on smaller supplies, will have a header tank within the property to provide sufficient water pressure for the household and also to act as a balancing tank to equalise the pressure differences experienced in the system when pumps are operating to bring water into the property. However, if the header tank is not properly constructed and protected then any material that may be present in the roof space, whether that be dust or mice or bat droppings, will have the potential to enter the tank and so contaminate the supply. If the property has a header tank which feeds the main domestic (potable) tap, usually the kitchen cold water tap, and that tank is not properly protected then the risk characterisation score should reflect the situation encountered and a “Yes” response entered. The hazard assessment likelihood score should also reflect the situation with an almost certain score (value = 16). If the header tank is present and unprotected but does not feed the main domestic (potable) tap then the risk assessment can be moderated but the risk to other taps in the property should be highlighted in Section F and noted on the diagram at Section B.

Item 53 – Header tank has not been cleaned in the last 12 months

If the header tank has an appropriate vermin-proof cover (Item 52) it will still require to be maintained by cleaning at least every 12 months to prevent the build-up of slime and scum which will naturally grow on the tank walls. If the tank has not been cleaned in the 12 months prior to the investigation then the risk characterisation score should reflect the situation encountered and a “Yes” response entered. The hazard assessment likelihood score should also reflect the situation with an unlikely score (value = 2).

Item 54 – Any point of entry/point of use treatment equipment has not been serviced in accordance with the manufacturer’s instructions in the last 12 months

If any point of entry/point of use devices have had no maintenance undertaken in the 12 months preceding the investigation then this suggests that the level of care and attention required to ensure the system is operating as effectively as possible is lacking. If this is the case then the risk characterisation score should reflect the situation encountered and a “Yes” response entered. The hazard assessment likelihood score should also reflect the situation with an unlikely score (value = 2).

Item 55 – If present ultraviolet (UV) lamps are not operating

While ultraviolet disinfection systems if properly installed and maintained are an effective treatment option to prevent potentially harmful micro-organisms from causing disease they can provide a false sense of security if they are not looked after. A particularly common fault is for the UV bulb to stop operating. The UV bulb is at the heart of the installation and is responsible for the disinfection process. If there is not an automatic warning system on the installation then the loss of the bulb could go undetected. Similarly if the bulb has not been changed in accordance with the manufacturer's recommended replacement period then the efficiency or operation of the bulb could be impaired or have ceased to function at all. It is important, therefore, to assess if the UV bulbs (lamps) are operating on a UV system at the time of the inspection. If they are not operating then the risk characterisation score should reflect the situation encountered and a "Yes" response entered. The hazard assessment likelihood score should also reflect the situation based on an assessment of when the UV bulb (lamp) ceased to function.

Item 56 – Is there a noticeable change in the level and flow of water throughout the year

This question deals with the issue of constancy of supply as it relates to the quality of the source. If the source is highly dependable and provides adequate levels of water throughout the year then it is likely that the source is not under direct influence from either the surface or from prevailing climatic conditions. On the other hand, if the supply is "flashy" and changes with the weather then it is likely that it is under the influence of surface flow and prevailing weather conditions which increases its vulnerability to contamination from the surface. If there are noticeable changes in level and flow the risk characterisation response will be "Yes". The hazard assessment likelihood in these circumstances will be almost certain (value = 16). This circumstance may also cause the investigating officer to reconsider if the supply is in fact a well or if it would be better treated as a surface-derived supply.

Item 57 – Is there a noticeable change in the appearance of the water (colour, turbidity – cloudiness) after heavy rainfall or snow melt

If the supply is under the influence from either the surface or the weather then the quality experienced cannot be guaranteed if there are conditions prevailing which make surface flow (e.g. flooding) or adverse weather conditions likely. If there are noticeable changes in the appearance of the water then the risk characterisation response will be "Yes". The hazard assessment likelihood in these circumstances will be dependent on whether weather or surface influence is considered the most likely cause.

Section D(iii) Soil leaching risk survey

4.6 Background to soil and land use factors underpinning the assessment of groundwater vulnerability

4.6.1 Introduction to concepts of vulnerability and risk associated with soils and groundwaters

Wherever groundwater is present there is potential for contamination through human activity. No soil or geological strata is completely impermeable and likewise no pollutant is completely immobile. The concept of groundwater vulnerability, or the susceptibility of groundwater to microbiological contamination from surface or near-surface derived pollutants, recognises that the potential risk of contamination is greater under certain hydrological, geological, land use and soil conditions than others. In site-specific terms, groundwater contamination depends on the natural or man-made characteristics of the site in that the ease with which the potential pollutant can migrate to the underlying water table or spring source is dependent upon the physical, chemical and biological properties of the soil and rocks pertaining to the site. The factors which define the vulnerability of groundwater resources to a given pollutant or activity, acting singly or in combination, are as follows:

- presence and nature of the overlying soil
- presence and nature of the drift deposits
- nature of the solid geological strata within the unsaturated zone
- depth to groundwater
- nature of contaminant.

It must also be recognised that contamination can only occur if a potential pollutant is present, therefore land use is a critical factor. Similarly, the intrinsic factors listed above can be modified by man-made structures or excavations.

The key to groundwater vulnerability classification lies in the unsaturated zone, namely that volume of soil and unsaturated material situated above the water table. In the absence of major fissures or cracks within that zone, water movement is essentially slow, being confined to interconnected soil pores within an aerobic environment. However, the rate of this movement depends on the moisture content of the soil and therefore varies throughout the year. The overlying soil provides the potential for interception, adsorption and elimination of bacteria and viruses. Where vertical fissures occur or shattered rock is close to the surface, there is the potential for rapid flow of micro-organisms to groundwater and therefore a reduction in the ability of the soil and substrate to act as a barrier or filter.

4.6.2 Use of soil information for both general protection of groundwater resource and specific protection of individual water supply sources

4.6.2.1 Introduction

It should be stressed that a full assessment of the risks posed to groundwater by potentially polluting activities on the land surface can only be achieved by actual field investigation, which, in many instances, will involve detailed soil and hydrogeological investigations both close to the water supply source and often within a wider field of interest in relation to the zone of influence and capture zones (see section 3.3). Such investigation would, for example, be relevant to determine the suitability of a site for a new water supply. Where this is deemed necessary expert assistance should always be sought. It is also possible to assess groundwater vulnerability without field studies from close examination of existing environmental data, although this approach is not without limitations.

4.6.2.2 Presence and nature of overlying soil

Soil is the thin upper layer of the earth's crust and is the product of complex interactions between five recognised soil forming factors: namely the action of **climate, living organisms** and **topography** on the **parent material** over a period of time. Development of soil arises primarily from the accumulation of mineral grains from either the physical or chemical weathering of rocks and the addition of organic material (humus) from decaying vegetation. As plants become established, topsoils develop as organic matter is incorporated into the soil and nutrients are released from minerals to the soil solution where they can be taken up by plant roots. Gradually, the soil matures at a rate which is dependent upon the local climate.

A vertical section through soil, as seen in the face of a pit or excavation, is referred to as a soil profile which exhibits a number of distinct layers or horizons. These are the product of soil forming processes taking place within the soil matrix. Where soils are uncultivated, there is usually a complex assemblage of horizons but, for convenience, it is often appropriate to talk of a three-fold division into:

a) topsoil - this is usually a dark brown to dark greyish brown colour due to the incorporation of decomposed organic material. This layer has a high biological activity resulting in an intimate mixing of mineral and organic material to give uniform colours.
b) subsoil - this is essentially pedogenically altered parent material where soil forming processes have been active to break down minerals and reorganise the soil material into aggregates of bound soil particles. Organic material is much less abundant than in the topsoil.
c) parent material - the relatively unaltered material at the base of the soil profile where the soil forming processes have had least influence. The depth to parent material within the soil depends not only on the resistance to weathering but also on the length of time the weathering processes have been active.

4.6.2.3 Presence and nature of the drift deposits

In many areas drift deposits are present overlying the solid geology and are characterised, in many instances, by vertical and horizontal variation both in thickness and lithology. Therefore, where the drift is of substantial thickness and of low permeability it can provide an effective barrier to downward percolation of any pollutant which has passed through the soil zone. However, detailed and reliable maps of drift deposits are unavailable on a national scale and where there is uncertainty about drift composition and thickness, they are treated as a special case in any groundwater vulnerability assessment. In instances where the low permeability drift deposits are sufficiently thick (up to 5 metres) to afford complete protection to underlying major or minor aquifers from surface downward pollutants, such aquifers are not depicted on the map.

4.6.2.4 Nature of solid geology within the unsaturated zone

Geological strata with a groundwater content in exploitable quantities are referred to as aquifers, in contrast to rocks without the ability to transmit substantial quantities of water which are classed as non-aquifers. All aquifers vary in their general and hydraulic characteristics and in the unsaturated zone such variation determines the vulnerability of the groundwater to pollution. Permeable strata are classified, for convenience, into highly permeable aquifers and moderately permeable aquifers, the former having generally less capacity for attenuating contaminated recharge entering at the surface. A third category of weakly or non-permeable aquifers has also been recognised. Within the Scottish context the principal aquifers are shown in Table 3.1.

4.6.2.5 Soil classification

The systematic mapping for soils in Scotland began in 1947 with the aim of understanding their distribution and characteristics. By 1987 most of the arable soils in Scotland had been mapped at 1:25 000 scale and for publication at 1:63 360 scale, and the entire country had also been mapped at the reconnaissance scale of 1:250 000. The system of soil classification used in these series of maps is based principally on morphological features recognisable by surveyors in the field and takes only limited cognisance of chemical characteristics. It relies, therefore, on the recognition of central concepts of soil classes and the comparison of soil profiles within them. The lowest commonly used category in the classification system, and the unit shown on the most detailed maps, is the Soil Series, of which there are over 800 identified. Each Soil Series has a limited and defined range of diagnostic properties that distinguish it and allow it consistent national recognition in accordance with a definition as follows: a group of soils similar in character and arrangement of horizons within the profile and developed on the same soil parent material. Soil Series are named after the place where they were first described or are extensive. For example, Countesswells Series is developed entirely on glacial till derived from granite, has the morphological characters of a humus-iron podzol and was first mapped at Countesswells, within the grounds of the then Macaulay Institute for Soil Research, Aberdeen.

A Soil Association is a grouping of Soil Series in which the soils are developed on similar parent materials but differ in characteristics related to local variations in texture, relief and hydrologic conditions. They are generally characterised and named after the most frequently occurring component Soil Series.

Allied to the soil mapping is an extensive database of measured and observed soil physical and chemical properties which allow identification of several important diagnostic properties which influence the movement of pollutants in soil. These factors can be considered as follows:

a) slowly permeable layer - the presence of a dense, compact layer within the soil impedes the downward percolation of water with resultant intermittent waterlogging within the soil material. If present, slowly permeable layers can prevent contaminants within the soil solution moving vertically but careful consideration should be given to possible lateral movement downslope into receiving basins where problems may arise. Waterlogging is often associated with these layers, either within the layer itself or in the layers immediately above. Where waterlogging occurs the strong brown colours normally found within the subsoil of free draining soils are replaced by drab colours, greys and generally intense mottling. Horizons with these morphological characteristics are referred to as gleyed horizons. In some cases these slowly permeable layers can exist without clear evidence of waterlogging, for example, on slopes or mounds, or where the soils are very red in colour or in drier parts of the country. Either this layer is ineffective in intercepting downward percolating water, or other soil, site and climatic factors are operating to reduce waterlogging above it. As it can be difficult to interpret the degree of protection afforded by these situations precisely within the field or from existing soil maps, such soils are generally considered to give only medium protection to groundwater supplies.

b) gley characteristics without the slowly permeable layer - where gley characteristics are present and compact, dense subsoil horizons compatible with a slowly permeable layer are absent, it is likely that the soil is affected by groundwater. Given that this groundwater table is evident within the soil profile then even relatively short-lived potential contaminants entering the soil are likely to reach the groundwater. Such soils should be considered as affording a poor level of protection and should be placed in the high risk category.

c) soil porosity - under normal conditions soils develop a structure where the porosity allows gradual percolation of the soil solution through the soil matrix. In some cases the cracks and pores can be of sufficient width that they form pathways for rapid downward movement of water when the soil is unsaturated, termed by-pass flow. Liquid discharges entering at or near the surface of such soils have the potential to rapidly by-pass the upper, most attenuating soil layers. Similarly, a proportion of any diffuse-source contaminants dissolved in the soil water fraction are likely to move rapidly out of the upper soil layers as soon as there is a significant rainfall event. In such situations, if there are no slowly permeable layers present and the subsoil is shallow over shattered rock or gravel, or is seasonally affected by groundwater (as described in b above), then a significant proportion of any potential contaminants entering the soil are likely to move rapidly to underlying strata or to groundwater. These soils are of high risk.

d) soil adsorption capacity - in simple terms, the ability of a soil to adsorb contaminants or bacteria depends on several factors with clay content and organic matter content being of particular significance. These soil particles carry a net negative surface charge which allows the chemical bonding of positively charged ionic pollutants and certain microorganisms. Once bound, these contaminants can be chemically degraded through the normal processes of weathering within the soil. Thus the lower the clay and soil organic matter content, the lower the ability to attenuate potential contaminants.

e) soil parent material - the presence of rock, shattered rock or gravel within the soil profile indicates the presence of geological material. Where such material occurs within the soil profile, any potential contaminant entering the soil is likely to reach groundwater relatively quickly and, because the ability of geological material to attenuate potential pollutants is far less than that of weathered soil material, the potential for groundwater contamination is greater.

4.6.3 Use of groundwater vulnerability maps

4.6.3.1 Introduction

A methodology for classifying soils into three leaching potential classes has been developed for use in groundwater vulnerability maps[22] as identified for use in Scotland[23]. This classification also embraces all Soil Series which have been mapped to date within Scotland, with each soil series being assigned a value corresponding to the ease with which a representative pollutant could move through the soil. This representative pollutant is assumed not only to be soluble in water so that it moves through the soil column in solution but also able to adsorb or stick onto clay particles and organic matter. Whilst it is recognised that not all pollutants have these characteristics, the classification does provide a generalised picture and many of the central concepts are valid in the assessment of the risks of microbiological contamination.

4.6.3.2 Soil leaching potential categories

Palmer *et al.*[22] published a classification which defines three main categories of leaching potential ranging from high to low. These classes were derived primarily for assessing the vulnerability of major aquifers to contamination from a wide range of pollutants and are as follows:

Class 1 High vulnerability or soil leaching potential

Soils in which water has the potential to move relatively rapidly from the surface to underlying strata or to shallow groundwater. This may be because there is fissured rock or gravel near to the soil surface, or because the soil has a low volumetric water content, or because, at certain times of the year, there is either groundwater near to the soil surface or there is by-pass flow through the upper soil layers. In such soils there is a high risk that, at certain times of the year, contaminants will move rapidly through the soil with little time for attenuation. The high category has been subdivided into four classes with soils in the H1 subclass having a greater soil leaching potential than H2, etc.

H1 Soils with groundwater at shallow depth. Soils with rock, rock-rubble or gravel at shallow depth. Undrained lowland peat soils with permanently wet topsoils.
H2 Sandy soils with low topsoil organic matter content.
H3 Sandy soils with a moderate topsoil organic matter content. Soils with rock, rock-rubble or gravel at relatively shallow depth within the soil profile.
HU Soils in urban areas and areas of restored mineral workings for sand/gravel.

Class 2 Intermediate vulnerability or soil leaching potential

Soils in which it is possible that significant amounts of water will penetrate to below two metres in depth. In such soils contaminants may move vertically through the soil, but are likely to be substantially attenuated by the processes of biological and chemical degradation, adsorption and dilution. The intermediate category has been divided into two subclasses; mineral soils are placed in I1 and peat soils in I2.

I1 Deep loamy and clayey soils unaffected by marked seasonal waterlogging, with a topsoil of low or moderate organic matter content.

I2 Lowland peat soils which have been drained for agricultural use.

Class 3 Low vulnerability or soil leaching potential

Soils in which excess water movement is predominantly horizontal, with little likelihood of any contaminants penetrating below two metres in depth. Where such soils fringe those in classes 1 and 2 however, lateral drainage may contribute to groundwater recharge and hence potential pollution. There is no subdivision of the low category of soil leaching potential.

L Soils with a dense subsoil which restricts downward water movement. Upland soils with a permanently wet peaty topsoil.

4.6.3.3 Benefits derived from groundwater vulnerability maps

In England and Wales a series of such maps have been published by the Environmental Agency at the scale of 1:100 000. Similar maps within Scotland are being produced by the Scottish Environmental Protection Agency. In simple terms, the maps contain three layers of information which from the surface downwards include:

- soil leaching potential classes and subclasses;
- presence, where applicable, of low permeability drift deposits at the surface above aquifers by stipple ornament;
- permeability of the geological deposits (major/minor/non-aquifer; see Table 3.1).

Together these layers of information produced 27 different vulnerability combinations, some of which must be interpreted with caution because of limitations within the following:

- soil data, in particular differences in map scale and variability within mapping units;
- drift data, in particular possible mismatches with soil information;
- geological data, in particular lack of data on the variability of mapped units, inadequate description of drift deposits and difficulties of portraying multi-aquifers as a single unit.

However these vulnerability combinations provide critical information for assessing the level of protection afforded to shallow groundwater by the soil and drift deposits, in particular the soil leaching potential. This information has been systematised allowing the rapid assessment of the protection afforded by the soil to private water supplies in terms of microbiological contamination. This information can be used to give assistance to site specific assessments in the area immediately surrounding a water supply when used in conjunction with soil inspection pits. Alternatively, and where the exact location of the source is not known, or where there is a substantial catchment area associated with the supply, interpreted soil maps (as exemplified in Appendix C) can be used. This approach has the benefit that the interpretation of the soils information is made by experts and it has a spatial component which takes account of the fact that the supply should be protected within a 50 metre radius. Either soil interpretation or interpretative soil maps must be used in conjunction with information on land use. Even water supplies which are classified as having a soil which offers poor protection may not become contaminated if the land use in the surrounding area precludes the introduction of a contaminant.

4.6.3.3 Other factors which influence groundwater vulnerability

There are a series of site-specific factors which can contribute towards possible groundwater contamination but, in most instances, it is not possible to quantify the degree of risk. Examples of these are listed below:

- Physical disturbance of aquifers and groundwater flow. These activities lead to the disturbance of the physical barrier offered by the soil and may provide preferential pathways of water (and contaminant) movement to shallow groundwaters. These include: most forms of groundwater extraction; landfill operations; nearby borehole construction; any activity which interconnects naturally separate aquifers; existing or modified field drainage schemes that intercept recharge water; quarrying and gravel extraction both above and below the water table.

- Waste disposal to land. Many waste disposal practices have the potential to cause groundwater contamination. In this respect, the environment protection agencies have laid down certain regulations, many of them statutory, to ensure specific objectives. For example, there will normally be objections at the planning stage to waste disposal activities which extend to or below the water table within prescribed limits of a source. However, the disposal of slurries and other wastes on agricultural land in the vicinity of a private water supply is not subject to the same regulation, although codes of good agricultural practice do exist.

- Contaminated land, being land currently or previously used in connection with the following activities: sewage treatment works; landfill sites and other waste disposal and recycling activities; waste lagoons. The environmental agencies will seek to protect water supplies where any of the above activities are to be found in close proximity to a water source.

- The application of liquid effluents, sludges and slurries to land. Three categories of waste are recognised, being controlled wastes (industrial effluent sludges, both organic and inorganic in nature), sewage sludges and agriculture waste. Where the environment agencies consider that any of these deposits will give rise to a significant risk of polluting groundwater or surface water, there will be a presumption against spreading or compliance with existing environmental legislation. Wherever possible, farmers should have a waste management plan for their farm with information relevant to suitable land available for spreading liquid effluents, sludges and slurries.

- Discharges to underground strata. Three areas of concern have been identified:

  - sewage effluent discharges including septic tank and sewage treatment plant;
  - effluents from individual properties or small housing estates;
  - trade effluent discharges;
  - surface water discharges which include contaminated run-off from roofs; and
  - impermeable areas such as roads, car parks, storage areas, etc.

- Diffuse pollution of groundwater. Diffuse pollution refers to pollution spread over time and space and caused by mechanisms other than local and specific discharges or events. Such pollutants are usually at much lower levels than other sources and are therefore at lower concentrations in the soil water. However, the build-up over a long period can generate potential problems. Diffuse pollution varies in character between urban and rural areas. Within the former, the two most notable examples of pollution arise from industrial sites and discharges from sewage systems. In contrast, within rural areas, the pollutant is not from an individual point discharge but arises from activities connected with intensive arable and livestock farming.

- Additional activities or developments which pose a threat to groundwater quality include miscellaneous activities such as: storage of farm wastes and intensive livestock housing; graveyards and animal burial sites; sewage works; storm overflows.

4.6.3.4 Conclusion

Soil can offer protection to the shallow groundwaters associated with many private water supplies while a combination of soil and geological factors need to be considered when assessing deep groundwaters. The necessary soil information needed to make such assessments is obtained either by simple site inspection or from interpretations of soil maps; however, both the current and past land use practices will have a bearing on the ability of the soil to function as a filter and buffer to potential contaminants and on the presence of these contaminants. Therefore, land use remains a key component in any site appraisal.

4.6.4 Soil and land use factors underpinning the assessment of surface water vulnerability

4.6.4.1 Introduction

In some instances, private water supplies are fed by surface waters. The role of soils in offering protection to these sources is much more limited than that described above for groundwaters but nonetheless, differences in soil type will have an influence on the risk of microbiological contamination of these waters. Clearly, the soil has no role where the contaminant is deposited directly into the water body, but where a potential contaminant is deposited near to a water body, then there are a number of factors which affect the risk of contamination. The main factors are surface run-off which washes the contaminant into the water body and stream extension (both laterally and upslope) which entrains the contaminant.

The degree of surface flow is dependent on the intensity and duration of rainfall, the soil type, slope and land use. In general terms, high intensity rainfall, like that associated with thunder storms, is likely to initiate overland flow in most soils as the infiltration rate of the soil is exceeded by the rainfall intensity. More recently, it has been recognised that low intensity rainfall over a prolonged period of time can also lead to overland flow. In both cases the soil type can have a major influence on the amount of rainfall that can be absorbed before the initiation of run-off. Soils with open, porous structures and with no slowly permeable layer will be able to absorb more than shallow soils or those with slowly permeable layers near to the soil surface. The land use can act as an interceptor for rainfall (for example, a forest), reducing the actual amount that reaches the soil surface as well as providing the opportunity for the presence of potential contaminants (for example, open moorland which is grazed by domestic and wild animals).

Stream extension is the process whereby the apparent stream network as seen under dry conditions extends during rainfall, with the development of ephemeral streams and rivulets which occupy topographic hollows and are interconnected with the normal stream network. In many Scottish catchments, these streams and rivulets become dry soon after the rain has stopped. However, during rainfall the water flowing along these pathways will often be sufficiently fast and deep to entrain contaminants such as animal faeces. The occurrence of these pathways is difficult to predict from soil maps but some soil types will be more likely to behave in this way than others.

During periods of rainfall, the levels of streams and rivers generally rise and may extend out beyond their normal channel to occupy their floodplain. In many small catchments, these floodplains may only be a few metres wide, but any faecal material or other potential contaminants on the surface may be entrained in the stream.

4.6.4.2 Soil assessment

The risk assessment of the vulnerability of surface waters is not as well developed as that of groundwaters, however, the concepts of surface and immediate sub-surface flow have been developed in other sub-disciplines within soil science and can be used to derive a provisional vulnerability classification. The general concepts are derived from the Hydrology of Soil Types (HOST) technical report (Boorman *et al.*, 1995). This work derived a classification of UK soils which both describes the dominant pathways of water movement through the soil and assigns proportions of the rainfall likely to lead to a fast response in streams and rivers. These proportions are termed standard percentage run-off and can be used to indicate the soils likely to have a high incidence of overland flow as well as those likely to cause a rapid rise in river levels or to initiate stream extension. This work indicates that soils with peaty surface layers tend to initiate surface run-off quicker than soils with a mineral surface layer and that soils with a slowly permeable layer close to the soil surface will initiate surface run-off more quickly than deep, porous soils.

4.6.4.3 Conclusion

Although still an underdeveloped area of microbiological risk assessment, the results and concepts derived from soil hydrological research can be used to rank the role of soil in assessing the vulnerability of these waters to contamination. However, the very fact that there is no protection from the direct entry of contaminants into surface waters means that these sources must remain at a high risk of contamination.

SECTION D (iii) Soil leaching risk survey

Using the National Grid Reference derived in Section C (7(iii)) the appropriate soil leaching risk map is examined and the category of the soil associated with the source is determined using the table below.

If the source cannot be identified then the risk characterisation for the soil leaching risk classification will be assigned a “High” value.

If there appear to be several soil leaching potentials at or near the point where the source has been determined then the soil leaching potential with the highest risk characterisation score will be used to complete the risk assessment.

The appropriate hazard assessment score will be assigned according to the table.

Soil Leaching Risk Classification	Risk Characterisation	Hazard Assessment
Low	Low	4
Intermediate 1	Moderate	8
Intermediate 2	Moderate	8
High 1	High	16
High 2	High	16
High 3	High	16
Built up	High	16

The following (simplified) explanation of soil leaching potential is taken from the soil leaching risk map legend.

Principles

The purpose of the soil leaching potential maps for microbiological risk assessment is to show, in broad terms, the potential of soils to attenuate possible pollutants by adsorption and degradation. Where the soil has a limited ability to attenuate, there is an increased possibility that potential pollutants will leach from the soil and penetrate underlying groundwater. In areas where the geological drift is thick and of low permeability, the soils are of less significance and groundwater may be less vulnerable to contamination than shown by the map.

The scale of the underlying soil mapping means that the map units may not comprise single soil types, thus only the Soil Leaching Potential that constitutes the greatest proportion of a map unit can be shown. The map is a compromise between the representation of natural complexity and simplicity of interpretation at the scale of representation. This places limitations on the resolution and precision of the map information. The variety of soil, potential pollutants and the generalised nature of Soil Leaching Potential classification means that individual sites and circumstances should be subject to more detailed assessment.

Soil leaching potential classification

The ability of a soil to protect underlying groundwaters from contamination depends on the physical properties that affect the downward passage of water and the chemical properties that affect the attenuation of contaminants. These include: texture (clay and organic matter contents), structure, soil water regime and the presence of distinctive layers such as raw peaty topsoil and rock or gravel at shallow depth. In areas where the geological drift is thick and of low permeability, the soils are of less significance and groundwater may be less vulnerable to contamination than shown by the map. All soils in Scotland can be grouped into one of six classes. Where the soil cover has been considerably altered, for example, in urban areas, they are designated as being at high risk of leaching and form a separate class.

For the purpose of the Microbiological Risk Assessment procedure, it is recommended that three classes will be sufficient: High, Medium and Low risk corresponding to the three main soil leaching potential classes of High, Intermediate and Low.

Soils of high leaching potential (H)

Soils with little ability to attenuate diffuse source contaminants and in which non-adsorbed diffuse contaminants and liquid discharges have the potential to move rapidly to underlying strata or to shallow groundwater. Three subclasses are recognised:

H1 Soils that readily transmit liquid discharges because they are either shallow or susceptible to by-pass flow directly to rock, gravel or groundwater.

H2 Deep, permeable, coarse textured soils that readily transmit a wide range of contaminants because of their rapid drainage and low attenuation potential.

H3 Coarse textured or moderately shallow soils which readily transmit non-adsorbed contaminants and liquid discharges but which have some ability to attenuate adsorbed contaminants because of their organic matter content.

HU Soils over current and restored mineral workings and in urban areas that are often disturbed or absent. A worst case vulnerability classification (equivalent to H1) is therefore assumed for these areas, until proved otherwise.

Soils of intermediate leaching potential (I)

Soils with a moderate ability to attenuate diffuse source contaminants or in which it is possible that some non-adsorbed diffuse source contaminants and liquid discharges could penetrate the soil layer. Two subclasses are recognised:

I1 Deep, permeable, medium textured soils that can possibly transmit a wide range of pollutants.

I2 Deep, permeable, medium textured soils with high topsoil organic matter contents that can possibly transmit non- or weakly-adsorbed diffuse contaminants and liquid discharges, but are unlikely to transmit adsorbed contaminants.

Soils of low leaching potential (L)

Soils in which contaminants are unlikely to penetrate the soil layer due to the presence of a low permeability horizon. Water and contaminant movement is, therefore, largely horizontal but the soils may also have the ability to attenuate contaminants. Lateral flow from these soils may contribute to groundwater recharge elsewhere in the catchment. These soils may have a high clay or organic matter content.

Notes

(i) Where no subclasses are indicated for the Intermediate and High soil leaching potentials, the underpinning map units comprise a number of distinctive soil types. Only the soil leaching potential of the dominant soil type is given.

(ii) The map is a compromise between the representation of natural complexity and simplicity of interpretation at the chosen scale. This places limitations on the resolution and precision of map information. In this case, the variety of soils that has to be covered is wide, and the classification used is generalised. Individual sites and circumstances will always require further and more detailed assessment.

(iii) The map only represents conditions at the surface and, therefore, where the soil and/or underlying formations have been disturbed or removed, for example, during mineral extraction, the leaching potential may have been changed. Hence, where there is evidence of disturbance, site specific data will need to be used.

D (iv) Overall risk assessment

(a) Risk characterisation

The overall risk assessment for the source is taken as the highest individual risk category identified from each of the three surveys.

The overall risk characterisation category will be recorded as the risk assessment score for the source.

Survey Section	Risk Characterisation Category
General Site Survey	
Source Survey	
Soil Leaching Risk Survey	
Overall Risk	

(b) Hazard assessment

Individual components in each of the surveys with a hazard assessment score of 16 or greater should be considered as priority candidates for remedial works capable of reducing the overall risk characterisation category.

SECTION E

If the type of the supply has not been determined then the risk assessment will not have been completed. In this case the overall risk assessment for the supply will default to High Risk to ensure that appropriate control measures are put in place to maintain public health.

SECTION F

Additional Notes – this section can be used to include additional information or observations made during the investigation.

This page is intentionally blank

Section 4.6 – Annex 1

Well Risk Assessment pro forma

Private water supply risk assessment form

WELL SUPPLY

OVERALL RISK ....

Section A – Supply Details

1. Supply category

Type A1 / A2 / A3   Type B (circle appropriate category)

2. Address and telephone number of responsible person

....

....

....

Post Code ....

Telephone Number (including full STD Code) ....

Email Address ....

3. Name of person (or persons) who is relevant person in relation to the supply

(a) ....

(b) ....

(c) ....

(d) details of additional sheets ....

4. Address of relevant person (or persons) (if different from above)

(a) ....

....

....

Post Code ....

Telephone Number (including full STD Code) ....

Email Address ....

(b) ....

....

....

Post Code ....

Telephone Number (including full STD Code) ....

Email Address ....

(c) ....

....

....

Post Code ....

Telephone Number (including full STD Code) ....

Email Address ....

(d) details of additional sheets ....

5. Details of premise(s) served by the supply and purpose for which water is supplied

(a) ....

....

....

Post Code ....

Supply purpose ....

(b) ....

....

....

Post Code ....

Supply Purpose ....

(c) ....

....

....

Post Code ....

Supply Purpose ....

(d) details of additional sheets ....

Section B

6. Provide a diagram of the supply showing source(s), intermediate storage and/or collection tanks and properties on the supply. The diagram is indicative only and is intended to aid completion of the rest of this section.

Notes: Items should be labelled from source (A) through intermediate tanks (B) to properties (C) with individual components numbered, e.g. for a supply with one source this would be A1; two intermediate tanks (B1 and B2 respectively) and two properties (C1 and C2) respectively.

7. Description of the source of the supply including (i) details of supply source(s), (ii) location of the source(s) and (iii) National Grid Reference of location(s) of source(s). Cross reference from Item 6 above.

(i) ....

....

....

(ii) ....

....

....

(iii) National Grid Reference _N_ / _J_ / _0_ / _0_ / _0_ / _0_ / _0_ / _0_

8. (a) Estimated daily volume of water provided by the supply .... m^3 per day

(b) Number of persons served by supply (at maximum occupancy) ....

9. Details of any water treatment processes associated with the supply

(a) At source – identify which of the following systems are present: (cross reference to Item 6)

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

(b) Intermediate Water Storage Tank/Chamber (cross reference to Item 6)

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

(c) At property (cross reference to Item 6)

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

(d) details of additional sheets ....

Section C

10. Details of departures authorised

....

....

....

11. Details of sample results for previous 12 months or last available (reference location of information, e.g. paper or electronic files, reference number, sample numbers, etc.)

....

....

....

12. Details of previous (last 2) investigations and actions taken

....

....

....

13. Details of enforcement notices served

....

....

....

14. Result of previous risk assessment (if applicable)

....

....

....

15. Details of location of Notice for Type A supplies (location)

....

....

....

16. Is Notice appropriate (conforms to requirements of the Regulations)? Yes ☐ No ☐

17. Details of action taken (or to be taken) by relevant persons to comply with

(a) results of sampling

....

....

....

....

(b) results of follow-up to sampling

....

....

....

....

18. Whether supply exempt under Regulation 2(4)

....

....

....

19. Details of other information relating to the supply collated by the local authority

....

....

....

20. Is there a Water Safety Plan/ Emergency Action Plan available for the supply?

Yes ☐ No ☐

21. If "Yes" to Item 20, is it fit for purpose? Yes ☐ No ☐

22. If "No" to Item 21, what deficiencies are required to be addressed (provide details)?

....

....

....

Section D

D(i) General site survey

Are any of the following known to be present and likely to influence water quality at the source?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
23	Evidence or history of poor drainage causing stagnant / standing water	H	L	H		8	
24	History of livestock production (rearing, housing, grazing) – including poultry	H	L	H		16	
25	Evidence of wildlife	M	L	M		4	
26	Surface run-off from agricultural activity diverted to flow into the source/supply	H	L	H		8	
27	Soil cultivation with wastewater irrigation or sludge / slurry/ manure application	H	L	H		16	
28	Disposal of organic wastes to land	H	L	H		8	
29	Farm wastes and/or silage stored on the ground (not in tanks or containers)	M	L	M		8	
30	Remediation of land using sludge or slurry	H	L	H		16	
31	Forestry activity	M	L	M		4	
32	Awareness of the presence of drinking water supply/source by agricultural workers	L	H	H		4	
33	Waste disposal sites (including scrap yard, car yard, rubbish and hazardous waste disposal, landfill or incinerator including on-farm incineration)	H	L	H		8	
34	Disposal sites for animal remains	H	L	H		8	
35	unsewered human sanitation including septic tanks, pit latrines, soakaways	H	L	H		16	
36	Sewage pipes, mains or domestic (e.g. leading to / from septic tank)	H	L	H		8	
37	Sewage effluent lagoons	H	L	H		16	
38	Sewage effluent discharge to adjacent watercourse (where present)	H	L	H		16	
39	Supplies or wells not in current use	H	L	H		8	
40	Evidence of use of pesticides (including sheep dip) near source	H	L	H		8	
41	Evidence of industrial activity likely to present a contamination threat	H	L	H		8	

[1] The Hazard Assessment Score is derived from Likelihood value multiplied by the Severity value. The values are :

Likelihood	Definition	Value
Almost certain	Once per day (or permanent feature)	16
Likely	Once per week	8
Moderate likely	Once per month	4
Unlikely	Once per year	2
Rare	Once every 5 years	1

Risk Characterisation

Tick the appropriate box for each question.

If any question is High Risk (H) then the Risk Characterisation Score is **High**. ☐

If no question is High Risk but there are Moderate Risks (M) identified then the Risk Characterisation Score is **Moderate**. ☐

If no question is High Risk (H) or Moderate Risk (M) then the Risk Characterisation Score is **Low**. ☐

Hazard Assessment

If the Hazard Assessment Score is 16 or greater for any individual component then the issues associated with that component should be considered as a priority for remedial works to reduce the hazard experienced by the supply.

D (ii) Supply survey

Are any of the following known to occur in relation to the supply (source, pipework and properties served)?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
42	No stock proof fence (to BS1722 or equivalent) at a minimum of 4 metres around the source?	H	L	H		8	
43	No suitable barrier present to prevent ingress of surface flows into the well (e.g. cut-off ditch lined with impermeable material, steep incline/decline such as embankments, appropriate walls, etc.)	H	L	H		16	
44	No concrete apron, a minimum of 1200mm, sloping away from the well and in good repair?	H	L	H		8	
45	The top of the well not 150mm above the apron described in [44]?	H	L	H		16	
46	No reinforced pre-cast concrete cover slab, or equivalent, in satisfactory condition with a watertight, vermin-proof inspection cover present to BS497 (lockable steel type or equivalent) with or without ventilation?	H	L	H		16	
47	The well construction in an unsatisfactory state-of-repair?	H	L	H		8	
48	Supply network constructed from material liable to fracture, e.g. asbestos-concrete, clay, etc.	M	L	M		8	
49	Intermediate tanks (e.g. collection chambers, holding tanks, break-pressure tanks) are not adequately protected (i.e. do not have protection described in [42] to [45] above)?	H	L	H		8	
50	Junctions present in the supply network, particularly supplying animal watering systems, have no back-siphon protection?	H	L	H		4	
51	No maintenance (including chlorination) has been undertaken in the previous 12 months?	H	L	H		8	
52	If present, header tank within the property(s) does not have a vermin-proof cover?	H	L	H		4	
53	Header tank has not been cleaned in the last 12 months?	H	L	H		8	
54	Any point of entry/point of use treatment equipment has not been serviced in accordance with the manufacturer's instructions in the last 12 months?	H	L	H		8	
55	If present ultraviolet (UV) lamps are not operating?	H	L	H		16	
56	Is there a noticeable change in the level and flow of water throughout the year?	H	L	H		4	
57	Is there a noticeable change in the appearance of the water (colour, turbidity – cloudiness) after heavy rainfall or snow melt?	H	L	H		8	

[1] The Hazard Assessment Score is derived from Likelihood value multiplied by the Severity value. For details see Section D (i).

Risk Characterisation

Tick the appropriate box for each question.

If any question is High Risk (H) then the Risk Characterisation Score is **High**. ☐

If no question is High Risk but there are Moderate Risks (M) identified then the Risk Characterisation Score is **Moderate**. ☐

If no question is High Risk (H) or Moderate Risk (M) then the Risk Characterisation Score is **Low**. ☐

Hazard Assessment

If the Hazard Assessment Score is 16 or greater for any individual component then the issues associated with that component should be considered as a priority for remedial works to reduce the hazard experienced by the supply.

D (iii) Soil leaching risk survey

Using the NGR identified in 7 determine and record below the soil leaching potential from the appropriate soil leaching potential map covering the geographic area of interest for location of the source.

National Grid Reference N / J / 0 / 0 / 0 / 0 / 0 / 0

Soil Leaching Risk Classification Assigned ....

Risk Characterisation Score ....

Hazard Assessment Score ....

Table D1 - Soil leaching risk characterisation and hazard assessment scores

Soil Leaching Risk Classification	Risk Characterisation	Hazard Assessment
Low	Low	4
Intermediate 1	Moderate	8
Intermediate 2	Moderate	8
High 1	High	16
High 2	High	16
High 3	High	16
Built up	High	16

D (iv) Overall risk assessment

(a) Risk characterisation

The overall risk assessment for the source is taken as the highest individual risk category identified from each of the three surveys.

The overall risk characterisation category will be recorded as the risk assessment score for the source.

Survey Section	Risk Characterisation Category
General Site Survey	
Source Survey	
Soil Leaching Risk Survey	
Overall Risk	

(b) Hazard assessment

Individual components in each of the surveys with a hazard assessment score of 32 or greater should be considered as priority candidates for remedial works capable of reducing the overall risk characterisation category.

Section E

You have been unable to discern the type of supply and so the overall risk assessment for this source must be given as **High Risk**.

Section F – Additional Notes

This page is intentionally blank

4.7 Spring risk assessment (see 4.7 Annex 1 for full form)

Overall Risk – this is taken from the overall risk assessment in section D(iv)(a) of the risk assessment form.

SECTION A – Supply details

Item 1 – Supply category

The supply category that is required to be identified is taken from The Private Water Supplies (Scotland) Regulations 2006 Part 1(2). These state:

"Type A supply" means a private water supply for human consumption purposes which

(a) on average, provides 10 or more cubic metres of water per day or serves 50 or more persons, or
(b) regardless of the volume of water provided or the number of persons served, is supplied or used as part of a commercial or public activity,

and references in this definition –

(i) to the average volume of water provided by such a supply, are references to such volume (calculated as a daily average) as may be reasonably estimated to have been distributed or, if not distributed, used or consumed from the supply during the year prior to the year in which these Regulations come into force; and that estimate may be on the assumption that five persons use one cubic metre of water per day; and
(ii) to the average number of persons served by such a supply, are references to such number of persons as may be reasonably estimated to be the maximum number served by the supply on any one day during the year prior to the year in which these Regulations come into force.

"Type B supply" means a private water supply other than a Type A supply; and "year" means a calendar year.

Item 2 – Address and telephone number of responsible person

"Responsible person" is a term used in the Regulations referring to the person who owns or otherwise is responsible for the domestic distribution system which included the pipework, fitting and appliances which are installed between the taps that are normally used for human consumption purposes and the distribution network which is not the responsibility of a relevant person (see Item 3). Full contact details of the responsible person should be recorded here.

Item 3 – Name of person (or persons) who is relevant person in relation to the supply

The term "relevant person" refers to the person considered by the local authority to be the person providing the supply, or occupying the land from, or on, which the supply is obtained or located, and any person who exercises powers of management or control in relation to the supply.

The relevant and responsible person may be one and the same person in some instances.

In some instances there may be more than 3 relevant persons in which case additional sheets should be used to record the information and details of these additional sheets should be included in section (d) and the sheets appended to the form when completed.

Item 4 – Address of relevant person (or persons) (if different from above)

Where the responsible person and the relevant person are different then the contact details for the relevant person or persons should be recorded in this section.

In some instances there may be more than 3 relevant persons in which case additional sheets should be used to record the information and details of these additional sheets should be included in section (d) and the sheets appended to the form when completed.

Item 5 – Details of premise(s) served by the supply and purpose for which water is supplied

This item seeks to capture details of any premise that may be served by the supply and the purpose for which the water is being supplied. It is necessary to have as complete a list of properties served by a private water supply as possible in order that the true interconnectivity of the supply may be assessed and the potential population affected by any breach of the Regulations or incidence of waterborne disease outbreak can be assessed rapidly and efficiently. For larger supplies this exercise will be challenging but attention to detail will ensure that the most comprehensive and accurate records are compiled which will assist in future investigations relating to the supply.

Additional sheets (as required) should be appended to the form and a note of these made at section (d).

SECTION B

Item 6 – Diagram of the supply

This is intended to enable the investigating officer to provide a schematic sketch showing the interrelationships between the various components of the supply such as source, intermediate tanks and properties being supplied. While there is undoubtedly a balance to be struck between too much detail and insufficient detail, a guiding principle should be to provide sufficient information to enable colleagues who have not visited the site to quickly navigate around the supply.

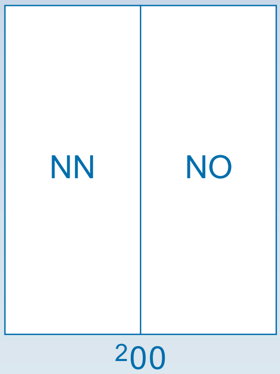
Item 7 – Description of the source of the supply

The description provided should complement the schematic sketch provided at Item 6. The purpose of having a written description is to provide a record of the condition of the infrastructure at the time of the risk assessment. This will enable a baseline to be established against which any future developments made to the supply can be benchmarked. If the facility exists it would be appropriate to also include relevant photographic evidence of the various components so long as they are uniquely identified and cross-referenced within the risk assessment report.

A full National Grid Reference for the source (or the closest point to the source identified) should also be provided.

How to give a grid reference to nearest 100 metres

The example below is taken from Ordnance Survey Braemar to Blair Atholl Sheet 43 1:50000 Landranger Series.

100 000 metre Grid Square Identification	**Example - Altaltan**			
	1. Read letters identifying 100 000 metre square in which the point lies.	NO		
	2. FIRST QUOTE EASTINGS Locate first VERTICAL grid line to LEFT of point and read LARGE figures labelling the line either in the top or bottom margin or on the line itself. Estimate tenths from grid line to point.		18 4	
	3. AND THEN QUOTE NORTHINGS Locate first HORIZONTAL grid line BELOW line either in the left or right margin or on the line itself. Estimate tenths from grid line to point.			63 5
	EXAMPLE REFERENCE	NO 184 635		
Ignore the smaller figures of any grid number: these are for finding the full coordinates. Use ONLY the LARGER figure of the grid number. Example: $^{2}80^{000\text{m}}$				

Extract from 1:50 000 sheet 43 showing location of Altaltan

Item 8 – Estimated daily volume of water provided by the supply

If the volume of water is not being measured, e.g. via a water meter, then the investigating officer can make an estimate of the volume based on 200 litres of water per day per person served by the supply. While the figure will only be an estimate every effort should be made to identify the maximum number of people who are being supplied with water from the supply. It is not sufficient just to base the estimate on historical records, e.g. the classification of the supply made under previous regulatory frameworks. It is important to have a robust and defensible maximum occupancy for the supply as this may well have an impact on the sampling frequency to which the supply is subjected.

Item 9 – Details of any water treatment processes associated with the supply

While it is important to document any treatment that occurs on the supply it is not practicable to list all possible treatment types or systems that may be encountered. The risk assessment form concentrates on the provision of standard disinfection equipment/processes but all other treatment systems should be included in the description including items such as sediment traps of pH correction systems. Each of the treatment processes should be cross-referenced to those identified on the schematic provided at Item 6.

For larger systems it will not be practicable to complete Item 9 (c) and so a table should be drawn up listing the properties and the treatments associated with each property differentiating between point of entry and point of use devices, e.g.:

Responsible Person	Property address (including post code)	Point of entry device (specify)	Point of use device (specify)	Notes
Mr D Able	1 Wellside Cottage, Nethermuir, ZZ1 1AA	UV lamp	None	located in lean-to on north side of house, pre-filter bypassed
Mrs C Brown	3 Wellside Cottage, Nethermuir, ZZ1 1AA	UV lamp	None	On maintenance contact with Bloggs Plumbing, Nethermuir
Ms B Charlie	Springside House, By Nethermuir, ZZ1 2BA	None	UV lamp	Under sink in kitchen – poor access for changing bulb
Rev. A Davis	Riverbank Cottage, Nethermuir, ZZ1 1AB	None	None	

These details should be recorded as additional sheets on the form at Item 9 (d)

SECTION C

Item 10 – Details of departures authorised

Provide details of any temporary departures granted under Part IV of the Private Water Supplies (Scotland) Regulations 2006. These details should summarise the details provided in the original temporary departure and should cross-reference to the complete application. If applicable the temporary departure authorisation (Regulation 6(7) of the above Regulations) can be appended to the risk assessment. Details of this should be recorded in Section F.

Item 11 – Details of sample results for previous 12 months or last available (reference location of information, e.g. paper or electronic files, reference number, sample numbers, etc.)

The inclusion of this information is to assist the investigation officer in their investigations. Details of the previous sampling results will enable areas of concern to be highlighted and assist in focusing on areas where actual breaches of the drinking water quality standards have occurred. For example, if lead is highlighted as failing in the sample results, while lead is not specifically being looked for in the risk assessment, the investigation officer may take the opportunity of the investigation to attempt to determine whether there are any known lead pipes or tanks associated with the supply or through examination of the appropriate geological map whether lead is naturally occurring in the vicinity of the source. If lead pipes or tanks are present then appropriate advice can be provided on the need for their removal; if lead is naturally occurring at the source then discussions around locating a more acceptable alternative source for the supply can be entered into.

Item 12 – Details of previous (last two) investigations and actions taken

If there have been investigations into previous failures then the last two such investigations should be summarised here along with the actions that were taken or were understood to have been agreed to have been taken. This information will provide the investigation officer with a background to the problems that have been encountered previously along with an understanding of what actions have been attempted to improve the situation and whether these actions have proved to be successful. If they have proved to be unsuccessful then this information will allow the investigation officer to consider alternative solutions that have not been previously implemented.

Item 13 – Details of enforcement notices served

If any enforcement notices have been served that affect the supply under investigation, details of these should be provided here. If necessary additional information may be appended to the risk assessment and details of these should be provided in Section F.

Item 14 – Results of previous risk assessment (if applicable)

If the source or supply has previously been risk assessed then the details of the previous risk assessment(s) should be included with the current risk assessment. The previous risk assessments should be appended to the current form and details of these additional sheets should be recorded against this item.

Item 15 – Details of location of Notice for Type A supplies (location)

Regulation 31 of the Private Water Supplies (Scotland) Regulations 2006 requires that up-to-date information about the quality of the water provided in commercial or public premises shall be displayed in a prominent location. This notice forms part of the communication of risk to members of the public and so the location of the notice should be recorded to ensure that appropriate risk communication is being undertaken.

Item 16 – Is Notice appropriate (conforms to requirements of the Regulations)

Regulation 31 (2) details the form that the information notice must take. This item confirms that the appropriate form of the notice is being displayed as the form of the notice interlinks with additional information available to both owners/users and visitors to private water supplies making it vital that the appropriate form of the notice is utilised.

Item 17 – Details of action taken (or to be taken) by relevant persons to comply with (a) results of sampling (b) results of follow-up to sampling

If sampling results indicate that the supply fails to comply with the requirements of the Regulations, this section should be completed to identify what suggested/agreed remedial steps should be taken to prevent future failures.

Item 18 – Whether supply exempt under Regulation 2 (4)

If the supply is used solely for washing a crop after it has been harvested or during the distillation of spirits (solely in the mashing process or for washing plant but for no other purpose) and which does not affect, either directly or indirectly, the fitness for human consumption of any food or drink or, as the case may be, spirits in their finished form, then the provisions of the Private Water Supply (Scotland) Regulations 2006 do not apply to that supply with the exception of the provisions of regulation 29. If the supply is exempted under the provisions of regulation 2(4) then a full risk assessment is not required to be completed but good practice would require a partially completed form to be retained by the local authority containing the information required by regulation 29.

Item 19 – Details of other information relating to the supply collated by the local authority

If the local authority has other relevant information relating to the supply then these details should be included here or appended to the form and details of the additional sheets recorded under this item.

Item 20 – Is there a Water Safety Plan/Emergency Action Plan available for the supply

Some supplies may have a water safety plan or emergency action plan that details steps to be taken to ensure the quality of water at the source and steps to be taken in the event of a loss of constancy or quality from that supply.

Item 21 – If "Yes" to Item 20, is it fit for purpose

This item requires an assessment by the investigation officer as to whether or not the water safety plan or emergency action plan is suitable for the premises it relates to.

Item 22 – If "No" to Item 20, what deficiencies are required to be addressed (provide details)

If the assessment undertaken in Item 21 suggests there are inadequacies in the water safety plan or emergency action plan then the deficiencies should be noted against this item with suggestions, where appropriate, as to what improvements may be considered to the plan(s).

SECTION D

General introduction

In this part of the form each of the indicators being looked for, e.g. disposal sites for animal remains, will have two separate scores associated with them.

The first score will be the Risk Characterisation score.

The Risk Characterisation score has three values – High, Moderate or Low – and is based on the presence or absence of the indicator based on the evidence available to the person undertaking the risk assessment. The form is preloaded with the risk characterisation value based on the individual indicator being present or absent. If the assessor cannot determine if the indicator is present then the "Don't know" option should be used.

The assessor should tick the appropriate response box for each indicator. If any response is identified as High Risk (H) then the Risk Characterisation Score will be **HIGH**. If no response is High Risk but there are Moderate Risks (M) identified then the Risk Characterisation Score will be **Moderate**. If no response is High Risk or Moderate Risk then the Risk Characterisation Score is **Low**.

The second score is the Hazard Assessment score.

The Hazard Assessment Score is also based on the indicator being present but this scoring allows the extent of the potential influence of the indicator to be taken into account. Thus the likelihood score is dependent on a knowledge or estimate of the time period during which the indicator may be present at the source under investigation. The table in the form provides guidance on the values to be assigned based on how frequently the indicator is known, or thought, to be present. If the indicator is present continuously, i.e. once per day or a permanent feature, then the likelihood value assigned will be 16 as the indicator is almost certainly there continuously; if the indicator is present once a week then the likelihood value assigned will be 8; if the indicator is present once a month then the value will be 4; if the indicator is present once a year then the likelihood value assigned will be 2; and if the indicator is known, or thought, to occur rarely such as once every five or more years, then the value assigned will be 1. Once the likelihood value has been assigned on the form the Hazard Assessment Score is determined by multiplying the Likelihood Value by the Severity (which is pre-loaded on the form) to give the overall Hazard Assessment Score.

The Hazard Assessment Score is an index and there is no implied mathematical relationship to risk. The Hazard Assessment Score is a convenient way of prioritising actions or interventions so that resources are effectively targeted to those areas that pose the greatest potential risk of contamination to the source under investigation.

If the Hazard Assessment Score is **16** or greater for an individual component then the issues associated with that component should be considered as a priority for remedial works to reduce the hazard experienced by the supply.

The value of 16 is considered to be appropriate when only a rare event may produce a catastrophic outcome, e.g. sewage effluent discharge to adjacent watercourse (item 38). However, if the presence of sewage effluent discharge to an adjacent watercourse were to occur more frequently than once every 5 years or more then the Hazard Assessment Score would reflect this change by increasing the score, and hence flag the requirement to take appropriate action to reduce the likelihood of the occurrence.

Hazard assessment matrix

	Severity of consequences				
Likelihood	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	16	32	64	128	256
Likely	8	16	32	64	128
Moderately likely	4	8	16	32	64
Unlikely	2	4	8	16	32
Rare	1	2	4	8	16

Each of the indicators in Section D will now be considered in turn.

SECTION D(i) General site survey

Item 23 – Evidence or history of poor drainage causing stagnant/standing water

If standing water can be seen present around the well head area or if there is evidence of standing water having been present, e.g. mud or vegetation consistent with marshy ground such as reeds, then the hazard should be scored as being present and the risk characterisation assigned as “Yes”. If there is a suggestion that the likelihood of the standing water being present (or evidence of having been present) is a long-standing occurrence then the likelihood score for the hazard assessment should reflect this.

Item 24 – History of livestock production (rearing, housing, grazing) – including poultry

Any evidence of domestic livestock production being present (either directly by the presence of animals in the vicinity of the supply) or indirectly (through presence of broken ground around the supply or the presence of animal droppings around the supply) should result in the risk characterisation being scored as “Yes”. Further investigations will be required to decide on the persistence of such presence in order to allow the hazard assessment likelihood score to be accurately assigned.

Item 25 – Evidence of wildlife

Any evidence of wildlife, mammals (rabbits, deer, etc.), birds (gulls, geese, migratory birds, etc.), reptiles (newts, frogs including spawn) etc. at the source could indicate the potential for contamination of the supply either from faecal material or from carcasses falling into the supply. If evidence of wildlife is found then the risk characterisation should be scored as “Yes”. Account should be taken of the likely frequency of the presence of wildlife, e.g. a rabbit warren nearby will suggest permanent presence; migratory birds will suggest a seasonal presence which will require the suggested likelihood values to be moderated to reflect this seasonal presence by raising the once per year score of 2 to 4.

Item 26 – Surface run-off from agricultural activity diverted to flow into source/supply

This indicator is intended to deal with field drains and other drainage systems employed on agricultural land which may be connected to the source or supply. The indicator also deals with instances where there is overland flow from agricultural land that ends up in a watercourse or entering the source and potentially contaminating the supply, e.g. applied slurry, where there is potential for it to be washed into field drains or watercourse or similar drainage systems. If there are drainage systems or similar present in areas of agricultural activity then the risk characterisation response will be "Yes". The likelihood value will be based on the probable time the land is being subjected to agricultural applications.

Item 27 – Soil cultivation with wastewater irrigation or sludge/slurry/manure application

This indicator differs from Item 26 in that there will be active application of the materials in conjunction with the disruption of the soil itself, e.g. via ploughing or sub-soil injection. If such activities are considered to be undertaken then the risk characterisation will be "Yes". The likelihood value will be based on the probable time/duration that such activities occur at.

Item 28 – Disposal of organic wastes to land

This indicator deals with any other organic waste, e.g. abattoir wastes or "blood and guts". The scoring for this indicator will be irrespective of whether there has been disruption of the soil. If such activities are considered to be undertaken then the risk characterisation will be "Yes". The likelihood value will be based on the probable time/duration that such activities occur at.

Item 29 – Farm wastes and/or silage stored on the ground (not in tanks or containers)

If there are middens or areas where silage are being stored in polyethylene bags (or equivalent) or other farm-derived wastes where there is no bunded storage and there is the potential for spillage entering drainage systems, then this item should be scored such that the risk exists. If the storage appears to be a permanent or long-term feature then the hazard assessment should be scored as almost certain (value 16) or likely (value 8).

Item 30 – Remediation of land using sludge or slurry

In some areas brownfield sites or derelict land will be remediated using sewage-derived sludge or slurry or similar materials. The rate of application will typically be higher than those used in Item 27 and this should be borne in mind when assessing both the risk characterisation and hazard assessment parts of the risk assessment form.

Item 31 – Forestry activity

Forestry activities have the potential to cause significant disruption to water supplies to the area in which they are being undertaken. The disruption may occur when forests are being planted, when thinning activities are being carried out or when the timber is being harvested. Account should be taken of the maturity of the forest and the likelihood of activity starting or changing during the period of the risk assessment. If the risk assessment is not scheduled to be time-limited then the potential for disruption should be highlighted.

Item 32 – Awareness of the presence of drinking water supply/source by agricultural workers

If the awareness of the presence of a drinking water source is absent from those agricultural or forestry workers who may be available to be interviewed or if there is evidence of disregard for the presence of such sources, e.g. ploughing to the margins of a well or spring, then the risk characterisation will be “No” or “Don’t Know” to reflect the high level of risk such a lack of knowledge may be introducing to the supply. Lack of awareness on the hazard assessment should be scored as almost certain (16) again to reflect the potential for introduction of harmful materials or disturbance of the supply.

Item 33 – Waste disposal sites (including scrap yard, car yard, rubbish and hazardous waste disposal, landfill or incinerator including on-farm incineration)

The presence of disposal sites may influence the quality of water at the source by allowing the introduction of microbiological or chemical contaminants into the supply, depending on the nature of the materials being disposed. Incineration is also included in this section as the question of both airborne material and disposal sites for ash residues need to be considered when making the overall assessment of the likely impact of this item on the water quality at the source. If any waste disposal sites are present then the risk characterisation will be "Yes" and the associated hazard assessment should reflect the permanent nature (or longevity) of such sites in terms of their potential to continue to release polluting materials for many years after their immediate use has ceased.

Item 34 – Disposal sites for animal remains

This definition includes on-farm carcass disposal, burial pits, e.g. arising from foot-and-mouth disease, and vicinity to human burial sites such as graveyards or family plots away from traditional burial sites. If any disposal sites are present then the risk characterisation will be "Yes" and the associated hazard assessment should reflect the permanent nature (or longevity) of such sites in terms of their potential to continue to release polluting materials for many years after their immediate use has ceased.

Item 35 – Unsewered human sanitation including septic tanks, pit latrines, soakaways

If unsewered human sanitation is present near the source then there is considerable potential for raw human sewage to contaminate the source of the drinking water supply. Great care must be taken when assessing the positioning of septic tanks as well as their condition (maintenance), the areas where the soakaway is positioned, the condition of any pipes leading from the septic tank to the soakaway (is there evidence of different vegetation which may indicate a leaking pipe) and the discharge point of the soakaway if this is directed towards a surface receiving water. Similarly if there are pit latrines in use, e.g. at a campsite or areas where chemical toilets are discharged, the area surround the disposal point or latrine should be considered carefully in terms of allowing contact with the source. The contact may not be visible as there may be some connectivity underground and so some thought must be given to the soil leaching potential of the site.

Item 36 – Sewage pipes, mains or domestic (e.g. leading to/from septic tank)

In addition to Item 35 consideration must be given to the path that sewers may take. If the line of the pipe intersects with the area from which the drinking water source is being recharged (the area from where the water is being drawn) then there is the potential that any failure (leak) from the sewer or similar pipe will introduce raw sewage directly into the water source. It is unlikely that the path of such pipes will be clearly visible and so some care in interpreting the area will need to be taken, e.g. areas where the vegetation/ground appears to be drier indicating that there is a pipe buried below the surface or if there is a fracture in the pipe areas that would not naturally be damp or areas where there is vegetation indicative of wet or nutrient enriched conditions such as reeds or nettles.

Item 37 – Sewage effluent lagoons

Sewage effluent lagoons bring the potential that leaking material from the lagoon may enter the soil and pass into the groundwater providing a direct route for the contamination of the source with raw sewage. Farm effluent lagoons may be viewed as being the same in terms of the risks posed to the source when assessing the scoring values to be assigned.

Item 38 – Sewage effluent discharge to adjacent watercourse (where present)

While some aspects of this item may be identified when reviewing Item 35, Item 38 draws attention to the potential for sewage effluent discharges from a variety of sources such as municipal wastewater treatment works, septic tanks, privately owned/operated sewage treatment systems or reed beds. If there is evidence of discharge to a watercourse that is adjacent to the source of the supply under investigation then the risk characterisation should reflect the circumstances and "Yes" should be recorded. Similarly, for the hazard assessment the permanent, or semi-permanent, nature of the hazard should be reflected in the likelihood value assigned which should be almost certain (value 16).

Item 39 – Supplies or wells not in current use

If there are supplies or wells not in use that are associated with the supply under investigation then the potential for material to be introduced directly into the source water exists. For example, if an older, out of use well is located adjacent to the currently operational well and the out of use well is not properly sealed then the opportunity exists for faeces or animals to enter the older well and contaminate the same source of water that the new well is drawing from.

Item 40 – Evidence of use of pesticides (including sheep dip) near source

If disposal sites for pesticides (including sheep dip) are known to be close to the source under investigation then the risk characterisation should reflect this as should the hazard assessment. If there is evidence of the area having been used for dipping sheep (with dip tanks, fanks, etc.) then this evidence should be taken into account when assessing the site.

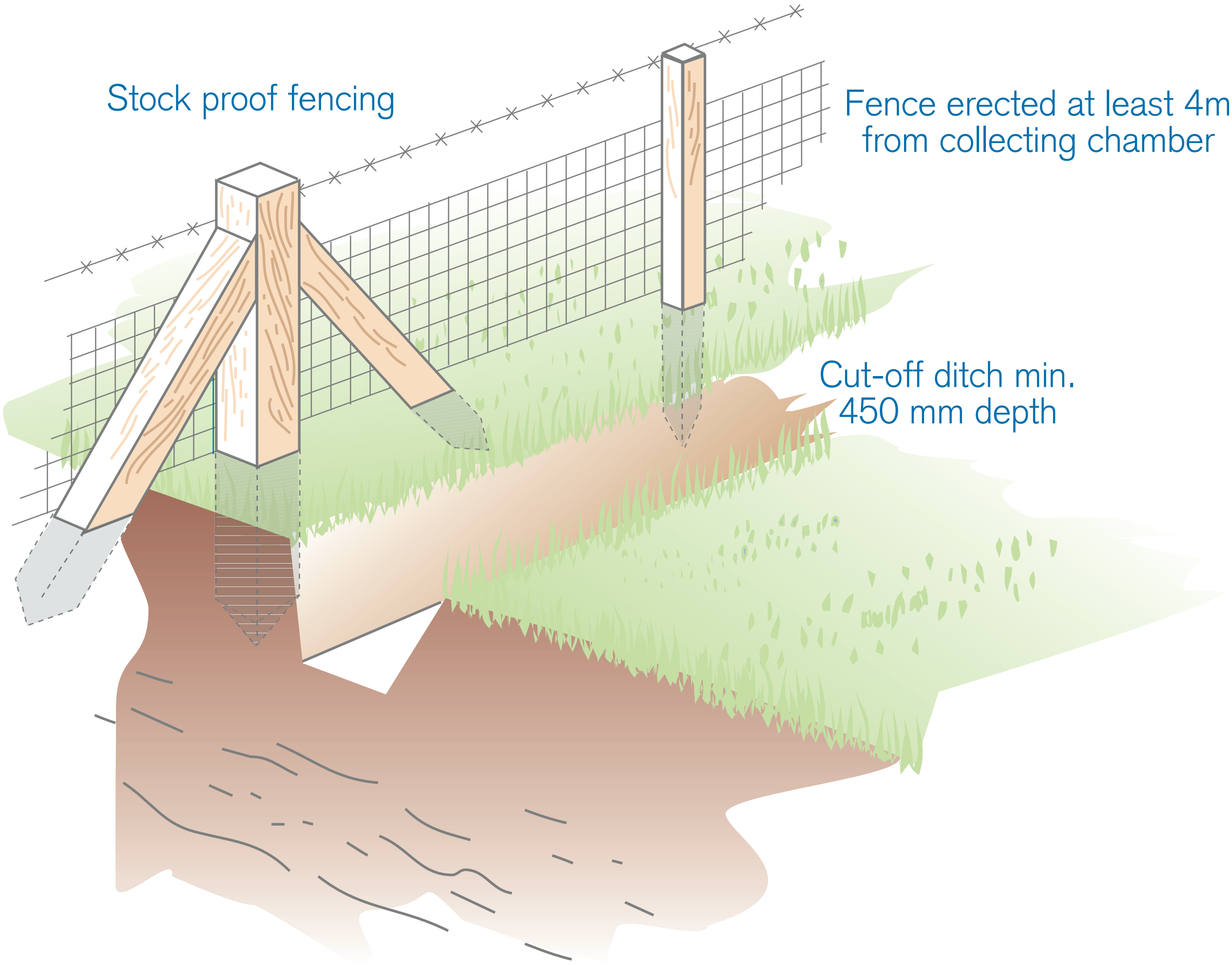
Item 41 – Evidence of industrial activity likely to present a contamination threat

If there is evidence of the area adjacent to the source having been used for industrial activity which may pose a contamination threat then this should be recorded on the risk assessment. Such activities may include chemical or pharmaceutical production, mineral or other extraction such as coal mining, areas where old fuel tanks may have been located or may still be in place either below or above ground, or industries where solvents would have been in use and may have been disposed of on to the ground, e.g. electroplating, metal working or electronics. This list is not exhaustive and so appropriate interpretation of the previous use to which the site may have been put will be required by the investigation officer.

Item 42 – No stock proof fence (to BS1722 or equivalent) at a minimum of four metres around the source

Figure 9.1 identifies a fence to BS1722. The fence must be erected at a minimum of four metres around the source to ensure that any animals who may frequent the area around the fence, e.g. for scratching, do not have an opportunity to contaminate the area of the source with faecal material which may be deposited. If there is no fence or the fence is deficient in terms of the distance or specification of construction (i.e. not fit for purpose) then the risk characterisation will be "Yes" and the hazard assessment will reflect the permanent nature of the deficiency.

Figure 9.1 Fence and ditch



Item 43 – No suitable barrier present to prevent ingress of surface flows into the well (e.g. cut-off ditch lined with impermeable material, steep incline/decline such as embankments, appropriate walls, etc.)

The well head areas need to be protected from the ingress of surface flows (such as flooding). This can be accomplished in a variety of ways such as having a cut-off ditch surrounding the well with an impermeable lining and a suitable discharge downslope from the well head area or conveying the water away from the immediate vicinity of the well head. Another method would be to have the well head area built up such that it protrudes above the ground level and the slopes convey surface flows away from the well head. It should be borne in mind that surface flows, while including flooding, are not restricted to flooding. In certain ground conditions the impermeable nature of the soil during periods of dry weather will produce a surface akin to concrete which will result in rainfall, such as a heavy summer downpour, running over the surface rather than percolating into the soil. Such conditions need to be protected against by use of appropriately engineered well head arrangements. If suitable arrangements are absent from the site under investigation then the risk characterisation will be scored as "Yes" with the hazard assessment reflecting the permanent nature of the deficiency by scoring the likelihood as almost certain (value 16).

Item 44 – Overflow/washout pipe not fitted with vermin-proof cap

The overflow pipe or washout pipe should be fitted with an appropriately-sized metal mesh or similar material to prevent the entry of vermin into the collection chamber. It should be borne in mind when assessing the covers that small rodents such as field mice can easily negotiate holes the diameter of a standard pencil. If an appropriate cover is not in place then the risk characterisation should be scored as "Yes" and the hazard assessment likelihood should also reflect the permanent nature of the deficiency by scoring as almost certain (value = 16).

Item 45 – Inlet pipe not fitted with course filter or screen

The inlet pipe should have some facility to prevent ingress of detritus. If suitable arrangements are absent from the site under investigation then the risk characterisation will be scored as "Yes" with the hazard assessment reflecting the permanent nature of the deficiency by scoring the likelihood as almost certain (value 16).

Item 46 – If chamber present no reinforced pre-cast concrete cover slab, or equivalent, in satisfactory condition with a watertight, vermin-proof inspection cover present to BS497 (lockable steel type or equivalent) with or without ventilation

A properly constructed and well-fitting well cover is essential to maintaining the integrity of the source. The cover should be watertight to prevent ingress of rainwater; vermin-proof to prevent animals from entering the well (vermin-proof means having no holes, remember a field mouse can easily enter a space where a pencil will fit); and lockable to prevent malicious (or just curious) persons gaining access to the supply. If ventilation is present ensure that it is also vermin-proof with appropriate wire mesh in place. If suitable arrangements are absent from the site under investigation then the risk characterisation will be scored as "Yes" with the hazard assessment reflecting the permanent nature of the deficiency by scoring the likelihood as almost certain (value 16).

Item 47 – Construction in an unsatisfactory state-of-repair

The fabric of the well itself (i.e. below ground) should be in good repair to prevent any short-circuiting with water entering from or near the soil surface. If suitable arrangements are absent from the site under investigation then the risk characterisation will be scored as "Yes" with the hazard assessment reflecting the permanent nature of the deficiency by scoring the likelihood as almost certain (value 16).

Item 48 – Supply network constructed from material liable to fracture (e.g. asbestos concrete, clay, etc.)

If the network of pipes that lead from the well are constructed of materials that are liable to deterioration or fracture, e.g. if heavy farm machinery is driven over the top of the pipeline, then the integrity of the system will be lost and potentially polluting material may enter the pipes through the fractures or the whole supply will be lost through pipe blockages. If it is considered likely that such materials have been used for all or part of the pipework being used to convey water from the source then the risk characterisation must reflect this with a "Yes" score and the hazard assessment must similarly reflect the permanent nature of the hazard by scoring as almost certain (value 16).

Item 49 – Intermediate tanks (e.g. collection chambers, holding tanks, break-pressure tanks) are not adequately protected (i.e. do not have protection described in [42] to [46])

The level of protection for all intermediate tanks or similar structures should be equivalent to that recommended for the source itself as the potential for contamination to enter the system via such intermediate points is just as high as for the source itself. If any of the intermediate tanks or similar structures are deficient in respect of the requirements provided in Items 42 to 46 then this should be reflected in the risk characterisation and hazard assessment. If there is more than one intermediate tank or similar structure, the deficient ones should be noted in section F and cross-referenced with the diagram provided in Section B (Item 6).

Item 50 – Junctions present in the supply network, particularly supplying animal water systems, have no back-siphon protection

If there are provisions made to provide water to animal watering troughs or other connections where back-siphonage may occur, e.g. from a hosepipe permanently connected, there is potential for the contents of the trough or container to be back-siphoned into the distribution pipe and for the contents of the trough or container to enter the supply. Clearly the contents of a cattle watering trough or a barrel into which the end of a hose has been dangled for some weeks will do little to improve the quality of the drinking water being provided. It is essential that where connections are made on the system prior to the first taps to be used for domestic (potable) consumption appropriate back-siphonage prevention devices are fitted. If they are not or there is no evidence to support claims that they have been fitted then the risk characterisation must reflect this with a “Yes” response. Similarly the hazard assessment should highlight the permanent nature of the situation with an almost certain (value 16) rating.

Item 51 – No maintenance (including chlorination) has been undertaken in the previous 12 months

If the system has had no maintenance undertaken in the 12 months preceding the investigation then this suggests that the level of care and attention required to ensure the system is operating as effectively as possible is lacking. If this is the case then the risk characterisation score should reflect the situation encountered and a “Yes” response entered. The hazard assessment likelihood score should also reflect the situation with an unlikely score (value = 2).

