Spring 2021

National Water Resources Plan - Framework Plan

Technical Appendices

Appendix J

Irish Waters Multi Barrier Approach for Achieving Safe and Secure Drinking Water

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Data Disclaimer:

This document uses best available data at time of writing. Some sources may have been updated in the interim period. As data relating to population forecasts and trends are based on information gathered before the Covid 19 Pandemic, monitoring and feedback will be used to capture any updates. The National Water Resources Plan will also align to relevant updates in applicable policy.

1.1 Introduction

A ‘barrier’ consists of any actions, processes, procedures, standards or assets (treatment plants, water mains, pumping stations etc.) put in place across the entire system from catchment to tap to achieve water of sufficient quality and quantity. Currently, Irish Water has identified eight key Barriers, and associated control measures (set out in Figure 1.1).

Of these, the first four barriers (Barriers 1 – 4) and Barrier 5 are the most critical, as failure of one or more of these could present an immediate health risk to our customers or loss of public water supply.

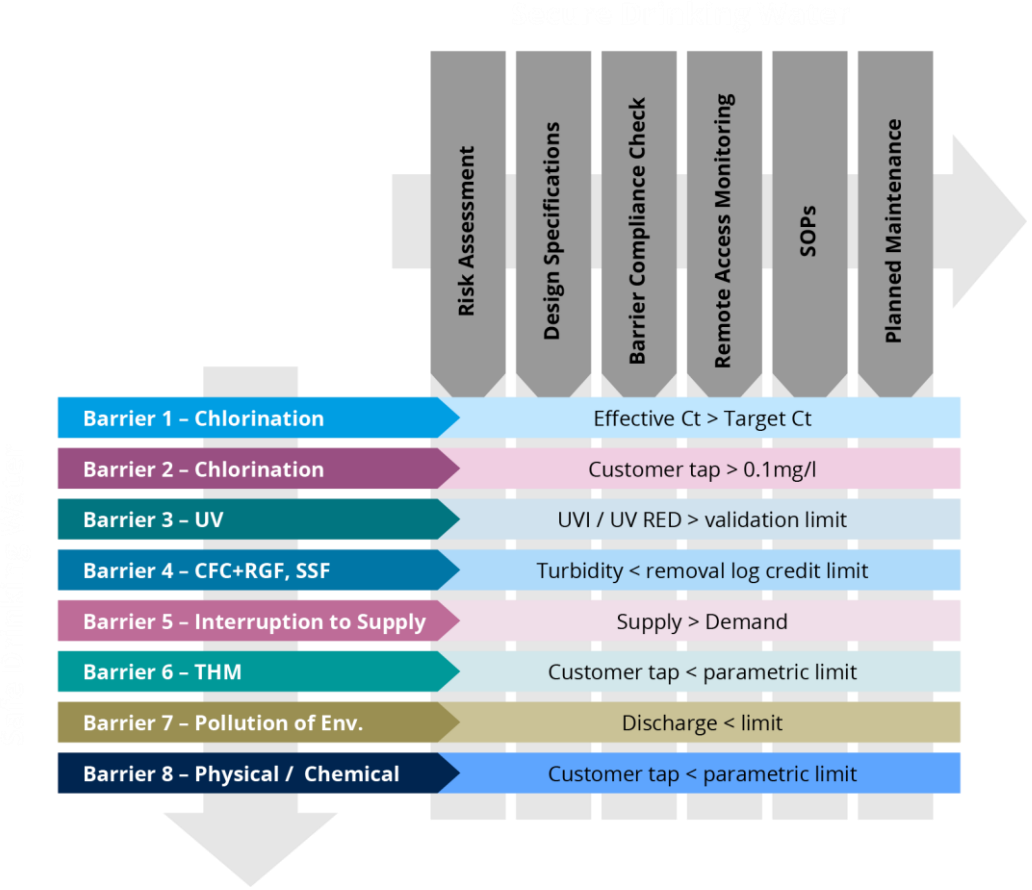

Figure 1.1 - Irish Water’s Multi-Barrier approach for achieving Safe & Secure Drinking Water

Barriers and their control measures are aligned with water quality requirements to achieve a safe and secure water supply and are summarised as follows:

1.2 Barrier 1: Chlorination (Primary Disinfection at our water treatment plants)

One of the most critical stages of the drinking water treatment process is to disinfect the water. This is to ensure that any bacteria which may have survived the various treatment stages are destroyed. In Ireland the main form of disinfection used is chlorine. Chlorine is added to the water either in liquid or gas form in carefully controlled doses and allowed appropriate contact time to ensure any bacterial or viral microorganisms are incapable of causing human illness. This is Barrier 1.

Under the Multi-Barrier approach Irish Water uses a statistical method called ‘log reduction’ to describe relative numbers of live pathogens that would remain in the treated water, relative to the numbers present before treatment. So for example 1-log reduction will reduce the initial number by 90%, 2-log will reduce the initial number by 99%, 3-log will reduce the initial number by 99.9% etc. This is further illustrated in Figure 1.2 below.

