

**Manitoba Water
Stewardship**

Best Practices Manual for Small Drinking Water Systems

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**Prepared for
Office of Drinking Water
Prepared by**

 **GENIVAR**

(Formerly Cochrane Engineering Ltd.)

Manitoba 

BEST PRACTICES MANUAL
FOR
SMALL
DRINKING WATER
SYSTEMS

Office of Drinking Water
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1.0 Introduction

New regulations pursuant to *The Drinking Water Safety Act*, administered by the Office of Drinking Water, resulted in changes to the approval, licensing, monitoring, record-keeping and reporting requirements for drinking water systems in Manitoba. It is recognized that many small drinking water systems may not have the same level of access to technical services and resources as larger public water systems. This manual of best practices (a comprehensive, integrated and co-operative approach to continuous improvement of all facets of operations for delivering superior standards of performance) is to assist small drinking water systems with regulatory, management and operational challenges.

This manual includes:

- ❑ a summary of legislation, regulations and guidelines applicable to small water systems.
- ❑ a description of general operating and maintenance requirements for source water development, pumping, treatment and distribution facilities; sampling and testing schedules; safety, seasonal use and emergency planning.
- ❑ a description of best practices for various elements of a water system's operation, including templates for record-keeping (metering data, water quality testing, routine O&M (Operations and Maintenance) tasks, repair notations, etc.).
- ❑ a list of additional resources that owners and operators should consult for more detailed guidance on topics that are most relevant to their water systems.

For more detailed protocols for seasonal water systems, refer to the Manitoba Water Stewardship document "Seasonal Water System Start-up/Shut Down Protocol".

1.1 Small Drinking Water Systems Best Practices Summary

Small drinking water systems should:

- ❑ produce high quality, stable water that is biologically and chemically safe and aesthetically acceptable to water users;
- ❑ comply with all provincial regulations applicable to the operation and maintenance of the water system;
- ❑ be knowledgeable of the water system infrastructure (assets) and their location;
- ❑ be knowledgeable of the condition of the water system;
- ❑ maintain a plan to upgrade inadequate components and replace aging components;
- ❑ maintain an adequate disinfection residual in all parts of the system;
- ❑ maintain positive water pressures under foreseeable operating conditions;
- ❑ implement a backflow prevention and cross-connection control program;
- ❑ monitor the quality of the water including at the source, in the treatment plant, in the distribution system and at the point of use (i.e., at the tap);
- ❑ maintain comprehensive records;
- ❑ ensure proper disinfection and flushing procedures are used for repairs and new construction;
- ❑ monitor for internal and external corrosion of piping and equipment and, if necessary, implement measures to reduce the rate of corrosion;
- ❑ meter water supply and consumption to estimate water usage and losses and, if necessary, implement a leak detection program;
- ❑ maintain the source water intake, dam, raw water reservoir or wellhead site;
- ❑ maintain the treatment plant, pumping stations, and reservoirs;
- ❑ maintain the distribution system valves and hydrants;
- ❑ flush and/or swab the watermains;
- ❑ use a maintenance management system to track and schedule activities;
- ❑ maintain a spare parts inventory;
- ❑ prepare contingency plans to address operation under emergency situations;
- ❑ prepare a financial plan to ensure the water system is sustainable;
- ❑ maintain public relations through public education and participation in public events;
- ❑ maintain adequate staffing and funding levels to undertake best practice activities and provide training for staff; and
- ❑ develop a working relationship with Office of Drinking Water staff to help ensure protection of public health.

2.0 Small Drinking Water Systems Legislation

The Drinking Water Safety Act received Royal Assent August 9, 2002 and was proclaimed January 30, 2004. The supporting regulations, MR 40/2007 the Drinking Water Safety Regulation and MR 41/2007 the Drinking Water Quality Standards Regulation Regulations, came-into-force on March 1, 2007.

The Public Health Act also addresses issues related to public water systems (those with 15 or more service connections) as follows:

- Protection of Water Sources Regulation (326/88R)
- Water Supplies Regulation (330/88R)

A permit is required under *The Drinking Water Safety Act* to construct or alter (ex: upgrade or extend) a public water system. The new regulations also require that every public water system obtain an operating licence that sets out site-specific water treatment and water quality standards, and monitoring, reporting and record-keeping requirements. Beginning in March of 2008, operating licences will be issued to semi-public water systems (14 or less connections but not a private (residential) water system). The primary objectives of water system operation are to protect the public health and ensure due diligence is exercised.

Other pertinent legislation for Drinking Water Systems:

- The Water Rights Act
- Manitoba Plumbing Code
- The Environment Act
- Water and Wastewater Facility Operators Regulation (77/2003)

For more information: <http://www.gov.mb.ca/waterstewardship/odw/reg-info/acts-regs/index.html>

2.1 Office of Drinking Water

Office of Drinking Water staff carry out periodic inspections of water systems to evaluate design, operational and monitoring, and provide advice on compliance issues. They are also available to provide technical assistance to water system owners and operators during emergency and non-emergency situations, making them an excellent resource.

The Office of Drinking Water is to be contacted IMMEDIATELY in all emergency situations.

