Drinking Water Quality Regulator for Scotland

DRINKING WATER QUALITY
IN SCOTLAND 2016

PUBLIC WATER SUPPLY

SAFEGUARDING YOUR DRINKING WATER QUALITY

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FOREWORD

This is the fifteenth report from the Drinking Water Quality Regulator for Scotland (DWQR). The report provides a summary of the quality of Scotland's public water supplies for 2016. Our report also describes the work of the DWQR during the calendar year 2016 in scrutinising the quality of drinking water provided by Scottish Water.

Compliance with the standards set out in our legislation and in the EU Drinking Water Directive in 2016 was 99.91%, demonstrating the continuing high quality of drinking water that consumers in Scotland receive. This reflects the benefits of on-going investment in water quality and the focus given by Scottish Water to improving operational practices and the maintenance of its assets. Maintaining this high level of compliance requires constant vigilance from Scottish Water and a thorough understanding of risks so that proactive intervention can take place before drinking water quality standards are compromised.

During 2016 we submitted a report to the Procurator Fiscal following our investigations into a drinking water quality incident from 2015, when over 6,000 properties in North Lanarkshire suffered restrictions on the use of their water following contamination of the supply. This incident caused considerable inconvenience and worry to the consumers affected, and our investigation found deficiencies with Scottish Water's operational processes. The case concluded earlier this year when Scottish Water pleaded guilty to the charge of supplying water unfit for human consumption.

26 drinking water quality incidents occurred during 2016 which required detailed investigation, less than the 35 incidents which occurred during 2015. Incidents occur for a variety of reasons, though some common themes were evident during 2016, these included failure of equipment, lack of monitoring and in some cases human error. There is still considerable scope for Scottish Water to reduce the numbers of drinking water quality incidents through improved maintenance and monitoring of water treatment processes and ensuring that lessons learnt are shared across operating areas.

Very high levels of compliance with standards and a high level of public confidence is something that I expect Scottish Water to safeguard, through robust assessment of risks and the diligent operation and maintenance of resilient water supply systems.

Scottish Water are clearly committed to the continued improvement of drinking water supply systems and the quality of water that consumers receive. I am encouraged by the work I have seen on the implementation of their water quality strategy which sets out how assets, processes and data are being used to proactively improve water supply systems.

Sue Petch
Drinking Water Quality Regulator for Scotland

EXECUTIVE SUMMARY

In Scotland, the public water supply is provided by Scottish Water. All other supplies, owned and managed by individuals, are known as private water supplies. The Drinking Water Quality Regulator for Scotland (DWQR) regulates the quality of water supplied by Scottish Water, ensuring that drinking water supplies meet the requirements of the Public Water Supplies (Scotland) Regulations 2014 ("the Regulations").

Some key facts about the public water supply in Scotland for 2016 are shown below:

Scottish Water supplied **1.8** billion litres of drinking water per day

from **241** water treatment works

through **47,000** km of water mains

99.91% satisfactory samples from consumers' taps

Scottish Water takes and analyses its own samples to demonstrate that the water supplied complies with regulatory requirements. In 2016, 311,560 tests were undertaken on samples collected across drinking water assets, though predominantly from consumers' taps. This sampling and analysis is independently accredited, and is consistent with water industry practice in the rest of the UK.

The DWQR assesses Scottish Water's monitoring programme and results. These are discussed in Section 1 of this report. We also inspect a range of Scottish Water activities and assets that could affect quality and investigate any water quality incidents that are reported. Information on our audit and investigative work is given in Sections 2 and 3 of this report. During 2016 we conducted the following activities in fulfilment of our scrutiny function:

Investigated **26** drinking water quality incidents	Assessed Scottish Water's sampling and monitoring programme of **311,560** samples	Evaluated **798** water quality event notifications
Responded to **86** consumer contacts	Carried out **17** technical inspections of assets and activities	Reviewed risk assessments and improvement plans for **241** supplies

1 DRINKING WATER QUALITY 2016

Water Treatment Works

Scottish Water has 241 water treatment works (WTW) that treat water to ensure it is safe to drink and complies with the standards set out in the Regulations. Treatment works in Scotland range from large supplies serving whole cities to very small works that supply small communities consisting of a few properties. Regardless of size, Scottish Water is expected to ensure that its works are capable of treating the range of raw water quality which may be found in source waters.

The majority of regulatory analysis takes place on samples collected from consumers' taps, but some important sampling also takes place on water as it leaves each treatment works. The number of samples which need to be collected each year varies depending on the volume of water supplied by the treatment works.

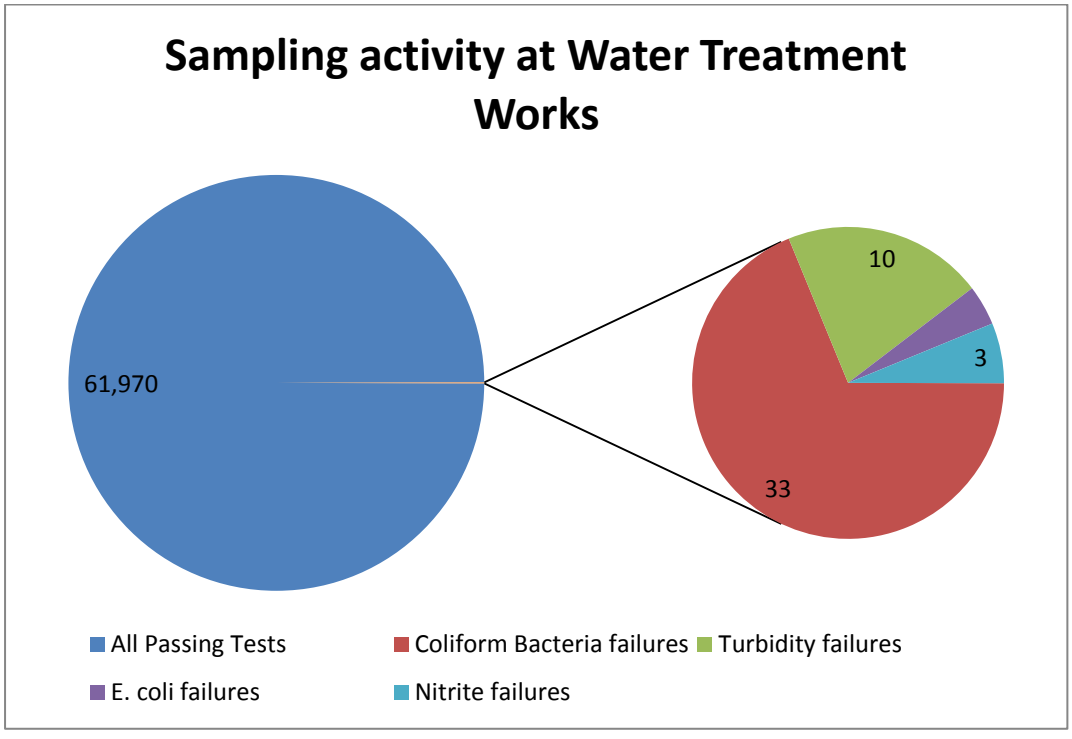

Figure 1 Proportion of treatment works sample failures

Over 60,000 tests were undertaken on samples collected at treatment works. Of these, 48 failed to meet the required standard. A summary of all the tests carried out on water supplied from treatment works is given in Table 2 of the Performance Tables.

Microbiological Quality at Treatment Works

Coliforms and *E. coli* are two parameters measured in water leaving treatment works in order to verify that disinfection has been successful. All failures must be fully investigated by Scottish Water and reported to DWQR, the local NHS board and local authority.

When investigating sample failures at treatment works, Scottish Water should be considering a number of factors, such as changes in the quality of the incoming raw water, issues or unexpected changes in the treatment process, the circumstances of sampling, including the condition of the sample line and sample tap, and evidence from samples taken downstream in the distribution system. Consideration should be given to taking additional samples, including between stages of the treatment process, to establish whether there is a genuine problem and where this might be. Data from on-line monitoring can also yield very useful information on quality around the time of the failure. Scottish Water routinely carries out root cause analysis of investigations of sample failures and this has been beneficial in understanding and resolving the causes underlying many failures.

Microbiological compliance, as shown in **Figure 2**, has generally improved over the years (summary data is given in Table 3 in Performance Tables). There were 33 detections of coliforms at treatment works, representing a significant deterioration on performance reported in 2015. Two *E. coli* were detected, against no detections in 2015. Scottish Water has committed significant resource into improving this performance and has a number of water quality improvement initiatives under way which include asset capability assessments; the development of a bacterial barrier assessment tool; and extensive investigation using flow cytometry. The early indications based on 2017 data are that water treatment works performance is improving.

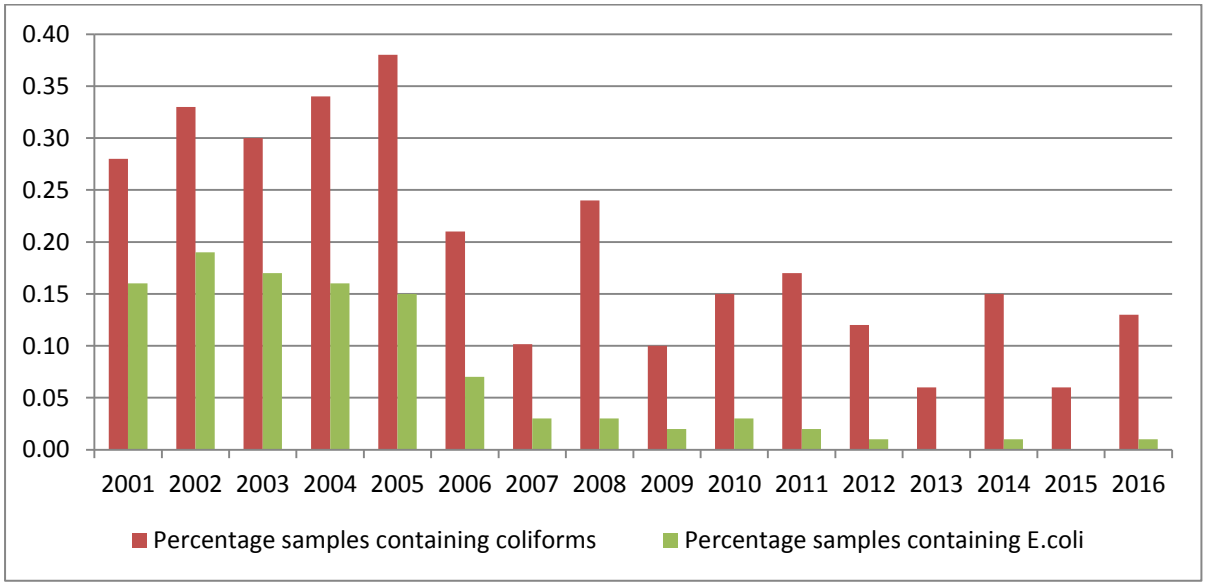

Figure 2 Year on Year Microbiological Failures at Water Treatment Works

Two treatment works recorded more than one microbiological failure in 2016.

Carron Valley, a large works which supplies much of central Scotland, recorded three failures. This is of concern, especially in light of two final water turbidity failures and microbiological failures in Balmore Carron Valley water supply zone that occurred during the year. In response to these failures DWQR carried out an inspection of the treatment works. Scottish Water attributed the failures to the integrity of the clear water tank, and work is being undertaken to rectify this, which DWQR has verified. Continued vigilance is required at this important site.