Item 52 – If present, header tank within the property(s) does not have a vermin-proof cover

Many properties served by a private supply, particularly those on smaller supplies, will have a header tank within the property to provide sufficient water pressure for the household and also to act as a balancing tank to equalise the pressure differences experienced in the system when pumps are operating to bring water into the property. However, if the header tank is not properly constructed and protected then any material that may be present in the roof space, whether that be dust or mice or bat droppings, will have the potential to enter the tank and so contaminate the supply. If the property has a header tank which feeds the main domestic (potable) tap, usually the kitchen cold water tap, and that tank is not properly protected then the risk characterisation score should reflect the situation encountered and a “Yes” response entered. The hazard assessment likelihood score should also reflect the situation with an almost certain score (value = 16). If the header tank is present and unprotected but does not feed the main domestic (potable) tap then the risk assessment can be moderated but the risk to other taps in the property should be highlighted in Section F and noted on the diagram at Section B.

Item 53 – Header tank has not been cleaned in the last 12 months

If the header tank has an appropriate vermin-proof cover (Item 52) it will still require to be maintained by cleaning at least every 12 months to prevent the build-up of slime and scum which will naturally grow on the tank walls. If the tank has not been cleaned in the 12 months prior to the investigation then the risk characterisation score should reflect the situation encountered and a “Yes” response entered. The hazard assessment likelihood score should also reflect the situation with an unlikely score (value = 2).

Item 54 – Any point of entry/point of use treatment equipment has not been serviced in accordance with the manufacturer’s instructions in the last 12 months

If any point of entry/point of use devices have had no maintenance undertaken in the 12 months preceding the investigation then this suggests that the level of care and attention required to ensure the system is operating as effectively as possible is lacking. If this is the case then the risk characterisation score should reflect the situation encountered and a “Yes” response entered. The hazard assessment likelihood score should also reflect the situation with an unlikely score (value = 2).

Item 55 – If present ultraviolet (UV) lamps are not operating

While ultraviolet disinfection systems if properly installed and maintained are an effective treatment option to prevent potentially harmful micro-organisms from causing disease they can provide a false sense of security if they are not looked after. A particularly common fault is for the UV bulb to stop operating. The UV bulb is at the heart of the installation and is responsible for the disinfection process. If there is not an automatic warning system on the installation then the loss of the bulb could go undetected. Similarly if the bulb has not been changed in accordance with the manufacturer's recommended replacement period then the efficiency or operation of the bulb could be impaired or have ceased to function at all. It is important, therefore, to assess if the UV bulbs (lamps) are operating on a UV system at the time of the inspection. If they are not operating then the risk characterisation score should reflect the situation encountered and a "Yes" response entered. The hazard assessment likelihood score should also reflect the situation based on an assessment of when the UV bulb (lamp) ceased to function.

Item 56 – Is there a noticeable change in the level and flow of water throughout the year

This question deals with the issue of constancy of supply as it relates to the quality of the source. If the source is highly dependable and provides adequate levels of water throughout the year then it is likely that the source is not under direct influence from either the surface or from prevailing climatic conditions. On the other hand, if the supply is "flashy" and changes with the weather then it is likely that it is under the influence of surface flow and prevailing weather conditions which increases its vulnerability to contamination from the surface. If there are noticeable changes in level and flow the risk characterisation response will be "Yes". The hazard assessment likelihood in these circumstances will be almost certain (value = 16). This circumstance may also cause the investigating officer to reconsider if the supply is in fact a well or if it would be better treated as a surface-derived supply.

Item 57 – Is there a noticeable change in the appearance of the water (colour, turbidity – cloudiness) after heavy rainfall or snow melt

If the supply is under the influence from either the surface or the weather then the quality experienced cannot be guaranteed if there are conditions prevailing which make surface flow (e.g. flooding) or adverse weather conditions likely. If there are noticeable changes in the appearance of the water then the risk characterisation response will be "Yes". The hazard assessment likelihood in these circumstances will be dependent on whether weather or surface influence is considered the most likely cause.

Section D (iii) Soil leaching risk survey

4.7 Background to soil and land use factors underpinning the assessment of groundwater vulnerability

4.7.1 Introduction to concepts of vulnerability and risk associated with soils and groundwaters

Wherever groundwater is present there is potential for contamination through human activity. No soil or geological strata is completely impermeable and likewise no pollutant is immobile. The concept of groundwater vulnerability, or the susceptibility of groundwater to microbiological contamination from surface or near-surface derived pollutants, recognises that the potential risk of contamination is greater under certain hydrological, geological, land use and soil conditions than others. In site-specific terms, groundwater contamination depends on the natural or man-made characteristics of the site in that the ease with which the potential pollutant can migrate to the underlying water table or spring source is dependent upon the physical, chemical and biological properties of the soil and rocks pertaining to the site. The factors which define the vulnerability of groundwater resources to a given pollutant or activity, acting singly or in combination, are as follows:

- presence and nature of the overlying soil
- presence and nature of the drift deposits
- nature of the solid geological strata within the unsaturated zone
- depth to groundwater
- nature of contaminant.

It must also be recognised that contamination can only occur if a potential pollutant is present, therefore land use is a critical factor. Similarly, the intrinsic factors listed above can be modified by man-made structures or excavations.

The key to groundwater vulnerability classification lies in the unsaturated zone, namely that volume of soil and unsaturated material situated above the water table. In the absence of major fissures or cracks within that zone, water movement is essentially slow, being confined to interconnected soil pores within an aerobic environment. However, the rate of this movement depends on the moisture content of the soil and therefore varies throughout the year. The overlying soil provides the potential for interception, adsorption and elimination of bacteria and viruses. Where vertical fissures occur or shattered rock comes close to the earth’s surface, there is the potential for rapid flow of micro-organisms to groundwater and therefore a reduction in the ability of the soil and substrate to act as a barrier or filter.

4.7.2 Use of soil information for both general protection of groundwater resource and specific protection of individual water supply sources

4.7.2.1 Introduction

It should be stressed that a full assessment of the risks posed to groundwater by potentially polluting activities on the land surface can only be achieved by actual field investigation, which, in many instances, will involve detailed soil and hydrogeological investigations both close to the water supply source and often within a wider field of interest in relation to the zone of influence and capture zones (see section 3.3). Such investigation would, for example, be relevant to determine the suitability of a site for a new water supply. Where this is deemed necessary expert assistance should always be sought. It is also possible to assess groundwater vulnerability without field studies from close examination of existing environmental data, although this approach is not without limitations.

4.7.2.2 Presence and nature of overlying soil

Soil is the thin upper layer of the earth's crust and is the product of complex interactions between five recognised soil forming factors: namely the action of **climate, living organisms** and **topography** on the **parent material** over a period of time. Development of soil arises primarily from the accumulation of mineral grains from either the physical or chemical weathering of rocks and the addition of organic material (humus) from decaying vegetation. As plants become established, topsoils develop as organic matter is incorporated into the soil and nutrients are released from minerals to the soil solution where they can be taken up by plant roots. Gradually, the soil matures at a rate which is dependent upon the local climate.

A vertical section through soil, as seen in the face of a pit or excavation, is referred to as a soil profile which exhibits a number of distinct layers or horizons. These are the product of soil forming processes taking place within the soil matrix. Where soils are uncultivated, there is usually a complex assemblage of horizons but, for convenience, it is often appropriate to talk of a three-fold division into:

a) topsoil - this is usually a dark brown to dark greyish brown colour due to the incorporation of decomposed organic material. This layer has a high biological activity resulting in an intimate mixing of mineral and organic material to give uniform colours.
b) subsoil - this is essentially pedogenically altered parent material where soil forming processes have been active to break down minerals and reorganise the soil material into aggregates of bound soil particles. Organic material is much less abundant than in the topsoil parent material - the relatively unaltered material at the base of the soil profile where the soil forming processes have had least influence. The depth to parent
c) material within the soil depends not only on the resistance to weathering but also on the length of time the weathering processes have been active.

4.7.2.3 Presence and nature of the drift deposits

In many areas drift deposits are present overlying the solid geology and are characterised, in many instances, by vertical and horizontal variation both in thickness and lithology. Therefore, where the drift is of substantial thickness and of low permeability it can provide an effective barrier to downward percolation of any pollutant which has passed through the soil zone. However, detailed and reliable maps of drift deposits are unavailable on a national scale and where there is uncertainty about drift composition and thickness, they are treated as a special case in any groundwater vulnerability assessment. In instances where the low permeability drift deposits are sufficiently thick (up to 5 metres) to afford complete protection to underlying major or minor aquifers from surface downward pollutants, such aquifers are not depicted on the map.

4.7.2.4 Nature of solid geology within the unsaturated zone

Geological strata with a groundwater content in exploitable quantities are referred to as aquifers, in contrast to rocks without the ability to transmit substantial quantities of water which are classed as non-aquifers. All aquifers vary in their general and hydraulic characteristics and in the unsaturated zone such variation determines the vulnerability of the groundwater to pollution. Permeable strata are classified, for convenience, into highly permeable aquifers and moderately permeable aquifers, the former having generally less capacity for attenuating contaminated recharge entering at the surface. A third category of weakly or non-permeable aquifers has also been recognised.

4.7.2.5 Soil classification

The systematic mapping for soils in Scotland began in 1947 with the aim of understanding their distribution and characteristics. By 1987 most of the arable soils in Scotland had been mapped at 1:25 000 scale and for publication at 1:63 360 scale, and the entire country had also been mapped at the reconnaissance scale of 1:250 000. The system of soil classification used in these series of maps is based principally on morphological features recognisable by surveyors in the field and takes only limited cognisance of chemical characteristics. It relies, therefore, on the recognition of central concepts of soil classes and the comparison of soil profiles within them. The lowest commonly used category in the classification system, and the unit shown on the most detailed maps, is the Soil Series, of which there are over 800 identified. Each Soil Series has a limited and defined range of diagnostic properties that distinguish it and allow it consistent national recognition in accordance with a definition as follows: a group of soils similar in character and arrangement of horizons within the profile and developed on the same soil parent material. Soil Series are named after the place where they were first described or are extensive. For example, Countesswells Series is developed entirely on glacial till derived from granite, has the morphological characters of a humus-iron podzol and was first mapped at Countesswells, within the grounds of the then Macaulay Institute for Soil Research, Aberdeen.

A Soil Association is a grouping of Soil Series in which the soils are developed on similar parent materials but differ in characteristics related to local variations in texture, relief and hydrologic conditions. They are generally characterised and named after the most frequently occurring component Soil Series.

Allied to the soil mapping is an extensive database of measured and observed soil physical and chemical properties which allow identification of several important diagnostic properties which influence the movement of pollutants in soil. These factors can be considered as follows:

a) slowly permeable layer - the presence of a dense, compact layer within the soil impedes the downward percolation of water with resultant intermittent waterlogging within the soil material. If present, slowly permeable layers can prevent contaminants within the soil solution moving vertically but careful consideration should be given to possible lateral movement downslope into receiving basins where problems may arise. Waterlogging is often associated with these layers, either within the layer itself or in the layers immediately above. Where waterlogging occurs the strong brown colours normally found within the subsoil of free draining soils are replaced by drab colours, greys and generally intense mottling. Horizons with these morphological characteristics are referred to as gleyed horizons. In some cases these slowly permeable layers can exist without clear evidence of waterlogging, for example, on slopes or mounds, or where the soils are very red in colour or in drier parts of the country. Either this layer is ineffective in intercepting downward percolating water, or other soil, site and climatic factors are operating to reduce waterlogging above it. As it can be difficult to interpret the degree of protection afforded by these situations precisely within the field or from existing soil maps, such soils are generally considered to give only medium protection to groundwater supplies.

b) gley characteristics without the slowly permeable layer - where gley characteristics are present and compact, dense subsoil horizons compatible with a slowly permeable layer are absent, it is likely that the soil is affected by groundwater. Given that this groundwater table is evident within the soil profile then even relatively short-lived potential contaminants entering the soil are likely to reach the groundwater. Such soils should be considered as affording a poor level of protection and should be placed in the high risk category.

c) soil porosity - under normal conditions soils develop a structure where the porosity allows gradual percolation of the soil solution through the soil matrix. In some cases the cracks and pores can be of sufficient width that they form pathways for rapid downward movement of water when the soil is unsaturated, termed by-pass flow. Liquid discharges entering at or near the surface of such soils have the potential to rapidly by-pass the upper, most attenuating soil layers. Similarly, a proportion of any diffuse-source contaminants dissolved in the soil water fraction are likely to move rapidly out of the upper soil layers as soon as there is a significant rainfall event. In such situations, if there are no slowly permeable layers present and the subsoil is shallow over shattered rock or gravel, or is seasonally affected by groundwater (as described in b above), then a significant proportion of any potential contaminants entering the soil are likely to move rapidly to underlying strata or to groundwater. These soils are of high risk.

d) soil adsorption capacity - in simple terms, the ability of a soil to adsorb contaminants or bacteria depends on several factors with clay content and organic matter content being of particular significance. These soil particles carry a net negative surface charge which allows the chemical bonding of positively charged ionic pollutants and certain microorganisms. Once bound, these contaminants can be chemically degraded through the normal processes of weathering within the soil. Thus the lower the clay and soil organic matter content, the lower the ability to attenuate potential contaminants.

e) soil parent material - the presence of rock, shattered rock or gravel within the soil profile indicates the presence of geological material. Where such material occurs within the soil profile, any potential contaminant entering the soil is likely to reach groundwater relatively quickly and, because the ability of geological material to attenuate potential pollutants is far less than that of weathered soil material, the potential for groundwater contamination is greater.

4.7.3 Use of groundwater vulnerability maps

4.7.3.1 Introduction

A methodology for classifying soils into three leaching potential classes has been developed by the Soil Survey and Land Research Centre for use in groundwater vulnerability maps[22] as identified for use in Scotland. This classification also embraces all Soil Series which have been mapped to date within Scotland, with each soil series being assigned a value corresponding to the ease with which a representative pollutant could move through the soil. This representative pollutant is assumed not only to be soluble in water so that it moves through the soil column in solution but also able to adsorb or stick onto clay particles and organic matter. Whilst it is recognised that not all pollutants have these characteristics, the classification does provide a generalised picture and many of the central concepts are valid in the assessment of the risks of microbiological contamination.

4.7.3.2 Soil leaching potential categories

Palmer *et al.*[22] published a classification which defines three main categories of leaching potential ranging from high to low. These classes were derived primarily for assessing the vulnerability of major aquifers to contamination from a wide range of pollutants and are as follows:

Class 1 High vulnerability or soil leaching potential

Soils in which water has the potential to move relatively rapidly from the surface to underlying strata or to shallow groundwater. This may be because there is fissured rock or gravel near to the soil surface, or because the soil has a low volumetric water content, or because, at certain times of the year, there is either groundwater near to the soil surface or there is by-pass flow through the upper soil layers. In such soils there is a high risk that, at certain times of the year, contaminants will move rapidly through the soil with little time for attenuation. The high category has been subdivided into four classes with soils in the H1 subclass having a greater soil leaching potential than H2, etc.

- H1 Soils with groundwater at shallow depth. Soils with rock, rock-rubble or gravel at shallow depth. Undrained lowland peat soils with permanently wet topsoils.
- H2 Sandy soils with low topsoil organic matter content.
- H3 Sandy soils with a moderate topsoil organic matter content. Soils with rock, rock-rubble or gravel at relatively shallow depth within the soil profile.
- HU Soils in urban areas and areas of restored mineral workings for sand/gravel.

Class 2 Intermediate vulnerability or soil leaching potential

Soils in which it is possible that significant amounts of water will penetrate to below two metres in depth. In such soils contaminants may move vertically through the soil, but are likely to be substantially attenuated by the processes of biological and chemical degradation, adsorption and dilution. The intermediate category has been divided into two subclasses; mineral soils are placed in I1 and peat soils in I2.

I1 Deep loamy and clayey soils unaffected by marked seasonal waterlogging, with a topsoil of low or moderate organic matter content.

I2 Lowland peat soils which have been drained for agricultural use.

Class 3 Low vulnerability or soil leaching potential

Soils in which excess water movement is predominantly horizontal, with little likelihood of any contaminants penetrating below two metres in depth. Where such soils fringe those in classes 1 and 2 however, lateral drainage may contribute to groundwater recharge and hence potential pollution. There is no subdivision of the low category of soil leaching potential.

L Soils with a dense subsoil which restricts downward water movement. Upland soils with a permanently wet peaty topsoil.

4.7.3.3 Benefits derived from groundwater vulnerability maps

In England and Wales a series of such maps have been published by the Environmental Agency at the scale of 1:100 000. Similar maps within Scotland are being produced by the Scottish Environmental Protection Agency. In simple terms, the maps contain three layers of information which from the surface downwards include:

- soil leaching potential classes and subclasses;
- presence, where applicable, of low permeability drift deposits at the surface above aquifers by stipple ornament;
- permeability of the geological deposits (major/minor/non-aquifer; see Table 3.1).

Together these layers of information produced 27 different vulnerability combinations, some of which must be interpreted with caution because of limitations within the following:

- soil data, in particular differences in map scale and variability within mapping units;
- drift data, in particular possible mismatches with soil information;
- geological data, in particular lack of data on the variability of mapped units, inadequate description of drift deposits and difficulties of portraying multi-aquifers as a single unit.

However these vulnerability combinations provide critical information for assessing the level of protection afforded to shallow groundwater by the soil and drift deposits, in particular the soil leaching potential. This information has been systematised allowing the rapid assessment of the protection afforded by the soil to private water supplies in terms of microbiological contamination. This information can be used to give assistance to site specific assessments in the area immediately surrounding a water supply when used in conjunction with soil inspection pits. Alternatively, and where the exact location of the source is not known, or where there is a substantial catchment area associated with the supply, interpreted soil maps (as exemplified in Appendix C) can be used. This approach has the benefit that the interpretation of the soils information is made by experts and it has a spatial component which takes account of the fact that the supply should be protected within a 50 metre radius. However, maps of this kind are not yet widely available for Scotland, there is a cost associated with their production, the scale of the available soil information may not always be suitable and there is an inherent variability in soils which can not always be shown on maps. Either soil interpretation or interpretative soil maps must be used in conjunction with information on land use. Even water supplies which are classified as having a soil which offers poor protection may not become contaminated if the land use in the surrounding area precludes the introduction of a contaminant.

4.7.3.3 Other factors which influence groundwater vulnerability

There are a series of site-specific factors which can contribute towards possible groundwater contamination but, in most instances, it is not possible to quantify the degree of risk. Examples of these are listed below:

- Physical disturbance of aquifers and groundwater flow. These activities lead to the disturbance of the physical barrier offered by the soil and may provide preferential pathways of water (and contaminant) movement to shallow groundwaters. These include: most forms of groundwater extraction; landfill operations; nearby borehole construction; any activity which interconnects naturally separate aquifers; existing or modified field drainage schemes that intercept recharge water; quarrying and gravel extraction both above and below the water table.

- Waste disposal to land. Many waste disposal practices have the potential to cause groundwater contamination. In this respect, the environment protection agencies have laid down certain regulations, many of them statutory, to ensure specific objectives. For example, there will normally be objections at the planning stage to waste disposal activities which extend to or below the water table within prescribed limits of a source. However, the disposal of slurries and other wastes on agricultural land in the vicinity of a private water supply is not subject to the same regulation, although codes of good agricultural practice do exist.

- Contaminated land, being land currently or previously used in connection with the following activities: sewage treatment works; landfill sites and other waste disposal and recycling activities; waste lagoons. The environmental agencies will seek to protect water supplies where any of the above activities are to be found in close proximity to a water source.

- The application of liquid effluents, sludges and slurries to land. Three categories of waste are recognised, being controlled wastes (industrial effluent sludges, both organic and inorganic in nature), sewage sludges and agriculture waste. Where the environment agencies consider that any of these deposits will give rise to a significant risk of polluting groundwater or surface water, there will be a presumption against spreading or compliance with existing environmental legislation. Wherever possible, farmers should have a waste management plan for their farm with information relevant to suitable land available for spreading liquid effluents, sludges and slurries.

- Discharges to underground strata. Three areas of concern have been identified:

  – sewage effluent discharges including septic tank and sewage treatment plant;
  – effluents from individual properties or small housing estates;
  – trade effluent discharges;
  – surface water discharges which include contaminated run-off from roofs; and
  – impermeable areas such as roads, car parks, storage areas, etc.

Diffuse pollution of groundwater. Diffuse pollution refers to pollution spread over time and space and caused by mechanisms other than local and specific discharges or events. Such pollutants are usually at much lower levels than other sources and are therefore at lower concentrations in the soil water. However, the build-up over a long period can generate potential problems. Diffuse pollution varies in character between urban and rural areas. Within the former, the two most notable examples of pollution arise from industrial sites and discharges from sewage systems. In contrast, within rural areas, the pollutant is not from an individual point discharge but arises from activities connected with intensive arable and livestock farming.

Additional activities or developments which pose a threat to groundwater quality include miscellaneous activities such as: storage of farm wastes and intensive livestock housing; graveyards and animal burial sites; sewage works; storm overflows.

4.7.3.4 Conclusion

Soil can offer protection to the shallow groundwaters associated with many private water supplies while a combination of soil and geological factors need to be considered when assessing deep groundwaters. The necessary soil information needed to make such assessments is obtained either by simple site inspection or from interpretations of soil maps; however, both the current and past land use practises will have a bearing on the ability of the soil to function as a filter and buffer to potential contaminants and on the presence of these contaminants. Therefore, land use remains a key component in any site appraisal.

4.7.4 Soil and land use factors underpinning the assessment of surface water vulnerability

4.7.4.1 Introduction

In some instances, private water supplies are fed by surface waters. The role of soils in offering protection to these sources is much more limited than that described above for groundwaters but nonetheless, differences in soil type will have an influence on the risk of microbiological contamination of these waters. Clearly, the soil has no role where the contaminant is deposited directly into the water body, but where a potential contaminant is deposited near to a water body, then there are a number of factors which affect the risk of contamination. The main factors are surface run-off which washes the contaminant into the water body and stream extension (both laterally and upslope) which entrains the contaminant.

The degree of surface flow is dependent on the intensity and duration of rainfall, the soil type, slope and land use. In general terms, high intensity rainfall, like that associated with thunder storms, is likely to initiate overland flow in most soils as the infiltration rate of the soil is exceeded by the rainfall intensity. More recently, it has been recognised that low intensity rainfall over a prolonged period of time can also lead to overland flow. In both cases the soil type can have a major influence on the amount of rainfall that can be absorbed before the initiation of run-off. Soils with open, porous structures and with no slowly permeable layer will be able to absorb more than shallow soils or those with slowly permeable layers near to the soil surface. The land use can act as an interceptor for rainfall (for example, a forest), reducing the actual amount that reaches the soil surface as well as providing the opportunity for the presence of potential contaminants (for example, open moorland which is grazed by domestic and wild animals).

Stream extension is the process whereby the apparent stream network as seen under dry conditions extends during rainfall, with the development of ephemeral streams and rivulets which occupy topographic hollows and are interconnected with the normal stream network. In many Scottish catchments, these streams and rivulets become dry soon after the rain has stopped. However, during rainfall the water flowing along these pathways will often be sufficiently fast and deep to entrain contaminants such as animal faeces. The occurrence of these pathways is difficult to predict from soil maps but some soil types will be more likely to behave in this way than others.

During periods of rainfall, the levels of streams and rivers generally rise and may extend out beyond their normal channel to occupy their floodplain. In many small catchments, these floodplains may only be a few metres wide, but any faecal material or other potential contaminants on the surface may be entrained in the stream.

4.7.4.2 Soil assessment

The risk assessment of the vulnerability of surface waters is not as well developed as that of groundwaters, however, the concepts of surface and immediate sub-surface flow have been developed in other sub-disciplines within soil science and can be used to derive a provisional vulnerability classification. The general concepts are derived from the Hydrology of Soil Types (HOST) technical report[24]. This work derived a classification of UK soils which both describes the dominant pathways of water movement through the soil and assigns proportions of the rainfall likely to lead to a fast response in streams and rivers. These proportions are termed standard percentage run-off and can be used to indicate the soils likely to have a high incidence of overland flow as well as those likely to cause a rapid rise in river levels or to initiate stream extension. This work indicates that soils with peaty surface layers tend to initiate surface run-off quicker than soils with a mineral surface layer and that soils with a slowly permeable layer close to the soil surface will initiate surface run-off more quickly than deep, porous soils.

4.7.4.3 Conclusion

Although still an underdeveloped area of microbiological risk assessment, the results and concepts derived from soil hydrological research can be used to rank the role of soil in assessing the vulnerability of these waters to contamination. However, the very fact that there is no protection from the direct entry of contaminants into surface waters means that these sources must remain at a high risk of contamination.

SECTION D (iii) Soil leaching risk survey

Using the National Grid Reference derived in Section C (7(iii)) the appropriate soil leaching risk map is examined and the category of the soil associated with the source is determined using the table below.

If the source cannot be identified then the risk characterisation for the soil leaching risk classification will be assigned a “High” value.

If there appear to be several soil leaching potentials at or near the point where the source has been determined then the soil leaching potential with the highest risk characterisation score will be used to complete the risk assessment.

The appropriate hazard assessment score will be assigned according to the table.

Soil Leaching Risk Classification	Risk Characterisation	Hazard Assessment
Low	Low	4
Intermediate 1	Moderate	8
Intermediate 2	Moderate	8
High 1	High	16
High 2	High	16
High 3	High	16
Built up	High	16

The following (simplified) explanation of soil leaching potential is taken from the soil leaching risk map legend.

Principles

The purpose of the soil leaching potential maps for microbiological risk assessment is to show, in broad terms, the potential of soils to attenuate possible pollutants by adsorption and degradation. Where the soil has a limited ability to attenuate, there is an increased possibility that potential pollutants will leach from the soil and penetrate underlying groundwater. In areas where the geological drift is thick and of low permeability, the soils are of less significance and groundwater may be less vulnerable to contamination than shown by the map.

The scale of the underlying soil mapping means that the map units may not comprise single soil types, thus only the Soil Leaching Potential that constitutes the greatest proportion of a map unit can be shown. The map is a compromise between the representation of natural complexity and simplicity of interpretation at the scale of representation. This places limitations on the resolution and precision of the map information. The variety of soil, potential pollutants and the generalised nature of Soil Leaching Potential classification means that individual sites and circumstances should be subject to more detailed assessment.

Soil leaching potential classification

The ability of a soil to protect underlying groundwaters from contamination depends on the physical properties that affect the downward passage of water and the chemical properties that affect the attenuation of contaminants. These include: texture (clay and organic matter contents), structure, soil water regime and the presence of distinctive layers such as raw peaty topsoil and rock or gravel at shallow depth. In areas where the geological drift is thick and of low permeability, the soils are of less significance and groundwater may be less vulnerable to contamination than shown by the map. All soils in Scotland can be grouped into one of six classes. Where the soil cover has been considerably altered, for example, in urban areas, they are designated as being at high risk of leaching and form a separate class.

For the purpose of the Microbiological Risk Assessment procedure, it is recommended that three classes will be sufficient: High, Medium and Low risk corresponding to the three main soil leaching potential classes of High, Intermediate and Low.

Soils of high leaching potential (H)

Soils with little ability to attenuate diffuse source contaminants and in which non-adsorbed diffuse contaminants and liquid discharges have the potential to move rapidly to underlying strata or to shallow groundwater. Three subclasses are recognised:

H1 Soils that readily transmit liquid discharges because they are either shallow or susceptible to by-pass flow directly to rock, gravel or groundwater.

H2 Deep, permeable, coarse textured soils that readily transmit a wide range of contaminants because of their rapid drainage and low attenuation potential.

H3 Coarse textured or moderately shallow soils which readily transmit non-adsorbed contaminants and liquid discharges but which have some ability to attenuate adsorbed contaminants because of their organic matter content.

HU Soils over current and restored mineral workings and in urban areas that are often disturbed or absent. A worst case vulnerability classification (equivalent to H1) is therefore assumed for these areas, until proved otherwise.

Soils of intermediate leaching potential (I)

Soils with a moderate ability to attenuate diffuse source contaminants or in which it is possible that some non-adsorbed diffuse source contaminants and liquid discharges could penetrate the soil layer. Two subclasses are recognised:

I1 Deep, permeable, medium textured soils that can possibly transmit a wide range of pollutants.

I2 Deep, permeable, medium textured soils with high topsoil organic matter contents that can possibly transmit non- or weakly-adsorbed diffuse contaminants and liquid discharges, but are unlikely to transmit adsorbed contaminants.

Soils of low leaching potential (L)

Soils in which contaminants are unlikely to penetrate the soil layer due to the presence of a low permeability horizon. Water and contaminant movement is, therefore, largely horizontal but the soils may also have the ability to attenuate contaminants. Lateral flow from these soils may contribute to groundwater recharge elsewhere in the catchment. These soils may have a high clay or organic matter content.

Notes

(i) Where no subclasses are indicated for the Intermediate and High soil leaching potentials, the underpinning map units comprise a number of distinctive soil types. Only the soil leaching potential of the dominant soil type is given.

(ii) The map is a compromise between the representation of natural complexity and simplicity of interpretation at the chosen scale. This places limitations on the resolution and precision of map information. In this case, the variety of soils that has to be covered is wide, and the classification used is generalised. Individual sites and circumstances will always require further and more detailed assessment.

(iii) The map only represents conditions at the surface and, therefore, where the soil and/or underlying formations have been disturbed or removed, for example, during mineral extraction, the leaching potential may have been changed. Hence, where there is evidence of disturbance, site specific data will need to be used.

D (iv) Overall risk assessment

(a) Risk characterisation

The overall risk assessment for the source is taken as the highest individual risk category identified from each of the three surveys.

The overall risk characterisation category will be recorded as the risk assessment score for the source.

Survey Section	Risk Characterisation Category
General Site Survey	
Source Survey	
Soil Leaching Risk Survey	
Overall Risk	

(b) Hazard assessment

Individual components in each of the surveys with a hazard assessment score of 16 or greater should be considered as priority candidates for remedial works capable of reducing the overall risk characterisation category.

Section E

If the type of the supply has not been determined then the risk assessment will not have been completed. In this case the overall risk assessment for the supply will default to High Risk to ensure that appropriate control measures are put in place to maintain public health.

Section F

Additional Notes – this section can be used to include additional information or observations made during the investigation.

Section 4.7 – Annex 1

Spring Risk Assessment pro forma

Private water supply risk assessment form

SPRING SUPPLY

OVERALL RISK ....

Section A – Supply Details

1. Supply category

Type A1 / A2 / A3   Type B (circle appropriate category)

2. Address and telephone number of responsible person

....

....

....

Post Code ....

Telephone Number (including full STD Code) ....

Email Address ....

3. Name of person (or persons) who is relevant person in relation to the supply

(a) ....

(b) ....

(c) ....

(d) details of additional sheets ....

4. Address of relevant person (or persons) (if different from above)

(a) ....

....

....

Post Code ....

Telephone Number (including full STD Code) ....

Email Address ....

(b) ....

....

....

Post Code ....

Telephone Number (including full STD Code) ....

Email Address ....

(c) ....

....

....

Post Code ....

Telephone Number (including full STD Code) ....

Email Address ....

(d) details of additional sheets ....

5. Details of premise(s) served by the supply and purpose for which water is supplied

(a) ....

....

....

Post Code ....

Supply purpose ....

(b) ....

....

....

Post Code ....

Supply Purpose ....

(c) ....

....

....

Post Code ....

Supply Purpose ....

(d) details of additional sheets ....

Section B

6. Provide a diagram of the supply showing source(s), intermediate storage and/or collection tanks and properties on the supply. The diagram is indicative only and is intended to aid completion of the rest of this section.

Notes: Items should be labelled from source (A) through intermediate tanks (B) to properties (C) with individual components numbered, e.g. for a supply with one source this would be A1; two intermediate tanks (B1 and B2 respectively) and two properties (C1 and C2) respectively.

7. Description of the source of the supply including (i) details of supply source(s), (ii) location of the source(s) and (iii) National Grid Reference of location(s) of source(s). Cross reference from Item 6 above.

(i) ....

....

....

(ii) ....

....

....

(iii) National Grid Reference _N_ / _J_ / _0_ / _0_ / _0_ / _0_ / _0_ / _0_

8. (a) Estimated daily volume of water provided by the supply .... m^3 per day

(b) Number of persons served by supply (at maximum occupancy) ....

9. Details of any water treatment processes associated with the supply

(a) At source – identify which of the following systems are present: (cross reference to Item 6)

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

(b) Intermediate Water Storage Tank/Chamber (cross reference to Item 6)

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

(c) At property (cross reference to Item 6)

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

(d) details of additional sheets ....

Section C

10. Details of departures authorised

....

....

....

11. Details of sample results for previous 12 months or last available (reference location of information, e.g. paper or electronic files, reference number, sample numbers, etc.)

....

....

....

12. Details of previous (last 2) investigations and actions taken

....

....

....

13. Details of enforcement notices served

....

....

....

14. Result of previous risk assessment (if applicable)

....

....

....

15. Details of location of Notice for Type A supplies (location)

....

....

....

16. Is Notice appropriate (conforms to requirements of the Regulations)? Yes ☐ No ☐

17. Details of action taken (or to be taken) by relevant persons to comply with

(a) results of sampling

....

....

....

....

(b) results of follow-up to sampling

....

....

....

....

18. Whether supply exempt under Regulation 2(4)

....

....

....

19. Details of other information relating to the supply collated by the local authority

....

....

....

20. Is there a Water Safety Plan/ Emergency Action Plan available for the supply?

Yes ☐ No ☐

21. If "Yes" to Item 20, is it fit for purpose? Yes ☐ No ☐

22. If "No" to Item 21, what deficiencies are required to be addressed (provide details)?

....

....

....

Section D – Springs

D (i) General site survey

Are any of the following known to be present and likely to influence water quality at the source?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
23	Evidence or history of poor drainage causing stagnant / standing water	H	L	H		8	
24	History of livestock production (rearing, housing, grazing) – including poultry	H	L	H		16	
25	Evidence of wildlife	M	L	M		4	
26	Surface run-off from agricultural activity diverted to flow into the source/supply	H	L	H		8	
27	Soil cultivation with wastewater irrigation or sludge / slurry/ manure application	H	L	H		16	
28	Disposal of organic wastes to land	H	L	H		8	
29	Farm wastes and/or silage stored on the ground (not in tanks or containers)	M	L	M		8	
30	Remediation of land using sludge or slurry	H	L	H		16	
31	Forestry activity	M	L	M		4	
32	Awareness of the presence of drinking water supply/source by agricultural workers	L	H	H		4	
33	Waste disposal sites (including scrap yard, car yard, rubbish and hazardous waste disposal, landfill or incinerator including on-farm incineration)	H	L	H		8	
34	Disposal sites for animal remains	H	L	H		8	
35	Unsewered human sanitation including septic tanks, pit latrines, soakaways	H	L	H		16	
36	Sewage pipes, mains or domestic (e.g. leading to / from septic tank)	H	L	H		8	
37	Sewage effluent lagoons	H	L	H		16	
38	Sewage effluent discharge to adjacent watercourse (where present)	H	L	H		16	
39	Supplies or wells not in current use	H	L	H		8	
40	Evidence of use of pesticides (including sheep dip) near source	H	L	H		8	
41	Evidence of industrial activity likely to present a contamination threat	H	L	H		8	

[1] The Hazard Assessment Score is the product of the Likelihood and Severity values. The values are :

Likelihood	Definition	Value
Almost certain	Once per day (or permanent feature)	16
Likely	Once per week	8
Moderate likely	Once per month	4
Unlikely	Once per year	2
Rare	Once every 5 years	1

Risk Characterisation

Tick the appropriate box for each question.

If any question is High Risk (H) then the Risk Characterisation Score is **High**. ☐

If no question is High Risk but there are Moderate Risks (M) identified then the Risk Characterisation Score is **Moderate**. ☐

If no question is High Risk (H) or Moderate Risk (M) then the Risk Characterisation Score is **Low**. ☐

Hazard Assessment

If the Hazard Assessment Score is 16 or greater for any individual component then the issues associated with that component should be considered as a priority for remedial works to reduce the hazard experienced by the supply.

D (ii) Supply survey

Are any of the following known to occur at the head works site or in relation to the supply?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
42	No stock proof fence (to BS1722 or equivalent) at a minimum of 4 metres around the source?	H	L	H		8	
43	No suitable barrier present to prevent ingress of surface flows into the well (e.g. cut-off ditch lined with impermeable material, steep incline/decline such as embankments, appropriate walls, etc.)	H	L	H		16	
44	Overflow/washout pipe not fitted with vermin proof cap	H	L	H		8	
45	Inlet pipe not fitted with course filter or screen	H	L	H		16	
46	If chamber present no reinforced pre-cast concrete cover slab, or equivalent, in satisfactory condition with a watertight, vermin-proof inspection cover present to BS497 (lockable steel type or equivalent) with or without ventilation?	H	L	H		16	
47	Construction in an unsatisfactory state-of-repair?	H	L	H		8	
48	Supply network constructed from material liable to fracture, e.g. asbestos-concrete, clay, etc.?	H	L	H		8	
49	Intermediate tanks (e.g. collection chambers, holding tanks, break-pressure tanks) are not adequately protected (i.e. do not have protection described in [42] to [46] above)?	H	L	H		8	
50	Junctions present in the supply network, particularly supplying animal watering systems, have no back-siphon protection?	H	L	H		4	
51	No maintenance (including chlorination) has been undertaken in the previous 12 months?	H	L	H		8	
52	If present, header tank within the property(s) does not have a vermin-proof cover?	H	L	H		4	
53	Header tank has not been cleaned in the last 12 months?	H	L	H		8	
54	Any point of entry/point of use treatment equipment has not been serviced in accordance with the manufacturer's instructions in the last 12 months?	H	L	H		8	
55	If present ultraviolet (UV) lamps are not operating?	H	L	H		16	
56	Is there a noticeable change in the level and flow of water throughout the year?	H	L	H		4	
57	Is there a noticeable change in the appearance of the water (colour, turbidity – cloudiness) after heavy rainfall or snow melt?	H	L	H		8	

[1] The Hazard Assessment Score is the product of the Likelihood and Severity values. For details see Section D.

Risk Characterisation

Tick the appropriate box for each question.

If any question is High Risk (H) then the Risk Characterisation Score is **High**. ☐

If no question is High Risk but there are Moderate Risks (M) identified then the Risk Characterisation Score is **Moderate**. ☐

If no question is High Risk (H) or Moderate Risk (M) then the Risk Characterisation Score is **Low**. ☐

Hazard Assessment

If the Hazard Assessment Score is 16 or greater for any individual component then the issues associated with that component should be considered as a priority for remedial works to reduce the hazard experienced by the supply.

D (iii) Soil leaching risk survey

Using the NGR identified in Section B (7)(iii) determine and record below the soil leaching potential from the appropriate soil leaching potential map covering the geographic area of interest for location of the source.

National Grid Reference __N__ / __J__ / __0__ / __0__ / __0__ / __0__ / __0__ / __0__

Soil Leaching Risk Classification Assigned ....

Risk Characterisation Score ....

Hazard Assessment Score ....

Table D1 - Soil leaching risk characterisation and hazard assessment scores

Soil Leaching Risk Classification	Risk Characterisation	Hazard Assessment
Low	Low	8
Intermediate 1	Moderate	16
Intermediate 2	Moderate	32
High 1	High	64
High 2	High	128
Built up	High	16

D (iv) Overall risk assessment

(a) Risk characterisation

The overall risk assessment for the source is taken as the highest individual risk category identified from each of the three surveys.

The overall risk characterisation category will be recorded as the risk assessment score for the source.

Survey Section	Risk Characterisation Category
General Site Survey	
Source Survey	
Soil Leaching Risk Survey	
Overall Risk	

(b) Hazard assessment

Individual components in each of the surveys with a hazard assessment score of 32 or greater should be considered as priority candidates for remedial works capable of reducing the overall risk characterisation category.

Section E

You have been unable to discern the type of supply and so the overall risk assessment for this source must be given as **High Risk**.

Section F – Additional Notes

This page is intentionally blank

4.8 Borehole risk assessment (see 4.8 Annex 1 for full form)

Overall Risk – this is taken from the overall risk assessment in section D(iv)(a) of the risk assessment form.

SECTION A – Supply details

Item 1 – Supply category

The supply category that is required to be identified is taken from The Private Water Supplies (Scotland) Regulations 2006 Part 1(2). These state:

"Type A supply" means a private water supply for human consumption purposes which

(a) on average, provides 10 or more cubic metres of water per day or serves 50 or more persons, or
(b) regardless of the volume of water provided or the number of persons served, is supplied or used as part of a commercial or public activity,

and references in this definition –

(i) to the average volume of water provided by such a supply, are references to such volume (calculated as a daily average) as may be reasonably estimated to have been distributed or, if not distributed, used or consumed from the supply during the year prior to the year in which these Regulations come into force; and that estimate may be on the assumption that five persons use one cubic metre of water per day; and
(ii) to the average number of persons served by such a supply, are references to such number of persons as may be reasonably estimated to be the maximum number served by the supply on any one day during the year prior to the year in which these Regulations come into force;

"Type B supply" means a private water supply other than a Type A supply; and "year" means a calendar year.

Item 2 – Address and telephone number of responsible person

"Responsible person" is a term used in the Regulations referring to the person who owns or otherwise is responsible for the domestic distribution system which included the pipework, fitting and appliances which are installed between the taps that are normally used for human consumption purposes and the distribution network which is not the responsibility of a relevant person (see Item 3). Full contact details of the responsible person should be recorded here.

Item 3 – Name of person (or persons) who is relevant person in relation to the supply

The term "relevant person" refers to the person considered by the local authority to be the person providing the supply, or occupying the land from, or on, which the supply is obtained or located, and any person who exercises powers of management or control in relation to the supply.

The relevant and responsible person may be one and the same person in some instances.

In some instances there may be more than 3 relevant persons in which case additional sheets should be used to record the information and details of these additional sheets should be included in section (d) and the sheets appended to the form when completed.

Item 4 – Address of relevant person (or persons) (if different from above)

Where the responsible person and the relevant person are different then the contact details for the relevant person or persons should be recorded in this section.

In some instances there may be more than 3 relevant persons in which case additional sheets should be used to record the information and details of these additional sheets should be included in section (d) and the sheets appended to the form when completed.

Item 5 – Details of premise(s) served by the supply and purpose for which water is supplied

This item seeks to capture details of any premise that may be served by the supply and the purpose for which the water is being supplied. It is necessary to have as complete a list of properties served by a private water supply as possible in order that the true interconnectivity of the supply may be assessed and the potential population affected by any breach of the Regulations or incidence of waterborne disease outbreak can be assessed rapidly and efficiently. For larger supplies this exercise will be challenging but attention to detail will ensure that the most comprehensive and accurate records are compiled which will assist in future investigations relating to the supply.

Additional sheets (as required) should be appended to the form and a note of these made at section (d).

SECTION B

Item 6 – Diagram of the supply

This is intended to enable the investigating officer to provide a schematic sketch showing the interrelationships between the various components of the supply such as source, intermediate tanks and properties being supplied. While there is undoubtedly a balance to be struck between too much detail and insufficient detail, a guiding principle should be to provide sufficient information to enable colleagues who have not visited the site to quickly navigate around the supply.

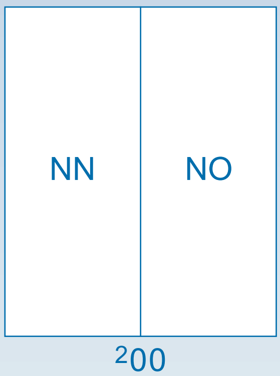
Item 7 – Description of the source of the supply

The description provided should complement the schematic sketch provided at Item 6. The purpose of having a written description is to provide a record of the condition of the infrastructure at the time of the risk assessment. This will enable a baseline to be established against which any future developments made to the supply can be benchmarked. If the facility exists it would be appropriate to also include relevant photographic evidence of the various components so long as they are uniquely identified and cross-referenced within the risk assessment report.

A full National Grid Reference for the source (or the closest point to the source identified) should also be provided.

How to give a grid reference to nearest 100 metres

The example below is taken from Ordnance Survey Braemar to Blair Atholl Sheet 43 1:50000 Landranger Series.

100 000 metre Grid Square Identification	Example - Altaltan			
	1. Read letters identifying 100 000 metre square in which the point lies.	NO		
	2. FIRST QUOTE EASTINGS Locate first VERTICAL grid line to LEFT of point and read LARGE figures labelling the line either in the top or bottom margin or on the line itself. Estimate tenths from grid line to point.		18 4	
	3. AND THEN QUOTE NORTHINGS Locate first HORIZONTAL grid line BELOW line either in the left or right margin or on the line itself. Estimate tenths from grid line to point.			63 5
	EXAMPLE REFERENCE	NO 184 635		
Ignore the smaller figures of any grid number: these are for finding the full coordinates. Use ONLY the LARGER figure of the grid number. Example: 2 80 000m				

Extract from 1:50 000 sheet 43 showing location of Altaltan

Due to OS licence conditions, you/your agent may only use this map for official business dealings with the Scottish Executive. If you wish to use the map for other uses, you must first obtain a separate licence from OS.

Item 8 – Estimated daily volume of water provided by the supply

If the volume of water is not being measured, e.g. via a water meter, then the investigating officer can make an estimate of the volume based on 200 litres of water per day per person served by the supply. While the figure will only be an estimate every effort should be made to identify the maximum number of people who are being supplied with water from the supply. It is not sufficient just to base the estimate on historical records, e.g. the classification of the supply made under previous regulatory frameworks. It is important to have a robust and defensible maximum occupancy for the supply as this may well have an impact on the sampling frequency to which the supply is subjected.

Item 9 – Details of any water treatment processes associated with the supply

While it is important to document any treatment that occurs on the supply it is not practicable to list all possible treatment types or systems that may be encountered. The risk assessment form concentrates on the provision of standard disinfection equipment/processes but all other treatment systems should be included in the description including items such as sediment traps of pH correction systems. Each of the treatment processes should be cross-referenced to those identified on the schematic provided at Item 6.

For larger systems it will not be practicable to complete Item 9 (c) and so a table should be drawn up listing the properties and the treatments associated with each property differentiating between point of entry and point of use devices, e.g.

Responsible Person	Property address (including post code)	Point of entry device (specify)	Point of use device (specify)	Notes
Mr D Able	1 Wellside Cottage, Nethermuir, ZZ1 1AA	UV lamp	None	located in lean-to on north side of house, pre-filter bypassed
Mrs C Brown	3 Wellside Cottage, Nethermuir, ZZ1 1AA	UV lamp	None	On maintenance contact with Bloggs Plumbing, Nethermuir
Ms B Charlie	Springside House, By Nethermuir, ZZ1 2BA	None	UV lamp	Under sink in kitchen – poor access for changing bulb
Rev. A Davis	Riverbank Cottage, Nethermuir, ZZ1 1AB	None	None	

These details should be recorded as additional sheets on the form at Item 9 (d)

SECTION C

Item 10 – Details of departures authorised

Provide details of any temporary departures granted under Part IV of the Private Water Supplies (Scotland) Regulations 2006. These details should summarise the details provided in the original temporary departure and should cross-reference to the complete application. If applicable the temporary departure authorisation (Regulation 6(7) of the above Regulations) can be appended to the risk assessment. Details of this should be recorded in Section G.

Item 11 – Details of sample results for previous 12 months or last available (reference location of information, e.g. paper or electronic files, reference number, sample numbers, etc.)

The inclusion of this information is to assist the investigation officer in their investigations. Details of the previous sampling results will enable areas of concern to be highlighted and assist in focusing on areas where actual breaches of the drinking water quality standards have occurred. For example, if lead is highlighted as failing in the sample results, while lead is not specifically being looked for in the risk assessment, the investigation officer may take the opportunity of the investigation to attempt to determine whether there are any known lead pipes or tanks associated with the supply or through examination of the appropriate geological map whether lead is naturally occurring in the vicinity of the source. If lead pipes or tanks are present then appropriate advice can be provided on the need for their removal; if lead is naturally occurring at the source then discussions around locating a more acceptable alternative source for the supply can be entered into.

Item 12 – Details of previous (last two) investigations and actions taken

If there have been investigations into previous failures then the last two such investigations should be summarised here along with the actions that were taken or were understood to have been agreed to have been taken. This information will provide the investigation officer with a background to the problems that have been encountered previously along with an understanding of what actions have been attempted to improve the situation and whether these actions have proved to be successful. If they have proved to be unsuccessful then this information will allow the investigation officer to consider alternative solutions that have not been previously implemented.

Item 13 – Details of enforcement notices served

If any enforcement notices have been served that affect the supply under investigation, details of these should be provided here. If necessary additional information may be appended to the risk assessment and details of these should be provided in Section G.

Item 14 – Results of previous risk assessment (if applicable)

If the source or supply has previously been risk assessed then the details of the previous risk assessment(s) should be included with the current risk assessment. The previous risk assessments should be appended to the current form and details of these additional sheets should be recorded against this item.

Item 15 – Details of location of Notice for Type A supplies (location)

Regulation 31 of the Private Water Supplies (Scotland) Regulations 2006 requires that up-to-date information about the quality of the water provided in commercial or public premises shall be displayed in a prominent location. This notice forms part of the communication of risk to members of the public and so the location of the notice should be recorded to ensure that appropriate risk communication is being undertaken.

Item 16 – Is Notice appropriate (conforms to requirements of the Regulations)

Regulation 31 (2) details the form that the information notice must take. This item confirms that the appropriate form of the notice is being displayed as the form of the notice interlinks with additional information available to both owners/users and visitors to private water supplies making it vital that the appropriate form of the notice is utilised.

Item 17 – Details of action taken (or to be taken) by relevant persons to comply with (a) results of sampling (b) results of follow-up to sampling

If sampling results indicate that the supply fails to comply with the requirements of the Regulations, this section should be completed to identify what suggested/agreed remedial steps should be taken to prevent future failures.

Item 18 – Whether supply exempt under Regulation 2 (4)

If the supply is used solely for washing a crop after it has been harvested or during the distillation of spirits (solely in the mashing process or for washing plant but for no other purpose) and which does not affect, either directly or indirectly, the fitness for human consumption of any food or drink or, as the case may be, spirits in their finished form, then the provisions of the Private Water Supply (Scotland) Regulations 2006 do not apply to that supply with the exception of the provisions of regulation 29. If the supply is exempted under the provisions of regulation 2(4) then a full risk assessment is not required to be completed but good practice would require a partially completed form to be retained by the local authority containing the information required by regulation 29.

Item 19 – Details of other information relating to the supply collated by the local authority

If the local authority has other relevant information relating to the supply then these details should be included here or appended to the form and details of the additional sheets recorded under this item.

Item 20 – Is there a Water Safety Plan/Emergency Action Plan available for the supply

Some supplies may have a water safety plan or emergency action plan that details steps to be taken to ensure the quality of water at the source and steps to be taken in the event of a loss of constancy or quality from that supply.

Item 21 – If "Yes" to Item 20, is it fit for purpose

This item requires an assessment by the investigation officer as to whether or not the water safety plan or emergency action plan is suitable for the premises it relates to.

Item 22 – If "No" to Item 20, what deficiencies are required to be addressed (provide details)

If the assessment undertaken in Item 21 suggests there are inadequacies in the water safety plan or emergency action plan then the deficiencies should be noted against this item with suggestions, where appropriate, as to what improvements may be considered to the plan(s).

SECTION D

General introduction

In this part of the form each of the indicators being looked for, e.g. disposal sites for animal remains, will have two separate scores associated with them.

The first score will be the Risk Characterisation score

The Risk Characterisation score has three values – High, Moderate or Low – and is based on the presence or absence of the indicator based on the evidence available to the person undertaking the risk assessment. The form is preloaded with the risk characterisation value based on the individual indicator being present or absent. If the assessor cannot determine if the indicator is present then the "Don't know" option should be used.

The assessor should tick the appropriate response box for each indicator. If any response is identified as High Risk (H) then the Risk Characterisation Score will be **HIGH**. If no response is High Risk but there are Moderate Risks (M) identified then the Risk Characterisation Score will be **Moderate**. If no response is High Risk or Moderate Risk then the Risk Characterisation Score is **Low**.

The second score is the Hazard Assessment score.

The Hazard Assessment Score is also based on the indicator being present but this scoring allows the extent of the potential influence of the indicator to be taken into account. Thus the likelihood score is dependent on a knowledge or estimate of the time period during which the indicator may be present at the source under investigation. The table in the form provides guidance on the values to be assigned based on how frequently the indicator is known, or thought, to be present. If the indicator is present continuously, i.e. once per day or a permanent feature, then the likelihood value assigned will be 16 as the indicator is almost certainly there continuously; if the indicator is present once a week then the likelihood value assigned will be 8; if the indicator is present once a month then the value will be 4; if the indicator is present once a year then the likelihood value assigned will be 2; and if the indicator is known, or thought, to occur rarely such as once every five or more years, then the value assigned will be 1. Once the likelihood value has been assigned on the form the Hazard Assessment Score is determined by multiplying the Likelihood Value by the Severity (which is pre-loaded on the form) to give the overall Hazard Assessment Score.

The Hazard Assessment Score is an index and there is no implied mathematical relationship to risk. The Hazard Assessment Score is a convenient way of prioritising actions or interventions so that resources are effectively targeted to those areas that pose the greatest potential risk of contamination to the source under investigation.

If the Hazard Assessment Score is **16** or greater for an individual component then the issues associated with that component should be considered as a priority for remedial works to reduce the hazard experienced by the supply.

The value of 16 is considered to be appropriate when only a rare event may produce a catastrophic outcome, e.g. sewage effluent discharge to adjacent watercourse. However, if the presence of sewage effluent discharge to an adjacent watercourse were to occur more frequently than once every 5 years or more then the Hazard Assessment Score would reflect this change by increasing the score, and hence flag the requirement to take appropriate action to reduce the likelihood of the occurrence.

Hazard assessment matrix

	Severity of consequences				
Likelihood	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	16	32	64	128	256
Likely	8	16	32	64	128
Moderately likely	4	8	16	32	64
Unlikely	2	4	8	16	32
Rare	1	2	4	8	16

Each of the indicators in Section D will now be considered in turn.

Section D(i) Boreholes with headworks located below ground

General site survey

Item 23 – Evidence or history of poor drainage causing stagnant/standing water

If standing water can be seen present around the well head area or if there is evidence of standing water having been present, e.g. mud or vegetation consistent with marshy ground such as reeds, then the hazard should be scored as being present and the risk characterisation assigned as "Yes". If there is a suggestion that the likelihood of the standing water being present (or evidence of having been present) is a long-standing occurrence then the likelihood score for the hazard assessment should reflect this.

Item 24 – History of livestock production (rearing, housing, grazing) – including poultry

Any evidence of domestic livestock production being present (either directly by the presence of animals in the vicinity of the supply) or indirectly (through presence of broken ground around the supply or the presence of animal droppings around the supply) should result in the risk characterisation being scored as "Yes". Further investigations will be required to decide on the persistence of such presence in order to allow the hazard assessment likelihood score to be accurately assigned.

Item 25 – Evidence of wildlife

Any evidence of wildlife, mammals (rabbits, deer, etc.), birds (gulls, geese, migratory birds, etc.), reptiles (newts, frogs including spawn) etc. at the source could indicate the potential for contamination of the supply either from faecal material or from carcasses falling into the supply. If evidence of wildlife is found then the risk characterisation should be scored as "Yes". Account should be taken of the likely frequency of the presence of wildlife, e.g. a rabbit warren nearby will suggest permanent presence; migratory birds will suggest a seasonal presence which will require the suggested likelihood values to be moderated to reflect this seasonal presence by raising the once per year score of 2 to 4.

Item 26 – Surface run-off from agricultural activity diverted to flow into source/supply

This indicator is intended to deal with field drains and other drainage systems employed on agricultural land which may be connected to the source or supply. The indicator also deals with instances where there is overland flow from agricultural land that ends up in a watercourse or entering the source and potentially contaminating the supply, e.g. applied slurry, where there is potential for it to be washed into field drains or watercourse or similar drainage systems. If there are drainage systems or similar present in areas of agricultural activity then the risk characterisation response will be "Yes". The likelihood value will be based on the probable time the land is being subjected to agricultural applications.

Item 27 – Soil cultivation with wastewater irrigation or sludge/slurry/manure application

This indicator differs from Item 26 in that there will be active application of the materials in conjunction with the disruption of the soil itself, e.g. via ploughing or sub-soil injection. If such activities are considered to be undertaken then the risk characterisation will be "Yes". The likelihood value will be based on the probable time/duration that such activities occur at.

Item 28 – Disposal of organic wastes to land

This indicator deals with any other organic waste, e.g. abattoir wastes or "blood and guts". The scoring for this indicator will be irrespective of whether there has been disruption of the soil. If such activities are considered to be undertaken then the risk characterisation will be "Yes". The likelihood value will be based on the probable time/duration that such activities occur at.

Item 29 – Farm wastes and/or silage stored on the ground (not in tanks or containers)

If there are middens or areas where silage are being stored in polyethylene bags (or equivalent) or other farm-derived wastes where there is no bunded storage and there is the potential for spillage entering drainage systems, then this item should be scored such that the risk exists. If the storage appears to be a permanent or long-term feature then the hazard assessment should be scored as almost certain (value 16) or likely (value 8).

Item 30 – Remediation of land using sludge or slurry

In some areas brownfield sites or derelict land will be remediated using sewage-derived sludge or slurry or similar materials. The rate of application will typically be higher than those used in Item 27 and this should be borne in mind when assessing both the risk characterisation and hazard assessment parts of the risk assessment form.

Item 31 – Forestry activity

Forestry activities have the potential to cause significant disruption to water supplies to the area in which they are being undertaken. The disruption may occur when forests are being planted, when thinning activities are being carried out or when the timber is being harvested. Account should be taken of the maturity of the forest and the likelihood of activity starting or changing during the period of the risk assessment. If the risk assessment is not scheduled to be time-limited then the potential for disruption should be highlighted.

Item 32 – Awareness of the presence of drinking water supply/source by agricultural workers

If the awareness of the presence of a drinking water source is absent from those agricultural or forestry workers who may be available to be interviewed or if there is evidence of disregard for the presence of such sources, e.g. ploughing to the margins of a well or spring, then the risk characterisation will be "No" or "Don't Know" to reflect the high level of risk such a lack of knowledge may be introducing to the supply. Lack of awareness on the hazard assessment should be scored as almost certain (16) again to reflect the potential for introduction of harmful materials or disturbance of the supply.

Item 33 – Waste disposal sites (including scrap yard, car yard, rubbish and hazardous waste disposal, landfill or incinerator including on-farm incineration)

The presence of disposal sites may influence the quality of water at the source by allowing the introduction of microbiological or chemical contaminants into the supply, depending on the nature of the materials being disposed. Incineration is also included in this section as the question of both airborne material and disposal sites for ash residues need to be considered when making the overall assessment of the likely impact of this item on the water quality at the source. If any waste disposal sites are present then the risk characterisation will be “Yes” and the associated hazard assessment should reflect the permanent nature (or longevity) of such sites in terms of their potential to continue to release polluting materials for many years after their immediate use has ceased.

Item 34 – Disposal sites for animal remains

This definition includes on-farm carcass disposal, burial pits, e.g. arising from foot-and-mouth disease, and vicinity to human burial sites such as graveyards or family plots away from traditional burial sites. If any disposal sites are present then the risk characterisation will be “Yes” and the associated hazard assessment should reflect the permanent nature (or longevity) of such sites in terms of their potential to continue to release polluting materials for many years after their immediate use has ceased.

Item 35 – Unsewered human sanitation including septic tanks, pit latrines, soakaways

If unsewered human sanitation is present near the source then there is considerable potential for raw human sewage to contaminate the source of the drinking water supply. Great care must be taken when assessing the positioning of septic tanks as well as their condition (maintenance), the areas where the soakaway is positioned, the condition of any pipes leading from the septic tank to the soakaway (is there evidence of different vegetation which may indicate a leaking pipe) and the discharge point of the soakaway if this is directed towards a surface receiving water. Similarly if there are pit latrines in use, e.g. at a campsite or areas where chemical toilets are discharged, the area surround the disposal point or latrine should be considered carefully in terms of allowing contact with the source. The contact may not be visible as there may be some connectivity underground and so some thought must be given to the soil leaching potential of the site.

Item 36 – Sewage pipes, mains or domestic (e.g. leading to/from septic tank)

In addition to Item 35 consideration must be given to the path that sewers may take. If the line of the pipe intersects with the area from which the drinking water source is being recharged (the area from where the water is being drawn) then there is the potential that any failure (leak) from the sewer or similar pipe will introduce raw sewage directly into the water source. It is unlikely that the path of such pipes will be clearly visible and so some care in interpreting the area will need to be taken, e.g. areas where the vegetation/ground appears to be drier indicating that there is a pipe buried below the surface or if there is a fracture in the pipe areas that would not naturally be damp or areas where there is vegetation indicative of wet or nutrient enriched conditions such as reeds or nettles.

Item 37 – Sewage effluent lagoons

Sewage effluent lagoons bring the potential that leaking material from the lagoon may enter the soil and pass into the groundwater providing a direct route for the contamination of the source with raw sewage. Farm effluent lagoons may be viewed as being the same in terms of the risks posed to the source when assessing the scoring values to be assigned.

Item 38 – Sewage effluent discharge to adjacent watercourse (where present)

While some aspects of this item may be identified when reviewing Item 35, Item 38 draws attention to the potential for sewage effluent discharges from a variety of sources such as municipal wastewater treatment works, septic tanks, privately owned/operated sewage treatment systems or reed beds. If there is evidence of discharge to a watercourse that is adjacent to the source of the supply under investigation then the risk characterisation should reflect the circumstances and “Yes” should be recorded. Similarly, for the hazard assessment the permanent, or semi-permanent, nature of the hazard should be reflected in the likelihood value assigned which should be almost certain (value 16).

Item 39 – Supplies or wells not in current use

If there are supplies or wells not in use that are associated with the supply under investigation then the potential for material to be introduced directly into the source water exists. For example, if an older, out of use well is located adjacent to the currently operational well and the out of use well is not properly sealed then the opportunity exists for faeces or animals to enter the older well and contaminate the same source of water that the new well is drawing from.

Item 40 – Evidence of use of pesticides (including sheep dip) near source

If disposal sites for pesticides (including sheep dip) are known to be close to the source under investigation then the risk characterisation should reflect this as should the hazard assessment. If there is evidence of the area having been used for dipping sheep (with dip tanks, fanks, etc.) then this evidence should be taken into account when assessing the site.

Item 41 – Evidence of industrial activity likely to present a contamination threat

If there is evidence of the area adjacent to the source having been used for industrial activity which may pose a contamination threat then this should be recorded on the risk assessment. Such activities may include chemical or pharmaceutical production, mineral or other extraction such as coal mining, areas where old fuel tanks may have been located or may still be in place either below or above ground, or industries where solvents would have been in use and may have been disposed of on to the ground, e.g. electroplating, metal working or electronics. This list is not exhaustive and so appropriate interpretation of the previous use to which the site may have been put will be required by the investigation officer.

SECTION D (ii) Supply survey

Item 42 – Below ground chamber not watertight

If the chamber is not watertight then there is a risk that a continued influx of water will inundate the top of the borehole causing potentially contaminated surface water to enter the supply. The entry could either be via an uncapped pipe or casing (forming the top of the borehole) or down the side of the pipe through inappropriate or absent grouting material. There should be no standing water in the bottom of the chamber. If there is evidence that the chamber is not watertight then the risk characterisation score should be "Yes" and the hazard assessment likelihood score should reflect the almost certain nature of the hazard (value = 16).

Item 43 – Borehole lining (casing) does not extend at least 150mm above level of floor

If the borehole lining (casing) does not extend above the level of the floor then there is an increased risk or the top of the borehole either being inundated with water (should water enter the chamber) or of vermin entering the pipe and introducing contamination into the borehole either through faecal material or decomposition of their remains should they become lodged in the borehole. If there is evidence that the casing does not extend at least 150 mm above the floor level then the risk characterisation score should be "Yes" and the hazard assessment likelihood score should reflect the almost certain nature of the hazard (value = 16).

Item 44 – Watertight lining cap not fitted

The top of the borehole (casing) should be capped off to prevent material falling into the borehole when the chamber is opened or if water or vermin should enter the chamber. If any cables or similar materials penetrate the cap (e.g. the power cable for the borehole pump) then the cables should also be sealed as they pass through the cap. Investigating officers may wish to enquire if materials used to seal either the cap itself or cables passing through the cap are suitable for use in drinking water installations for although there should be no direct contact with the water surface there is a potential for some of the material to enter the borehole particularly during construction or maintenance. If there is evidence that a watertight lining cap has not been fitted or is not in place then the risk characterisation score should be "Yes" and the hazard assessment likelihood score should reflect the almost certain nature of the hazard (value = 16).

Item 45 – No suitable barrier present to prevent ingress of surface flows into the well (e.g. cut-off ditch lined with impermeable material, steep incline/decline such as embankments, appropriate walls, etc.)

The borehole needs to be protected from the ingress of surface flows (such as flooding). This can be accomplished in a variety of ways such as having a cut-off ditch surrounding the borehole with an impermeable lining and a suitable discharge downslope from the borehole or conveying the water away from the immediate vicinity of the borehole. It should be borne in mind that surface flows, while including flooding, are not restricted to flooding. In certain ground conditions the impermeable nature of the soil during periods of dry weather will produce a surface akin to concrete which will result in rainfall, e.g. a heavy summer downpour, running over the surface rather than percolating into the soil. Such conditions need to be protected against by use of appropriately engineered borehole arrangements. If suitable arrangements are absent from the site under investigation then the risk characterisation will be scored as “Yes” with the hazard assessment reflecting the permanent nature of the deficiency by scoring the likelihood as almost certain (value 16).

Item 46 – The top of the chamber not 150 mm above ground level

This requirement is to ensure that in all but extreme weather conditions there will be very little opportunity for the borehole to be inundated with surface flows. If suitable arrangements are absent from the site under investigation then the risk characterisation will be scored as “Yes” with the hazard assessment reflecting the permanent nature of the deficiency by scoring the likelihood as almost certain (value 16).

Item 47 – No reinforced pre-cast concrete cover slab, or equivalent, in satisfactory condition with a watertight, vermin-proof inspection cover present to BS497 (lockable steel type or equivalent) with or without ventilation

A properly constructed and well-fitting well cover is essential to maintaining the integrity of the source. The cover should be watertight to prevent ingress of rainwater; vermin-proof to prevent animals from entering the well (vermin-proof means having no holes, remember a field mouse can easily enter a space where a pencil will fit); and lockable to prevent malicious (or just curious) persons gaining access to the supply. If ventilation is present ensure that it is also vermin-proof with appropriate wire mesh in place. If suitable arrangements are absent from the site under investigation then the risk characterisation will be scored as “Yes” with the hazard assessment reflecting the permanent nature of the deficiency by scoring the likelihood as almost certain (value 16).

Item 48 – The chamber construction in an unsatisfactory state-of-repair

If the chamber is in an unsatisfactory state-of-repair then there is an increased risk of vermin entering or of surface flows inundating the structure. If there is evidence that the chamber is in an unsatisfactory state-of-repair then the risk characterisation score should be "Yes" and the hazard assessment likelihood score should reflect the almost certain nature of the hazard (value = 16).

Item 49 – Supply network constructed from material liable to fracture (e.g. asbestos concrete, clay, etc.)

If the network of pipes that lead from the well are constructed of materials that are liable to deterioration or fracture, e.g. if heavy farm machinery is driven over the top of the pipeline, then the integrity of the system will be lost and potentially polluting material may enter the pipes through the fractures or the whole supply will be lost through pipe blockages. If it is considered likely that such materials have been used for all or part of the pipework being used to convey water from the source then the risk characterisation must reflect this with a "Yes" score and the hazard assessment must similarly reflect the permanent nature of the hazard by scoring as almost certain (value 16).

Item 50 – Intermediate tanks (e.g. collection chambers, holding tanks, break-pressure tanks) are not adequately protected (i.e. do not have protection described in [45] to [47])

The level of protection for all intermediate tanks or similar structures should be equivalent to that recommended for the source itself as the potential for contamination to enter the system via such intermediate points is just as high as for the source itself. If any of the intermediate tanks or similar structures are deficient in respect of the requirements provided in Items 45 to 47 then this should be reflected in the risk characterisation and hazard assessment. If there is more than one intermediate tank or similar structure, the deficient ones should be noted in section G and cross-referenced with the diagram provided in Section B (Item 6).

Item 51 – Junctions present in the supply network, particularly supplying animal water systems, have no back-siphon protection

If there are provisions made to provide water to animal watering troughs or other connections where back-siphonage may occur, e.g. from a hosepipe permanently connected, there is potential for the contents of the trough or container to be back-siphoned into the distribution pipe and for the contents of the trough or container to enter the supply. Clearly the contents of a cattle watering trough or a barrel into which the end of a hose has been dangled for some weeks will do little to improve the quality of the drinking water being provided. It is essential that where connections are made on the system prior to the first taps to be used for domestic (potable) consumption appropriate back-siphonage prevention devices are fitted. If they are not or there is no evidence to support claims that they have been fitted then the risk characterisation must reflect this with a "Yes" response. Similarly the hazard assessment should highlight the permanent nature of the situation with an almost certain (value 16) rating.

Item 52 – No maintenance (including chlorination) has been undertaken in the previous 12 months

If the system has had no maintenance undertaken in the 12 months preceding the investigation then this suggests that the level of care and attention required to ensure the system is operating as effectively as possible is lacking. If this is the case then the risk characterisation score should reflect the situation encountered and a "Yes" response entered. The hazard assessment likelihood score should also reflect the situation with an unlikely score (value = 2).

Item 53 – If present, header tank within the property(s) does not have a vermin-proof cover

Many properties served by a private supply, particularly those on smaller supplies, will have a header tank within the property to provide sufficient water pressure for the household and also to act as a balancing tank to equalise the pressure differences experience in the system when pumps are operating to bring water into the property. However, if the header tank is not properly constructed and protected then any material that may be present in the roof space, whether that be dust or mice or bat droppings, will have the potential to enter the tank and so contaminate the supply. If the property has a header tank which feeds the main domestic (potable) tap, usually the kitchen cold water tap, and that tank is not properly protected then the risk characterisation score should reflect the situation encountered and a "Yes" response entered. The hazard assessment likelihood score should also reflect the situation with an almost certain score (value = 16). If the header tank is present and unprotected but does not feed the main domestic (potable) tap then the risk assessment can be moderated but the risk to other taps in the property should be highlighted in Section G and noted on the diagram at Section B.

Item 54 – Header tank has not been cleaned in the last 12 months

If the header tank has an appropriate vermin-proof cover (Item 53) it will still require to be maintained by cleaning at least every 12 months to prevent the build-up of slime and scum which will naturally grow on the tank walls. If the tank has not been cleaned in the 12 months prior to the investigation then the risk characterisation score should reflect the situation encountered and a "Yes" response entered. The hazard assessment likelihood score should also reflect the situation with an unlikely score (value = 2).

Item 55 – Any point of entry/point of use treatment equipment has not been serviced in accordance with the manufacturer's instructions in the last 12 months

If any point of entry/point of use devices have had no maintenance undertaken in the 12 months preceding the investigation then this suggests that the level of care and attention required to ensure the system is operating as effectively as possible is lacking. If this is the case then the risk characterisation score should reflect the situation encountered and a "Yes" response entered. The hazard assessment likelihood score should also reflect the situation with an unlikely score (value = 2).

Item 56 – If present ultraviolet (UV) lamps are not operating

While ultraviolet disinfection systems if properly installed and maintained are an effective treatment option to prevent potentially harmful micro-organisms from causing disease they can provide a false sense of security if they are not looked after. A particularly common fault is for the UV bulb to stop operating. The UV bulb is at the heart of the installation and is responsible for the disinfection process. If there is not an automatic warning system on the installation then the loss of the bulb could go undetected. Similarly if the bulb has not been changed in accordance with the manufacturer's recommended replacement period then the efficiency or operation of the bulb could be impaired or have ceased to function at all. It is important, therefore, to assess if the UV bulbs (lamps) are operating on a UV system at the time of the inspection. If they are not operating then the risk characterisation score should reflect the situation encountered and a "Yes" response entered. The hazard assessment likelihood score should also reflect the situation based on an assessment of when the UV bulb (lamp) ceased to function.