Resource -

Office of Drinking Water homepage:

http://www.gov.mb.ca/waterstewardship/drinking_water/index.html

3.0 Owner and Operator Responsibilities

3.1 Owner Responsibilities

Although an owner may designate a manager or operator(s) to conduct the day-to-day operations of a water system, the owner (either a person, municipal council, cooperative, or board of commissioners) is **ultimately responsible** for providing safe drinking water, and meeting all public responsibilities and regulatory requirements that apply to the water system.

Owners must:

- ❑ understand the terms and conditions of the Operating Licence or other approval conditions for their drinking water system.
- ❑ understand their obligations under *The Drinking Water Safety Act* and associated regulations.
- ❑ hire competent and certified operators.
- ❑ allocate sufficient financial resources for source water protection, proper system operation and maintenance, and operator training.
- ❑ ensure that system operating reports and records are maintained and provided to regulators upon request.

3.2 Operator Responsibilities

The operator is responsible for ensuring the system is operated in accordance with all conditions outlined in their Operating Licence and any other conditions set out by the Office of Drinking Water.

Operators must:

- ❑ deliver drinking water to water quality standards;
- ❑ operate all water system facilities in accordance with licence conditions;
- ❑ protect drinking water sources taking all reasonable steps;
- ❑ maintain and submit records to the regulatory agency as required and immediately report to the Office of Drinking Water violations of the Operating Licence or other operational conditions noting corrective actions taken;
- ❑ immediately report to the owner and the Office of Drinking water any concerns with water system operations that may compromise water quality or public health and document the steps taken, or to be taken, to address the issue; and
- ❑ maintain their provincial operator certification requirements.

Resource -

NSEL due diligence handbook: <http://www.gov.ns.ca/enla/water/drinkingWaterDiligence.asp>

4.0 Well Operation and Maintenance

Wellhead piping should be configured in such a way as to minimize the potential for contamination of the water source while also providing for proper testing and control of the well. Systems should have a raw water sampling port upstream of any treatment. The following are some recommended operational duties to help develop a preventative maintenance program for the water supply well.

4.1 Daily Duties

Record well pump run times, pump cycle starts and meter reading (if equipped). Take readings at the same time every day. Comparing the daily numbers will help to identify potential well pump problems. See sample Daily Well Pump Log sheet.

Inspect well pumps, motors, and controls. Operators should always be on the lookout for any defects in the system. Look, listen, and feel for any unusual sights, sounds or vibrations. Make sure the seals are intact and the system is not “running hot.” Check all timers to ensure that the pump operating times are equalized. Controls should be operated manually to verify that they are working. See sample Well Water Supply System Checklist.

4.2 Weekly Duties

Record the pumping rate for each well or source water pump. If the meter only registers total volume (m^3), not flow rates (L/sec), then dividing a measured volume (L) over a specific pump run time (sec) will give an approximate flow rate (L/sec). A noticeable change in pumping rate can indicate that there is a pump or well casing problem. However, pumping rates will vary based on the head the pump is pumping against (i.e., the water level in the well and/or pressure in the piping system).

4.3 Monthly Duties

Read Hydro meter for well pumps (if available). If pumping accounts for a large part of the energy use, track water production with energy use; note any unexpected changes in energy use over time. Abnormally high Hydro meter readings could indicate that the pumps are working harder to perform their job, which could mean that maintenance or replacement will be required.

4.4 Long-Term Duties

Have a qualified driller undertake an inspection of the well including televising of the well. Over time, issues can develop with well casing, screens and other well components. Periodically, every 5 or 10 years or based on identified ongoing capacity or operational issues, a detailed well inspection should be undertaken. Plan for well maintenance and pump replacement, particularly submersible pumps which are more difficult to service, in advance including possible temporary shutdown. Verify overall capability to supply peak water demands (i.e., is there sufficient pump capacity, is another well required as part of contingency planning).

5.0 Well Abandonment

Wells are a direct conduit to the groundwater in aquifers. It is important to properly abandon wells that are no longer in use or are contaminated. The Office of Drinking Water can provide information on well abandonment. Well abandonment (decommissioning) should be undertaken by a qualified person, for example, a licensed water well driller.

Resource –

Water Well Info: <http://www.gov.mb.ca/waterstewardship/odw/public-info/water-well/index.html>

DAILY WELL PUMP LOG

Month/Year: _____

Date	Running Time (Hours)	Number of Cycle Starts	Notes or Comments
1 st			
2 nd			
3 rd			
4 th			
5 th			
6 th			
7 th			
8 th			
9 th			
10 th			
11 th			
12 th			
13 th			
14 th			
15 th			
16 th			
17 th			
18 th			
19 th			
20 th			
21 st			
22 nd			
23 rd			
24 th			
25 th			
26 th			
27 th			
28 th			
29 th			
30 th			
31 st			

Total: _____ Hours

WELL WATER SUPPLY SYSTEM CHECKLIST

Inspection Date: _____

Checked <input checked="" type="checkbox"/>		Inspection Item	Notes
Y	N		
<input type="checkbox"/>	<input type="checkbox"/>	Any leaks in the piping system?	
<input type="checkbox"/>	<input type="checkbox"/>	Bearings and parts adequately sealed?	
<input type="checkbox"/>	<input type="checkbox"/>	Motor quiet? Not running hot?	
<input type="checkbox"/>	<input type="checkbox"/>	Hydro-pneumatic tank maintaining pressure?	
<input type="checkbox"/>	<input type="checkbox"/>	_____	From equipment manual
<input type="checkbox"/>	<input type="checkbox"/>	_____	From equipment manual
<input type="checkbox"/>	<input type="checkbox"/>	_____	From equipment manual
<input type="checkbox"/>	<input type="checkbox"/>	_____	From equipment manual
<input type="checkbox"/>	<input type="checkbox"/>	_____	From equipment manual