Two coliform failures occurred at Afton Water Treatment Works, which supplies parts of Eastern Ayrshire. Scottish Water did not find a cause for either of these failures.

The two *E. coli* detections were at the island treatment works of North Hoy in Orkney and Colonsay in the Inner Hebrides. The North Hoy failure resulted in a "boil water" notice being imposed for a short period. Ultimately, Scottish Water concluded that both failures were unrepresentative of the water supplied to consumers.

Chemical Quality at Treatment Works

Water is tested for two chemical parameters, nitrite and turbidity, in samples taken from treatment works. Nitrite is a compound of nitrogen that can occur in supplies where ammonia is added to chlorine in a process called chloramination. This process needs to be tightly managed, and the presence of nitrite in significant quantities can indicate that it is not controlled as it should be. Following four consecutive years with no exceedances of the ex-works standard, there were three failures in 2016. All of these were from the same treatment works – Badentinan in Moray. While DWQR is content with the validity of chloramination as a water treatment process, concerns over the consistent control of the process across Scotland resulted in DWQR considering enforcement action and requesting an independent review of Scottish Water's operational approach at its chloramination sites.

Turbidity is a measure of the extent to which particulate matter in the water scatters light – effectively how cloudy the water appears. Turbid waters cannot be properly disinfected, hence a treatment standard of 1.0 nephelometric turbidity units (NTU) has been set in the Regulations. In 2016 there were 10 exceedances of the standard for turbidity at 9 treatment works, the same as in 2015. Summary data is shown in Table 4 in Performance Tables.

One site – Carron Valley WTW in central Scotland – recorded two samples which failed the ex-works standard for turbidity (as it did in 2015). Once again, these were attributed to the sampling arrangement at the works, and Scottish Water has committed to investigate and resolve this situation.

Cryptosporidium at Treatment Works

Cryptosporidium is a microscopic protozoan parasite that can live in the gut of humans and other animals. *Cryptosporidium* oocysts can enter a water supply if faecal material is washed into the source (raw) water and oocysts are not removed by the treatment process. *Cryptosporidium* is not inactivated by chlorine and requires the water treatment process to be well optimised and monitored in order to ensure that it is physically removed. Scottish Water tests water supplies for *Cryptosporidium* in order to verify that these processes are effective. Ultra-violet (UV) light can be effective at inactivating oocysts, and Scottish Water uses this process at a small number of sites where physical removal of oocysts by the original treatment process may not be consistent.

Tullich UV Treatment Unit

The number of detections of *Cryptosporidium* reported in final water samples was 87, a slight increase on the previous year, but still a significant reduction on historic levels. The treatment works reporting the most frequent detections were Tullich, serving Oban, where 31 samples contained oocysts and Lochaline in Morvern, with 8. Both of these treatment works have recently installed UV treatment, so all oocysts are inactivated.

A completely new treatment works is under construction at Tullich to supply Oban. This is due for completion during 2017. A new membrane treatment process has been constructed at Lochaline and went into supply in May 2017.

New Tullich WTW – June 2017

A number of repeated detections of oocysts were recorded at treatment works where this is comparatively unusual. Turriff, serving a significant portion of Aberdeenshire, had 5 detections. These have been attributed to problems with the filters which are progressively being refurbished. Bonnycraig, serving Peebles in the Scottish Borders, recorded 3 detections with concerns emerging in relation to both the coagulation and filtration processes. Although work is under way to optimise these as far as possible, UV treatment has also now been installed.

Service Reservoirs

Service reservoirs are located at points in the distribution system to store water, both for hydraulic reasons and to even out the demand for water through the day. If these service reservoirs are not maintained they can be prone to inward leakage from contaminated surface water. This needs to be controlled through inspection and maintenance. Scottish Water adopts a risk-based approach to cleaning and refurbishing storage tanks.

DWQR inspects a selection of structures each year in order to ensure that they are being maintained and operated in a manner that minimises risk to water quality.

Coliforms and *E. coli* are two parameters measured in samples regularly taken from service reservoirs to verify that disinfection is effective within the distribution system and to identify any instances where the water may have become contaminated. All coliform failures must be fully investigated by Scottish Water and reported to DWQR, the local NHS board and local authority.

Summary results for service reservoirs in 2016 (Tables 6 & 7 in Performance Tables) show that there was a lower overall incidence of bacteriological sample failures than reported in 2015. Figure 3 shows comparative annual performance since 2007.

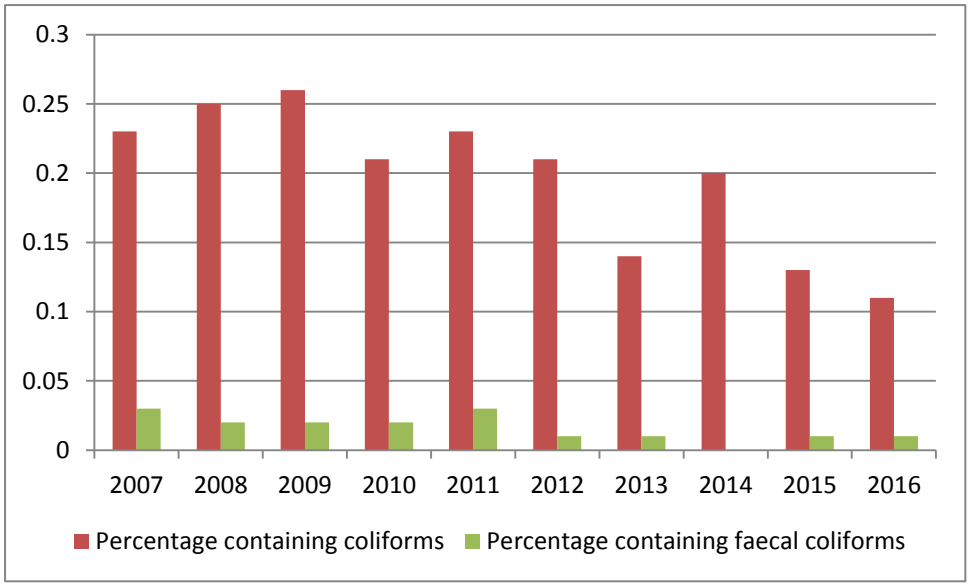

Figure 3 Year on Year Microbiological Failures at Service Reservoirs

The Regulations require that no sample from service reservoirs should contain *E. coli* and at least 95% of samples may not contain coliforms. Fifty-three samples contained coliforms, compared with sixty-three in 2015 (one service reservoir failed to meet the 95% requirement) and four samples contained *E. coli*. The *E. coli* failures were as follows:

Following a reported failure at Carlops service reservoir by Carlops, Scottish Borders, investigations by Scottish Water concluded that an error had occurred in the laboratory, and it was unlikely to be a genuine water quality failure.

Two *E. coli* failures occurred at Colpy service reservoir near Cairnhill, Aberdeenshire. No definitive cause for the first detection could be determined, and it was thought to have been caused by environmental contamination of the sample tap. The second failure, two months later, was attributed to integrity issues; despite a recent refurbishment of the tank, sheep faeces were found on the roof of the tank and there was ingress of surface water into the tank. Scottish Water bypassed the service reservoir until remedial work was completed.

No cause could be determined for the *E. coli* failure at Broomhills service reservoir near Chesters, Scottish Borders, which was in a good state of repair with adequate chlorine levels.

All service reservoirs except one met the regulatory requirement that 95% of samples should not contain coliforms. These failures were at Drumoak service reservoir, near Peterculter, Aberdeenshire, where two out of 36 samples contained coliforms. An Inspection Report in 2015 showed that there were several points of ingress into the tank, and this tank has now been removed from service.

A number of other service reservoirs have had coliform failures in at least two of the last five years. These are:

Strichen Bransbog at Strichen, Aberdeenshire (2015 and 2016), attributed to a failure of the sample point, which has since been upgraded. This service reservoir was included in DWQR's inspection programme for 2016.

Graemsay in the Orkney Islands (2011, 2012, 2013, 2015, 2016). Investigations by Scottish Water into the failure in 2016 showed that the sample failures were not representative of water quality at the service reservoir but instead were attributed to falsification of records and non-conformance with Scottish Water's sampling procedures. In addition to this finding it was also necessary for Scottish Water to make a number of improvements to the service reservoir and the supplying treatment works.

Portknockie by Cullen, Moray (2015 and 2016) was cleaned and inspected following the failure in August 2015, and the sample point was found to be below standard and in need of replacement. Points of ingress into the tank have been resolved.

Lanes at Barr, near Girvan, South Ayrshire (2015 and 2016). The most likely cause has been concluded to be ingress into the service reservoir through leaking hatches which have been repaired.

Torphins Cockardie near Banchory, Aberdeenshire (2015 and 2016) has been attributed to ingress into the service reservoir. Repairs to the tank are being progressed and are scheduled for completion by the end of June 2017.

The monitoring requirement for service reservoirs is to take weekly samples when they are in service and a 'live' part of the water supply route. A number of reservoirs fell short of recording 52 samples in the year and DWQR is satisfied that this is substantially due to the reservoir being withdrawn from supply for a period of time for inspection, cleaning, repair or frozen sample points.

Water Quality at Consumers' Taps

Scottish Water's supply area is divided into 289 water supply zones. Most sampling to assess regulatory compliance takes place at consumers' taps, and testing takes place for 51 parameters. Sampling frequencies are determined by the size of the population in the water supply zone.

In 2016, 148,944 tests were carried out on samples taken at consumers' taps. Of these, 131 failed to meet the standard set out in the Regulations. This means that 99.91% of tests carried out at consumers' taps complied with the standards. The equivalent figures for 2015 were 123 failing samples and 99.92% compliance, demonstrating a poorer performance.

Eighty-five supply zones failed to meet one or more of the standards, which is a slightly poorer position than 2015's figure of 77.

Scottish Water's overall figure for Mean Zonal Compliance (MZC) in 2016 was 99.92% (the methodology for calculating this measure is shown in Appendix D). This allows comparison with performance in England and Wales, where the MZC measure is used as an indicator of overall drinking water quality.

Table 1 below shows the failing test results of samples taken from randomly selected consumers' taps. Compliance for a number of key parameters is then discussed in more detail. The number of samples taken for each parameter that Scottish Water is required to test for is shown in Table 8 of the Performance Table report.

Table 1 Summary of Failing Tests on Consumer Tap Samples During 2016

Parameter	Total No. of Samples	No. Failed Samples	No. Zones with Failures	% Compliance
Failing Parameters				
Coliform Bacteria	14,058	37	28	99.74
E. coli	14,058	1	1	99.99
Clostridium perfringens	5,033	6	6	99.88
Enterococci	1,505	1	1	99.93
Iron	5,027	23	18	99.54
Manganese	5,027	10	7	99.80
Lead (10)	1,501	13	12	99.13
Total Trihalomethanes	1,506	8	8	99.47
Nitrite	2,418	7	6	99.71
Nickel	1,501	6	6	99.60
Odour	5,069	6	6	99.88
Taste	5,066	5	5	99.90
Turbidity	5,073	1	1	99.98
Hydrogen ion (pH)	5,067	1	1	99.98
Aluminium	5,027	1	1	99.98
Ammonium	5,066	1	1	99.98
Benzo 3,4 Pyrene	1,534	1	1	99.93
PAH – Sum of 4 Substances	1,507	1	1	99.93
Radon	173	2	2	98.84
All other parameters	63,728	0	0	100.00
SCOTLAND	**148,944**	**131**	**85**	**99.91**

Coliform Bacteria

Coliform Bacteria or 'Total Coliforms' represent the group of bacteria of which *E. coli* is one species. They are common in the environment and do not necessarily indicate faecal contamination but should not be present in the water supply as they are readily deactivated by chlorine, which is added in controlled amounts to all of Scottish Water's supplies.