Item 57 – Is there a noticeable change in the level and flow of water throughout the year

This question deals with the issue of constancy of supply as it relates to the quality of the source. If the source is highly dependable and provides adequate levels of water throughout the year then it is likely that the source is not under direct influence from either the surface or from prevailing climatic conditions. On the other hand, if the supply is "flashy" and changes with the weather then it is likely that it is under the influence of surface flow and prevailing weather conditions which increases its vulnerability to contamination from the surface. If there are noticeable changes in level and flow the risk characterisation response will be "Yes". The hazard assessment likelihood in these circumstances will be almost certain (value = 16). This circumstance may also cause the investigating officer to reconsider if the supply is in fact a well or if it would be better treated as a surface-derived supply.

Item 58 – Is there a noticeable change in the appearance of the water (colour, turbidity – cloudiness) after heavy rainfall or snow melt

If the supply is under the influence from either the surface or the weather then the quality experienced cannot be guaranteed if there are conditions prevailing which make surface flow (e.g. flooding) or adverse weather conditions likely. If there are noticeable changes in the appearance of the water then the risk characterisation response will be "Yes". The hazard assessment likelihood in these circumstances will be dependent on whether weather or surface influence is considered the most likely cause.

D (iii) Overall risk assessment

(a) Risk characterisation

The overall risk assessment for the source is taken as the highest individual risk category identified from each of the two surveys.

The overall risk characterisation category will be recorded as the risk assessment score for the source.

Survey Section	Risk Characterisation Category
General Site Survey	
Source Survey	
Overall Risk	

(b) Hazard assessment

Individual components in each of the surveys with a hazard assessment score of 16 or greater should be considered as priority candidates for remedial works capable of reducing the overall risk characterisation category.

SECTION E (i) Boreholes with headworks located below ground

General site survey

Item 59 – Evidence or history of poor drainage causing stagnant/standing water

If standing water can be seen present around the well head area or if there is evidence of standing water having been present, e.g. mud or vegetation consistent with marshy ground such as reeds, then the hazard should be scored as being present and the risk characterisation assigned as “Yes”. If there is a suggestion that the likelihood of the standing water being present (or evidence of having been present) is a long-standing occurrence then the likelihood score for the hazard assessment should reflect this.

Item 60 – History of livestock production (rearing, housing, grazing) – including poultry

Any evidence of domestic livestock production being present either directly (by the presence of animals in the vicinity of the supply) or indirectly (through presence of broken ground around the supply or the presence of animal droppings around the supply) should result in the risk characterisation being scored as “Yes”. Further investigations will be required to decide on the persistence of such presence in order to allow the hazard assessment likelihood score to be accurately assigned.

Item 61 – Evidence of wildlife

Any evidence of wildlife, mammals (rabbits, deer, etc.), birds (gulls, geese, migratory birds, etc.), reptiles (newts, frogs including spawn), etc. at the source could indicate the potential for contamination of the supply either from faecal material or from carcasses falling into the supply. If evidence of wildlife is found then the risk characterisation should be scored as “Yes”. Account should be taken of the likely frequency of the presence of wildlife, e.g. a rabbit warren nearby will suggest permanent presence; migratory birds will suggest a seasonal presence which will require the suggested likelihood values to be moderated to reflect this seasonal presence by raising the once per year score of 2 to 4.

Item 62 – Surface run-off from agricultural activity diverted to flow into source/supply

This indicator is intended to deal with field drains and other drainage systems employed on agricultural land which may be connected to the source or supply. The indicator also deals with instances where there is overland flow from agricultural land that ends up in a watercourse or entering the source and potentially contaminating the supply, e.g. applied slurry where there is potential for it to be washed into field drains or watercourse or similar drainage systems. If there are drainage systems or similar present in areas of agricultural activity then the risk characterisation response will be "Yes". The likelihood value will be based on the probable time the land is being subjected to agricultural applications.

Item 63 – Soil cultivation with wastewater irrigation or sludge/slurry/manure application

This indicator differs from Item 62 in that there will be active application of the materials in conjunction with the disruption of the soil itself, e.g. via ploughing or sub-soil injection. If such activities are considered to be undertaken then the risk characterisation will be "Yes". The likelihood value will be based on the probable time/duration that such activities occur at.

Item 64 – Disposal of organic wastes to land

This indicator deals with any other organic waste e.g. abattoir wastes or "blood and guts". The scoring for this indicator will be irrespective of whether there has been disruption of the soil. If such activities are considered to be undertaken then the risk characterisation will be "Yes". The likelihood value will be based on the probable time/duration that such activities occur at.

Item 65 – Farm wastes and/or silage stored on the ground (not in tanks or containers)

If there are middens or areas where silage are being stored in polyethylene bags (or equivalent) or other farm-derived wastes where there is no bunded storage and there is the potential for spillage entering drainage systems then this item should be scored such that the risk exists. If the storage appears to be a permanent or long-term feature then the hazard assessment should be scored as almost certain (value 16) or likely (value 8).

Item 66 – Remediation of land using sludge or slurry

In some areas brownfield sites or derelict land will be remediated using sewage-derived sludge or slurry or similar materials. The rate of application will typically be higher than those used in Item 63 and this should be borne in mind when assessing both the risk characterisation and hazard assessment parts of the risk assessment form.

Item 67 – Forestry activity

Forestry activities have the potential to cause significant disruption to water supplies to the area in which they are being undertaken. The disruption may occur when forests are being planted, when thinning activities are being carried out or when the timber is being harvested. Account should be taken of the maturity of the forest and the likelihood of activity starting or changing during the period of the risk assessment. If the risk assessment is not scheduled to be time-limited then the potential for disruption should be highlighted.

Item 68 – Awareness of the presence of drinking water supply/source by agricultural workers

If the awareness of the presence of a drinking water source is absent from those agricultural or forestry workers who may be available to be interviewed or if there is evidence of disregard for the presence of such sources, e.g. ploughing to the margins of a well or spring, then the risk characterisation will be "No" or "Don't Know" to reflect the high level of risk such a lack of knowledge may be introducing to the supply. Lack of awareness on the hazard assessment should be scored as almost certain (16) again to reflect the potential for introduction of harmful materials or disturbance of the supply.

Item 69 – Waste disposal sites (including scrap yard, car yard, rubbish and hazardous waste disposal, landfill or incinerator including on-farm incineration)

The presence of disposal sites may influence the quality of water at the source by allowing the introduction of microbiological or chemical contaminants into the supply, depending on the nature of the materials being disposed. Incineration is also included in this section as the question of both airborne material and disposal sites for ash residues need to be considered when making the overall assessment of the likely impact of this item on the water quality at the source. If any waste disposal sites are present then the risk characterisation will be "Yes" and the associated hazard assessment should reflect the permanent nature (or longevity) of such sites in terms of their potential to continue to release polluting materials for many years after their immediate use has ceased.

Item 70 – Disposal sites for animal remains

This definition includes on-farm carcass disposal, burial pits, e.g. arising from foot-and-mouth disease, and vicinity to human burial sites such as graveyards or family plots away from traditional burial sites. If any disposal sites are present then the risk characterisation will be "Yes" and the associated hazard assessment should reflect the permanent nature (or longevity) of such sites in terms of their potential to continue to release polluting materials for many years after their immediate use has ceased.

Item 71 – Unsewered human sanitation including septic tanks, pit latrines, soakaways

If unsewered human sanitation is present near the source then there is considerable potential for raw human sewage to contaminate the source of the drinking water supply. Great care must be taken when assessing the positioning of septic tanks as well as their condition (maintenance), the areas where the soakaway is positioned, the condition of any pipes leading from the septic tank to the soakaway (is there evidence of different vegetation which may indicate a leaking pipe) and the discharge point of the soakaway if this is directed towards a surface receiving water. Similarly if there are pit latrines in use, e.g. at a campsite or areas where chemical toilets are discharged, the area surround the disposal point or latrine should be considered carefully in terms of allowing contact with the source. The contact may not be visible as there may be some connectivity underground and so some thought must be given to the soil leaching potential of the site.

Item 72 – Sewage pipes, mains or domestic (e.g. leading to/from septic tank)

In addition to Item 71 consideration must be given to the path that sewers may take. If the line of the pipe intersects with the area from which the drinking water source is being recharged (the area from where the water is being drawn) then there is the potential that any failure (leak) from the sewer or similar pipe will introduce raw sewage directly into the water source. It is unlikely that the path of such pipes will be clearly visible and so some care in interpreting the area will need to be taken, e.g. areas where the vegetation/ground appears to be drier indicating that there is a pipe buried below the surface or if there is a fracture in the pipe areas that would not naturally be damp or areas where there is vegetation indicative of wet or nutrient enriched conditions such as reeds or nettles.

Item 73 – Sewage effluent lagoons

Sewage effluent lagoons bring the potential that leaking material from the lagoon may enter the soil and pass into the groundwater providing a direct route for the contamination of the source with raw sewage. Farm effluent lagoons may be viewed as being the same in terms of the risks posed to the source when assessing the scoring values to be assigned.

Item 74 – Sewage effluent discharge to adjacent watercourse (where present)

While some aspects of this item may be identified when reviewing Item 35, Item 38 draws attention to the potential for sewage effluent discharges from a variety of sources such as municipal wastewater treatment works, septic tanks, privately owned/operated sewage treatment systems or reed beds. If there is evidence of discharge to a watercourse that is adjacent to the source of the supply under investigation then the risk characterisation should reflect the circumstances and “Yes” should be recorded. Similarly, for the hazard assessment the permanent, or semi-permanent, nature of the hazard should be reflected in the likelihood value assigned which should be almost certain (value 16).

Item 75 – Supplies or wells not in current use

If there are supplies or wells not in use that are associated with the supply under investigation then the potential for material to be introduced directly into the source water exists. For example, if an older, out of use well is located adjacent to the currently operational well and the out of use well is not properly sealed then the opportunity exists for faeces or animals to enter the older well and contaminate the same source of water that the new well is drawing from.

Item 76 – Evidence of use of pesticides (including sheep dip) near source

If disposal sites for pesticides (including sheep dip) are known to be close to the source under investigation then the risk characterisation should reflect this as should the hazard assessment. If there is evidence of the area having been used for dipping sheep (with dip tanks, fanks, etc.) then this evidence should be taken into account when assessing the site.

Item 77 – Evidence of industrial activity likely to present a contamination threat

If there is evidence of the area adjacent to the source having been used for industrial activity which may pose a contamination threat then this should be recorded on the risk assessment. Such activities may include chemical or pharmaceutical production, mineral or other extraction such as coal mining, areas where old fuel tanks may have been located or may still be in place either below or above ground, or industries where solvents would have been in use and may have been disposed of on to the ground, e.g. electroplating, metal working or electronics. This list is not exhaustive and so appropriate interpretation of the previous use to which the site may have been put will be required by the investigation officer.

SECTION E (ii) Supply survey

Item 78 – Housing covering headworks not watertight and/or vermin proof and/or secure

If the housing covering the headworks is not watertight then there is a risk that the top of the borehole could be inundated with surface water and contamination enter the borehole. If the housing is not vermin proof then vermin such as small rodents or amphibians may enter the structure and either contaminate the borehole directly with faecal material or if they enter the borehole itself the supply will become contaminated with their decomposing remains. If the housing is not secure then there is a risk that the curious or malicious may enter the structure and introduce contamination into the supply either accidentally or deliberately. If there is evidence that the housing is not secure against these hazards then the risk characterisation score should be "Yes" and the hazard assessment likelihood score should reflect the almost certain nature of the hazard (value = 16).

Item 79 – Borehole lining (casing) does not extend at least 150 mm above level of floor

If the borehole lining (casing) does not extend above the level of the floor then there is an increased risk of the top of the borehole either being inundated with water (should water enter the chamber) or of vermin entering the pipe and introducing contamination into the borehole either through faecal material or decomposition of their remains should they become lodged in the borehole. If there is evidence that the casing does not extend at least 150 mm above the floor level then the risk characterisation score should be "Yes" and the hazard assessment likelihood score should reflect the almost certain nature of the hazard (value = 16).

Item 80 – Watertight cap not fitted

The top of the borehole (casing) should be capped off to prevent material falling into the borehole when the chamber is opened or if water or vermin should enter the chamber. If any cables or similar materials penetrate the cap (e.g. the power cable for the borehole pump) then the cables should also be sealed as they pass through the cap. Investigating officers may wish to enquire if materials used to seal either the cap itself or cables passing through the cap are suitable for use in drinking water installations for although there should be no direct contact with the water surface there is a potential for some of the material to enter the borehole particularly during construction or maintenance. If there is evidence that a watertight lining cap has not been fitted or is not in place then the risk characterisation score should be "Yes" and the hazard assessment likelihood score should reflect the almost certain nature of the hazard (value = 16).

Item 81 – No suitable barrier present to prevent ingress of surface flows into the well (e.g. cut-off ditch lined with impermeable material, steep incline/decline such as embankments, appropriate walls, etc.)

The borehole needs to be protected from the ingress of surface flows (such as flooding). This can be accomplished in a variety of ways such as having a cut-off ditch surrounding the borehole with an impermeable lining and a suitable discharge downslope from the borehole or conveying the water away from the immediate vicinity of the borehole. It should be borne in mind that surface flows, while including flooding, are not restricted to flooding. In certain ground conditions the impermeable nature of the soil during periods of dry weather will produce a surface akin to concrete which will result in rainfall, e.g. a heavy summer downpour, running over the surface rather than percolating into the soil. Such conditions need to be protected against by use of appropriately engineered borehole arrangements. If suitable arrangements are absent from the site under investigation then the risk characterisation will be scored as "Yes" with the hazard assessment reflecting the permanent nature of the deficiency by scoring the likelihood as almost certain (value 16).

Item 82 – No concrete apron sloping away from borehole lining

A concrete apron sloping away from the top of the borehole (casing) should be provided to ensure any water that may ingress the structure is flowing away from the top of the borehole. If this is not present then the risk characterisation will be scored as "Yes" with the hazard assessment likelihood score reflecting the permanent nature of the hazard by scoring as almost certain (value = 16).

Item 83 – No reinforced pre-cast concrete cover slab, or equivalent, in satisfactory condition with a watertight, vermin-proof inspection cover present to BS497 (lockable steel type or equivalent) with or without ventilation

A properly constructed and well-fitting well cover is essential to maintaining the integrity of the source. The cover should be watertight to prevent ingress of rainwater; vermin-proof to prevent animals from entering the well (vermin-proof means having no holes, remember a field mouse can easily enter a space where a pencil will fit); and lockable to prevent malicious (or just curious) persons gaining access to the supply. If ventilation is present ensure that it is also vermin-proof with appropriate wire mesh in place. If suitable arrangements are absent from the site under investigation then the risk characterisation will be scored as "Yes" with the hazard assessment reflecting the permanent nature of the deficiency by scoring the likelihood as almost certain (value 16).

Item 84 – The housing construction in an unsatisfactory state-of-repair

If the housing is in an unsatisfactory state-of-repair then there is an increased risk of vermin entering or of surface flows inundating the structure. If there is evidence that the housing is in an unsatisfactory state-of-repair then the risk characterisation score should be "Yes" and the hazard assessment likelihood score should reflect the almost certain nature of the hazard (value = 16).

Item 85 – Supply network constructed from material liable to fracture (e.g. asbestos concrete, clay, etc.)

If the network of pipes that lead from the well are constructed of materials that are liable to deterioration or fracture, e.g. if heavy farm machinery is driven over the top of the pipeline, then the integrity of the system will be lost and potentially polluting material may enter the pipes through the fractures or the whole supply will be lost through pipe blockages. If it is considered likely that such materials have been used for all or part of the pipework being used to convey water from the source then the risk characterisation must reflect this with a "Yes" score and the hazard assessment must similarly reflect the permanent nature of the hazard by scoring as almost certain (value 16).

Item 86 – Intermediate tanks (e.g. collection chambers, holding tanks, break-pressure tanks) are not adequately protected (i.e. do not have protection described in 78 to 85)

The level of protection for all intermediate tanks or similar structures should be equivalent to that recommended for the source itself as the potential for contamination to enter the system via such intermediate points is just as high as for the source itself. If any of the intermediate tanks or similar structures are deficient in respect of the requirements provided in Items 42 to 45 then this should be reflected in the risk characterisation and hazard assessment. If there is more than one intermediate tank or similar structure, the deficient ones should be noted in section F and cross-referenced with the diagram provided in Section B (Item 6).

Item 87 – Junctions present in the supply network, particularly supplying animal water systems, have no back-siphon protection

If there are provisions made to provide water to animal watering troughs or other connections where back-siphonage may occur, e.g. from a hosepipe permanently connected, there is potential for the contents of the trough or container to be back-siphoned into the distribution pipe and for the contents of the trough or container to enter the supply. Clearly the contents of a cattle watering trough or a barrel into which the end of a hose has been dangled for some weeks will do little to improve the quality of the drinking water being provided. It is essential that where connections are made on the system prior to the first taps to be used for domestic (potable) consumption that appropriate back-siphonage prevention devices are fitted. If they are not or there is no evidence to support claims that they have been fitted then the risk characterisation must reflect this with a "Yes" response. Similarly the hazard assessment should highlight the permanent nature of the situation with an almost certain (value 16) rating.

Item 88 – No maintenance (including chlorination) has been undertaken in the previous 12 months

If the system has had no maintenance undertaken in the 12 months preceding the investigation then this suggests that the level of care and attention required to ensure the system is operating as effectively as possible is lacking. If this is the case then the risk characterisation score should reflect the situation encountered and a "Yes" response entered. The hazard assessment likelihood score should also reflect the situation with an unlikely score (value = 2).

Item 89 – If present, header tank within the property(s) does not have a vermin-proof cover

Many properties served by a private supply, particularly those on smaller supplies, will have a header tank within the property to provide sufficient water pressure for the household and also to act as a balancing tank to equalise the pressure differences experienced in the system when pumps are operating to bring water into the property. However, if the header tank is not properly constructed and protected then any material that may be present in the roof space, whether that be dust or mice or bat droppings, will have the potential to enter the tank and so contaminate the supply. If the property has a header tank which feeds the main domestic (potable) tap, usually the kitchen cold water tap, and that tank is not properly protected then the risk characterisation score should reflect the situation encountered and a "Yes" response entered. The hazard assessment likelihood score should also reflect the situation with an almost certain score (value = 16). If the header tank is present and unprotected but does not feed the main domestic (potable) tap then the risk assessment can be moderated but the risk to other taps in the property should be highlighted in Section G and noted on the diagram at Section B.

Item 90 – Header tank has not been cleaned in the last 12 months

If the header tank has an appropriate vermin-proof cover (Item 52) it will still require to be maintained by cleaning at least every 12 months to prevent the build-up of slime and scum which will naturally grow on the tank walls. If the tank has not been cleaned in the 12 months prior to the investigation then the risk characterisation score should reflect the situation encountered and a “Yes” response entered. The hazard assessment likelihood score should also reflect the situation with an unlikely score (value = 2).

Item 91 – Any point of entry/point of use treatment equipment has not been serviced in accordance with the manufacturer’s instructions in the last 12 months

If any point of entry/point of use devices have had no maintenance undertaken in the 12 months preceding the investigation then this suggests that the level of care and attention required to ensure the system is operating as effectively as possible is lacking. If this is the case then the risk characterisation score should reflect the situation encountered and a “Yes” response entered. The hazard assessment likelihood score should also reflect the situation with an unlikely score (value = 2).

Item 92 – If present ultraviolet (UV) lamps are not operating

While ultraviolet disinfection systems if properly installed and maintained are an effective treatment option to prevent potentially harmful micro-organisms from causing disease they can provide a false sense of security if they are not looked after. A particularly common fault is for the UV bulb to stop operating. The UV bulb is at the heart of the installation and is responsible for the disinfection process. If there is not an automatic warning system on the installation then the loss of the bulb could go undetected. Similarly if the bulb has not been changed in accordance with the manufacturer’s recommended replacement period then the efficiency or operation of the bulb could be impaired or have ceased to function at all. It is important, therefore, to assess if the UV bulbs (lamps) are operating on a UV system at the time of the inspection. If they are not operating then the risk characterisation score should reflect the situation encountered and a “Yes” response entered. The hazard assessment likelihood score should also reflect the situation based on an assessment of when the UV bulb (lamp) ceased to function.

Item 93 – Is there a noticeable change in the level and flow of water throughout the year

This question deals with the issue of constancy of supply as it relates to the quality of the source. If the source is highly dependable and provides adequate levels of water throughout the year then it is likely that the source is not under direct influence from either the surface or from prevailing climatic conditions. On the other hand, if the supply is "flashy" and changes with the weather then it is likely that it is under the influence of surface flow and prevailing weather conditions which increases its vulnerability to contamination from the surface. If there are noticeable changes in level and flow the risk characterisation response will be "Yes". The hazard assessment likelihood in these circumstances will be almost certain (value = 16). This circumstance may also cause the investigating officer to reconsider if the supply is in fact a well or if it would be better treated as a surface-derived supply.

Item 94 – Is there a noticeable change in the appearance of the water (colour, turbidity – cloudiness) after heavy rainfall or snow melt

If the supply is under the influence from either the surface or the weather then the quality experienced cannot be guaranteed if there are conditions prevailing which make surface flow (e.g. flooding) or adverse weather conditions likely. If there are noticeable changes in the appearance of the water then the risk characterisation response will be "Yes". The hazard assessment likelihood in these circumstances will be dependent on whether weather of surface influence is considered the most likely cause.

E (iii) Overall risk assessment

(a) Risk characterisation

The overall risk assessment for the source is taken as the highest individual risk category identified from each of the two surveys.

The overall risk characterisation category will be recorded as the risk assessment score for the source.

Survey Section	Risk Characterisation Category
General Site Survey	
Source Survey	
Overall Risk	

(b) Hazard assessment

Individual components in each of the surveys with a hazard assessment score of 16 or greater should be considered as priority candidates for remedial works capable of reducing the overall risk characterisation category.

Section F

If the type of the supply has not been determined then the risk assessment will not have been completed. In this case the overall risk assessment for the supply will default to High Risk to ensure that appropriate control measures are put in place to maintain public health.

Section G

Additional Notes – this section can be used to include additional information or observations made during the investigation.

Section 4.8 – Annex 1

Borehole Risk Assessment pro forma

Private water supply risk assessment form

BOREHOLE SUPPLY

OVERALL RISK ....

Section A – Supply Details

1. Supply category

Type A1 / A2 / A3   Type B   (circle appropriate category)

2. Address and telephone number of responsible person

....

....

....

Post Code ....

Telephone Number (including full STD Code) ....

Email Address ....

3. Name of person (or persons) who is relevant person in relation to the supply

(a) ....

(b) ....

(c) ....

(d) details of additional sheets ....

4. Address of relevant person (or persons) (if different from above)

(a) ....

....

....

Post Code ....

Telephone Number (including full STD Code) ....

Email Address ....

(b) ....

....

....

Post Code ....

Telephone Number (including full STD Code) ....

Email Address ....

(c) ....

....

....

Post Code ....

Telephone Number (including full STD Code) ....

Email Address ....

(d) details of additional sheets ....

5. Details of premise(s) served by the supply and purpose for which water is supplied

(a) ....

....

....

Post Code ....

Supply purpose ....

(b) ....

....

....

Post Code ....

Supply Purpose ....

(c) ....

....

....

Post Code ....

Supply Purpose ....

(d) details of additional sheets ....

Section B

6. Provide a diagram of the supply showing source(s), intermediate storage and/or collection tanks and properties on the supply. The diagram is indicative only and is intended to aid completion of the rest of this section.

Notes: Items should be labelled from source (A) through intermediate tanks (B) to properties (C) with individual components numbered, e.g. for a supply with one source this would be A1; two intermediate tanks (B1 and B2 respectively) and two properties (C1 and C2) respectively.

7. Description of the source of the supply including (i) details of supply source(s), (ii) location of the source(s) and (iii) National Grid Reference of location(s) of source(s). Cross reference from Item 6 above.

(i) ....

....

....

(ii) ....

....

....

(iii) National Grid Reference _N_ / _J_ / _0_ / _0_ / _0_ / _0_ / _0_ / _0_

8. (a) Estimated daily volume of water provided by the supply .... m^3 per day

(b) Number of persons served by supply (at maximum occupancy) ....

9. Details of any water treatment processes associated with the supply

(a) At source – identify which of the following systems are present: (cross reference to Item 6)

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

(b) Intermediate Water Storage Tank/Chamber (cross reference to Item 6)

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

(c) At property (cross reference to Item 6)

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

(d) details of additional sheets ....

Section C

10. Details of departures authorised

....

....

....

11. Details of sample results for previous 12 months or last available (reference location of information, e.g. paper or electronic files, reference number, sample numbers, etc.)

....

....

....

12. Details of previous (last 2) investigations and actions taken

....

....

....

13. Details of enforcement notices served

....

....

....

14. Result of previous risk assessment (if applicable)

....

....

....

15. Details of location of Notice for Type A supplies (location)

....

....

....

16. Is Notice appropriate (conforms to requirements of the Regulations)? Yes ☐ No ☐

17. Details of action taken (or to be taken) by relevant persons to comply with

(a) results of sampling

....

....

....

....

(b) results of follow-up to sampling

....

....

....

....

18. Whether supply exempt under Regulation 2(4)

....

....

....

19. Details of other information relating to the supply collated by the local authority

....

....

....

20. Is there a Water Safety Plan/ Emergency Action Plan available for the supply?

Yes ☐ No ☐

21. If "Yes" to Item 20, is it fit for purpose? Yes ☐ No ☐

22. If "No" to Item 21, what deficiencies are required to be addressed (provide details)?

....

....

....

Section D – Boreholes with headworks located below ground

D (i) General site survey

Are any of the following known to be present and likely to influence water quality at the source?e?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
23	Evidence or history of poor drainage causing stagnant / standing water	H	L	H		8	
24	History of livestock production (rearing, housing, grazing) – including poultry	H	L	H		16	
25	Evidence of wildlife	M	L	M		4	
26	Surface run-off from agricultural activity diverted to flow into the source/supply	H	L	H		8	
27	Soil cultivation with wastewater irrigation or sludge / slurry/ manure application	H	L	H		16	
28	Disposal of organic wastes to land	H	L	H		8	
29	Farm wastes and/or silage stored on the ground (not in tanks or containers)	M	L	M		8	
30	Remediation of land using sludge or slurry	H	L	H		16	
31	Forestry activity	M	L	M		4	
32	Awareness of the presence of drinking water supply/source by agricultural workers	L	H	H		4	
33	Waste disposal sites (including scrap yard, car yard, rubbish and hazardous waste disposal, landfill or incinerator including on-farm incineration)	H	L	H		8	
34	Disposal sites for animal remains	H	L	H		8	
35	Unsewered human sanitation including septic tanks, pit latrines, soakaways	H	L	H		16	
36	Sewage pipes, mains or domestic (e.g. leading to / from septic tank)	H	L	H		8	
37	Sewage effluent lagoons	H	L	H		16	
38	Sewage effluent discharge to adjacent watercourse (where present)	H	L	H		16	
39	Supplies or wells not in current use	H	L	H		8	
40	Evidence of use of pesticides (including sheep dip) near source	H	L	H		8	
41	Evidence of industrial activity likely to present a contamination threat	H	L	H		8	

[1] The Hazard Assessment Score is the product of the Likelihood and Severity values. The values are :

Likelihood	Definition	Value
Almost certain	Once per day (or permanent feature)	16
Likely	Once per week	8
Moderate likely	Once per month	4
Unlikely	Once per year	2
Rare	Once every 5 years	1

Risk Characterisation

Tick the appropriate box for each question.
If any question is High Risk (H) then the Risk Characterisation Score is **High**.
If no question is High Risk but there are Moderate Risks (M) identified then the Risk Characterisation Score is **Moderate**.
If no question is High Risk (H) or Moderate Risk (M) then the Risk Characterisation Score is **Low**.

Hazard Assessment

If the Hazard Assessment Score is 16 or greater for any individual component then the issues associated with that component should be considered as a priority for remedial works to reduce the hazard experienced by the supply.

D (ii) Supply survey

Are any of the following known to occur at the head works site or in relation to the supply?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
42	Below ground chamber not watertight	H	L	H		8	
43	Borehole lining (casing) does not extend at least 150mm above level of floor	H	L	H		8	
44	Watertight lining cap not fitted	H	L	H		8	
45	No suitable barrier present to prevent ingress of surface flows into the chamber (e.g. cut-off ditch lined with impermeable material, steep incline/decline such as embankments, appropriate walls, etc.)	H	L	H		16	
46	The top of the chamber not 150mm above ground level?	H	L	H		16	
47	No reinforced pre-cast concrete cover slab, or equivalent, in satisfactory condition with a watertight, vermin-proof inspection cover present to BS497 (lockable steel type or equivalent) with or without ventilation?	H	L	H		16	
48	The chamber construction in an unsatisfactory state-of-repair?	H	L	H		8	
49	Supply network constructed from material liable to fracture, e.g. asbestos-concrete, clay, etc.?	H	L	H		8	
50	Intermediate tanks (e.g. collection chambers, holding tanks, break-pressure tanks) are not adequately protected (i.e. have protection described in [1] to [5] above)?	H	L	H		8	
51	Junctions present in the supply network, particularly supply animal watering systems, have no back-siphon protection?	H	L	H		4	
52	No maintenance (including chlorination) has been undertaken in the previous 12 months?	H	L	H		8	
53	If present, header tank within the property (s) does not have a vermin-proof cover?	H	L	H		4	
54	Header tank has not been cleaned in the last 12 months?	H	L	H		8	
55	Any point of entry/point of use treatment equipment has not been serviced in accordance with the manufacturer's instructions in the last 12 months?	H	L	H		8	
56	If present ultraviolet (UV) lamps are not operating?	H	L	H		16	
57	Is there a noticeable change in the level and flow of water throughout the year?	H	L	H		4	
58	Is there a noticeable change in the appearance of the water (colour, turbidity – cloudiness) after heavy rainfall or snow melt?	H	L	H		8	

[1] The Hazard Assessment Score is the product of the Likelihood and Severity values. For details see Section D.

Risk Characterisation

Tick the appropriate box for each question.

If any question is High Risk (H) then the Risk Characterisation Score is **High**. ☐

If no question is High Risk but there are Moderate Risks (M) identified then the Risk Characterisation Score is **Moderate**. ☐

If no question is High Risk (H) or Moderate Risk (M) then the Risk Characterisation Score is **Low**. ☐

Hazard Assessment

If the Hazard Assessment Score is 16 or greater for any individual component then the issues associated with that component should be considered as a priority for remedial works to reduce the hazard experienced by the supply.

D (iv) Overall risk assessment

(a) Risk characterisation

The overall risk assessment for the source is taken as the highest individual risk category identified from each of the two surveys.

The overall risk characterisation category will be recorded as the risk assessment score for the source.

Survey Section	Risk Characterisation Category
General Site Survey	
Source Survey	
Overall Risk	

(b) Hazard assessment

Individual components in each of the surveys with a hazard assessment score of 32 or greater should be considered as priority candidates for remedial works capable of reducing the overall risk characterisation category.

Section E – Boreholes with headworks located above ground

E (i) General site survey

Are any of the following known to be present and likely to influence water quality at the source?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
59	Evidence or history of poor drainage causing stagnant / standing water	H	L	H		8	
60	History of livestock production (rearing, housing, grazing) – including poultry	H	L	H		16	
61	Evidence of wildlife	M	L	M		4	
62	Surface run-off from agricultural activity diverted to flow into the source/supply	H	L	H		8	
63	Soil cultivation with wastewater irrigation or sludge / slurry/ manure application	H	L	H		16	
64	Disposal of organic wastes to land	H	L	H		8	
65	Farm wastes and/or silage stored on the ground (not in tanks or containers)	M	L	M		8	
66	Remediation of land using sludge or slurry	H	L	H		16	
67	Forestry activity	M	L	M		4	
68	Awareness of the presence of drinking water supply/source by agricultural workers	L	H	H		4	
69	Waste disposal sites (including scrap yard, car yard, rubbish and hazardous waste disposal, landfill or incinerator including on-farm incineration)	H	L	H		8	
70	Disposal sites for animal remains	H	L	H		8	
71	Unsewered human sanitation including septic tanks, pit latrines, soakaways	H	L	H		16	
72	Sewage pipes, mains or domestic (e.g. leading to / from septic tank)	H	L	H		8	
73	Sewage effluent lagoons	H	L	H		16	
74	Sewage effluent discharge to adjacent watercourse (where present)	H	L	H		16	
75	Supplies or wells not in current use	H	L	H		8	
76	Evidence of use of pesticides (including sheep dip) near source	H	L	H		8	
77	Evidence of industrial activity likely to present a contamination threat	H	L	H		8	

[1] The Hazard Assessment Score is the product of the Likelihood and Severity values. The values are :

Likelihood	Definition	Value
Almost certain	Once per day (or permanent feature)	16
Likely	Once per week	8
Moderate likely	Once per month	4
Unlikely	Once per year	2
Rare	Once every 5 years	1

Risk Characterisation

Tick the appropriate box for each question.

If any question is High Risk (H) then the Risk Characterisation Score is **High**. ☐

If no question is High Risk but there are Moderate Risks (M) identified then the Risk Characterisation Score is **Moderate**. ☐

If no question is High Risk (H) or Moderate Risk (M) then the Risk Characterisation Score is **Low**. ☐

Hazard Assessment

If the Hazard Assessment Score is 16 or greater for any individual component then the issues associated with that component should be considered as a priority for remedial works to reduce the hazard experienced by the supply.

E (ii) Supply survey

Are any of the following known to occur at the head works site or in relation to the supply?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
78	Housing covering headworks not watertight and/or vermin proof and/or secure	H	L	H		8	
79	Borehole lining (casing) does not extend at least 150mm above level of floor	H	L	H		8	
80	Watertight lining cap not fitted	H	L	H		8	
81	No suitable barrier present to prevent ingress of surface flows into the chamber (e.g. cut-off ditch lined with impermeable material, steep incline/decline such as embankments, appropriate walls, etc.)	H	L	H		16	
82	No concrete apron sloping away from borehole lining	H	L	H		16	
83	No reinforced pre-cast concrete cover slab, or equivalent, in satisfactory condition with a watertight, vermin-proof inspection cover present to BS497 (lockable steel type or equivalent) with or without ventilation?	H	L	H		16	
84	The housing construction in an unsatisfactory state-of-repair?	H	L	H		8	
85	Supply network constructed from material liable to fracture, e.g. asbestos-concrete, clay, etc.?	H	L	H		8	
86	Intermediate tanks (e.g. collection chambers, holding tanks, break-pressure tanks) are not adequately protected (i.e. have protection described in [1] to [5] above)?	H	L	H		8	
87	Junctions present in the supply network, particularly supply animal watering systems, have no back-siphon protection?	H	L	H		4	
88	No maintenance (including chlorination) has been undertaken in the previous 12 months?	H	L	H		8	
89	If present, header tank within the property (s) does not have a vermin-proof cover?	H	L	H		4	
90	Header tank has not been cleaned in the last 12 months?	H	L	H		8	
91	Any point of entry/point of use treatment equipment has not been serviced in accordance with the manufacturer's instructions in the last 12 months?	H	L	H		8	
92	If present ultraviolet (UV) lamps are not operating?	H	L	H		16	
93	Is there a noticeable change in the level and flow of water throughout the year?	H	L	H		4	
94	Is there a noticeable change in the appearance of the water (colour, turbidity – cloudiness) after heavy rainfall or snow melt?	H	L	H		8	

[1] The Hazard Assessment Score is the product of the Likelihood and Severity values. For details see Section E.

Risk Characterisation

Tick the appropriate box for each question.

If any question is High Risk (H) then the Risk Characterisation Score is **High**. ☐

If no question is High Risk but there are Moderate Risks (M) identified then the Risk Characterisation Score is **Moderate**. ☐

If no question is High Risk (H) or Moderate Risk (M) then the Risk Characterisation Score is **Low**. ☐

Hazard Assessment

If the Hazard Assessment Score is 16 or greater for any individual component then the issues associated with that component should be considered as a priority for remedial works to reduce the hazard experienced by the supply.

E (iv) Overall risk assessment

(a) Risk characterisation

The overall risk assessment for the source is taken as the highest individual risk category identified from each of the two surveys.

The overall risk characterisation category will be recorded as the risk assessment score for the source.

Survey Section	Risk Characterisation Category
General Site Survey	
Source Survey	
Overall Risk	

(b) Hazard assessment

Individual components in each of the surveys with a hazard assessment score of 32 or greater should be considered as priority candidates for remedial works capable of reducing the overall risk characterisation category.

Section F

You have been unable to discern the type of supply and so the overall risk assessment for this source must be given as **High Risk**.

Section G – Additional Notes

4.9 Surface Supply Risk Assessment (see 4.9 Annex 1 for full form)

Overall Risk – this is taken from the overall risk assessment in section D(iv)(a) of the risk assessment form.

SECTION A – Supply details

Item 1 – Supply category

The supply category that is required to be identified is taken from The Private Water Supplies (Scotland) Regulations 2006 Part 1(2). These state:

"Type A supply" means a private water supply for human consumption purposes which

(a) on average, provides 10 or more cubic metres of water per day or serves 50 or more persons, or
(b) regardless of the volume of water provided or the number of persons served, is supplied or used as part of a commercial or public activity,

and references in this definition –

(i) to the average volume of water provided by such a supply, are references to such volume (calculated as a daily average) as may be reasonably estimated to have been distributed or, if not distributed, used or consumed from the supply during the year prior to the year in which these Regulations come into force; and that estimate may be on the assumption that five persons use one cubic metre of water per day; and
(ii) to the average number of persons served by such a supply, are references to such number of persons as may be reasonably estimated to be the maximum number served by the supply on any one day during the year prior to the year in which these Regulations come into force.

"Type B supply" means a private water supply other than a Type A supply; and "year" means a calendar year.

Item 2 – Address and telephone number of responsible person

"Responsible person" is a term used in the Regulations referring to the person who owns or otherwise is responsible for the domestic distribution system which included the pipework, fitting and appliances which are installed between the taps that are normally used for human consumption purposes and the distribution network which is not the responsibility of a relevant person (see Item 3). Full contact details of the responsible person should be recorded here.

Item 3 – Name of person (or persons) who is relevant person in relation to the supply

The term “relevant person” refers to the person considered by the local authority to be the person providing the supply, or occupying the land from, or on, which the supply is obtained or located, and any person who exercises powers of management or control in relation to the supply.

The relevant and responsible person may be one and the same person in some instances.

In some instances there may be more than three relevant persons in which case additional sheets should be used to record the information and details of these additional sheets should be included in section (d) and the sheets appended to the form when completed.

Item 4 – Address of relevant person (or persons) (if different from above)

Where the responsible person and the relevant person are different then the contact details for the relevant person or persons should be recorded in this section.

In some instances there may be more than three relevant persons in which case additional sheets should be used to record the information and details of these additional sheets should be included in section (d) and the sheets appended to the form when completed.

Item 5 – Details of premise(s) served by the supply and purpose for which water is supplied

This item seeks to capture details of any premise that may be served by the supply and the purpose for which the water is being supplied. It is necessary to have as complete a list of properties served by a private water supply as possible in order that the true interconnectivity of the supply may be assessed and the potential population affected by any breach of the Regulations or incidence of waterborne disease outbreak can be assessed rapidly and efficiently. For larger supplies this exercise will be challenging but attention to detail will ensure that the most comprehensive and accurate records are compiled which will assist in future investigations relating to the supply.

Additional sheets (as required) should be appended to the form and a note of these made at section (d).

SECTION B

Item 6 – Diagram of the supply

This is intended to enable the investigating officer to provide a schematic sketch showing the interrelationships between the various components of the supply such as source, intermediate tanks and properties being supplied. While there is undoubtedly a balance to be struck between too much detail and insufficient detail, a guiding principle should be to provide sufficient information to enable colleagues who have not visited the site to quickly navigate around the supply.

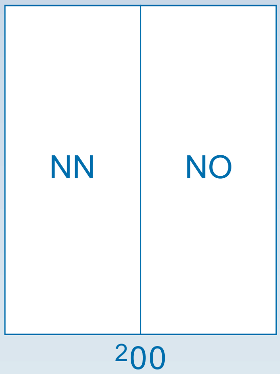
Item 7 – Description of the source of the supply

The description provided should complement the schematic sketch provided at Item 6. The purpose of having a written description is to provide a record of the condition of the infrastructure at the time of the risk assessment. This will enable a baseline to be established against which any future developments made to the supply can be benchmarked. If the facility exists it would be appropriate to also include relevant photographic evidence of the various components so long as they are uniquely identified and cross-referenced within the risk assessment report.

A full National Grid Reference for the source (or the closest point to the source identified) should also be provided.

How to give a grid reference to nearest 100 metres

The example below is taken from Ordnance Survey Braemar to Blair Atholl Sheet 43 1:50000 Landranger Series.

100 000 metre Grid Square Identification	Example - Altaltan			
	1. Read letters identifying 100 000 metre square in which the point lies.	NO		
	2. FIRST QUOTE EASTINGS Locate first VERTICAL grid line to LEFT of point and read LARGE figures labelling the line either in the top or bottom margin or on the line itself. Estimate tenths from grid line to point.		18 4	
	3. AND THEN QUOTE NORTHINGS Locate first HORIZONTAL grid line BELOW line either in the left or right margin or on the line itself. Estimate tenths from grid line to point.			63 5
	EXAMPLE REFERENCE	NO 184 635		
Ignore the smaller figures of any grid number: these are for finding the full coordinates. Use ONLY the LARGER figure of the grid number. Example: 2 80 000m				

Extract from 1:50 000 sheet 43 showing location of Altaltan

Due to OS licence conditions, you/your agent may only use this map for official business dealings with the Scottish Executive. If you wish to use the map for other uses, you must first obtain a separate licence from OS.

Item 8 – Estimated daily volume of water provided by the supply

If the volume of water is not being measured, e.g. via a water meter, then the investigating officer can make an estimate of the volume based on 200 litres of water per day per person served by the supply. While the figure will only be an estimate every effort should be made to identify the maximum number of people who are being supplied with water from the supply. It is not sufficient just to base the estimate on historical records, e.g. the classification of the supply made under previous regulatory frameworks. It is important to have a robust and defensible maximum occupancy for the supply as this may well have an impact on the sampling frequency to which the supply is subjected.

Item 9 – Details of any water treatment processes associated with the supply

While it is important to document any treatment that occurs on the supply it is not practicable to list all possible treatment types or systems that may be encountered. The risk assessment form concentrates on the provision of standard disinfection equipment/processes but all other treatment systems should be included in the description including items such as sediment traps of pH correction systems. Each of the treatment processes should be cross-referenced to those identified on the schematic provided at Item 6.

For larger systems it will not be practicable to complete Item 9 (c) and so a table should be drawn up listing the properties and the treatments associated with each property differentiating between point of entry and point of use devices, e.g.

Responsible Person	Property Address (including post code)	Point of entry device (specify)	Point of use device (specify)	Notes
Mr D Able	1 Wellside Cottage, Nethermuir, ZZ1 1AA	UV lamp	None	located in lean-to on north side of house, pre-filter bypassed
Mrs C Brown	3 Wellside Cottage, Nethermuir, ZZ1 1AA	UV lamp	None	On maintenance contact with Bloggs Plumbing, Nethermuir
Ms B Charlie	Springside House, By Nethermuir, ZZ1 2BA	None	UV lamp	Under sink in kitchen – poor access for changing bulb
Rev. A Davis	Riverbank Cottage, Nethermuir, ZZ1 1AB	None	None	

These details should be recorded as additional sheets on the form at Item 9 (d)

SECTION C

Item 10 – Details of departures authorised

Provide details of any temporary departures granted under Part IV of the Private Water Supplies (Scotland) Regulations 2006. These details should summarise the details provided in the original temporary departure and should cross-reference to the complete application. If applicable the temporary departure authorisation (Regulation 6(7) of the above Regulations) can be appended to the risk assessment. Details of this should be recorded in Section F.

Item 11 – Details of sample results for previous 12 months or last available (reference location of information, e.g. paper or electronic files, reference number, sample numbers, etc.)

The inclusion of this information is to assist the investigation officer in their investigations. Details of the previous sampling results will enable areas of concern to be highlighted and assist in focusing on areas where actual breaches of the drinking water quality standards have occurred. For example, if lead is highlighted as failing in the sample results, while lead is not specifically being looked for in the risk assessment, the investigation officer may take the opportunity of the investigation to attempt to determine whether there are any known lead pipes or tanks associated with the supply or through examination of the appropriate geological map whether lead is naturally occurring in the vicinity of the source. If lead pipes or tanks are present then appropriate advice can be provided on the need for their removal; if lead is naturally occurring at the source then discussions around locating a more acceptable alternative source for the supply can be entered into.

Item 12 – Details of previous (last two) investigations and actions taken

If there have been investigations into previous failures then the last two such investigations should be summarised here along with the actions that were taken or were understood to have been agreed to have been taken. This information will provide the investigation officer with a background to the problems that have been encountered previously along with an understanding of what actions have been attempted to improve the situation and whether these actions have proved to be successful. If they have proved to be unsuccessful then this information will allow the investigation officer to consider alternative solutions that have not been previously implemented.

Item 13 – Details of enforcement notices served

If any enforcement notices have been served that affect the supply under investigation, details of these should be provided here. If necessary additional information may be appended to the risk assessment and details of these should be provided in Section F.

Item 14 – Results of previous risk assessment (if applicable)

If the source or supply has previously been risk assessed then the details of the previous risk assessment(s) should be included with the current risk assessment. The previous risk assessments should be appended to the current form and details of these additional sheets should be recorded against this item.

Item 15 – Details of location of Notice for Type A supplies (location)

Regulation 31 of the Private Water Supplies (Scotland) Regulations 2006 requires that up-to-date information about the quality of the water provided in commercial or public premises shall be displayed in a prominent location. This notice forms part of the communication of risk to members of the public and so the location of the notice should be recorded to ensure that appropriate risk communication is being undertaken.

Item 16 – Is Notice appropriate (conforms to requirements of the Regulations)

Regulation 31 (2) details the form that the information notice must take. This item confirms that the appropriate form of the notice is being displayed as the form of the notice interlinks with additional information available to both owners/users and visitors to private water supplies making it vital that the appropriate form of the notice is utilised.

Item 17 – Details of action taken (or to be taken) by relevant persons to comply with (a) results of sampling (b) results of follow-up to sampling

If sampling results indicate that the supply fails to comply with the requirements of the Regulations, this section should be completed to identify what suggested/agreed remedial steps should be taken to prevent future failures.

Item 18 – Whether supply exempt under Regulation 2 (4)

If the supply is used solely for washing a crop after it has been harvested or during the distillation of spirits (solely in the mashing process or for washing plant but for no other purpose) and which does not affect, either directly or indirectly, the fitness for human consumption of any food or drink or, as the case may be, spirits in their finished form, then the provisions of the Private Water Supply (Scotland) Regulations 2006 do not apply to that supply with the exception of the provisions of regulation 29. If the supply is exempted under the provisions of regulation 2(4) then a full risk assessment is not required to be completed but good practice would require a partially completed form to be retained by the local authority containing the information required by regulation 29.

Item 19 – Details of other information relating to the supply collated by the local authority

If the local authority has other relevant information relating to the supply then these details should be included here or appended to the form and details of the additional sheets recorded under this item.

Item 20 – Is there a Water Safety Plan/Emergency Action Plan available for the supply

Some supplies may have a water safety plan or emergency action plan that details steps to be taken to ensure the quality of water at the source and steps to be taken in the event of a loss of constancy or quality from that supply.

Item 21 – If “Yes” to Item 20, is it fit for purpose

This item requires an assessment by the investigation officer as to whether or not the water safety plan or emergency action plan is suitable for the premises it relates to.

Item 22 – If “No” to Item 20, what deficiencies are required to be addressed (provide details)

If the assessment undertaken in Item 21 suggests there are inadequacies in the water safety plan or emergency action plan then the deficiencies should be noted against this item with suggestions, where appropriate, as to what improvements may be considered to the plan(s).

SECTION D

General Introduction

In this part of the form each of the indicators being looked for, e.g. disposal sites for animal remains, will have two separate scores associated with them.

The first score will be the Risk Characterisation score

The Risk Characterisation score has three values – High, Moderate or Low – and is based on the presence or absence of the indicator based on the evidence available to the person undertaking the risk assessment. The form is preloaded with the risk characterisation value based on the individual indicator being present or absent. If the assessor cannot determine if the indicator is present then the "Don't know" option should be used.

The assessor should tick the appropriate response box for each indicator. If any response is identified as High Risk (H) then the Risk Characterisation Score will be **HIGH**. If no response is High Risk but there are Moderate Risks (M) identified then the Risk Characterisation Score will be **Moderate**. If no response is High Risk or Moderate Risk then the Risk Characterisation Score is **Low**.

The second score is the Hazard Assessment score

The Hazard Assessment Score is also based on the indicator being present but this scoring allows the extent of the potential influence of the indicator to be taken into account. Thus the likelihood score is dependent on a knowledge or estimate of the time period during which the indicator may be present at the source under investigation. The table in the form provides guidance on the values to be assigned based on how frequently the indicator is known, or thought, to be present. If the indicator is present continuously, i.e. once per day or a permanent feature, then the likelihood value assigned will be 16 as the indicator is almost certainly there continuously; if the indicator is present once a week then the likelihood value assigned will be 8; if the indicator is present once a month then the value will be 4; if the indicator is present once a year then the likelihood value assigned will be 2; and if the indicator is known, or thought, to occur rarely such as once every five or more years, then the value assigned will be 1. Once the likelihood value has been assigned on the form the Hazard Assessment Score is determined by multiplying the Likelihood Value by the Severity (which is pre-loaded on the form) to give the overall Hazard Assessment Score.

The Hazard Assessment Score is an index and there is no implied mathematical relationship to risk. The Hazard Assessment Score is a convenient way of prioritising actions or interventions so that resources are effectively targeted to those areas that pose the greatest potential risk of contamination to the source under investigation.

If the Hazard Assessment Score is **16** or greater for an individual component then the issues associated with that component should be considered as a priority for remedial works to reduce the hazard experienced by the supply.

The value of 16 is considered to be appropriate when only a rare event may produce a catastrophic outcome, e.g. sewage effluent discharge to adjacent watercourse (Item 38). However, if the presence of sewage effluent discharge to an adjacent watercourse were to occur more frequently than once every 5 years or more then the Hazard Assessment Score would reflect this change by increasing the score, and hence flag the requirement to take appropriate action to reduce the likelihood of the occurrence.

Hazard assessment matrix

	Severity of consequences				
Likelihood	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	16	32	64	128	256
Likely	8	16	32	64	128
Moderately likely	4	8	16	32	64
Unlikely	2	4	8	16	32
Rare	1	2	4	8	16

Each of the indicators in Section D will now be considered in turn.

Section D (i) General site survey

Item 23 – History of livestock production (rearing, housing, grazing) – including poultry

Any evidence of domestic livestock production being present (either directly by the presence of animals in the vicinity of the supply) or indirectly (through presence of broken ground around the supply or the presence of animal droppings around the supply) should result in the risk characterisation being scored as “Yes”. Further investigations will be required to decide on the persistence of such presence in order to allow the hazard assessment likelihood score to be accurately assigned.

Item 24 – Evidence of wildlife

Any evidence of wildlife, mammals (rabbits, deer, etc.), birds (gulls, geese, migratory birds, etc.), reptiles (newts, frogs including spawn) etc. at the source could indicate the potential for contamination of the supply either from faecal material or from carcasses falling into the supply. If evidence of wildlife is found then the risk characterisation should be scored as “Yes”. Account should be taken of the likely frequency of the presence of wildlife, e.g. a rabbit warren nearby will suggest permanent presence; migratory birds will suggest a seasonal presence which will require the suggested likelihood values to be moderated to reflect this seasonal presence by raising the once per year score of 2 to 4.

Item 25 – Surface run-off from agricultural activity diverted to flow into source/supply

This indicator is intended to deal with field drains and other drainage systems employed on agricultural land which may be connected to the source or supply. The indicator also deals with instances where there is overland flow from agricultural land that ends up in a watercourse or entering the source and potentially contaminating the supply, e.g. applied slurry where there is potential for it to be washed into field drains or watercourse or similar drainage systems. If there are drainage systems or similar present in areas of agricultural activity then the risk characterisation response will be “Yes”. The likelihood value will be based on the probable time the land is being subjected to agricultural applications.

Item 26 – Soil cultivation with wastewater irrigation or sludge/slurry/manure application

This indicator differs from Item 25 in that there will be active application of the materials in conjunction with the disruption of the soil itself, e.g. via ploughing or sub-soil injection. If such activities are considered to be undertaken then the risk characterisation will be "Yes". The likelihood value will be based on the probable time/duration that such activities occur at.

Item 27 – Disposal of organic wastes to land

This indicator deals with any other organic waste, e.g. abattoir wastes or "blood and guts". The scoring for this indicator will be irrespective of whether there has been disruption of the soil. If such activities are considered to be undertaken then the risk characterisation will be "Yes". The likelihood value will be based on the probable time/duration that such activities occur at.

Item 28 – Farm wastes and/or silage stored on the ground (not in tanks or containers)

If there are middens or areas where silage are being stored in polyethylene bags (or equivalent) or other farm-derived wastes where there is no bunded storage and there is the potential for spillage entering drainage systems, then this item should be scored such that the risk exists. If the storage appears to be a permanent or long-term feature then the hazard assessment should be scored as almost certain (value 16) or likely (value 8).

Item 29 – Remediation of land using sludge or slurry

In some areas brownfield sites or derelict land will be remediated using sewage-derived sludge or slurry or similar materials. The rate of application will typically be higher than those used in Item 26 and this should be borne in mind when assessing both the risk characterisation and hazard assessment parts of the risk assessment form.

Item 30 – Forestry activity

Forestry activities have the potential to cause significant disruption to water supplies to the area in which they are being undertaken. The disruption may occur when forests are being planted, when thinning activities are being carried out or when the timber is being harvested. Account should be taken of the maturity of the forest and the likelihood of activity starting or changing during the period of the risk assessment. If the risk assessment is not scheduled to be time-limited then the potential for disruption should be highlighted.

Item 31 – Awareness of the presence of drinking water supply/source by agricultural workers

If the awareness of the presence of a drinking water source is absent from those agricultural or forestry workers who may be available to be interviewed or if there is evidence of disregard for the presence of such sources, e.g. ploughing to the margins of a well or spring, then the risk characterisation will be "No" or "Don't Know" to reflect the high level of risk such a lack of knowledge may be introducing to the supply. Lack of awareness on the hazard assessment should be scored as almost certain (16) again to reflect the potential for introduction of harmful materials or disturbance of the supply.

Item 32 – Waste disposal sites (including scrap yard, car yard, rubbish and hazardous waste disposal, landfill or incinerator including on-farm incineration)

The presence of disposal sites may influence the quality of water at the source by allowing the introduction of microbiological or chemical contaminants into the supply, depending on the nature of the materials being disposed. Incineration is also included in this section as the question of both airborne material and disposal sites for ash residues need to be considered when making the overall assessment of the likely impact of this item on the water quality at the source. If any waste disposal sites are present then the risk characterisation will be "Yes" and the associated hazard assessment should reflect the permanent nature (or longevity) of such sites in terms of their potential to continue to release polluting materials for many years after their immediate use has ceased.

Item 33 – Disposal sites for animal remains

This definition includes on-farm carcass disposal, burial pits, e.g. arising from foot-and-mouth disease, and vicinity to human burial sites such as graveyards or family plots away from traditional burial sites. If any disposal sites are present then the risk characterisation will be "Yes" and the associated hazard assessment should reflect the permanent nature (or longevity) of such sites in terms of their potential to continue to release polluting materials for many years after their immediate use has ceased.

Item 34 – Unsewered human sanitation including septic tanks, pit latrines, soakaways

If unsewered human sanitation is present near the source then there is considerable potential for raw human sewage to contaminate the source of the drinking water supply. Great care must be taken when assessing the positioning of septic tanks as well as their condition (maintenance), the areas where the soakaway is positioned, the condition of any pipes leading from the septic tank to the soakaway (is there evidence of different vegetation which may indicate a leaking pipe) and the discharge point of the soakaway if this is directed towards a surface receiving water. Similarly if there are pit latrines in use, e.g. at a campsite or areas where chemical toilets are discharged, the area surround the disposal point or latrine should be considered carefully in terms of allowing contact with the source. The contact may not be visible as there may be some connectivity underground and so some thought must be given to the soil leaching potential of the site.

Item 35 – Sewage pipes, mains or domestic (e.g. leading to/from septic tank)

In addition to Item 34 consideration must be given to the path that sewers may take. If the line of the pipe intersects with the area from which the drinking water source is being recharged (the area from where the water is being drawn) then there is the potential that any failure (leak) from the sewer or similar pipe will introduce raw sewage directly into the water source. It is unlikely that the path of such pipes will be clearly visible and so some care in interpreting the area will need to be taken, e.g. areas where the vegetation/ground appears to be drier indicating that there is a pipe buried below the surface or if there is a fracture in the pipe areas that would not naturally be damp or areas where there is vegetation indicative of wet or nutrient enriched conditions such as reeds or nettles.

Item 36 – Sewage effluent lagoons

Sewage effluent lagoons bring the potential that leaking material from the lagoon may enter the soil and pass into the groundwater providing a direct route for the contamination of the source with raw sewage. Farm effluent lagoons may be viewed as being the same in terms of the risks posed to the source when assessing the scoring values to be assigned.

Item 37 – Sewage effluent discharge to adjacent watercourse (where present)

While some aspects of this item may be identified when reviewing Item 34, Item 37 draws attention to the potential for sewage effluent discharges from a variety of sources such as municipal wastewater treatment works, septic tanks, privately owned/operated sewage treatment systems or reed beds. If there is evidence of discharge to a watercourse that is adjacent to the source of the supply under investigation then the risk characterisation should reflect the circumstances and “Yes” should be recorded. Similarly, for the hazard assessment the permanent, or semi-permanent, nature of the hazard should be reflected in the likelihood value assigned which should be almost certain (value 16).

Item 38 – Evidence of use of pesticides (including sheep dip) near source

If disposal sites for pesticides (including sheep dip) are known to be close to the source under investigation then the risk characterisation should reflect this as should the hazard assessment. If there is evidence of the area having been used for dipping sheep (with dip tanks, fanks, etc.) then this evidence should be taken into account when assessing the site.

Item 39 – Evidence of industrial activity likely to present a contamination threat

If there is evidence of the area adjacent to the source having been used for industrial activity which may pose a contamination threat then this should be recorded on the risk assessment. Such activities may include chemical or pharmaceutical production, mineral or other extraction such as coal mining, areas where old fuel tanks may have been located or may still be in place either below or above ground, or industries where solvents would have been in use and may have been disposed of on to the ground, e.g. electroplating, metal working or electronics. This list is not exhaustive and so appropriate interpretation of the previous use to which the site may have been put will be required by the investigation officer.

SECTION D (ii) Supply survey

Item 40 – Supply network constructed from material liable to fracture (e.g. asbestos concrete, clay, etc.)

If the network of pipes that lead from the well are constructed of materials that are liable to deterioration or fracture, e.g. if heavy farm machinery is driven over the top of the pipeline, then the integrity of the system will be lost and potentially polluting material may enter the pipes through the fractures or the whole supply will be lost through pipe blockages. If it is considered likely that such materials have been used for all or part of the pipework being used to convey water from the source then the risk characterisation must reflect this with a "Yes" score and the hazard assessment must similarly reflect the permanent nature of the hazard by scoring as almost certain (value 16).

Item 41 – Intermediate tanks (e.g. collection chambers, holding tanks, break-pressure tanks) are not adequately protected

The level of protection for all intermediate tanks or similar structures should be equivalent to that recommended for the source itself as the potential for contamination to enter the system via such intermediate points is just as high as for the source itself. If any of the intermediate tanks or similar structures are deficient then this should be reflected in the risk characterisation and hazard assessment. If there is more than one intermediate tank or similar structure, the deficient ones should be noted in section F and cross-referenced with the diagram provided in Section B (item 6).

Item 42 – Junctions present in the supply network, particularly supplying animal water systems, have no back-siphon protection

If there are provisions made to provide water to animal watering troughs or other connections where back-siphonage may occur, e.g. from a hosepipe permanently connected, there is potential for the contents of the trough or container to be back-siphoned into the distribution pipe and for the contents of the trough or container to enter the supply. Clearly the contents of a cattle watering trough or a barrel into which the end of a hose has been dangled for some weeks will do little to improve the quality of the drinking water being provided. It is essential that where connections are made on the system prior to the first taps to be used for domestic (potable) consumption appropriate back-siphonage prevention devices are fitted. If they are not or there is no evidence to support claims that they have been fitted then the risk characterisation must reflect this with a "Yes" response. Similarly the hazard assessment should highlight the permanent nature of the situation with an almost certain (value 16) rating.

Item 43 – No maintenance (including chlorination) has been undertaken in the previous 12 months

If the system has had no maintenance undertaken in the 12 months preceding the investigation then this suggests that the level of care and attention required to ensure the system is operating as effectively as possible is lacking. If this is the case then the risk characterisation score should reflect the situation encountered and a “Yes” response entered. The hazard assessment likelihood score should also reflect the situation with an unlikely score (value = 2).

Item 44 – If present, header tank within the property(s) does not have a vermin-proof cover

Many properties served by a private supply, particularly those on smaller supplies, will have a header tank within the property to provide sufficient water pressure for the household and also to act as a balancing tank to equalise the pressure differences experience in the system when pumps are operating to bring water into the property. However, if the header tank is not properly constructed and protected then any material that may be present in the roof space, whether that be dust or mice or bat droppings, will have the potential to enter the tank and so contaminate the supply. If the property has a header tank which feeds the main domestic (potable) tap, usually the kitchen cold water tap, and that tank is not properly protected then the risk characterisation score should reflect the situation encountered and a “Yes” response entered. The hazard assessment likelihood score should also reflect the situation with an almost certain score (value = 16). If the header tank is present and unprotected but does not feed the main domestic (potable) tap then the risk assessment can be moderated but the risk to other taps in the property should be highlighted in Section F and noted on the diagram at Section B.

Item 45 – Header tank has not been cleaned in the last 12 months

If the header tank has an appropriate vermin-proof cover (Item 44) it will still require to be maintained by cleaning at least every 12 months to prevent the build-up of slime and scum which will naturally grow on the tank walls. If the tank has not been cleaned in the 12 months prior to the investigation then the risk characterisation score should reflect the situation encountered and a “Yes” response entered. The hazard assessment likelihood score should also reflect the situation with an unlikely score (value = 2).

Item 46 – Any point of entry/point of use treatment equipment has not been serviced in accordance with the manufacturer's instructions in the last 12 months

If any point of entry/point of use devices have had no maintenance undertaken in the 12 months preceding the investigation then this suggests that the level of care and attention required to ensure the system is operating as effectively as possible is lacking. If this is the case then the risk characterisation score should reflect the situation encountered and a "Yes" response entered. The hazard assessment likelihood score should also reflect the situation with an unlikely score (value = 2).

Item 47 – If present ultraviolet (UV) lamps are not operating

While ultraviolet disinfection systems if properly installed and maintained are an effective treatment option to prevent potentially harmful micro-organisms from causing disease they can provide a false sense of security if they are not looked after. A particularly common fault is for the UV bulb to stop operating. The UV bulb is at the heart of the installation and is responsible for the disinfection process. If there is not an automatic warning system on the installation then the loss of the bulb could go undetected. Similarly if the bulb has not been changed in accordance with the manufacturer's recommended replacement period then the efficiency or operation of the bulb could be impaired or have ceased to function at all. It is important, therefore, to assess if the UV bulbs (lamps) are operating on a UV system at the time of the inspection. If they are not operating then the risk characterisation score should reflect the situation encountered and a "Yes" response entered. The hazard assessment likelihood score should also reflect the situation based on an assessment of when the UV bulb (lamp) ceased to function.

Item 48 – Is there a noticeable change in the level and flow of water throughout the year

This question deals with the issue of constancy of supply as it relates to the quality of the source. If the source is highly dependable and provides adequate levels of water throughout the year then it is likely that the source is not under direct influence from either the surface or from prevailing climatic conditions. On the other hand, if the supply is "flashy" and changes with the weather then it is likely that it is under the influence of surface flow and prevailing weather conditions which increases its vulnerability to contamination from the surface. If there are noticeable changes in level and flow the risk characterisation response will be "Yes". The hazard assessment likelihood in these circumstances will be almost certain (value = 16). This circumstance may also cause the investigating officer to reconsider if the supply is in fact a well or if it would be better treated as a surface-derived supply.

Item 49 – Is there a noticeable change in the appearance of the water (colour, turbidity – cloudiness) after heavy rainfall or snow melt

If the supply is under the influence from either the surface or the weather then the quality experienced cannot be guaranteed if there are conditions prevailing which make surface flow (e.g. flooding) or adverse weather conditions likely. If there are noticeable changes in the appearance of the water then the risk characterisation response will be “Yes”. The hazard assessment likelihood in these circumstances will be dependent on whether weather or surface influence is considered the most likely cause.

D (iii) Overall risk assessment

(a) Risk characterisation

The overall risk assessment for the source is taken as the highest individual risk category identified from each of the three surveys.

The overall risk characterisation category will be recorded as the risk assessment score for the source.

Survey Section	Risk Characterisation Category
General Site Survey	
Source Survey	
Soil Leaching Risk Survey	
Overall Risk	

(b) Hazard assessment

Individual components in each of the surveys with a hazard assessment score of 16 or greater should be considered as priority candidates for remedial works capable of reducing the overall risk characterisation category.

Section E

If the type of the supply has not been determined then the risk assessment will not have been completed. In this case the overall risk assessment for the supply will default to High Risk to ensure that appropriate control measures are put in place to maintain public health.

Section F

Additional Notes – this section can be used to include additional information or observations made during the investigation.

This page is intentionally blank

Section 4.9 – Annex 1

Surface Supply Risk Assessment pro forma

Private Water Supply Risk Assessment Form

SURFACE DERIVED SUPPLY

OVERALL RISK ....

Section A – Supply Details

1. Supply category

Type A1 / A2 / A3   Type B (circle appropriate category)

2. Address and telephone number of responsible person

....

....

....

Post Code ....

Telephone Number (including full STD Code) ....

Email Address ....

3. Name of person (or persons) who is relevant person in relation to the supply

(a) ....

(b) ....

(c) ....

(d) details of additional sheets ....

4. Address of relevant person (or persons) (if different from above)

(a) ....

....

....

Post Code ....

Telephone Number (including full STD Code) ....

Email Address ....

(b) ....

....

....

Post Code ....

Telephone Number (including full STD Code) ....

Email Address ....

(c) ....

....

....

Post Code ....

Telephone Number (including full STD Code) ....

Email Address ....

(d) details of additional sheets ....

5. Details of premise(s) served by the supply and purpose for which water is supplied

(a) ....

....

....

Post Code ....

Supply purpose ....

(b) ....

....

....

Post Code ....

Supply Purpose ....

(c) ....

....

....

Post Code ....

Supply Purpose ....

(d) details of additional sheets ....

Section B

6. Provide a diagram of the supply showing source(s), intermediate storage and/or collection tanks and properties on the supply. The diagram is indicative only and is intended to aid completion of the rest of this section.

Notes: Items should be labelled from source (A) through intermediate tanks (B) to properties (C) with individual components numbered, e.g. for a supply with one source this would be A1; two intermediate tanks (B1 and B2 respectively) and two properties (C1 and C2) respectively.

7. Description of the source of the supply including (i) details of supply source(s), (ii) location of the source(s) and (iii) eight-figure National Grid Reference of location(s) of source(s). Cross reference from Item 6 above.

(i) ....

....

....

(ii) ....

....

....

(iii) National Grid Reference _N_ / _J_ / _0_ / _0_ / _0_ / _0_ / _0_ / _0_

8. (a) Estimated daily volume of water provided by the supply .... m^3 per day

(b) Number of persons served by supply (at maximum occupancy) ....

9. Details of any water treatment processes associated with the supply

(a) At source – identify which of the following systems are present: (cross reference to Item 6)

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

(b) Intermediate Water Storage Tank/Chamber (cross reference to Item 6)

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

(c) At property (cross reference to Item 6)

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

Identifier (from Item 6) ....

[tick which of the following treatments are present]

	Chlorination
	Filter
	UV
	Ozone
	UV without pre-filter
	Untreated
	Unknown
	Other (details) ....

(d) details of additional sheets ....

Section C

10. Details of departures authorised

....

....

....

11. Details of sample results for previous 12 months or last available (reference location of information, e.g. paper or electronic files, reference number, sample numbers, etc.)

....

....

....

12. Details of previous (last 2) investigations and actions taken

....

....

....

13. Details of enforcement notices served

....

....

....

14. Result of previous risk assessment (if applicable)

....

....

....

15. Details of location of Notice for Type A supplies (location)

....

....

....

16. Is Notice appropriate (conforms to requirements of the Regulations)? Yes ☐ No ☐

17. Details of action taken (or to be taken) by relevant persons to comply with

(a) results of sampling

....

....

....

....

(b) results of follow-up to sampling

....

....

....

....

18. Whether supply exempt under Regulation 2(4)

....

....

....

19. Details of other information relating to the supply collated by the local authority

....

....

....

20. Is there a Water Safety Plan/ Emergency Action Plan available for the supply?

Yes ☐ No ☐

21. If "Yes" to Item 20, is it fit for purpose? Yes ☐ No ☐

22. If "No" to Item 21, what deficiencies are required to be addressed (provide details)?

....

....

....

Section D – Surface derived sources

D (i) General site survey

Are any of the following known to be present and likely to influence water quality at the source?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
23	History of livestock production (rearing, housing, grazing) – including poultry	H	L	H		16	
24	Evidence of wildlife	M	L	M		4	
25	Surface run-off from agricultural activity diverted to flow into the source/supply	H	L	H		8	
26	Soil cultivation with wastewater irrigation or sludge / slurry/ manure application	H	L	H		8	
27	Disposal of organic wastes to land	H	L	H		8	
28	Farm wastes and/or silage stored on the ground (not in tanks or containers)	M	L	M		8	
29	Remediation of land using sludge or slurry	H	L	H		16	
30	Forestry activity	M	L	M		4	
31	Awareness of the presence of drinking water supply/source by agricultural workers	L	H	H		4	
32	Waste disposal sites (including scrap yard, car yard, rubbish and hazardous waste disposal, landfill or incinerator including on-farm incineration)	H	L	H		8	
33	Disposal sites for animal remains	H	L	H		8	
34	Unsewered human sanitation including septic tanks, pit latrines, soakaways	H	L	H		16	
35	Sewage pipes, mains or domestic (e.g. leading to / from septic tank)	H	L	H		8	
36	Sewage effluent lagoons	H	L	H		16	
37	Sewage effluent discharge to adjacent watercourse (where present)	H	L	H		16	
38	Evidence of use of pesticides (including sheep dip) near source	H	L	H		8	
39	Evidence of industrial activity likely to present a contamination threat	H	L	H		8	

[1] The Hazard Assessment Score is the product of the Likelihood and Severity values. The values are :

Likelihood	Definition	Value
Almost certain	Once per day (or permanent feature)	16
Likely	Once per week	8
Moderate likely	Once per month	4
Unlikely	Once per year	2
Rare	Once every 5 years	1

Risk Characterisation

Tick the appropriate box for each question.

If any question is High Risk (H) then the Risk Characterisation Score is **High**. ☐

If no question is High Risk but there are Moderate Risks (M) identified then the Risk Characterisation Score is **Moderate**. ☐

If no question is High Risk (H) or Moderate Risk (M) then the Risk Characterisation Score is **Low**. ☐

Hazard Assessment

If the Hazard Assessment Score is 16 or greater for any individual component then the issues associated with that component should be considered as a priority for remedial works to reduce the hazard experienced by the supply.

D (ii) Supply survey

Are any of the following known to occur at the head works site or in relation to the supply?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
40	Supply network constructed from material liable to fracture e.g. asbestos-concrete, clay etc.?	H	L	H		8	
41	Intermediate tanks (e.g. collection chambers, holding tanks, break-pressure tanks) are not adequately protected	H	L	H		8	
42	Junctions present in the supply network, particularly supplying animal watering systems, have no back-siphon protection?	H	L	H		4	
43	No maintenance (including chlorination) has been undertaken in the previous 12 months?	H	L	H		8	
44	If present, header tank within the property (s) does not have a vermin-proof cover?	H	L	H		4	
45	Header tank has not been cleaned in the last 12 months?	H	L	H		8	
46	Any point of entry/point of use treatment equipment has not been serviced in accordance with the manufacturer's instructions in the last 12 months?	H	L	H		8	
47	If present ultraviolet (UV) lamps are not operating?	H	L	H		16	
48	Is there a noticeable change in the level and flow of water throughout the year?	H	L	H		4	
49	Is there a noticeable change in the appearance of the water (colour, turbidity – cloudiness) after heavy rainfall or snow melt?	H	L	H		8	

[1] The Hazard Assessment Score is the product of the Likelihood and Severity values. For details see Section D.