6.0 Wellhead Protection

Preventing groundwater contamination is much more cost effective than cleaning up a contaminated site or treating contaminated groundwater. The development and implementation of a wellhead protection plan is the first step toward maintaining a safe water supply and will typically require the support and co-operation of the local community. The four main elements are:

6.1 Identify the Critical Area to Protect

Map the surrounding land area that could contribute surface water and pollutants to the water supply. Gather information about the well, underlying soil and groundwater flow direction to set boundaries for a protection area. A well driller typically provides a well log for a new well that contains information on well construction and soil layers. If you do not have a copy of the well log, contact your local Drinking Water Officer. The idea is to develop a map of land areas where, if pollutants are spilled or discharged on the surface, they could filter through the soil to the ground water and be drawn into the well. As a starting point, draw a circle of a certain radius (ex: 300m) around the well. Protection upstream of groundwater flow is typically more critical. The advice of a qualified person such as a hydrogeologist may be required to determine the wellhead protection boundaries.

6.2 Inventory the Potential Contaminants within that Area

This inventory usually results in a list and a map of facilities and activities within the critical protection area that may release contaminants into the ground water supply. Some examples of the many different types of potential pollutant sources include landfills, underground or above-ground fuel storage tanks, residential or commercial septic systems, storm water runoff from streets and lawns, farms that apply pesticides and fertilizers, feedlots, manure storage and spreading, and sludge disposal sites.

6.3 Develop a Management Strategy Designed to Minimise the Potential of Contamination

Prioritize the potential pollutant sources and where possible, implement measures to prevent contamination, wherever possible, such as ensuring unused wells are properly sealed and installing fencing around the wellhead. Develop wellhead protection priorities and work towards eliminating or reducing the contamination risk. Implement contingency plans in the event of contamination.

6.4 Regularly Inspect Wellheads

Wellhead covers or seals prevent contaminated surface water and other deleterious material from entering the well. Visually inspect all well covers. Ensure that they are elevated above the adjacent ground level, that the ground is sloped to drain away from the well casing, and free of cracks and excessive wear. If native soils are permeable (ex: sand), add a clay layer and seed grass sloping the area away from the wellhead to prevent erosion and excessive seepage.

Resource –

Saskatchewan Well Head Protection EPB 299, 2004:

[http://www.se.gov.sk.ca/environment/protection/water/EPB 299 - Wellhead Protection.pdf](http://www.se.gov.sk.ca/environment/protection/water/EPB_299_-_Wellhead_Protection.pdf)

7.0 Surface Water Intake Structures

7.1 Intakes

Inspect intakes at minimum once a year ensuring intake screens are not plugged, and in satisfactory condition. Check the structure location to minimise the intake of silt, sand and other deleterious substances. Backflush the intake line if possible. Use a qualified diver to inspect the intake screen and remove built up material. Consider the need for a new or upgraded intake if operational issues occur frequently.

7.2 Raw Water Pumping and Raw Water Storage

Low lift pump stations are often required to pump raw water from a lake or river intake, or raw water reservoir to the water treatment plant. For raw water pump operation and maintenance procedures, refer to section on Well Operation and Maintenance.

Construct raw water reservoirs with a minimum of two cells. This enables withdrawal of raw water from the second cell when the first cell is being filled, repaired, or when sediment and vegetation is being removed. Cells should be deep enough to restrict light penetration within the depth of the reservoir, discouraging the growth of aquatic plants. Manage reservoirs to control taste, odour, colour, iron and manganese as much as possible. Use reservoir management techniques to address problems with algae, weeds, low dissolved oxygen and loss of storage capacity. Artificial circulation, aeration, algaecides, phosphorous precipitation, sediment removal, dilution, and flushing are reservoir management techniques that may be considered to improve the water quality. Adjusting the timing and location of water withdrawals can also improve the quality of the water sent to the plant. Discuss any plans for reservoir management with the Office of Drinking Water.

7.3 Source Water Protection

For a system that uses surface water from a stream, river, lake or reservoir, the land area nearby and upstream of the intake is the critical protection area. A watershed boundary is typically drawn using a topographic map to include the land areas where rain or melted snow flows over or through the ground and eventually enters the water source upstream of the water system's intake. Similar to a Wellhead Protection plan, the next steps would be to inventory the potential contaminants and develop a management strategy. Typically a committee of local representatives develops these plans on a regional basis. It is important for water system owners and operators to be aware of local land use activities and discharges (including any water treatment plant waste) that may affect their source water quality, and become involved in local watershed or source water protection activities through the local Conservation District.

Resource – US EPA Source Water Protection Training Documents:

<http://cfpub.epa.gov/safewater/sourcewater/sourcewater.cfm?action=Assessments>

8.0 Basic Filter Operation and Maintenance

Nearly all surface water treatment facilities and some groundwater treatment facilities employ some form of filtration to either remove particulate matter for turbidity control, or a critical water quality parameter such as iron and/or manganese.

