The Environmental Protection Agency

EPA DRINKING WATER ADVICE NOTE
Advice Note No. 10: Service Reservoir Inspection, Cleaning and Maintenance

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Office of Environmental Enforcement

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1 INTRODUCTION

A regular programme of reservoir inspection, cleaning and maintenance will reduce the potential for microbiological, chemical or physical problems from reservoirs including:

- **Contamination by pathogens (e.g. *Cryptosporidium, E. coli*). This can occur where reservoirs are uncovered, structurally unsound, not fully sealed and hatches and vents are left exposed to external contaminating vectors such as birds, insects and vermin. These have direct potential health impacts to the consumer;**
- **Sediment accumulation. This may increase disinfectant demand, microbial growth, disinfection by-product formation and increased turbidity in the water;**
- **Formation of disinfection by products (e.g trihalomethanes). This can depend on the volume and residence time in the reservoir. If reservoirs are kept full and underutilised (i.e. storing water for longer than originally intended), the stored water ages and water quality may be affected with disinfection decay;**
- **Deliberate introduction of harmful substances into reservoirs. This can occur when reservoirs are not fully secured against vandalism;**
- **Increased chlorine demand. This leads to unnecessary use of excessive amounts of chlorine that may increase odour and taste complaints.**

There are a number of aesthetic indicators that may suggest that problems are occurring within service reservoirs. These include:

- Poor taste and odour from stale water. This kind of environment is condusive to the growth of odour and taste causing microorganisms.
- Sediment accumulation carried into the reservoir from the source water. Sediment can build up overtime if the reservoir is not regularly cleaned.
- Water temperature. Stagnant water will approach ambient temperature.

Water quality monitoring and modelling (both hydraulic and quality) is a useful tool to assess the impact of the storage of reservoir water on the water quality in the distribution network.

This Advice Note sets out EPA guidance on the actions that are necessary to ensure service reservoirs are proactively inspected, cleaned and maintained so that the potential hazards listed above are prevented.

2 ACTIONS TO BE TAKEN BY THE OPERATOR

Water Services Authorities (WSAs) should prepare a programme for the regular inspection, cleaning and maintenance of all service reservoirs within the public water supply network. The frequency of inspection, cleaning and maintenance will depend on the following factors:

- **The source of the supply (e.g. reservoirs containing surface water subject to coagulation will need to be cleaned more frequently than those containing good quality clear groundwaters);**
- **The operational performance of the water treatment plant from which the water originates (e.g. a plant with elevated levels of turbidity or aluminium will need a greater frequency of cleaning).**
- **The materials used in the reservoir structure;**
- **The age of the reservoir structure;**
- **Historical monitoring from the reservoir (e.g. trends in chlorine levels);**
- **The location of the reservoir, security issues and potential polluting activities in the vicinity of the reservoir.**

Consequently, the frequency of inspection, cleaning and maintenance will vary from one reservoir to another. However, the WSA should aim to inspect reservoirs on a regular basis having regard to the risks posed and the factors above.

The key steps that should be taken when executing a programme of reservoir inspection, cleaning and maintenance are outlined in the following sections and include:

1. External and internal inspections of service reservoirs taking into account security issues and statutory health and safety requirements;
2. Cleaning service reservoirs effectively and training of operators in clean standard practices;
3. Disinfection of reservoirs;
4. Safe disposal of sediment and wash water;
5. Regular maintenance of reservoirs and
6. Maintaining standards and relevant qualifications.

These steps are outlined in more detail in the sections that follow.

2.1 INSPECTION OF SERVICE RESERVOIRS

Water Services Authorities should have a detailed schematic of the locations of all service reservoirs in the network. The construction drawings, where available, should form part of the reservoir maintenance file as should details of when the reservoirs were last inspected and cleaned. A log should be maintained to record this information and be made available to the EPA on request. Before any internal inspection is made of the reservoir a walk over (if possible) and around the reservoir should be conducted to first check security arrangements. The area should be cordoned off and warning signs erected to prevent people entering the area. The WSA should ensure that a suitably qualified inspector/engineer checks the following at a minimum and provide a detailed report. The report should address the following questions as a minimum:

- Is there open access to the reservoir surrounds or is the location fenced off to the general public and livestock?
- Is there a roof on the reservoir?
- Are there vents, overflows coming from the reservoir that could pose a risk of contamination?
- Are there open or unlocked manhole covers on the reservoir that could pose a risk of contamination?
- Are there structural cracks/holes/deterioration on the exterior structure of the reservoir that could pose a risk of contamination? Is there evidence of leaks?
- Is there vegetation growing from the reservoir roof or walls that could penetrate or compromise the structure?
- Is the reservoir secure from run-off from the surrounding land?