Risk Characterisation

Tick the appropriate box for each question.

If any question is High Risk (H) then the Risk Characterisation Score is **High**. ☐

If no question is High Risk but there are Moderate Risks (M) identified then the Risk Characterisation Score is **Moderate**. ☐

If no question is High Risk (H) or Moderate Risk (M) then the Risk Characterisation Score is **Low**. ☐

Hazard Assessment

If the Hazard Assessment Score is 16 or greater for any individual component then the issues associated with that component should be considered as a priority for remedial works to reduce the hazard experienced by the supply.

D (iv) Overall risk assessment

(a) Risk characterisation

The overall risk assessment for the source is taken as the highest individual risk category identified from each of the two surveys.

The overall risk characterisation category will be recorded as the risk assessment score for the source.

Survey Section	Risk Characterisation Category
General Site Survey	
Source Survey	
Soil Leaching Risk Survey	
Overall Risk	

(b) Hazard assessment

Individual components in each of the surveys with a hazard assessment score of 32 or greater should be considered as priority candidates for remedial works capable of reducing the overall risk characterisation category.

Section E

You have been unable to discern the type of supply and so the overall risk assessment for this source must be given as **High Risk**.

Section F – Additional Notes

4.10 References

[1] Protocol on Water and Health to the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lake, done in London, on 17 June 1999. United Nations Economic and Scoail Council. MP.WAT/2000/1 EUR/ICP/EHCO 020205/8FIN. Pamphlet: What it is, why it matters (WHO 2001).

[2] Guidelines for Drinking-water Quality. 3rd Edition. Volume 1 – Recommendations. World Health Organisation, Geneva. 2004 ISBN 9241546387.

[3] From Source to Tap: Guidance on the Multi-Barrier Approach to Safe Drinking Water. Draft prepared for Federal-Provincial-Territorial Committee on Environmental and Occupational Health. 2003.

[4] Hrudey, S.E., E.J.Hrudey. Safe Drinking Water: Lessons from Recent Outbreaks in Affluent Nations. IWA Publishing. 2004. ISBN 1843390426.

[5] Clapham, D. Small Water Supplies: A practical guide. Spon Press. 2004. ISBN 0415282829.

[6] Anon. Drinking Water Quality in Scotland 1997. The Scottish Office. Agriculture, Environment and Fisheries Department. Water Services Unit. HMSO. 1998. ISBN 0 7480 7179 2

[7] Lamb, A.J., D.C.Reid, A.Lilly, J.H.Gauld, B.A.McGaw, J.Curnow. Improved Source Protection for Private Water Supplies: Report of the Development of a Microbiological Risk Assessment Approach. The Scottish Office. Agriculture, Environment and Fisheries Department. Water Services Unit. 1998.

[8] Anon. E coli O157 and Private Water Supplies (AEFD Circular No 1/1997). The Scottish Office. Agriculture, Environment and Fisheries Department. Water Services Unit. 1997.

[9] Stanfield, G., P.Gale, C.Young, J.Blackmore, R.L.Norton. Improved Source Protection for Private Water Supplies. The Scottish Office. Agriculture, Environment and Fisheries Department. 1997.

[10] Anon. Manual on the Treatment of Private Water Supplies. Drinking Water Inspectorate. HMSO. 1993.

[11] Anon. Groundwater protection for small sources. Volume 1 – Review of available methodologies and existing practice. National Rivers Authority Environment Agency Groundwater Centre, Solihull, UK. 1995.

[12] Anon. Code of Good Agricultural Practice for the protection of water. MAFF Publications, London. 1991.

[13] Anon. Private Water Supplies in Scotland – A Manual of Best Practice for Environmental Health Officers and Support Staff. The Royal Environmental Health Institute of Scotland. March 2000.

[14] Jackson, P.J., G.R.Dillon, T.E.Irving, G.Stanfield. Manual on Treatment for Small Water Supply Systems. Final Report to the Department of the Environment, Transport and the Regions. Drinking Water Inspectorate Report No 4936/1. 2001.

[15] Pennington, H. et al. The Pennington Group Report. HMSO 1997.

[16] Anon. Prevention of Environmental Pollution from Agricultural Activity. A Code of Good Practice. The Scottish Office. Agriculture, Environment and Fisheries Department. HMSO. 1997.

[17] Anon. Keeping It Safe. Is Your Private Water Supply Safe? The Scottish Executive. 2001.

[18] Anon. Private Water Supply Regulation: A Consultation. The Scottish Executive. 2001. ISBN 0-7559-3277-3

[19] Lilly, A., A.C.Edwards, M.McMaster. Microbiological Risk Assessment Source Protection for Private Water Supplies: Validation study. The Scottish Executive/Macaulay Institute. 2003.

[20] Anon. The Private Water Supplies (Scotland) Regulations 1992. Statutory Instrument No 575 (S.64). HMSO. 1992.

[21] Lilly, A., D Kay. Analysis of Risk Protocol Options for Private Water Supplies. The Scottish Executive/Macaulay Institute/Centre for Research into Environment and Health. 2004.

[22] Palmer, R.C., Holman, I.P., Robins, N.S. and Lewis, M.A. 1995. Guide to groundwater vulnerability mapping in England and Wales. National Rivers Authority. HMSO.

[23] Lewis M.A., Lilly, A and J.S. Bell. 2000. Groundwater vulnerability mapping in Scotland: Modifications to classification used in England and Wales. In: Groundwater in The Celtic Regions: Studies in Hard Rock and Quaternary Hydrogeology. Eds. N.S. Robins and B.D.R. Misstear. Geological Society Special Publication No. 182. pp 71-79.

[24] Boorman, D.B., Hollis, J.M. and Lilly, A. 1995. Hydrology of soil types: a hydrologically-based classification of the soils of the United Kingdom. Institute of Hydrology Report No.126. Institute of Hydrology, Wallingford.

This page is intentionally blank

SECTION 5

RISK ASSESSMENT CASE STUDIES

Section Contents

Annexes

5.1 Introduction

These cases studies illustrate the **practicalities of carrying out risk assessments** on private water supplies. They focus on the **site survey** and **supply survey** questions, providing many useful photographs as well as the diagram required for each study.

Obtaining the input of the relevant or responsible person/s is crucial, and both makes the assessment easier and ensures the process is an inclusive one.

Not all the survey questions will apply to a given supply, while others will be scored as high risk because they cannot be answered. The case studies have many examples of this and also describe the process for supplies with multiple sources, including examples where the nature and/or location of the supply is uncertain.

5.2 Case study 1 – Surface supply in the Scottish Borders

Dawyck Botanical Garden draws its **supply from an artificial pond** coming from a tributary of the Tweed. There are two holding tanks and a chlorinator feeding the visitor centre and 3 cottages.

This case study highlights the risk of animal remains (dead sheep), wild life, commercial forestry activity (sump oil) and of intermediate tanks having inadequate protection from vermin. Uncertainty about the pipe materials also resulted in the supply network being designated as high risk, but this could be re-assessed at a later date with new information. Changing flow and turbidity were also noted and the overall risk was high with recommended interventions focusing on the above.

5.3 Case study 2 – Estate supply from Perthshire

This is a good example of a **multiple-source supply with uncertainties about source nature and location**. The supply's three sources were previously classed as springs but one source is closer to being a well, another is more like a surface abstraction and the location of the third is not known. All three sources feed one of two holding tanks, while only the well feeds the second tank. Both of the known sources and both tanks were assessed individually, highlighting a large number of high risk areas including the presence of wildlife, livestock, agricultural activity (including agri-chemical run-off), lack of maintenance, forestry activity and inadequate protection of tanks (one of which had been coated with bitumen paint).

Several questions were also scored as "Don't know" (High Risk) because the relevant person was not present, though these could be followed-up later. The study also has an additional note about a high risk join in the lines from the two known sources. Since both the well and the surface source were classified as high risk, as would (automatically) the unknown source, the supply overall was assessed as high risk.

5.4 Case study 3 – Knuttmound Estate Supply, West Perthshire

This is a good example of the complex issues that private water supplies can present. The supply has 4 sources and serves around 180 people in their homes, as well as 2 hotels and a boarding school which controls one of the supplies. It is not clear if that source is connected though.

The other three sources were assessed individually. One was reclassified from spring to well and was assessed on this basis, **including a soil leaching survey**.

The **second source proved inaccessible** because of a deer fence and a steep slope, and so was designated high risk by uncertainty.

The **third source was reclassified** from spring to surface water and there is a good diagram and explanation of this. It was also noted that surface supply assessment did not cover the security of the site in terms of fences etc. so they were listed in additional notes, which shows that **sources may not fall into a single classification.**

Two further additional notes were made about the overall system, relating to evidence of lead pipework and an additional storage tank being found adjacent to the operational one.

The three identified sources had **several risk characteristics** between them, including poor drainage, evidence of livestock and wildlife, lack of fences, ditches and protective well features etc., but this case study also **highlights why supplies cannot be compared via their scores -** because many questions will not be appropriate to a given supply. The scores are there to identify issues, not to rank supplies.

5.5 Case study 4 – Waterbottom Borehole near Peebles

This is an example of a small borehole supply with **headworks below ground**.
The 19 metre-deep borehole feeds 3 nearby properties (around 10 people).

The site survey found herbicide on the headworks and the supply survey found there was no cut-off ditch, the chamber top was not above ground level and no maintenance had been done in the last year. The supply was assessed as high risk with an additional note about the need for a lock for the chamber.

5.6 Case study 5 – Border Estate Supply

This is an **extensive supply with multiple sources and very basic collection equipment** consisting of plastic pipes and buckets.

Again, the **sources were reclassified** from springs to surface waters, because the collection chambers were not within the rock matrix and were under surface influence. This case study shows many photographs of the collection points and intermediate storage points, and **assesses their vulnerability using both the surface and springs risk questions.**

Here the **relevant person could give answers** to questions on the nature of the supply network and the flow and turbidity of the water, assisting considerably.

5.7 Case study 6 – Rooster Cottage/Farm Borehole

This is an example of a small borehole supply with **headworks below ground**. It serves 4 people in the cottage and farm. There were risks arising from **pesticide use** because of the source's location in arable land, and from the absence of a ditch to divert flow from the borehole chamber, although the chamber walls had been raised.

The **responsible person's knowledge** of some issues and uncertainty of others led to a number of high risk characterisations, relating to drainage, sewerage, network materials and maintenance.

5.8 Case study 7 – Surface supplies good and bad designs

This section shows diagrams of a model **surface supply** with protection from flooding, livestock and vermin. It also shows photographs of some bad designs and high-risk problems found in the field.

5.9 Case study 8 – Groundwater well heads

This section has photographs and descriptions illustrating good and bad designs for well heads found in practice, highlighting the risk to any electrical pumping equipment as well as of the risk of contaminating the supply.

5.10 References

There is one reference concerning springs.

SECTION 5

ANNEXES

Section 5 Annexes

The **completed assessment pro formas** for the case studies (5.1 to 5.7) are annexed here, including **a soil leaching potential map** for the Knuttmound Estate case study.

Private Water Supplies

This page is intentionally blank

5. RISK ASSESSMENT CASE STUDIES

5.1 Introduction

> Common sense is the best distributed commodity in the world,
> for every man is convinced that he is well supplied with it.
> *Descartes, 1637*

There can be no substitute for common sense and, as Descartes says, we all think we have our own personal supply which has seen us through all manner of encounters. While this may very well be true it is almost certain that those with whom you discuss matters of risk and private water supplies will be convinced of their own common sense's superiority over officialdom in general and you in particular.

These case studies have been developed to assist you in preparing for the day when your professional judgement and personal common sense are challenged. The case studies have focused on the risk assessment part of the exercise. The other parts of the risk assessment forms (Sections A, B and C) are straightforward exercises in collating information. The possible exception to this is Section B (6) where a diagram of the supply is requested. Diagrams for each case study are supplied and these have been annotated as instructed in the rubric of the risk assessment form.

Throughout these case studies certain guidelines for completion of the risk assessment forms have been adopted to aid the completion of the forms.

Perhaps the most important and over-riding guideline is

(a) Ensure that you have access to, or the presence of, all those people whom you consider will have knowledge and information pertinent to the supply and the types of questions you will be asking.

The risk assessment process can be carried out without input from relevant persons but the task will be made much simpler if they are present. Their presence will allow you to ask questions and clarify points raised through the risk assessment process but more importantly it will emphasise to the relevant person that the process is an inclusive one – partnership rather than dictatorship. Making contact and ensuring participation will aid in the development not only of the risk assessment but also in the relationship with the relevant person.

The other guidelines applied are:

(b) If the particular question is not appropriate to the circumstances encountered then the question is scored through and not completed.
(c) If the Risk Characterisation assessment results in a low risk score then the corresponding hazard assessment does not require to be completed.
(d) If the Risk Characterisation assessment results in a High Risk occurring due to a positive response in the Don't Know category then the hazard assessment will be undertaken assuming a worst-case

for the corresponding risk. An example of this can be found in Case Study 2 where at Site A1 no information was known about changes in water flow or appearance. The risk characterisation was scored as Don't Know (High) and the hazard assessment assumed that there would be changes in water flow and appearance and assessed the likelihood and overall score on that basis.

Where there are multiple sources that are derived from discrete or widely different catchments then each source should be considered separately in terms of the risk assessment part of the overall exercise. Similarly, where there are extended, complex distribution systems where not all of the sources feed all of the distribution system (see Case Study 2) then the separate sources and their associated intermediate tanks and distribution systems should be considered as separate components of the overall assessment. The rules will remain the same – for the supply the highest level of risk will be the risk category assigned.

In cases where it is uncertain precisely what type of source is being assessed then the most vulnerable source type should be assumed. For example, if there is some debate over whether a supply is being fed from a well or a spring it could be appropriate to score on the basis of the supply being a well. Similarly, if there is some doubt over whether a supply is a spring or a surface derived source it could be appropriate to score on the basis of a surface derived source as this has the highest inherent risk associated with it.

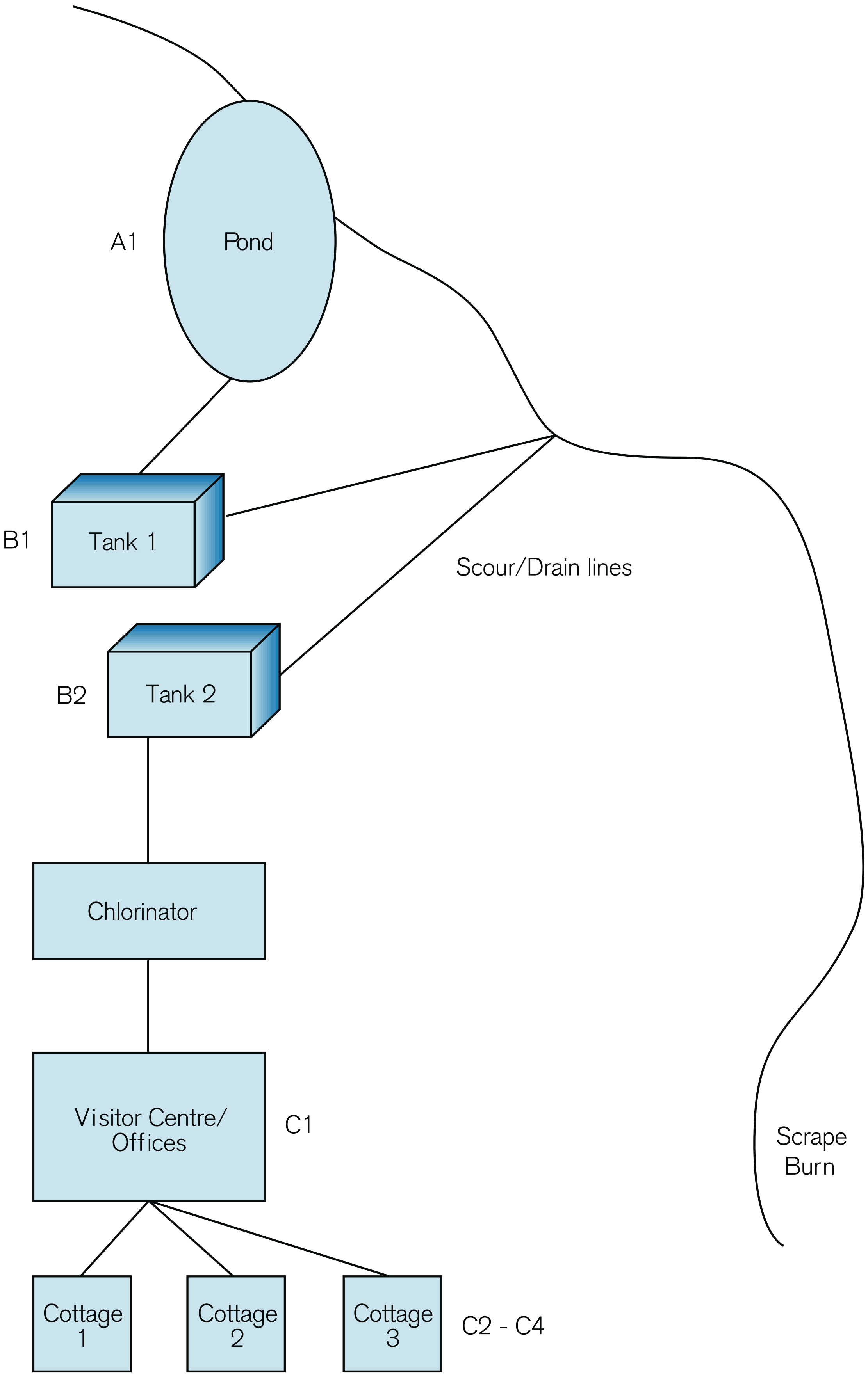
5.2 Case study 1 – Surface-derived water supply from the Scottish Borders

Dawyck Botanical Garden (pronounced "daw ick") in Peebleshire is one of four gardens maintained by the Royal Botanic Garden in Edinburgh. The Garden is located on the south bank of the River Tweed eight miles south-west of Peebles and about 28 miles south of Edinburgh, Scotland's capital city. The gardens at Dawyck have an elevation staring of 165m above sea level rising to 250m and they have an almost Continental climate with temperatures ranging from -19˚C to 28.5˚C and a low rainfall typically ranging between 875mm to 1070mm with the wettest months occurring between October and January. The Dawyck Botanical Garden can trace its origins back over 300 years with some trees still growing that were planted in 1680. The editorial team are very grateful to David Knott, Curator at Dawyck, for giving permission to use the site for this case study.

Water used to supply the visitor centre and three cottages in the Garden is drawn from the Scrape Burn (a tributary of the Tweed). The burn (which is the Scots term for a stream) flows into an artificial pond from where the water is abstracted into two tanks before it flows on to a small chlorination system and then into supply. There are 10 people living in the cottages with a further seven staff working at the visitor centre with a further 24,000 people visiting the visitor centre annually.

Figure 5.1 shows a diagram of the supply while Annex 5.1 gives the risk assessment scores for the supply.

Figure 5.1 Case Study 1: Dawyck Botanic Garden Supply



For the general site survey the assessed risks arose from the following:

Question 23 was scored Yes – risk characterisation high - as there was evidence of sheep grazing around the burn in the reaches above the Garden boundary. Indeed several dead sheep have had to be removed from the catchment in previous years – some quite close to the burn itself. Figure 5.2 illustrates the animal remains found near the Scrape Burn. The hazard assessment likelihood was scored as permanent (16) giving an overall score of 256.

Figure 5.2 Animal remains beside Scrape Burn

Question 24 was scored yes – risk characterisation medium - as there was evidence of wildlife in the catchment including deer – roe and fallow, rabbits and other rodents. The hazard assessment likelihood was scored as permanent (16) giving an overall score of 64.

Figure 5.3 Scrape Burn catchment showing erosion on heather moor at head of catchment

Question 30 was scored as yes – risk characterisation medium – as the catchment area includes large areas of commercial forestry as well as the forestry activity associated with the maintenance of the Garden. The hazard assessment likelihood was scored as permanent (16) as the activity occurs intermittently throughout the year and may not be notified to the Garden when the work is being undertaken in areas outwith the Garden.

Figure 5.4 Sump oil on trackway

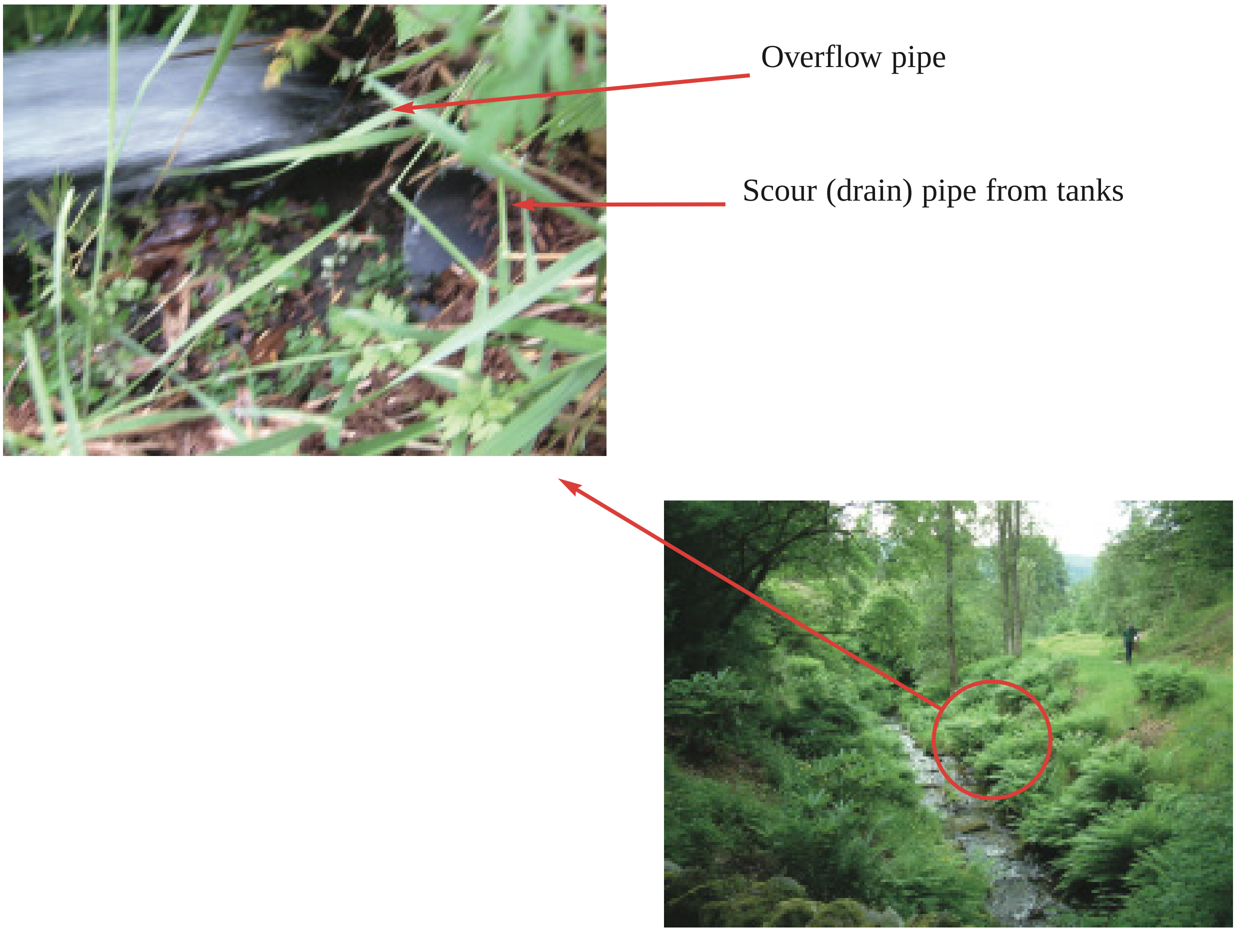
Scrape Burn is down slope on right hand side of the picture.

For the supply survey the assessed risks arose from the following:

Question 40 was scored as Don’t Know – risk characterisation High – as the details of the pipe materials were not known at the time of the assessment. Once the information is determined then the assessed risk can be re-evaluated in the light of the evidence presented. The hazard assessment likelihood was scored as permanent (16) giving an overall score of 128.

Question 41 was scored as yes – risk characterisation High – as the drain and scour lines did not have vermin protection at their outlets. The hazard assessment likelihood was scored as permanent (16) giving an overall score of 128.

Figure 5.5 Drain and scour pipe details from collection tanks showing vermin protection absent



Question 48 was scored as Yes - risk characterisation High – the garden staff noted that the burn experiences significant changes in the level and flow throughout the year depending on the prevailing weather conditions. The hazard assessment likelihood was considered as once per year (scoring 2).

Question 49 was scored as Yes – risk characterisation High – as in the experience of the staff there were significant changes in the appearance of the water following heavy rainfall. Again the hazard assessment likelihood was considered as once per year (scoring 2).

Overall these scores result in the source risk being assessed as High with recommended interventions focusing on trying to reduce access of animals to the burn, controlling forestry activity in the catchment, protecting drain and scour pipes from entry by vermin, identifying pipe materials and being aware that heavy rainfall can have detrimental effects on the water quality.

Figure 5.6 Scrape Burn showing evidence of historical spate flow conditions

Scrape Burn showing wind fallen logs carried by the burn when in spate

Pond formed from Scrape Burn used as source of drinking water supply at Dawyck Garden

(Note gravel deposits washed into the pond during spate flows)

5.3 Case Study 2 – Estate supply from Perthshire

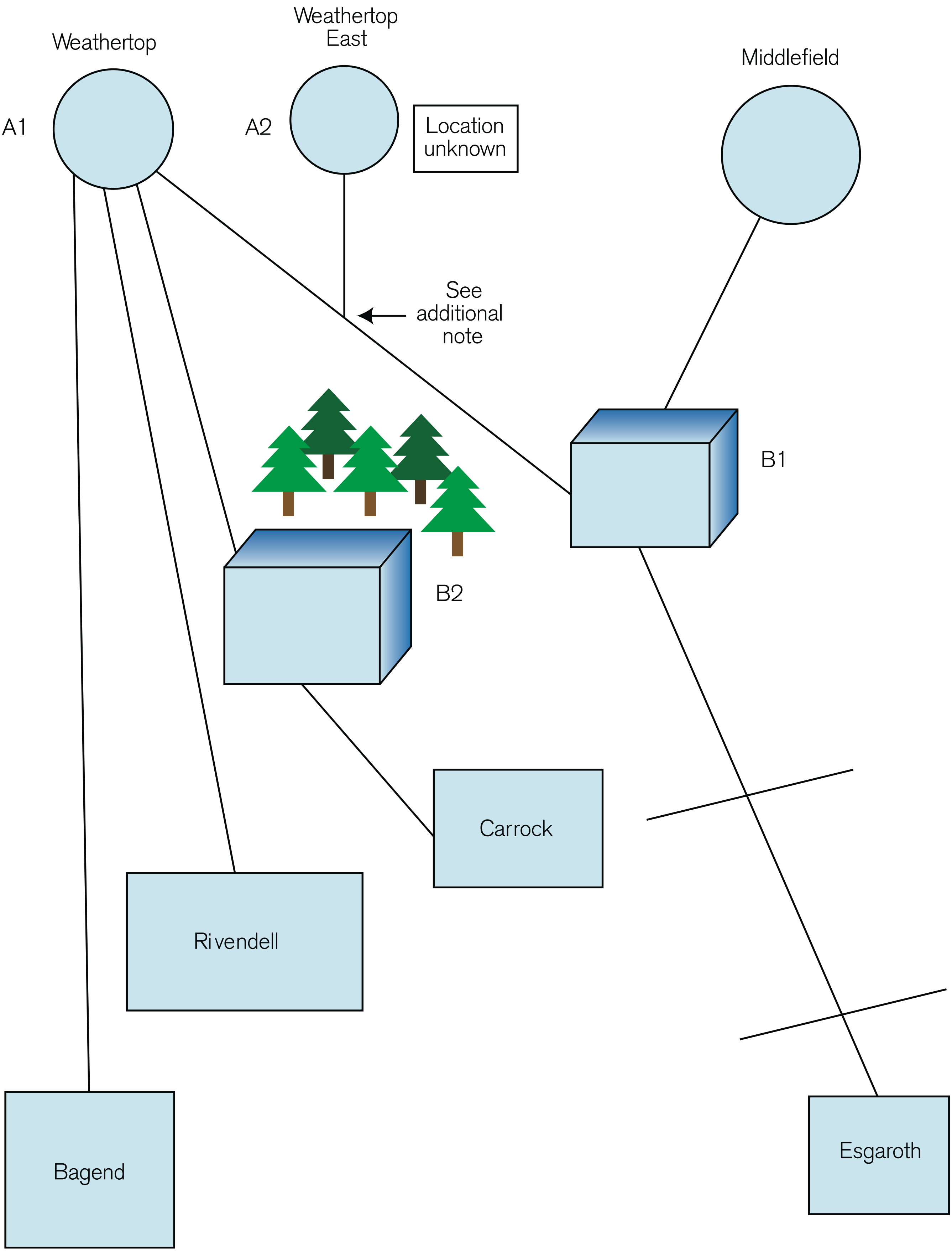
The supply was originally part of an estate supply and currently supplies some 19 properties with a population of 41. The supply has three sources which have previously been classified as springs and has a brick build storage tank serving part of the network. The network extends to around four miles in extent although the actual distance of pipe work is unknown. The catchment area has extensive agriculture with livestock (cattle and sheep) and some mixed forestry. There is no clear responsibility for the maintenance of the sources and for one of the sources, while its existence is known, the precise location of the source has not been found.

The names of the locations used in this case study have been altered to preserve the anonymity of the supply.

An examination of the site of the two known sources suggested that while they had been originally classified as springs the site (A1) was closer to a well in terms of its construction and collection of water while site A3 was closer to a surface abstraction. Risk assessments were undertaken at each of the two sources that could be located.

Figure 5.7 is a diagram of the supply with Annexes 5.2 and 5.3 providing the risk assessments for the two known sources.

Figure 5.7 Case Study 2: Perthshire Estate Supply



If we first consider the source A1 (Weathertop) for the general site survey the assessed risks arose from the following (see also Annex 5.2).

The source collection chamber was located in an area of boggy ground. Due to the waterlogged nature of the ground and the construction of the source it was unlikely that this was a spring supply. Springs may well be feeding the boggy ground but the source had not tapped directly into the source of the spring and so any water collected was under the influence of the surface/soil water. For this reason the source was assessed as a surface water source. The boggy conditions were almost certainly a permanent feature in all but the driest of conditions.

Figure 5.8 General situation encountered at source A1 (Weathertop)

Question 23 was scored as Yes – risk characterisation High – as there was evidence of the surrounding catchment being used for livestock production on a year-round basis. The hazard assessment likelihood score was 16 giving an overall score of 256.

Figure 5.9 Evidence of faecal material deposited on top of collection tank at site A1

Question 24 was scored as Yes – risk characterisation Moderate – as there was evidence of wildlife in the area. As this was almost certainly a permanent feature the hazard assessment likelihood score was 16 giving an overall score of 64.

Question 25 was scored as Yes – risk characterisation High – as the source collection structure was down-slope of an area where agri-chemicals and other materials were being stored. The materials appeared to have been present for a long period of time and so the hazard assessment likelihood score was 16 giving an overall score of 128.

Question 32 was scored as Yes – risk characterisation High – for the reasons given in response to question 25. Again the hazard assessment likelihood score was 16 giving an overall score of 128.

Figure 5.10 Agri-chemical storage upslope of collection system and boggy ground. Waste disposal/waste storage area is behind this area

For the supply survey at location A1 (Weathertop) the assessed risks arose from the following:

Question 40 was scored Yes – risk characterisation High – as the tank (B2 Figure 5.11), which was located in a wood, had inadequate protection around it. The hazard assessment likelihood score was scored as permanent (16) with an overall score of 128.

Question 43 was scored as Yes – risk characterisation High – as there had been no maintenance undertaken on the system in the previous 12 months. The hazard assessment likelihood score was scored as permanent (16) with an overall score of 128.

Figure 5.11 Tank B2 located in wooded area with inadequate protection

Questions 44 - 47 were not relevant to the situation encountered and so were left blank. As a result of the risk characterisation not being relevant the hazard assessment for these questions did not have to be completed.

Question 48 was scored as Don't Know – risk characterisation High. As the relevant person was not present during the investigation of the site the precise details could not be ascertained at the time of the visit. It would be perfectly acceptable to score on the basis described but to follow-up with either a telephone call or further visit to try and secure a definitive answer to the question. The hazard assessment was assessed on the basis of there being some influence on the collection system from surface flows resulting in a change in the flow into the system. The hazard assessment likelihood score was considered to be moderately likely (4) resulting in an overall hazard assessment score of 16.

Question 49 was scored as Don't Know – risk characterisation High. This is a similar situation to that described for Question 48 above and similar processes were applied to arriving at the final hazard score of 32.

Figure 5.12 General catchment area immediately adjacent to source A1 (Weathertop)

We can now turn to the second identified source (A3 Middlefield in Figure 5.13). Annex 5.3 has further details. The source was considered to be a surface abstraction.

Figure 5.13 General Location of Source A3 Middlefield

Question 23 was scored as Yes – risk characterisation High – as the source was immediately adjacent to fields containing cattle and sheep. The fields were utilised for livestock production on a continuous basis and so the hazard assessment likelihood score was permanent (16) with an overall score of 256.

Question 24 was scored as Yes – risk characterisation Moderate – as there was evidence of wildlife activity in the vicinity of the abstraction point. The hazard assessment likelihood score was considered to be permanent (16) with an overall score of 64.

Question 25 was scored as Yes – risk characterisation High – as the abstraction point was down-slope from areas of livestock production. The hazard assessment likelihood score was considered to be permanent (16) with an overall score of 128.

Question 30 was scored as Yes – risk characterisation Moderate – as the abstraction point was adjacent to wooded areas populated with mostly broadleaf trees. The hazard assessment likelihood score was considered to be permanent (16) with an overall score of 64.

Question 41 was scored as Yes – risk characterisation High – as the tank was not secure against vermin and, despite having had substantial remedial works undertaken, was in a poor state of repair. There was also evidence that the inside of the tank had been coated with a bitumen paint which was totally inappropriate for such a use. The hazard assessment likelihood score was considered to be permanent (16) with an overall score of 128.

Figure 5.14 Tank B2 showing inappropriate bitumen paint used in internal tank repairs

Question 43 was scored as Yes – risk characterisation High – as there had been no record of the distribution system (pipes) being disinfected. The hazard assessment likelihood score was considered to be permanent (16) with an overall score of 128.

Questions 44 – 49 were not relevant to the situation and so were left blank.

An additional note (See Figure 5.15) was also made concerning the state of the chamber where the lines from source A1 and A2 join. This was of poor construction with no effective protection against livestock, wildlife or inundation from rainfall/overland flow (flooding). The chamber was down-slope from an agricultural field with evidence of run off coming from the field near to the chamber. This additional evidence would also be considered to be a High Risk component of the system.

Figure 5.15 Chamber where pipework from sources A1 and A2 are considered to join

The overall risk assigned to the whole estate supply was High Risk based on the two source surveys undertaken at sites A1 and A3.

Figure 5.16 Tank B2 showing poor external condition and structural repairs

5.4 Case Study 3 – Knuttmound Estate Supply, West Perthshire

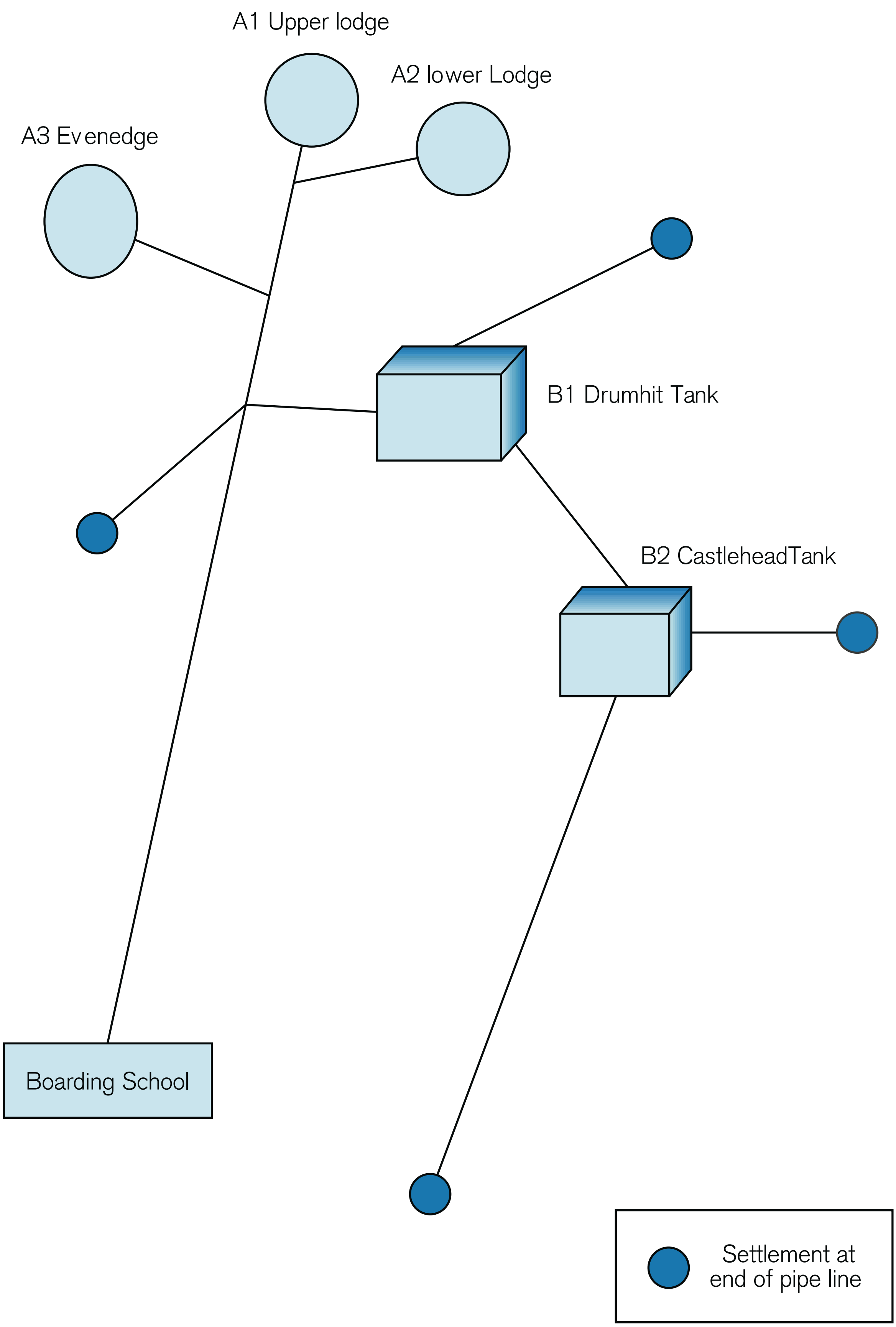
The supply for the Knuttmound Estate serves 68 domestic properties as well as two hotels and a boarding school with an estimated population for the domestic properties of around 180. The total occupancy capacity for the two hotels and the school was uncertain at the time of the risk assessment. The situation is further complicated by the fact that the school has recently changed its main source of water to the mains supply but has retained the connection to the private water supply to enable the school authorities to reduce their metered water bill should the need arise.

The supply is drawn from four sources, one of which is under the control of the school but details as to whether this particular source has been retained within the overall supply system were contradictory and will require further investigation. The remaining three sources were assessed individually with the overall results applicable for the supply as a whole.

The pipework for the distribution network is mainly asbestos cement. There is a chlorination system which treats part of the network and the boarding school and some individual properties have point of entry/point of use treatment systems based around UV.

Figure 5.17 is a diagram showing the supply as it was understood at the time of the risk assessment.

Figure 5.17 Knuttmound Estate Supply, Perthshire



We first consider the risk assessment for the source A1 (Upper Lodge). The risk assessment is provided in Annex 5.4. The source had originally been identified from historic records as a spring but examination at the site revealed that extensive modifications at the source had been undertaken with a well sunk into an area of boggy ground and extensive field drains laid to feed water into the collection point (i.e. the well structure). Having considered this evidence at the site the source was scored using the well risk assessment form.

Figure 5.18 Site A1 Upper Lodge

General Site Survey

Question 23 – the risk characterisation was assessed as High as there was evidence of poor drainage and stagnant surface water. The well had been constructed by excavating a hole and inserting concrete rings to form the well structure. The area around the outside of these concrete rings had been backfilled with gravel which also formed the basis of drainage channels radiating out from the well. The area around the well away from the gravel backfill was extremely boggy as evidenced by standing pools of water and also the vegetation types in the vicinity. The hazard assessment considered these conditions to be permanent and so the likelihood score was 16 with the overall score as 128.

Figure 5.19 Well structure and boggy ground around source A1

Question 24 – the risk characterisation was High and the hazard assessment likelihood score of 16 was based on permanent presence of livestock in the vicinity resulting in an overall score of 256.

Question 25 – the risk characterisation was Medium and the hazard assessment likelihood score of 16 was based on permanent presence of wildlife in the vicinity resulting in an overall score of 64.

Question 32 – the absence of the relevant person resulted in the response being Don’t Know, resulting in a risk characterisation of High. The hazard assessment was scored as moderately likely as the recent work undertaken at the site would suggest that some workers would be aware of the presence of the source. This resulted in an overall hazard assessment of 16.

Figure 5.20

Evidence of sheep (cast wool) at well

Sheep near well (upslope)

Supply Survey

Question 42 – (lack of fence) - risk characterisation was High with the likelihood being assessed as permanent giving an overall hazard assessment score of 128.

Question 43 – (no cut-off ditch) - risk characterisation was High with the likelihood being assessed as permanent giving an overall hazard assessment score of 256.

Question 44 – (no concrete apron) - risk characterisation was High with the likelihood being assessed as permanent giving an overall hazard assessment score of 128.

Question 45 – risk characterisation was Low as the top of the well was 150mm above the surface of the ground. While this was not a concrete apron, the height would be appropriate if a concrete apron were to be retrofitted at the site. So it was considered inappropriate to draw specific attention to this aspect when the other deficiencies concerning the well construction were dealt with in other parts of the risk assessment.

Question 46 – (lack of appropriate cover) - risk characterisation was High with the likelihood being assessed as permanent giving an overall hazard assessment score of 256.

Figure 5.21

Figure 5.22

Evidence of presence of sheep on top of well cover – cast wool

Question 49 and questions 52 – 55 were not appropriate to the situation at source A1 and so were not completed. This highlights why the comparison between supplies is not as simple as comparing the scores – a poor supply where questions can be answered may not score as badly as a good supply where many questions are left unanswered. The purpose of the scores is to identify issues within the supply being examined, not to rank supplies against each other.

Questions 50 and 51 could not be answered in the absence of the relevant person and so were scored as High Risk due to this lack of knowledge. The hazard assessment was scored on the basis of the risk being present resulting in scores of 64 and 128 respectively.

Similarly Questions 56 and 57 could not be answered in the absence of the relevant person and so were scored as High Risk due to this lack of knowledge. The hazard assessment was scored on the basis of the risk being present resulting in scores of 16 and 32 respectively.

The soil leaching risk survey relied upon identifying the source type and location. The soil leaching potential is important as this will determine if soil type has a part to play in source protection. In this case study the source type was a well and the soil leaching has a significant role to play in source protection. From the grid reference for the source it was determined that the soil leaching potential for the source was High1 giving a soil leaching risk potential of High.

The overall risk for the source A1 was HIGH.

If we now consider the risk assessment for source A2 (Lower Lodge) the access to the site was severely restricted due to a deer fence and very steep slope. As access was not available at the time of the risk assessment the source was unclassified and so source A2 was designated as High Risk. A full risk assessment for the source A2 was not undertaken.

Figure 5.23 Source A2 Lower Lodge

Source A3 (Evenedge) is located in an area of boggy ground. The source was historically identified as a spring source. While the boggy area may be being fed by water flowing from the ground the collection tank location and construction made it unlikely that the spring was being tapped at source i.e. within the rock formation. The boggy area may well be a seepage area with any water being collected from this area not being a spring water. When the water emerges from the rock formations into the seepage area the water will then be liable to contamination from the surface. For this reason the collection system as source A3 was scored as a surface water (Annex 5.5). Figure 5.24 gives more details on seepage areas and springs.

Water will flow from an unconfined aquifer wherever the water table intersects the ground surface. Where the flow from an aquifer is diffuse it is termed a seepage; where it is localised, as for example along a fault or fissure, it is called a spring (after Price, 1996).

Figure 5.24 Seepage areas and springs

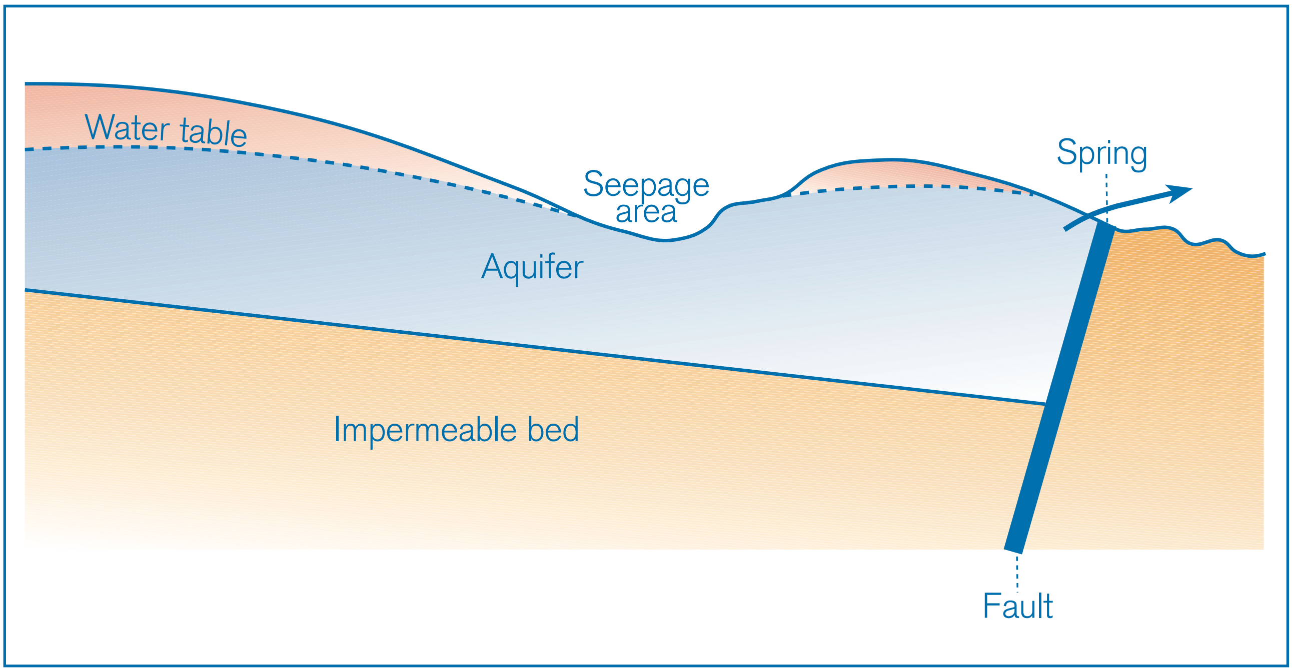


Figure 5.25 Source A3 Evenedge

The general site survey at source A3 risk assessment resulted in the following issues being highlighted:

Question 24 was scored as Yes – risk characterisation Moderate – as the presence of wildlife at the source was highly probable. The hazard assessment likelihood was almost certain (value 16) resulting in an overall score of 64.

Question 31 could not be accurately answered as the relevant person was not present during the risk assessment process. The risk characterisation was therefore High with the hazard assessment being scored on the assumption that agricultural workers did not know there was a supply in the area resulting in a likelihood score of 16 and an overall score of 64.

Question 34 was scored as Don't Know as there was a habitation above the abstraction site which may have had a septic tank. The Don't Know rating would suggest the need for further investigations into this matter. The hazard assessment was undertaken on the assumption that there was unsewered human sanitation in the vicinity on a permanent basis (value 16) giving an overall hazard assessment score of 256.

Question 39 was assessed as Yes – risk characterisation High – as the abstraction site was surrounded by arable crops which could be subjected to pesticide application which may directly (from run off) or indirectly (from wind drift) enter the source area and hence the supply. The likelihood was judged as being Likely and scored at 8. While such applications will not generally occur on a weekly basis, the higher score was used to ensure that the overall hazard assessment score reached above the intervention level provided in guidance. This issue links to Question 31 and with both Question 31 and 39 scoring at 64, the scores will ensure that appropriate attention and awareness is achieved from agricultural workers in relation to the location of the source and appropriate activities to be undertaken near it.

Figure 5.26

Overflow pipe at source A3

The supply survey at source A3 resulted in the following:

Question 40 – based on the historic information concerning the supply this was scored as Yes – risk characterisation High – as records suggested the use of asbestos cement pipes within the distribution network.

Question 41 – the intermediate tank B1 (at Drumhit) also functioned as a chlorination point for part of the system. The tank was not adequately protected from ingress of vermin or from flooding. The tank was located in an area beside a farm yard where cattle and sheep were moved and beside a field in which livestock were grazed. This resulted in the risk characterisation being scored as Yes – High – and the likelihood score as 16 with an overall hazard assessment score of 128.

Question 42 – from the information available an accurate assessment could not be made and so the risk characterisation was scored as Don’t Know – High – with the hazard assessment being assessed on the basis of junctions with no back-siphonage protection being present as a permanent feature of the system – likelihood value 16 overall score 128.

Questions 48 and 49 could not be accurately assessed and so were scored as Don’t Know (high risk) with the likelihood scores being rated at 4 for both questions resulting in respective hazard assessment scores of 16 and 32.

Figure 5.27 Tank B1 Drumhit

Tank B1

Chlorine reserve at Tank B1

Figure 5.28 Tank at B1 (Drumhit)

Chlorinator at Tank B1

There were three other issues potentially affecting the quality of water being provided by the system which were noted as additional items:

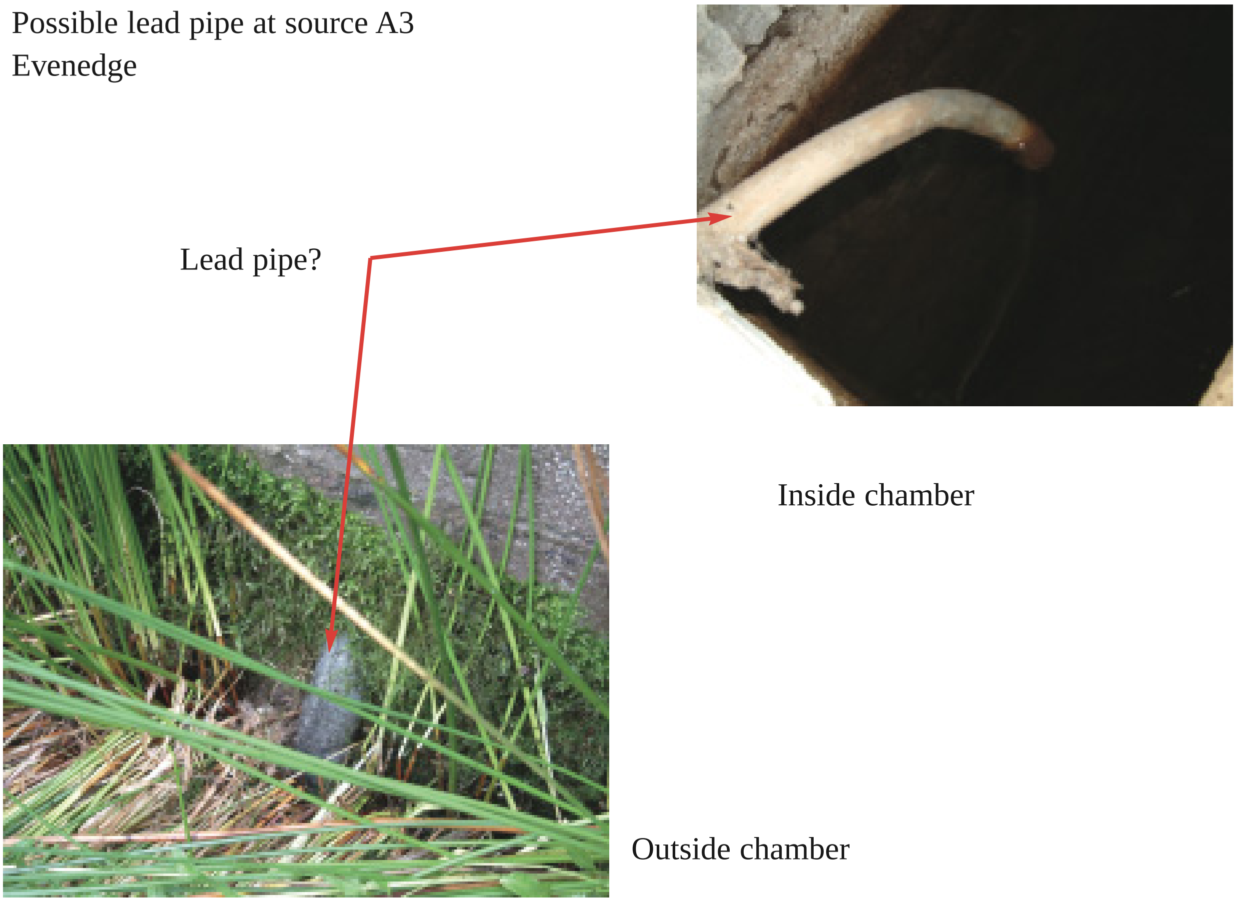
(a) lead pipe – at source A3 (Evenedge) there was evidence that at least part of the system was plumbed using lead pipe. This should be brought to the attention of the relevant person and appropriate sampling undertaken to determine whether the lead levels exceed the Regulatory limits.

(b) at source A3 (Evenedge) the surface supply risk assessment does not cover the security of the site in terms of fences, etc. As the site does not easily fit into the pro formas and the surface supply was the most appropriate in terms of the likely source of the water, the additional items relating to the security of the site and the chamber should also be considered. There was no stock proof fence, no cut-off ditch and the chamber was not vermin-proof. These issues should all be added to the final communication to the relevant person when communicating the results of the investigation and suggested actions for improving the integrity of the supply.

(c) at Tank B1 (Drumhit) a second tank was found adjacent to the operational tank B1. This will require further investigation to determine if it is still used or if it has been properly disconnected from the supply. If it has not been properly disconnected to prevent any material contained in it entering the supply then it will pose a serious risk to the integrity of the system.

Figure 5.29

Possible lead pipe at source A3
Evenedge



5.5 Case Study 4 – Waterbottom Borehole near Peebles, Scotland

The borehole feeds 3 properties (approximately 10 people) in close proximity to the borehole site itself. Annex 5.6 provides the risk assessment details for this supply.

The borehole was constructed in 1995. It was drilled to a total depth of 19.0 metres and the depth of overburden was 9.0 metres. The depth to groundwater was 6.0 metres which was found to rise overnight to 3.05 metres below ground level. The borehole was lined with 90 x 80mm diameter A.B.S. well casing from ground level to 6.75m and 6.75 to 19.0m with 90 x 80mm diameter well screen through the overburden and the unstable rock formations (see Figure 5.30).

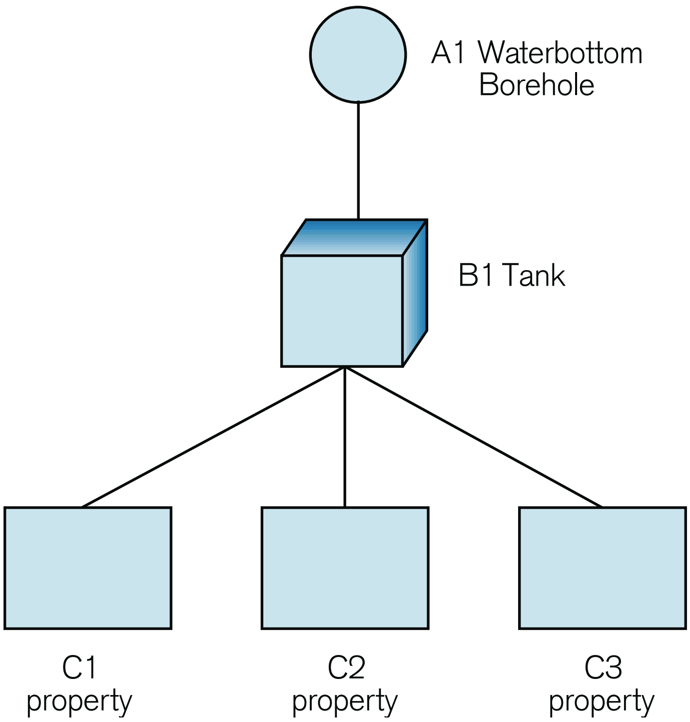
Figure 5.30 Waterbottom Borehole drill log

Project:-	Drilling Method & Site
	Rotary Open Hole 150/108
Client:-	Co-ordinates:- East / North
	Orientation:- Vertical
	Date:-

Ground Meter Levels	Samples Type	Samples Depth	In-situ Testing SPT CPT	RQD	TCR	SCR	DESCRIPTION OF STRATA		Ord. Datum Level mOD	SYMBOLIC LEGEND
M		M	Blows	%	%	%	Ground Level mOD	Depth		
							Topsoil	0.2	-0.20	
							Medium Dense Brown Silty Sandy Gravel	3.0	-3.0	
							Firm Greenish Brown Clayey Very Sandy Silt	6.0	-6.0	
							Medium Dense Brown Silty Sandy Gravel	9.0	-9.0	
							Highly Fractured (Unstable) Greywacke Sandstone	19.0	-19.0	

	Remarks:-	BOREHOLE No 1

Figure 5.31 Waterbottom Supply diagram



The general site survey identified only one item affecting the integrity of the supply.

Question 40 – there was evidence of recent application of herbicide around and over the top of the borehole head works. This activity resulted in the risk characterisation being scored as Yes – High risk. The likelihood of such applications being repeated was judged to be likely (value 8) giving an overall hazard assessment score of 64.

The supply survey element of the risk assessment identified the following issues:

Question 45 – there was no cut-off ditch or other protection to prevent surface flow (flood) conditions breaching the below-ground borehole headworks. The risk characterisation was therefore scored as Yes – High risk. As the situation would remain permanent until such time as remedial works were undertaken the likelihood score was evaluated as permanent (16) giving an overall hazard assessment score of 256.

Question 46 – the top of the chamber was not raised above the ground level. This resulted in the risk characterisation being scored as Yes – High risk and the likelihood value as permanent (16) giving an overall hazard assessment score of 256.

Question 52 – no maintenance had been undertaken on the system during the previous 12 months. The risk characterisation score was therefore Yes – High Risk with the likelihood of such action having not been taken as permanent (value 16) giving an overall hazard assessment score of 128.

Additional comments recorded were that the cover on the borehole chamber be fitted with a lock. The present arrangement, while difficult to effect removal of the cover, does not secure the cover adequately.

Figure 5.32 Waterbottom Borehole

5.6 Case Study 5 – Border Estate Supply

The supply is part of a former estate supply system and is extensive in nature. The supply serves a residential health care facility (population around 50) as well as a number of houses and a school. The population is over 100 (Type A2). Historical records suggested that the supply was drawn from an extensive area of springs and had been classified as a spring supply. The surface water risk assessment has been utilised as the site investigations revealed that all the “spring” sources were under, or potentially under, the influence of surface flows suggesting that surface water risks were the most appropriate to consider.

Figure 5.33 is a diagram showing the supply as found during the investigations. Annex 5.7 provides details of the risk assessment.

Figure 5.33 Border Estate Supply

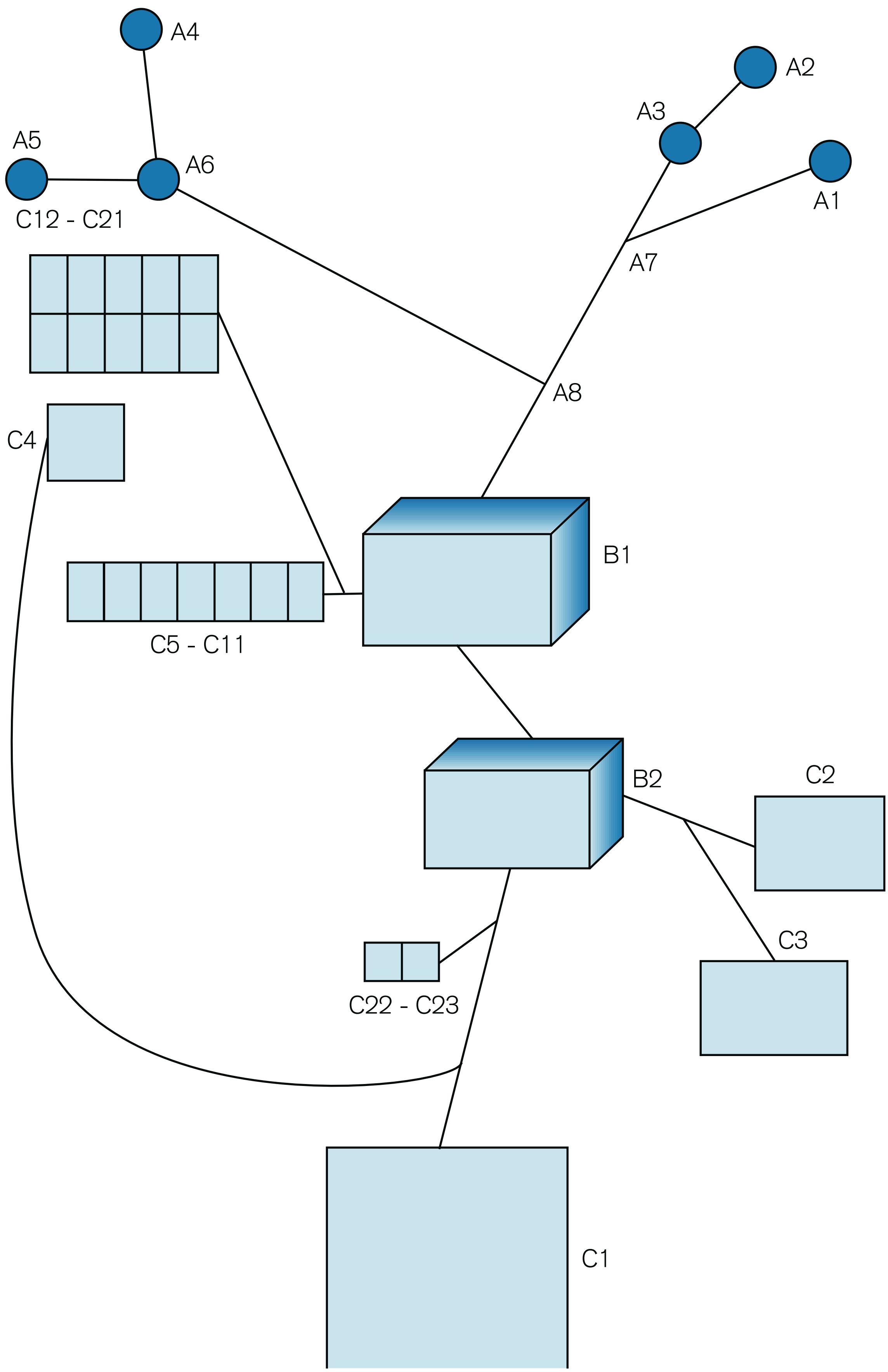
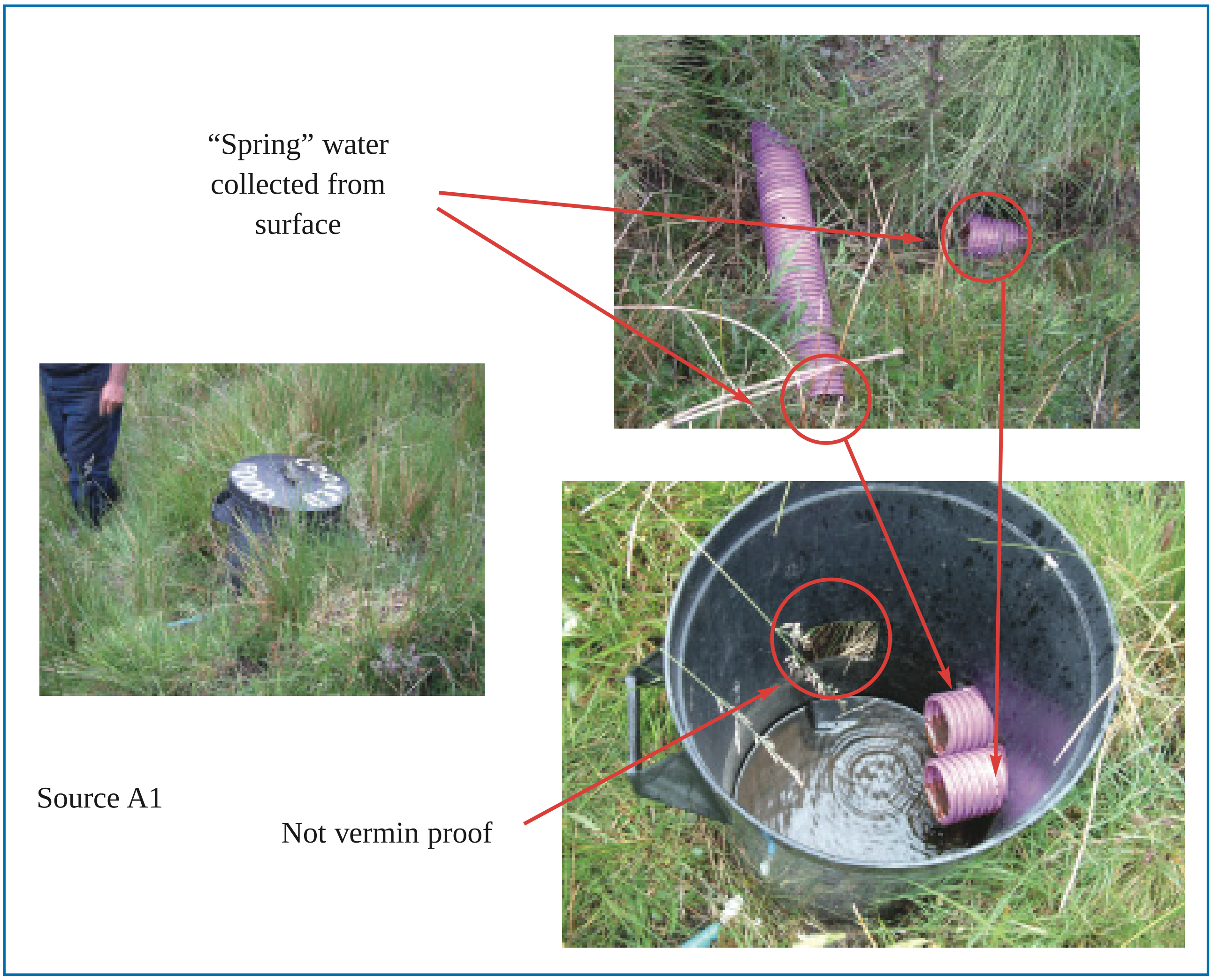


Figure 5.34 Source A1



The sources A1 – A6 were all of a similar nature – springs issuing from the hillside with a collection chamber either down-slope of the point where the spring emerged or within the soil horizon. None of the chambers were constructed so that they were within the rock matrix and therefore capturing the groundwater *in situ*. This meant that all the "springs" were capable of being under surface influence and so were scored as surface water. Further, given the common nature of the systems a single assessment was appropriate to cover the six separate collection areas.

Figures 5.34 – 5.38 provide evidence of the general condition of the sources and the intermediate collection tanks which also act as additional collection points. In general, while the groundwater risk assessment is appropriate, the additional comments section of the form would also be used to note that where there are structures present they are not water or vermin-proof and therefore allow additional points of entry for material best kept out of the drinking water supply.

Figure 5.35

Source A2

Figure 5.36

Source A5

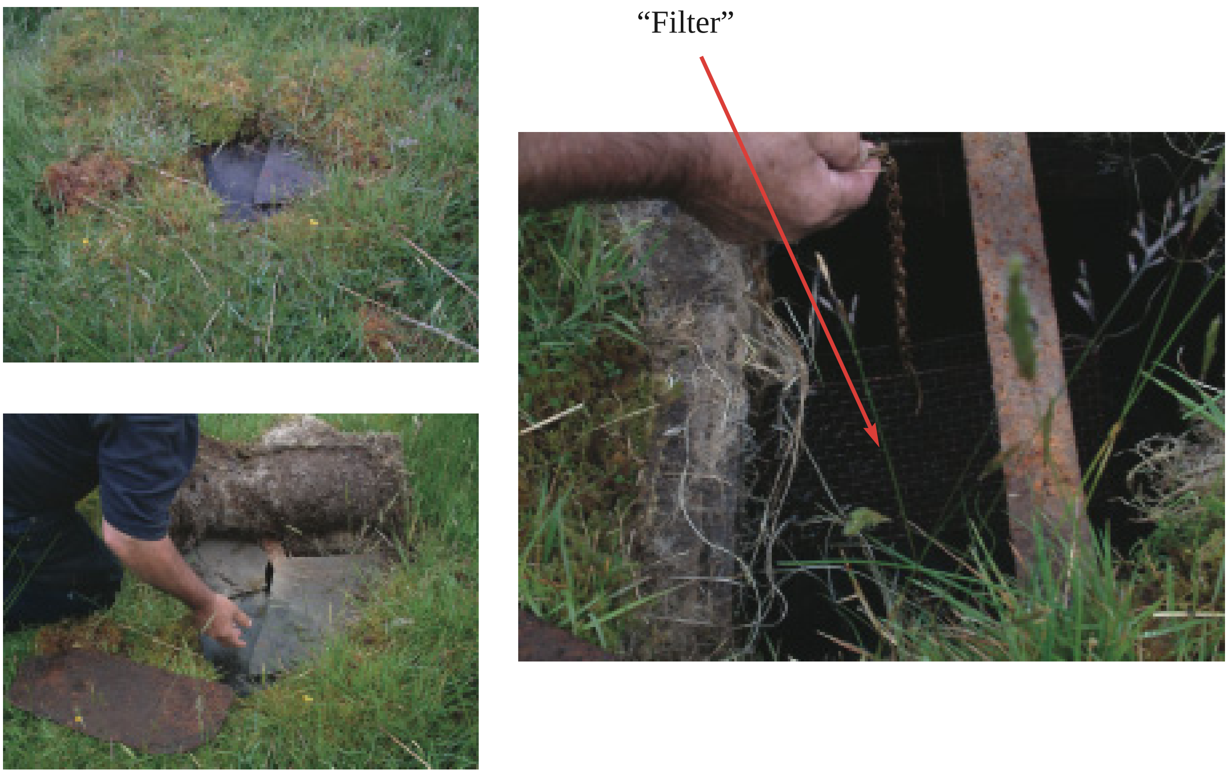
Figure 5.37

Source A6

Figure 5.38

A7 – intermediate collection/storage tank

Figure 5.39



A8 – intermediate storage and collection tank

For the general site survey risk characterisation for Question 23 – history of livestock production - was scored as “Yes” (High Risk). While no livestock were found at the time of the investigation there was ample evidence of their presence in the area. The hazard assessment likelihood score was therefore likely (8) with an overall hazard assessment score of 128.

Question 24 was also scored as high risk and the likelihood score was almost certain (16) giving an overall hazard assessment score of 64. Figure 38 provides evidence of deer in the catchment although evidence of rabbits was also found.

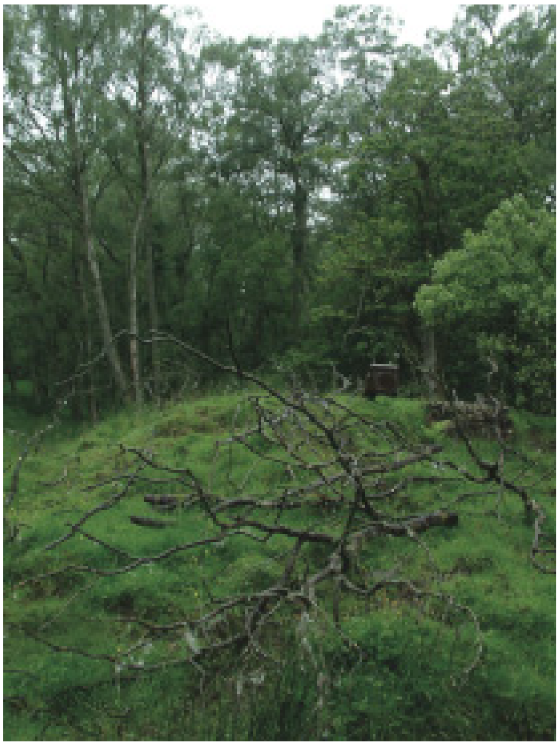
There was evidence of extensive forestry activity in the catchment and so Question 30 was scored accordingly – risk characterisation Moderate; hazard assessment likelihood permanent (16), overall hazard assessment score 64.