Coliforms were detected in 37 samples in 2016, which is a poorer performance than the 34 recorded the previous year.

There does not appear to be a geographical pattern to the exceedances with the majority (22) of the failures occurring singly in different supply zones. Five zones recorded two failures and one, Balmore Carron Valley, recorded five failures. When these failures occur, Scottish Water takes further samples from the premises and also from neighbours to determine if there is a local property issue or a wider supply system concern. A significant proportion of failures, however, are found to be caused by hygiene issues at the kitchen tap.

Scottish Water notifies the consumer of the findings and provides the appropriate advice in each case.

Scottish Water has demonstrated that improvements are possible by such means as thorough treatment of water, diligent maintenance of storage points and distribution systems to ensure their integrity and cleanliness and careful management of residual chlorine and water age. The importance of maintaining these measures is demonstrated by the five failures in Balmore Carron Valley and twin failures in Carron Valley B zone. Both zones are supplied by Carron Valley water treatment works and investigation found there to be contributory factors from treatment, trunk mains and storage points in the distribution system towards the failure of this microbiological standard at consumer's taps.

E.coli

E. coli is an extremely important parameter because it is an indicator of faecal contamination and the microbiological safety of the water. The detection of *E. coli* in a water sample may be an indication that the supply in that area has become contaminated or it may simply relate to the tap from which the sample was taken. Scottish Water must investigate each failure thoroughly to try to determine the cause and respond appropriately.

Compliance for this parameter is relatively stable with only a few failures occurring each year. One sample failed from the Strathyre supply zone in 2016. On investigation, this failure was attributed to the condition of the kitchen tap.

Clostridium perfringens

Clostridium perfringens is a secondary indicator of faecal pollution. Clostridial spores can survive in water much longer than organisms of the coliform group and will resist disinfection. Their presence in disinfected waters may indicate deficiencies in treatment. In distribution systems and at customer taps, they can be an indicator of some historic contamination having occurred.

There were six failures of this standard in six different supply zones. The causes of these individual cases were either unable to be conclusively determined or were attributed to kitchen tap hygiene.

Enterococci

Enterococci are a group of bacteria that live in the gut of warm blooded animals, so their presence in the water supply can indicate contamination of that supply by faecal matter. Some species of Enterococci cause infection, so their detection in a water sample must be taken seriously and investigated. They should not be present in the water supply and immediate action must be taken if they are found.

Enterococci were detected in one sample from the Glendevon supply zone in 2016. Investigation of the failure identified the condition of the consumer's tap to be the cause.

Iron

Iron occurs naturally in some water supplies but should be predominantly removed by the treatment process. It is used as an alternative flocculant to aluminium at a few treatment works in Scotland. The most common cause of failures of the iron standard at consumer taps is corroding cast iron water mains which can cause sediment to build up in distribution systems. High concentrations of iron can cause discoloured water supplies, greatly inconveniencing consumers.

Scottish Water has embarked on a large programme of renovation of the water mains that cause the most significant water quality issues and has developed techniques and measures to ensure that quality is managed on an on-going basis in the meantime. This should also have the effect of reducing the number of discoloration complaints received by Scottish Water from consumers.

Compliance with the iron standard has improved over the years and 2016 saw a slightly better performance than the previous year with 23 samples failing within 18 supply zones. Perhaps unusually, there was no standout failing zone in 2016 but five where two failures occurred and the remaining failures recorded singly in separate zones. A study is planned to be completed during 2017 to inform of the required investment for mains rehabilitation works.

Manganese

Manganese occurs naturally in some raw waters, especially in the West of Scotland. If it is not removed effectively by the treatment process it can accumulate as fine black sediment in distribution system pipework and cause severely discoloured water supplies and great inconvenience for consumers. Overall compliance continued to improve in 2016, but has further to go. Even a relatively low concentration of manganese in the final water of a treatment works can accumulate in pipes and cause problems in distribution pipework.

Two water supply zones recorded more than one failure in 2016, Daer Camps A in the South Region and Muirdykes in the West. All the single zone failures and both failures in the Daer Camps A zone were attributed to disturbance of deposits in the water mains. Three failures in the Muirdykes zone were due to inadequate treatment at Muirdykes WTW. New filters have been constructed at this treatment works to enable manganese removal and these were introduced to the process stream during the spring of 2017.

Lead

In Scotland, lead does not occur naturally in significant concentrations in our water supplies. The problem arises when drinking water comes into contact with lead supply pipes, lead tanks, and lead solder joints on copper pipes, or inferior quality brass fittings and taps, particularly for longer periods (e.g. overnight/ weekends / holiday periods). This can result in high lead levels in the drinking water supply.

DWQR has established a project to review policy to drive achievement of a reduction of exposure to lead in drinking water. The project looks to strengthen or introduce mechanisms with a range of stakeholders and influencers to raise awareness with consumers and promote the removal of lead service pipes and plumbing.

Although the majority of lead piping is privately owned and therefore outside Scottish Water's direct control, the company does have a responsibility under the Regulations to minimise the risk from dissolved lead. The standard for lead reduced from 25µg/l to 10µg/l at the end of 2013. Against the 10 standard, over the past three years there have been 12, 15 and in 2016, 13 failures. All but two of those 13 occurred singly, in separate zones. Two failures were recorded in the Daer Coulter supply zone. In all cases, there was lead within the domestic plumbing system but Scottish Water also needed to replace six of its own communication pipes as a result of the failing samples. Scottish Water also notified the householders of the health risks of lead and that they should seek to replace their own customer-side pipework.

Scottish Water is required to treat water supplied to zones where there is a demonstrable risk of failure of the lead standard. This is achieved by adding small amounts of orthophosphoric acid to the supply and optimising the dosing to provide a coating to lead pipes and thereby reducing the plumbosolvency effect. Of the 13 failures, seven occurred in zones with this treatment in place. Six zones were considered to be of low risk of failure and Scottish Water must keep these under review.

Total Trihalomethanes (THM)

THM are one group of disinfection by-products that can form when organic substances combine with chlorine used to disinfect the water. As Scotland's upland waters are naturally rich in these organic compounds, management of THM formation presents Scottish Water with a challenge. Scottish Water has devoted much effort to reducing the formation of THM in its water supplies and has made significant inroads on this issue but there has been a poorer performance in 2016 where eight failures occurred in separate zones.

In addition to meeting the standard for total THMs, Scottish Water is also required to minimise the production of all disinfection by-products. **Figure 4** shows reducing numbers of zones affected at different levels of THM within the standard which suggests not only improvement at the prescribed concentration or value (PCV), but a more in-depth progress and that Scottish Water is endeavouring to reduce by-product formation.

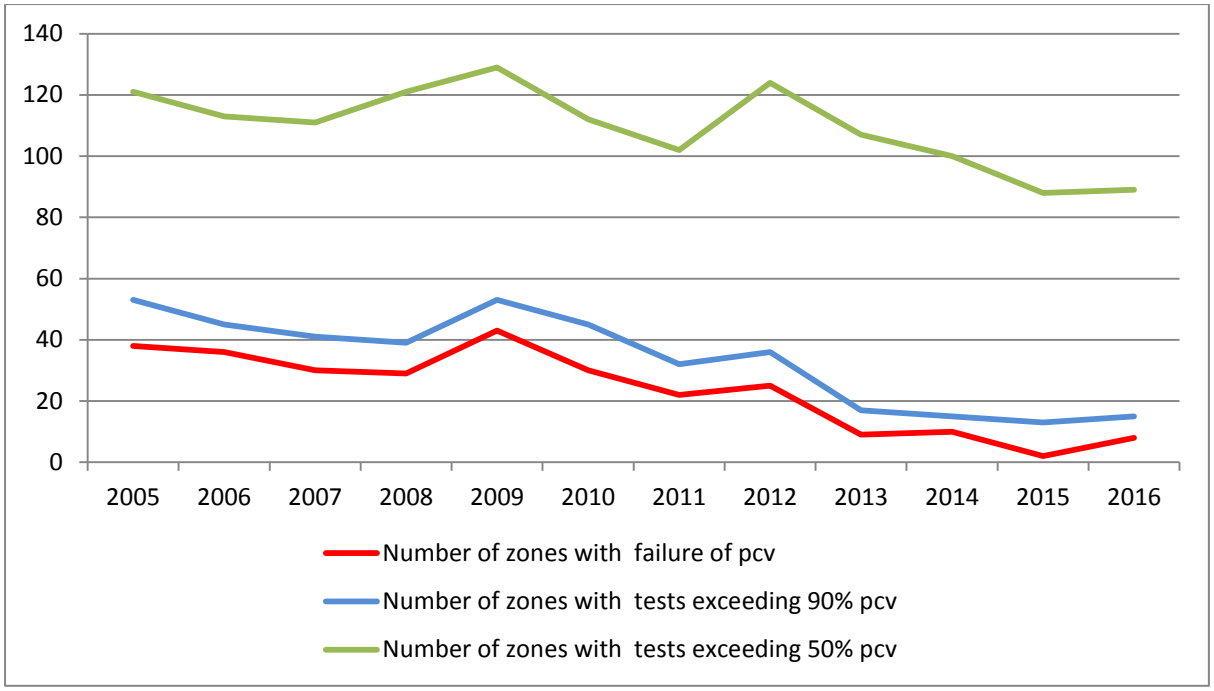

Figure 4 THM Performance 2005 - 2016

Three of the failing zones, Tarbert Argyll, Whalsay and Kaim Lochwinnoch also record a further sample where THMs are within 10% of the PCV. In all, there are 10 zones with measurements of THM values in the band of 90 – 100 µg/l indicating they are perhaps at risk of exceeding the PCV. Seven of the sites failing or at highest risk of failing have improvement works in progress scheduled to be completed in 2017. Over the next four years, Scottish Water has planned improvements to be completed at a further two sites and plans to undertake studies on another five of the failing or high risk sites to inform potential investment in the next investment period from 2021. DWQR expects Scottish Water to continue to persevere with its work to minimise the formation of disinfection by-products.

Nitrite

Nitrite forms when nitrifying bacteria act on ammonia that is added to chlorine in a process known as chloramination. If the process is not tightly controlled and nitrifying bacteria are allowed to persist in the distribution system due to high water residence times, failures of this parameter can result.

In 2016 there were seven failures of this parameter which is similar to performance in 2015. One supply zone, Spynie in Moray, accounted for two of those failures and the others occurred singly in different zones. In both Spynie instances, which were in different areas in the zone, the cause was attributed to the residence time of the water within the distribution system.