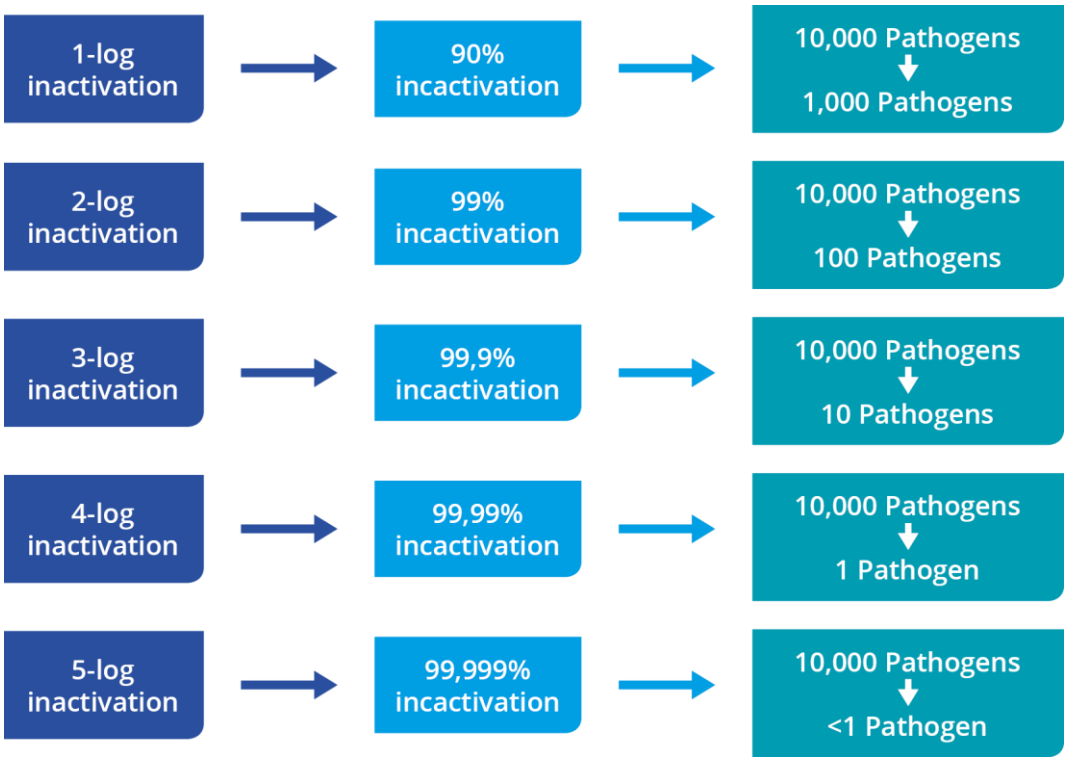

Figure 0.2 - Irish Water's log inactivation approach for disinfection

To achieve Irish Water's Bacterial and Viral Compliance target of 99.99% (4-log inactivation), the water must be disinfected to achieve a minimum Contact Time target. Irish Water has defined how this target is calculated for every treatment plant that uses chlorine, and incorporates parameters such as Turbidty, pH, and Temperature.

Irish Water has implemented a National Disinfection Programme to bring all our chlorination systems to this standard.

1.3 Barrier 2: Chlorination (Secondary Disinfection, within our treatment networks)

Barrier 2 focuses on the distribution pipe network and assesses whether the drinking water remains disinfected up to the customer tap.

Where residual chlorine levels prove difficult to maintain at peripheral locations within large networks, we will undertake risk management / mitigation measures as appropriate, including network flushing, enhanced operational monitoring, or booster chlorination.

1.4 Barrier 3: Ultraviolet Disinfection

Waterborne protozoa such as *Cryptosporidium* or *Giardia* have an outer shell (which in *Cryptosporidium* is called an Oocyst and in *Giardia* called a Cyst) which makes them highly resistant to chlorination. They are however susceptible to radiation from ultraviolet (UV) light, which is the basis of Irish Water's Barrier 3. UV light is a form of electromagnetic radiation which penetrates the hard-outer shell of the *Cryptosporidium* Oocyst and permanently alters its DNA rendering it unable to reproduce or infect a host.

As the risk of finding protozoa such as *Cryptosporidium* in source waters depends on localised factors, we undertake scheme specific risk assessments of source waters. This risk assessment includes the following:

- Analysis of catchment specific datasets for *Cryptosporidium* loadings from animal and human faeces;
- Consideration of factors such as rainfall, soil susceptibility and slope as potential pathways for *Cryptosporidium* to reach abstraction locations;
- Review of dilution ranges of the receiving water; and
- Source contamination history, as established by scheme specific *Cryptosporidium* testing.

The net outcome of this site specific risk assessment is a maximum potential *Cryptosporidium* loading at the point of abstraction, taking into account worst case scenarios in the upstream catchment.

This Crypto loading will inform the target 'log inactivation' requirement of the source in question, which can typically vary from 1-log (90%) to 5-log (99.999%). Where Barrier 3 UV disinfection is required by Irish Water's risk assessment methodology, the UV disinfection will be utilised within the treatment process prior to the Barrier 1 and 2 chlorination process elements and after the Barrier 4 process.