The overall risk assessment for the general site survey was High.

Figure 5.40 “Scrape” in catchment

Following discussion with the relevant person the supply survey Question 40 was answered as Yes (High Risk) as there were parts of the supply network that were liable to fracture. The likelihood score was judged to be moderate (4) giving an overall hazard assessment score of 32.

Figure 5.41 Intermediate Tank B1



Intermediate tank B1

The risk characterisation for Question 41 was High – intermediate tank B1 (Figure 39) was in a very poor state of repair and the local landowner actively used the top of the tank as winder grazing for sheep; intermediate tank B2 (Figure 40) was in a similar poor state of repair with sheep evidently using the tank for grazing as their wool had been caught on the ineffective fence surrounding the structure. Neither were vermin-proof nor were they capable of stopping the ingress of water through the structure. For these reasons the hazard assessment was almost certain (16) giving an overall hazard assessment score of 128.

Both Questions 48 and 49 were assessed as High risk as there was evidence from the relevant person that significant changes were seen in both the flow of water and the appearance of the water throughout the year. These facts would lend further weight towards the view that the sources are under surface flow influence – true groundwater springs would not display such changes. The likelihood for each was almost certain (16) and so the overall hazard assessment scores were 64 and 128 respectively.

The risk score for the supply survey was High and so the overall risk score for the supply was also High.

Figure 5.42

Intermediate tank B2

5.7 Case Study 6 – Rooster Cottage/Farm Borehole

The supply to Rooster Cottage and Rooster Farm comes from a borehole supply. The population served is four. Figure 5.43 shoes the layout of the supply. Annex 5.8 provides the details of the risk assessment.

The borehole has the head works located below ground and so section D of the risk assessment form was the appropriate section to be completed. The general site survey was completed and the responsible person for Rooster Cottage was able to inform the investigation team that the borehole location was affected by poor drainage. Question 23 was assessed as having a risk characterisation of High with a hazard assessment likelihood of unlikely (once per year) scored 2 giving an overall hazard assessment score of 16.

Question 26 was also assessed as high risk due to the immediate location of arable cultivation, with a hazard assessment likelihood of unlikely (once per year) scored 2 giving an overall hazard assessment score of 16.

Figure 5.43 Rooster Cottage/Rooster Farm Borehole

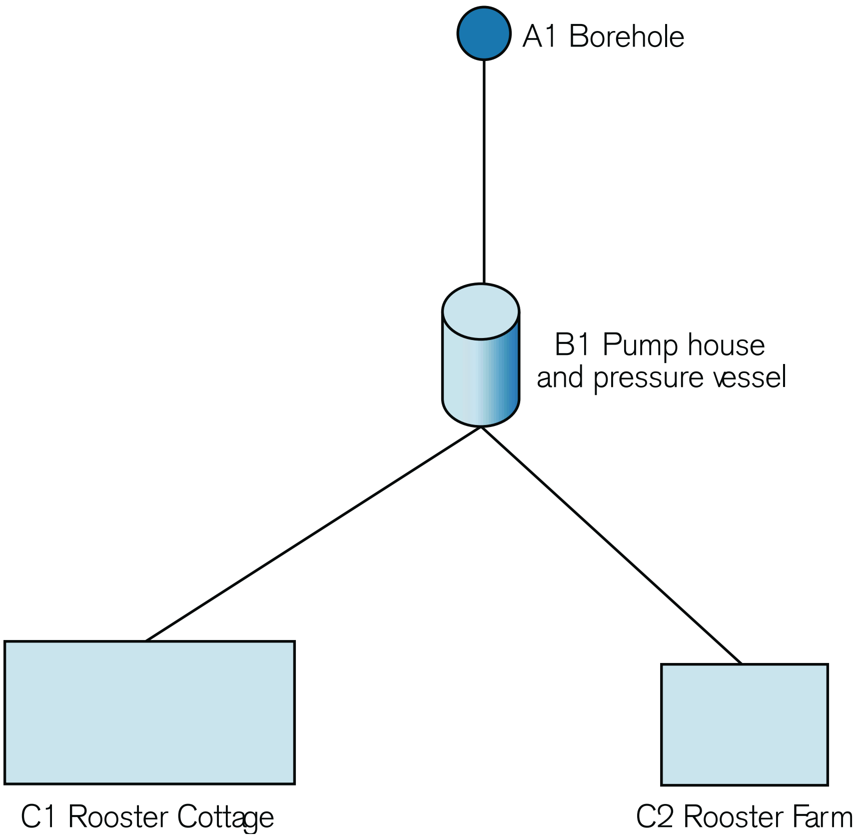


Figure 5.44

The responsible person for Rooster Cottage was unable to comment on the location of septic tanks or where sewerage pipes run and so Questions 35 and 36 had a risk characterisation of Don't Know (High) with a hazard assessment likelihood of almost certain (16) for both questions giving an overall hazard assessment score of 256 and 128 respectively.

Due to the very close location of arable crops and no attempt to ensure an adequate separation from the borehole the risk that pesticides or other materials may sprayed or applied to the field could enter the borehole is high and so the risk characterisation is High with the hazard assessment likelihood being moderately likely (4) with an overall score of 32.

The risk of the borehole head works being inundated with flood water from a nearby burn had resulted in the height of the chamber walls being raised. The work had not, however, included the installation of a ditch to divert flow away from the chamber in the event of more floods. The supply survey identified this deficiency in Question 45 – risk characterisation High; hazard assessment likelihood 16 with an overall hazard assessment score of 256.

The responsible person who was assisting the investigation did not know what materials were used for the pipe work and so question 49 was scored as Don't Know – Risk characterisation High; Hazard assessment likelihood 16 with an overall score of 128.

Discussion with the responsible person suggested that there had been no maintenance on the system in the previous 12 months. Question 52 was scored accordingly with the risk characterisation being scored as High; hazard assessment likelihood unlikely (2) with an overall hazard assessment score of 16.

Figure 5.45

B1 pump house and pressure vessel for Rooster supply

5.8 References

Introducing Groundwater, 2nd Edition 1996. Michael Price. Chapman & Hall, London, Weinheim, New York, Tokyo, Melbourne, Madras. ISBN 0412485001.

This page is intentionally blank

ANNEXES

Annex 5.1 Case Study 1 Risk Assessment (part only) SURFACE SUPPLY

D (i) General site survey

Are any of the following known to be present and likely to influence water quality at the source?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
23	History of livestock production (rearing, housing, grazing) – including poultry	H	L	H	16	16	256
24	Evidence of wildlife	M	L	M	16	4	64
25	Surface run-off from agricultural activity diverted to flow into the source/supply	H	L	H	-	8	-
26	Soil cultivation with wastewater irrigation or sludge / slurry/ manure application	H	L	H	-	16	-
27	Disposal of organic wastes to land	H	L	H	-	8	-
28	Farm wastes and/or silage stored on the ground (not in tanks or containers)	M	L	M	-	8	-
29	Remediation of land using sludge or slurry	H	L	H	-	16	-
30	Forestry activity	M	L	M	16	4	64
31	Awareness of the presence of drinking water supply/source by agricultural workers	L	H	H	-	4	-
32	Waste disposal sites (including scrap yard, car yard, rubbish and hazardous waste disposal, landfill or incinerator including on-farm incineration)	H	L	H	-	8	-
33	Disposal sites for animal remains	H	L	H	-	8	-
34	Unsewered human sanitation including septic tanks, pit latrines, soakaways	H	L	H	-	16	-
35	Sewerage pipes, mains or domestic (e.g. leading to / from septic tank)	H	L	H	-	8	-
36	Sewage effluent lagoons	H	L	H	-	16	-
37	Sewage effluent discharge to adjacent watercourse (where present)	H	L	H	-	16	-
38	Evidence of use of pesticides (including sheep dip) near source	H	L	H	-	8	-
39	Evidence of industrial activity likely to present a contamination threat	H	L	H	-	8	-

D (ii) Supply survey

Are any of the following known to occur at the head works site or in relation to the supply?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
40	Supply network constructed from material liable to fracture, e.g. asbestos-concrete, clay, etc.?	H	L	H	16	8	128
41	Intermediate tanks (e.g. collection chambers, holding tanks, break-pressure tanks) are not adequately protected	H	L	H	16	8	128
42	Junctions present in the supply network, particularly supplying animal watering systems, have no back-siphon protection?	H	L	H	-	4	-
43	No maintenance (including chlorination) has been undertaken in the previous 12 months?	H	L	H	-	8	-
44	If present, header tank within the property (s) does not have a vermin-proof cover?	H	L	H	-	4	-
45	Header tank has not been cleaned in the last 12 months?	H	L	H	-	8	-
46	Any point of entry/point of use treatment equipment has not been serviced in accordance with the manufacturer's instructions in the last 12 months?	M	L	M	-	8	-
47	If present, ultraviolet (UV) lamps are not operating?	H	L	H	-	16	-
48	Is there a noticeable change in the level and flow of water throughout the year?	H	L	H	2	4	8
49	Is there a noticeable change in the appearance of the water (colour, turbidity – cloudiness) after heavy rainfall or snow melt?	H	L	H	2	8	16

D (iv) Overall risk assessment

(a) Risk characterisation

The overall risk assessment for the source is taken as the highest individual risk category identified from each of the two surveys.

The overall risk characterisation category will be recorded as the risk assessment score for the source.

Survey Section	Risk Characterisation Category
General Site Survey	HIGH
Source Survey	HIGH
Overall Risk	**HIGH**

(b) Hazard assessment

Individual components in each of the surveys with a hazard assessment score of 32 or greater should be considered as priority candidates for remedial works capable of reducing the overall risk characterisation category.

Annex 5.2 Perthshire Estate Supply Source A1 SURFACE SUPPLY

D (i) General site survey

Are any of the following known to be present and likely to influence water quality at the source?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
23	History of livestock production (rearing, housing, grazing) – including poultry	H	L	H	16	16	256
24	Evidence of wildlife	M	L	M	16	4	64
25	Surface run-off from agricultural activity diverted to flow into the source/supply	H	L	H	16	8	128
26	Soil cultivation with wastewater irrigation or sludge / slurry/ manure application	H	L	H	-	16	-
27	Disposal of organic wastes to land	H	L	H	-	8	-
28	Farm wastes and/or silage stored on the ground (not in tanks or containers)	M	L	M	-	8	-
29	Remediation of land using sludge or slurry	H	L	H	-	16	-
30	Forestry activity	M	L	M	16	4	64
31	Awareness of the presence of drinking water supply/source by agricultural workers	L	H	H	-	4	-
32	Waste disposal sites (including scrap yard, car yard, rubbish and hazardous waste disposal, landfill or incinerator including on-farm incineration)	H	L	H	16	8	128
33	Disposal sites for animal remains	H	L	H	-	8	-
34	Unsewered human sanitation including septic tanks, pit latrines, soakaways	H	L	H	-	16	-
35	Sewerage pipes, mains or domestic (e.g. leading to / from septic tank)	H	L	H	-	8	-
36	Sewage effluent lagoons	H	L	H	-	16	-
37	Sewage effluent discharge to adjacent watercourse (where present)	H	L	H	-	16	-
38	Evidence of use of pesticides (including sheep dip) near source	H	L	H	-	8	-
39	Evidence of industrial activity likely to present a contamination threat	H	L	H	-	8	-

D (ii) Supply survey

Are any of the following known to occur at the head works site or in relation to the supply?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
40	Supply network constructed from material liable to fracture, e.g. asbestos-concrete, clay, etc.?	H	L	H	-	8	-
41	Intermediate tanks (e.g. collection chambers, holding tanks, break-pressure tanks) are not adequately protected	H	L	H	16	8	128
42	Junctions present in the supply network, particularly supplying animal watering systems, have no back-siphon protection?	H	L	H	-	4	-
43	No maintenance (including chlorination) has been undertaken in the previous 12 months?	H	L	H	16	8	128
44	If present, header tank within the property (s) does not have a vermin-proof cover?	H	L	H	-	4	-
45	Header tank has not been cleaned in the last 12 months?	H	L	H	-	8	-
46	Any point of entry/point of use treatment equipment has not been serviced in accordance with the manufacturer's instructions in the last 12 months?	H	L	H	-	8	-
47	If present, ultraviolet (UV) lamps are not operating?	H	L	H	-	16	-
48	Is there a noticeable change in the level and flow of water throughout the year?	H	L	H	4	4	16
49	Is there a noticeable change in the appearance of the water (colour, turbidity – cloudiness) after heavy rainfall or snow melt?	H	L	H	4	8	32

D (iv) Overall risk assessment

(a) Risk characterisation

The overall risk assessment for the source is taken as the highest individual risk category identified from each of the two surveys.

The overall risk characterisation category will be recorded as the risk assessment score for the source.

Survey Section	Risk Characterisation Category
General Site Survey	HIGH
Source Survey	HIGH
Overall Risk	**HIGH**

(b) Hazard assessment

Individual components in each of the surveys with a hazard assessment score of 32 or greater should be considered as priority candidates for remedial works capable of reducing the overall risk characterisation category.

Annex 5.3 Perthshire Estate Supply Source A3 Surface Supply

D (i) General site survey

Are any of the following known to be present and likely to influence water quality at the source?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
23	History of livestock production (rearing, housing, grazing) – including poultry	H	L	H	16	16	256
24	Evidence of wildlife	M	L	M	16	4	64
25	Surface run-off from agricultural activity diverted to flow into the source/supply	H	L	H	16	8	128
26	Soil cultivation with wastewater irrigation or sludge / slurry/ manure application	H	L	H	-	16	-
27	Disposal of organic wastes to land	H	L	H	-	8	-
28	Farm wastes and/or silage stored on the ground (not in tanks or containers)	M	L	M	-	8	-
29	Remediation of land using sludge or slurry	H	L	H	-	16	-
30	Forestry activity	M	L	M	16	4	64
31	Awareness of the presence of drinking water supply/source by agricultural workers	L	H	H	-	4	-
32	Waste disposal sites (including scrap yard, car yard, rubbish and hazardous waste disposal, landfill or incinerator including on-farm incineration)	H	L	H	-	8	-
33	Disposal sites for animal remains	H	L	H	-	8	-
34	Unsewered human sanitation including septic tanks, pit latrines, soakaways	H	L	H	-	16	-
35	Sewerage pipes, mains or domestic (e.g. leading to / from septic tank)	H	L	H	-	8	-
36	Sewage effluent lagoons	H	L	H	-	16	-
37	Sewage effluent discharge to adjacent watercourse (where present)	H	L	H	-	16	-
38	Evidence of use of pesticides (including sheep dip) near source	H	L	H	-	8	-
39	Evidence of industrial activity likely to present a contamination threat	H	L	H	-	8	-

D (ii) Supply survey

Are any of the following known to occur at the head works site or in relation to the supply?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
40	Supply network constructed from material liable to fracture, e.g. asbestos-concrete, clay, etc.?	H	L	H	-	8	-
41	Intermediate tanks (e.g. collection chambers, holding tanks, break-pressure tanks) are not adequately protected	H	L	H	16	8	128
42	Junctions present in the supply network, particularly supplying animal watering systems, have no back-siphon protection?	H	L	H	-	4	-
43	No maintenance (including chlorination) has been undertaken in the previous 12 months?	H	L	H	16	8	128
44	If present, header tank within the property (s) does not have a vermin-proof cover?	H	L	H	-	4	-
45	Header tank has not been cleaned in the last 12 months?	H	L	H	-	8	-
46	Any point of entry/point of use treatment equipment has not been serviced in accordance with the manufacturer's instructions in the last 12 months?	M	L	M	-	8	-
47	If present, ultraviolet (UV) lamps are not operating?	H	L	H	-	16	-
48	Is there a noticeable change in the level and flow of water throughout the year?	H	L	H	-	4	-
49	Is there a noticeable change in the appearance of the water (colour, turbidity – cloudiness) after heavy rainfall or snow melt?	H	L	H	-	8	-

D (iv) Overall risk assessment

(a) Risk characterisation

The overall risk assessment for the source is taken as the highest individual risk category identified from each of the two surveys.

The overall risk characterisation category will be recorded as the risk assessment score for the source.

Survey Section	Risk Characterisation Category
General Site Survey	HIGH
Source Survey	HIGH
Overall Risk	**HIGH**

(b) Hazard assessment

Individual components in each of the surveys with a hazard assessment score of 32 or greater should be considered as priority candidates for remedial works capable of reducing the overall risk characterisation category.

Annex 5.4 Knuttmound Estate Source A1

D (i) General site survey

Are any of the following known to be present and likely to influence water quality at the source?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
23	Evidence or history of poor drainage causing stagnant / standing water	H	L	H	16	16	128
24	History of livestock production (rearing, housing, grazing) – including poultry	H	L	H	16	16	256
25	Evidence of wildlife	M	L	M	16	4	64
26	Surface run-off from agricultural activity diverted to flow into the source/supply	H	L	H	-	8	-
27	Soil cultivation with wastewater irrigation or sludge / slurry/ manure application	H	L	H	-	16	-
28	Disposal of organic wastes to land	H	L	H	-	8	-
29	Farm wastes and/or silage stored on the ground (not in tanks or containers)	M	L	M	-	8	-
30	Remediation of land using sludge or slurry	H	L	H	-	16	-
31	Forestry activity	M	L	M	-	4	-
32	Awareness of the presence of drinking water supply/source by agricultural workers	L	H	H	4	4	16
33	Waste disposal sites (including scrap yard, car yard, rubbish and hazardous waste disposal, landfill or incinerator including on-farm incineration)	H	L	H	-	8	-
34	Disposal sites for animal remains	H	L	H	-	8	-
35	Unsewered human sanitation including septic tanks, pit latrines, soakaways	H	L	H	-	16	-
36	Sewerage pipes, mains or domestic (e.g. leading to / from septic tank)	H	L	H	-	8	-
37	Sewage effluent lagoons	H	L	H	-	16	-
38	Sewage effluent discharge to adjacent watercourse (where present)	H	L	H	-	16	-
39	Supplies or wells not in current use	H	L	H	-	8	-
40	Evidence of use of pesticides (including sheep dip) near source	H	L	H	-	8	-
41	Evidence of industrial activity likely to present a contamination threat	H	L	H	-	8	-

D (ii) Supply survey

Are any of the following known to occur in relation to the supply (source, pipework and properties served)?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
42	No stock proof fence (to BS1722 or equivalent) at a minimum of 4 metres around the source?	H	L	H	16	8	128
43	No suitable barrier present to prevent ingress of surface flows into the well (e.g. cut-off ditch lined with impermeable material, steep incline/decline such as embankments, appropriate walls, etc.)	H	L	H	16	8	256
44	No concrete apron, a minimum of 1200mm, sloping away from the well and in good repair?	H	L	H	16	8	128
45	The top of the well not 150mm above the apron described in [44]?	H	L	H	-	16	-
46	No reinforced pre-cast concrete cover slab, or equivalent, in satisfactory condition with a watertight, vermin-proof inspection cover present to BS497 (lockable steel type or equivalent) with or without ventilation?	H	L	H	16	16	256
47	The well construction in an unsatisfactory state-of-repair?	H	L	H	-	8	-
48	Supply network constructed from material liable to fracture, e.g. asbestos-concrete, clay, etc.	H	L	H	16	8	128
49	Intermediate tanks (e.g. collection chambers, holding tanks, break-pressure tanks) are not adequately protected (i.e. do not have protection described in [42] to [45] above)?	H	L	H	-	8	-
48	Is there a noticeable change in the level and flow of water throughout the year?	H	L	H	2	4	8
50	Junctions present in the supply network, particularly supplying animal watering systems, have no back-siphon protection?	H	L	H	16	4	64
51	No maintenance (including chlorination) has been undertaken in the previous 12 months?	H	L	H	16	8	128
52	If present, header tank within the property (s) does not have a vermin-proof cover?	H	L	H	-	4	-
53	Header tank has not been cleaned in the last 12 months?	H	L	H	-	8	-
54	Any point of entry/point of use treatment equipment has not been serviced in accordance with the manufacturer's instructions in the last 12 months?	M	L	M	-	8	-
55	If present, ultraviolet (UV) lamps are not operating?	H	L	H	-	16	-
56	Is there a noticeable change in the level and flow of water throughout the year?	H	L	H	4	4	16
57	Is there a noticeable change in the appearance of the water (colour, turbidity – cloudiness) after heavy rainfall or snow melt?	H	L	H	4	8	32

D (iii) Soil leaching risk survey (see also Figure A4.1)

Using the NGR identified in [7] to determine and record below the soil leaching potential from the appropriate soil leaching potential map covering the geographic area of interest for location of the source.

National Grid Reference N / O / 0 / 1 / 8 / 0 / 1 / 8

Soil Leaching Risk Classification Assigned HIGH1

Risk Characterisation Score HIGH

Hazard Assessment Score 16

Table Soil leaching risk characterisation and hazard assessment scores

Soil Leaching Risk Classification	Risk Characterisation	Hazard Assessment
Low	Low	4
Intermediate 1	Moderate	8
Intermediate 2	Moderate	8
High 1	High	16
High 2	High	16
High 3	High	16
Built up	High	16

D (iv) Overall risk assessment

(a) Risk characterisation

The overall risk assessment for the source is taken as the highest individual risk category identified from each of the three surveys.

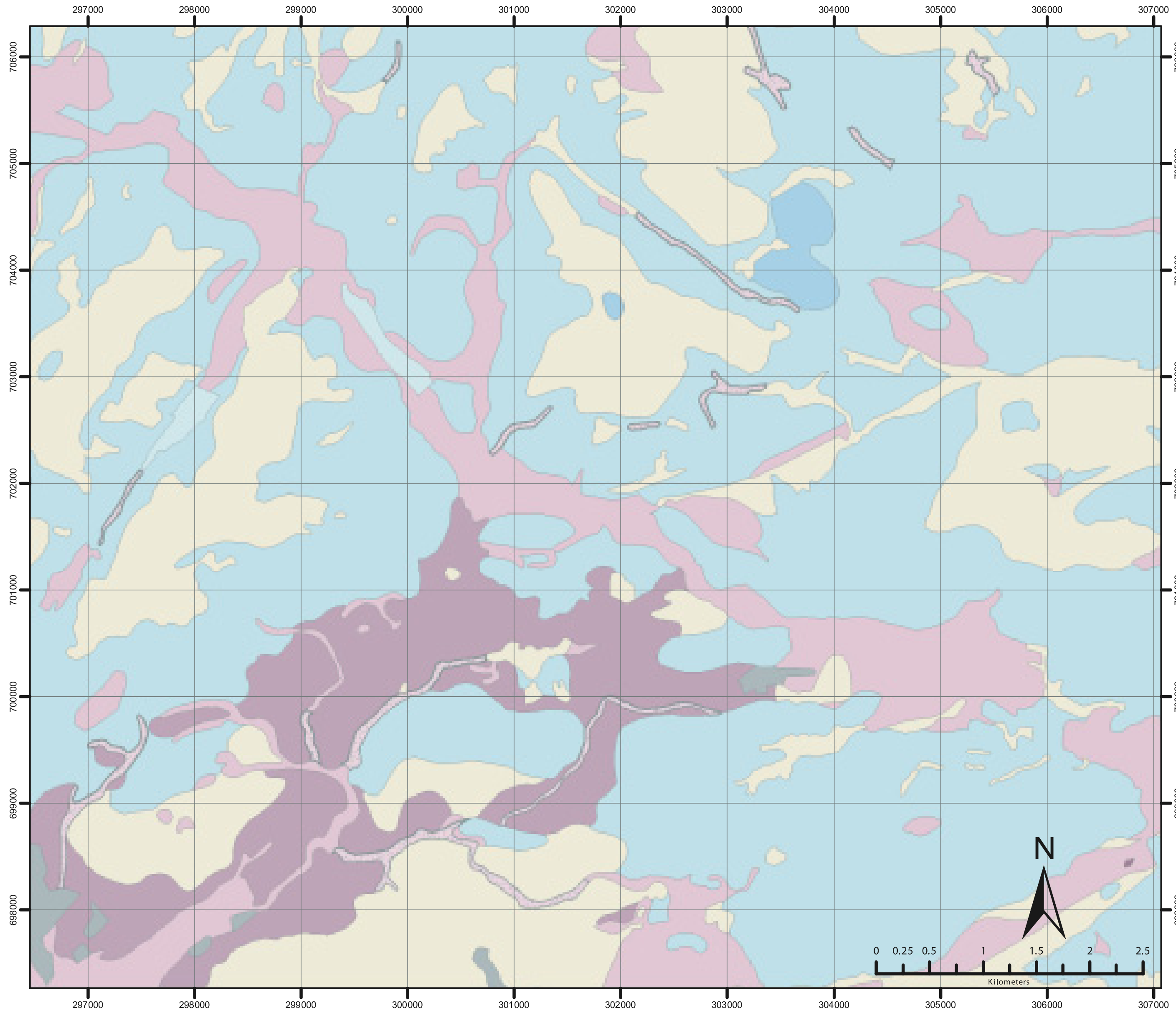
The overall risk characterisation category will be recorded as the risk assessment score for the source.

Survey Section	Risk Characterisation Category
General Site Survey	HIGH
Source Survey	HIGH
Soil Leaching Risk Survey	HIGH
Overall Risk	**HIGH**

(b) Hazard assessment

Individual components in each of the surveys with a hazard assessment score of 32 or greater should be considered as priority candidates for remedial works capable of reducing the overall risk characterisation category.

Figure A4.1 Soil Leaching Potential Map for area around Knuttmound Estate



Soil Leaching Potential for Microbiological Risk Assessment Scale 1:50 000

Soil Leaching Potential Classes

- Low
- Intermediate *
- Intermediate 1
- Intermediate 2
- High *
- High 1
- High 2
- High 3
- Built- up

* Where no subclasses are indicated for the Intermediate and High soil leaching potentials, the underpinning map units comprise a number of distinctive soil types. Only the Soil Leaching Potential of the dominant soil type is given.

This map is a compromise between the representation of natural complexity and simplicity of interpretation at the chosen scale.
This places limitations on the resolution and precision of map information. In this case, the variety of soils that has to be covered is wide, and the classification used is generalised. Individual sites and circumstances will always require further and more detailed assessment.

The map only represents conditions at the surface and, therefore, where the soil and/or underlying formations have been disturbed or removed, for example, during mineral extraction, the leaching potential may have been changed. Hence, where there is evidence of disturbance, site specific data will need to be used.

The Soil Leaching Potential Maps, commissioned by the Scottish Executive, Drinking Water Unit, have been compiled by The Macaulay Institute from data derived from Scotland's National Soil Map at 1:250,000 and 1:25 000 scale. ' The Macaulay Institute 2003.

Topography based on the Ordnance Survey 1:50 000 maps, with the permission of Her Majesty's Stationery Office.' Crown copyright. Ordnance Survey Licence Number GD272191/2003.
Soil Leaching Potential dataset shown on this map is derived from the 1:250 000 scale National Soil Map. ' The Macaulay Institute 2003. All rights reserved.

The map was compiled by: Allan Lilly, John Bell, Paula Horne, Ann Malcolm, Jonathan Ball and Margaret McKeen, The Macaulay Institute.

The Macaulay Institute, Craigiebuckler, Aberdeen, Scotland, AB15 8QH. Tel. +44 (0) 1224 498200. Fax. +44 (0) 1224 311556. http://www.macaulay.ac.uk.

Annex 5.5 Source A3 Knuttmound Estate

D (i) General site survey

Are any of the following known to be present and likely to influence water quality at the source?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
23	History of livestock production (rearing, housing, grazing) – including poultry	H	L	H	-	16	-
24	Evidence of wildlife	M	L	M	16	4	64
25	Surface run-off from agricultural activity diverted to flow into the source/supply	H	L	H	-	8	-
26	Soil cultivation with wastewater irrigation or sludge / slurry/ manure application	H	L	H	-	16	-
27	Disposal of organic wastes to land	H	L	H	-	8	-
28	Farm wastes and/or silage stored on the ground (not in tanks or containers)	M	L	M	-	8	-
29	Remediation of land using sludge or slurry	H	L	H	-	16	-
30	Forestry activity	M	L	M	-	4	-
31	Awareness of the presence of drinking water supply/source by agricultural workers	L	H	H	16	4	64
32	Waste disposal sites (including scrap yard, car yard, rubbish and hazardous waste disposal, landfill or incinerator including on-farm incineration)	H	L	H	-	8	-
33	Disposal sites for animal remains	H	L	H	-	8	-
34	Unsewered human sanitation including septic tanks, pit latrines, soakaways	H	L	H	16	16	256
35	Sewerage pipes, mains or domestic (e.g. leading to / from septic tank)	H	L	H	-	8	-
36	Sewage effluent lagoons	H	L	H	-	16	-
37	Sewage effluent discharge to adjacent watercourse (where present)	H	L	H	-	16	-
38	Evidence of use of pesticides (including sheep dip) near source	H	L	H	8	8	64
39	Evidence of industrial activity likely to present a contamination threat	H	L	H	-	8	-

D (ii) Supply survey

Are any of the following known to occur at the head works site or in relation to the supply?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
40	Supply network constructed from material liable to fracture, e.g. asbestos-concrete, clay, etc.?	H	L	H	16	8	128
41	Intermediate tanks (e.g. collection chambers, holding tanks, break-pressure tanks) are not adequately protected	H	L	H	16	8	128
42	Junctions present in the supply network, particularly supplying animal watering systems, have no back-siphon protection?	H	L	H	16	4	64
43	No maintenance (including chlorination) has been undertaken in the previous 12 months?	H	L	H	-	8	-
44	If present, header tank within the property (s) does not have a vermin-proof cover?	H	L	H	-	4	-
45	Header tank has not been cleaned in the last 12 months?	H	L	H	-	8	-
46	Any point of entry/point of use treatment equipment has not been serviced in accordance with the manufacturer's instructions in the last 12 months?	M	L	M	-	8	-
47	If present, ultraviolet (UV) lamps are not operating?	H	L	H	-	16	-
48	Is there a noticeable change in the level and flow of water throughout the year?	H	L	H	4	4	16
49	Is there a noticeable change in the appearance of the water (colour, turbidity – cloudiness) after heavy rainfall or snow melt?	H	L	H	4	8	32

D (iv) Overall risk assessment

(a) Risk characterisation

The overall risk assessment for the source is taken as the highest individual risk category identified from each of the two surveys.

The overall risk characterisation category will be recorded as the risk assessment score for the source.

Survey Section	Risk Characterisation Category
General Site Survey	HIGH
Source Survey	HIGH
Overall Risk	**HIGH**

(b) Hazard assessment

Individual components in each of the surveys with a hazard assessment score of 32 or greater should be considered as priority candidates for remedial works capable of reducing the overall risk characterisation category.

Annex 5.6 Case Study 4 – Waterbottom Borehole

D (i) General site survey

Are any of the following known to be present and likely to influence water quality at the source?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
23	Evidence or history of poor drainage causing stagnant / standing water	H	L	H	-	16	-
24	History of livestock production (rearing, housing, grazing) – including poultry	H	L	H	-	16	-
25	Evidence of wildlife	M	L	M	-	4	-
26	Surface run-off from agricultural activity diverted to flow into the source/supply	H	L	H	-	8	-
27	Soil cultivation with wastewater irrigation or sludge / slurry/ manure application	H	L	H	-	16	-
28	Disposal of organic wastes to land	H	L	H	-	8	-
29	Farm wastes and/or silage stored on the ground (not in tanks or containers)	M	L	M	-	8	-
30	Remediation of land using sludge or slurry	H	L	H	-	16	-
31	Forestry activity	M	L	M	-	4	-
32	Awareness of the presence of drinking water supply/source by agricultural workers	L	H	H	-	4	-
33	Waste disposal sites (including scrap yard, car yard, rubbish and hazardous waste disposal, landfill or incinerator including on-farm incineration)	H	L	H	-	8	-
34	Disposal sites for animal remains	H	L	H	-	8	-
35	Unsewered human sanitation including septic tanks, pit latrines, soakaways	H	L	H	-	16	-
36	Sewerage pipes, mains or domestic (e.g. leading to / from septic tank)	H	L	H	-	8	-
37	Sewage effluent lagoons	H	L	H	-	16	-
38	Sewage effluent discharge to adjacent watercourse (where present)	H	L	H	-	16	-
39	Supplies or wells not in current use	H	L	H	-	8	-
40	Evidence of use of pesticides (including sheep dip) near source	H	L	H	8	8	64
41	Evidence of industrial activity likely to present a contamination threat	H	L	H	-	8	-

D (ii) Supply survey

Are any of the following known to occur at the head works site or in relation to the supply?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
42	Below ground chamber not watertight	H	L	H	-	8	-
43	Borehole lining (casing) does not extend at least 150mm above level of floor	H	L	H	-	8	-
44	Watertight lining cap not fitted	H	L	H	-	8	-
45	No suitable barrier present to prevent ingress of surface flows into the chamber (e.g. cut-off ditch lined with impermeable material, steep incline/decline such as embankments, appropriate walls, etc.)	H	L	H	16	16	256
46	The top of the chamber not 150mm above ground level?	H	L	H	16	16	256
47	No reinforced pre-cast concrete cover slab, or equivalent, in satisfactory condition with a watertight, vermin-proof inspection cover present to BS497 (lockable steel type or equivalent) with or without ventilation?	H	L	H	-	16	-
48	The chamber construction in an unsatisfactory state-of-repair?	H	L	H	-	8	-
49	Supply network constructed from material liable to fracture, e.g. asbestos-concrete, clay, etc.?	H	L	H	-	8	-
50	Intermediate tanks (e.g. collection chambers, holding tanks, break-pressure tanks) are not adequately protected (i.e. have protection described in [1] to [5] above)?	H	L	H	-	8	-
51	Junctions present in the supply network, particularly supply animal watering systems, have no back-siphon protection?	H	L	H	-	4	-
52	No maintenance (including chlorination) has been undertaken in the previous 12 months?	H	L	H	16	8	128
53	If present, header tank within the property (s) does not have a vermin-proof cover?	H	L	H	-	4	-
54	Header tank has not been cleaned in the last 12 months?	H	L	H	-	8	-
55	Any point of entry/point of use treatment equipment has not been serviced in accordance with the manufacturer's instructions in the last 12 months?	M	L	M	-	8	-
56	If present, ultraviolet (UV) lamps are not operating?	H	L	H	-	16	-
57	Is there a noticeable change in the level and flow of water throughout the year?	H	L	H	-	4	-
58	Is there a noticeable change in the appearance of the water (colour, turbidity – cloudiness) after heavy rainfall or snow melt?	H	L	H	-	8	-

D (iv) Overall risk assessment

(a) Risk characterisation

The overall risk assessment for the source is taken as the highest individual risk category identified from each of the two surveys.

The overall risk characterisation category will be recorded as the risk assessment score for the source.

Survey Section	Risk Characterisation Category
General Site Survey	HIGH
Source Survey	HIGH
Overall Risk	**HIGH**

(b) Hazard assessment

Individual components in each of the surveys with a hazard assessment score of 32 or greater should be considered as priority candidates for remedial works capable of reducing the overall risk characterisation category.

Annex 5.7 Case Study 5 – Border Estate Supply

D (i) General site survey

Are any of the following known to be present and likely to influence water quality at the source?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
23	History of livestock production (rearing, housing, grazing) – including poultry	H	L	H	8	16	128
24	Evidence of wildlife	M	L	M	16	4	64
25	Surface run-off from agricultural activity diverted to flow into the source/supply	H	L	H	-	8	-
26	Soil cultivation with wastewater irrigation or sludge / slurry/ manure application	H	L	H	-	16	-
27	Disposal of organic wastes to land	H	L	H	-	8	-
28	Farm wastes and/or silage stored on the ground (not in tanks or containers)	M	L	M	-	8	-
29	Remediation of land using sludge or slurry	H	L	H	-	16	-
30	Forestry activity	M	L	M	16	4	64
31	Awareness of the presence of drinking water supply/source by agricultural workers	L	H	H	-	4	-
32	Waste disposal sites (including scrap yard, car yard, rubbish and hazardous waste disposal, landfill or incinerator including on-farm incineration)	H	L	H	-	8	-
33	Disposal sites for animal remains	H	L	H	-	8	-
34	Unsewered human sanitation including septic tanks, pit latrines, soakaways	H	L	H	-	16	-
35	Sewerage pipes, mains or domestic (e.g. leading to / from septic tank)	H	L	H	-	8	-
36	Sewage effluent lagoons	H	L	H	-	16	-
37	Sewage effluent discharge to adjacent watercourse (where present)	H	L	H	-	16	-
38	Evidence of use of pesticides (including sheep dip) near source	H	L	H	-	8	-
39	Evidence of industrial activity likely to present a contamination threat	H	L	H	-	8	-

D (ii) Supply survey

Are any of the following known to occur at the head works site or in relation to the supply?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
40	Supply network constructed from material liable to fracture, e.g. asbestos-concrete, clay, etc.?	H	L	H	4	8	32
41	Intermediate tanks (e.g. collection chambers, holding tanks, break-pressure tanks) are not adequately protected	H	L	H	16	8	128
42	Junctions present in the supply network, particularly supplying animal watering systems, have no back-siphon protection?	H	L	H	-	4	-
43	No maintenance (including chlorination) has been undertaken in the previous 12 months?	H	L	H	-	8	-
44	If present, header tank within the property (s) does not have a vermin-proof cover?	H	L	H	-	4	-
45	Header tank has not been cleaned in the last 12 months?	H	L	H	-	8	-
46	Any point of entry/point of use treatment equipment has not been serviced in accordance with the manufacturer's instructions in the last 12 months?	M	L	M	-	8	-
47	If present, ultraviolet (UV) lamps are not operating?	H	L	H	-	16	-
48	Is there a noticeable change in the level and flow of water throughout the year?	H	L	H	16	4	64
49	Is there a noticeable change in the appearance of the water (colour, turbidity – cloudiness) after heavy rainfall or snow melt?	H	L	H	16	8	128

D (iv) Overall risk assessment

(a) Risk characterisation

The overall risk assessment for the source is taken as the highest individual risk category identified from each of the two surveys.

The overall risk characterisation category will be recorded as the risk assessment score for the source.

Survey Section	Risk Characterisation Category
General Site Survey	HIGH
Source Survey	HIGH
Overall Risk	**HIGH**

(b) Hazard assessment

Individual components in each of the surveys with a hazard assessment score of 32 or greater should be considered as priority candidates for remedial works capable of reducing the overall risk characterisation category.

Annex 5.8 Case Study 6 – Rooster Cottage/Farm

D (i) General site survey

Are any of the following known to be present and likely to influence water quality at the source?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
23	Evidence or history of poor drainage causing stagnant / standing water	H	L	H	2	8	16
24	History of livestock production (rearing, housing, grazing) – including poultry	H	L	H	-	16	-
25	Evidence of wildlife	M	L	M	-	4	-
26	Surface run-off from agricultural activity diverted to flow into the source/supply	H	L	H	2	8	16
27	Soil cultivation with wastewater irrigation or sludge / slurry/ manure application	H	L	H	-	16	-
28	Disposal of organic wastes to land	H	L	H	-	8	-
29	Farm wastes and/or silage stored on the ground (not in tanks or containers)	M	L	M	-	8	-
30	Remediation of land using sludge or slurry	H	L	H	-	16	-
31	Forestry activity	M	L	M	-	4	-
32	Awareness of the presence of drinking water supply/source by agricultural workers	L	H	H	-	4	-
33	Waste disposal sites (including scrap yard, car yard, rubbish and hazardous waste disposal, landfill or incinerator including on-farm incineration)	H	L	H	-	8	-
34	Disposal sites for animal remains	H	L	H	-	8	-
35	Unsewered human sanitation including septic tanks, pit latrines, soakaways	H	L	H	16	16	256
36	Sewerage pipes, mains or domestic (e.g. leading to / from septic tank)	H	L	H	16	8	128
37	Sewage effluent lagoons	H	L	H	-	16	-
38	Sewage effluent discharge to adjacent watercourse (where present)	H	L	H	-	16	-
39	Supplies or wells not in current use	H	L	H	-	8	-
40	Evidence of use of pesticides (including sheep dip) near source	H	L	H	4	8	32
41	Evidence of industrial activity likely to present a contamination threat	H	L	H	-	8	-

D (ii) Supply survey

Are any of the following known to occur at the head works site or in relation to the supply?

		Risk Characterisation			Hazard Assessment [1]		
		Yes	No	Don't know	Likelihood	Severity	SCORE
42	Below ground chamber not watertight	H	L	H	-	8	-
43	Borehole lining (casing) does not extend at least 150mm above level of floor	H	L	H	-	8	-
44	Watertight lining cap not fitted	H	L	H	-	8	-
45	No suitable barrier present to prevent ingress of surface flows into the chamber (e.g. cut-off ditch lined with impermeable material, steep incline/decline such as embankments, appropriate walls, etc.)	H	L	H	16	16	256
46	The top of the chamber not 150mm above ground level?	H	L	H	-	16	-
47	No reinforced pre-cast concrete cover slab, or equivalent, in satisfactory condition with a watertight, vermin-proof inspection cover present to BS497 (lockable steel type or equivalent) with or without ventilation?	H	L	H	-	16	-
48	The chamber construction in an unsatisfactory state-of-repair?	H	L	H	-	8	-
49	Supply network constructed from material liable to fracture, e.g. asbestos-concrete, clay, etc.?	H	L	H	-	8	-
50	Intermediate tanks (e.g. collection chambers, holding tanks, break-pressure tanks) are not adequately protected (i.e. have protection described in [1] to [5] above)?	H	L	H	-	8	-
51	Junctions present in the supply network, particularly supply animal watering systems, have no back-siphon protection?	H	L	H	-	4	-
52	No maintenance (including chlorination) has been undertaken in the previous 12 months?	H	L	H	2	8	16
53	If present, header tank within the property (s) does not have a vermin-proof cover?	H	L	H	-	4	-
54	Header tank has not been cleaned in the last 12 months?	H	L	H	-	8	-
55	Any point of entry/point of use treatment equipment has not been serviced in accordance with the manufacturer's instructions in the last 12 months?	M	L	M	-	8	-
56	If present, ultraviolet (UV) lamps are not operating?	H	L	H	-	16	-
57	Is there a noticeable change in the level and flow of water throughout the year?	H	L	H	-	4	-
58	Is there a noticeable change in the appearance of the water (colour, turbidity – cloudiness) after heavy rainfall or snow melt?	H	L	H	-	8	-

D (iv) Overall risk assessment

(a) Risk characterisation

The overall risk assessment for the source is taken as the highest individual risk category identified from each of the two surveys.

The overall risk characterisation category will be recorded as the risk assessment score for the source.

Survey Section	Risk Characterisation Category
General Site Survey	HIGH
Source Survey	HIGH
Overall Risk	**HIGH**

(b) Hazard assessment

Individual components in each of the surveys with a hazard assessment score of 32 or greater should be considered as priority candidates for remedial works capable of reducing the overall risk characterisation category.

This page is intentionally blank

SECTION 6

WATER TREATMENT PROCESSES

Section Contents

Private Water Supplies

6.1 Introduction

Larger water supplies are usually treated by point of entry methods based on a full investigation of site conditions. Anyone planning to install or upgrade a water treatment process should seek expert guidance. For small supplies, a disinfection stage should only be dispensed with if the supply can be shown by risk assessment and frequent surveillance to be consistently pathogen-free.

Potential treatment suppliers should be certified, experienced and have references for similar projects. They must also provide adequate training and guidance for the end user.

For some contaminants, several techniques could be appropriate and the choice should be made on grounds of cost, taking into account local circumstances.

6.2 Multiple barriers

Microbiological contamination is generally the most important to human health as this can lead to infectious diseases. All water sources require treatment prior to consumption. Usually, this consists of a number of stages, with initial pre-treatment by settling or pre-filtration through coarse media, and then sand filtration followed by chlorination. This is called the multiple barrier principle, and it extends back from the treatment stage to the catchment.

It requires effective source protection, careful choice of aquifer or water intake and well-designed, well-maintained abstraction structures.

SUMMARY 6.3 – 6.4

6.3 Coagulation and flocculation

Coagulation and flocculation are used to remove colour, turbidity, algae and other micro-organisms from surface waters, as well as iron and aluminium.

The most commonly used coagulants are aluminium sulphate and ferric sulphate, although other coagulants are available. Coagulants such as aluminium sulphate or ferric sulphate are dosed in solution at a point of high turbulence.

Coagulation reduces the time required to settle out suspended solids and is very effective in removing fine particles, as well as many protozoa, bacteria and viruses.

The principal disadvantages for small supplies are the cost and the need for accurate dosing and frequent monitoring.

6.4 Sedimentation

Sedimentation tanks reduce the flow of water to permit suspended solids to settle under gravity. Tank selection is based on simple settlement tests or experience.

They are usually rectangular and designed to both distribute the incoming flow and collect the clarified water as evenly as possible across the full tank width. They should be covered and will require cleaning when performance drops off.

6.5 Filtration

General – turbidity and algae are removed by screens, gravel filters and slow sand (biological) or rapid gravity (physical) filters.

Screens remove particulate material and debris on surface water intakes. Coarse screens remove weeds and debris while band screens or microstrainers will remove smaller particles including fish and large algae.

Gravel filters remove turbidity and algae, and can operate for several years before cleaning is needed. Filter size depends on water quality, flow rate and size of gravel.

Slow sand filters are tanks that remove turbidity, algae and micro-organisms in a simple, reliable process often used for small supplies if sufficient land is available.

The top few centimetres of sand contain the accumulated solids and are replaced periodically. A variant called the 'Inverness filter' has been widely used in Scotland.

Rapid gravity filters remove floc (precipitate) from coagulated waters, and turbidity, algae and iron and manganese from raw waters. Granular activated carbon medium can remove organic compounds, and alkaline filters can increase the pH value of acidic water. These filters produce a dilute sludge that must be disposed of properly.

Pressure filters can be used to maintain head and eliminate the need for pumping into supply. Operation and performance are generally as for the rapid gravity filter.

6.6 Aeration

These processes transfer oxygen into water and remove gases and volatile compounds by air stripping. The former is normally done by a simple cascade or diffusion of air into water, and the latter by packed tower aerators.

6.7 Chemical treatment

Control of pH – pH may need to be adjusted for several reasons, including quality standards, corrosion and disinfection. Increased pH can be achieved by using alkaline substances or by aeration, and reduced pH by dosing with a suitable acid.

Iron and manganese removal in groundwaters is by oxidation (with care not to cause colloid species) and filtration or coagulation. Surface waters will need filtration.

Taste and odour removal methods include aeration, ozonation and adsorption on activated carbon, depending on the cause.

Nitrate removal is usually by ion-exchange through a column of synthetic resin beads. Nitrate-selective resins are preferred.

Surface waters may require pre-treatment by coagulation to remove organic colour and suspended solids, which would foul the resin.

Nitrate can also be removed by some membrane processes and by biological denitrification, but this is too costly and complex for small water supplies.

6.8 Membrane processes

The most significant are reverse osmosis, ultrafiltration, microfiltration and nanofiltration. Some can remove colour and organic compounds; others can remove *Cryptosporidium, Giardia* and potentially human viruses and bacteriophages, but must not be relied upon as the sole means of disinfection.

6.9 Disinfection

General – contamination by sewage or by human or animal faeces is the greatest danger associated with drinking water. This is because sewage from human or animal sources may contain the causative organisms of many communicable diseases. The use of disinfection to kill or inactivate pathogenic micro-organisms is necessary if the raw water contains such organisms.

Surface waters are more prone to contamination than groundwaters. Disinfection with chlorine is widely used for large water supplies but less so for small supplies. Other methods include ultraviolet irradiation and ozonation.

Ct value can be used to rank relative susceptibilities of micro-organisms to disinfection.

Ultraviolet (UV) irradiation is preferred for small supplies except for certain schemes, but the water must be of good quality and low in colour and turbidity. Pre-filtration is advisable, especially if *Cryptosporidium* is likely to be present.

Low pressure mercury lamps are most commonly used; normally separated from the water by a 'sleeve' to prevent cooling. Typical lamp life is 10 to 12 months after which replacement is required.

For effective disinfection, both the residence time of water in the reactor and UV intensity must be adequate.

UV irradiation equipment is compact and simple to operate, and maintenance is modest but essential. Other advantages include short contact time and no known health risks. However, lamps must be cleaned of scale or replaced regularly, so an appropriate storage tank may be needed.

Chlorine chemistry – Hypochlorous acid is a more powerful disinfectant than the hypochlorite ion and chlorination processes are usually chosen favourable to its formation. These processes need careful control to minimise taste, odour and the formation of THMs. Small water supplies should consider alternatives like UV.

Chlorine sources – liquefied chlorine gas comes in pressurised containers, but chlorine gas leaks are very dangerous and it is not recommended for small supplies.

Sodium hypochlorite solution can be delivered to site in drums or generated on site by the electrolysis of brine, and there is a wide choice of dosing equipment available.

Calcium hypochlorite is stable when dry and several months' supply can be stored, but it will react with moisture in the air to form chlorine gas. Tablets are most commonly used, as their rate of dissolution is predictable.

Chlorination methods – on small supplies, only marginal chlorination would be used in most cases, to produce a suitable residual-free chlorine concentration.

Breakpoint chlorination could be used to remove ammonia but the contact system must not permit short-circuiting or retention in dead zones.

6.9 Disinfection (continued)

Chlorination control – residual control is the most common method, where the water is dosed continuously and the residual is monitored to adjust the chlorine dose.

Ozone gas used with granular activated carbon filters can destroy bacteria and viruses and reduce colour, taste and odour. It cannot be relied upon as the sole means of disinfection for *Cryptosporidium*, however.

It is not widely used because of its complexity, high power requirements and cost.

6.10 Corrosion control

General – can cause structural failure, leaks, loss of capacity and deterioration of water quality, including contamination by metals. Control parameters include calcium, bicarbonate, carbonate and dissolved oxygen concentrations, as well as pH.

Lead corrosion (plumbosolvency) tends to be worst in waters with a low pH and low alkalinity. Pending pipe replacement, the pH should be maintained at 8.0 to 8.5. Dosing with orthophosphate may also help.

Copper – many corrosion problems are associated with new pipe in which a protective oxide layer has not yet formed.

Nickel leaching falls off over time. Increase of pH should also help to reduce it.

Concrete and cement – a pH of 8.5 or higher may be necessary to control corrosion.

Characterising corrosivity – no corrosion index applies to all materials, but the Langelier Index, the Larson ratio and Turner diagrams can all be useful.

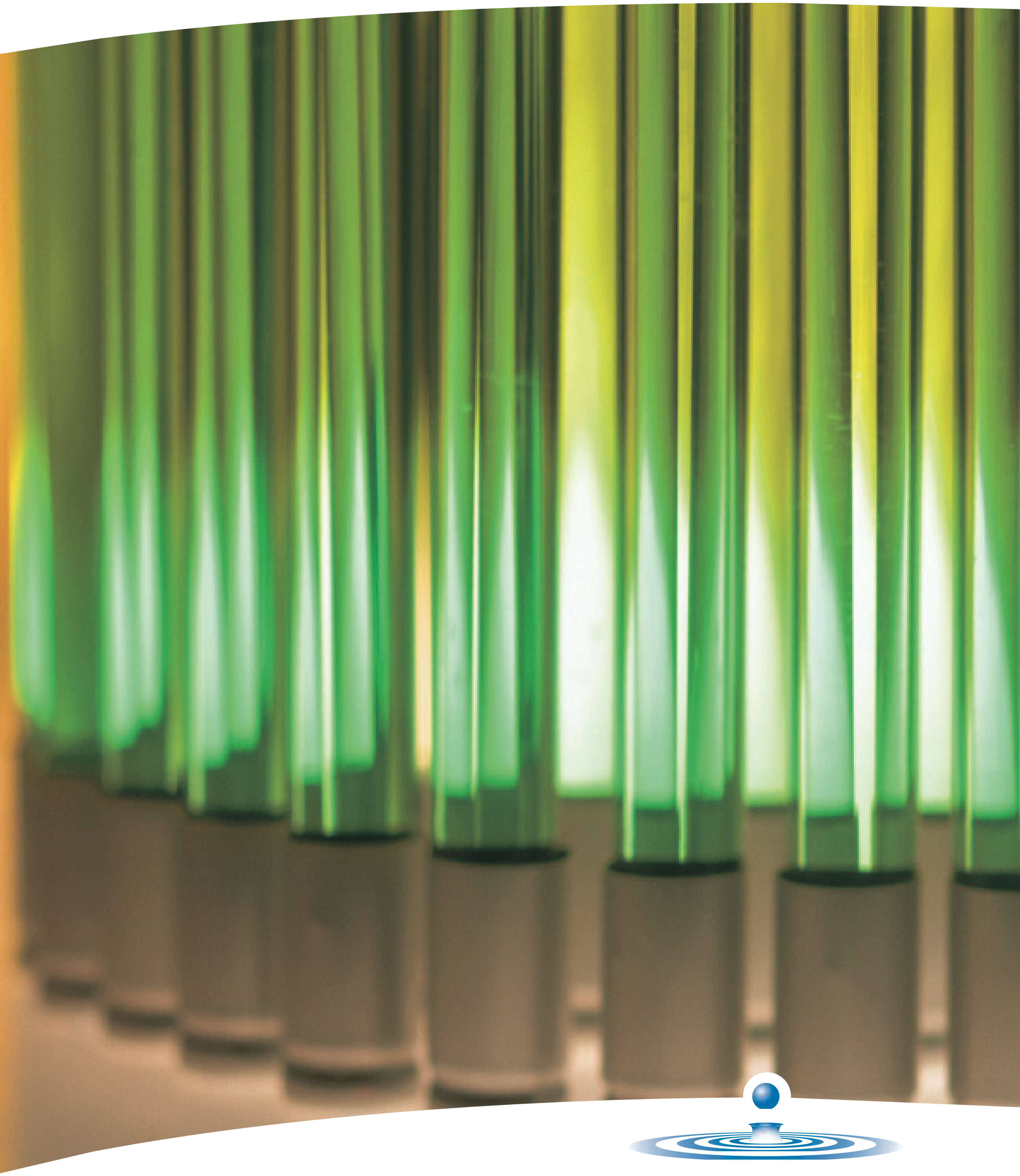
Water treatment for corrosion control – the most common methods are adjusting pH (though this can affect disinfection), increasing the alkalinity and/or hardness, or adding corrosion inhibitors. Wherever practicable, lead pipework should be replaced.

6.11 Treated water storage

The storage tank and other parts of the water supply system should be disinfected before use. Storage tanks must be insulated, lockable (but not airtight), insect-proof, and regularly inspected.

6.12 Maintenance and training requirements

Proper maintenance involves a regular, preventive, programme performed by persons familiar with the equipment. The supplier should provide comprehensive training and supporting documentation.



Private Water Supplies

This page is intentionally blank

6 WATER TREATMENT PROCESSES

6.1 Introduction

Larger water supplies, serving many properties or commercial or industrial premises, are usually treated by point of entry treatment methods, similar in principle to those used at municipal water treatment works. It is essential that the design of any treatment process is based on a full investigation of site conditions, including chemical and microbiological analysis of water and the results of laboratory or pilot-scale tests to determine the effectiveness of the process and the chemical dosing requirements. This chapter provides an overview of the basic principles of water treatment – anyone planning to install or upgrade a water treatment process should seek expert guidance.

For small supplies, for treatment to be truly precautionary it should include a preventive element. In practice this means that treatment of a groundwater supply should automatically include disinfection – a disinfection stage should only be dispensed with if the supply can be shown by risk assessment and frequent surveillance to be likely to be consistently pathogen-free.

It is important to choose equipment suppliers and consultants carefully. Recommendations from previous clients can be useful provided that they relate to similar types of project. Consultants should be members of an appropriate professional institution. Purchasers of water treatment plant and supplies should:

- ensure that potential suppliers are aware of the size and nature of the water supply;
- confirm that potential suppliers can furnish suitable equipment;
- check whether the supplier is certified to the ISO 9000 quality system;
- establish whether suppliers can provide references relating to similar projects;
- if practicable inspect other, similar, installations; and
- establish that the operating and maintenance manual, and training, will be adequate for the end user of the equipment.

A range of water treatment processes is covered here and in the following chapter, which deals with point of use systems for treatment of water at a single tap. Table 6.1 indicates the capability of the various treatment techniques for removing common contaminants. For some contaminants, potentially several techniques could be appropriate and the choice between processes should be made on grounds of cost, taking into account local circumstances. For example, membrane processes can remove a broad spectrum of contaminants but cheaper and simpler alternatives may be just as effective in particular cases. It is likely that a combination of processes will be required to deal with particular waters, for example filtration followed by UV to remove particles and inactivate micro-organisms.

Table 6.1 Overview of treatment methods

	Bacteria	Cysts	Viruses	Algae	Coarse Particles	Turbidity	Colour	Aluminium	Ammonia	Arsenic	Iron & Manganese	Nitrate	Pesticides	Solvents	Taste & Odour
Coagulation/flocculation[1]	+	+	+	+	++	++	++	++		+	++				
Sedimentation					++	+		+			+				
Gravel filter/screen				+	++	+		+			+				
Rapid sand filtration	+	+	+	+	++	+		+			+				
Slow sand filtration	++	++	++	++	++	++		+			+				
Chlorination	++		++	+			+		++						
Ozonation	++	+	++	++			+						++		++
UV	++	+	++	+											
Activated carbon							+						+	+	++
Activated alumina										++					
Ceramic filter	++	++		++	++	++									
Ion exchange									+	+		++			
Membranes	++	++	++	++	++	++	++	++		+	++	++	++		++

+ Partly effective

++ Effective/preferred technique

[1] Pre-oxidation may be required for effective removal of aluminium, arsenic, iron and manganese.

6.2 Multiple barriers

All water sources require treatment prior to consumption to ensure that they do not present a health risk to the user. Health risks from poor quality water can be due to microbiological or chemical contamination. Microbiological contamination is generally the most important to human health as this can lead to infectious diseases. Chemical contamination, with the exception of a few substances such as cyanide and nitrate, tends to represent a more long-term health risk. Substances in water which affect its appearance, odour or taste may make water objectionable to consumers. As micro-organisms can be associated with particles in water, physical contamination may also represent a health risk as it makes disinfection more difficult.

Most treatment systems are designed to remove microbiological contamination and those physical constituents such as suspended solids (turbidity) that affect aesthetic acceptability or promote survival of micro-organisms. A final disinfection stage is nearly always included to inactivate any remaining micro-organisms. When a persistent disinfectant, such as chlorine, is applied this also provides a ‘residual’ that will act as a preservative during storage and/or distribution in larger systems.

Treatment processes are based on the physical removal of contaminants through filtration, settling (often aided by some form of chemical addition) or biological removal of micro-organisms. Usually, treatment consists of a number of stages, with initial pre-treatment by settling or pre-filtration through coarse media, sand filtration followed by chlorination. This is called the multiple barrier principle.

This is an important concept as it provides the basis for effective treatment of water and prevents complete failure of treatment due to a malfunction of a single process. For instance, with a system that comprises coagulation/flocculation, sedimentation and rapid sand filtration with terminal disinfection, failure of the rapid sand filter does not mean that untreated water will be supplied. The coagulation/flocculation and sedimentation processes will remove a great deal of the suspended particles, and therefore many of the micro-organisms in the water, and the terminal disinfection will kill many of the remainder. Provided that the rapid sand filter is repaired promptly, there should be little decrease in water quality.

The multiple barrier principle extends back from the treatment stage to the catchment, so a key element is to ensure that the source of water is protected and maintained at as high a quality as possible. Proper selection and protection of water sources are of prime importance in the provision of safe drinking water. The subsurface is often an effective medium for attenuating contaminants present on the catchment while the design and good maintenance of the well, borehole, spring or intake can help exclude localised pollution. It is always better to protect water from contamination than to treat it after it has been contaminated. Effective source protection, careful choice of aquifer or water intake and well-designed, well-maintained abstraction structures all constitute effective barriers in the multiple barrier principle.

6.3 Coagulation and flocculation

Coagulation and flocculation are used to remove colour, turbidity, algae and other micro-organisms from surface waters. The addition of a chemical coagulant to the water causes the formation of a precipitate, or floc, which entraps these impurities. Iron and aluminium can also be removed under suitable conditions. The floc is separated from the treated water by sedimentation and filtration, although flotation processes may be used in place of sedimentation.

The most commonly used coagulants are aluminium sulphate and ferric sulphate, although other coagulants are available. Coagulants are dosed in solution at a rate determined by raw water quality near the inlet of a mixing tank or flocculator. The coagulant is rapidly and thoroughly dispersed on dosing by adding it at a point of high turbulence. The water then passes into the sedimentation tank to allow aggregation of the flocs, which settle out to form sludge.

The advantages of coagulation are that it reduces the time required to settle out suspended solids and is very effective in removing fine particles that are otherwise very difficult to remove. Coagulation can also be effective in removing many protozoa, bacteria and viruses.

The principal disadvantages of using coagulants for treatment of small supplies are the cost and the need for accurate dosing and frequent monitoring. Coagulants need accurate dosing equipment to function efficiently and the dose required depends on raw water quality that can vary rapidly. The efficiency of the coagulation process depends on the raw water properties, the coagulant used and operational factors including mixing conditions, coagulant dose rate and pH value. The choice of coagulant and determination of optimum operating conditions for a specific raw water have to be determined by bench-scale coagulation tests (‘jar tests’).

Thus, while coagulation and flocculation are the most effective treatment for removal of colour and turbidity they may not be suitable for small water supplies because of the level of control required and the need to dispose of significant volumes of thin sludge.

Figure 6.1 How does Coagulation work?

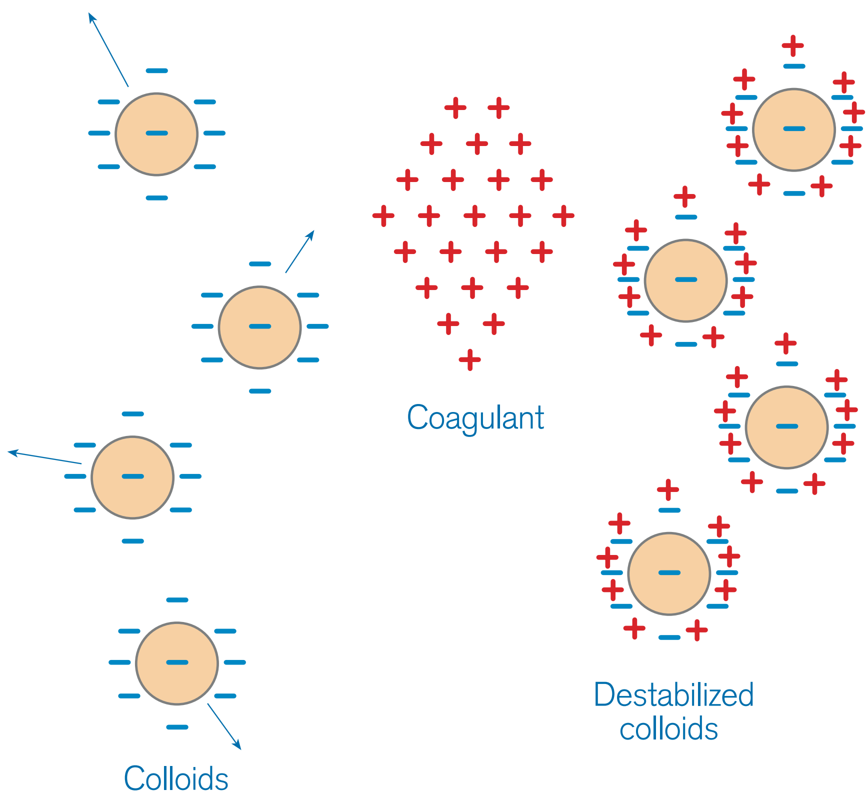
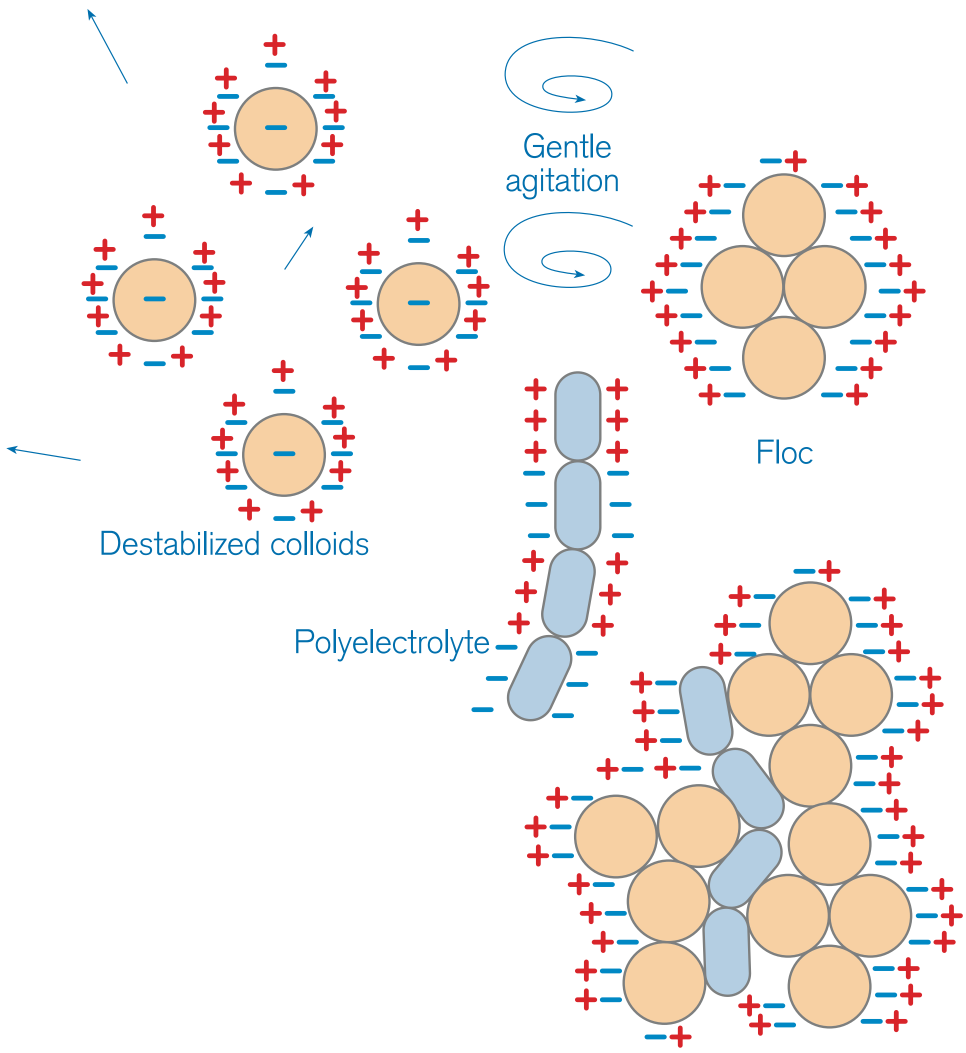


Figure 6.2 How does Flocculation work?

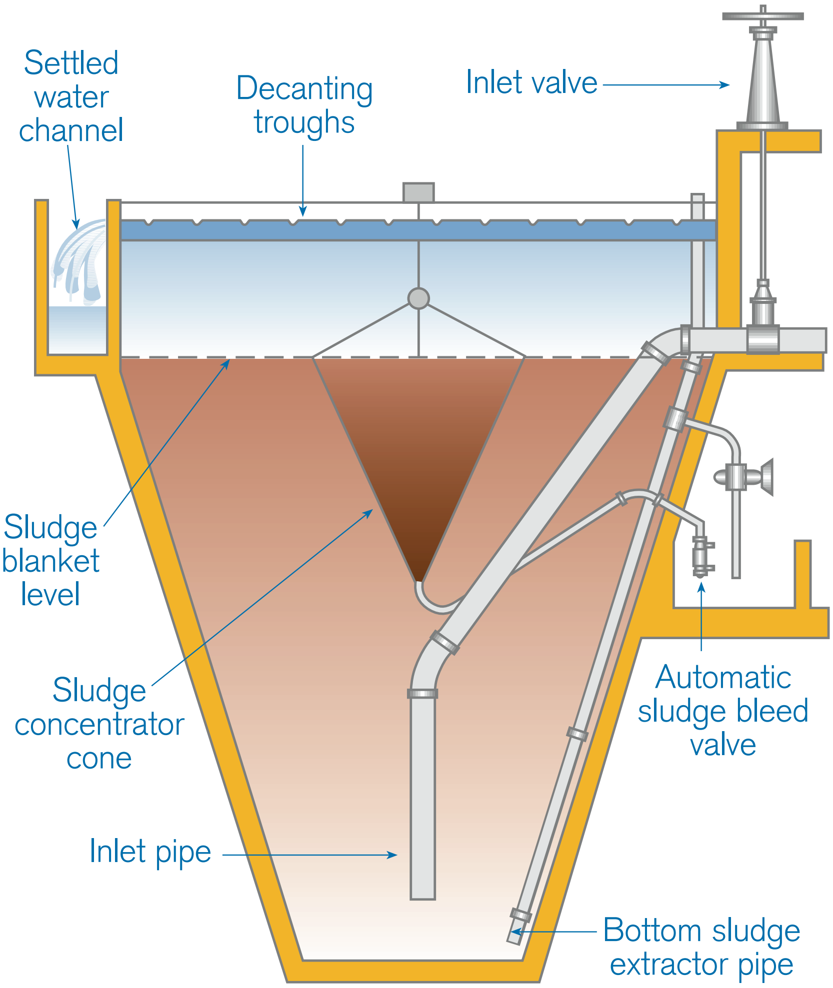


6.4 Sedimentation

Simple sedimentation (i.e. unassisted by coagulation) may be used to reduce turbidity and solids in suspension. Sedimentation tanks are designed to reduce the velocity of flow of water so as to permit suspended solids to settle under gravity. There are many different designs of tanks and selection is based on simple settlement tests or by experience of existing tanks treating similar waters.

Sedimentation tanks are usually rectangular with length to width ratios between 2:1 and 5:1. The depth of the tank is usually between 1.5 and 2.0 m. The inlet and outlet must be at opposite ends of the tank. The inlet should be designed to distribute the incoming flow as evenly as possible across the tank width and to avoid streaming which would otherwise reduce sedimentation efficiency. Baffles may be installed to prevent short-circuiting. The outlet should be designed to collect the clarified water over the entire tank width. The tank should be covered to prevent contamination. Sedimentation tanks require cleaning when performance drops off. This will not normally be more frequent than once per year.

Figure 6.3 Sedimentation tank



6.5 Filtration

6.5.1 General

Turbidity and algae are removed from raw waters by screens, gravel filters and slow sand or rapid gravity filters. The difference between slow and rapid sand filtration is not a simple matter of the speed of filtration, but in the underlying concept of the treatment process. Slow sand filtration is essentially a biological process whereas rapid sand filtration is a physical treatment process.

6.5.2 Screens

Screens are effective for the removal of particulate material and debris from raw waters and are used on many surface water intakes. Coarse screens will remove weeds and debris while band screens or microstrainers will remove smaller particles including fish and may be effective in removing large algae. Microstrainers are used as a pre-treatment to reduce solids loading before slow sand filters or chemical coagulation. A microstrainer consists of a rotating drum fitted with very fine mesh panels. Raw water flows through the mesh and suspended solids including algae are retained and removed by water wash, producing a wastewater, which may require treatment before disposal.

6.5.3 Gravel filters

Gravel filters may be used to remove turbidity and algae. A simple gravel filter for the protection of a stream or river inlet is described in Section 3.4.1. A larger gravel filter may consist of a rectangular channel or tank divided into several sections and filled with graded gravel (size range 4 to 30 mm). The raw water enters through an inlet distribution chamber and flows horizontally through the tank, encountering first the coarse and then the finer gravel. The filtered water is collected in an outlet chamber. Solids removed from the raw water accumulate on the floor of the filter. Gravel filters can operate for several years before cleaning becomes necessary. The size of a gravel filter will depend on water quality, flow rate and size of gravel. A filter can be up to 12 m long, 2 to 5 m wide and 1 to 1.5 m deep. The filter should normally be sized for a flow rate of between 0.5 to 1.0 cubic metres per square metre of filter surface area per hour ($m^3/m^2.h$).