Nickel

Nickel is a compound that occurs in the environment only at very low levels. It is used for many different applications but mainly in the production of stainless steel and other metal products. Its presence in drinking water generally arises from contact with plumbing fittings, such as nickel or chromium-plated taps or certain types of kettles.

Six exceedances occurred during 2016 across six separate zones which were attributed to the type of tap or plumbing fittings.

Taste and Odour

Failures of the standard for both taste and odour occurred at three locations in 2016, in Carron Valley A, Clatto West and Muirdykes supply zones. Taste only failures were recorded in Lochmaddy and in Lomond Hills borehole mix zones and three odour only failures in Daer A, Killylour and Lochenkit zones. The Lochmaddy failure was caused by an episode of high organics combined with chlorine, three failures were attributed to localised low turnover in the water mains and in the other three, no cause could be found.

Turbidity

Turbidity in water is caused by suspended particles or colloidal matter that obstructs light transmission through it, making it appear cloudy. The standard is primarily an aesthetic one, but high turbidities need to be investigated, especially in water leaving the treatment works, as they could indicate a problem with the treatment process and may mean that the effectiveness of disinfection has been compromised. Failures can occur at consumers' taps for a number of reasons, but the most common cause is the disturbance of sediment in the bottom of corroding iron water mains.

A single failure occurred in a sample in the Bradan C zone which also failed the iron standard. These were attributed to disturbance of deposits in the water mains and flushing of the supply restored water quality.

Hydrogen Ion (pH)

The pH of a substance is the measure of how many hydrogen ions it contains, with large numbers of hydrogen ions making it more acidic. Most waters in Scotland are naturally soft and have a low pH. Such water can be corrosive to metals used in plumbing, therefore Scottish Water needs to correct this to bring the pH into the required range. High pH values can sometimes occur where water is in prolonged contact with some water mains containing cement. Waters with a very high pH can have a taste that some consumers find unpleasant.

Compliance for pH improved in 2016 with a single failure occurring in the Waternish Skye zone. This was attributed to the water mains or supply pipe materials and residence time or turnover of the water. Flushing of the supply restored water quality.

Aluminium

Aluminium can be naturally occurring in water. It is also used as a flocculant in some water treatment processes and, if these are not operating efficiently, it can enter the water supply system via this route.

There was one aluminium failure in 2016 in the Bradan C supply zone attributable to disturbance of pipeline deposits by a re-zoning of the supply area.

Ammonium

Ammonium in drinking water is not of immediate health relevance. It can however compromise disinfection efficiency, result in nitric formation in distribution systems and cause taste and odour problems. Ammonia is used at some water treatment works where chloramination forms the disinfection process.

A single failure of the standard occurred in the Fort William zone and this was attributed to a problem with the dosing pump at the treatment works.

Benzo 3,4 Pyrene

Polynuclear aromatic hydrocarbons, or PAHs, form a class of diverse organic compounds, one of which is Benzo 3,4 pyrene (also known as Benzo (a) pyrene). The main source of PAH contamination in drinking water is usually the coal tar coating of old water mains or distribution pipes, used to protect the pipes from corrosion.

There was a single failure of this standard and the associated PAH – Sum of four substances standard in a sample from the Glencorse A supply zone. Resamples proved satisfactory and Scottish Water was unable to determine a specific cause for the detection in the sample.

Radon

Radon is an odourless, colourless, radioactive gas that occurs naturally. It is released from certain rocks and the risk of occurrence varies according to geology. Although direct ingestion of radon in water is harmless, prolonged exposure to radon in air by inhalation has been linked to an increased risk of lung cancer. It is likely that any radon dissolved in water will readily gas off upon exposure to atmospheric pressure, adding to the total radon contact of the air.

The Private and Public Water Supplies (Miscellaneous Amendments) (Scotland) Regulations 2015 were introduced on 28 November 2015. Their purpose is to limit the contribution that radon in drinking water makes to the total concentration of airborne radon. There is therefore no PCV for Radon in water supplies but an action level. Where a sample exceeds 100 Bq/l, Scottish Water must undertake further investigation to identify the source of the high radon value. There were two samples which exceeded the action value, one each in the Stronsay zone and the Oykel Bridge zone for which Scottish Water undertook the required

investigations. An improvement scheme is to be carried out at Oykel Bridge WTW by March 2021. Subsequent sampling at Stronsay showed the supply to be satisfactory and it continues to be subject to normal monitoring.

Consumer Contacts

When a consumer calls Scottish Water regarding the quality of their water supply, the contact is recorded and classified according to the nature of the issue.

Scottish Water received 10,659 consumer contacts relating to water quality, equating to a contact rate of 21.3 per 10,000 population, and again this year this is the lowest rate of contact experienced. The reduction in consumer calls about discoloration largely accounted for the overall improvement on last year's 11,292 contacts, although the number of calls about tastes and odours tempered the performance.

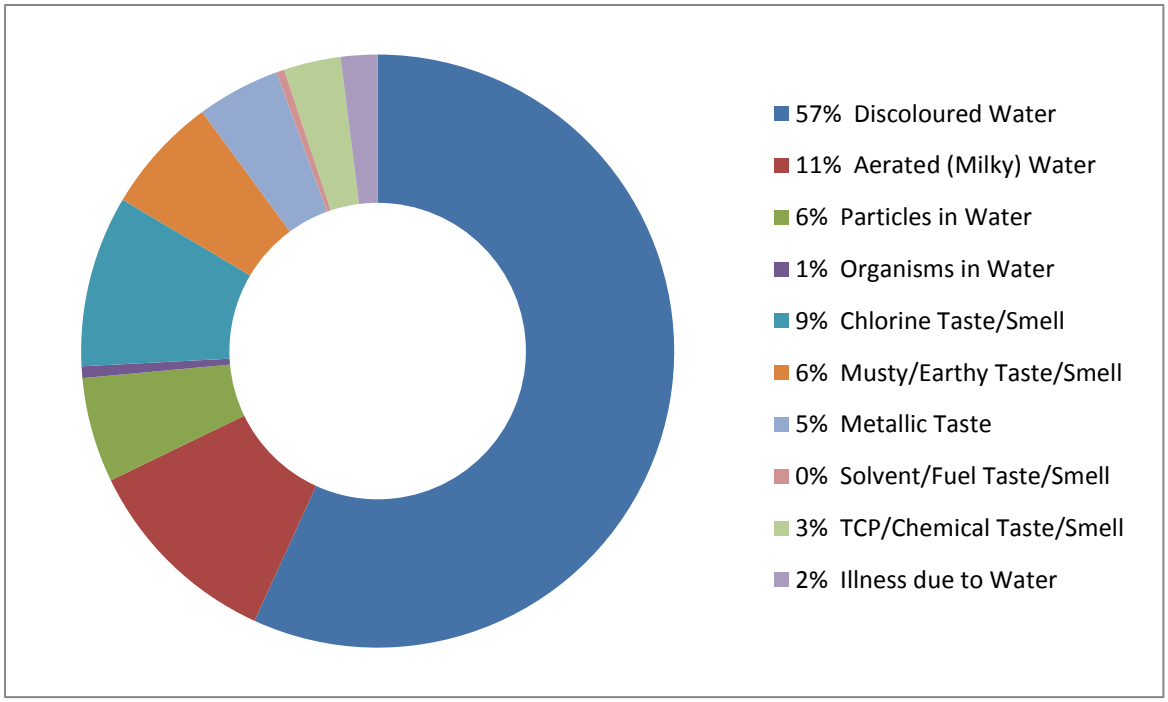

Figure 5 Breakdown of Consumer Contacts by Type

Figure 5 shows 68% of calls were received in response to discoloured water and aerated (or milky) water. These two categories not only reflect problems with the condition of the water supply network but they also highlight problems caused by operational activity where flow changes within the water mains are caused by the operation of valves or by burst mains. The diagram also shows the significant proportion (over 23%) of contacts relating to the taste or smell of the water supply causing concern to consumers.

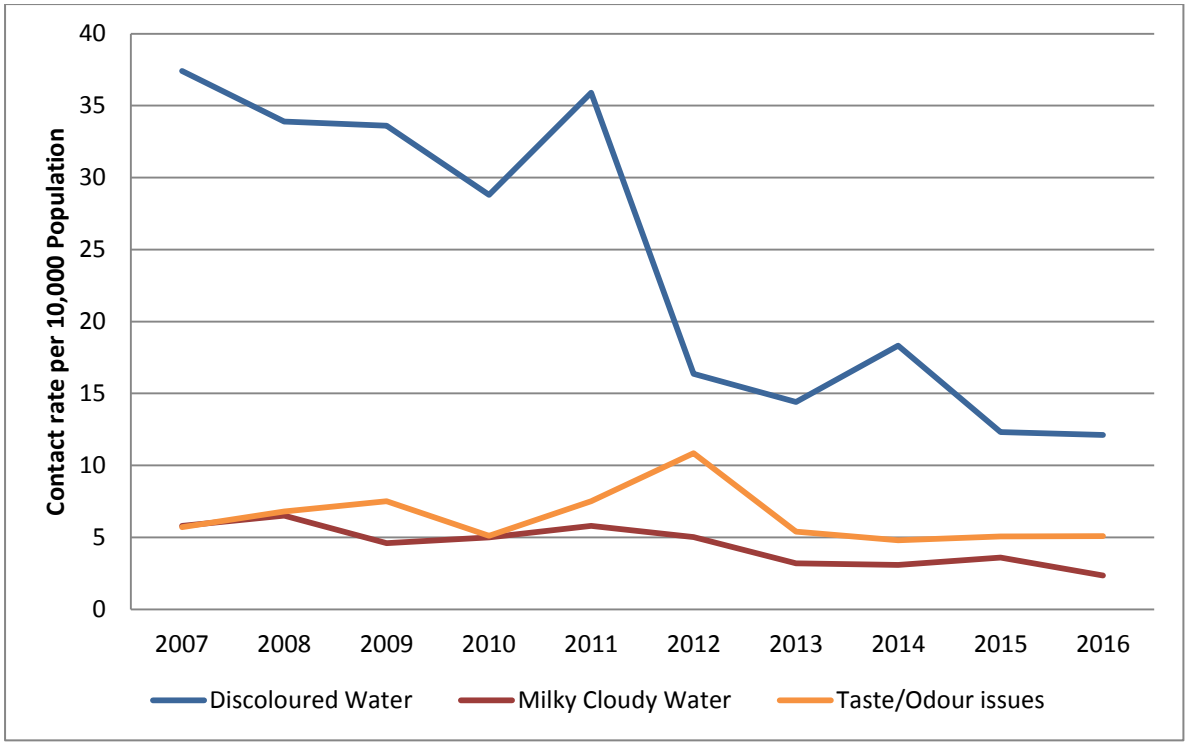

Figure 6 Trend in Key Contact Categories

Whilst it is acknowledged that the proportions of categories will shift as the overall numbers change, **Figure 6** further illustrates the point in terms of the trends in key contact types. The downward trend has continued this year through the slight reduction in discoloration complaints and the more pronounced decrease in aerated water. It is a matter of concern that Scottish Water has not been able to make progress with reducing taste and odour contacts as these have continued to demonstrate a consistent level over the past four years.