The monitoring of filter operation includes observation of the flow rate, headloss, turbidity levels for each filter, backwashing and air scouring cycles. These operational data can provide the operator with an evaluation of the filter's condition and will indicate the need for corrective action, inspection or other actions. For example, the filter should be backwashed when the flow rate decreases, the turbidity increases, and the head loss increases. If these changes happen in a relatively short period of time, the operator should check the filter influent since it may contain large amounts of particulate matter. This would indicate the raw water conditions have changed and the chemical feed rates should be adjusted. Another option may be to reduce the plant flow if possible. If excessive head losses are indicated immediately after backwashing, the underdrain system may be clogged or fouled due to corrosion or chemical deposits. In the case of an iron/manganese removal plant, iron and manganese parameters may be used in place of turbidity measurements.

For those systems using granulated activated carbon media, refer to the manufacturer's recommendation for service life and replacement, and trends in operational data (ex: colour or UVA/UVT readings). Over time the media becomes exhausted, and must be replaced.

8.1 Daily Duties

Check filter influent and effluent turbidity where filters are being used for removal of particulate matter (turbidity control), using an approved field measurement device such as a turbidimeter (nephelometer), and record the turbidity measurements. Calibrate instruments as per manufacturer's recommendations. Where on-line turbidity instruments are in place, compare portable instrument measurements to on-line instrument readings. If there are notable discrepancies, ensure instruments are properly calibrated. If the filters are used for removal of iron, manganese or other parameters, record influent and effluent values for the critical treatment parameters.

8.2 Monthly Duties

Inspect and lubricate backwash and surface wash pumps according to the manufacturer's recommendations.

Inspect the surface wash equipment (where applicable) for free operation and proper position over the media; check nozzles for blockage.

Routinely check filter control valves for leakage, and regularly work the valves to ensure proper operation.

Inspect the air scour/blower (where applicable) and check oil levels.

Check cartridge filters (where applicable). If there is excessive discoloration or backpressure, they likely require replacement. Check seals to ensure there are no leaks. Always keep replacement filters on hand that are of the same pore size.

8.3 Annual Duties

Inspect the filter media (where accessible). If media is not easily accessible plan for filter shutdown and inspection/maintenance well in advance. Ensure that the media uniformly graded and distributed. Ensure there is the proper depth of each gradation layer of media. Expose the underdrain system to check if the holes or nozzles are clogged. Evaluate any corrosion or equipment issues and take appropriate corrective actions.

Resource -

AWWA Filter O&M Manual:

<http://www.awwa.org/bookstore/product.cfm?id=90908>

9.0 Chemical Feed Systems

Each system should have a summary sheet that lists equipment-specific information on maintenance needs, including supplier, age of pump and other equipment, changes or repairs, etc. **Spare parts or spare pumps if appropriate must be kept on hand for critical components such as disinfection systems so breakdowns can be repaired quickly and worn parts can be replaced when the feeder is disassembled for maintenance.**

9.1 Daily Duties

Check chemical solution tanks and record amounts used. Record either the volume or weight of chemical used. Note the time the tank is filled and at what level so that an accurate usage calculation can be made the next day. Compare the volume of chemical used to the volume of water produced. This will help determine whether chemical usage is in an acceptable range based on the concentration of the chemical and the desired dose. Note important raw water conditions (ex: turbidity) in order to develop a historical record to help in making future adjustments under similar conditions. Trends should be observed, as changes in the trend could indicate underfeed, overfeed, scaling and plugging of lines, etc. Tanks should also be checked for leaks and blockages. See sample Daily Chemical Solution Usage sheet.

Inspect chemical feed pumps for proper operation. Make sure the feeder is not broken or plugged and that it is adjusted correctly. Check to see if the chemical feeder is supplying the correct dosage by using a volumetric measuring device such as a graduated cylinder. Check chemical feed rates at different times of the day to ensure the chemical feed is consistent or properly proportioned.

9.2 Quarterly Duties

Inspect and clean chemical feed lines to make sure they're not clogged or kinked and ensure solution tanks are clean, especially when injecting fluids that calcify such as sodium hypochlorite. These deposits and other build-ups can clog the fittings, increase the back pressure and interfere with check valve operation. Ensure that the foot valve is suitably above the tank bottom to allow space for sediment accumulation.

Calibrate chemical feed pumps. The pumps should be calibrated to ensure that they deliver the appropriate amount of chemicals to the water system. Measure the amount of solution withdrawn by the pump over a given time period or use the pump calibration column (if available), record this value and speed/stroke length settings and compare this rate with the desired feed rate. Refer to the manufacturer's instructions to adjust the feed pump accordingly. Be sure to record any new speed and stroke settings anytime a change is made. Ensure that the feed pump is suitably sized for the application.

9.3 Annual Duties

Overhaul chemical feed pumps (O rings, check valves, and diaphragms) completely at least once a year. Include cleaning the feeder head, cleaning and checking all valves and O rings for wear, and cleaning and checking the condition of check valves and pump control valves. Replace worn parts, including diaphragms. Spare parts should be kept on hand so breakdowns can be repaired quickly. **Spare parts or spare pumps if appropriate must be kept on hand for critical components such as disinfection systems.** Calibrate chemical feed pumps after overhaul.