6.5.4 Slow sand filters

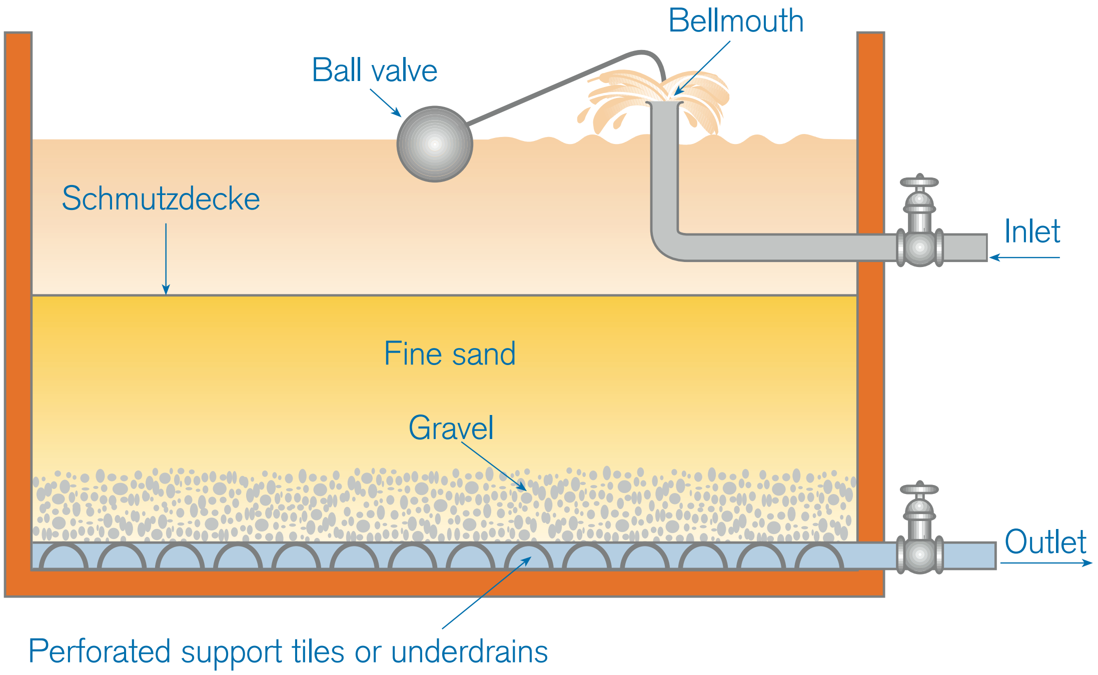
Slow sand filters, sometimes preceded by microstraining or coarse filtration, are used to remove turbidity, algae and micro-organisms. Slow sand filtration is a simple and reliable process and is therefore often suitable for the treatment of small supplies provided that sufficient land is available.

Slow sand filters usually consist of tanks containing sand (size range 0.15-0.30 mm) to a depth of between 0.5 to 1.5 m. For small supplies, modular units of 1.25 m diameter are available – a tandem installation would occupy a concrete apron of about 8 to 10 m^2. The raw water flows downwards and turbidity and micro-organisms are removed by filtration in the top few centimetres of the sand. A biological layer of sludge, known as the 'schmutzdecke', develops on the surface of the filter that can be effective in removing micro-organisms. Treated water is collected in underdrains or pipework at the bottom of the filter. The top few centimetres of sand containing the accumulated solids are removed and replaced periodically. Filter runs of between 2 and 10 weeks are possible, depending on raw water quality and flow rate. Slow sand filters are often operated in tandem; one in service whilst the other is cleaned and time allowed for the schmutzdecke to re-establish.

A variant of the slow sand filter, the 'Inverness filter' or 'Argyll filter', has been widely used in Scotland. It uses the same grade of sand and operates at the same flow rate as the traditional slow sand filter but the water flows upwards. Filtration is achieved throughout the filter bed and a true 'schmutzdecke' does not develop. The sand is 'washed' by opening a valve at the bottom of the filter and allowing the filter bed to drain rapidly.

Slow sand filters should be sized for a water flow rate of between 0.1 and 0.3 $m^3/m^2.h$. The flow rate should be controlled and the filter designed with a treated water reservoir of sufficient capacity to accommodate fluctuations in demand, and thus permit operation of filters at a steady and continuous rate.

Figure 6.4 Slow sand filter



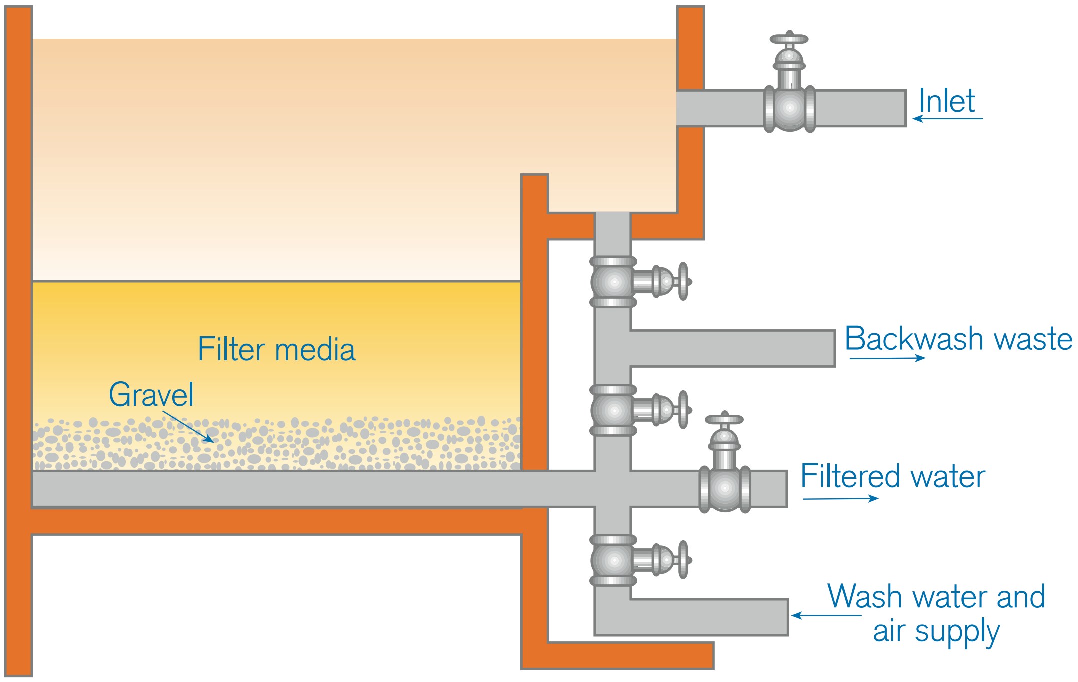
6.5.5 Rapid gravity filters

Rapid gravity filters are most commonly used to remove floc from coagulated waters. They may also be used to remove turbidity, algae and iron and manganese from raw waters. Granular activated carbon medium is used to remove organic compounds and filters incorporating an alkaline medium are used to increase the pH value of acidic water.

Rapid gravity sand filters usually consist of rectangular tanks containing silica sand (size range 0.5 to 1.0 mm) to a depth of between 0.6 and 1.0 m. The water flows downwards and solids become concentrated in the upper layers of the bed. Treated water is collected *via* nozzles in the floor of the filter. The accumulated solids are removed periodically by backwashing with treated water, usually preceded by scouring of the sand with air. Frequency of backwashing depends on loading rate and raw water quality and is typically every 24 hours. Backwashing can be initiated automatically after a pre-determined headloss has been reached or may be carried out manually. A dilute sludge that requires disposal is produced which may be discharged to sewer, soakaway or, after treatment, to a watercourse provided that any required discharge consent is obtained.

A number of proprietary filters contain media of different sizes and densities. In some filters, the raw water flows upwards and improved filtration efficiency is claimed. The size of a rapid gravity filter is determined by the filtration rate if backwashed automatically, or by the solids retention if backwashed manually. Filters should normally have sufficient area to enable them to be operated at no more than 6 m/h at peak flow or to retain 1 kg of solids per square metre of bed between washes at peak loading, whichever is greater.

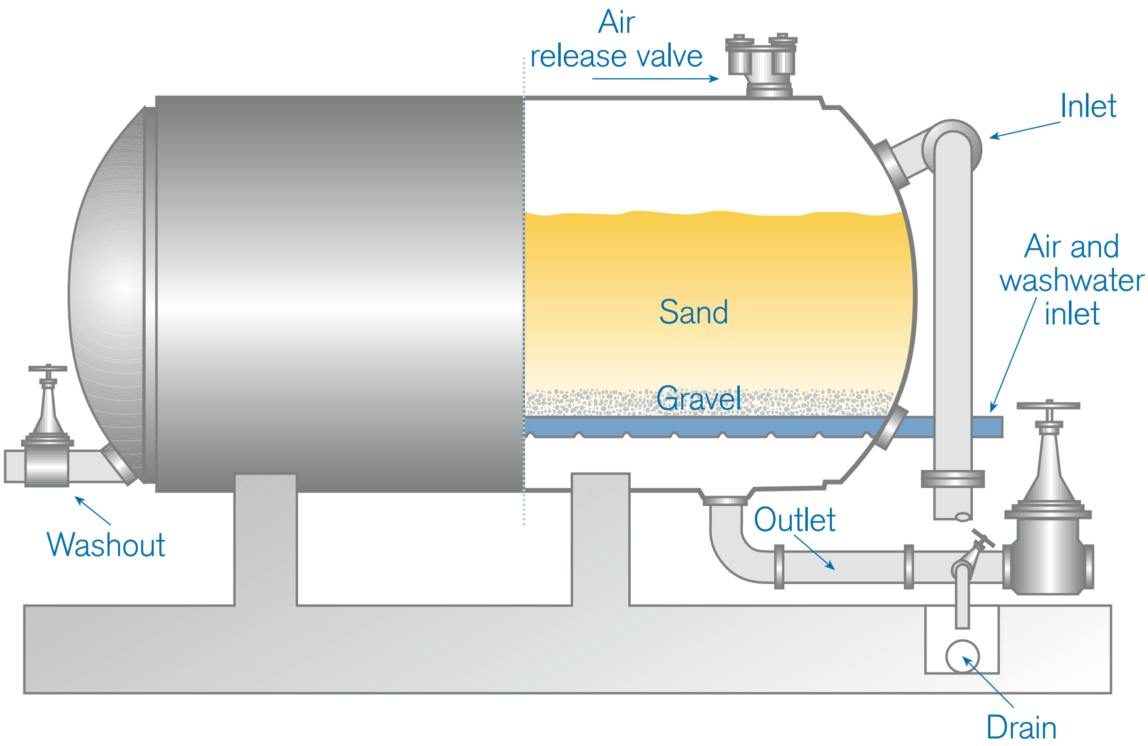
Figure 6.5 Rapid gravity filter



6.5.6 Pressure filters

Pressure filters are sometimes used where it is necessary to maintain head in order to eliminate the need for pumping into supply. The filter bed is enclosed in a cylindrical shell. Small pressure filters, capable of treating up to about 15 m^3/h, can be manufactured in glass reinforced plastics. Larger pressure filters are manufactured in specially coated steel. Operation and performance are generally as described for the rapid gravity filter (see Section 6.5.5) and similar facilities are required for backwashing and disposal of the dilute sludge. A similar range of contaminants can be removed depending on the filter medium.

Figure 6.6 Pressure filter



6.6 Aeration

Aeration processes are designed to achieve efficient mass transfer of oxygen into water and removal of gases and volatile compounds by air stripping. Oxygen transfer can usually be achieved using a simple cascade or diffusion of air into water, without the need for elaborate equipment. Stripping of gases or volatile compounds, however, may require specialised plant that provides a high degree of mass transfer.

For oxygen transfer, cascade or step aerators are designed so that water flows in a thin film to achieve efficient mass transfer. Cascade aeration may introduce a significant headloss; design requirements are between 1 and 3 metres to provide a loading of 10 to 30 $m^3/m^2.h$. If such headloss is unacceptable the alternative is to use compressed air diffused through a system of submerged perforated pipes. These types of aerator are used for oxidation and precipitation of iron and manganese.

To achieve air stripping various techniques can be used including counter-current cascade aeration in packed towers, diffused aeration in basins and spray aeration. Packed tower aerators are most commonly used because of their high energy efficiency and compact design. Air stripping is used for removal of volatile organics (e.g. solvents), some taste and odour causing compounds, and radon (Section 7.1).

6.7 Chemical treatment

6.7.1 Control of pH

The pH value of water may need to be adjusted during treatment and before distribution for several reasons, including:

- to ensure that the pH value meets the water quality standards;
- to control corrosion in the distribution system and consumers' installations or to reduce plumbosolvency;
- to improve the effectiveness and efficiency of disinfection;
- to facilitate the removal of iron and manganese; and
- to facilitate the removal of colour and turbidity by chemical coagulation.

Many raw surface waters are slightly acidic and coagulation processes further increase acidity. Increase of pH can be achieved by:

- dosing with sodium hydroxide, calcium hydroxide or sodium carbonate;
- passage of the water through a bed of alkaline medium; or
- removal of excess carbon dioxide by aeration.

Where necessary, reduction of pH can be achieved by dosing with a suitable acid such as sulphuric acid, hydrochloric acid, sodium hydrogen sulphate or carbon dioxide.

6.7.2 Iron and manganese removal

In groundwaters, iron is usually present as dissolved ferrous compounds. To remove iron in this form, it is necessary to oxidise ferrous iron, usually by aeration, to the insoluble ferric hydroxide and to remove the precipitated material in a subsequent filtration stage. It is important to ensure that oxidation does not give rise to colloidal species which may pass through the filters. If the iron is present as an organic complex, a strong oxidant such as chlorine or potassium permanganate must be used. Manganese is usually present as dissolved manganous compounds. Removal is achieved by oxidation to insoluble manganese dioxide using catalytic filters or potassium permanganate followed by filtration, or by coagulation at high pH followed by filtration.

In surface waters, iron and manganese are usually present in their oxidised forms and are associated with the suspended solids, which can be removed by filtration. Where coagulation is practised for the removal of colour and turbidity, iron removal may be achieved simultaneously. Iron and manganese may be combined with organic matter in very stable forms. The usual treatment in this case is coagulation followed by oxidation with chlorine or potassium permanganate and filtration.

6.7.3 Taste and odour removal

Taste and odour can be removed by several methods, including aeration, ozonation and adsorption on activated carbon. The method used will depend on the source of the taste and odour. Adsorption on activated carbon is generally the most effective method for the removal of 'earthy' or 'mouldy' taste and odour. Powdered activated carbon can be dosed directly to the water before coagulation and sedimentation. Granular activated carbon may be used as a filter medium replacing sand in existing filters or alternatively in a post-filtration adsorption stage.

6.7.4 Nitrate removal

Nitrate removal is usually achieved by ion-exchange. Water is passed through a column of synthetic resin beads that remove anions including nitrate and exchange them for equivalent amounts of chloride. When the capacity for exchange is exhausted, the resin is regenerated by backwashing with a concentrated solution of sodium chloride. This restores the resin to its initial chloride form. The bed is then rinsed with clean water and returned to service. The waste solution and rinse waters, containing high concentrations of sodium chloride, as well as nitrate, are collected for disposal.

Conventional anion exchange resins have a higher affinity for sulphate than for nitrate. This means that they preferentially remove sulphate and reduce the capacity for nitrate, leading in turn to higher running costs (for regenerant) and greater volumes of waste for disposal. As a result, nitrate-selective resins, which give better uptake of nitrate in the presence of sulphate and reduce process costs, are preferred.

Nitrate-selective resins also add less chloride to the treated water because of the lower sulphate removal; this is desirable since high chloride concentrations and chloride-to-bicarbonate ratios are associated with increased corrosion of certain metals. A sodium bicarbonate rinse can be used after regeneration with sodium chloride to convert the resin in the lower part of the bed to the bicarbonate form and reduce the chloride-to-bicarbonate ratio during the early part of the run.

An ion-exchange plant consists of two or more reactors operated in parallel. Run lengths of up to 24 hours can be achieved before regeneration is necessary. Regeneration consumes up to 2 percent of the volume of treated water and takes about two hours. Performance is affected by the choice of resin, the concentrations of nitrate and sulphate in the raw water, and the volume and concentration of sodium chloride solution used for regeneration. Operation of an ion-exchange plant is normally fully automatic.

Even when using nitrate-selective resins the concentrations of nitrate, sulphate, bicarbonate and chloride vary during a run. These variations can be balanced out by operating two or more beds out of phase and blending the products or by installing large mixing tanks prior to distribution.

Surface waters may require pre-treatment by coagulation to remove organic colour and suspended solids, which would foul the resin.

Nitrate can also be removed by some membrane processes and by biological denitrification. Membrane processes are described in Section 6.8. In biological denitrification, nitrate is converted to nitrogen by de-nitrifying bacteria which, in the absence of dissolved oxygen, use the nitrate as an oxygen source. Biological denitrification occurs naturally in some confined aquifers but is not appropriate for the treatment of small water supplies because of the complexity of the process and the relatively high capital cost.

6.8 Membrane processes

The membrane processes of most significance in water treatment are reverse osmosis, ultrafiltration, microfiltration and nanofiltration. These processes have traditionally been applied to the production of water for industrial or pharmaceutical applications but are now being applied to the treatment of drinking water. Their characteristics are given in Figure 6.2.

If two solutions are separated by a semi-permeable membrane, i.e. a membrane that allows the passage of solvent but not of the solute, the solvent will pass from the lower concentration solution to the higher concentration solution. This process is known as osmosis. It is possible, however, to force the flow of solvent in the opposite direction, from the higher to the lower concentration, by increasing the pressure on the higher concentration solution. The required pressure differential is known as the osmotic pressure and the process as reverse osmosis.

Reverse osmosis results in the production of a treated water stream and a relatively concentrated waste stream. Typical operating pressures are in the range 15 to 50 bar depending on the application. Membrane pore sizes are less than 0.002 µm. The most common application of reverse osmosis is desalination of sea water although the use of reverse osmosis for nitrate removal has also been proposed.

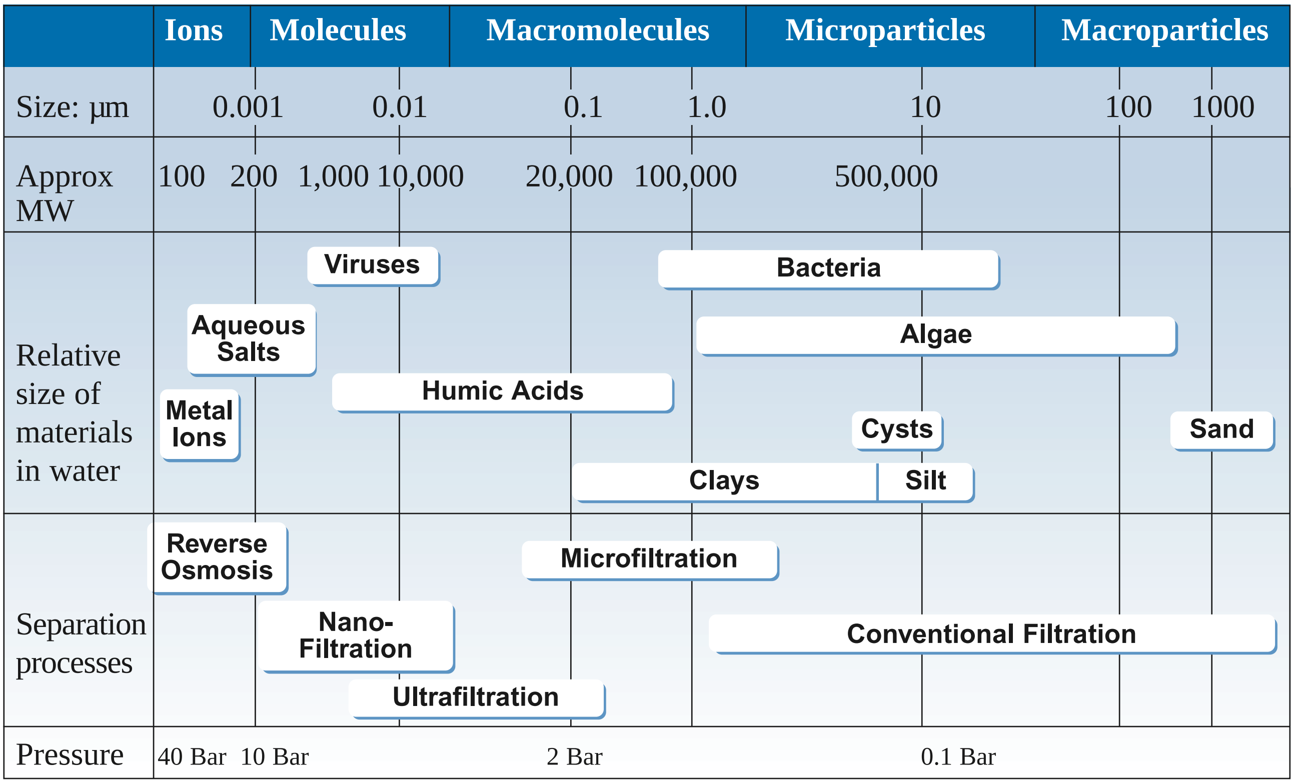
Ultrafiltration is similar in principle to reverse osmosis, but the membranes have much larger pore sizes (typically 0.002 to 0.03 µm) and operate at lower pressures. Ultrafiltration membranes reject organic molecules of molecular weight above 800 and usually operate at pressures less than 5 bar. Microfiltration membranes have pore sizes typically in the range 0.01 to 12 µm and do not separate molecules but reject colloidal and suspended material at operating pressures of 1 to 2 bar.

Nanofiltration uses a membrane with properties between those of reverse osmosis and ultrafiltration membranes; pore sizes are typically 0.001 to 0.01 µm. Nanofiltration membranes allow monovalent ions such as sodium or potassium to pass but reject a high proportion of divalent ions such as calcium and magnesium and organic molecules of molecular weight greater than 200. Operating pressures are typically about 5 bar. Nanofiltration may be effective for the removal of colour and organic compounds.

Microfiltration is a direct extension of conventional filtration into the sub-micron range. Microfiltration is capable of sieving out particles greater than 0.05 µm and will remove most bacteria and amoeboid cysts. It has been used for water treatment in combination with coagulation or powdered activated carbon (PAC) to remove viruses, bacteria, dissolved organic carbon and to improve permeate flux.

Membrane processes can provide adequate removals of pathogenic bacteria, *Cryptosporidium, Giardia* and, potentially, human viruses and bacteriophages. However, they should not be relied upon as the sole means of disinfection as there is no simple means to check membrane integrity to warn of potential break-through of micro-organisms.

Table 6.2 Characteristics of membrane processes



6.9 Disinfection

6.9.1 General

Contamination by sewage or by human or animal faeces is the greatest danger associated with water for drinking. This is because sewage from human or animal sources may contain the causative organisms of many communicable diseases. The use of disinfection to kill or inactivate pathogenic micro-organisms is necessary if the raw water contains such organisms.

Surface waters may contain between a few tens of *E. coli* per 100 ml in a source derived from a protected upland catchment and many thousands of *E. coli* per 100 ml in a source derived from a lowland river containing treated sewage effluents. Groundwaters are less prone to contamination.

Several disinfection methods are used in water treatment. Disinfection with chlorine is the most widely used method for large water supplies but its application is less common in small supplies. Other methods that are increasingly used include ultraviolet irradiation and ozonation.

Different micro-organisms have different susceptibilities to disinfectants, and disinfectants vary in their potency. For a given micro-organism, disinfection efficiency is affected especially by disinfectant concentration and contact time, and also by disinfectant demand of the water, pH and temperature. The product of disinfectant concentration (C in mg/l, measured at the end of the contact period) and time (t in minutes) is called Ct (in mg/l.min) and is an expression of exposure to the disinfectant:

$$Ct = C \times t$$

The greater the Ct value, or exposure, the more effective disinfection is. Either concentration or contact time, or both, can be manipulated to obtain a desired Ct value. Values of Ct can be useful for comparing the efficiency of disinfectants – the lower the value of Ct to attain a given kill of micro-organisms, the more effective the disinfectant. The Ct value can also be used to rank the relative susceptibility of different micro-organisms – the higher the Ct value necessary to achieve a given level of kill the more resistant the micro-organism.

In the case of ultraviolet irradiation, Ct cannot be calculated in the same way and the exposure is expressed as UV radiation energy density, which is equivalent to (power x time) per unit area, expressed in milliwatt seconds per square centimetre ($mW.s/cm^2$).

6.9.2 Ultraviolet irradiation

Ultraviolet (UV) irradiation is the preferred method for disinfection of small supplies except for larger schemes in which it is necessary to maintain a residual disinfectant during storage and distribution. UV disinfection efficiency is particularly affected by water quality and flow rate. The water to be disinfected must be of good quality and particularly low in colour and turbidity. It is generally necessary for the turbidity of water to be less than 5 NTU, preferably much lower, for successful UV disinfection. Therefore pre-filtration is advisable, especially if *Cryptosporidium* is likely to be present, as discussed below.

Special lamps are used to generate UV radiation, and are enclosed in a reaction chamber made of stainless steel or, less commonly, plastics. Low pressure mercury lamps, which generate 85% of their energy at a wavelength of 254 nm, are most commonly used; their wavelength is in the optimum germicidal range of 250 to 265 nm. These lamps are similar in design, construction and operation to fluorescent tubes except that they are constructed of UV-transparent quartz instead of phosphor-coated glass. The optimum operating temperature of the lamp is around 40 °C so the lamp is normally separated from the water by a 'sleeve' to prevent cooling by the water. The intensity of UV radiation emitted decreases with lamp age; typical lamp life is about 10 to 12 months after which the output is about 70% of that of a new lamp, and lamp replacement is required.

The usual UV reactor configuration is a quartz-sleeved low pressure mercury lamp in direct contact with the water; water enters the unit and flows along the annular space between the quartz sleeve and the wall of the chamber. Other configurations include lamps separated from the water, for example lamps surrounded by 'bundles' of PTFE tubes through which the water flows.

Disinfection will only be effective provided that a sufficient dose of UV is applied. The 'dose' of UV radiation is expressed as an energy flux, in units of $mW.s/cm^2$ (milliwatt seconds per square centimetre), which is the product of the intensity given out by the lamp and the residence time of water in the reactor. The minimum dose required for disinfection depends on several factors, including the susceptibility of micro-organisms but is generally taken to be in the range 16 to 40 $mW.s/cm^2$.

It is important, to ensure effective disinfection, that both residence time and UV intensity are adequate. UV intensity will be diminished by ageing of the lamp, fouling of the lamp by deposits, and absorption of UV radiation by water contaminants such as natural colour. For these reasons, lamps need to be changed at the recommended intervals and the quartz sleeve may require periodic cleaning. Some units incorporate a manual 'wiper' for cleaning whilst others incorporate automatic mechanical cleaning.

Colour and turbidity will both affect radiation intensity in the reactor and turbidity may protect micro-organisms from the radiation. The water to be treated should be tested for transmissivity by the manufacturer or supplier in order to estimate worst-case transmission values and to adjust contact time accordingly. More advanced units incorporating UV monitors have the facility to automatically adjust the energy input to the UV lamp to achieve the required UV intensity.

6.9.2 Ultraviolet irradiation (continued)

The water flow rate affects the retention time in the reactor, which is designed for a maximum flow rate. The maximum water flow rate should not be exceeded.

There is evidence that UV is effective in inactivating *Cryptosporidium* provided that a sufficient UV dose is applied although there is a dearth of data on effectiveness under high-risk conditions of water quality. However, where *Cryptosporidium* is likely to be present and cyst removal is required then pre-filtration capable of removing particles of 1 mm diameter is recommended prior to UV disinfection. Pre-filtration provides an additional barrier to passage of oocysts into the treated water, removes particles that shield micro-organisms from the UV light and helps to reduce fouling of the UV lamp.

Several new treatment technologies have been developed for inactivation of *Cryptosporidium*. These include pulsed UV or white light systems and combined filtration-irradiation or adsorption-irradiation techniques that increase exposure to UV, for example by trapping the micro-organisms on a filter then subjecting them to UV irradiation. Pulsed UV and pulsed white light devices that generate high intensity, short duration, pulses of radiation are reported to give more effective inactivation of oocysts than conventional UV systems. At present, such systems are not applied to any extent for treatment of small water supplies.

UV irradiation equipment is compact and simple to operate. Maintenance requirements are modest, although specific systematic maintenance is essential. Other advantages include short contact time and the absence of any known by-products of significance to health. An ‘overdose’ of UV presents no danger and actually adds a safety factor. The principal disadvantage is the absence of any residual effect, necessitating careful attention to hygiene in the storage and distribution system.

The build-up of scale on the sleeves of the lamps will eventually reduce their transmittance and they must be cleaned or replaced regularly. Some units have UV intensity monitors and alarms which provide a continuous check on performance and these are strongly recommended. These devices may prevent the flow of water if the required intensity of UV radiation is not achieved, for example when the lamps are warming-up or because of scale formation. UV intensity monitors may not be available on smaller units and it is therefore essential that the manufacturer’s instructions regarding lamp warm-up, cleaning and replacement are followed to ensure optimal performance.

Lamp replacement is usually a simple operation but may involve a significant downtime for reactors with many lamps. This difficulty may be overcome by use of multiple units or by having a treated water storage tank capable of maintaining supply whilst maintenance is carried out. The materials of construction and design of storage systems should not allow deterioration in water quality to occur.

6.9.3 Chlorine

6.9.3.1 Chemistry

Chlorine, whether in the form of pure chlorine gas from a cylinder, sodium hypochlorite or calcium hypochlorite, dissolves in water to form hypochlorous acid (HOCl) and hypochlorite ion (OCl^-). For example, chlorine gas dissolves rapidly in water, initially forming hypochlorous and hydrochloric acids:

$$Cl_2 + H_2O \leftrightarrows HOCl + HCl$$

Hypochlorous acid is a weak acid which undergoes partial dissociation to produce a hydrogen ion (H^+) and a hypochlorite ion (OCl^-):

$$HOCl \leftrightarrows H^+ + OCl^-$$

The total concentration of chlorine, hypochlorous acid and hypochlorite ions is referred to as the ‘free available chlorine’. If ammonia is present in the raw water, the hypochlorous acid can react to produce chloramines. The total concentration of the chloramines and any organic nitrogen chlorine-containing compounds is referred to as the ‘combined available chlorine’. Combined available chlorine is a less powerful disinfectant than free available chlorine but gives a more persistent residual.

Formation of combined chlorine is due to a sequence of reactions. Hydrogen in ammonia is progressively replaced by chlorine as follows:

NH_3	$\rightarrow$	NH_2C1	$\rightarrow$	$NHC1_2$	$\rightarrow$	NCl_3
Ammonia		Monochloramine		Dichloramine		Trichloramine

If a large chlorine dose is applied (relative to ammonia), as is practised in breakpoint chlorination, then nitrogen is formed.

$$2NH_2C1 + Cl_2 \rightarrow N_2 + 4HC1$$

The effectiveness of chlorine for disinfection depends on the form of chlorine, its concentration and the contact time. Hypochlorous acid is a more powerful disinfectant than the hypochlorite ion and chlorination is usually practised at values of pH favourable to its formation. The World Health Organization recommends that for the effective disinfection of drinking water “the pH should preferably be less than 8.0 and the contact time greater than 30 minutes, resulting in a free chlorine residual of 0.2 to 0.5 mg/l”.

Chlorination processes need to be carefully controlled in order to minimise problems with complaints of taste and odour. There may also be a need to control the formation of THMs (see Section 2.4.6). Therefore, for small supplies, consideration should be given to using alternatives to chlorination, such as UV.

6.9.3.2 Sources of chlorine

Chlorination can be achieved by using liquefied chlorine gas, sodium hypochlorite solution or calcium hypochlorite granules. Chlorine gas is very reactive and highly toxic and must be carefully stored and handled. It is used for treatment of large public supplies but the inherent danger of using chlorine gas has resulted in an increased use of sodium hypochlorite or the electrolysis of brine (electro-chlorination) as alternative sources of chlorine.

The use of chlorine gas for treatment of small water supplies is not recommended. Gas chlorination is generally not appropriate for supplies of less than 10 m^3/d or where the available head is less than about 4 m. Leaks of chlorine gas are very dangerous. A separate area is necessary for storage of chlorine gas and an alarm system to detect leakage of chlorine must be installed. It is common practice to install alarm systems to indicate failure of the chlorine injector system or carrier water flow.

Liquefied chlorine gas is supplied in pressurised containers. The gas is withdrawn from the cylinder and is dosed into water by a chlorinator, which both controls and measures the gas flow rate.

Sodium hypochlorite solution (14 to 15% by mass (m/m) available chlorine) can be delivered to site in drums. No more than one month’s supply should be delivered at one time, as its decomposition (particularly on exposure to light) results in a loss of available chlorine and an increase in concentration of chlorate, relative to chlorine.

Alternatively, sodium hypochlorite solution (0.5 to 1.0% mass per volume (m/V) available chlorine) can be generated on site by the electrolysis of brine (sodium chloride solution). A typical electrochlorination system consists of a water softener, a salt saturator, a voltage rectifier, an electrolysis cell and a storage tank containing up to three days’ supply of hypochlorite solution. Hydrogen, which is produced during electrolysis, must be vented safely. These systems are compact and eliminate the need to store and handle the toxic and corrosive chlorination chemicals.

There is a wide choice of equipment available for dosing sodium hypochlorite solution. Simple gravity-fed systems in which sodium hypochlorite solution is dripped at a constant rate into a tank of water have been used successfully and have proven reliable provided that the rate of flow into supply and the chlorine demand of the water are constant. Where the flow is more variable, water-powered hypochlorinators that adjust the flow of sodium hypochlorite proportionately to the flow of water may be suitable. Electric dosing pumps can operate under flow proportional or chlorine residual control and thus maintain a consistent chlorine residual under conditions of variable flow or chlorine demand.

6.9.3.2 Sources of chlorine (continued)

Calcium hypochlorite can be supplied in powdered, granular or tablet form (65 to 70% m/m available chlorine). Calcium hypochlorite is stable when dry and several months' supply can be stored. It will however react with moisture in the air to form chlorine gas. Calcium hypochlorite dosers are relatively simple. Most allow calcium hypochlorite to dissolve in a known volume of make-up water, which is then mixed with the main supply. Tablets are most commonly used, as their rate of dissolution is predictable. Control of dosage (proportional to the rate of dissolution) is often limited to changing the depth of immersion of the tablets in the make-up water or to changing the proportion of the make-up water to total flow.

6.9.3.3 Methods of chlorination

Several regimes of chlorination can be used, including marginal (simple) chlorination, breakpoint chlorination, superchlorination/dechlorination and chloramination. On small supplies, it is probable that only marginal chlorination would be used in most cases. Marginal chlorination involves the dosing of chlorine to produce a suitable residual free available chlorine concentration.

Breakpoint chlorination could be used for removal of ammonia. Sufficient chlorine is added to exceed the demand for chloramine production and to ensure a free available chlorine residual. The chlorine dose must be carefully controlled to avoid forming dichloramine and nitrogen trichloride which can cause taste and odour problems. Breakpoint chlorination requires a dose of around 10 mg/l chlorine dosed per mg/l ammonia removed – the actual dose depends on water quality and has to be determined for each water.

The resultant free available chlorine residual should remain in the range 0.2 to 0.5 mg/l. It is recommended that the contact time should be at least 30 minutes. The design of the contact system is very important. Applied chlorine must be mixed rapidly with the water and the system must not permit short-circuiting or retention in dead zones.

6.9.3.4 Control of chlorination

Residual control is the most common method of control where chlorine is dosed continuously into the water. If the quality of the water and hence the chlorine demand varies appreciably, it is necessary to use a control system to maintain a constant chlorine residual. A sample of chlorinated water is withdrawn downstream of the chlorination system and the chlorine residual in the treated water is monitored continuously. The signal from the chlorine analyser system is used to adjust the chlorine dose thus maintaining the required residual chlorine concentration. Where water quality is invariably good, constant rate control or flow proportional control may be appropriate. In the former, a constant dose of chlorine is applied and in the latter a chlorine dose proportional to the flow of water is applied automatically under control of a signal from the flow sensor.

6.9.4 Ozone

Ozone is a powerful oxidant and disinfectant that effectively destroys bacteria and viruses. It is also more effective than chlorine in the destruction of *Cryptosporidium* oocysts. However it cannot be relied upon as the sole means of disinfection of waters that may contain *Cryptosporidium* under the conditions of dosing and water temperature normally used and found in the UK. Ozone may also reduce levels of colour, taste and odour in water. Ozonation tends to increase the concentration of Assimilable Organic Carbon (AOC), i.e. that fraction of the total organic carbon which can be utilised by bacteria. This can lead to multiplication of bacteria within the distribution system unless the AOC concentration is reduced by adsorption on granular activated carbon filters.

Ozone is a gas produced by the discharge of an alternating current through dry air. Small units can operate from a 240 Volt mains supply but larger installations require 3 phase 415 Volt supplies or higher. The ozone-containing air is mixed with the raw water in a contact column. For effective disinfection, the ozone contact system should give at least 4 minutes retention time and the ozone residual should be at least 0.4 mg/l throughout the contact period. Ozone decomposes rapidly and does not leave a persistent residual. Unless the water is used immediately, it is advisable to provide a disinfectant residual by applying a small dose of chlorine. Ozone gas is highly toxic and any excess in the vent gases from the contactor must be destroyed using a thermal or catalytic destructor.

Ozone reacts with many organic and inorganic constituents of water, thus there is an ozone demand (analogous to a chlorine demand) that must be satisfied and the ozone dose required should be determined by trials. Ozonation does not produce THMs but does form bromate if bromine compounds are present. The identity and toxicity of many of the organic oxidation products of ozone are unknown.

Small-scale package ozonation equipment is available that could be suitable for treatment of small water supplies. However, ozone is not widely used because of the high power requirements, complexity of the equipment and relatively high capital cost.

6.10 Corrosion control

6.10.1 General

Corrosion is the partial dissolution of the materials constituting the treatment and supply systems, tanks, pipes, valves, and pumps. It may lead to structural failure, leaks, loss of capacity, and deterioration of chemical and microbiological water quality. The internal corrosion of pipes and fittings can have a direct impact on the concentration of some water constituents, including lead, copper and nickel. Corrosion control is therefore an important aspect of the management of a water supply system.

Corrosion control involves many parameters, including the concentrations of calcium, bicarbonate, carbonate, and dissolved oxygen, as well as pH. The detailed requirements differ depending on water quality and for each distribution system material. The pH controls the solubility and rate of reaction of most of the metal species involved in corrosion reactions. It is particularly important in relation to the formation of a protective film at the metal surface. For particular metals, alkalinity (carbonate and bicarbonate) and calcium (hardness) also affect corrosion rates.

6.10.2 Lead

Lead corrosion (plumbosolvency) is of particular concern. Lead piping is still common in old houses, and lead solders have been used widely for jointing copper tube. The solubility of lead is governed by the formation of insoluble lead carbonates. The solubility of lead increases markedly as the pH is reduced below 8 because of the substantial decrease in the equilibrium carbonate concentration. Thus, plumbosolvency tends to be at a maximum in waters with a low pH and low alkalinity, and a useful interim control procedure pending pipe replacement is to maintain pH in the range 8.0 to 8.5 and possibly to dose orthophosphate.

6.10.3 Copper

Copper tubing may be subject to general corrosion, impingement attack and pitting corrosion. General corrosion is most often associated with soft, acid waters; waters with pH below 6.5 and hardness of less than 60 mg/l $CaCO_3$ are very aggressive to copper. Impingement attack is the result of excessive flow velocities and is aggravated in soft water at high temperature and low pH. The pitting of copper is commonly associated with hard groundwaters having a carbon dioxide concentration above 5 mg/l and high dissolved oxygen. Surface waters with organic colour may also be associated with pitting corrosion. A high proportion of general and pitting corrosion problems are associated with new pipe in which a protective oxide layer has not yet formed.

6.10.4 Nickel

Concentrations of nickel up to 1 mg/l may arise due to the leaching of nickel from new nickel-chromium plated taps and from stainless steel pipes and fittings. Nickel leaching falls off over time. Increase of pH to control corrosion of other materials should also help to reduce leaching of nickel.

6.10.5 Concrete and cement

Concrete is a composite material consisting of a cement binder in which an inert aggregate is embedded. Cement is primarily a mixture of calcium silicates and aluminates together with some free lime. Cement mortar, in which the aggregate is fine sand, is used as a protective lining in iron and steel water pipes. In asbestos–cement pipe, the aggregate is asbestos fibres. Cement is subject to deterioration on prolonged exposure to aggressive water – due either to the dissolution of lime and other soluble compounds or to chemical attack by aggressive ions such as chloride or sulphate – and this may result in structural failure. Aggressiveness to cement is related to the 'Aggressivity Index', which has been used specifically to assess the potential for the dissolution of concrete. A pH of 8.5 or higher may be necessary to control cement corrosion.

6.10.6 Characterising corrosivity

Most of the indices that have been developed to characterise the corrosion potential of waters are based on the assumption that water with a tendency to deposit a calcium carbonate scale on metal surfaces will be less corrosive. The Langelier Index (LI) is the difference between the actual pH of a water and its 'saturation pH', this being the pH at which a water of the same alkalinity and calcium hardness would be at equilibrium with solid calcium carbonate. Waters with positive LI are capable of depositing calcium carbonate scale from solution.

There is no corrosion index that applies to all materials, and corrosion indices, particularly those related to calcium carbonate saturation, have given mixed results. The parameters related to calcium carbonate saturation status are, strictly speaking, indicators of the tendency to deposit or dissolve calcium carbonate (calcite) scale, not indicators of the 'corrosivity' of water. For example there are many waters with negative Langelier Index that are non-corrosive, and many with positive LI that are corrosive. Nevertheless there are many documented instances of the use of saturation indices for corrosion control based on the concept of laying down a protective 'eggshell' scale of calcite in iron pipes. In general waters with high pH, calcium and alkalinity are less corrosive and this tends to be correlated with a positive LI.

The ratio of the chloride and sulphate concentrations to the bicarbonate concentration (Larson ratio) has been shown to be helpful in assessing the corrosiveness of water to cast iron and steel. A similar approach has been used in studying zinc dissolution from brass fittings - the Turner diagram.

6.10.7 Water treatment for corrosion control

To control corrosion in water distribution networks the methods most commonly applied are adjusting pH, increasing the alkalinity and/or hardness, or adding corrosion inhibitors such as sodium polyphosphates or silicates and orthophosphate. The quality and maximum dose to be used should be in line with appropriate national specifications for such water treatment chemicals. Although pH adjustment is an important approach its possible impact on other aspects of water supply technology, including disinfection, must always be taken into account.

Treatment to reduce plumbosolvency usually involves pH adjustment. When the water is very soft (less than 50 mg/l $CaCO_3$), the optimum pH is about 8.0 to 8.5. Alternatively, dosing with orthophosphoric acid or sodium orthophosphate might be more effective particularly when plumbosolvency occurs in non-acidic waters. Wherever practicable, lead pipework should be replaced. Grants for pipe replacement may be available from the local authority and some water companies offer a lead pipe replacement service.

6.11 Treated water storage

A water supply system needs to include some form of treated water storage to provide a reserve of drinking water in the event of planned maintenance or problems with the source or treatment and to cater for fluctuations in demand. Storage may take the form of a small covered reservoir, providing sufficient head to supply more than one property, or may be a suitably positioned storage tank (e.g. in the roof space of the property), from which water flows under gravity to the taps.
The tank or reservoir should hold a volume sufficient to accommodate the peak demand and the maximum period of interruption of supply.

The storage tank, and other parts of the water supply system, may be contaminated during construction and should therefore be disinfected before use. This may be achieved by filling the system with a strong (20 mg/l) solution of chlorine and leaving to stand for several hours, preferably overnight. The chlorine solution should be drained off and the system rinsed thoroughly using treated water.

All storage tanks must be insulated to guard against freezing during the winter. Insulation will also prevent the water from warming up too much during the summer months. The tank must be fitted with a lockable, well-fitting (but not airtight) lid to exclude light and pollutants. It is especially important to guard against the ingress of insects and animals and all openings must be protected using a fine mesh screen.

The storage tank must be inspected regularly; at least annually and preferably every six months. If necessary, any accumulated silt can be flushed or siphoned out and the system disinfected as described above.

6.12 Maintenance and training requirements

One of the most neglected aspects of small water supply systems is maintenance. The usual practice is to deal with equipment failures as they arise, with the risk that contaminated water will be supplied until the problem is fixed. Proper maintenance involves a regular, preventive, maintenance programme. This enables early identification of problems. Equipment manufacturer's maintenance instructions must be followed as a minimum requirement. Simple checks can be used to give forewarning of problems:

- daily (or more frequent) check on operation of disinfection equipment (e.g. check that UV lamp is on, measure chlorine residual);
- investigate causes of dirty or discoloured water;
- regular cleaning of filters, sedimentation tanks and so on;
- site inspection to check for signs of pollution of the water source; and
- structural inspection of the treatment plant, storage tanks and pipework.

Maintenance should always be performed by people familiar with the equipment. Some suppliers of treatment equipment may offer maintenance and servicing contracts. At the time a water treatment plant is installed and commissioned, the supplier should provide training on routine operation and maintenance tasks. The training should cover:

- checking that treatment is operating correctly;
- topping-up chemicals as required;
- routine maintenance of the equipment; and
- making simple repairs.

This on-site training should be supported by appropriate documentation, such as an operation and maintenance manual.

SECTION 7

POINT OF USE/POINT OF ENTRY TREATMENT

Section Contents

7.1 Introduction

A point of use (POU) device is any form of water treatment apparatus within a householder's premises, normally at the point of supply. Usually, only water for drinking and cooking is treated, so the householder must be made aware of the need to use the dedicated tap.

Point of use devices for small water supplies may need appropriate pre-treatment, and careful attention must be paid to maintenance.

7.2 and 7.3 Point of entry and point of use systems

Both are either single or multiple units, used to purify water by the removal of solids, chemicals and disinfectants. Point of entry (POE) systems are located outside the premises; point of use systems within, normally at the kitchen sink. However, the main difference is that in most POU systems, water cannot be stored following treatment.

7.4 Considerations of point of use treatment

In private water supplies, two or more systems will usually be needed, e.g. UV disinfection would need a pre-filter to remove turbidity.

7.5 Particulate filters

Particle filters can reduce turbidity and micro-organisms, or remove specific inorganic particulates like iron, aluminium or manganese compounds. Many are incorporated into proprietary point of use devices to protect subsequent processes such as activated carbon filtration, reverse osmosis or UV disinfection.

Filter replacement is after a specific time or volume depending on the quality of water being treated. Some filters have silver to prevent or inhibit bacteria. Hard water may block the device, and manufacturers' advice should be sought.

7.6 Reverse osmosis (RO) units

RO units will remove e.g. sodium, calcium, nitrate and fluoride, as well as pesticides, solvents and pathogens, but raw water supplies will usually require pre-treatment.

The RO membrane needs chemical cleaning, usually after several years, and periodic disinfection of the storage tank is recommended.

Water treated by RO will generally be very soft and will have insufficient fluoride to protect against dental caries, but this may be the only practicable means of rendering water potable. Some units have a 're-hardener' system.
RO also tends to waste water, but there may be no alternative.

7.7 Nitrate removal units

Ion exchange can be used to remove nitrate ions from water. However, excessive chloride concentrations could result and lead to corrosion of pipework and fittings.

Also, where this treatment is applied to a source with unsatisfactory bacteriological quality, it will be necessary to provide a disinfection stage after the resin.

7.8 Adsorption filters

Activated carbon - Granular activated carbon (GAC) is the most common medium employed although powdered activated carbon (PAC) and block carbon are also used.

Activated carbon filters will remove (to varying degrees) suspended solids, chlorine and organic contaminants, but their effectiveness can be limited by POU devices.

There is also concern that direct consumption of water from activated carbon devices may cause health problems due to bacteria from them.

Activated alumina filters - can remove arsenic and other chemicals, including fluoride.

SUMMARY 7.9 – 7.12

7.9 Water conditioners

Ion-exchange softeners – necessitate a separate unsoftened drinking water supply.

‘De-alkalisation’ can also soften water, and resins are available as disposable cartridges that must be replaced as recommended by the manufacturer.

Chemical water conditioners – can reduce scale formation, and can be installed under mains pressure, but a disinfection stage may also be needed.

Physical water conditioners – generate magnetic or electrical fields or release trace concentrations of zinc or other metals, causing the calcium salts to encrust less. However, these devices are not proven, and they may also need a disinfection stage.

7.10 Disinfection units

Ultraviolet irradiation – POU units are available for domestic use. They should be as close as possible to the drinking water tap and are most effective with water of low colour and turbidity. Manufacturers’ guidelines must be closely followed.

Chlorination – generally unsuitable for point of use treatment.

Ozonation – small package ozone units are available for a single home or business.

Combination devices – include a pre-treatment so the POU device can be effective.

7.11 Maintenance requirements

Regular maintenance is essential for safe drinking water. Manufacturers’ maintenance instructions are a minimum requirement, since they may assume the equipment treats mains drinking water, while raw waters for private supplies will always be of worse quality than this.

Key points to observe include disconnecting power before servicing; changing filter cartridges regularly and using special care to replace and clean UV lamps.

7.12 Quality assurance of point of use devices

Background – protocols have been produced for evaluating water treatment units.

NSF standards – developed by an independent, not-for-profit organisation working with manufacturers, users and regulators.

The test protocols – only products that conform to the test protocols or relevant (e.g. NSF) standards should be used for treatment of drinking water.

Private Water Supplies

This page is intentionally blank

7 POINT OF USE/POINT OF ENTRY TREATMENT

7.1 Introduction

A point-of-use device is any form of water treatment apparatus that may be installed or used by a householder within his premises and normally at the point of supply. A point-of-use device may be installed before the householder's tap (plumbed in-line or otherwise attached to the water pipe), connected to the tap by an adapter or separate from the plumbing system (such as a free-standing gravity filter). These devices handle relatively small volumes and it is usual for only water used for drinking and cooking to be treated. The treated water is supplied to a separate tap. It is important that the householder is made aware of the need to use the dedicated drinking water tap. Moreover, point of use treatment may not be appropriate if the untreated water would pose a risk to health if used for bathing or washing. In any case, it may be necessary to consider the possibility of providing an alternative supply, rather than attempting to improve a supply of inferior quality.

Some point of use devices have been designed and developed to provide additional treatment to mains water, although equipment designed for use with raw water sources is available. The manufacturers' recommendations regarding installation and maintenance are often based on arbitrary assumptions that take no account of the quality of individual water sources. In some cases quality typical of municipally treated water supplies is assumed. Recommendations concerning the replacement of filters are often vague and maintenance requirements may be underestimated. If the quality of water to be treated is poorer than mains water, maintenance requirements will be increased.

Contaminants in a raw water source may be present at higher concentrations than in a public supply and may affect the performance of some point of use devices. For example hardness compounds may precipitate on filters and membranes and iron and manganese compounds may deposit on UV tubes. Some manufacturers of point of use devices incorporating activated carbon specifically state that their devices should not be used on waters that are microbiologically unsafe or of unknown quality.

The foregoing observations do not rule out the application of point of use devices to small water supplies but appropriate pre-treatment may be required and careful attention must be paid to maintenance of the device. Where there is any doubt as to the effect of water quality on the performance of a point of use device, water quality data should be obtained and expert advice on the applicability of the device should be taken.

7.2 Point of entry

This is best described as a system, either a single unit or multiple units, which is used for the purifying of water by the removal of solids, chemicals and disinfectants.

It is important to remember that the point of entry system is located outside the premises and can, in fact, be some distance from the premises.

Depending on the system used the water may be stored after use. Table 7.1 details point of entry treatment systems.

7.3 Point of use system

This is best described as a system, either of a single or multiple units, which is used for the purifying of water by the removal of solids, chemicals and disinfectants.

The difference with the point of use treatment is that it is located within the premises, normally at the point of supply i.e. kitchen sink.

The main difference, however, is that in most points of use treatment, water cannot be stored following treatment.

Table 7.1 Point of entry treatments

Type of Treatment	Description	Removal of Parameters	Uses	Advantages	Disadvantages	Cost
Coagulation and flocculation.	The addition of chemical coagulant causing floc or precipitate which entraps impurities.	Turbidity, algae, iron, aluminium, solids.	Mostly on large scale private water supplies.	One of the best methods of removing algae. Does not require power supply.	Operational difficulties, knowledge of system, disposal of sludge, does not kill bacteria.	Relatively high.
Sedimentation (storage and settlement).	Water stored in a suitable tank or chamber where the reduced velocity of the flow allows particulate to settle out.	Solids, turbidity, colour.	Excellent system for small scale supply.	Will remove the majority of suspended solids; usually requires cleaning annually. Does not require power supply.	Contamination from ground water if installed incorrectly, does not kill bacteria.	Relatively low.
Screens.	Various sizes of screens and microstrainers.	Particulate material and debris.	Useful for supplies fed from surface water run offs eg streams, small lochs.	Useful for removal of particulate material. Does not require power supply.	Requires cleaning during parts of heavy use. Does not kill bacteria.	Relatively low.
Sand Filters.	Various types of sand filters available – slow sand filters rapid gravity sand filters & pressurised sand filters.	Removal of floc in conjunction with coagulation and flocculation, turbidity, colour, algae and some micro-organisms.	Can be used in some areas to treat upland surface waters. Has got potential for treatment of small scale supplies.	Will remove the majority of suspended solids and also excellent for removing algae.	Some operational difficulties, knowledge of systems, does not kill bacteria. Some require power supply.	Medium to expensive.

Table 7.1 Point of entry treatments (Cont'd)

Type of Treatment	Description	Removal of Parameters	Uses	Advantages	Disadvantages	Cost
Gravel Filters.	Water run through a tank containing gravel beds of different sizes of gravel.	Removal of turbidity, colour and algae.	Excellent system for small scale supplies.	Filters may only require cleaning once over several years. Does not require power supply.	Matching size of filter with flow rate.	Relatively low.
Chemical removal oxidation, ion exchange, reverse osmosis after ultra, micro and nano filtration.	Removal or iron, maganese, taste, odour and nitrate.	As per specific systems.	From small scale supply to larger.	Excellent systems for removal of specific chemicals.	Knowledge of system and also contamination of system from bacteria. Some require power supply.	Relatively low to relatively expensive.
Disinfection Chlorine.	Application of chlorine by use of various methods to disinfect the supply.	Pathogenic bacteria.	Suited to large scale supplies.	Residual effect excellent for stored waters.	Operational difficulties, knowledge of system. Requires power supply.	Relatively high.
Disinfect Ozone.	Disinfection of the water supply using ozone.	Pathogenic bacteria and viruses, ozone may also reduce colour, taste and odour.	Larger scale supplies.	–	Operational difficulties, knowledge of system. Requires power supply.	Exceedingly expensive.
Disinfection UV Radiation.	The passing of UV light into the water.	Pathogenic bacteria and viruses.	Excellent for small scale supplies.	Simple to operate.	Required power supply.	Relatively cheap.

Table 7.1 Point of entry treatments (Cont'd)

Type of Treatment	Description	Removal of Parameters	Uses	Advantages	Disadvantages	Cost
pH Control.	The passing of water through substances which will either increase or reduce the pH.	pH alteration.	From small scale supplies to large supplies.	pH control which affects other systems prevents plumbosolvency. Does not require power supply.	Does not kill bacteria.	Relatively cheap.

Table 7.2 Point of use systems

Type of Treatment	Description	Removal of Parameters	Uses	Advantages	Disadvantages	Cost
Particulate Filters.	Filters of pleated paper, woven cartridges, resin bonded cartridges or ceramic candles.	Particulate matter and inorganic particles.	Usually used to protect another point of use device such as UV disinfection.	Excellent for removing particulate matter.	Prone to blockage, can contaminate water with bacteria as bacteria can grow within the filters.	Relatively low to medium.
Activated carbon filters.	Utilisation of activated carbon to absorb suspended solids and other chemicals.	Suspended solids, turbidity, colour, taste, odour, chlorine, particulates, THMs.	Excellent system for removal of listed parameters and to protect other point of use systems.	Best method for removing listed parameters in small scale supplies.	Bacteria growth within the filter which can result in contamination of water supply.	Low to medium.
Reverse Osmosis Units.	The removal of contaminants by use of the reverse osmosis process.	Solids, turbidity, colour and to varying degrees, inorganic and organic chemicals.	Mostly for medium size private water supplies.	Excellent system for removal of most organic and inorganic substances.	Wastes a great deal of water. Reduces the hardness and alkalinity to unacceptable levels.	Medium to relatively high.
Anion exchange units.	The removal of ions using the anion exchange or the cation exchange method.	Used for the removal of calcium, magnesium and nitrate.	Small scale to large supplies.	Excellent system for removal of nitrates.	Regeneration requires to be carried out, softened water could have elevated sodium levels.	Low to medium.

Table 7.2 Point of use systems (Cont'd)

Type of Treatment	Description	Removal of Parameters	Uses	Advantages	Disadvantages	Cost
Disinfection unit (UV).	The passing of the UV radiation through the water to kill bacteria.	Removal of bacteria.	Small to large scale supplies.	Effective for the killing of pathogenic bacteria.	Requires continuous maintenance and bulb replacement mains supply.	Low to medium.

7.4 Considerations of point of use treatment

Some point of use devices are designed specifically to augment mains supply by the removal of chemicals such as chlorine.

In private water supplies where the condition of the water falls below that of the public supply, problems can be encountered with devices not operating correctly due to the vast quantities to be removed or the addition of such other contaminants which affect the capability of the unit. These results mean usually having to provide two systems or more to ensure effectiveness of the system. In particular, if water supplies with a high turbidity and colour are to be disinfected by UV radiation, a pre-filter will require to be fitted to remove turbidity and colour as the UV radiation is ineffective in highly coloured and turbid waters.

7.5 Particulate filters

There are several types of particulate filters using different media to remove suspended matter from water in the range 0.5 to 50 µm, or greater. Particulate filters may be used to reduce turbidity and micro-organisms, or to remove specific inorganic particulates such as iron, aluminium or manganese compounds. Many particulate filters are incorporated into proprietary point-of-use devices to protect subsequent processes such as activated carbon filtration, reverse osmosis or UV disinfection.

Filters are made in several forms, for example discs, woven or resin-bonded cartridges and ceramic candles. Filtration is effected by pleated paper and felt, woven cartridge filters manufactured from viscose, polypropylene, fibrillated polypropylene, nylon or fibreglass, non-woven cartridges manufactured from resin-bonded polyester, and Kieselguhr ceramic.

Water passes through the filter and particles and micro-organisms may be retained depending on the pore size of the filter. Particle removal may be achieved by surface filtration or by retention within the filter material. Some of the cartridge and ceramic filters have graded pore sizes so that larger particles are retained on the surface while smaller particles penetrate the filter where they are retained. As the filter blocks the flow rate of water decreases and this is often the first sign that a filter needs replacing or cleaning. Replacement of a filter is usually recommended after a specific time or after a specific volume of water has been filtered and filtration period will depend on the quality of water being treated. A ceramic candle may additionally require periodic cleaning of the surface. Growth of bacteria on these filters and the possible contamination of the treated water are of concern. Some filters are impregnated with silver to prevent or inhibit the growth of bacteria.

The treatment capacity of these filters depends on the water quality, water pressure and the pressure drop across the filter, which in turn is dependent on pore size and porosity. An 18 cm ceramic candle operating under gravity may have an output of 20 litres per day whereas a 13 cm ceramic candle operating at 3 bar may have an output of 150 litres per hour. In hard water areas (greater than about 200 mg/l $CaCO_3$), calcium carbonate may precipitate and block the device. The manufacturer's advice on suitability should, therefore, be sought.

7.6 Reverse osmosis units

Reverse osmosis (RO) has been used in recent years for the production of drinking water from low quality raw waters. Large-scale RO plants are used for the desalination of seawater to produce drinking water in countries where adequate supplies of fresh water are not available. Because of the high concentrations of dissolved salts in seawater, the osmotic pressure is high and operating pressures up to 70 bar are used. Domestic RO units operate at much lower pressures, as low as 1 bar, because of the typically lower concentration of dissolved salts in the water to be treated. RO systems will remove, to varying degrees, a range of physically and chemically diverse substances including dissolved inorganic species (e.g. sodium, calcium, nitrate and fluoride) and organic pollutants including pesticides and solvents. RO can also produce pathogen-free water.

The water to be treated by RO must be of good quality to prevent fouling or scaling of the membrane and a raw water supply will usually require pre-treatment.

Raw water enters the RO unit and treated water flows through the semi-permeable membrane, usually manufactured from polyamide. Some membranes such as cellulose acetate may support bacterial growth and are therefore unsuitable. The flow rate of treated water is very low at the pressures used in a domestic unit and the treated water is collected in a storage tank to buffer supply and demand. Usually a level sensor in the storage tank controls the operation of the RO unit.

The membrane does not become exhausted or saturated although it will require periodic chemical cleaning and replacement, usually after several years. The storage tank must be constructed of a material suitable for potable water and be protected from contamination. Periodic disinfection of the tank is recommended. There is evidence that inadequate cleaning of the storage system and pipework associated with RO units can result in proliferation of bacteria that are of health significance.

Water treated by reverse osmosis will generally be very soft. It is not known whether regular long-term consumption of water containing unusually low levels of dissolved inorganic constituents has any effect on health. Such water will contain insufficient fluoride to protect against dental caries. In addition, although there is no established explanation for the tendency for areas supplied with naturally soft water to have higher rates of cardiovascular disease than hard water areas, it appears sensible to avoid regular consumption of artificially softened water where there is an alternative. However, in the context of private supplies RO may offer the only practicable means of rendering potable a water source containing an excess of dissolved inorganic constituents. Some units have a ‘re-hardener’ system to increase the hardness and alkalinity of the treated water, thus rendering it less aggressive. It is not known whether this is a necessary or effective measure to protect health.

A further disadvantage of RO could be that a relatively high volume of water is wasted. Typically, for each volume of drinking water produced, three volumes must be wasted unless it can be used for non-potable purposes such as toilet flushing. RO should be considered if no alternative treatment could make a raw water safe to drink.

7.7 Nitrate removal units

Ion exchange, using nitrate-specific anion exchange resins, can be used to remove nitrate ions from water. Water is passed through a bed of anion exchange resin and the anions in the water, including nitrate, are replaced by chloride ions. The resins used are ‘nitrate selective’, i.e. nitrate is exchanged in preference to other ions such as sulphate and bicarbonate. The chloride concentration in the treated water will invariably be increased, possibly to above the indicator parameter value of 250 mg/l; this could have an adverse effect on the taste of the water but probably would not have implications for health. However, excessive chloride concentrations could lead to corrosion of pipework and fittings.

Ion exchange units are installed in-line and the resin is regenerated as required (manually or automatically) with sodium chloride solution (brine). Microbiological growth on the resin could result in the formation of nitrite from nitrate but, as the brine also acts as a disinfectant, this should not be a problem provided that regeneration is performed at intervals of five days or less. Units incorporating replaceable or disposable cartridges containing resin are also available.

Where anion exchange treatment is applied to a source that exhibits unsatisfactory bacteriological quality, it will be necessary to provide a disinfection stage after the resin.

7.8 Adsorption filters

7.8.1 Activated carbon

Activated carbon removes contaminants from water by physical adsorption. Adsorption will be affected by the amount and type of the carbon, the nature and concentration of the contaminant, retention time of water in the unit, and general water quality (temperature, pH, etc.). Granular activated carbon (GAC) is the most common medium employed although powdered activated carbon (PAC) and block carbon are also used. The filter medium is contained in replaceable cartridges; a particulate filter at the outlet of the cartridge removes carbon fines from the treated water. Other similar types of filter are pre-coated activated carbon filters and filters using different adsorbents, such as bone charcoal (an adsorbent made from charred animal bones, consisting principally of hydroxyapatite together with about 10% by weight of carbon).

Activated carbon filters will remove (to varying degrees) suspended solids, chlorine and organic contaminants including pesticides, trihalomethanes (THMs) and some of the humic substances responsible for the yellow to brown coloration in ‘peaty’ waters. The hydraulic retention time is a critical factor in determining the removal of contaminants. In point of use devices this is often short and can limit the removal of contaminants, particularly pesticides. Domestic devices for treatment of mains water are probably used primarily for aesthetic reasons – removal of compounds causing taste and odour; removal of residual chlorine; partial removal of colour; removal of suspended solids and turbidity.

Unfortunately, activated carbon is an ideal medium for the accumulation and growth of micro-organisms. There is concern that direct consumption of water from activated carbon devices may cause health problems due to bacteria released into the water; inhalation of bacteria-containing aerosols, for example during washing, could also be harmful. Activated carbon removes chlorine from the water, and bacterial growth can occur even on filters treating chlorinated water.

Some filters are impregnated with silver to inhibit the growth of bacteria. However, it has been demonstrated that high numbers of bacteria can be found in water treated by silver impregnated units; apparently silver serves as a selective agent, inactivating some bacteria but allowing others to grow. The problem of bacterial growth will be increased if the user fails to install or maintain the filter as recommended by the manufacturer. Some manufacturers specifically state that their devices should not be used on waters that are “microbiologically unsafe or of unknown quality”.

7.8.2 Activated alumina filters

Activated alumina is manufactured by calcining aluminium hydroxide. Filters containing granular activated alumina can be used for the removal of arsenic and other chemicals, including fluoride. In point of use applications, once the activated alumina bed reaches its capacity, the spent cartridge has to be replaced and disposed of or returned to the supplier for regeneration.

7.9 Water conditioners

7.9.1 Ion-exchange softeners

It is sometimes beneficial to remove calcium and magnesium in order to prevent scaling and encrustation with limescale from very hard waters. Softening is achieved by cation exchange. Water is passed through a bed of cationic resin and the calcium ions and magnesium ions in the water are replaced by sodium ions. Unlike the carbonates and bicarbonates of calcium and magnesium, sodium carbonates and bicarbonates do not cause scale formation or increased use of soap for washing. When the ion-exchange resin is exhausted, i.e. the sodium ions are depleted, it is regenerated using a solution of sodium chloride.

Water softening can reduce the total hardness below that recommended in the UK for artificially softened drinking water (60 mg/l as Ca)[1] and could possibly result in a breach of the UK national standard for sodium (200 mg/l)[2]. Softened water should not be used for drinking but may be used for washing – water softeners of this type are not intended for the production of drinking water. Blending softened and unsoftened water can produce partially softened water, suitable for drinking. In all cases where these devices are installed, a separate unsoftened drinking water supply must be maintained.

The process of 'de-alkalisation' can also soften water. Water is passed through a bed of weakly acidic resin and the calcium ions and magnesium ions are replaced by hydrogen ions. The hydrogen ions react with the carbonate and bicarbonate ions to produce carbon dioxide. The hardness of the water is thus reduced without any increase in sodium levels. De-alkalisation resins are available as disposable cartridges. They must be replaced after the interval recommended by the manufacturer, otherwise they become exhausted or colonised by bacteria during periods of non-use.

[1] The UK Department of Health has stated that "in view of the consistency of the [epidemiological] evidence [of a weak inverse association between natural water hardness and cardiovascular disease mortality], it remains prudent not to undertake softening of drinking water supplies ... it appears sensible to avoid regular consumption of softened water where there is an alternative".

[2] The UK Department of Health has advised that there should be a mandatory standard for sodium of 200 mg/l to help prevent infantile hypernatraemia (raised sodium levels in the plasma, commonly leading to permanent neurological damage) and to assist in reducing sodium intake in the general population.

7.9.2 Chemical water conditioners

Dosing the water with polyphosphate-based compounds can reduce scale formation. The hardness compounds are modified and the problems associated with temporary hardness are eliminated. It is also claimed that a thin protective film forms on the internal surfaces of the pipework, reducing corrosion.

Several devices are available which can be installed under mains pressure, treating the whole flow to a household or only part of the flow. Water contacts the slowly dissolving polyphosphate crystals, which are contained in a replaceable cartridge. The frequency of replacement depends on demand for water but is typically between several weeks and several months.

Chemical water conditioners do not usually affect micro-organisms and if such devices are used to treat water of unsatisfactory bacteriological quality it will be necessary to incorporate a disinfection stage.

7.9.3 Physical water conditioners

A variety of devices on the market generate magnetic or electrical fields for the water to pass through, or may be intended to release trace concentrations of zinc or other metals. Some of these devices must be plumbed into the pipework, whilst others are non-intrusive and can be simply clamped on or wrapped around the pipework. The effect of these devices can be to physically condition the water. The physical conditioning causes no change to the chemical composition of the water and only exerts a physical effect. Since the chemical composition is not changed, the calcium salts still precipitate when the water is heated or concentrated by evaporation. The effect of the physical conditioning, or presence of zinc, is to cause the calcium salts to precipitate differently such that they are less encrusting. Physical conditioning can produce some of the benefits of softening but without actually removing calcium.

Unfortunately there is an inadequate understanding of the design characteristics needed to secure reliable operation of physical water conditioners. There is ample evidence of the potential of magnetic fields to modify the crystalline structure of precipitated calcium carbonate. However, many other factors appear to determine the performance of specific products under defined conditions of water quality and design of the water supply system. These factors include: flowrate, magnetic field strength, temperature, time lag between conditioning and use of water and concentration of iron in the water supply. Until these devices are conclusively proven to work, it is recommended that physical conditioners should only be purchased from firms offering an extended-time money-back guarantee.

Physical water conditioners do not affect micro-organisms and if such devices are used to treat water of unsatisfactory bacteriological quality it will be necessary to incorporate a disinfection stage.

7.10 Disinfection units

7.10.1 Ultraviolet irradiation

UV disinfection is discussed fully in Section 5.9.2. Point of use UV disinfection units are available for domestic use. These units are installed in-line. No residual disinfecting capacity is imparted to the treated water so the unit should be located as close as possible to the drinking water tap. UV devices are most effective when the water is of low colour and turbidity. UV devices are often installed together with other upstream treatments, such as filtration, to prepare the water for effective disinfection.

Manufacturers' recommendations must be followed regarding installation, operation and maintenance. In particular, the maximum design flow rate should not be exceeded, lamps should be allowed to reach their operating temperatures before water is passed through the unit and lamps should be cleaned and replaced as recommended. A continuous UV monitor and an alarm or fail-safe device is strongly recommended and although not usually fitted as standard on point of use units, they are usually available as an extra.

7.10.2 Chlorination

Chlorination is discussed fully in Section 5.9.3. Chlorination is generally unsuitable for point of use treatment.

7.10.3 Ozonation

Ozonation is discussed fully in Section 7.9.4. Small package ozone units are available, suitable for the treatment of water for a single home or business

7.10.4 Combination devices

Some point of use devices require a high quality water in order to operate effectively, for example reverse osmosis units and ultraviolet irradiation units require that the influent water is of very low turbidity. Where such devices are used on small supplies, pre-treatment of the water may be required. Combination devices are designed for this purpose and it is usual for point of use devices that require a high quality of water to include pre-treatment units. The Test Protocols described in Chapter 7 require that the device is tested in association with any pre-treatment unit that is specified by the manufacturer.

7.11 Maintenance requirements

Point of use water treatment equipment in general is not 'fit and forget' technology – regular maintenance is essential to ensure the continued supply of safe drinking water. Equipment manufacturers' maintenance instructions must be followed as a minimum requirement. Ideally maintenance requirements should reflect the raw water quality and flow, but this is often not the case and instructions may be vague. Manufacturers' maintenance instructions may be based on the assumption that the equipment will be used to treat mains drinking water. Raw waters used for private supplies will always be of worse quality than public supplies and maintenance requirements quoted for treatment of feed water of potable standard will be inadequate.

Maintenance requirements must be clear and the consequences of failing to maintain adequately should be highlighted. The majority of devices that fail do so as a result of inadequate maintenance. Special points to observe include:

- Power supplies should be disconnected prior to servicing.
- Filter cartridges must be changed on a regular basis. The water supply must be turned off before the housing is unscrewed and the cartridge is removed. The housing should be rinsed out with clean water (only use cleaning materials if specified by the manufacturer) and the new cartridge installed. The old cartridge may be contaminated and must be disposed of safely; precautions should be taken to prevent contamination of the replacement filter. Manufacturers of point of use devices should provide, within their instructions for filter units, guidance on the safe handling and disposal of used filter elements.
- UV lamps should be disconnected from the electricity supply and withdrawn carefully. Replacement is simply the reverse operation but care must be taken not to handle the glass. Exposure to UV irradiation must be avoided.
- Intermittent operation may reduce the life of a UV lamp and frequent on/off operation should be avoided (this may invalidate any warranty). Low pressure lamps give out little heat and will not be damaged by operation under no flow conditions. However, scale formation may be greater under these conditions and more frequent cleaning of the quartz sleeve may be required. Again care must be taken when withdrawing and installing the sleeve.