Over 39% of all taste and odour complaints are about chlorine - the level of complaints is 2.0 per 10,000, which has reversed the trend from the lowest level seen last year. This issue continues to be an emotive subject with consumers as it often highlights a concern with the general levels of chlorine in supplies. It is important that Scottish Water continues to review the disinfection plans and chlorine residuals in water supply systems to ensure these are appropriate and to identify opportunities to reduce the amount of chlorine being added whilst not compromising microbiological safety. Other taste and odour complaints tend to be episodic, driven by a particular event.

Although the chart illustrates the significant improvement made in reducing discoloration for consumers across the country, the issue remains a consistent concern in some parts. **Figure 7** shows the areas of the country covered by the public water supply networks and highlights those where discoloration contacts have been significantly above the average rate over the past few years. **Figure 8** provides more detail of the zones in which they occur. The maps clearly illustrate the point that the areas mostly affected by discoloration are in the west and central belt of Scotland.

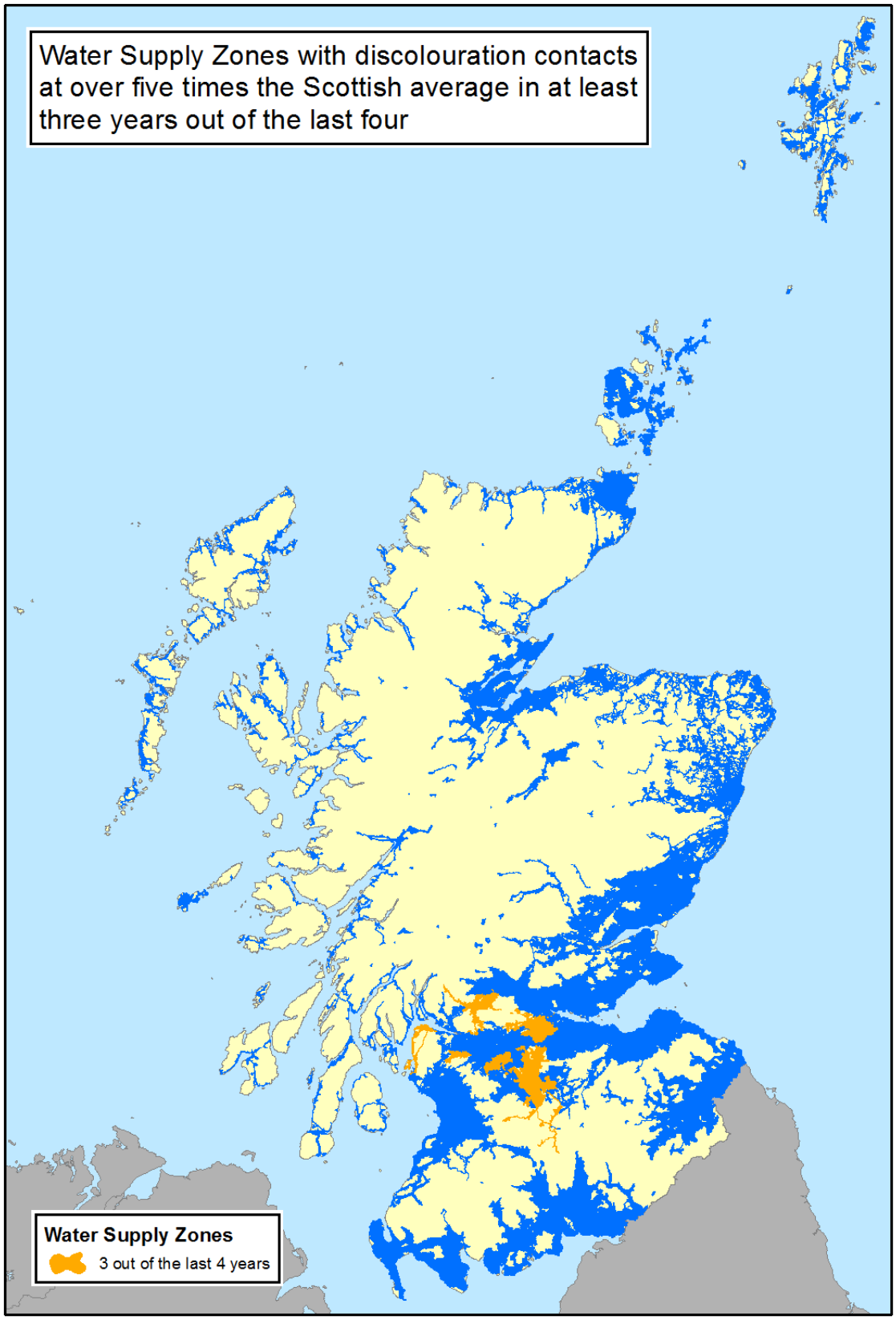

Figure 7 Areas of consistently high volumes of discoloured water contacts

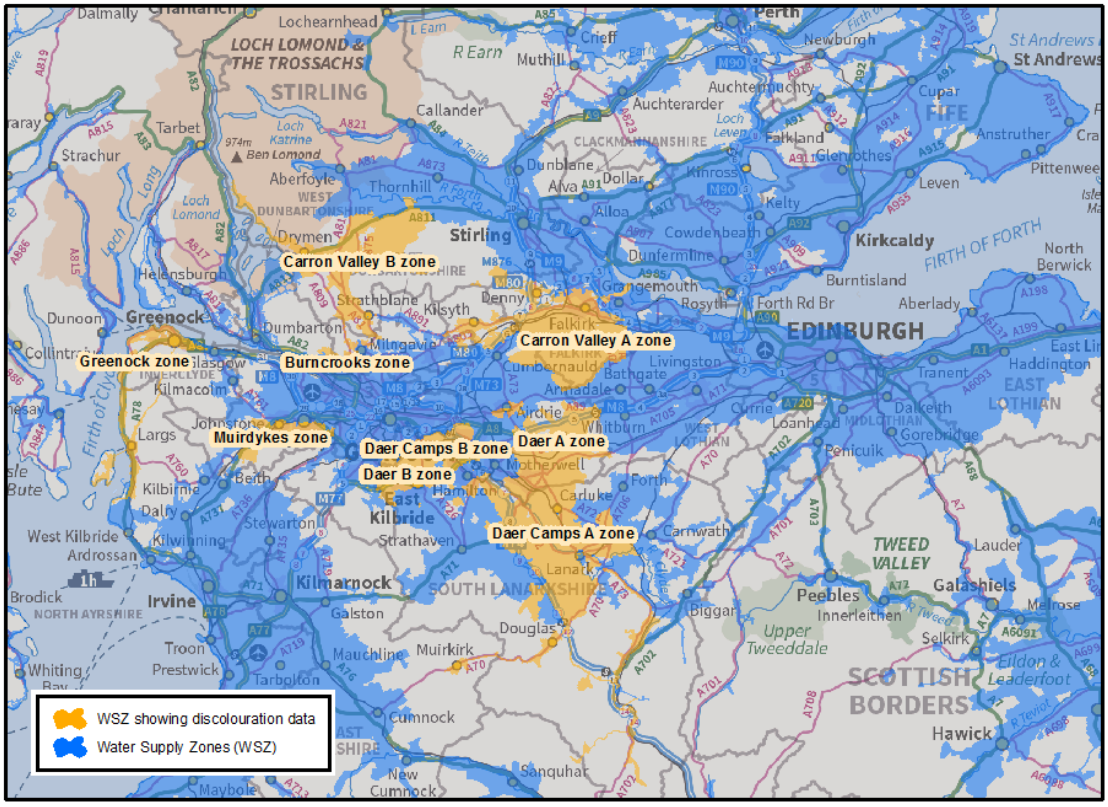

Figure 8 Supply Zones with High Discoloured Water Contacts

Of the ten supply zones highlighted in **Figure 8**, Scottish Water has investment plans for improvements for Muirdykes, Greenock and Carron Valley B water supply zones. DWQR expects Scottish Water to be reviewing the contacts it receives on a regular basis and ensure those areas showing persistently higher than average levels of discoloured water contacts are included in plans for remediation.

The overall contact rate for all categories of consumer contacts in 2016 was 21.3 per 10,000. In geographic terms, the areas where most issues were raised by consumers are shown in **Figure 9**. There are 8 zones where more than 200 contacts were received. This has reduced from 11 zones in 2015 and the chart shows the supply zones ranked by contact rate. The general preponderance of discoloration and aerated water is readily illustrated.

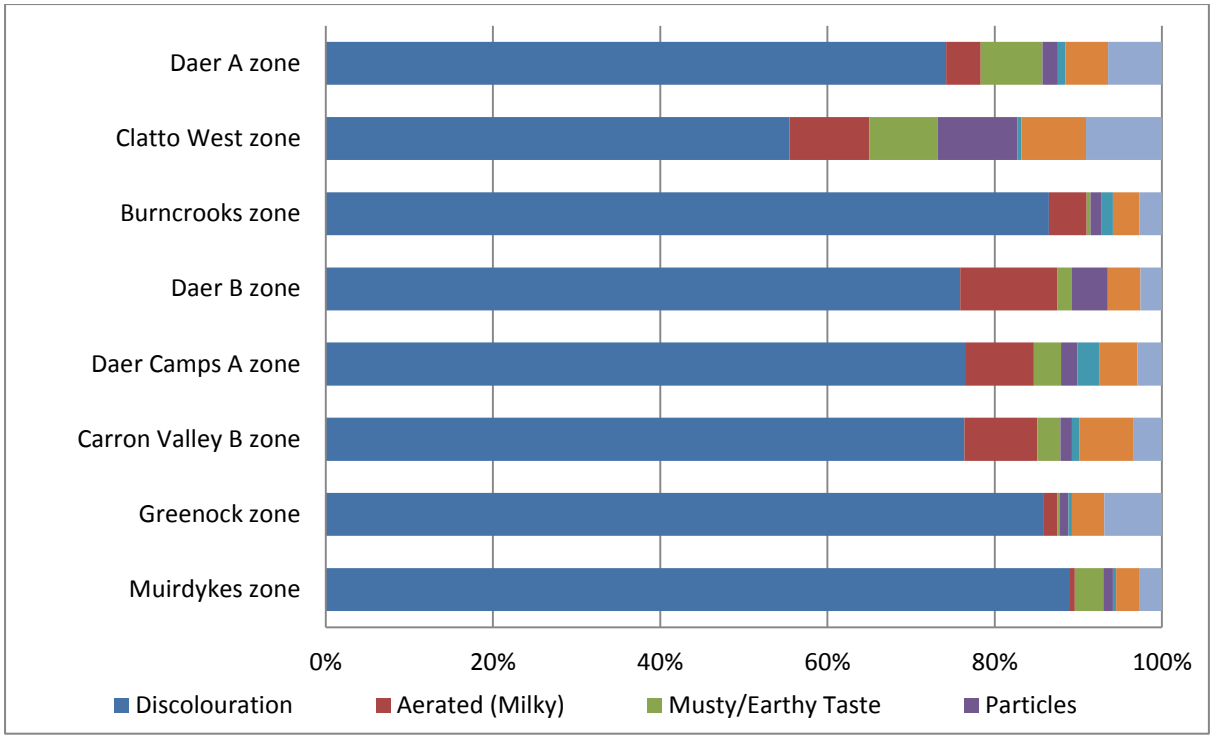

Figure 9 Water Supply Zones With Most Water Quality Complaints

There were two supply zones where the level of contacts was more than three and a half times the overall Scotland contact rate generating over 77 contacts per 10,000 population. Muirdykes and Burncrooks zones, both in the west region, are entirely different in terms of size and consumer base with 528 complaints recorded for Muirdykes and 222 for Burncrooks. In each case, the volume of contacts relating to discoloured water was the issue of prime concern for consumers in their area.