If any of the above are detected then the security of the reservoir is at risk of contamination and as such an action programme should be prepared and implemented to address these risks.

The inspection should also cover the following:

- An assessment of the structural integrity of reservoirs including an examination for any signs of structural defects or weaknesses or breaches of structural integrity. Steel reservoirs on concrete foundations should have the juncture between the tank and base assessed, where visible. An assessment should be made to determine whether a more detailed structural assessment appears warranted.
- An assessment of the appropriateness of the volume and detention time of the tank should be performed. A tank that is too large may cause stagnant water and/or loss of chlorine residual.
- An assessment of the filling/emptying regime of the reservoir (e.g. does the reservoir ever run dry and run the risk of re-disturbance of sediments in the reservoir when water is restored?).
- An assessment of the hydraulic performance of the reservoir (e.g. is there preferential flow or inadequate mixing)?
- An assessment of the performance of reservoir valves should be made.
- An assessment of the performance of reservoir probes should be made, including chlorine residual monitors, as appropriate.
- An analysis of the reservoir water quality should also be made.
- An assessment to confirm that the reservoir meets Health and Safety statutory requirements.

Following the external reservoir inspection the internal inspection can take place. There are three broad options for internal inspection and cleaning of reservoirs:

1. Empty the reservoir fully to allow access (this may not always be an option if there is not enough water available to take the reservoir out of service);
2. Use divers as part of the inspection;
3. Use remote operating vehicles (ROV) to inspect and clean the reservoirs.

In Ireland Option 1 is the most popular method to inspect and clean a reservoir and is the most preferable method as it is the most thorough method of cleaning. A reservoir can be bypassed if there is sufficient alternative storage in the network (e.g. multiple reservoirs or multiple chambers in the reservoirs) or if disruptions to supply can be kept to a minimum. Where taking the reservoir off line is problematic (e.g. there is no reservoir bypass) it can be possible to utilise a temporary bypass (e.g. linking the inlet and outlet pipes directly) or to undertake the work at night to minimise disruption. Temporary storage is also an option that may be possible in some circumstances.

If it is not feasible to take the reservoir off line then a diver or ROV could be used provided that adequate sanitary and health and safety procedures are in place to prevent contamination or accidents and access through the reservoir hatch is possible. If the WSA makes the decision to take the reservoir off line then any anticipated shortage of water should be communicated to consumers well in advance. Inspection cleaning and disinfection can take on average one day. However, this can vary depending on the size and nature of the reservoir in question. Professional evaluation should only be carried out by a suitably trained and qualified engineer or experienced contractor. An internal review of the reservoir structure should be made. The interior of the tank should be inspected for corrosion, cracks, holes, pitting etc. that may create the potential for contamination. A roof flood test should be carried out to check for structural cracks which may allow ingress. This is where the roof area of the reservoir is flooded and visually monitored from beneath for any signs of ingress. Steel tanks are monitored for thickness of panels, corrosion and any roof impairments. An analysis of the flow through the tank should also be performed, including assessments of any baffles, mechanical mixing systems or separate inlets/outlets.

Although using a diver for underwater inspection does not require the reservoir to be drained, the reservoir should be taken offline and isolated from the distribution. All diving equipment and clothing should be fully disinfected before entering the reservoir.

Remote operating vehicles can be used to inspect and clean the internal structure of the reservoir without having to empty the contents. They provide close circuit video to a technician who operates the unit. There are some limitations with the use of ROV's for cleaning purposes as they generally do not clean the wall, columns and roof areas of the reservoir.

It is critical that appropriate procedures are followed when inspecting, cleaning and refilling reservoirs is undertaken. There is a risk of contamination of the public water supply during cleaning and when the reservoirs are being refilled e.g. if valves have not been adequately shut and the pipework to the distribution network remains open when cleaning commences.