Mount a copy of the owner's manual on the wall next to the pump with a parts schematic complete with part numbers. **Spare pumps should be considered for each chemical application to provide 100% redundancy.**

9.4 Jar Testing

Jar testing is a method used to determine the dosage for a given chemical to create the desired change (ex: optimal coagulant dose for floc formation). Chemical feed rates can be determined from these results.

Jar testing instructions are beyond the scope of this document. However, they can be found in operator's handbooks, or from a chemical supplier. In many instances, the chemical supplier themselves will perform the jar tests for the operator.

CAUTION: Always wear eye protection and appropriate protective clothing when working with chemical feed systems. Maintain chemical MSDS sheets in readily accessible locations. Ensure all chemical containers are properly labelled and stored.

The following table may be used to do a quick check to help ensure that the chemical feed pumps are dosing near the correct rates over a 24-hr period.

DOSAGE RATE CALCULATION : (a) x (b) / (c) = (d)

(a)	(b)	(c)	(d)	
Concentration of Chemical Solution*	Volume of Solution Pumped over 24-hrs	Volume of water treated over 24-hrs	Calculated Dosage	Expected Dosage
(mg/L = ppm)	(L)	(L)	(mg/L)	(mg/L)

* Note that 1% = 10,000 ppm

DAILY CHEMICAL SOLUTION USAGE

CHEMICAL: _____

Chemical Pump Settings: Speed _____ Stroke _____ Month/Year _____

Day	Water Produced units: _____	Solution Used units: _____	Solution used per _____ of water produced	Notes or Comments
1 st				
2 nd				
3 rd				
4 th				
5 th				
6 th				
7 th				
8 th				
9 th				
10 th				
11 th				
12 th				
13 th				
14 th				
15 th				
16 th				
17 th				
18 th				
19 th				
20 th				
21 st				
22 nd				
23 rd				
24 th				
25 th				
26 th				
27 th				
28 th				
29 th				
30 th				
31 st				

10.0 Ultraviolet Disinfection

Factors that affect UV light disinfection system performance are: lamp output, lamp aging, and plating or fouling of surfaces. To better control these factors, operators must ensure continuous dose measurement (i.e., accurate intensity and flow-rate measurement) and proper maintenance (cleaning as well as lamp and sleeve replacement regimes). To ensure continued system operation, a maintenance schedule needs to be in place. With the variety of UV systems available, the operator should refer to the manufacturer's O&M manual for detailed maintenance tasks specific to their unit.

10.1 Weekly Duties

Check online UV Transmittance (UVT) monitor calibration; re-calibrate as required.

10.2 Monthly Duties

Check reactor housing, sleeves, wiper seals, and O rings for leaks; replace as required.

Check UV intensity sensor calibration as per manufacturer's instructions.

10.3 Quarterly Duties

Check cleaning efficiency. If fouling is visible on the sleeves; record UV intensity sensor reading and manually clean sleeves as per manufacturer's recommendations. After cleaning, record UV intensity again and compare to original reading. Replacement of the sleeve may be required if UV intensity is not restored to its validated level.

Check cleaning fluid reservoir; replenish as required.

CAUTION: UV light can cause skin and eye damage! Avoid looking directly at the UV bulb when it is turned on. Follow the manufacturer's recommendations on maintenance procedures.

10.4 Monitoring

Monitor water turbidity, colour and/or UV Absorbance (Transmittance) since they provide an indication of natural barriers to UV light transmission. Some dissolved minerals, such as calcium, significantly reduce UV absorbance. Pay special attention to the cleaning schedule where fouling agents, such as iron, are present.

Resource -

US EPA Ultraviolet Disinfection Guidance Manual:

http://www.epa.gov/safewater/disinfection/lt2/pdfs/guide_lt2_uvguidance.pdf

11.0 General Plant Maintenance

In order for operators to safely and effectively carry out their required tasks, all facilities should be kept clean and free of clutter. Chemicals and equipment not related to the operation of the water system should not be stored in the plant.

11.1 Daily Duties

Check instrumentation for proper signal input/output including all devices which monitor flow rate, volume, pressure, level, etc.

Complete a daily security check of locks, hatches, doors, windows, vents, security lighting and alarms to ensure proper operation, Routinely check for signs of intrusion or vandalism. Check that well caps, seals, and vents are intact and sealed.

Inspect testing equipment. Ensure the correct chemical reagents are being used for each type of application. Reagents should be safely stored and clearly marked with the name and date of preparation. Manufacturer-prepared reagents should be properly discarded when the expiration is reached.

11.2 Weekly Duties

Check the backup power source to ensure it will operate when needed.

11.3 Monthly Duties

Perform an inventory of spare parts, equipment, repair clamps, pipes, and valves, and always maintain the spare parts inventory.

11.4 Annual Duties

Inspect and exercise all valves inside the treatment plant and pump house routinely. The frequency depends on the type of valve but should be inspected at least twice a year and include completely closing, reopening, and re-closing the valve until it seats properly. Record the number and direction of turns to closure. Leaking or damaged valves should be scheduled for repair.