Discoloration complaints in the Muirdykes zone were driven by the manganese content in the water supply and also through deposits within the distribution system being disturbed by changing flows. This in turn is a reflection of the current inability of the water treatment works to remove manganese from the raw water allowing it to pass into distribution. DWQR declared a water quality incident over the significant level of consumer concern in the Paisley area in August. DWQR categorised this as a major water quality event. The incident assessment for the Muirdykes zone and the Royal Alexandra Hospital can be viewed on the DWQR website http://dwqr.scot/regulator-activity/water-quality-incidents/2016-incidents/

In response to an Undertaking made to Scottish Ministers, new filters have been constructed at this treatment works to enable manganese removal and these were introduced to the process stream during the spring of 2017. In contrast, within the Burncrooks zone, a burst water main in July caused a significant number of calls to be made as increased flows in the system and changes made to the flow direction through the water mains network to maintain supplies caused disturbance of deposits. Scottish Water is working through its cleanliness index project to understand better those areas with greatest risk of discoloration and the mitigation actions that can be implemented to reduce consumer concerns.

Consumer Contacts to DWQR

Scottish Water has a responsibility to investigate water quality complaints and supply issues, and the DWQR guides consumers to report any concerns to Scottish Water in the first instance to enable their investigation and resolution. Where consumers are dissatisfied with Scottish Water's response and have pursued a formal complaint with Scottish Water, the DWQR can carry out an investigation of the issues.

The DWQR is committed to ensuring consumer complaints are properly investigated and has an agreement with the Scottish Public Services Ombudsman (SPSO) on the arrangements and processes required to provide a fair and transparent assessment of water quality complaints.

Table 2 Consumer Contacts Received by DWQR

Contact Category	Number of Contacts				
	2016	2015	2014	2013	2012
Appearance					
Discoloured Water	12	3	6	6	8
Aerated (Milky) Water	2	0	1	2	3
Particles in Water	1	0	1	2	2
Organisms in Water	0	0	1	0	0
Taste and Odour					
Chlorine	4	2	9	5	19
Metallic	0	1	0	2	2
Solvent/Fuel Taste/Smell	0	1	0	0	0
Musty/Earthy	2	0	0	2	0
TCP/Chemical Taste/Smell	0	0	0	1	1
Other contact about Water Quality					
Illness due to Water	4	2	2	2	1
Other Contact	4	6	3	10	10
Total Public Water Supply Water Quality contacts	**29**	**15**	**23**	**32**	**46**
Public water supply issues & requests for information	21	8	23	27	42
Private water supply issues	29	23	16	12	7
General Enquiries to DWQR	36	32	37	21	37
Total Consumer Contacts to DWQR	**115**	**78**	**99**	**92**	**132**

Table 2 shows the various categories of consumer contacts received by the DWQR in 2016. Overall, 86 contacts were received in relation to the public water supply. Whilst the number of general queries to DWQR remains similar to previous years, the number of contacts on water quality issues has increased with the principal issue reflecting consumer frustrations regarding discoloured water.

There were no cases of formal investigations of complaints against Scottish Water pursued by DWQR in 2016.

2 WATER QUALITY EVENTS AND INCIDENTS

Scottish Water is required to tell the DWQR about all events that have affected or could affect water quality or cause concern to consumers. This includes all regulatory sample failures; operational sample failures that are significant or unexpected; any failure of a treatment process; significant numbers of consumer contacts or issues which attract significant media interest.

Each event is reviewed and classified into one of five categories: not significant, minor, significant, serious or major. Those events categorised into one of the latter three categories are classed as incidents requiring further detailed investigation by DWQR. Where further information is required a full report may be requested from Scottish Water. It should be noted that where a full report is not requested, this does not suggest in any way that the incident is less serious.

Incidents are fully investigated by DWQR staff, a written assessment is produced, and recommendations are made where appropriate. A short summary of the incident assessment is published on the DWQR website. For the most serious incidents, enforcement action or even prosecution may be considered.

In 2016, 798 events were notified to DWQR, the majority of which were not significant. This is a small deterioration compared with 2015, when there were 746 reported events. Twenty six events were classified as Incidents and **Table 3** shows the numbers of these and the Scottish Water operating areas that they occurred in. A summary of these incidents is available on our website www.dwqr.scot. The number of incidents in 2016 represents an improvement on 2015 when 35 drinking water quality incidents occurred. However, DWQR expects Scottish Water to continue to take steps to improve its identification and control of risks and reduce the number of such incidents. Any drinking water quality incident has the potential to have a lasting impact on consumers' confidence in their supply.

Table 3 Event Classification 2016

	Not significant	Minor	Significant	Serious	Major
North	187	20	8	0	1
East	96	45	3	2	0
West	172	22	5	1	1
South	203	27	3	2	0
Total	**658**	**114**	**19**	**5**	**2**

The reasons for the determination of an event as an incident are shown in **Figure 10**.

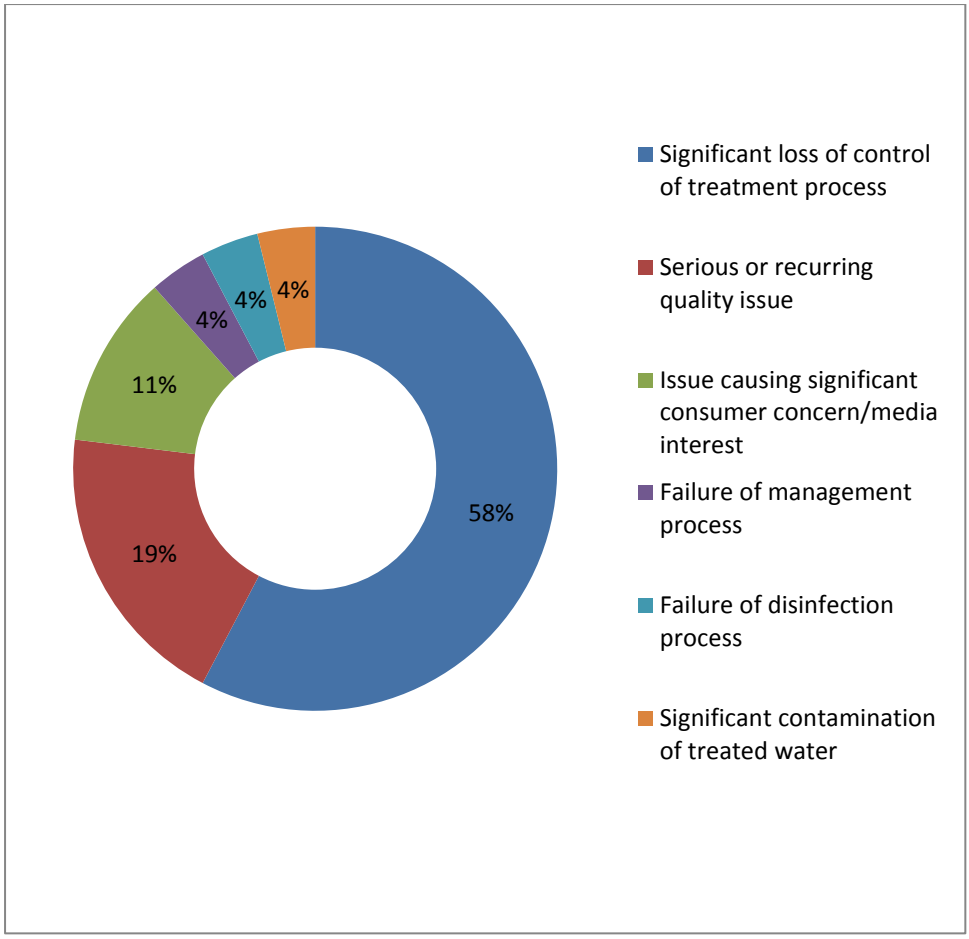

Figure 10 Reasons for Determination of an Incident

The majority of incidents were caused by a failure of or loss of control of a critical treatment process. The reasons for these failures vary, but are often associated with a sequence of events which include failure of critical alarm generation or incorrect alarm settings; lack of monitoring at key points within the process; inappropriate alarm response; critical standby equipment awaiting repair. DWQR has also investigated a number of incidents which highlighted failings of adherence to procedures in place to safeguard drinking water quality. It is essential that Scottish Water learns from these incidents and builds this into its risk assessment process, ensuring that lessons learnt are shared across operating areas and remedial action is not restricted to the affected location. Several incidents are worthy of highlighting as they present significant learning points for Scottish Water and these are discussed in more detail below.

Aviemore Supply Zone – consumer concern – April 2016

Scottish Water informed DWQR that consumers in the Aviemore supply zone were dissatisfied with the taste and odour of their supply and planned to hold a public meeting to announce plans for improvement. Subsequent to this meeting there was significant media coverage. In addition to this, between March and June 2016, 36 complaints were received

by Scottish Water, two complaints were received directly by DWQR, and one by the local authority. Complaints were received for unpleasant taste (especially chlorine), skin irritation, and concerns regarding the proposal to introduce chloramination to the supply. In response to the increased consumer concern, DWQR conducted a full audit of the treatment works in April 2016 and reviewed water quality data. DWQR found the treatment works to be operating satisfactorily and the water quality produced fully complied with regulatory parameters. NHS Highland had reported no sustained increase in skin complaints since the water supply changed in 2012, and that the level of skin complaints within the community is comparable to the national average.

In 2012 Scottish Water constructed a new water supply to serve the Badenoch and Strathspey area. A number of complaints were received at this time due to increased hardness of the water and increased chlorine taste. DWQR investigated these complaints at the time and found that while the new supply fully complied with regulatory parameters and decreased the likelihood of non-compliance, consumer confidence was severely impacted by the change in the water aesthetics.

After this time consumer complaints reduced to levels consistent with the Scottish Water average, but in March 2016 concerns re-emerged following a Scottish Water Board meeting which was held in Aviemore. Scottish Water, having continued to investigate the source of any possible tastes or odours in the Aviemore supply, proposed that the disinfection type be changed to chloramination in an effort to reduce any possible aesthetic issues. Scottish Water responded to the consumer complaints and media interest with a comprehensive approach involving community liaison and scrutiny of operational practices. However, the consumer confidence lost in 2012 when the new water supply came into service may have been further eroded and it could take considerable efforts by Scottish Water to restore this.

Aviemore WTW Monitors

Scottish Water has proposed to introduce chloramination to the treatment works to improve the taste and odour of the supply and this changeover took place in April 2017.

Chloramination is a robust process that is recognised by DWQR as an acceptable method of disinfection. Currently over 25% of the public water supply in Scotland is chloraminated. As with all treatment processes, DWQR expects Scottish Water to carefully monitor and manage the process and to continue to address the concerns of the local population during the introduction of chloramination.