7.12 Quality assurance of point of use devices

7.12.1 Background

A series of test protocols has been produced as an aid for anyone with responsibility for the installation or operation of small drinking water systems. The purpose of the protocols is to provide a consistent basis for evaluating and reporting on the claims made for the performance of water treatment units. It is recommended that testing be carried out in laboratories accredited to ISO 9000 or equivalent for testing or calibration that is relevant to the protocols. Each protocol represents a standard of good practice. Compliance with a protocol does not confer immunity from relevant legal requirements.

The protocols were drafted by the Committee on Point of Use Device Test Protocols. This Committee was appointed by the Department of the Environment in 1991 to provide advice to local authorities on water treatment for private water supplies. Production and editing of the protocols was carried out by WRc under the terms of a DOE research contract.

The protocols incorporate existing standards produced by British Water and were developed on the basis of existing copyrighted standards (ANSI/NSF Standards 42, 44, 53, 55, 58 and 62) produced by NSF International. British Water and NSF International played an active role in developing the protocols and their contributions and permission to make use of copyright material are gratefully acknowledged.

7.12.2 NSF standards

NSF International is an independent, not-for-profit organisation that works with manufacturers, users and regulators to develop and maintain standards, then tests and evaluates products to their requirements. NSF's Drinking Water Treatment Unit (DWTU) programme has the following standards for point of use and point of entry treatment technologies:

- ANSI/NSF 42: Drinking water treatment units - Aesthetic effects
- ANSI/NSF 44: Cation exchange water softeners
- ANSI/NSF 53: Drinking water treatment units - Health effects
- ANSI/NSF 55: Ultraviolet microbiological water treatment systems
- ANSI/NSF 58: Reverse osmosis drinking water treatment systems
- ANSI/NSF 62: Drinking water distillation systems

7.12.2 NSF standards (continued)

All have basic requirements that products must satisfy in order to be certified to the standard:

- verification of contaminant reduction claims made by the manufacturer or assembler for which certification is requested;
- structural integrity testing of the product;
- toxicological assessment and acceptance of all materials used in the fabrication of the product;
- extraction testing and health effects assessments of all materials in contact with the water to assure the product is not adding any substance of toxicological significance; and
- review and acceptance of all labelling and sales literature used with the product.

All certified products bear the NSF Mark and appear in the listing book and on the internet at www.nsf.org.

7.12.3 The test protocols

The following Sections provide a summary of the principal requirements and testing specified in the protocols. All of the protocols include general requirements relating to the suitability of materials in contact with drinking water. The following summaries cover the performance requirements specified in the protocols. The actual protocols should be consulted regarding the detailed requirements and test methodology. The protocols are available in *Adobe Acrobat* format and can be downloaded from http://www.dwi.detr.gov.uk/regs/protocol/index.htm.
Annexes 6.A – 6.E reproduce these test protocols.

It is recommended that only products that conform to the requirements of the test protocols, or relevant standards of international standing (e.g. NSF standards), should be used for treatment of drinking water.

Annex 7.A

7.A Ultraviolet (UV) disinfection units

7.A.1 Performance requirements

Performance indication. Systems shall be equipped with a UV sensor and alarm to monitor UV transmission or intensity through the water during operation.

Disinfection performance. Disinfection performance for a UV system shall provide a minimum UV dose equivalent to 38,000 µW.sec/cm^2 at the fail-safe point.

UV alarm performance. The alarm shall operate for at least 100 on-off cycles.

7.A.2 Testing

Challenge water is specified as chlorine-free water spiked with *Bacillus subtilis* spores (5×10^4 to 1×10^5 spores/ml). Sufficient parahydroxybenzoic acid (PHBA) is added to reduce UV light transmission to the fail-safe set point in the device.

A calibration is performed to determine the actual UV sensitivity of the *Bacillus subtilis* challenge used in the performance test method. This is done by using a radiometer to determine the output of a UV lamp (not the unit under study). Then samples of challenge water in petri dishes are irradiated for various time periods to provide a graph of organism survival versus total UV dose which is interpolated to determine the inactivation for a UV dose of 38,000 µW.sec/cm^2.

Testing of flow-through systems is carried out in duplicate using an operating cycle of 50 percent on, 50 percent off with a 15 to 40 minute cycle, 8 hours per day over a 10 day period. Samples of influent and effluent water are collected at specified sampling points. A test method is also given for batch treatment systems. To pass the protocol, the geometric mean of all *B. subtilis* spore counts on influent samples minus the geometric mean of counts on all effluent samples have to demonstrate a reduction of *B. subtilis* equal to or greater than the reduction caused by a dose of 38,000 µW.sec/cm^2.

A UV alarm system performance test is performed to determine that the UV alarm sensor provided with the system will activate 100 consecutive times in response to decreased UV intensity. The dose of PHBA sufficient to activate the alarm system is determined. This dose is then injected into the feed to the unit in order to activate the alarm. This is repeated 100 consecutive times.

Annex 7.B

7.B Activated carbon filter units

7.B.1 Performance requirements

Rated capacity. The manufacturer or supplier shall state the activated carbon filter rated capacity. This will be confirmed by conducting contaminant reduction tests. This rated capacity will allow for an over-run of at least 20% (e.g. to achieve a rating of 10,000 litres a unit would have to treat 12,000 litres).

Chemical contaminant reduction. The unit may be classified for chemical contaminant reduction in one of the categories below for each chemical contaminant tested.

Category	Reduction (%)
A	≥90
B	70 to 89
C	50 to 69
No category	<50

Silver leaching. The silver content in treated water samples shall not exceed 80 µg/l.

Microbiological growth potential. The geometric mean of the treated water Total Viable Counts (flowing samples) shall be no greater than five times the geometric mean of the influent TVC. The TVCs in stagnation samples shall be no greater than ten times the geometric mean of the TVCs of the influent samples. There shall be no demonstrable increase in *Pseudomonas aeruginosa* numbers. Samples taken immediately after start-up shall have total and faecal coliform counts not exceeding 0 per 100 ml.

Taste and odour. The flowing sample taken at 120% capacity shall comply with the standards for taste and odour.

7.B.2 Testing

The test conditions, test apparatus and test water quality are specified in detail. Duplicate units are tested and water samples are taken to correspond to treated water volumes of 25, 50, 75, 100 and 120% of the manufacturer's claimed capacity. Plumbed-in units are run with an operating cycle of 10% on, 90% off, with a 15 to 40 minute cycle (e.g. 3 min on, 27 min off), for not more than 16 hours per day, 7 days per week. Two stagnation periods are imposed: one period of 80 ± 8 hours after 50% capacity and one of 7 to 10 days after 100% of claimed capacity. Surrogate compounds may be used to test removal of PAHs, phenols, surfactants and THMs but for other species individual compounds have to be tested.

A microbiological growth potential test is conducted to determine whether a filter supports microbiological growth. Silver leaching and taste and odour testing are carried out at the same time. The suitability of the test rig has to be determined prior to the test. The basic test procedure is the same as for chemical reduction testing. For each sampling time (e.g. corresponding to 20% of capacity), samples of influent and effluent are taken and analysed .The odour and taste of the 7-day stagnation sample taken at 100% capacity and the flowing sample taken at 120% capacity are determined. Where an activated carbon filter has silver impregnated carbon and/or other silver treated components in contact with the filtered water the treated water is tested to determine the amount of silver being leached.

Annex 7.C

7.C Ceramic and cartridge filters

7.C.1 Performance requirements

Mechanical filtration units. Claims for particulate reduction may be made for the classes below provided that at least 85% removal of the specified size rating is achieved.

Class	Rating (μm nominal)
I	0.5 to less than 1
II	1 to less than 5
III	5 to less than 15
IV	15 to less than 30
V	30 to less than 50
VI	50 and up

Bacteriological filtration. Claims for reduction of pathogenic bacteria may be made where filtration efficiency of greater than 99.9% is measured against a particle size of 0.5 to 1.0 μgm. Claims for cyst reduction may be made where filtration efficiency of greater than 99.9% is measured against a maximum particle size of 1 to 1.5 μgm.

Filter media. All media, which may be subject to blocking, shall be tested to withstand the maximum pressure drop stipulated by the manufacturer.

Bacteriostatic units. The geometric mean of the treated water Total Viable Counts (TVCs) (flowing samples) shall be no greater than five times the geometric mean of the influent TVC. The TVCs in stagnation samples shall be no greater than ten times the geometric mean of the TVCs of the influent samples; and there shall be no demonstrable increase in *Pseudomonas aeruginosa* numbers.

Silver leaching. The silver content in treated water samples shall not exceed 80 μg/l.

Microbiological contamination. Samples taken immediately after start-up shall have total and faecal coliform counts not exceeding 0 per 100 ml.

Pressure drop. The pressure drop across the clean filter cartridge and housing shall not exceed that specified by the manufacturer at the rated service flow.

7.C.2 Testing

The test conditions, test apparatus and test water quality are specified in detail. Duplicate units are tested. Particulate test water is prepared using standard test dusts. Challenge water is fed to the filters and two successive feed and effluent particle counts are determined for each of the two filters under test.

To test the integrity of the filter media, challenge water is pumped through the test filter until the manufacturer's stated maximum pressure drop is achieved. Influent and effluent samples are checked for turbidity and evidence of media in the effluent.

The pressure drop across the unit is determined by measuring the influent and effluent pressures of the unit under flow.

A test is conducted on filters claimed to be bacteriostatic. Silver leaching testing is carried out at the same time. The suitability of the test rig has to be determined prior to the test. Test water is run through the unit using a cycle of 50% on, 50% off with a minimum cycle time of two hours. Samples of influent and effluent are taken after 25, 50, 75, 100 and 120% of the manufacturer's claimed capacity. In addition, the filter units are allowed to stagnate for a period of 80 ± 8 hours at 50% capacity and for a period of 7 to 10 days at 100% capacity.

Annex 7.D

7.D In situ regenerated ion-exchange nitrate removal units

7.D.1 Performance requirements

Accuracy of the brine system. The brine refill and draw system shall be accurate to within ±5% of the manufacturer's stated figures.

Rated nitrate capacity. The claimed capacity shall be based on the average volume of treated water per pressure vessel produced in three runs between successive regenerations. The treated water nitrite concentration shall be no more than 0.1 mg/l.

Regeneration water volume. The total volume of regeneration water for each pressure vessel shall not exceed 18 bed volumes (BV).

Rinse effectiveness. On completion of a normal regeneration cycle the conductivity of the treated water shall not be more than 20% higher than the conductivity of the mains or test water.

Overrun. When overrun by a factor of twice the rated capacity volume the treated water nitrate level shall not exceed 110% of the influent test water and the nitrite concentration shall not exceed 0.1 mg/l.

Microbiological contamination. Samples taken immediately after start-up shall have total and faecal coliform counts not exceeding 0 per 100 ml.

Microbiological colonisation. Samples of treated water taken one day before and one day after regeneration shall have total viable counts (22 °C, 72 hour) no greater than 100 times the corresponding influent water counts.

7.D.2 Testing

The test conditions, test apparatus and test water quality are specified in detail. Test water has a nitrate concentration of 150±10 mg/l as NO_3, a sulphate concentration of 250±10 mg/l as SO_4, and a nitrite concentration <0.01 mg/l as NO_2. The suitability of the test apparatus for bacteriological testing has to be demonstrated prior to the test run. The unit is conditioned over five exhaustion/regeneration cycles prior to testing. At this stage the coliform counts are measured to check for microbiological contamination. The volume of the brine system is measured five times to determine its accuracy.

The rated nitrate capacity is determined by running the unit and determining nitrate concentrations at intervals. The regeneration water volume is measured during these runs. The overrun test is conducted in a similar manner, running the unit to twice the rated nitrate capacity.

Rinse effectiveness is determined by comparing the conductivity of the test water and treated water immediately following regeneration.

To test whether the resin bed becomes colonised by micro-organisms to an unacceptable extent, samples of influent and treated water are taken and Total Viable Count (22 ˚C, 72 hours) is determined.

Annex 7.E

7.E Reverse osmosis units

7.E.1 Performance requirements

Total Dissolved Solids reduction. Reverse osmosis systems shall reduce the TDS by at least 75%.

Chemical reduction. The system shall reduce the level of contaminant from an influent challenge level of twice the regulated value. The unit may be classified according to the removal achieved, as for activated carbon units (Section 7.3.1).

Product water contamination. Treated water shall be monitored for metals used in the product and the arithmetic mean of all samples and 95% of the individual product water samples shall comply with the regulated concentrations of these metals.

Microbiological growth potential. The geometric mean of the treated water Total Viable Counts shall be no greater than five times the geometric mean of the influent TVC. There shall be no demonstrable increase in *Pseudomonas aeruginosa* numbers.

Microbiological contamination. Samples taken immediately after start-up shall have total and faecal coliform counts not exceeding 0 per 100 ml.

7.E.2 Testing

The test conditions, test apparatus and test water quality are specified in detail. For testing TDS reduction by reverse osmosis membranes a 750 mg/l sodium chloride solution is used (conductivity 1500 µS/cm). For testing nanofiltration membranes a magnesium sulphate solution with a conductivity of 1000 µS/cm is used. The unit is operated continuously and conductivity is measured every five minutes for one hour.

To test chemical reduction, the unit is operated for 7 days against challenge water spiked with contaminants and run continuously. A minimum of 20 samples is taken from the outlet tap and the samples shall be taken at intervals of not less than three hours. The concentrations of metals are measured in the permeate during the chemical contaminant reduction tests to check for contamination from metals in contact with treated water.

The suitability of the test apparatus for bacteriological testing has to be demonstrated prior to the test run. The reverse osmosis unit is checked for microbiological contamination by starting the unit up and immediately sampling for total coliforms, faecal coliforms and total viable count (22 °C, 72 h). The test for microbiological contamination is made on at least 20 samples taken at intervals of not less than three hours.

SECTION 8

TREATMENT FOR RADON AND URANIUM

Section Contents

SUMMARY 8.1 – 8.2

8.1 Radon removal

Introduction – removal is mainly by decay storage, GAC or aeration. Location is crucial for hydraulic reasons and radiation exposure. Point of use systems are not acceptable.

Decay storage is feasible for low levels of activity only.

Granular activated carbon – filters must be shielded or isolated. Certain levels cause disposal problems, and filters must be handled with care.

Aeration is the preferred treatment. There are many methods and radon can easily be vented. The system may need a pressure tank or additional pump.

8.2 Uranium removal

Ion-exchange (preferred) and reverse osmosis are the only suitable options for private supplies. Removal is rarely practised, so professional advice must be sought.

Private Water Supplies

This page is intentionally blank

8 TREATMENT FOR RADON AND URANIUM

8.1 Radon removal

8.1.1 Introduction

There are three main treatment methods for radon removal – decay storage, GAC (Granular Activated Carbon) and aeration. Due to the large size of the radon atom, it can also be removed by reverse osmosis and nanofiltration techniques. With all the removal systems, location is a key issue, both for hydraulic reasons and radiation exposure. Some systems may require an additional pump to be installed, or a bypass system. This increases the complexity of the system. Where a system results in the build-up of radioactive substances, it may not be appropriate to keep it under the sink. On the other hand, if the radiation risk means that there is a need to build an extra outbuilding to house a unit, the cost may be prohibitively expensive. For radon removal, point of use systems fitted to the drinking water tap (as opposed to point of entry systems, which treat the entire supply) are not acceptable as radon is released wherever water is used in the house and it can then be inhaled. Table 8.1 summarises the features of the principal methods for radon removal.

8.1.2 Decay storage

As radon (^{222}Rn) has a half-life of 3.82 days (i.e. its radioactivity halves every 3.82 days), it is possible (provided that mixing and short-circuiting are avoided) to store it to achieve an adequate reduction in radioactivity. The amount of time required will depend on the level of activity.
An eight-fold reduction would take two weeks to achieve. For household consumption, this would typically require two 10 m^3 tanks, used alternately – impracticably large for most locations. With a lower activity level, requirements would be less and this option may be feasible.

8.1.3 Granular activated carbon

GAC was first used in the US in 1981 for radon removal. The method has been found to be very effective and is generally quoted as achieving about 95% radon removal. GAC is commonly used for removing taste, colour, odour and synthetic organic chemicals. It works by adsorption and the extremely high internal surface area within the porous structure is responsible for its effectiveness. GAC filters are described in Section 8.8.1.

The main drawback of GAC is that as the radon is trapped in the filter, the radioactivity of the filter increases. Although radon decays rapidly, there is a continuously increasing radioactivity due to other radionuclides being trapped and the build up of longer-lived radionuclides further down the radon decay chain (notably ^{210}Pb). As such, it is important to either shield the filters or place them in a separate shed outdoors or in an unused basement. There are also disposal problems with these levels – the filters have to be handled with care.

Table 8.1 Radon removal techniques

Treatment option	Efficiency	Availability	Disposal issues	Approximate cost per household	Other issues
Decay storage	Up to 100%	Storage tanks readily available.	Good ventilation system required (or very large tanks).	Variable, depending on size of tank and ventilation system.	Low maintenance. Would need to be designed for each site. Would require further testing and monitoring. Cannot handle higher levels easily.
GAC specifically designed for radon removal	Variable. Up to >99.9%	Common technology. Many carbon suppliers and suitable apparatus.	Carbon becomes radioactive and high radiation doses reported around filter as well – needs careful placement/shielding. Used filter may need specialist disposal.	£500 - £1,000, assuming no pre-treatment and no new building required. Possible annual filter replacement and high disposal costs.	Widely used in USA. Computer program available for home users (free download from EPA) to assess radiation risks and removal rates. Waste disposal and maintenance are key concerns. A number of available carbons have been specifically tested for radon removal. Not as effective or 'safe' as aeration.
GAC – standard water treatment package	Unknown. May be up to 99.9%	Yes – domestic water treatment companies.	As GAC above.	About £2,500.	Provides a complete water treatment system. From initial observations, size of GAC filter too small for effective radon removal. No specific units have quoted radon removal rates. Expensive, and complex waste/maintenance issues.
Aeration	Up to >99.9%	Widely used technology but not for this application at this scale – companies are able to design and test systems. A few ready-tested ones available.	Adequate ventilation required.	£1,000 upward. Running costs about £20 p/a.	Can operate without pre-treatment, unless water is very hard and needs softening. Some very good package systems available. Low maintenance – one annual clean recommended. With less disposal issues, no radiation build up and reasonable costs, aeration appears to be the best solution.

8.1.3 Granular activated carbon (continued)

With local authority permission, substances up to a radioactivity of 15 Bq/g can be disposed of to landfill with other household waste. The time before the filter reaches this level will depend on activity levels of radon in the raw water and on the retention time in the GAC. Once a GAC filter is taken out of service its radioactivity will fall as the adsorbed radon and other radionuclides decay – it has been shown that after three to four weeks out of service the activity of a GAC unit can be close to background levels.[1]

In order to avoid clogging of the filter and to extend its life, it may well be necessary to pre-treat the water.

8.1.4 Aeration

Aeration is the preferred treatment for radon removal. In the natural environment this process ensures that most waters coming from springs in radon emitting rocks quickly lose their radon to the atmosphere. The main reason why problems occur with radon in many private supplies is because the water is either abstracted from the rock directly or very soon after. There are many different aeration methods (Section 5.6). With aeration, radon can be easily vented to the outside air. This prevents build up of radiation levels and means there are no disposal issues. As such, the system will, typically, require less maintenance. Depending on the system, there may be a need for a pressure tank or an additional pump.

[1] Lowry, J.D. and Brandow, J.E. (1985). Removal of radon from water supplies. *Journal of Environmental Engineering* 111(4), 511-527.

8.2 Uranium removal

Unlike radon, uranium does not transfer from water to air once inside houses and thus treatment at point of use seems more appropriate than treatment at point-of-entry. Point of use treatment has the potential advantage that much smaller volumes require treatment. Many methods are available for removing heavy metals from water and as such there is no shortage of possible solutions to a problem with uranium but ion-exchange and reverse osmosis are the only suitable options for private water supplies, the former is normally the preferred method. For ion-exchange, by changing the resin in commercially available water softening equipment it will be possible to easily provide effective treatment systems. Reverse osmosis is also effective. It has the advantage that package point of use systems are available that can be used without any modifications. Uranium removal is rarely practised so advice should be sought from professional water treatment equipment suppliers or consultants. Table 8.2 summarises available systems.

Table 8.2 Uranium removal techniques

Treatment option	Efficiency	Availability	Disposal issues	Approximate cost per household	Other issues
Reverse osmosis Point of use (under sink)	>95%	Package systems available from domestic water treatment suppliers.	Waste stream unlikely to be a problem. There will be a build up over time on the membrane and to some extent on any preceding GAC filter; this should be monitored.	About £500. Running costs about £40 a year.	Pre-treatment for radon removal required. Possibly a need for shielding of the system, due to build-up on the RO membrane. No direct process guarantees from manufacturers. Regular changing of the membranes and any pre-filters would be required.
Reverse osmosis Point of entry (whole supply)	>95%	Package systems available from domestic water treatment firms. Also available from medical sector.	As above.	About £2,500, with £200 a year running costs.	Possible need for shielding/careful location. Again, no direct process guarantees. Regular filter changes required. Generally, treating far more water than is required.
Ion-exchange Point-of-use (under sink)	>95% (dependent on resin)	Many water softeners available. Suitable resins (to replace those in the softeners) are also available.	Resin can be effectively regenerated, meaning no long term build-up. Regenerant stream should be suitable for disposal (sufficient dilution possible).	From £500, plus resin cost. Low annual running cost (£20?) depending on water usage and type of system.	Well proven and effective system, although no tests done in UK. As such, a testing regime may be of benefit. The type of resin used is very important. Note: Not used as a softener.
Ion-exchange Point-of-entry	>95% (dependent on resin)	As above.	As above.	Similar to above; higher running cost.	As above. Treating far more water than required.

This page is intentionally blank

SECTION 9(S)

LEGISLATIVE BACKGROUND – SCOTLAND

Section contents

Private Water Supplies

SECTION 9(S)

Private Water Supplies

Private Water Supplies

9(S).1 Summary

The primary driver for legislative change is the revised Drinking Water Directive (Council Directive 98/83/EC[1]). This fundamentally updates the previous Drinking Water Directive 80/778/EEC[2] to take account of medical, scientific and technological advances and lays down prescribed standards on the quality of water intended for human consumption. The Directive is transposed into domestic legislation, in respect of private water supplies, through the Private Water Supplies (Scotland) Regulations 2006 ("the 2006 Regulations"). Other drivers for change include the World Health Organisation Guidelines on Drinking Water Quality and the *E.coli* 0157 Task Force Report of June 2001, which included a number of significant recommendations in relation to private water supplies.

The World Health Organisation's Guidelines and the Task Force Report stress the benefits of carrying out a thorough risk assessment from water source through treatment to the point of consumption, rather than just undertaking the more usual and regular monitoring and sampling of a private supply which provide water quality information at a specific point in time. The 2006 Regulations incorporate these recommendations and latest guidance.

The Water (Scotland) Act 1980 ("the 1980 Act") remains the primary legislation pertaining to water supplies in Scotland.

Rather than the widely cast objective of the previous Drinking Water Directive (80/778/EEC) which was *"concerned with standards for water intended for human consumption"*, the purpose of the revised Directive is much more targeted. Article 1 of the revised Directive states that:

"The objective of this Directive shall be to protect human health from the adverse effects of any contamination of water intended for human consumption by ensuring that it is wholesome and clean".

This means that the informal approach of the Private Water Supplies (Scotland) Regulations 1992 which simply encouraged 'relevant persons' to maintain and improve supplies will no longer be sufficient. The 2006 Regulations therefore require formal action to be taken to ensure that water quality standards meet the stringent requirements of the revised Directive.

The 2006 Regulations will have a significant impact on larger supplies – defined in the Drinking Water Directive as those providing 10m^3 or more of water a day or serving 50 or more persons, and supplies to commercial or public activities irrespective of their size. These supplies will be required to meet the revised quality standards set by the Directive and are referred to as Type A supplies in the 2006 Regulations. Supplies which do not fall within the scope of the Directive , including smaller supplies, are referred to as Type B supplies in the 2006 Regulations and will be subject to a set of nationally set quality parameters very much in line with existing provisions.

[1] OJ L330, 05.12.1998 P32

[2] OJ L229, 30.08.1980 P0011 - 0029

9(S).1.1 The main changes

(a) The 2006 Regulations amend the 1980 Act to place a duty on local authorities to monitor larger, Type A private water supplies. In relation to Type B supplies, local authorities will continue to have discretionary powers basically in line with their current obligations under the 1980 Act and the 1992 Regulations.

(b) Public or commercial premises, such as hotels, campsites and holiday lets will need to ensure that their private water supply meets the revised quality standards specified in the 2006 Regulations and the Directive. These premises will also be required to prominently display an information notice. This notice is intended to alert tourists, particularly those from vulnerable groups, that the water is from a private supply and allow them the informed choice of whether they wish to consume the water.

(c) The long term expectation is that all Type A private water supplies will eventually meet the quality standards set by the Directive. However, until that standard can be achieved, the 2006 Regulations enable derogations to be granted from the prescribed quality standards provided that *"no derogation constitutes a potential danger to human health and provided that the supply of water intended for human consumption cannot otherwise be maintained by any other means"* (Article 9 of the Drinking Water Directive). Derogations are strictly time limited. There is an initial period of up to three years which can be extended to six years to ensure private supplies comply with the revised quality standards. In exceptional circumstances the Commission may sanction a further derogation not exceeding three years. **There can be no derogation in respect of microbiological parameters since these pose an immediate risk to health.**

(d) The 2006 Regulations require the cause of a supply failure to be investigated and established and for appropriate remedial action to be taken. A key aspect of the Executive's policy to meet this Directive obligation is the introduction of risk assessments based on World Health Organisation guidelines. Risk assessments are seen as an essential element of an effective drinking water quality surveillance and control programme. The 2006 Regulations place local authorities under a duty to complete a risk assessment for Type A supplies and to provide information and advice to enable owners to complete a risk assessment for Type B supplies. A completed risk assessment links the 2006 Regulations with the Grant Scheme.

(e) The 2006 Regulations provide for local authorities to recover through charges the costs they incur through carrying out monitoring, sampling and the completion of risk assessments.

9(S).1.2 Role of the Drinking Water Quality Regulator for Scotland

The role of Drinking Water Quality Regulator for Scotland was established in the Water Industry (Scotland) Act 2002 ("the 2002 Act") to provide independent verification that water quality legislation is being complied with. The 2002 Act provides the Regulator with wide ranging powers in respect of drinking water quality for both public and private supplies.

The extent of the Regulator’s supervisory functions in respect of private water supplies will increase and local authorities will need to satisfy the Regulator that they are effectively carrying out their functions under the 2006 Regulations and the 1980 Act. This enhanced role is necessary as Member States are required to demonstrate compliance with the water quality standards set down in the Drinking Water Directive.

9(S).2 Guidance for The Private Water Supplies (Scotland) Regulations 2006

9(S).2.1 Introduction

This Section of the Guidance is intended to be read alongside the text of the Private Water Supplies (Scotland) Regulations 2006 ("the 2006 Regulations). **It does not purport to offer any authoritative interpretation of the 2006 Regulations.** The 2006 Regulations revoke the 1992 Regulations, and the 1980 Act remains the primary piece of legislation regarding private water supplies in Scotland.

9(S).2.2 Part I - General

9(S).2.2.1 Regulation 1 – Citation and commencement

The 2006 Regulations may be cited as the Private Water Supplies (Scotland) Regulations 2006. The coming into force date for these Regulations is 3 July 2006.

9(S).2.2.2 Regulation 2 - Interpretation

Private water supplies vary in size from those that serve one household to those that serve several hundred. In some cases, consumers own the land their supply is located upon, but this is rare and is even less likely to apply to the whole catchment area for their supply. The 2006 Regulations recognise these types of complexities with a flexible approach that places responsibility for securing the wholesomeness of a private supply on a 'relevant person'.

The 2006 Regulations are underpinned by the definitions set out in regulation 2, and the most significant of these are explained below.

(a) "Domestic distribution system"

Under the Drinking Water Directive, certain obligations relating to the quality of water intended for human consumption purposes fall upon "relevant persons". In specified circumstances those obligations do not apply, in particular when any deterioration in the quality of water supplied may be attributed to a domestic distribution system (DDS) except in premises and establishments where water is supplied to the public.

The DDS is usually the pipe work and other fitments within the curtilage of premises and which are the responsibility of the owner or occupier of the premises, rather than a relevant person. In certain circumstances the DDS may extend beyond the immediate boundaries of the property to the point of connection to a distribution network. The distribution network is the system (including pipes, fittings and appliances) used to convey a private water supply from its source or point of collection to a DDS.

(b) "Human consumption purposes"

The definition of “human consumption purposes” in regulation 2 is derived from Article 2(1) of the Directive and includes water used for drinking, washing or cooking, or food production purposes and for personal hygiene activities, such as brushing teeth.

Water used in any food-production undertaking for the manufacture, processing, preservation or marketing of food products intended for human consumption purposes is covered by this definition unless the local authority is satisfied that the quality of water cannot affect the wholesomeness of the foodstuff in its finished form.

(c) “Private water supply”

A “private water supply” is, by default, any supply of water which is not provided by Scottish Water as part of its core functions. The definition in the 2006 Regulations differs slightly from that in the 1980 Act. The definition is the same as that in section 47(2) of the Local Government in Scotland Act 2003. This refinement to the 1980 Act definition of “private water supply” is desirable as the 2006 Regulations will act as a route into the Grant Scheme for private water supplies.

(d) “Type A supply”

Article 3 of the Drinking Water Directive provides for limited exemptions from its provisions. These exemptions relate to natural mineral waters and medicinal products, which are covered by separate legislation, and water which has no influence either directly or indirectly on the health of consumers, for example, water used for crop washing, or during the distillation of spirits. See also section 9(S).2.5.2.

The Directive also permits water intended for human consumption purposes from an individual supply providing less than $10m^3$ a day as an average or serving fewer than 50 persons to be exempted **unless the water is supplied as part of a commercial or public activity.**

Any private water supply which does not meet one of these exemption criteria is subject to the Directive’s requirements. The 2006 Regulations refer to supplies which are subject to the full application of the Directive as a “Type A supply”, defined as:

“a private water supply for human consumption purposes which:

- on average provides 10 or more cubic metres of water per day or serves 50 or more persons, or
- regardless of the volume of water provided or the number of persons served, is supplied or used as part of a commercial or public activity”.

In determining whether a supply serves 50 or more persons for the purpose of this definition, it is the maximum occupation of the premises served by the supply which is to be considered, to ensure that the appropriate level of monitoring is undertaken to protect human health. In addition, if the supply is provided as part of a commercial or public activity then the supply is a Type A supply.

The Directive does not define the term ‘commercial or public activity’ it is Executive policy that local authorities should view commercial or public activities as including all food production undertakings (except where the quality of the final product is not affected by the quality of the water), caravan sites, campsites, bed and breakfast establishments, all holiday let accommodation, church and village halls. This list is not exhaustive.

Tied or tenanted properties which provide essential long term affordable domestic rural housing should not be treated as a ‘commercial activity’ for the purposes of the 2006 Regulations. The strengthened provisions of housing legislation are seen as the more appropriate route for addressing problems of substandard housing.

Tenants, who may be at no more risk than those in owner-occupied housing, will be at liberty to request that their local authority undertake quality checks of their drinking water. They can also apply for financial assistance through the Grant Scheme to help bring their supply up to modern standards. Local authorities will be under a duty to take appropriate action if there was an immediate risk to the health of any tenant in their area arising from an unwholesome supply of water.

(e) “Type B supply”

Smaller private water supplies providing less than $10m^3$ of water per day or serving less than 50 persons are defined as Type B supplies in the 2006 Regulations. These supplies will almost exclusively be to domestic properties. Type B supplies are exempt from the full provisions of the Drinking Water Directive and are subject to national water quality standards.

In terms of the 2006 Regulations, local authorities have discretionary powers in respect of Type B supplies. These powers supplement section 76F of the 1980 Act, which places a duty on every local authority to take all such steps as they consider appropriate to keep themselves informed about the wholesomeness and sufficiency of water supplies provided to premises in their area, including every private supply to any such premises.

9(S).2.2.3 Regulation 3 – Application of Regulations

The 2006 Regulations, apart from regulations 34(2) and 35, do not apply to private supplies used solely for the distillation of spirits, solely for washing crops after harvesting, solely for washing and cleaning down equipment but for no other purpose. Before exempting these private supplies from the requirements of the 2006 Regulations, the local authority must be satisfied that the quality of the water does not affect, either directly or indirectly, the fitness for human consumption of any food or drink or, as the case may be, spirits in their finished form.

9(S).2.3 Part II – Relevant Persons

9(S).2.3.1 Regulation 4 – Determination and notification of relevant person

Article 4 of the Drinking Water Directive requires action to be taken to ensure that water intended for human consumption purposes is wholesome and clean. The 2006 Regulations address this by requiring local authorities to determine for their respective interests the persons who, individually or collectively, provide the supply of drinking water; occupy the land from, or on which, the supply is obtained or located; or exercise powers of management or control in relation to the supply. Such persons are "relevant persons" for the purposes of the 2006 Regulations. The definition is intended to provide sufficient flexibility to take account of the wide variety of arrangements through which people access private water supplies. In making determinations, local authorities must have regard to any agreement, contract, or licence relating to the terms on which the water is supplied.

The local authority is under a duty to inform all those determined by it as relevant persons of that determination in writing, stating its reasons for that determination.. The local authority must inform all such relevant persons as soon as is reasonably practicable after the determination has been made.

It is anticipated that for the vast majority of private water supplies local authorities will already have details of persons likely to be determined relevant persons through the implementation and maintenance of the previous regulatory regime as set out in the 1992 Regulations.

9(S).2.3.2 Regulation 5 - Appeal against determination of relevant person

Where a person has been determined a relevant person, and are aggrieved by that determination, that person has a right of appeal against the decision by way of summary application. The appeal must be lodged within 21 days from the date of notification of the determination by the local authority of them as a relevant person. While the appeal is pending, any actions which may be required to be undertaken by the relevant person are not enforceable.

Rules and Guidance on Summary Application Procedures can be found on the court service website under "Rules and Legislation" at:

http://www.scotcourts.gov.uk/sheriff/summary_cause/guidance_notes.asp

9(S).2.4 Part III – Classification of private water supplies

9(S).2.4.1 Regulation 6 – Classification and level of supplies

Under the provisions of this regulation monitoring local authorities are under a duty to classify all private water supplies falling under their jurisdiction as either Type A or Type B supplies, according to the definitions given in regulation 2 i.e. a private water supply for human consumption purposes which on average provides 10 or more cubic metres of water per day or serves 50 or more persons, or regardless of the volume of water or the number of persons served, is supplied as part of a commercial or public activity is classified as a Type A supply. In the absence of other evidence assume occupancy at 2.5 persons per dwelling.

In addition Type A supplies are further classified into three distinct levels to fall in line with the sampling requirements imposed by the 2006 Regulations and the Directive. The greater the water usage per day the greater the sampling requirement that is needed to ensure that it is representative of the quality of water consumed.

If the volume of water provided by the supply is not known then an estimate of the volume may be made based on the number of consumers who will be provided for by the supply assuming that every five persons are equivalent to 1 cubic metre of water per day. The number of persons involved should be estimated by assessing the maximum number of persons likely to be served by the supply for their domestic purposes on any one day during the previous calendar year. The volume of water involved should be estimated from the maximum daily volume likely to be distributed or used in the current calendar year for domestic purposes.

While regulation 2 provides for estimates to be made on the basis of the previous year's consumption and/or occupancy rates, regulation 6 requires estimates to be made against the current year. The intention of regulation 6(2) and 6(3) is to ensure that all available evidence is taken into account by local authorities when they are deciding on the appropriate level of surveillance for a Type A supply, and they do not just use a *de minimis* approach by defaulting to figures that may have been used in the previous year. Accurate, auditable decision processes regarding the levels being set are required hence the requirement in regulation 6 to base estimates on the current year. This requirement does not prevent local authorities from using prior knowledge of the supply to assist in reaching its decision about the level (the process described in regulation 2). An example to illustrate this point may further assist in the interpretation of regulation 6.

A campsite, previously assessed as having a maximum of 40 pitches (maximum occupancy 160 persons or $32m^3$ water consumed – level 1) has expanded since the last assessment to provide a bunkhouse (occupancy 20), cafeteria, bar and an additional 40 pitches. The expansion of the site will raise the volume of water, at maximum occupancy, to $105m^3$ i.e. level 2. If the assessment had only taken account of the previous year's information, this hypothetical supply would have been misclassified.

In the case of supplies to premises used for commercial food production (the manufacturing, processing, preserving, preparing or marketing of food or drink for sale), the appropriate level should be determined on the basis of the estimated volume of water used in the food production process. Supplies to hotels and restaurants preparing food or drink for consumption on the premises should be classified according to the estimated volume of water used on the premises. Supplies to hospitals, other residential establishments and staff canteens should be assessed in the same way, as should supplies serving campsites, village halls, properties used for holiday lettings, and any other similar establishments with changing populations.

A multi-purpose supply which serves domestic properties as well as commercial or public activities such as food production undertakings and / or premises with changing populations should be classified as a Type A supply according to the estimated volume of water supplied.

9(S).2.5 Part IV - Wholesomeness

9(S).2.5.1 Regulation 7 – Wholesomeness: Private Water Supplies

Regulation 7 amends and updates the definition of "wholesome" in the 1980 Act and prescribes standards of wholesomeness for water supplied to any premises from a private water supply for human consumption purposes in respect of Type A supplies. In particular, regulation 7 provides that water is wholesome if it contains concentrations or values in respect of various properties, elements, organisms and substances that do not contravene the prescribed maximum, and in some cases, minimum concentrations or value (PCV). Some of the PCVs' are specified in regulation 7 but all are included in Tables A to C in Schedule 1 to the 2006 Regulations.

For Type A supplies the Directive's standards must be complied with, in the case of water supplied from a distribution network, at the point within premises or an establishment, at which it emerges from the tap that is normally used for human consumption purposes (the first point at which water entering a premises is likely to be consumed). The relevant person(s) shall be deemed to have fulfilled their obligations where it can be demonstrated that non-compliance with a standard is due to the domestic distribution system except in premises and establishments where water is supplied to the public.

It should be noted that regulation 2 defines "human consumption purposes" as including the maintenance of personal hygiene and so the requirement for the wholesomeness standard to be complied with will also extend to premises where water is provided to consumers via taps e.g. bedrooms, which may be used for activities such as preparation of beverages or cleaning of teeth. While individual local authorities will form their own views, it is understood that merely labelling taps, such as those found in bedrooms, with notices such as "not for drinking" or similar wording, is not sufficient to ensure that consumers do not consume water that is potentially unwholesome. All taps likely to be utilised for human consumption purposes should be capable of providing a wholesome supply of water.

Regulation 7(4) states that the standards for wholesomeness are to be complied with at the consumer's tap except in the case of water supplied from a tanker or intermittent short term supply. The consumer's tap is not defined in the 2006 Regulations or the Directive. Local authorities should assume that the consumer's tap to be used for monitoring to determine compliance with wholesomeness standards are those taps that are normally used for human consumption purposes. In a domestic property this tap is usually the cold water tap in the kitchen that is used for drinking and food preparation purposes. Uni-flow mixer taps (i.e. taps where the hot and cold water mix within the spout) should not be used for compliance testing – appropriate alternative sampling points should be identified within the premises being sampled such as the next available cold tap after the kitchen tap. Dual flow mixer taps may be used provided the water sample is taken from the tap when only the cold water valve is open. Local authorities may find it useful to record the sample tap location (e.g. kitchen cold water tap, downstairs cloakroom cold water tap) and type of tap as this could help with an subsequent investigations of failures required under Part VI or Part VIII of the 2006 Regulations where the failure may be the result of components of the domestic distribution system.

Detailed information about the properties and contaminants of water are contained in Section 2 of the Technical Manual. Section 3 provides more information about factors likely to impact on the principle sources of private supplies and their susceptibility to pollution. Section 10 provides more information on sampling techniques.

Where the wholesomeness standard of the private water supply cannot be maintained and in circumstances where the failure cannot be considered for a temporary departure, local authorities should consider the availability of powers under the Water (Scotland) Act 1980 to require Scottish Water to provide an alternative supply of water to the affected properties until such time as the wholesomeness standard can be achieved. This power does not affect other statutory avenues such as the serving of notices. Section 9(S).4 provides more details regarding these provisions.

9(S).2.5.2 Private Water Supplies utilised by Food Production Undertakings

A significant number of food production undertakings are dependent on a private supply for their water. These undertakings will be classified as a Type A supply for the purposes of the 2006 Regulations unless the local authority is satisfied that the quality of water has no influence, either directly or indirectly on the quality of the final production for human consumption.

The use of private water supplies as part of a food production undertaking could include the following activities:

- washing of foodstuffs (in particular high risk, ready to eat food such as salad items, fruit, or vegetables;
- cleaning of food production equipment, utensils and surfaces;
- as a food ingredient;
- for the production of ice; and
- for hand washing by food handlers.

As well as the 2006 Regulations food production undertakings are subject to specific food hygiene regulations, in particular Regulation (EC) No. 852 - 854/2004. For the purposes of Regulation (EC) No. 852 - 854/2004, the term “food hygiene” means the measures and conditions necessary to control hazards and to ensure fitness for human consumption of a foodstuff taking into account its intended use. To this end, food businesses are required to have an adequate supply of potable water to ensure that foodstuffs are not contaminated. In terms of the EC Regulation 'potable water' must meet the minimum requirements laid down in the Drinking Water Directive (as amended by Regulation (EC) No. 1882/2003) on the quality of water intended for human consumption purposes.

The requirement to have an adequate and potable supply of water also applies to moveable and/or temporary premises such as marquees, market stalls and mobile sales vehicles where foods are regularly prepared for placing on the market.

In order to make the maximum contribution to public health it is important for those local authority staff involved in the enforcement of the 2006 Regulations to liaise closely with food safety colleagues.

9(S).2.6 Part V - Type A Supplies: Temporary departure from requirements of Part IV

The long term requirement is that all private water supplies will eventually meet the new quality standards set by the Drinking Water Directive. However, it is recognised that not all supplies in Scotland will be in a position to immediately comply with the new standards. Until the prescribed quality standards can be achieved, Article 9 of the Directive permits Member States to grant a derogation or temporary departure (relaxation) from the chemical standards specified in the Drinking Water Directive.

Part V of the 2006 Regulations empowers local authorities to authorise temporary departures in prescribed circumstances. Temporary departures are strictly time limited and must specify the extent to which any parameter may depart from the prescribed concentration or value specified in Schedule 1 to the 2006 Regulations. There can be no derogation in respect of microbiological standards since any departure from these parameters would potentially result in an immediate danger to human health.

Local authorities are able to authorise temporary departures for supplies where some or all of the properties served by those supplies are in their area. Where only some of the properties served are in their area, the local authority should act jointly, or with the consent of, other local authorities in whose areas the remainder of the properties are situated.

In considering the potential public health consequences of the proposed temporary departure, local authorities should consult their local Health Board and also refer to relevant guidance issued by the Drinking Water Quality Regulator for Scotland as well as information produced by the World Health Organisation.

The granting of temporary departures does not remove the monitoring requirements of Part VII of the 2006 Regulations and the terms of the departure may actually increase the sampling frequency for the parameters in question. The departure only relaxes the concentration or value for that parameter(s) as specified in Schedule 1 to the 2006 Regulations.

The issue of temporary departures is not a consideration for Type B supplies since they are exempt from the provisions of the Drinking Water Directive and are assessed against a suite of nationally set wholesomeness standards.

9(S).2.6.1 Regulation 8 – Application for authorisation of temporary departure in respect of a Type A supply that is not wholesome

Regulation 8(1) of the 2006 Regulations enables a relevant person, in respect of a Type A supply, to make an application for an authorisation of a temporary departure where they have reason to believe that their supply is likely to fail the relevant quality standards. Regulation 8(2) details the information which the relevant person(s) must provide when making such an application.

Temporary departures should not be authorised lightly since they limit full compliance with the 2006 Regulations and undermine their objective of protecting public health. Regulation 8 therefore makes detailed provision regarding the requirements to be met when applying for a departure. The ‘relevant person’ shall promptly inform the population likely to be affected by any application for a temporary departure. Representations, from the affected population, can be made to the appropriate local authority in respect of the application within 28 days from the date of service of the notification.

Regulation 8 requires applicants for a temporary departure to not only provide evidence why a departure is required, but to include a summary of the steps that are necessary to secure compliance with the quality standards of the Directive. Even then, the Directive stipulates that the period for such departures should be limited to as short a time as possible, and no longer than 3 years, in the first instance, and every effort must be made to ensure that by the end of this period the original concern regarding the quality of the drinking water has been addressed to allow the supply to satisfy the full quality standards prescribed in the 2006 Regulations and the Directive.

Within regulation 8 (regulation 8(5)) there is specific provision made for persons notified under this regulation of an application for a temporary departure to make representations to the local authority in respect of the application. Local authorities must ensure that this provision is clearly drawn to the attention of persons notified by the relevant person so that they will have an opportunity of responding to the application should they so desire.

9(S).2.6.2 Regulation 9 - Authorisation of temporary departure: terms and conditions

The decision whether to approve an application from a relevant person for a temporary departure rests with the local authority. Regulation 9(1) requires the local authority to consider representations, received within the 28 day period for making representations, before determining an application for a temporary departure. In addition the local authority must be satisfied that:

- the authorisation is necessary to maintain a supply of water for human consumption purposes;
- a supply of water for those purposes cannot be maintained by any other reasonable means; and

- the supply of water in accordance with the authorisation does not constitute a potential danger to human health.

If the above conditions are satisfied the local authority **may authorise** a temporary departure.

The 2006 Regulations require temporary departures to be limited to as short a time as possible, but sufficient to enable remedial work to be completed, and subject to an initial maximum period of three years. Regulation 9(5) requires the authorisation to detail the terms and conditions imposed on a relevant person whilst the temporary departure is in force. The authorisation must also detail the steps which, in the opinion of the local authority, the relevant person(s) needs to take in order to bring that supply up to required quality standards, together with a timetable and an estimate of the cost of the improvement work and provision for reviewing progress. The authorisation needs to specify the extent to which any parameter may depart from the prescribed concentration or value specified in Schedule 1. Regulation 9(7) places a duty on local authorities to notify the relevant person of the terms and conditions of the temporary departure as soon as is reasonably practicable.

There may be occasions where a local authority is not minded to authorise a temporary departure because it is not satisfied that the authorisation is necessary to maintain a supply of water for human consumption purposes; that the supply cannot be maintained by any other means; or that the supply does not constitute a potential danger to human health. This is dealt with under the provisions of regulation 14.

Where an local authority receives an application for a temporary departure which it considers can be adequately addressed within 30 days of the contravention being identified, the local authority may treat the departure as trivial. Regulation 9(6) details the process in these circumstances.

9(S).2.6.3 Regulation 10 - Authorisation of a second temporary departure

The 2006 Regulations and the Directive recognise that in limited circumstances the period for an initial temporary departure granted under regulation 9 may need to be extended. The granting of a second departure is very much the exception and in recognition of this, Article 9(1) of the Drinking Water Directive requires the Member State to communicate the grounds for its decision on a second departure to the Commission. The 2006 Regulations introduce a number of practical measures to deliver this Community obligation.

The need to consider a second departure should not come as a surprise since the terms of the initial departure notice include provisions for reviewing progress against the proposed timetable for the improvement works. Where there is doubt that a Type A supply will meet the wholesomeness requirements of regulation 7(2) of the 2006 Regulations, local authorities are required to undertake a review to determine whether sufficient progress has been made towards improving the supply. It is suggested that this review should be commenced 6 months before the end of the departure period and should be completed within 2 months of its commencement.

Before granting a departure the local authority must be satisfied that the second authorisation is necessary to maintain a supply of water for human consumption purposes; that the supply cannot be maintained by any other means; and the supply does not constitute a potential danger to human health. It should be noted that using section 76D of the Water (Scotland) Act to oblige Scottish Water to provide a temporary supply would not be an appropriate method of obtaining a supply "by other means" as this power should only be invoked when there is a danger to human health. As a temporary departure cannot be considered in circumstances where the parameter in question would pose a danger to human health, section 76D is not accessible.

Where the local authority proposes to grant a second departure, they must notify the relevant person and the Scottish Ministers of the outcome of that review. The relevant person must then notify other users of the supply of the continuing relaxation of quality standards. The requirements of regulation 9(2) to (5) and (7) will apply to the authorisation of a second temporary departure.

9(S).2.6.4 Regulation 11 - Authorisation of a third temporary departure

Provision is made within the Directive, at Article 9(2), to deal with exceptional circumstances where it may be necessary to seek an authorised departure for a third period. There may be instances where improvements to individual supplies cannot rectify a wider water environment problem caused, for example, by unusually high levels of naturally occurring minerals such as manganese or iron, where treatment alone is not effective.

Applications for a third temporary departure must be approved by the European Commission, rather than the local authority, and so the timescales for triggering an application should be revised to accommodate the increased administration and scrutiny that such an application will receive. Consideration of whether a third departure is necessary should commence 12 months before the expiry of the second departure period. Where a local authority considers that an application for a third departure period is appropriate, it should forward review details and the grounds for the proposed third departure to the Scottish Ministers not later than 10 months before the end of the second departure period.

Where the Scottish Ministers are satisfied that there are exceptional circumstances for the granting of a third temporary departure they will ask the European Commission to approve the authorisation. Article 9(2) of the Directive requires the Commission to take a decision on any such request within three months.

The Directive makes no provision in respect of water supplies which may continue to fail wholesomeness standards at the end of a third departure.

9(S).2.6.5 Regulation 12 - Authorisation of temporary departure: other limitations

Regulations 9 to 11 of the 2006 Regulations enable local authorities to grant temporary departures where they are satisfied that such authorisations do not constitute a potential danger to human health. However, there may be instances where local authorities, whilst satisfied that the requirements of a departure application have been met, may nevertheless wish to limit its scope to an individual source or to particular premises or class of premises. Regulation 12 gives local authorities powers to do this.

For example, if part of a large supply network is being supplied from an additional source which has an iron problem, then the temporary departure application and authorisation may be limited to only those properties affected by the additional source and not the whole of the system.

9(S).2.6.6 Regulation 13 – Authorisation of temporary departure: publicity

The Directive stresses the importance of ensuring that the population affected by a temporary departure is promptly informed of the departure and the conditions governing it. This regulation provides local authorities with additional powers to require a relevant person(s), for example, to display a poster in commercial or public premises or place an advert in local newspapers to ensure that those persons who are affected are aware that water quality standards have been relaxed.

9(S).2.6.7 Regulation 14 – Refusal of temporary departure: notification and publicity

Should a local authority or the European Commission (in the case of a third departure) refuse to grant an application for a temporary departure then the reasons for this refusal must be communicated to the relevant person who shall in turn relay the decision to all those parties identified as having an interest in the application (i.e. those specified in regulation 8(4)(a) to (e)). The result of an application failing to be granted will be that the supply in question will continue to fail the wholesomeness requirements as detailed in regulation 7(2) and the local authority will be obliged to ensure that immediate steps are taken to rectify the situation under powers available in the Water (Scotland) Act 1980. Further details of these actions are provided in Section 9(S)4.

9(S).2.6.8 Regulation 15 - Revocation and modification of temporary departure

This regulation enables local authorities to revoke temporary departures or to modify the conditions attached to them, at any time, where new or additional information comes to light which indicates, for example, that the continuance of the original authorisation is likely to have an adverse effect on the quality of water intended for human consumption purposes.

The regulation requires local authorities to give the relevant person 28 days notice of their intention to revoke or modify an authorisation unless immediate revocation or modification is required in the interests of public health.

9(S).2.7 Part VI – Type A Supplies: Risk Assessments, Investigations and Remedial Action

9(S).2.7.1 Regulation 16 – Type A Supplies: Risk Assessment

The 2006 Regulations and the Directive require local authorities to find out the cause of a supply failure and initiate remedial action. A key aspect of the Executive's policy to meet this Directive obligation is the introduction of risk assessments. Risk assessments are increasingly seen as an essential element of an effective drinking water quality surveillance and control programme. Local authorities are therefore under a duty to complete a risk assessment for Type A supplies in their area. A completed risk assessment provides a route into the Grant Scheme which is designed to help those dependent on private supplies bring their supplies up to the standards of wholesomeness set out in the 2006 Regulations.

For most, if not all, private water supplies, it is not feasible to provide continuous monitoring of the supply or to take daily samples and analyse for a range of parameters. This means that the quality of the drinking water supply is unknown for most of the time and even when samples are taken and analysed, the results only provide information about the drinking water quality at the time the sample was taken and do not provide any assurance about the maintenance or the long term safety of the supply.

For a number of years a complementary approach to sampling has been under development. The approach is based around risk assessment and hazard management and is variously described as risk assessment or water safety planning. The Executive's *E.coli* O157 Task Force Report published in June 2001 recommended that a microbiological risk assessment protocol should be applied to all private water supplies. A similar approach is included in the latest Guidance issued by the World Health Organisation which confirms that *"the most effective means of consistently ensuring the safety of a drinking water supply is through the use of a comprehensive risk assessment and risk management approach that encompasses all steps in water supply from catchment to consumer"*.

Regulation 16 and Schedule 4 incorporate the concept of risk assessment within the regulatory framework. This will ensure that owners and users of private water supplies have access to the best and most up-to-date advice to enable them to identify potential problems for their supply and take appropriate steps to reduce those risks. This approach is intended to provide accessible and usable information so that users and owners of private water supplies can proactively look after their health and the health of those who use the supply.

The primary objectives of a risk assessment in ensuring good drinking water supply practice are the minimization of contamination of source waters, the reduction or removal of contamination through treatment processes and the prevention of contamination during storage, distribution and handling of drinking water. These objectives are equally applicable to larger piped drinking water supplies, small community supplies and household systems and are achieved through:

- development of an understanding of the specific system and its capability to supply water that meets health based targets;

- identification of potential sources of contamination and how they can be controlled;

- validation of control measures employed to control hazards;

- implementation of a system for monitoring the control measures within the private supply;

- timely corrective actions to ensure that safe water is consistently supplied; and

- undertaking verification of drinking water quality to ensure that the recommendations arising from the risk assessment are being implemented correctly and that quality standards meet the prescribed concentrations or values set down in the 2006 Regulations.

The Technical Manual[3] contains detailed guidance, together with a number of case studies, to assist local authorities to complete risk assessments in accordance with the requirements of regulation 16 and Schedule 4.

It is important that local authorities complete risk assessments at the earliest opportunity, but this cannot happen immediately for all Type A supplies in their area. Local authorities should be mindful of the need to have a strategy in place to protect human health should a contamination incident occur, and an action plan to complete the risk assessment as soon as practicable after the coming into force of the 2006 Regulations.

The Executive and health professionals place great importance on risk assessments; they are seen as key to the delivery of real and lasting improvements to private water supplies.

9(S).2.7.2 Regulation 17 - Investigations: Schedule 1 microbiological and chemical parameters

Article 8 of the Directive requires Member States to ensure that any failure to meet the prescribed quality standards is immediately investigated in order to identify the cause and that in such cases consumers are informed promptly and given any necessary advice.

Accordingly, regulation 17 sets out the steps a local authority is required to take when a private water supply fails, or is likely to fail, the quality standards of the 2006 Regulations (these are set out in Tables A and B in Schedule 1 to the 2006 Regulations). Local authorities have a duty to investigate any failure that may occur on a Type A supply.

The meaning of a “failure” is clear. It is when the analysis of a sample taken as required by the 2006 Regulations breaches a prescribed concentration or value specified for the parameters in Schedule 1 to the 2006 Regulations. A local authority may have reason to believe that the water supplied is likely to fail in the following circumstances:

[3] Private Water Supplies: Technical Manual. ISBN: 0 7559 5151 4

- there is evidence from the analysis of samples taken (as required by the 2006 Regulations) that the trend in the concentrations or values of a particular parameter is generally and steadily increasing (or decreasing) towards the prescribed concentration or value. And if the trend continues the water will fail to meet the prescribed concentration or value in the future, say within 5 years;

- no regulatory samples have exceeded the prescribed concentration or value for a particular parameter but there is other evidence, for example from incidents or consumer complaints, that the prescribed concentration or value has been exceeded;

- there is evidence from the risk assessment completed under regulation 16 of an actual or potential risk to human health from the water supply.

Regulation 17(1)(c) requires a local authority to investigate whether a failure to achieve the prescribed concentration or value may be attributable to the domestic distribution system or its maintenance.

Bacteriological parameters may be influenced by the condition of the domestic distribution system and particularly the design and hygiene status of the consumer's tap. Where a failure to achieve the prescribed concentration for Enterococci or *Escherischia coli (E.coli)* occurs the local authority should investigate the cause by taking further samples which may include:

- the original sample point;

- alternative consumer taps at the same property or other properties on the same supply;

- further sampling from related points in the distribution network.

- Additional information may be obtained by:

- review of the outcome of analysis from other samples that may have been taken from the private supply at a similar time to the original sample;

- taking a sample prior to and after disinfection of the consumer's tap;

- taking a swab from the surfaces of the tap that come into contact with the water supply.

The outcome of the further analysis will provide important information on the likelihood that the failure to achieve the prescribed concentration is attributable to the domestic distribution system. There is a strong indication that the failure is attributable to the domestic distribution system in any of the following circumstances:

- the failure to meet the prescribed concentration recurs at the original consumer's sample tap but all other samples meet the relevant prescribed concentrations;

- the failure to meet the prescribed concentration recurs in a sample taken before disinfection of the original consumer's tap but a sample taken following disinfection meets the relevant prescribed concentrations and all other samples meet the relevant prescribed concentrations;

- the failure to meet the prescribed concentration does not recur at the original consumer's tap but Enterococci or *Escherischia coli (E.coli)* are recovered from a swab taken from the surfaces of the tap and all other samples meet the prescribed concentrations.

Failures to achieve the prescribed concentration for copper, lead or nickel at the consumer's tap are commonly associated with the domestic distribution system, as the water interacts with copper or lead pipes (or solder) and brass fittings which contain nickel. The local authority should investigate the extent of these interactions by taking additional un-flushed samples after a suitable stagnation period and from other premises served by the supply.

In a case where a failure is attributable to the domestic distribution system or the maintenance of that system, the owner of the premises, rather than the relevant person, is responsible for rectifying the failure (this is in line with Article 2(2) of the Directive). The local authority, in conjunction with the local Health Board, must inform the owner of the premises of the nature of the failure and provide details of the steps (if any) that, in the opinion of the local authority, it is necessary or desirable for that person and any other consumers of that supply to take in the interests of their health. A copy of the notification should also be sent to the relevant person.

The notice from the local authority should inform the owner of the premises in simple layman terms of:

- the parameter(s) that has failed;

- the concentration or value of that parameter in the sample taken from the consumer's premises;

- the prescribed concentration or value of that parameter;

- the significance of the failure; and

- the reason for the failure.

The notice must also inform the consumer of the steps they should take to remedy the failure. These steps will depend on the nature of the parameter and the cause of the failure. Examples of the steps the local authority may consider are:

- failures of microbiological parameters – advise boiling water for drinking and food preparation pending investigation of the problem – a plumbing inspection may assist in the investigation – where the failure is associated with an individual fitting advise repair or replacement of the pipe work or fitting causing the problem;

- failures of the lead parameter (or other plumbing metals) – advise drawing off the water standing in the pipe work and using for purposes other than drinking or food preparation – advise consideration of replacing the pipe work within the premises contributing to the failure;

- failures of other parameters are likely to be caused by ingress to the pipe work within the consumer's premises (by permeation, leaking pipes or back siphonage) – advise where necessary and appropriate boiling water for drinking and food preparation or not to use water for drinking and food preparation – advise a plumbing inspection – where the failure is associated with an individual fitting advise, repair or replacement of the pipe work or fitting causing the problem.

The Technical Manual[4] provides detailed information on water treatment processes and point-of-use / point-of-entry treatment which may assist with the identification of the cause of the failure and appropriate remedial action.

9(S).2.7.3 Regulation 18 - Investigations: Schedule 1 indicator parameters

The quality standards (parametric values) listed in Tables A and B in Schedule 1 to the 2006 Regulations comprise the minimum requirements for a wholesome and clean supply of water intended for human consumption. Additionally, the values listed in Table C in Schedule 1, are 'indicator parameters', which can provide early warning that the water supply may be likely to fail these minimum quality requirements and constitute a risk to public health. Local authorities must investigate failures and identify appropriate remedial actions.

All occasions when the specifications for the ammonium, coliform bacteria and colony counts parameters are not met at the consumer's tap should be investigated, in particular to determine whether the inability to meet the specification is due to the domestic distribution system or the maintenance of that system. When it is due to the domestic distribution system the local authority must notify the owner of the premises and inform them of the nature of the problem and provide details of the steps, which in the opinion of the local authority, it is necessary or desirable to take in the interests of public health. For the microbiological parameters, that advice could be to boil water for drinking and food preparation, and to get a plumbing inspection to identify and rectify the cause of the problem.

9(S).2.8 Part VII – Type A Supplies: Monitoring

The majority of parameters are subject to either check or audit monitoring. Check monitoring is carried out at a higher frequency than audit monitoring and is designed to collect information at regular intervals on the organoleptic and microbiological quality of water and, where relevant the effectiveness of drinking water treatment. Audit monitoring is carried out at a lower frequency for the purposes of checking that the water supplied meets the quality standards laid down in the 2006 Regulations and the Drinking Water Directive. Each local authority should draw up an annual programme of monitoring which will enable them to take and analyse the number of samples required by the 2006 Regulations.

[4] Private Water Supplies: Technical Manual. ISBN: 0 7559 5151 4

9(S).2.8.1 Regulation 19 – Check monitoring – interpretation

Parameters included for check monitoring are those that have the potential to cause immediate harm to human health or to indicate an immediate risk to human health. For this reason such parameters are sampled for more frequently than other parameters, and no temporary departure may be considered or granted in respect of such parameters.

9(S).2.8.2 Regulation 20 – Audit monitoring – interpretation

The Directive specifies a list of parameters whose concentration or value or level should not be breached such that drinking water does not pose a risk to human health. Parameters subject to audit monitoring may have the capacity to impact upon human health if their concentration or value or level were consistently breached. The parameters may do harm, but the effects are only measurable (in human health terms) after prolonged exposure to the failing limits. While this means that the immediate risk to human health is not as great when compared with parameters subject to check monitoring, the practical implications for private water supplies remain the same, in that the supply will fail the wholesomeness standard should any of the audit monitoring parameters be breached.

9(S).2.8.3 Regulation 21 – Monitoring duties and powers

This regulation enables monitoring local authorities to take and analyse samples from Type A supplies in their area, and requires authorisations or decisions on audit monitoring to be considered by the monitoring local authority when drawing up its sampling programme.

Where a supply is obtained from a temporary source, such as a tanker or similar type of arrangement, specific provisions regarding the monitoring of such supplies must be followed. These are set out in regulation 21(3).

9(S).2.8.4 Regulation 22 – Monitoring: general provision

It is essential that the samples taken under these Regulations provide as accurate an indication of the quality of water for human consumption from private water supplies as possible. Regulation 22(1) recognises this requirement and places a duty on local authorities to ensure samples are taken so as to be representative of the quality of water consumed throughout the year. This envisages that sampling programmes, where only a single samples is required, should cycle through the calendar year on a rolling basis so that every sample from a supply is not always taken in the same season, or even month. For example, a possible solution would be to advance (or retreat) the scheduled sample event by 3 months for every succeeding year which will have the desired effect. Local authorities may wish to utilise a more sophisticated approach but which ever solution is used, cognisance to the representative nature of a rolling sampling programme is required. Where there are several samples to be taken in a calendar year, the sampling events should also be identified such that they give a clear picture of the quality of the supply under a variety of prevailing climatic conditions.

On larger supplies where there are several properties that may be sampled, every effort should be made to ensure that the same premises are not used for all, or even the majority, of sampling events.

When a local authority takes a sample it shall have regard to the requirements specified in regulation 7(4) (a) to (d) in relation to the point of compliance for the purposes of establishing the wholesomeness, or otherwise, of the supply.

All appropriate parameters covered under check monitoring (regulation19) and audit monitoring (regulation 20) will be analysed in accordance with the requirements specified in Schedule 5. Schedule 5 details the analytical methodologies to be used for microbiological parameters (Table A) and the performance characteristics of methods of analysis for chemical and physical parameters (Table B). In practice, Scottish Ministers and their UK partners have undertaken work to provide such equivalence data to the Commission for all of the microbiological methods being used routinely for drinking water analysis in the UK. Local authorities should satisfy themselves that appropriate methods are being used for their samples. For chemical and physical parameters listed in Table B the methodology employed must be capable of satisfying the criteria listed in terms of trueness (trueness is a metrological characteristic which can be defined as the closeness of an average measurement to a "true" value (accuracy is the closeness of a single measurement to the "true" value)); precision (precision is reproducibility – a precise measurement means the same measurement repeated several times with the measurements all being very close to one another); and limit of detection (the smallest detectable concentration an analytical instrument can determine at a given confidence level).

This regulation also requires local authorities to take and commence analysis of a sample upon the request of a relevant person, within 28 days of the request being made. Such a sample must be representative of the quality of water for human consumption and should be measured against the wholesomeness requirements set out in regulation 7(2).

This regulation also gives local authorities the power to take additional samples in order to confirm or clarify the results of previous sampling or to determine the efficacy or otherwise of any remedial action that has been undertaken in respect of the supply.

9(S).2.8.5 Regulation 23 – Numbers of samples: Type A supplies

This regulation specifies the number of samples and the parameters to be monitored in respect of Type A supplies. In addition to the check and audit monitoring parameters that are required to be sampled and analysed, residual disinfectant must also be analysed for under the provisions of this regulation. Where no disinfection is operating on a supply, this should be formally noted rather than recording a zero return for disinfectant residuals.

A local authority, in accordance with regulation 23(2) may reduce the number of check monitoring samples taken in a year. This provision does not remove the requirement to sample all of the check monitoring parameters. Provision for reduced sampling is separate from the provisions in regulation 26 which apply only in respect of audit monitoring parameters. Regulation 26(4) provides that local authorities may use analytical data collected prior to the coming into force of the 2006 Regulations to inform their decisions to reduce check monitoring frequency. Similarly regulation 23(5) and (6) allow the local authority to calculate the appropriate number of samples that will be required to be taken to comply with the 2006 Regulations after they come into force on 3 July 2006 for the remainder of the calendar year 2006.

9(S).2.8.6 Regulation 24 - Monitoring: total indicative dose and tritium

The 2006 Regulations require sampling of private water supplies for the determination of radioactivity. Sampling is to be undertaken at the audit monitoring frequency specified in Table B in Schedule 2. Analysis is required for tritium as an individual radionuclide, which is effectively a screening parameter for the presence of contamination by artificial radionuclides. Monitoring for total indicative dose is routinely achieved by analysis for gross alpha and gross beta activities although it is calculated from the activities of individual radionuclides. The calculation of total indicative dose is only required if any of the screening values for gross alpha, gross beta or tritium are exceeded.

Regulation 24 enables the Scottish Ministers (in practice through the Drinking Water Quality Regulator), to notify local authorities that monitoring for radiological parameters is not required where they are satisfied that the water supply is well below the specification for the relevant parameters. The Regulator will inform local authorities by notice where he is satisfied that there is sufficient information to establish that water supplies meet these criteria, and there is therefore no need for audit monitoring in respect of those parameters. There are a very few areas in Scotland where the geological conditions are such that this radiation is present at detectable levels and fewer still where the specifications for radiation (total indicative dose and tritium) specified in Table C in Schedule 1 are reached. The Regulator will take into account existing and future geological and radiological surveys in determining whether local authorities should be required to sample for these parameters.

Section 7 of the Technical Manual provides detailed information on treatment methods for radon and uranium.

9(S).2.8.7 Regulation 25 - Additional Monitoring

Regulation 25 meets the provisions of Article 7(6) of the Drinking Water Directive by placing a duty on local authorities to undertake additional monitoring, on a case-by-case basis, if they have reason to suspect that substances and micro-organisms may be present in a private water supply in amounts or numbers which constitute a potential danger to human health. This would cover substances and micro-organisms that are not listed in Schedule 1 but whose presence in a private water supply may cause a health risk. It is important that monitoring strategies are not considered in isolation from other potential routes of exposure to chemicals in the environment.

9(S).2.8.8 Regulation 26 – Decision on audit monitoring

The overall aims of the 2006 Regulations and Directive is to ensure that consumers enjoy wholesome and clean water and to deliver real improvements to public health. However, the legislative framework covers a large number of parameters potentially found in drinking water in order to address the numerous and varied types of individual private supplies. Generally, only a limited number of parameters will be of concern under any given circumstance and Regulation 26 and Schedule 3 to the 2006 Regulations are intended to allow local authorities to respond to those chemical parameters of supplies that are of public health significance.

The World Health Organisation (WHO) Guidelines for drinking water quality point out that the health concerns associated with chemical parameters of drinking water differ from those associated with microbial contamination. Health concerns arise primarily from the ability of chemical parameters to cause adverse health effects after prolonged periods of exposure. The WHO points out that there are few chemical parameters that can lead to health problems resulting from a single exposure, except through the massive accidental contamination of a drinking water supply. In many, but not all such incidents, the water becomes undrinkable owing to unacceptable taste, odour and appearance.

The prescribed concentrations or values specified in the Drinking Water Directive are based on the WHO Guidelines and represent the concentration of a parameter that does not result in any significant risk to health over a lifetime of consumption. For some private supplies sampling for all parameters listed in Table B in Schedule 2 could represent an unreasonable financial burden given the low potential risk to health. Regulation 26 makes provision to exempt certain chemical parameters from the audit monitoring requirements of Schedule 2, where it can be demonstrated that a parameter is not likely to be present in a given supply in concentrations, which could give rise to a risk to human health. However, in all these considerations it is important to strike the correct balance between the protection of human health and the need to avoid unnecessary regulation.

The chemical parameters to be considered for exemption from the audit monitoring requirements of Table B in Schedule 2 are those that do not pose an immediate threat to human health and can be demonstrated to either not be present (as they are not used in, for example a treatment system) or have been sampled for a period of time and their absence has been demonstrated to the satisfaction of the local authority.

In considering decisions on audit monitoring under Regulation 26, a local authority should consider the degree of current compliance with the requirements of the 1992 Regulations as well as historic and other information they hold or have available to them. For example, consideration of soil leaching potential maps, geological data and relevant data from the Scottish Environment Protection Agency, particularly information collated by them in connection with their responsibilities under the Water Framework Directive for the protection of the wider water environment.

Prior to making a decision on audit monitoring under regulation 26, a local authority must also carry out an investigation in relation to the supply in accordance with the provisions of Schedule 3 to the 2006 Regulations. Where a local authority reasonably believes that one or more of the parameters listed in Schedule 3 is not likely to be present in a private water supply in its area in concentrations which could lead to the risk of a breach of the relevant parametric value it should undertake such investigations as are considered reasonable to:

- ensure that the circumstances referred to in column 3 of Schedule 3 in respect of that parameter does not exist; and

- ascertain whether any of the conditions referred to in column 4 of Schedule 3 in respect of that parameter apply.

Where a local authority is satisfied as a result of the investigations carried out in accordance with Schedule 3, that in respect of the supply, one or more of the parameters referred to in column 2 of Schedule 3 is not likely to be present in that supply in concentrations which could lead to the risk of a breach of the parametric value in respect of such parameters, it **may** consider granting an exemption in accordance with regulation 26.

In making informed decisions on what monitoring is required, local authorities will essentially be carrying out an initial risk assessment based on existing records. Local authorities are encouraged to carrying out an investigation in accordance with Schedule 3 **in advance of an initial monitoring visit** under the 2006 Regulations, to ensure as far as it is safe to do so, that they only sample for parameters which are likely to be present in a given supply. This record based assessment does not remove the requirement on local authorities to carry out a specific risk assessment in accordance with regulation 16 of the 2006 Regulations, from ‘source to tap’, for all Type A supplies in their area. The regulation 16 risk assessment should be used to inform future monitoring requirements by either removing or, exceptionally re-instating some of the audit monitoring parameters based on an assessment of the risk to human health. The regulation 16 risk assessment is also the best source of information to judge when review or repeat analysis for these parameters is required, for example, after 1 year, 3 years or other period based on assessment of the risk to the particular private supply.