Inspect, clean, and repair control panels at least once a year for corrosion and other problems that could cause shorts or failures.

Calibrate on-site testing equipment according to the manufacturer's recommendations so accurate readings are taken of water quality conditions.

12.0 Asset Management

A good asset management plan helps ensure the water system gets the most value from each asset as well as providing the financial resources to rehabilitate and replace them when necessary.

Take an inventory (see guides listed below) and familiarize yourself with what assets exist and their condition to help scheduling of rehabilitation and replacement of the various system assets.

Prioritize the assets ensuring that funds are allocated to the rehabilitation or replacement of the most important assets (i.e. pumps, disinfection equipment, etc.).

Develop an asset management plan. Create an annual budget that summarizes how much it will cost to operate and maintain the system for the year. This includes calculating how much reserve money needs to be set aside each year for future large purchases and upgrades. The Manitoba Public Utilities Board has published guidelines on how to set water rates to maintain a self-sufficient water system.

Implement the plan. Review what funds are available and how much more additional funding may be required to meet the set budget. System owners and customers should work together to find means to ensure that the system has the technical and financial means to deliver safe water.

Review the asset management plan every year as it is a flexible document that should evolve and grow along with the system.

Resource -

US EPA Asset Management Documents:

http://www.epa.gov/safewater/smallsys/pdfs/final_asset_inventory_for_small_systems.pdf

http://www.epa.gov/safewater/smallsys/pdfs/guide_smallsystems_asset_mgmnt.pdf

13.0 Treated Storage Reservoirs

The main types of storage facilities are underground and ground level storage reservoirs, and plastic storage tanks. Hydropneumatic tanks are a type of storage component that is commonly used in very small systems to minimize pump starts and stops by providing a small volume of on-line storage. The following are some recommended operational duties to help develop a preventative maintenance program for storage facilities.

13.1 Daily Duties

Check and record water levels in storage tanks and reservoirs. Keep them within normal operating range. Check for evidence of overflow and leaks. If the tank is overflowing, there may be a problem with the pump, or water level measurement and control system. If it is below normal, there may be a capacity or control problem. Water level measuring devices should also be checked. See sample Storage Tank/Reservoir Log.

Check and record water levels and pressure in hydropneumatic tanks. They can overflow, or waterlog at times, affecting overall system pressure. Monitoring system pressure can help identify leaks, open valves and even well pump problems.

13.2 Annual Duties

Inspect storage tanks and reservoirs for defects and sanitary deficiencies at least once a year to guard against water quality problems and excessive leakage. The inspection should include:

- ❑ ensuring that all openings are properly screened (vents, overflows etc.) to prevent the entry of small animals, small insects, and organic matter.
- ❑ checking vents and screens for blockage or tears.
- ❑ checking for any deterioration in the tank walls or the tank foundation. Note any excessive pitting in steel tanks, or large cracks in concrete structures.
- ❑ removing any notable silt build-up.
- ❑ ensuring that overflow pipes are above local flood levels; if not, install a suitable flap gate or similar device to prevent water intrusion to reservoir.

Storage tanks and reservoirs must be cleaned and disinfected before being placed back into service following inspection or maintenance. Any substance used to recoat or repair the interior of a drinking water storage tank must be certified safe for use with potable water (ex: ANSI/NSF Standard 61). If the tank is not drained for recoating or repairing, any substance or material used to repair interior coatings or cracks must also be suitable for underwater application, as indicated by the manufacturer. Confined space entry procedures may apply to water tank and reservoir maintenance activities.

Resource -

US EPA Finished Water Storage Facilities:

http://www.epa.gov/safewater/disinfection/tcr/pdfs/whitepaper_tcr_storage.pdf

STORAGE TANK / RESERVOIR LOG Cell/Tank No.: _____

Normal Operating Levels

High: _____

Low: _____

Month/Year: _____

Day	Water Level units: _____	Time of Reading	System Pressure units: _____	Notes or Comments
1 st				
2 nd				
3 rd				
4 th				
5 th				
6 th				
7 th				
8 th				
9 th				
10 th				
11 th				
12 th				
13 th				
14 th				
15 th				
16 th				
17 th				
18 th				
19 th				
20 th				
21 st				
22 nd				
23 rd				
24 th				
25 th				
26 th				
27 th				
28 th				
29 th				
30 th				
31 st				

14.0 Storage Reservoir Disinfection

All storage tanks and reservoirs should be disinfected in accordance with the latest AWWA Standard C652 and tested prior to being placed back into service following any maintenance or repairs. This procedure may also be used for emergency disinfection due to a system contamination event. (For disinfection of water treatment plants and wells, refer to AWWA Standard C653 and C654, respectively.) Two of the more common methods described in C652 are summarised below.

Method 1 – The water storage tank or reservoir shall be filled to overflow with potable water with a free chlorine residual of not less than 10 mg/L at the end of the prescribed retention period. If the water entering the storage facility has been chlorinated uniformly with chemical feed equipment, then the retention period is to be not less than 6 hours. If chlorine has been placed *manually* prior to filling, or after filling the reservoir, the retention time shall be not less than 24 hours. After flushing, two or more successive sets of samples, taken at 24-hr intervals, shall indicate microbiologically satisfactory water before the facility is placed back into service.