1.5 Barrier 4: Physical treatment process for removal of microbial, organic and inorganic contaminants

Barrier 4 encompasses a range of water treatment processes and technologies for the physical removal of contaminants. This involves different forms of filtration process types and coagulation/flocculation/clarification (CFC) processes. In CFC processes, chemicals called coagulants are used to agglomerate particulate and dissolved contaminants into flocs, which are subsequently removed from the treated drinking water by sedimentation or flotation processes.

Similar to the "Log Reduction" method used for Barrier 1, Barrier 4 uses a "Log Credit" method whereby different physical removal processes are awarded log credits based on the log reduction they are proven to achieve, see Table 1.1 below.

Table 0.1 - Protozoal log-credit removal efficacy for typical existing Barrier 4 processes

Protozoal log-Credits removal for Barrier 4 Removal Processes	Log Credit
Bag Filter	**1.0 (90%)**
Cartridge Filter	**2.0 (99%)**
Direct Filtration	**2.5 (99.5%)**
Slow Sand Filtration	**2.5 (99.5%)**
CFC + Rapid Gravity Filtration (RFG) / Pressure Filtration	**3.0 (99.9%)**
CFC + Rapid Gravity / Pressure Filtration + enhanced coagulation and filtration control	**4.0 (99.99%)**

Verification of the effectiveness of these physical removal processes is typically based on indicators such as Turbidity. For example, a CFC and Rapid Gravity will qualify for 3 Log Credits if the turbidity levels coming off each individual filter do not exceed 0.3NTU.

1.6 Barrier 5: Interruption to Supply

This barrier involves an evaluation and management of issues relating to Supply Demand Balance (see Chapters 4, 5 and 7), treatment process alarms, risks associated with critical infrastructural assets and distribution network resilience, as a means of assessing the risk to the continuity of supply to our customers.

1.7 Barrier 6: Trihalomethanes (THMs)

Trihalomethanes (THMs) are disinfection by-products that can form when natural organic matter (NOM) present in source water is not sufficiently removed by Barrier 4 and therefore reacts with chlorine over time. NOM originates from living and dead plants, animals and microorganisms and from the degradation products of these sources. Typically, NOM is removed by the Barrier 4 removal process. THMs refer to four separate constituent THM compounds, the cumulative concentration of which is known as Total THMs or TTHM's. The current Drinking Water Regulations (as amended) sets a parametric limit of 100 µg/l for TTHMs.

In water sources, where there are high levels of organic matter, usually expressed as mg/l of Total Organic Carbon (TOC), Irish Water must strive to remove this as part of our treatment process. High organic matter in raw water is associated with surface water sources and groundwater with surface water infiltration such as in karst regions. Catchments with greater coverage of organic soils, such as peat, have higher concentrations of TOC in raw water owing to leaching of organic matter from the soils. Human activities such as deforestation, peat extraction and agricultural intensification also cause higher concentrations of organic matter in raw water. Additionally, variation in TOC in individual catchments brought about by seasonal changes associated with changes in temperature, i.e. autumn and spring, and storm runoff events can also be observed.

Removal of organic matter reduces the extent to which THMs can form post treatment, during the subsequent chlorination dosing under Barrier 1. The preferred solution to TTHM parametric exceedances in water supplies is to upgrade / optimise the treatment process to ensure adequate removal of organic matter from the water.

1.8 Barrier 7: Pollution of the environment

Conventional Drinking Water treatment can generate both liquid and solid residuals. Liquid residuals are typically produced as a supernatant following settlement of sludge within settlement tanks or sludge lagoons, and are generally discharged to the receiving water or recirculated to the head of the water treatment plant. The second residual is a sludge waste, in liquid or dried cake format, which can contain aluminium, ferric salts or other chemical residues from the treatment process. Currently there is limited reuse potential for residual sludge and it is primarily disposed to landfill.

As part of Irish Water's Water Services Strategic Plan, we are developing and implementing a National Water Treatment Plant Sludge Strategy, which will reduce the environmental impacts from water treatment processes, such as:

- A standard national approach to on site treatment and management;
- A standard national approach to the management of residuals to a final destination;
- Direction in terms of the preferred outlets;
- Ensure the quality of the discharge is compatible with environmental objectives under the Water Framework Directive;
- Develop, with industry, more sustainable and economically viable alternatives for the recovery and reuse of some of this water treatment residual sludge.

1.9 Barrier 8: Physical and Chemical

Barrier 8 has 8 sub-barriers encompassing a suite of physical and chemical parameters. Each of these require a separate strategy / approach. For example, in relation to Lead, Irish Water is implementing the Lead in Drinking Water Mitigation Plan. In relation to Pesticides, Irish Water is working with a range of stakeholders, through the auspices of the National Pesticides in Drinking Water Action Group (NPDWAG) - this is explained in greater detail in Chapter 5 of the Framework Plan.