Corsehouse Zone – Algae – August 2016

Scottish Water introduced an additional raw water reservoir, Long Loch, to Corsehouse WTW which supplies Stewarton to supplement the supply and maintain raw water quality. Scottish Water was aware that there was a history of algae at Long Loch, and duly sampled for algae and carried out visual inspections in advance of using the Loch. However, four consumers contacted Scottish Water about the taste and odour of their supply after the Loch had been introduced into supply. Investigations showed that there was algae in Long Loch, and that the presence of decomposing geosmin was causing the taste and odour contacts. Scottish Water staff responded rapidly and effectively when they became aware of the incident by isolating Long Loch and carrying out extensive cleaning of the treatment works and flushing of the distribution system. It is reasonable to conclude that at the time, and with the information available, Scottish Water could not have anticipated this incident. However, algal blooms can develop rapidly, particularly in warm weather, and DWQR expects that the Corsehouse Drinking Water Safety Plan (DWSP), as well as sampling requirements for other raw water sources in Scotland which are considered to be at risk from algal blooms, should reflect the issues raised from this incident.

A total of 116 contacts were received in relation to taste and odour concerns over eleven days in the Corsehouse zone.

Sanday WTW – Aluminium – September 2016

A high aluminium alarm was generated by an on-line monitor at Sanday WTW in the Orkney Islands on 20 September 2016. A bench test carried out on the final water found a lower level of aluminium to that shown by the on-line instrumentation. Checks were carried out on the raw water and processes and these were found to be normal. A similar alarm had been received the week earlier where again, the bench test was significantly below the on-line values. It was decided to suppress the aluminium alarms until the instruments could be checked. Regular checks the next day found filtered turbidity above normal operating levels and aluminium above the PCV at 220µg/l. As there was no improvement by 26 September, additional water treatment was brought on line and a process scientist attended the site to assist with the investigation and optimisation of the process. Water leaving the treatment works exceeded the 200µg/l standard for aluminium from 21 to 30 September. Formal sampling of the water leaving the works and within the distribution zone commenced on 28 September with eight samples failing through to 1 October. The highest level of aluminium recorded in samples of water supplied to consumers was 347µg/l on 28 September, more than a week after the high level alarm. The trend of treated water aluminium levels show the measurements to be beyond the bandwidth of the instrument setting, and it is probable that consumers were exposed to higher levels of aluminium during the intervening week.

The cause of this event was the failure to respond to changing water quality from the loch, and valuable time was lost in bringing appropriate expertise to the site. Scottish Water identified eleven actions for improvement following this incident, and DWQR recommended one.

South Moorhouse WTW – pH – October 2016

A repair for a faulty final water lime dosing pump had been arranged. In order to avoid disturbance to the final water pH dosing, the Operator put the lime dosing pump into flow proportional mode, rather than the pH being flow proportional and also trimmed by readings from a pH monitor. However, a valve on the sample line had been accidently opened, which caused flooding in two rooms on the site. The Operator dealt with the open valve and the flooding, and forgot to return the final water lime pump to automatic.

The final water duty and standby lime dosing pumps automatically flush and switch over every nine hours, and when the changeover to the fixed pump occurred, the pump dose simply worked on a flow proportional basis. The pumps were not identical, and more lime was added when the changeover occurred. The pH of the treated water rose to pH 9.6, marginally above the PCV of 9.5, triggering an alarm at the Intelligent Control Centre (ICC), whose staff monitored the alarm for almost an hour before notifying Operational staff.

Once the Operator was called to the site, he quickly determined the cause of the issue and returned the pump to automatic, after which the pH levels returned to their normal levels. Given the circumstances, with the Operator dealing with flooding in the building, it is understandable that the switch to manual was forgotten. However, Scottish Water needs to develop a system to ensure that Operators are reminded that they have switched automatic systems to manual; this type of situation recurred at South Moorhouse WTW in January 2017, when a raw water inlet valve was left on manual and led to high aluminium levels in the supply.

The pH exceedance in the final water lasted for around seven hours. No samples were taken in the distribution system as a result of this incident, so the impact of the incident on consumers is unknown. This is unacceptable and sampling response to incidents must be adequately completed. There were no consumer contacts as a result of the incident.

South Moorhouse WTW – High aluminium levels – December 2016

Following an alarm for low coagulation pH at South Moorhouse WTW, Scottish Water's investigation showed that the lime dosing pump used to modify the coagulation pH had failed. There was no standby lime dosing pump as it had been awaiting repair for a month. No fitters were immediately available to fix the pump, so the Operator shut the works down.

When the fitter was available, no fault could be found with the pump, and so following maintenance checks, the pump was switched back on. It quickly became apparent that the pump was still faulty, and so as an interim solution, one of the final water lime dosing pumps was used instead. The fault in the pump was subsequently found to be a low oil level.

Final water aluminium level results from the works exceeded the PCV for five and a half hours. A scheduled sample was taken from the network, but no monitoring from consumers' properties was carried out in response to this incident, so the impact on consumers is unknown. This is unacceptable, and Scottish Water has been made aware that adequate sampling of the quality of water supplied to consumers is a regulatory requirement.

This incident should have been avoidable, had Scottish Water had appropriate pump maintenance tasks in place and an understanding by Operational, Electrical and Mechanical staff of how the pump operated and should have been maintained. It is simply unacceptable that there was no standby lime pump for the critical process of pH coagulation control.

There was a further incident at South Moorhouse WTW in January 2017. It is very unusual to have three incidents in such rapid succession from one treatment works, so DWQR audited the site in June 2017 and is monitoring its performance carefully.

Moffat WTW – Turbidity, aluminium and iron – November 2016

Scottish Water undertook work to refurbish one of its boreholes at Moffat WTW. It employed a contractor to use a technique known as airbursting, which injects high pressure air into the borehole in order to remove loose deposits and debris. This incident occurred due to a failure to follow the agreed method statement for the work. Had the debris from the borehole been removed promptly, this would undoubtedly have reduced the extent of the incident, although it is DWQR's opinion that there is some evidence that final water turbidities had started to rise before the production borehole restarted, suggesting that even the work as originally planned may have had an impact on final water. If so, this would lead to the conclusion that the cleaning method may not have been appropriate for the circumstances at Moffat and an alternative approach should have been found.

The sample taken from the final water at the time recorded a turbidity of almost twelve times the regulatory standard. Metals concentrations were also elevated, with both aluminium and iron at almost twice the regulatory standard. Final water turbidity gradually reduced once Scottish Water took steps to improve quality, but final water turbidity exceeded the treatment standard for 66 hours after the start of the incident. Elevated metals concentrations and turbidities were detected in the few samples taken from consumers' taps on the day of the incident but had returned to normal levels when the next set of samples was taken six days later. Perhaps surprisingly, there were no water quality complaints by consumers to Scottish Water.

Only two samples were taken in the distribution system on the day of the incident, with the next samples taken six days later. DWQR considers this to be a wholly inadequate response and a breach of the Public Water Supplies (Scotland) Regulations 2014. Liaison with DWQR, the health board and Dumfries and Galloway Environmental Health took place via email a week after the incident commenced, preventing a timely consideration of any health risk to consumers, and presenting an inexcusably complacent response to the serious situation, and a further breach of the Regulations.

Carfin (Balmore C) Contamination Incident and Prosecution Case – June 2015

In the DWQR's 2015 annual report, reference was made to a major incident in the Carfin area, Motherwell. A case was being prepared by DWQR for the Procurator Fiscal to prosecute Scottish Water, so it was inappropriate to report on it at the time; the case has now been through court proceedings and is summarised below.

On 17 June 2015, consumers in 6,085 properties in the Carfin area of North Lanarkshire received drinking water that contained high concentrations of hydrocarbons, iron and manganese. As a consequence, the water tasted, smelt and looked unacceptable to many of those intending to consume and use the water. Residents of the affected area were advised by Scottish Water on the evening of 17 June not to drink, cook or wash with the water – this restriction was lifted on the morning of 19 June. Investigation by Scottish Water has revealed that the inadvertent shutdown of the water main supplying the area during a planned repair resulted in contaminated water from two sources on the Newhouse Industrial Estate being siphoned back into the water supply system. The incident caused considerable inconvenience to many consumers, schools and businesses in the affected area and a loss of confidence in the safety of the public water supply. Some consumers also reported temporary adverse health effects having consumed the affected water, although medical experts concluded that the contamination was unlikely to have presented a risk to the health of anyone in both the short and longer term.

As a consequence of the seriousness of the incident, and in line with DWQR's enforcement policy, a case for prosecution for the offence of supplying water unfit for human consumption under Section 76C of the Water (Scotland) Act 1980 was submitted to the procurator fiscal in October 2016. This case was heard at Hamilton Sheriff Court on 6 June 2017, where Scottish Water pleaded guilty and were fined £3,250.

Although some of the contamination during the incident arose from a third party industrial source, some was residual contamination left in a length of redundant water main that remained connected to the water network. Poorly controlled work by Scottish Water on the water main upstream of the two sources caused a drop in pressure and allowed the contamination to enter the main and reach consumers. Scottish Water has a duty to operate its distribution systems in a way which minimises the risk from backflow. During its investigation, DWQR found a number of deficiencies with the governance and

implementation of Scottish Water's procedures for working on distribution systems. The company has undertaken work to make improvements since the incident.

3 AUDIT AND INSPECTION

An important part of DWQR's scrutiny role is to audit and inspect activities undertaken by Scottish Water. DWQR may choose to inspect any aspect of Scottish Water's activities that could affect water quality. Inspections commonly undertaken include water treatment works, storage points, distribution system activities, response to consumer water quality issues and analytical services. Auditing takes place against the requirements of the Regulations, as well as water industry best practice. DWQR also audits the completion of investment projects. Typically site visits will be undertaken prior to DWQR signing off the larger water treatment works projects and DWQR will audit a selection of Scottish Water's self-certification projects.

The inspection process provides a number of benefits:

- It enables DWQR to verify that Scottish Water is complying with regulatory requirements at sites across Scotland
- It allows DWQR to see new initiatives and areas of best practice
- It is an opportunity for DWQR staff to meet site-based Scottish Water staff and discuss water quality issues with them
- It raises awareness of DWQR and the regulations among Scottish Water staff
- It enables verification of the delivery of investment work
- It enables DWQR to build an awareness of common trends, risks or deficiencies across Scotland and use these to inform future policy and guidance.

Sites to be inspected are selected using a risk based process that takes into account sample failures and water quality events and incidents. DWQR may also choose to inspect sites randomly or directly following incidents. Other types of inspection may be undertaken in response to a particular issue or concern. In the past, DWQR has inspected the procurement of services affecting water quality and actions to complete DWQR recommendations.

DWQR uses standardised inspection templates to ensure consistency between inspectors, and the audit process is subject to an ISO accredited procedure. DWQR also participates in benchmarking audits with other regulators in the UK and beyond in order to drive consistency and spread best practice.

Where issues are noted during an inspection these are recorded as recommendations that are tracked and followed up. If common themes are identified, these are progressed centrally with senior Scottish Water staff. Elements of best practice are also highlighted when these are observed. Scottish Water always has an opportunity to comment on draft inspection reports and co-operates fully during the technical inspection process.

Once an inspection report has been finalised, the completed report is sent to Scottish Water and a summary placed on the DWQR website.