2.2 CLEANING OF SERVICE RESERVOIRS

Once the tank has been inspected and prepared for cleaning it is essential that all equipment is appropriately cleaned and fit for use in drinking water. Contractors and WSA staff should ensure that equipment used for wastewater/slurry tanks is not used and that equipment used is reserved solely for drinking water works in order to avoid cross contamination. This includes all safety equipment, personal protective clothing, access equipment and cleaning and chlorination equipment.

For individuals working in both wastewater and drinking water; drinking water works and reservoirs should always be visited first and a change of protective clothing made where necessary in order to avoid cross contamination. In addition, the location of some reservoirs can be in an area where there is faecal contamination from farm land and so further care should be taken in avoiding contamination of drinking water reservoirs. A foot bath with chlorine should be located beside the access hatch to be used before entry into the reservoir during reservoir cleaning.

All outlet pipes from the reservoir should be closed off before any cleaning of the internal structure of the reservoir takes place. This is to prevent any sediment from entering the distribution network. All internal surfaces shall be pressure washed to remove all contaminants, loose concrete, chemicals and foreign matter particles which may affect water quality. The floor should be cleaned off into the scour sump and all solids removed by wet vacuum and disposed of appropriately. There should be no direct discharge of wash water to local water courses without consultation with the relevant Inland Fisheries Ireland unit and Water Services Authority. This is discussed further in Section 2.4.

2.3 DISINFECTION OF SERVICE RESERVOIRS

Where a reservoir has been taken out of service and fully drained the internal structure of the reservoir should be fully disinfected following cleaning. A suitably qualified operator(s) wearing the appropriate personal protective equipment (PPE) should be employed to carry out disinfection of the reservoir after cleaning. When deciding on the disinfectant to be used the WSA should have regard to any potential reactions with material used in the structure of the reservoir (this may be particularly relevant where liners are present). The following provides some examples of the different methods of reservoir disinfection:

- Sodium hypochlorite can be injected into water to give a final measured free chlorine residual of between 25-35 mg/l to spray the internal surfaces of the reservoir. As per the cleaning procedure, all outlet pipes should be closed off during this time to prevent highly disinfected water entering the distribution network. The furthest point from the entry hatch is disinfected first moving towards the direction of the access point. During this time all points or objects such as ladders and columns are disinfected. The sterilised water shall be kept in the reservoir for at least 24 hours. The water should then be drained completely and the reservoir refilled with potable water..
- The entire reservoir is filled with chlorinated water (10 mg/l) for a specified period (6 to 24 hours) and then emptied completely (AWWA, Standard C652 Disinfection of Storage Tanks).
- Brush or spray all parts of the reservoir with a chlorine solution (200 mg/l) (AWWA, Standard C652 Disinfection of Storage Tanks)
- Fill 5% of the reservoir with chlorinated water (50 mg/l) for 6 hours minimum, and then fill the reservoir with treated water (i.e. with normal levels of chlorine) to overflow level for 24 hours and then use this water. (AWWA, Standard C652 Disinfection of Storage Tanks).

Once the reservoir has been cleaned and disinfected water samples should then be taken for analysis. The reservoir water should be put back into service only when the water results are in compliance with the drinking water standards and the water is deemed wholesome and clean. This may not be practical in all situations especially where the reservoir needs to be brought back into service before the tests results are made available. In that case residual chlorine concentrations should be checked for satisfactory levels. If the results are deemed unsatisfactory then disinfection should be carried out again.

2.4 SAFE DISPOSAL OF SEDIMENT AND WASH WATER.

Sediment material collected by vacuum tanker should be properly disposed of in a responsible manner e.g. waste water treatment plant. Analysis of the sediment for metals such as iron due to tank corrosion may be necessary (e.g. if iron is used as a coagulant). The WSA should confirm that the waste water treatment plant is capable of taking the sediment material and having regard to the Waste Water Treatment Plant discharge licence conditions as appropriate.

Where wash water has significant quantities of super-chlorinated water this should not be released to the environment where it has the potential to negatively impact on surface or groundwater systems. Such chlorinated water may kill fish or other life if discharged to a water course. Super-chlorinated water must not be discharged to a water course without the consultation with the local Inland Fisheries Ireland unit and the local authority. If there is provision to discharge to sewer or tanker away then a risk assessment should be carried out to ensure that the waste water treatment plant microbial community will not be adversely affected. This should only be done with the consent of the local authority.