Method 2 – A solution of 200 mg/L available chlorine shall be applied directly (brush or spray) to the surfaces of all parts of the storage tank or reservoir that is in contact with water. The disinfected surfaces shall be in contact with the strong chlorine solution for at least 30 minutes, after which the facility can be filled with potable water. This method is preferred, as Method 1 typically requires de-chlorination prior to disposal of the chlorinated disinfection water. With Method 2, the disinfection water is typically dilute enough to introduce to the distribution system.

Chlorinated water must not be released directly to a surface water body. Where de-chlorination is required, chlorine levels may be dissipated passively (natural decay over time) or using a chemical. Natural decay is a very slow process; thus chemicals are typically used to de-chlorinate. Sodium bisulphite, sodium sulphite and sodium thiosulphate are the most frequently used. The choice of chemical is dictated by site-specific issues such as the strength of chlorine, volume of water release, and distance from receiving waters.

Amount of chemical required to neutralize 378.5 m³ (100,000 USG) of water:

Residual Chlorine Concentration	Sodium Bisulphite		Sodium Sulphite		Sodium Thiosulphate	
mg/L	kg	(lb.)	kg	(lb.)	kg	(lb.)
1	0.54	(1.2)	0.64	(1.4)	0.54	(1.2)
10	5.67	(12.5)	6.62	(14.6)	5.44	(12.0)
50	28.39	(62.6)	33.11	(73.0)	27.22	(60.0)

Resource -

Emergency Disinfection: http://www.doh.wa.gov/ehp/dw/Publications/331-242_4-21-06.pdf

15.0 Watermain Repair and Disinfection

The construction, rehabilitation, and repair of watermains are a regular occurrence in many water systems. The frequency and nature of these activities represents a potential contamination risk to the water distribution system if proper procedures and standards are not followed. ***In the event of a major watermain break, the operator is to contact their local Drinking Water Officer who can be of assistance in providing mitigating measures to ensure the protection of public health.***

Any watermain repair or replacement should be properly disinfected in accordance with the latest AWWA Standard C651 and tested prior to being placed back into service.

Contamination can occur along many stages of the watermain repair or replacement. To minimize the potential for contamination, ensure the following actions are taken:

- ❑ Keep sections of new pipe sealed at both ends to prevent dirt and foreign matter from entering. Plug existing open watermain ends until tie-in or repair is to be made.
- ❑ Properly excavate around pipe to mitigate against soil intrusion into opened pipe section, maintain a de-watering system where necessary.
- ❑ Use NSF approved products, wherever possible, for any installation or repairs (ex: lubrication, rubber gaskets, etc.).
- ❑ Ensure that tools, equipment and any other items that come into contact with the watermain are properly cleaned and disinfected.
- ❑ Ensure proper disinfection of all piping, fittings and appurtenances.
- ❑ Ensure the repair is tight and not leaking.
- ❑ Investigate possible sources of cross connections after installation or repair (ex: leaking valve, backflow through distribution).
- ❑ Implement disinfection and flushing as per AWWA Standard C651.
- ❑ Prior to placing the main back into service, verify with bacteriological testing as per AWWA Standard C651, or as instructed by the Drinking Water Officer.

Resource:

AWWA Disinfecting Water Mains: <http://www.awwa.org/bookstore/product.cfm?id=43651>

16.0 System Drawing and Sample Siting Plan

16.1 System Drawing

Each system should have up-to-date and accurate drawings of the distribution system to aid in the proper operation of the system and to respond to emergency situations.

The complexity and level of detail required for the system drawing may vary depending on the size and type of water system. For most small drinking water systems, however, a detailed map drawn to scale is recommended. Legal plans and area maps can be used as suitable base plans with the distribution system drawn over them.

System drawings should include:

- all water sources appropriately numbered;
- treatment facilities;
- storage facilities;
- pumping facilities;
- distribution lines with sizes, and preferably type of pipe;
- valves with appropriate numbering;
- hydrants and flush-outs with appropriate numbering;
- sewer lines, lift stations, ancillary treatment locations; and
- major customers (sensitive users such as hospitals, large volume users, industrial/agricultural users).

16.2 Sample Siting Plan

Overlain on the system drawing should be the sample (monitoring) sites throughout the distribution system. The sample siting plan can then be used to determine if the system monitoring program suitably covers the distribution system to ensure that there are no places in the system where microbiological contamination could persist undetected.

The sample plan should also target areas with low flows and/or dead end lines.

17.0 Distribution System Flushing

The distribution system should be flushed in spring and/or fall to maintain water quality, remove sediment, maximise hydraulic capacity, and remove stagnant water at dead-end mains. Watermains may also be flushed periodically throughout the year in response to customer complaints as well as non-compliant samples, and by direction from the local Drinking Water Officer. Seasonal facilities should be disinfected and flushed at the start of each season. For protocols for seasonal water systems, refer to the Manitoba Water Stewardship document “Seasonal Water System Start-up/Shut-down Protocol”.

Uni-directional flushing (UDF) is recommended as it is typically the most effective method of flushing a water distribution system as it starts at the source and progresses from the largest to the smallest mains in a systematic manner. A flushing/swabbing program should also incorporate hydrant maintenance and valve exercising.