Water Treatment Works Inspections

In 2016, DWQR completed seven inspections of water treatment works. These are listed in Table 4. As always, Scottish Water staff operated their plants with a high degree of professionalism and pride and many examples of best practice were noted. As the inspections were risk or incident triggered, particular attention was paid to the deficiency that had triggered the audit, whether this was asset based or procedural.

Glenlatterach WTW

The greatest number of recommendations were centred around process control, especially in terms of the ability of the process to continue to operate under certain circumstances, and the monitoring of water quality parameters.

Most sites visited were maintained and operated to a high standard, but notable issues that DWQR identified included:

- The requirement for further assessment and improvement of disinfection;
- Insufficient signage around sampling points and monitors;
- Deficiencies in raw and treated water quality monitoring, both on-line monitoring and manual sampling. This was not only to give confirmation of water quality, but also to inform treatment process operation;
- Process control issues and the need for development of procedures for response to process alarms.

Table 4 Water Treatment Works Audited during 2016

Location	Date	Reason for Audit	No. of Recommendations
Balmichael (Arran)	March 2016	Incident investigation	5
Invermoriston (Loch Ness)	September 2016	Risk based	1
Whitehillocks (Laurencekirk)	September 2016	Risk based	2
Bonnycraig (Peebles)	September 2016	Risk based	1
Backies (Golspie)	October 2016	Risk based	1
Londornoch (Dornoch)	October 2016	Risk based	3
Glenlatterach (Moray)	October 2016	Risk based	0

Balmichael WTW

In addition to full site audits, DWQR also undertakes site visits in relation to water quality events and incident investigations and to follow up on remedial works recommended by DWQR following previous incidents. The sites visited are listed in Table 5.

Table 5 Sites Visited in Conjunction with Incident Investigations during 2016

Location	Date
Aviemore WTW	April 2016
Glenfarg WTW	April 2016
Suainaval WTW	May 2016
North Lochs WTW	May 2016
Kyle of Lochalsh WTW	June 2016
Camisky WTW	June 2016
Badachro WTW	September 2016
Balquhidder WTW	November 2016
Balmore WTW	November 2016
Carron Valley zone and WTW	November 2016

Benchmarking

DWQR retains close contact with the other water quality regulators in the UK and Europe to share best practice. During 2016 DWQR were guests of the Drinking Water Inspectorate and attended four water treatment works audits in England and Wales which afforded excellent benchmarking opportunities: both to ensure DWQR's operations team are auditing to a high standard; and to benchmark Scottish Water's operations and procedures against other water providers.

Storage and Distribution

Ten distribution audits were undertaken in 2016. The audits included inspection of new mains laying, replacement connections and repairs of burst mains.

Recommendations included the maintenance of hygiene equipment, cleaning tanks and updating water safety plans.

New water mains

Table 6 Distribution System Audits 2016

Location	Date	Reason for Audit	No. of Recommendations
Carron Valley B (Fintry)	March 2016	Risk based	1
Glencorse A (Edinburgh)	March 2016	Risk based	5
Glasgow	March 2016	Risk based	1
Perth Muirhall SR	March 2016	Risk based	2
Suainaval (Lewis)	May 2016	Risk based	1
Mannofield West (Insch)	August 2016	Risk based	5
Whitehillocks (Laurencekirk)	September 2016	Risk based	0
Turriff (Banff and Strichen)	October 2016	Risk based	0
Backies (Golspie)	October 2016	Risk based	2
Glendevon A (Dunfermline)	December 2016	Risk based	6

Investment

Scottish Water has been directed by Scottish Ministers to achieve a number of objectives to improve and protect drinking water quality. DWQR has a role to monitor progress with delivery of these outputs through the Outputs Monitoring Group (OMG) and also signs off those outputs associated with water treatment works improvements. Scottish Water self-certify improvements where the solution is either mains rehabilitation or the maining out of a treatment works from an already compliant existing works.

A number of treatment and mains rehabilitation project outputs scheduled for completion by April 2015 are late, for a number of reasons including access, design review, and requirements for additional treatment beyond the original project scope. DWQR and the OMG are monitoring progress with these projects closely.

Scottish Water entered a new investment period from 1 April 2015 which will run until 31 March 2021. This includes a number of outputs for improving and protecting drinking water. Only a small number of outputs were due to be delivered during 2016 as most projects are at feasibility study and option selection stage.

DWQR undertook a number of site visits and audits during the year, either to review progress or for the purposes of assessing the project's readiness for the output completion to be signed off. These are detailed in **Table 7**.

Table 7 Investment site visits undertaken during 2016

Location	Solution	Reason for Audit
Killylour	Coagulation, dissolved air flotation clarification, membrane treatment process	Sign off
Muirdykes	Manganese removal treatment stage	Progress review
Staffin	New membrane treatment process	Sign off
Kilmuir	New membrane treatment process	Sign off
Kilmaluig	New membrane treatment process	Sign off

A further 4 project outputs that did not require a site visit achieved Regulatory sign off. These are shown in **Table 8.**

Table 8 Projects achieving Regulatory sign off without site visit

Location	Solution	Sign Off
Balmichael	New membrane treatment plant	DWQR
Fetlar	New membrane treatment plant	DWQR
Lomond Hills	Change to operating procedure	Scottish Water – self certification
Newcastleton	New membrane treatment plant	DWQR

Killylour WTW – completed May 2016

In addition to treatment works improvement schemes, Scottish Water has a number of other drinking water quality improvement programmes, summarised in **Table 9** shown below. All the programme output completion is self-certified by Scottish Water. DWQR will be carrying out audits of this process during 2017.

Table 9 Water Quality Programme Outputs delivered in 2016

Programme	Outputs delivered	Location
Improvements to the reliability of supply (catchment and treatment)	2	Bunessan, Pateshill
Improvements to the reliability of supply (networks and storage)	10	Balmore, Blairlinnans, Ness, Neilston, Gairloch, Cargen, Glengap, Picketlaw, Tobermory, Foula
Number of water quality studies	37	
Number of zones made compliant with iron and Manganese (rehabilitation and cleaning)	None planned for 2016	

Programme	Outputs delivered	Location
Distribution mains cleaned (km)	None planned for 2016	

ANNEX A INFORMATION LETTERS ISSUED DURING 2016

Information

Letter number	Title
2016-1	Reporting of *Cryptosporidium* detections to DWQR

A copy of the letter is available on the DWQR website:

www.dwqr.scot

ANNEX B CURRENT UNDERTAKINGS AND ENFORCEMENT NOTICES

Where water supplies do not comply with the required water quality standard, there are a number of mechanisms available to DWQR to ensure that the necessary steps are taken to achieve compliance. These are set out in DWQR's Enforcement Policy, which is published on the DWQR website. www.dwqr.scot

Undertakings

In general, the DWQR will seek to secure compliance with legislation through co-operation, discussion and offering advice. This process of co-operation and discussion may result in Scottish Water giving a legally binding Undertaking to Scottish Ministers, under the provision of Section 76E of the Water (Scotland) Act 1980, setting out the steps that Scottish Water will take to secure compliance with the legislation. Such Undertakings provide a visible commitment from Scottish Water that the necessary improvement will be made.

In 2016, there were six on-going Undertakings:

Muirdykes water treatment works and supply zones - Manganese

Bradan water treatment works and supply zones - THMs

Amlaird water treatment works and supply zones - THMs

Craignure water treatment works – *Cryptosporidium*

Tullich water treatment works - *Cryptosporidium*

Tullich water treatment works - THMs

Enforcement Notices

When DWQR has evidence that Scottish Water has contravened a drinking water quality duty and the contravention is likely to recur *and* Scottish Water does not appear willing to take timely steps to rectify the situation, DWQR may serve an Enforcement Notice on Scottish Water under Section 10 of the Water Industry (Scotland) Act 2002. Such an Enforcement Notice must set out specific actions to be taken by Scottish Water within specified timescales. Failure to complete such actions by the due date is a criminal offence under Section 12 (5) of the Act.

In 2016, there was one active Enforcement Notice:

Invercannie water treatment works - *Cryptosporidium*

ANNEX C STATISTICAL METHODS USED IN THE REPORT

Water Quality Compliance Data for Local Authority Areas

In order to present drinking water quality data by local authority area, it has been necessary to report data for the group of supply zones within that area. Water supply zone boundaries do not fit local authority boundaries exactly, so the data for any supply zone which falls wholly or partly into the local authority area has been included.

This approach means that data from some supply zones is included twice or more in the Local Authority Area tables. For example, the same data for Glencorse A supply zone is included in the sections for East Lothian, Midlothian and City of Edinburgh.

Zonal Compliance

Zonal compliance is simply the percentage of samples meeting the prescribed concentration or value (PCV) for that parameter.

Mean Zonal Compliance

Mean zonal compliance (MZC) for an area is built up from zonal compliance figures for individual parameters in individual supply zones. This is a helpful tool when considering water quality at national, regional and local level as it provides a simple means of summarising drinking water compliance and comparing year on year performance. It is this measure which is used as the overall measure of drinking water quality by Drinking Water Inspectorate (DWI) for companies in England and Wales and it allows us to compare national performance. It uses only the 39 parameters that are listed in Schedule 1 of the Public Water Supplies (Scotland) Regulations 2014 for which there is a numerical value.

All parameters are weighted equally in the calculation but the sheer number of pesticide determinands has the potential to skew the MZC calculation by placing undue weight on pesticide analysis. For that reason, results for the individual pesticides not specifically mentioned in Schedule 1 of the Regulations have been pooled to produce a single "All Pesticides" parameter. The large number of different pesticides analysed every year is determined using a risk assessment process to define specific sampling requirements in each supply zone.

MZC can be quite variable year on year as it can significantly deteriorate should a parameter fail in a very small zone sampled only once per year – effectively giving 0% compliance for that zone. This is a particular issue in Scotland, as some of the water supply zones are very small, serving populations in single figures. Regulatory sample frequencies are based on population, hence sampling for certain parameters in these zones is infrequent, with perhaps only two samples being taken for each parameter per year. If one of these samples fails, this will adversely affect MZC to a much greater extent than a sample failure in a large supply.

For this reason the measure of overall water quality compliance at consumers' taps is also calculated and used to report year on year comparative performance.

Overall Quality Compliance

The Overall Quality Compliance for Scotland as measured at consumers' taps is simply the number of samples taken which met the required standards for parameters which have a numeric value in the Regulations.

Distribution Maintenance Index

The Distribution Maintenance Index (DMI) is the same as the Operational Performance Index (TIM) used in previous DWQR reports. It is used to reflect the performance of the distribution system for a zone or collection of zones, and is simply the arithmetic mean of the MZCs for turbidity, manganese and iron for the zone.

Worked Examples

Zonal Compliance

The zonal compliance for iron for a notional supply zone, Zone 1, is calculated as follows:

	No. samples taken for iron	No. samples failing	Zonal Compliance (Iron)
Zone 1	52	2	96.15

Mean Zonal Compliance

In order to calculate the MZC for iron for a group of 10 zones which include Zone 1, the arithmetic mean of all the zonal compliances for iron is taken.

Zone 1	96.15
Zone 2	98.6
Zone 3	100
Zone 4	100
Zone 5	100
Zone 6	100
Zone 7	100
Zone 8	100
Zone 9	100
Zone 10	100
MZC	99.48

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