Flushing water containing deposits may deoxygenate or partially deoxygenate a water course or may interfere with sewage treatment processes and should not be discharged without the consent of the local Inland Fisheries Ireland unit or the Local Authority respectively. Any super-chlorinated or flushing water that cannot be discharged at the site of the reservoir will need to be taken by tanker to a suitable disposal site.

It may be necessary to de-chlorinate water prior to disposal. De-chlorination can be achieved using a number of different chemical compounds, the most commonly used of which are sodium thiosulphate and sodium bisulphite (Water UK). Further information on dechlorination is available in the Water UK Technical Guidance Note No. 14 *Disposal of Chlorine Solutions and Chlorinated Water.*

2.5 MAINTENANCE

Following an assessment of the inspection and cleaning report provided by a competent engineer/ contractor, the WSA should ensure that all recommendations are addressed regarding structural improvements that are required both externally and internally and that the necessary security measures are addressed. It is best practice and less expensive to carry out preventative maintenance on reservoirs rather than waiting until a problem has escalated to crisis proportions. It is recommended that regular flushing of reservoirs is carried out when necessary to prevent sediment build up. Preventative maintenance should ensure that reservoir conditions do not deteriorate significantly since the last major inspection. It will be less resource demanding than a full detailed inspection and therefore the WSA should incorporate it into the drinking water works regular routine programme of scheduled maintenance. A methodology for preventative maintenance should start with an inspection to identify the items requiring maintenance. Periodic inspections of the following are recommended:

- Site access and security inspection and repair;
- Site maintenance inspection and repair;
- Foundations inspection and repair (where visible);
- Grout, fibreboard inspection and repair;
- Manholes and access doors inspection and repair;
- Exterior overflow pipes;
- Venting and
- Ladders

The WSA should ensure that all products used in the maintenance and repair works of reservoirs are listed in the Drinking Water Inspectorate "*List of Approved Products for use in Public Water Supply in the United Kingdom*" or an equivalent EU approval system. This UK list is available at *www.dwi.gov.uk/drinking-water-products/index.htm.*

All inspections, cleaning and maintenance actions should be recorded in separate reservoir logs. This information should be stored electronically for future reference.

2.6 STANDARDS AND QUALIFICATIONS

It is imperative and a legal requirement that the correct health and safety standards be adhered to before considering entering a reservoir or reservoir site for inspection. Appropriate training must be undertaken before any persons enter a reservoir for inspection. The Health and Safety Authority (HSA) may be consulted on the appropriate training requirements. Further details are available on the HSA website *www.hsa.ie*

All operators, maintenance staff and samplers (and any contractors and sub-contractors) working on the distribution network (including service reservoirs and water towers) where they could come into contact with treated drinking water or with equipment that is in contact with drinking water, should have been fully trained in hygienic practices commensurate with their duties. Where appropriate, this training should include the actions required if one of these personnel has an illness (for example gastroenteritis or Hepatitis A) that could pose a risk of contamination of the drinking water supply or spread of the illness to other personnel. Hygienic practices are particularly important for multifunctional personnel who may work on both water supply and sewage. As an example, in the UK there is a national water hygiene training scheme that all operators and contractors are required to pass to obtain the "National Water Hygiene Card" before they can work on the distribution network. This scheme consists of completing a health questionnaire, receiving comprehensive water hygiene training and successfully passing a multi-choice test paper. The scheme is operated by Energy and Utility Skills Register (EUSR) on behalf of the UK water industry (*http://www.eusr.co.uk/eusr/the-eusr-card/the-national-water-hygiene-card*).

3 REFERENCES AND FURTHER INFORMATION

1. AWWA, Standard C652 Disinfection of Storage Tanks.
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3. EPA (2011). The Provision and Quality of Drinking Water in Ireland. A Report for the Years 2008-2009.
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6. Glanbury Water Hygiene Solutions Cleaning, Chlorination & Structural Survey Procedures.
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11. Water UK (2010). Technical Guidance Note No. 14 Disposal of Chlorine Solutions and Chlorinated Water.
12. World Health Organisation (2004). Guidelines for Drinking Water Quality (3rd Ed).