There are many chemicals that may occur in drinking water, however, only a few are of immediate health concern in any given circumstance. The priority given to both monitoring and remedial action for chemical contaminants in drinking water should be managed to ensure that limited resources are not unnecessarily directed towards those of little or no health concern. The approach detailed in regulation 26 and Schedule 3 should lead to a balanced mix of chemical parameters being tested which are likely to be present or cannot be ruled out, and a flexible schedule for re-visiting these exemption determinations on the basis of a fully completed risk assessment from source to tap.

9(S).2.9 Part VIII – Type B supplies: Risk assessments, investigations and monitoring

9(S).2.9.1 Regulation 27 – Type B supplies: Risk Assessments

While the undertaking of risk assessments for Type B supplies is not compulsory, this regulation places a duty on local authorities to provide advice and assistance to a relevant person to enable them to undertake such a risk assessment for their supply and provides a power for the local authority to undertake a risk assessment whether or not requested to do so by the relevant person.

9(S).2.9.2 Regulation 28 – Investigations: Table D in Schedule 1 microbiological and chemical parameters

The regulation provides monitoring local authorities with powers to investigate private water supplies in their area that fail to meet the wholesomeness standards specified in regulation 7(3) and places a local authority that instigates such an investigation under a duty to inform the relevant person of the outcome as soon as is reasonably practicable. The relevant person is, in turn, also under a duty to inform all those using the supply of the circumstances and actions required to be taken to rectify the situation. Under this regulation there should be a clear flow of information from local authority to relevant person to every consumer on the supply about the problems identified and solutions being sought in relation to the supply.

9(S).2.9.3 Regulation 29 – Monitoring duties and powers

This regulation is analogous to regulation 22 for Type A supplies in that regulation 29 sets out the conditions under which a Type B supply will be deemed to comply with the wholesomeness standard specified in regulation 7(3); that samples will be taken that are representative of the quality of water supplied throughout the year; and defines the point of compliance from where such samples should be taken. The regulation also provides local authorities with a power to sample from Type B supplies at any time regardless of whether the relevant person has requested such a sample or not. Where a relevant person has made a request for a sample to be taken, this regulation places local authorities under a duty to take and analyse such a sample within 28 days of the request being made. The regulation also provides the power for local authorities to take samples to confirm or clarify previous results and to establish the efficacy of any remedial actions that may have been taken in regard to the supply.

9(S).2.9.4 Regulation 30 – Additional monitoring

The powers granted to local authorities under this regulation enable them to take samples and analyse for parameters that are not specified in the 2006 Regulations but whose presence is suspected and which may cause harm to the health of those using the supply.

9(S).2.10 Part IX – Private Water Supplies: Sampling, analysis and charging

9(S).2.10.1 Regulation 31 - Collection and analysis of samples

Annex III to the Drinking Water Directive requires Member States to ensure that any laboratory at which samples are analysed has a system of analytical quality control that is subject to independent checks which are approved by the Scottish Ministers (in practice the Drinking Water Quality Regulator for Scotland) for that purpose.

Regulation 31 specifies the minimum quality requirements for the taking, handling, storage and analysis of samples taken under the 2006 Regulations. It is intended to ensure that appropriately qualified staff and suitably accredited organisations are responsible for the analytical process. The regulation also requires that samples are managed appropriately to ensure that results are a true representation of the quality of the water at the time the sample was taken. The specific methods of analysis and performance characteristics are detailed at Schedule 5 to these Regulations.

In order to carry out sampling correctly, and secure the integrity of samples, it is important that all samplers are fully trained and competent prior to undertaking this work. Local authorities are encouraged to produce a comprehensive training programme to cover all aspects of collection and training.

The Technical Manual provides detailed guidance on the procedures for the sampling and analysis of private water supplies.

Within 28 days of the results of an analysis becoming available, the local authority should notify these to anyone who is to be charged for the sampling and analysis (regulation 33(4)). In forwarding the results the local authority should notify the course of action they intend to take in consequence and other relevant information if they consider this would be helpful. This will be particularly relevant where young children, elderly or vulnerable persons are likely to be affected by an unwholesome water supply.

9(S).2.10.2 Regulation 32 - Sampling of private water supplies: further provision

Regulation 32 gives local authorities wide ranging powers to carry out monitoring additional to the requirements of regulations 20 and 23 of the 2006 Regulations where they have reasonable grounds for believing that a water supply may be unwholesome. For example, this provision enables a local authority to undertake monitoring and sampling in response to localised flooding or a chemical spill in or near a private water supply.

9(S).2.10.3 Regulation 33 - Charges for sampling, analysis and risk assessment

Regulation 33 provides local authorities with discretionary powers to recover costs (up to prescribed maxima) from persons whose premises are served by a private water supply for expenses reasonably incurred by the authority in connection with the 2006 Regulations. The maximum charges set down in this regulation will be subject to periodic review by the Scottish Ministers.

The maximum permissible charges are as follows:

- An amount up to £70 for each visit made to a property to sample a supply or to undertake a risk assessment of a supply in accordance with the provisions of the 2006 Regulations. This charge, which applies to both Type A and Type B supplies, is to cover administrative time and resources in preparing for the visit, time on site, travelling to and from the property and follow up and advisory work.

- Type A supplies are subject to a maximum charge of £75 per analysis of **check monitoring parameters** (regulation 19 and Table A in Schedule 2);

- Type A supplies are subject to a maximum charge of £435 per analysis of the full suite of **audit monitoring parameters** (regulation 20 and Table B in Schedule 2);

- Type B supplies are subject to a maximum charge of £48 per analysis of domestic parameters (regulation 28 and Table C in Schedule 2);

- For Type A supplies the completion of an initial risk assessment in accordance with regulation 16 and Schedule 4 up to a maximum charge of £50;

- For Type A supplies Costs, reasonably incurred, in undertaking a review of an initial risk assessment in accordance with regulation 16(4) up to a maximum of £50. Local authorities should carefully consider the time and effort required to complete this review before seeking to recover the maximum amount;

- Local authorities may charge for expenses reasonably incurred in undertaking additional monitoring and sampling of a private supply in accordance with the provisions of regulation 25 or 30; and

- For Type B supplies local authorities may charge for the completion of a risk assessment in accordance with regulation 27(2).

Local authorities should not charge for the taking and analysis of samples to confirm the results of previous samples, under regulations 22(6)(a) or 29(6)(a) but can recover the costs of taking and analysing a sample following the completion of remedial works under regulation 22(6)(b) or 29(6)(b). The charging regime also applies to sampling carried out for new supplies or supplies not used for 12 months or more and being brought back into use, and to sampling carried out at the request of a relevant person or the owner / tenant of premises served by a private supply.

Regulation 33 provides local authorities with discretionary powers to charge a person(s) for expenses reasonably incurred by it and arising from the 2006 Regulations. For the purposes of regulation 33 that person(s) may be:

- identified in an agreement, contract, licence or other legally binding document relating to the terms on which water is supplied as being liable for the maintenance of, or for any costs associated with, the supply; and

- in any other case, the owner or tenant of the premises served by the supply.

In cases where owners or tenants of domestic premises are to be charged with the costs of sampling and analysis, and where more than one domestic premises is served by the supply, local authorities may apportion the costs equally amongst all premises served by the supply. In cases where a commercial or public activity is served by a supply and other premises are domestic, the local authority should have regard to the terms (if any) on which the water is supplied and the purpose for which it is used. For example, in the case of a public or commercial activity which makes an otherwise Type B supply a Type A supply, local authorities should consider whether the additional charges payable as a result of the additional sampling and analysis required by the 2006 Regulations are to be borne either wholly or predominantly by the commercial or public activity.

The charges specified in regulation 33 are the maximum charges and it is envisaged that local authorities will recover only the costs actually incurred. The recovery of costs is discretionary. There may be instances where local authorities consider that they should not attempt to recover the costs involved, for instance on economic or social grounds.

9(S).2.11 Part X – Private Water Supplies: Records and Information

9(S).2.11.1 Regulation 34 - Register of private water supplies

Local authorities already maintain a register of information on private water supplies. However, the Drinking Water Directive makes further requirements for consumers to be informed of the quality of water supplies, including the authorisation of temporary departures and details of remedial action taken or required. Regulation 34 implements this and seeks to promote maximum openness and transparency in relation to water quality matters, in line with the principles of the Freedom of Information (Scotland) Act 2002 and the Environmental Information (Scotland) Regulations 2004.

Local authorities are under a duty to maintain and update a detailed register of all private supplies in their area. The register should include details of supplies used for crop washing or for distillation purposes, despite such supplies not being subject to the full application of the 2006 Regulations. The Scottish Environment Protection Agency (SEPA) will draw on the information contained in the register of private supplies in terms of their functions under the Water Environment (Controlled Activities) (Scotland) Regulations 2005.

Local authorities are free to decide the format of the register of private supplies provided that it contains the information specified in regulation 34(1).

Local authorities should make initial entries in the register by 3rd January 2007 and thereafter within 28 days of the information being available. Local authorities should already hold information sufficient to populate the register with basic information about supplies in their area fairly quickly.

Regulation 34(6) sets the basic requirements for the retention of records to demonstrate that the sampling, transport storage and analysis of each sample taken complied with the requirements of Part VI or VII of the 2006 Regulations. Local authorities are required to retain the results of any analysis of samples taken in accordance with the 2006 Regulations for a period of 15 years. The requirement to retain records is in line with that placed on Scottish Water in respect of data on the drinking water quality of the public water supply and will enable future epidemiological or other studies that may be undertaken to have access to historic data. Local authorities should also retain more detailed records for a lesser period of 5 years, in order to demonstrate compliance with Part VI and VII of the 2006 Regulations should the results be challenged.

9(S).2.11.2 Regulation 35 - Provision of information

Regulation 35 places a duty on local authorities to make their register of private water supplies available for public inspection at all reasonable hours and to provide information to the Scottish Ministers, SEPA and local Health Boards on matters within the register.

While Regulation 35(2) enables local authorities to recover the reasonable costs of providing copies of register entries, there is an expectation that any person with a direct interest in a supply should be able to obtain copies of the entries on the register in respect of that supply free of charge.

Specific provision is included to facilitate the exchange of information between neighbouring local authorities to enable each authority to fulfil its respective obligations under the 2006 Regulations. To promote intra-authority data exchange, local authorities may need to review their registration under the Data Protection Act 1998 to ensure that, for example council tax data, may be exchanged to enable that authority to meet its obligations under the 2006 Regulations.

By 31 March each year, local authorities are required to provide the Scottish Ministers, SEPA and local Health Boards with an annual return in accordance with the form provided for that purpose. This information will be collated and published either by the Scottish Executive or incorporated into the Annual Report of the Drinking Water Quality Regulator for Scotland. The requirement to provide information to SEPA relates to their responsibilities in relation to the wider water environment.

9(S).2.11.3 Regulation 36 - Information Notice on Premises

The requirement to prominently display an information notice stems from the *E.coli* O157 Task Force Report of June 2001 which included a number of significant recommendations for private water supplies, including a strong view that information about water quality should be provided to all visitors. The Executive accepted all the recommendations in this Report.

Regulation 36 requires a relevant person to prominently display an information notice in commercial or public premises served by a private water supply. The notice is intended to draw to a visitor's attention that the water is from a private supply. The notice requires to be prominently displayed in a location to which the public reasonably has access. This would normally be at a reception area, for example, on a notice board together with fire, insurance or health and safety certificates. Local authorities may wish to discuss with relevant persons the most appropriate location for such a notice.

Copies of the information notice will be provided direct to local authorities, by the Scottish Executive, as part of the wider education and awareness programme to support the 2006 Regulations. In turn, local authorities should pass on copies to owners of commercial or public premises in their area. The information notice is designed to ensure that visitors to Scotland get a consistent message regarding the potential increased risks associated with a private supply enabling the visitor to make an informed choice about whether they wish to consume or use the water.

A copy of the information notice is included in Annex 1 at the end of this section.

9(S).2.12 Part XI - Miscellaneous

9(S).2.12.1 Regulation 37 - Revocations and savings

This regulation revokes the previous regulatory framework as provided in the Private Water Supplies (Scotland) Regulations 1992 and the Private Water Supplies (Scotland) Amendment Regulations 1998. Certain actions initiated under the previous regulatory regime, such as the collection and analysis of samples and the charging for expenses so incurred, are saved until such time as the actions have been discharged.

In addition, this regulation places a duty on local authorities to retain all information collected by it under Part IV of the 1992 Regulations for a period of fifteen years from the date on which it was collected.

9(S).3 The Private Water Supplies (Notices) (Scotland) Regulations 2006

9(S).3.1 Introduction

The Private Water Supplies (Notices) (Scotland) Regulations 2006 (“the Notices Regulations”) deliver a key element of the Executive’s policy (mainly addressed in the Private Water Supplies (Scotland) Regulations 2006 (“the Private Water Supplies Regulations”) to implement the Drinking Water Directive in respect of private water supplies. The Notices Regulations enhance existing domestic regulatory provision. In particular, they strengthen local authorities’ powers by modifying the application of the Water (Scotland) Act 1980 (“the 1980 Act”) to place a duty on local authorities to serve a notice under section 76G of the 1980 Act when a failure to meet the water quality standards prescribed in the Directive and the Private Water Supplies Regulations concern larger, Type A supplies or supplies to commercial or public activities. Local authorities will continue to have discretionary powers to issue a notice in respect of smaller, Type B supplies.

The Notices Regulations also create an offence of failing, without reasonable excuse, to take any step specified in a notice issued under section 76G of the 1980 Act. The offence is punishable on conviction by a fine not exceeding level 5 on the standard scale (currently £5,000).

9(S).3.2 Regulation 1 – Citation and commencement

The Notices Regulations come into force on 3rd July 2006, at the same time as the Private Water Supplies (Scotland) Regulations 2006.

9(S).3.2 Regulation 2 – Amendment of the 1980 Act in relation to private water supplies

Regulation 2 inserts a new section 76HA into the 1980 Act, which modifies the application of sections 76G and 76H of the 1980 Act as they apply to private water supplies to which the Private Water Supplies Regulations apply. New section 76HA(2)(a)(ii) modifies section 76g(1) of the 1980 Act and imposes a duty on local authorities to serve a notice on Type A supplies which do not meet the wholesomeness standards prescribed in Part IV of the Private Water Supplies Regulations. Local authorities retain their discretionary powers to serve notices on Type B supplies.

New section 76HA(3) inserts a new subsection (11) into section 76H of the 1980 Act and creates an offence in relation to the failure to take, without reasonable excuse, any step specified in a notice served under section 76G of the 1980 Act.

9(S).4 Other Formal Powers

9(S).4.1 Background

The principle aim of legislation pertaining to private water supplies is to ensure supplies are adequate and wholesome and do not prejudice public health. The aims and objectives of local authorities are to monitor the quality and quantity of water supplies and to encourage improvements where necessary. Formal powers are available, for example under the Water (Scotland) Act 1980, which may be used where and when felt appropriate; there are, however, particular difficulties associated with formal enforcement action and such action should be considered carefully. This section recommends the approach to take in relation to unsatisfactory water supplies, and although it focuses on wholesomeness the same approach equally applies to insufficient supplies. It is important that each local authority's environmental health department develops its own policies and procedures to cover these areas. This section provides a general framework within which such policies and procedures can be developed and implemented.

Although the 1980 Act and the Private Water Supplies Regulations are the principal pieces of legislation in this respect, other legislation may be relevant, including the Housing (Scotland) Act 1987, the Food Safety Act 1990, the Environmental Protection Act 1990 and the Caravan Sites and Control of Development Act 1960 (Model Standards).

In previous guidance on private water supplies mention of the application and use of Significant Medical Risk Values (SMRVs) issued by the Scottish Centre for Infection and Environmental Health (now Health Protection Scotland) was made. The use of SMRVs, while appropriate at the time of their development, are no longer appropriate given the significant changes in the regulatory framework for private water supplies, principally through the provisions of the Private Water Supplies Regulations. The "grey" areas of failure associated with the interpretation of results mediated by the SMRVs are no longer appropriate and local authorities and their appointed medical officers should discontinue any reference to these values when assessing the quality of water intended for human consumption from private water supplies. New guidance on this issue has been provided separately to local authorities.

The extent of any action that may be taken by a local authority, including advice and investigation, in relation to private water supplies may depend upon a number of factors, including those listed in Table 9(S).1.

Table 9(S).1 Potential actions regarding private water supplies

Degree of non-compliance with the requirements of the Private Water Supplies (Scotland) Regulations 2006	Likelihood of recurrence of failure
Reason for sample i.e. request, public health, programme	Tenure/Type/Level of premises
Type of supply	Historic data
Legal agreements between owners/relevant persons/users	Degree of co-operation with owners/occupiers
Availability of alternative supplies and ability to improve existing supply	Identification of relevant persons
Costs of improvement	Scottish Executive/Council/Departmental policies
Involvement of other agencies such as Scottish Environmental Protection Agency, Food Standards Agency etc	

Unless circumstances dictate otherwise (such as specific enforcement provisions within the Notices Regulations), it is recommended that an informal approach be adopted initially but should this not be effective, formal action should be contemplated. The initial steps should be carried out in such a manner that they do not prejudice the success of any subsequent enforcement action.

It is recognised, however, that formal action may require to be taken immediately dependant upon, for instance, the seriousness of the failure, the degree of co-operation with the relevant person, the type of premises and historic data. However, a reasonable period of time must be permitted within the Notice and therefore service of a Notice may not bring immediate resolution of the problem.

9(S).4.2 General framework for dealing with unsatisfactory private water supplies

9(S).4.2.1 Sample results

In general terms, a local authority first becomes aware of a quality failure on receipt of water sample results. Environmental Health Departments should ensure that samples are taken correctly and that laboratories are properly accredited to carry out analysis, as this will have a significant bearing on the success of any formal action. Samples should be taken in accordance with the recommendations elsewhere in this Manual, and in accordance with the requirements specified in the Private Water Supplies Regulations.

When obtaining water samples, Officers should obtain as much information as possible from the occupier/owner, including the location of the supply, surrounding land use and who else shares the supply. This information may already exist as part of the risk assessment for the supply.

Departments should also ensure that their records are accurate and that information is available to the appropriate Officers to enable effective action to be taken.

9(S).4.2.2 Interpretation of results

As previously stated above, the use of Significant Medical Risk Values (SMRVs) is no longer considered to be an appropriate approach to the interpretation of results for water intended for human consumption. It is envisaged that Environmental Health Departments and their Medical Officers will amend any previous policies and procedures to take account of the new regulatory regime and the replacement of the SMRVs with updated guidance which has been issued separately.

Where a risk assessment has previously been undertaken the results of this should be reviewed and the risk assessment revisited in light of the sampling results. Where a risk assessment has not been undertaken, it is recommended that one is undertaken to assist in the interpretation of the results being presented.

9(S).4.2.3 Initial Steps

When it is considered that a supply is unwholesome the first step is to ensure that measures are put in place to safeguard public health. This may include the issue of Boil Water Notices (water simply requires to be brought to the boil and allowed to cool) or treatment of the water with a hypochlorite solution. This advice should be distributed as quickly as possible to all relevant persons and all those using or associated with the supply. In order for this process to be of maximum effectiveness, it is essential that relevant information is available to Officers. This includes identification of the relevant person(s), details of any legal agreements between owners and users, the number of premises on the supply and the tenure of the properties. Advice and discussions should take place with the relevant person(s) who should ensure, as a matter of best practice, that all users of the supply are made aware of the Local Authority's advice and keep them up to date on progress, notwithstanding any other actions they may be required to take under the Private Water Supplies Regulations. Officers should consider whether further samples are required, including alternative sampling points, before detailed advice is given.

9(S).4.2.4 Advice

Environmental Health Departments should prepare standard letters and methods of distributing results. The relevant person(s) should be provided with general advice and, where appropriate and available, site specific advice.

Results and advice may be given face to face, by telephone, by fax or by email but should always be confirmed by letter which should detail the results, their interpretation and steps to remedy the supply. A target improvement date should be stated in the letter.

9(S).4.2.5 Re-samples

Officers should consider the need to monitor the quality of the supply whilst improvements are undertaken. Consideration should be given to widening the parameters sampled for. Samples may also be taken following each stage of improvements so that the effectiveness of improvements can be ascertained. Relevant person(s) and users of the supply should be kept up to date with sample results and progress on work.

9(S).4.2.6 Follow-up action

Once improvements have been carried out and the water re-sampled, an assessment should be made as to whether further improvements and samples are required.

It is anticipated that by adopting an informal approach initially and working closely with the relevant person(s), a greater degree of co-operation may be achieved than if formal enforcement action is taken at the outset. If formal action is subsequently taken, the local authority will be able to demonstrate it took all reasonable steps to try to improve the quality of sufficiency of the supply.

9(S).4.3 Formal Powers

9(S).4.3.1 Background

As discussed above, an informal approach is best adopted initially working closely with the relevant person(s) and users. Detailed records and copies of letters should be kept and the relevant person advised in writing of the possibility of formal action and consequences of non-compliance if remedial works are not carried out.

9(S).4.3.2 Notices

Local authorities have functions under Part VIA of the 1980 Act to remedy unwholesome or insufficient private water supplies. These functions include-

(i) Section 76D – Obligation placed on Scottish Water to provide a temporary supply

Where a private water supply is not providing a sufficient or wholesome supply for domestic purposes, the local authority may require Scottish Water to provide a supply, usually by tanker, for such period as the local authority specifies. The local authority is invoiced, but this can be recovered from the owner or occupier of the premises to which the supply is provided (section 76D(2)). Further guidance relating to this matter will be issued as a separate Information Letter.

(ii) Section 76G – Notice to improve supply due to being unwholesome or insufficient

The most likely form of formal action to be taken by a local authority is in terms of Section 76G. Before serving the Notice, the local authority should consider, where applicable, the following:

a) the seriousness of the breach;
b) consultation with the Consultant in Public Health Medicine or appointed Medical Officer of Health;
c) cause of illness;
d) historic data;
e) whether it is reasonable to serve the Notice;
f) whether a temporary departure under the 2006 Regulations can be granted;
g) improvements carried out to the supply and the time taken for these to be done;
h) condition of the supply;
i) details of relevant person(s) and any legal agreements;
j) Class (Type/Level) of supply/tenure/type of premises;
k) the degree of co-operation shown by the relevant person(s) and users of the supply;
l) availability of alternative supplies and the public mains; and
m) requirements of other legislation.

It is suggested that before serving a Notice a letter is sent to the relevant person(s) advising that the Local Authority intends serving Notice and allowing, say, 14 days for them to respond. The letter may ask them to advise the local authority whether a Notice should be served on any other person. A section 76I Notice may require to be considered to obtain relevant information in relation to sections 76F and 76G of the 1980 Act.

A section 76G Notice requires to specify:

- the reasons why, the local authority is satisfied that the private water for domestic or food production purposes (if served in respect of a private water supply to which the 1980 Act applies) or for human consumption purposes (if served in respect of a private water supply within the meaning of the Private Water Supply Regulations 2006) is not/was not/likely not to be wholesome or sufficient;

- the remedial steps which the local authority consider are required to ensure a supply which is wholesome and sufficient(this will require detailed investigation of the supply in order to identify steps). It is clear that detailed site investigations are required before formal action can be contemplated, which emphasises the need to gather information about the supply at an early stage e.g. during the undertaking of a risk assessment;

- the period in which the steps have to be carried out (at least 28 days must be allowed for representations and objections separate to the period in which the steps are to be taken). Depending upon which works are considered to be required, a period of up to 6 months may be appropriate for completion; and

- the effect of section 76H.

The Private Water Supplies (Notices) (Scotland) Regulations 2006 modify the effect of the 1980 Act as regards private water supplies to which those Regulations apply, such that failure by a relevant person to take any of the steps specified in a notice served under section 76G within the period specified in the notice without reasonable excuse is an offence, to which a relevant person is liable, on summary conviction, to a fine not exceeding level 5 on the standard scale.

Further guidance relating to this matter will be issued as an Information Letter.

(iii) Section 76I – Notice requiring information in relation to Section 76F to 76G

This section requires appropriate information to be provided and in terms of Section 76I(5) failure to provide the information is an offence. Further guidance relating to this matter will be issued as an Information Letter.

9(S).4.3.3 Representations/Non-compliance

The local authority requires specify in a notice served under section 76G of the 1980 Act, a period in which representations or objections may be made with respect to the notice, and should advise the recipient of the notice of the address to which any objections or representations should be sent, the need to state the reasons for any objection or representation. Section 76H of the 1980 Act details the procedure to be followed in the event representations or objections are received.

In terms of section 76H(5) of the 1980 Act, where any step specified in a notice served under section 76G is not complied with within the period specified in that notice, the local authority may decide to carry out that step, and may recover its expenses in so doing from the person on whom the notice was served. The recovery of expenses will be a consideration where the relevant person is from a vulnerable group, elderly or disabled.

It is offence under section 76H(11) for the relevant person to fail, without reasonable excuse, to take any of the steps specified in a notice within the period specified therein.

9(S).5 Guidance for The Private Water Supplies (Grants)(Scotland) Regulations 2006

9(S).5.1 Introduction - The Grants Regulations

Section 47(1) of the Local Government in Scotland Act 2003 (“the 2003 Act”) places a duty on local authorities to make grants to eligible persons for the purpose of enabling them to improve their private supply or to provide themselves with a private water supply. Section 47(3) of the 2003 Act enables the Scottish Ministers to provide for the detail of the grants scheme, and this has been provided for in the Private Water Supplies (Grants) (Scotland) Regulations 2006 (“the Grants Regulations”).

The Grants Regulations are closely linked to the Private Water Supplies (Scotland) Regulations 2006 (“the 2006 Regulations”). Their purpose is to provide non-means tested financial assistance to eligible persons – individuals and businesses - towards the costs of improvement works arising from the 2006 Regulations. Subject to regulation 8(2), the maximum grant is £800 per premises.

Research carried out for the Scottish Executive indicated that improvement costs are likely to vary greatly, largely in the range of £125 - £2,500 per premises, but that the most important health benefits are usually gained from installing ultra violet treatment and appropriate pre-filters. The £800 grant will meet or make a substantial contribution towards the costs faced by the majority of users. There will be cases where the supply requires work which exceeds this maximum and in such cases, and subject to regulation 8(2) of the Grants Regulations, it will be the responsibility of the eligible person to meet the additional costs.

The Grants Regulations contain discretionary provisions to enable local authorities to make larger grants in circumstances where the maximum grant is insufficient and **undue hardship** justifies more assistance (regulation 8(2) of the Grants Regulations). This discretion is there to be used, for example where an eligible person is in receipt of council tax benefit or in relation to supplies serving single premises where there is no other user to share the improvement costs.

9(S).5.1.1 Regulation 1 - Citation and Commencement

The grants scheme provided for under the Grants Regulations comes into force on 3rd July 2006, however, as those persons seeking a grant require to fulfil certain eligibility criteria before they may submit an application for a grant, it is unlikely that applications for a grant will be submitted until some time after that date.

9(S).5.1.2 Regulation 2 - Interpretation

This regulation provides for certain definitions to assist applicants and local authorities with making applications under the Grants Regulations, and processing applications for grants. In particular, the regulation provides for a definition of “approved works”, which comprise those works in respect of which a local authority determines that a grant is payable.

9(S).5.1.3 Regulation 3 – Eligible person

Regulation 3 defines who may be eligible for a grant. A person is eligible for a grant if two conditions are met. Firstly, they must be a relevant person or a responsible person (these terms are defined in the Private Water Supplies (Scotland) Regulations 2006) or own or occupy premises which depend on a private water supply. And secondly, the water supply which the person provides or receives must be subject to a temporary departure or a notice under section 76G of the Water (Scotland) Act 1980 (which would have identified specific problems which required to be remedied), or to a risk assessment (which would identify risks to the supply). This second requirement provides a clear basis for the local authority to verify that improvement work is required on a supply.

There may be more than one eligible person in respect of any particular premises and it would be open to either to apply for a grant, or to endorse the application of the other. However, once a grant has been made to an eligible person in respect of particular premises, any subsequent application by another eligible person for the same premises would be treated as a further application and the provisions of regulation 9(4) and (5) would apply.

9(S).5.1.4 Regulation 4 – Application for a grant

Regulation 4 makes provision for grant applications. Paragraph (1) provides that grant applications must be made to the local authority in whose area premises served by a private water supply is located, irrespective, for example, that the source of the supply is in another local authority area. It also provides that an application must be made by or on behalf of an eligible person and that it must be made in writing (including electronic communications) on a form approved by the local authority.

Paragraph (1) permits joint applications to be made by more than one eligible person, and for an eligible person to nominate someone else to apply for a grant on their behalf. For example, a grant application might be made towards works on the private water supply serving four cottages. A joint grant application could be submitted by a relevant person or responsible person in respect of all the cottages, or by the owners or occupiers of the cottages acting together, or by one of those people on behalf of themselves and their neighbours. On most occasions a joint approach should be considered to be the most effective way in which to improve a supply and to offer best value for money, and a local authority should look to encourage such joint improvement works. However, there will be occasions when not all those served by a supply want or need to upgrade it in the same way and it is equally possible for individual applications to be submitted.

Paragraph (2) provides that, in making an application, the applicant is required to provide details of the eligible person and the reasons for their eligibility, and to describe the source of the private water supply, the work which they propose to do to the supply and the estimated cost of the work. The proposed work is work which, in the opinion of the applicant, once carried out is likely to improve the nature or quality of the supply. For example, this could include direct interventions to improve water quality, such as fitting UV treatment, or indirect actions to improve water quality, such as protecting a source by erecting fencing. Applicants are also required to set out any other grants or financial assistance they have applied for or received in respect of the proposed works. Paragraph (3) provides a power for the local authority to require an applicant to provide additional information in relation to their grant application.

Paragraph (4) provides that a person may submit more than one grant application. This might be required where further improvement works to a supply are required, and regulation 9(4) and (5) provide that further grants are available in particular circumstances. It would also be required where a person was the eligible person for more than one premises or supply.

9(S).5.1.5 Regulation 5 – Purposes for which a grant may be approved

Regulation 5 places a duty on local authorities to only approve grant applications for works which are likely to improve a private water supply, including provision of new private water supply or distribution system within a premises.

9(S).5.1.6 Regulation 6 – Determination of applications

Regulation 6 sets out a local authority's powers and duties in determining grant applications. Paragraph (1) provides that a local authority may refuse a grant application, or approve it in whole or in part, for example, where it considers only some of the proposed works appropriate for a grant. Payments as a result of the approval, are subject to any conditions the local authority considers it reasonable to impose. The local authority may vary or revoke its approval at any time, subject to paragraph (6), which provides for consultation with the applicant that the local authority must undertake if it proposes to vary or revoke the approval of an application.

Paragraph (2) requires a local authority to determine a grant application and to notify the applicant of its decision as soon as reasonably practicable. If the local authority has refused or approved the application in part, its notification must include reasons for that decision.

Paragraph (3) requires a local authority, in approving a grant application, to set out the approved works and approved expenditure, which can be different to the works and expenditure proposed in the grant application. The local authority must also set out the amount of grant it intends to make towards the approved expenditure.

Paragraph (4) makes provision for cases where, after a grant application has been approved, it becomes clear that the approved expenditure is not sufficient to carry out the approved works, or that additional works to the approved works are required and that this could not have been foreseen at the time of the application. In these circumstances, the local authority may re-determine the expenditure and works it approved, and pay a supplementary grant towards the re-determined approved expenditure. This supplementary grant is limited in the same way as the original grant, as provided under regulation 8. Unless the local authority considers that the provisions in relation to hardship set out in regulation 8(2) apply, a supplementary grant cannot exceed the difference between the original grant and the maximum grant of £800. For example, if a grant of £600 had originally been calculated, a supplementary grant of up to £200 could be made.

Paragraph (5) provides a power for a local authority to consult persons or make inquiries that it considers reasonable before determining a grant application and to have regard to information gathered in this way in making its decision. If the local authority intends to take information gained from these inquiries into account, it is required to notify and provide details of this to the applicant.

9(S).5.1.7 Regulation 7 – Restriction on grant for works already begun

Regulation 7 provides that a local authority shall not approve a grant application for works which were completed before the application was made, and such completed works are thus ineligible for a grant. It also provides that a local authority shall not approve an application or part of an application for works which have already begun unless it is satisfied that there was a good reason for beginning the works. This means that if a grant application is not made in advance of starting works, without a good reason, (for example, urgent requirement for remedial works), a local authority may refuse the application or vary it to exclude works that had already started.

9(S).5.1.8 Regulation 8 – Payment and amount of grant

Regulation 8 makes provision for calculating the grant a local authority awards. Paragraph (1) provides that the maximum grant which may be awarded, (subject to paragraph (2)) is £800, and that a local authority may pay grant equal to the approved expenditure or £800, whichever is lower. The payment is to be made where the local authority is satisfied that expenditure has been incurred or is to be incurred for the approved works.

Paragraph (2) makes provision for cases where a local authority is satisfied that the eligible person could not finance the approved works without undue hardship. In these circumstances, a local authority may make a grant in excess of £800.

9(S).5.1.9 Regulation 9 – Claim for, and payment of, a grant or further grant

Regulation 9 makes provision for local authorities to pay grants that they have approved. Paragraph (2) provides that grants may be paid in full after the approved works have been completed, or in instalments, with the final instalment made when the works have been completed. Paragraph (3) provides that a local authority must be satisfied that the approved works, or relevant part of the approved works, have been satisfactorily completed before making a payment.

Paragraph (4) makes provision for further grant applications for premises in respect of which a grant has been paid. It applies where a grant has been paid in the five years preceding the date of the new grant application. Within this period, a local authority should only consider a further grant application if it is accompanied by a further risk assessment, or, where the local authority has indicated that that is not required, a statement of the reasons why further works are required to improve the private water supply. Paragraph (5) provides that, in determining a further application, unless the local authority considers that the provisions in relation to hardship set out in regulation 8(2) apply, a further grant cannot exceed the difference between the original grant (paid within the preceding five years) and the maximum grant of £800.

9(S).5.1.10 Regulation 10 – Persons or premises in respect of which a grant is not payable

Regulation 10 makes provision to exclude specific categories of persons and premises from being eligible for a grant. Any public body or office-holder is excluded, but not those persons or bodies who only exercise public functions from time to time. The other exclusions relate to premises which are being constructed, in which case the person constructing it is under a duty to secure the water supply, or to premises which are unoccupied, or no longer suitable for habitation or investment in for future habitation, to avoid spending public money on purposes that do not contribute to provision of a safe, improved private water supply for the long term user.

9(S).5.1.11 Regulation 11 – Cases in which grants may be re-calculated, withheld or repaid

Regulation 11 provides a power for a local authority to withhold, reduce or recover the whole or part of a grant. Paragraph (1) provides that the local authority may use this power where approved works are not completed to its satisfaction, where the person to whom the grant is payable ceases to be an eligible person, or if it believes that information upon which its decision to approve a grant application was based was incorrect, inaccurate or incomplete.

Paragraph (2) provides that before exercising its power to withhold, reduce or recover the whole or part of a grant, the local authority must give the eligible person written notification of what it is proposing to do and the reasons for it, and give them an opportunity to make representations regarding the proposed action, and to consider any representations it receives.

9(S).5.2 Operation of Grant Scheme

Separate guidance will be issued by Scottish Ministers to local authorities on the details of the operation of the Grant Scheme under section 47 of the Local Government in Scotland Act 2003.

Annex 1

Information notice.

Drinking water supply

important information

The vast majority of water supplied in Scotland is safe for drinking.

In some establishments, particularly those in more remote areas, water may be supplied from a private source separate from the regular mains water supply.

Examples of private sources of drinking water include streams, wells and boreholes.

Although the quality of this water is usually acceptable for drinking, under certain circumstances the quality may be lower than you would expect from a public supply.

The owner of these premises can provide further details about the quality of drinking water in this property, allowing you to make an informed decision.

Find more information about private water sources at **www.privatewatersupplies.gov.uk**

Private Water Supplies

This page is intentionally blank

SECTION 10

SAMPLING, STORAGE AND TRANSPORTATION OF WATER SAMPLES

Section Contents

Private Water Supplies

SECTION 10

SUMMARY 10.1 – 10.2

10.1 Introduction

The object is to obtain a representative sample of drinking water for analysis, without affecting the sample. This must take into account any point of use or point of entry devices.

10.2 Sampling points

These include drinking tap, well, spring, storage tank, bore hole and surface water.

Programmed samples should be taken from the point of drinking, cooking or food preparation, allowing for treatment filters and whether every property has them.

Request and Public Health Samples generally come from the drinking tap but may need to come from the source if there is concern.

10.3 Sampling of potable water

The guiding **principle** is to obtain a representative sample not adulterated in the process, observing all **health and safety** codes throughout.

Any unusual **environmental conditions**, e.g. farming activity at the source or concerns at the tap, should be noted and, if appropriate, raised with management prior to sampling.

Sampling Equipment will include protective gloves (for sterilising), safety glasses, paper tissue, chlorine wash/spray bottle, beaker, stopwatch, waste container, blow torch, lighter, and disinfectant wipes.

Reagents Preparation – chlorine solution should be prepared freshly each day of use, using protective equipment and correctly labelling the bottle. Great care must be taken not to breathe the gas, and old solution must be flushed away with copious water.

The **sampling procedure** must be in the order of metals first, then chemicals and then microbiological samples. Any **metal sample** must be from the first draw of the tap without rinsing the bottle. For **chemical samples** the tap must be flushed for at least 2 minutes.

Sterilisation of Taps with chlorine solution requires gloves and safety glasses, and can be done either by immersing the spout of the tap, or wiping with chlorine-soaked tissue, or by spraying from the bottle. Taps should be in good repair and procedures followed rigorously.

Sterilisation of Taps by flaming should not be done in domestic situations. For other taps, follow the procedure carefully and do NOT use gloves with a blow-torch.

Bacteriological Sampling is extremely sensitive to contamination. Procedures must be rigorously followed with regard to the handling, flushing, labelling and storage of bottles, as well as to tap flow and personal hygiene.

10.4 Sampling procedure flow diagram

The flow chart shows the order of steps for sampling potable water, including chlorine residual testing.

10.5 Sampling from locations other than the consumer's tap

Sampling from surface waters – the sample should not be from too near the bank, too far from the point of draw off or from too deep. Avoid stagnant areas and guard against damaging banks.

Take care that the sample does not touch the hand first, follow all health and safety, and use sampling devices and sterilisation as necessary.

Sampling from wells – should be done from a sterilised tap before the cistern, or from the sterilised mouth of a hand pump, if used. Samples may also be taken directly from the well.

Sampling from special locations – for deep wells, lochs etc. use a sterile weighted bottle or sampling device. At water treatment plants, tap samples may not be representative. Dip samples should be via a weighted device or a sterile sample bottle attached to a long pole.

Private Water Supplies

This page is intentionally blank

10. SAMPLING, STORAGE AND TRANSPORTATION OF WATER SAMPLES

10.1 Introduction

The objective of sampling is to obtain a representative volume of the water to be consumed as drinking water and to store and transport that sample in such a manner as to limit any changes that may occur in the sample before it is analysed.

When a sample is being taken from a property, it is important to ascertain whether either a point of entry device has been fitted to treat all water supplied to that property or a point of use device has been fitted to the kitchen tap or installed within the plumbing leading to the kitchen tap. If so, efforts should be made to find out from the consumer or from the supplier of the device which parameters it is designed to remove. If a point of use device has been fitted to improve the microbiological quality of the water, a sample should be taken from a tap not connected to the device in order to confirm that the water supplied to the rest of the property (for example, for personal hygeine) is not detrimental to health. Where either a point of use device or a point of entry device has been fitted to one of several properties served by a particular supply, analysis of a sample taken from that property will not be enough to demonstrate that wholesome water is being supplied to other consumers dependent on the same supply, who may not have fitted such a device.

10.2 Sampling points

Samples can be taken from a variety of sampling points, including drinking tap, well, spring, storage tank, borehole or surface water.

10.2.1 Programmed samples

In domestic premises samples should be taken at a tap used to supply water for drinking or cooking purposes. In cases of a shared supply account should be taken of installation of treatment filters. For example, if all premises have microbiological filters then the sample can be taken from any property. However, if not all premises have filters installed the sample should be taken from the property without the filter and possibly also a house with a filter.

In food production premises samples should be taken at a point immediately before the point where the supply is used for food production and after any treatment given to the water before use.

10.2.2 Request and public health samples

These will generally be taken from the drinking tap.

Further samples may require to be taken from the well or storage tank or spring etc. because of concern about the quality of water, previous failures or other public health concerns.

10.3 Sampling of potable water

10.3.1 Principle

Sample are taken in such a manner that they are:

(a) representative of the water received by the consumer
(b) not contaminated by any material which could affect any future chemical or bacteriological test

10.3.2 Health and Safety

All relevant health and safety codes should be observed at all times when undertaking sampling activities.

10.3.3 Environmental controls

If any unusual environmental conditions exist these should be noted and, if appropriate, discussed with line management prior to proceeding with sampling. The following are examples of situations when such actions may be taken:

(a) evidence of animals defecating close to a tap or source to be sampled
(b) evidence of farmers having spread manure in fields adjacent or nearby to the source of the supply
(c) leaking tap gland from around the tap spindle
(d) an appendage to the tap to be sampled is present and cannot be removed
(e) tap selected for sampling is difficult to sterilize
(f) evidence of a "dirty" tap
(g) sudden changes in water flow or pressure
(h) presence of discoloured water

10.3.4 Sampling equipment and reagents

The following is not intended to be a definitive list but merely to provide an indication of the equipment and reagents that may be employed in sampling activities.

(a) Equipment

- Protective gloves (disposable and/or non-disposable) for preparing chlorine sterilising solution and sterilising taps
- Safety glasses
- Paper tissue
- Bottle with large top containing chlorine solution for tap sterilisation (1% Cl w/v) or wash/spray bottle containing chlorine solution for tap sterilisation (1% Cl w/v)
- 1 beaker

- Stopwatch
- Container for waste chlorine sterilising solution
- Gas blow torch and spare gas cylinder
- Lighter
- "Azowipe" or "Trigene" disinfectant wipes or equivalent

(b) Reagents preparation

(i) Preparation of Presept tablet (2.5gram) Chlorine solution

This solution must be prepared freshly each day it is required.

Put on the safety spectacles and disposable or non-disposable gloves provided.

Fill the plastic bottle approximately 1/3 full with distilled/de-ionised water. Where distilled/de-ionised water is not available tap water may be used.

Slowly and cautiously add the FOUR (2.5 gram) Presept tablets one at a time and swirl the bottle until all the tablets have dissolved. Carry this out in a fume cupboard if possible or in a well ventilated area because as the tablets dissolve gases will be given off. Avoid breathing these gases.

Make up to the 500ml mark on the bottle with distilled/de-ionised water or tap water from a beaker. Place the top on the bottle and gently invert to mix the solution.

This solution contains "1% w/v available Chlorine" (10,000 ppm available Chlorine) and must be labelled 'Tap Sterilising Solution 1% w/v available chlorine'. The solution must be labelled with the expiry date.

Flush the old solution to drain or sink and flush with copious amounts of cold water.

10.3.5 Procedure

Samples required from a particular sample point **must be taken in a specific order**:

- Chemical sample for metals
- Chemical sample for other chemical analysis
- Microbiological samples

(a) Chemical sampling

(i) If a metal sample is requested this must be taken before flushing the tap and before taking any other sample. Fill the bottle with the first draw from the tap. Do not rinse the bottle.

(ii) Flush the tap for at least two minutes.
(iii) Take all other chemical samples required.

(b) Sterilisation of consumer taps – Chlorine solution

Staff undertaking sampling should wear gloves (disposable or non-disposable) and safety glasses when handling chlorine solution.

Remove any attachments, filter and/or devices from the tap, clean the inner and outer surfaces of the tap spout with a clean tissue moistened with chlorine solution or alternatively, a disinfectant wipe. This procedure should be repeated until the surfaces of the taps are clean. However if a tap cannot be satisfactorily disinfected with the attachment, filter and/or devices removed, another tap must be sampled where possible. Taps should be in good repair. If they leak between the spindle and the gland when the tap is turned on, ideally, they should not be used.

EITHER

Fill a bottle-top full of 1% chlorine solution for sterilising consumer's taps (enough to immerse the bottom half of the tap spout).

Hold the bottle-top so that the spout of the tap is immersed in the chlorine solution for 30 seconds (timed using a stopwatch). Remove the bottle-top from the tap spout and empty the remaining chlorine solution from the bottle-top into the waste container. Allow the chlorine solution to remain in contact with the tap for a further two minutes (timed using a stopwatch) before flushing.

If the tap cannot practically be immersed in the solution, soak a piece of tissue in the chlorine solution and hold around the end of the tap for 30 seconds (timed using a stopwatch). Remove the tissue from the tap and allow the chlorine solution to remain in contact with the tap for a further two minutes (timed using a stopwatch) before flushing.

Wipe off any excess chlorine solution from the outside of the tap with disinfectant wipe of CLEAN tissue dampened with chlorine solution (otherwise you may contaminate the tap).

Flush the tap for at least one minute to ensure the chlorine solutions is rinsed away.

OR

Use your wash/spray bottle filled with 1% chlorine solution to spray inside the tap as far up the spout as possible.

Leave for two minutes (timed using a stopwatch) to allow the 1% chlorine solution to disinfect the tap.

Wipe off any excess chlorine solution with disinfectant wipes of clean tissue dampened with chlorine solution (otherwise you may contaminate the tap).

Turn on the tap and run the water to waste at a uniform rate for at least one minute to ensure that the 1% chlorine solution is rinsed away before taking the bacteriological sample.

(c) Sterilisation of taps – flaming

In general in domestic situations flaming of taps should not be encouraged. For other taps, where safe to do so, the following procedure should be followed.

Light your gas blow-torch and flame around the mouth of the tap using a tight blue flame and working up the spout stopping short of the body of the tap. If this is done adequately, when the tap is turned on there may be a very short puff of steam so care should be taken when turning the tap back on. Extinguish the flame. Turn the tap on full, then adjust back to a suitable flow and run the water to waste at a uniform rate for at least 30 seconds. This will also ensure that any water heated in the tap during the flaming has been flushed away and is therefore not sampled. Do NOT use gloves when handling a blow-torch.

(d) Bacteriological sampling

This is taken following chemical sampling and tap sterilisation above. Bacteriological examination is an extremely sensitive technique and can easily be ruined by contamination.

Please observe the following:

- Never hold the bottle by the neck.
- Never flush out the bacteriological bottle prior to taking the sample. Ensure that a pre-sterilised bottle is used as indicated by the tape on the bottle being intact. Ensure that the bottle is within its expiry date.
- Never lay the bottle down on the ground, on a fence post or on any other area that animals may have been in contact with as this may cause cross contamination of bacteriological samples.
- Observe good personal hygiene.
- If there are any environmental conditions that may affect the sampling or test result contact your line management.

Reduce the flow if necessary to achieve an even flow before sampling.

Check on the bacteriological bottle that the sterile tape indicator is unbroken and that the expiry date is not past. If the sterile tape indicator or the expiry date is not satisfactory DO NOT USE the bottle.

Remove the top from the bacteriological bottle.

Do not lay the top down. Hold the top firmly between the fingers of one hand with the open end down. Do not allow the fingers to touch the inner surface of the top and do not turn the top over.

Without changing the water pressure place the bottle in the stream of water from the tap and fill to the base of the neck leaving a small gap at the top to allow mixing in the laboratory. Do not allow the bottle to overflow. (If the bottle does overflow or the top of lip of the bottle touches either your hand or the tap, discard this bottle and take a new bottle.)

Carefully replace the top.

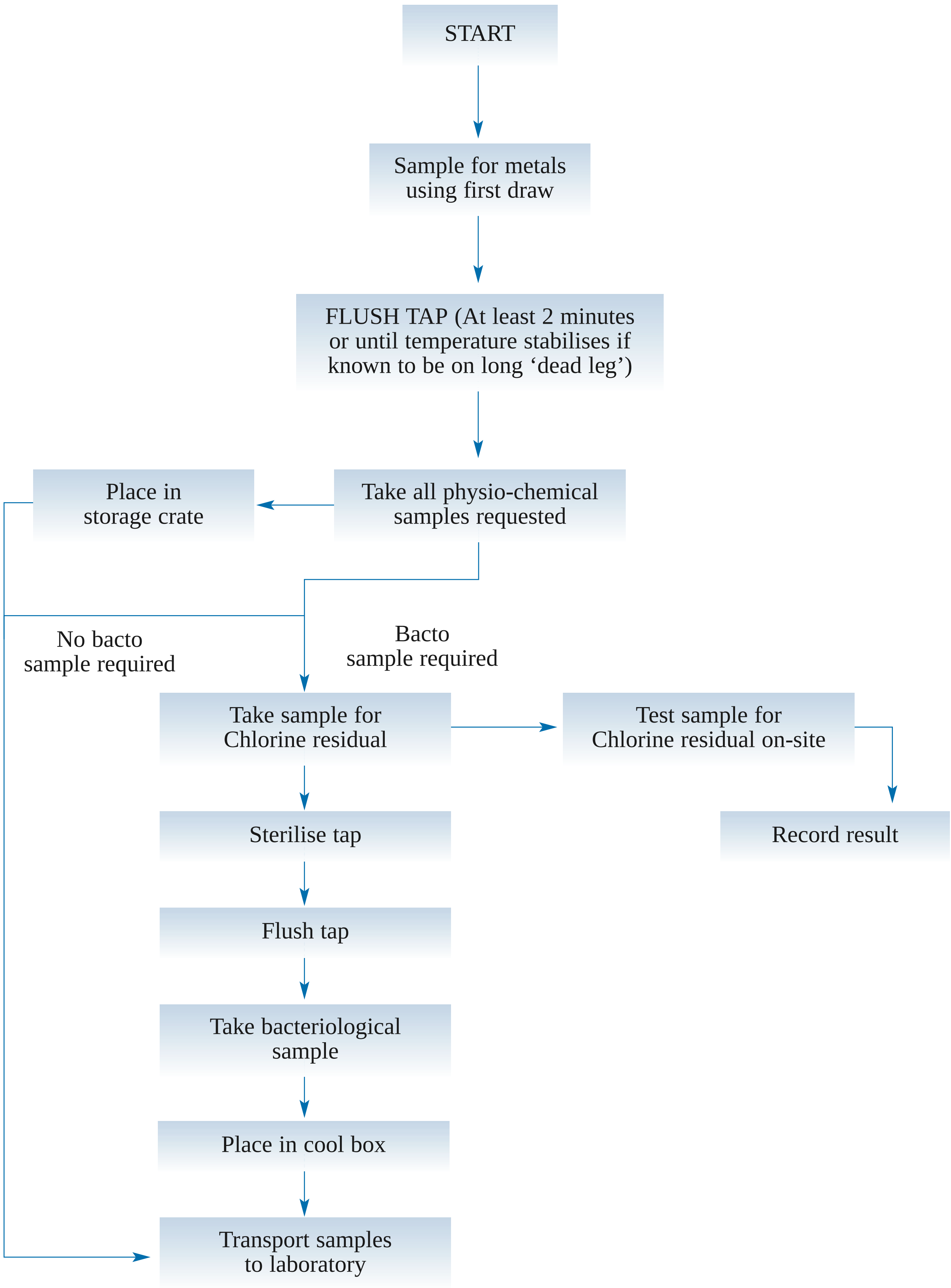
Turn off the tap.

Label all the bottles, at the time of sampling, with their appropriate pre-printed labels or hand written label with (as a minimum) site, sampling officer, purpose, time and date of sampling.

Ensure the chlorine solution bottle is free of drips and tightly sealed. Store well away from all sample bottles. Clean up behind you. Do not leave any rubbish behind.

Put the bacteriological bottle upright in a cooled insulated container (retaining a temperature of 2 – 8°C) and deliver to the laboratory as soon as possible. Actual operating range for the cool box must be maintained between 3 and 7°C due to the error on the cool box thermometer.

10.4 Sampling procedure flow diagram



10.5 Sampling from locations other than the consumer's tap

10.5.1 Sampling from surface waters

The aim in collecting samples directly from a river, burn, loch, reservoir, spring or shallow well must be to obtain samples representative of the water to be abstracted. It is therefore undesirable to take samples too near the bank or too far from the point of draw off. If abstraction is by means of a floating arm, the sample should not be taken from too great a depth. In burns or reservoirs, areas of relative stagnation should be avoided. Damage to the bank must be guarded against, otherwise fouling of the water may occur.

The sample should be taken as follows:

Remove the cover and stopper from the bottle and retain them in one hand.

Hold the bottle by the base with the other hand and plunge it neck downwards below the surface to a depth of about 30cm.

Tilt the bottle so that the neck points lightly upwards and point the mouth towards the current. Where no current exists, as in a reservoir, push the bottle forwards horizontally until full.

Remove the bottle and replace the stopper immediately.

Take care throughout that no water entering the bottle is likely to have come into previous contact with the hand.

If it is not possible to fill the bottle directly, as for example, where there is a high bank, the sample may often be obtained from a bridge by lowering into the water s specially weighted sampling device or a suitable container such as a metal jug. These may be sterilised either previously or on site. Alternatively a long pole fitted with a clamp to hold the sterile sampling bottle can be used.

Sampling officers should follow relevant Health and Safety legislation when taking samples.

10.5.2 Sampling from wells

Where pumping is mechanical, the sample should be collected from a previously sterilised tap on the rising main before the water passed into a reservoir or cistern. If the well is fitted with a hand pump, clean and flame the mouth and operate the hand pump for at least five minutes before taking the sample. Samples can be taken directly from the well by means of a sterile weighted bottle or jug or by means of a specially weighted sampling device.

10.5.3 Sampling from special locations

When sampling from a deep well or borehole or from the depths of a loch or reservoir, a sterile specially weighted bottle or sampling device should be used. When sampling at different parts of a water treatment plant, not all of which are served by sampling taps, dip samples should be taken using either a weighted sampling device or a sterile sample bottle attached to a long pole. It should be stressed that not all sampling taps in water treatment plants necessarily give a representative sample because of very long lengths of pipe work. In these circumstances it is advisable to run the water continuously to avoid stagnation and the possibility of microbial growth.

SECTION 11

WATERBORNE HAZARD RESPONSE FOR PRIVATE WATER SUPPLIES

Section Contents

Private Water Supplies

Private Water Supplies

11 WATERBORNE HAZARD RESPONSE FOR PRIVATE WATER SUPPLIES[1]

11.1 Introduction

For the vast majority of private water supplies the relevant local authority will act as the source of information and guidance relating to the suitability of management practices being adopted on individual supplies. Part of the role of the local authority will be to assist the relevant person to respond to situations where the quality of the water for human consumption purposes is either in question or has failed to meet the required wholesomeness standards. The local authority will provide the relevant person with appropriate suggested actions to be taken to protect the health of consumers using the supply and steps to be taken to address the deficiencies such that wholesome supplies can be re-established as quickly as practicable.

[1] This section is adapted from WHO 3rd Edition Guidelines for Drinking Water Quality (2004).

11.2 Management procedures

Before proceeding, it is worth setting out the definitions of some terms that will be used in this section.

(i) Management plan – management procedures for the operation of a private water supply will deal with the day-to-day operation of the system. These collected procedures are termed a 'management plan';
(ii) Incident – an incident is any situation in which there is reason to suspect that water supplied for human consumption purposes may be, or may become, unsafe;
(iii) Predictable incidents – many incidents can be anticipated, e.g. increase in turbidity following heavy rainfall;
(iv) Unforeseen events – some events that may impact on a private water supply may not have been anticipated and are not predictable.

Incident triggers could include:

- Non-compliance with operational monitoring criteria;
- Inadequate performance of a sewage treatment plant discharging to source water;
- Spillage of a hazardous substance into source water;
- Failure of the power supply to an essential control measure;
- Extreme rainfall/snow melt in a catchment;
- Detection of unusually high turbidity (source or treated water);
- Unusual taste, odour or appearance of water;
- Detection of microbial indicator parameters, including unusually high faecal indicator densities (source or treated water) and unusually high pathogen densities (source water); and
- Public health indicators or a disease outbreak for which water is a suspect vector.

While predictable incidents can be anticipated and appropriate responses detailed in the management plan, unforeseen events will not, by their very nature, have been anticipated and so the ability to respond to such events should be prepared for through the presentation of a generic response plan. This section will assist in the preparation of such a generic response plan.

The generic response plan can have a range of alert levels. These can be minor early warning, necessitating no more than additional investigation, through major to emergency. Discussions with the environment health officer will enable a list of likely incident triggers to be identified, e.g. heavy rainfall/snow melt in the catchment which may be minor or major depending on the level of treatment and the history of the quality of drinking water for the specific supply. While the scale of any response will be proportionate to both the size of the community being served by the private water supply and the degree of hazard posed to the supply, some issues will be common and should be considered as the minimum content of the response plan. These will include contact details for key personnel, often including several organisations and individuals, and relevant logistical and technical information. It is envisaged that the risk assessment for the supply will provide much of the required information.

Annex 1 provides *pro formas* that can be completed to provide a basic response plan.

The plan may need to be followed at very short notice and so appropriate preparations should be made in advance. An appropriate way to prepare is to rehearse the plan against a minor and a major alert level trigger to identify how well the plan operates and which, if any, areas require to be modified or strengthened.

It is anticipated that for major alert level triggers the local authority will be involved from an early stage and so the investigation and follow up to such incidents will be co-ordinated by their officers. For minor alert level triggers it is worth using such incidents to learn lessons and to re-evaluate the operation of the private water supply system to ensure that the risk of the same incident occurring again is significantly reduced or removed altogether.

Some threats to private water supplies may be considered serious enough to constitute an emergency. Under the Civil Contingencies Act (2004) certain provisions are made relating to the circumstances that constitute an emergency and which bodies can term such circumstances an emergency. Regardless of the legal position the preparation of the generic response plan for private water supplies will be of great assistance in such circumstances.

11.3 Responses to emergencies and unplanned events

While the relevant local authority will evaluate the potential health impacts of a given situation affecting a private water supply, the relevant person should have the ability to assist the local authority with any response that may be required. Immediate outcomes that may arise from the assessment of the severity of the impact to the private water supply by local authorities may fall into one of four categories:

(1) Do nothing
(2) Avoid using water for specific purposes including consumption
(3) “Boil Water” notice
(4) Close the supply.

While the “do nothing” category is self-explanatory the other options have consequences for the population affected and are never taken lightly. While the responsible person will have little or no role in the actual decisions they will play a vital role in ensuring that any communication with the affected population can be undertaken in an efficient and timely manner. The local authority will advise on appropriate communication strategies, but suggested notices for posting in public places in the vicinity of the incident and for delivery to individual premises are provided in Annex 2 to this section to facilitate any response that may be required.

Annex 1

Response Plan for [*insert supply name*]

Section A Key Contacts

Local Authority

Name ....

Telephone number (24 hour assistance) ....

Fax Number (24 hour assistance) ....

Address ....

Local Authority Environment Health Department

Environmental Health Officer's Name ....

Telephone number ....

Mobile Telephone Number ....

Email address ....

Relevant Person

Name ....

Telephone number (day) ....

Telephone number (evening) ....

Mobile telephone number ....

Fax number ....

Email address ....

Address ....

....

Relevant Person (alternative contact)

Name ....

Telephone number (day) ....

Telephone number (evening) ....

Mobile telephone number ....

Fax number ....

Email address ....

Address ....

Water Treatment Service Consultant/Provider

Name ....

Telephone number (day) ....

Telephone number (evening) ....

Mobile telephone number ....

Fax number ....

Email address ....

Address ....

Section B – Supply Details

Note – this section is taken from Section B of the relevant Risk Assessment undertaken for the supply.

Annex 2 – Generic Notices

A2.1 General Boil Notice
A2.2 Do not use for drinking or cooking
A2.3 Do not use for drinking, cooking or washing
A2.4 Do not use for any purpose
A2.5 All clear
A2.6 Blank notice

This page is intentionally blank

EMERGENCY

notice about your water supply

Boil your water

Private Water Supplies

The water to your home/premises requires to be boiled before it is safe to consume. The water only needs to be brought to the boil. Allow to cool in a sealed container.

Please ensure your neighbours – especially the elderly – know about the notice. We will advise you when the water is safe. This advice has been prepared by the Local Authority and the NHS board for you area.

You must use water that has been boiled for:

- **Drinking**
- **Cleaning teeth**
- **Preparing babies' feeds and disinfecting feeding equipment**
- **Preparing food**
  includes ice cubes and salads
- **Pet food and drink**
- **Washing open wounds**

You can use untreated tap water for:

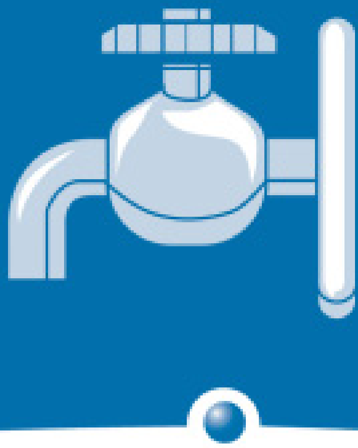
- **Bathing and washing**
  except open wounds
- **Washing dishes**
  use hot water and dry thoroughly before use
- **Washing clothes**
- **Flushing the toilet**

EMERGENCY

notice about your water supply

Do not use your tap water

for drinking or cooking



Private Water Supplies

Please note that your tap water may be contaminated. Boiling will not make it safe. Alternative water supplies will be made available. Water supplied from emergency tanks must be boiled before use.

Please ensure your neighbours – especially the elderly – know about the notice. We will advise you when the water is safe. This advice has been prepared by the Local Authority and the NHS board for you area.

Do not use tap water for the following:

- **Drinking**
- **Cleaning teeth**
- **Preparing babies' feeds and disinfecting feeding equipment**
- **Preparing food** includes ice cubes and salads
- **Pet food and drink**
- **Washing open wounds**

You can use untreated tap water for the following:

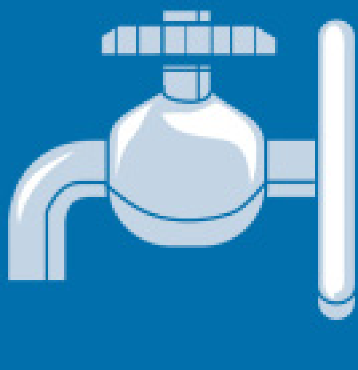
- **Bathing and washing** except open wounds
- **Washing dishes** use hot water and dry thoroughly before use
- **Washing clothes**
- **Flushing the toilet**

EMERGENCY

notice about your water supply

Do not use your tap water

for drinking, cooking or washing



Private Water Supplies

Please note that your tap water may be contaminated. Boiling will not make it safe. Alternative water supplies will be made available. Water supplied from emergency tanks must be boiled before use.

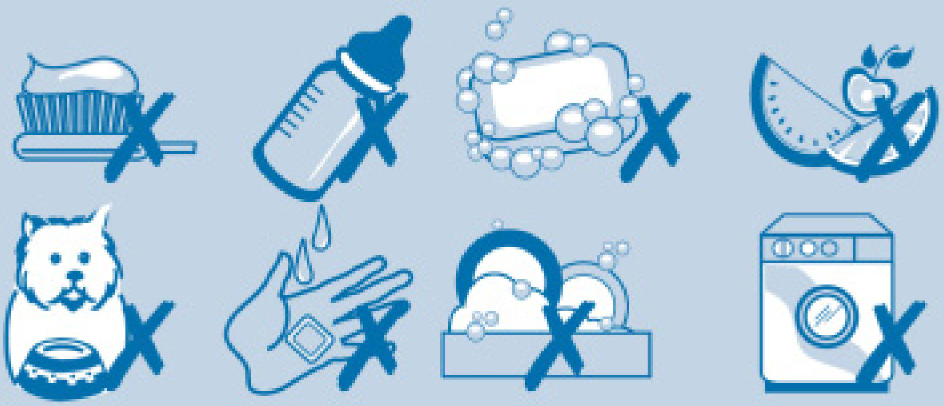
Please ensure your neighbours – especially the elderly – know about the notice. We will advise you when the water is safe. This advice has been prepared by the Local Authority and the NHS board for you area.

Do not use tap water for the following:

- **Drinking**
- **Cleaning teeth**
- **Preparing babies' feeds and disinfecting feeding equipment**
- **Washing and bathing**
- **Preparing food** includes ice cubes and salads
- **Pet food and drink**
- **Washing open wounds**
- **Washing dishes**
- **Washing clothes**

The water can be used for:

- **Toilet flushing**

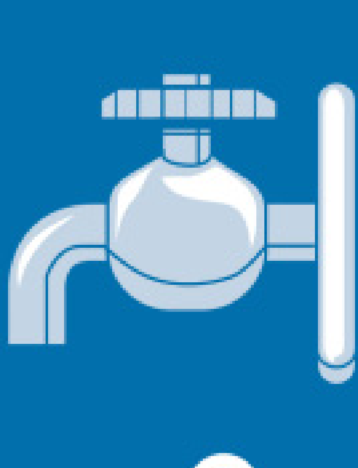


EMERGENCY

notice about your water supply

Do not use your tap water

for any purpose



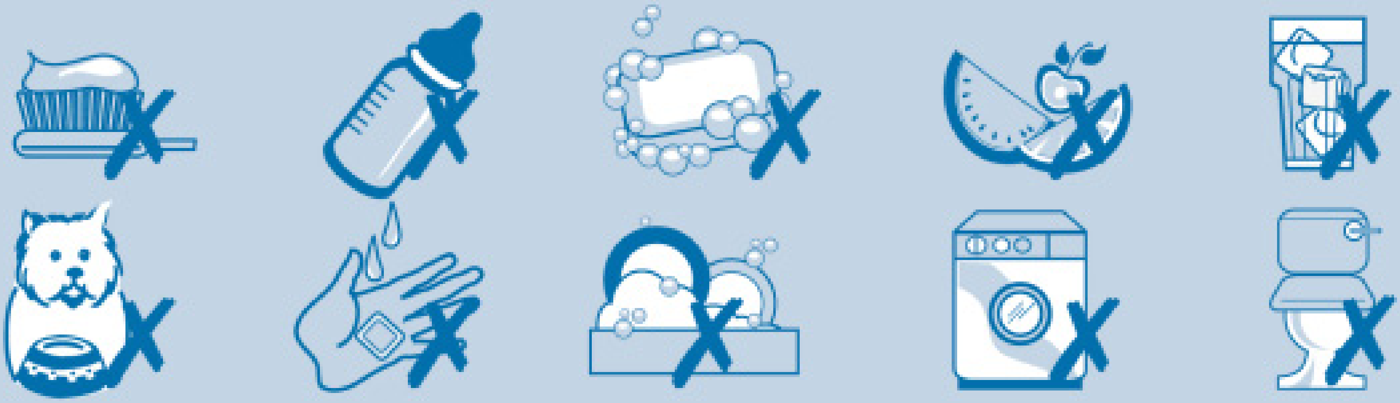
Private Water Supplies

Please note that your tap water may be contaminated. Boiling will not make it safe. Alternative water supplies will be made available. Water supplied from emergency tanks must be boiled before use.

Please ensure your neighbours – especially the elderly – know about the notice. We will advise you when the water is safe. This advice has been prepared by the Local Authority and the NHS board for you area.

Do not use tap water for the following:

- **Drinking**
- **Cleaning teeth**
- **Preparing babies' feeds and disinfecting feeding equipment**
- **Washing and bathing**
- **Preparing food** includes ice cubes and salads
- **Pet food and drink**
- **Washing open wounds**
- **Washing dishes**
- **Washing clothes**
- **Toilet flushing**
- **Any other use**

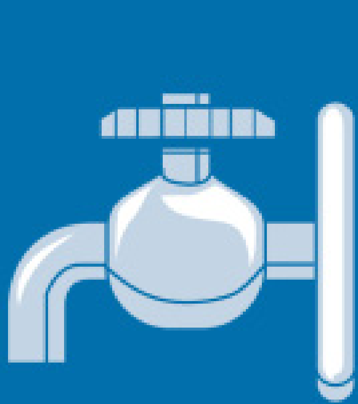


EMERGENCY

notice about your water supply

your tap water can now be used

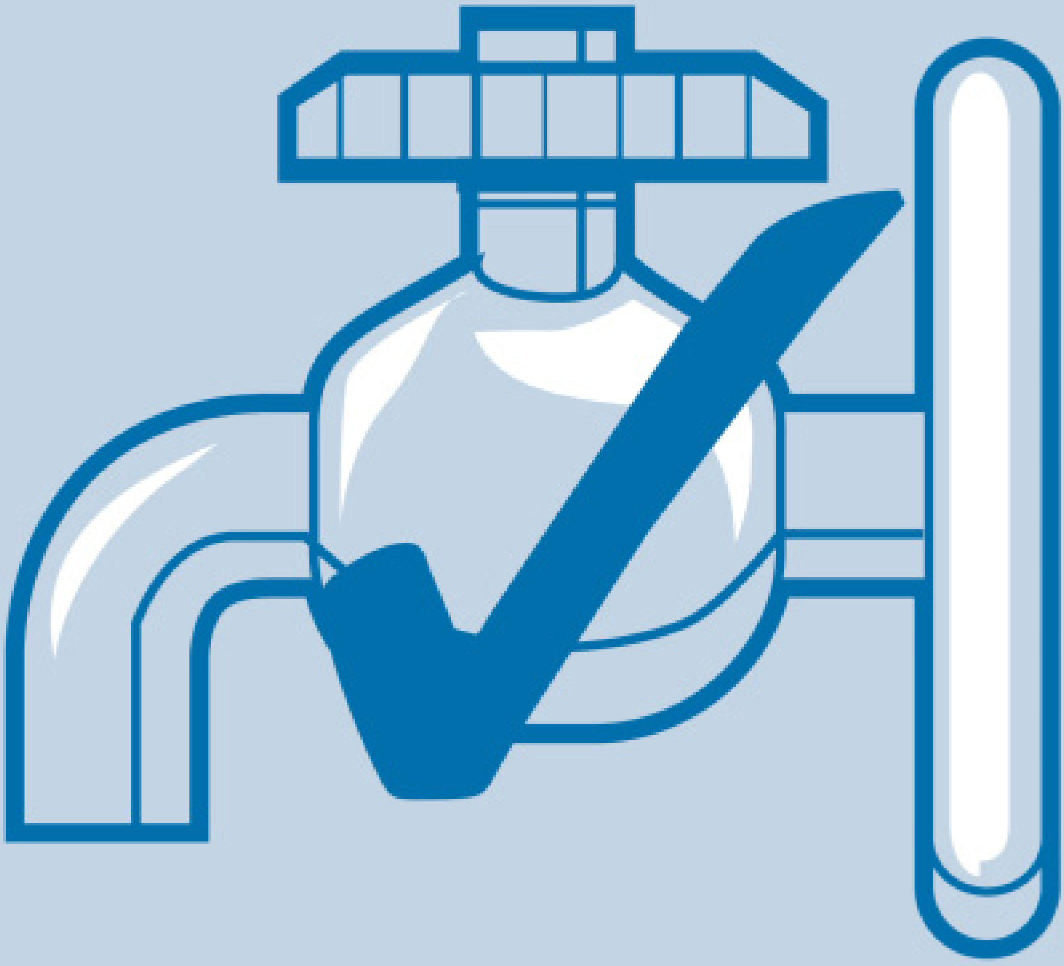
in the normal way



Private Water Supplies

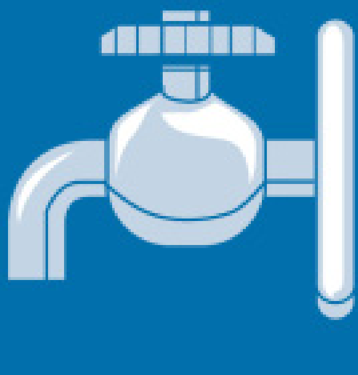
Tests have shown that your water supply is now safe to use as normal. The local NHS Board have agreed that the recent precautions are no longer necessary.

Please ensure your neighbours – especially the elderly – know about the notice. This advice has been prepared by the Local Authority and the NHS board for you area.



EMERGENCY

notice about your water supply



Private Water Supplies

Tests have shown that your water supply is now safe to use as normal. The local NHS Board have agreed that the recent precautions are no longer necessary.

Please ensure your neighbours – especially the elderly – know about the notice. This advice has been prepared by the Local Authority and the NHS board for you area.