17.1 Prior to Flushing Checklist

- ❑ Pre-plan the flushing sequence using system maps. Select the flush-out locations and consider installing new ones where necessary.
- ❑ Review drainage and dechlorination requirements (if flushing water will be directed to a surface water body).
- ❑ Notify customers in advance of possible impacts and duration.
- ❑ Ensure reservoirs are full to provide adequate amount of flushing water.

17.2 While Flushing Checklist

- ❑ Flushing velocity should be at minimum 0.75 m/sec (2.5 ft/s), but 1.5 m/sec (5.0 ft/sec) is preferred in order to achieve suitable biofilm removal.
- ❑ Open hydrant for a period long enough (5-10 minutes) to stir up deposits inside the watermain. Flush until the water is clear.
- ❑ Assure that system pressures in other parts of the distribution system do not drop below 140 kPa (20 psi).
- ❑ If discharging into a drainage course, check chlorine residual concentrations to ensure that chlorine has dissipated by the time the water reaches fishery habitat, or use a de-chlorinating agent to consume the chlorine.
- ❑ Collect two water samples from a flowing hydrant; the first after 2 or 3 minutes of flushing and the second just prior to closing the hydrant. Sample for chlorine residual, turbidity, and iron (where applicable).
- ❑ Document results and update records. See sample Flushing Logs.

Spot flush water systems at all dead ends and other locations where low chlorine residuals or failed bacteriological samples are found. If there are no facilities for this, it is strongly recommended they be installed.

17.3 Watermain Swabbing

In some cases, flushing a water distribution system may not effectively improve water quality or hydraulic capacity. If there is evidence of severe pipe tuberculation or corrosion (ex: on old cast iron pipes), water treatment chemical build-up (ex: alum floc) or silt/sand build-up, watermain swabbing using a soft foam swab may be required. Swabbing is generally conducted by qualified professionals. Swabbing is normally done in phases working from the source into the distribution system.

Resources –

Saskatchewan Environment EPB 242 (Appendix C):

[http://www.se.gov.sk.ca/environment/protection/water/EPB 242 - QA and QC for Water Treatment Utilities.pdf](http://www.se.gov.sk.ca/environment/protection/water/EPB_242_-_QA_and_QC_for_Water_Treatment_Uilities.pdf)

British Columbia Minister of Health Services UDF Best Management Practices:

[http://www.bcwwa.org/BMP/bmp_07_flushing/Uni-directional Flushing BMP Draft Version 1.pdf](http://www.bcwwa.org/BMP/bmp_07_flushing/Uni-directional_Flushing_BMP_Draft_Version_1.pdf)

FLUSHING LOGS

Date: _____

Location: _____

Flow Rate (_____)	Duration (minutes)	Static Pressure (_____)	Residual Pressure (_____)	Time to Clear Discoloration (minutes)	Comments

Date: _____

Location: _____

Flow Rate (_____)	Duration (minutes)	Static Pressure (_____)	Residual Pressure (_____)	Time to Clear Discoloration (minutes)	Comments

Date: _____

Location: _____

Flow Rate (_____)	Duration (minutes)	Static Pressure (_____)	Residual Pressure (_____)	Time to Clear Discoloration (minutes)	Comments

Date: _____

Location: _____

Flow Rate (_____)	Duration (minutes)	Static Pressure (_____)	Residual Pressure (_____)	Time to Clear Discoloration (minutes)	Comments

Date: _____

Location: _____

Flow Rate (_____)	Duration (minutes)	Static Pressure (_____)	Residual Pressure (_____)	Time to Clear Discoloration (minutes)	Comments

18.0 Hydrant Maintenance

Hydrants should be inspected and maintained twice a year, typically spring and fall, and after each use. Regular maintenance helps provide assurance that they will be fully functional when needed.

At minimum, a hydrant maintenance program should include:

- ❑ an updated system map indicating the location and number of all hydrants;
- ❑ a schedule for flow testing and performing routine maintenance;
- ❑ documentation for each hydrant, indicating type, date of installation, and maintenance records. See sample Hydrant Maintenance Log.

18.1 General Inspection and Maintenance Procedures

- ❑ Check for leakage (use listening device to detect non-visible leaks).
- ❑ Remove all nozzle caps and inspect threads; replace any missing caps and chains. clean and lubricate nozzle threads.
- ❑ Replace any missing or damaged nuts.
- ❑ Check barrel for cracks, clean exterior and re-paint if necessary.
- ❑ Open and close hydrant fully a few times and check for ease of operation.
- ❑ While hydrant is flowing, test isolation valve by closing it.
- ❑ Check for any exterior obstruction that could interfere with operation of the hydrant during an emergency.
- ❑ Check self-draining dry-barrel hydrants for proper drainage; if not self-draining, use bailer pump to remove water (any remaining water may freeze and damage the hydrant).
- ❑ If a hydrant is inoperable, tag it with a clearly visible marking and immediately report its condition to the fire department. Schedule hydrant for repairs.
- ❑ Prepare record of inspection and maintenance operations and any repair work
- ❑ All materials, paints, linings, coatings, adhesives, lubricants, etc. in direct contact with potable water must be suitable for potable water use (ex: certified to ANSI/NSF 61 Standard).
- ❑ If a hydrant is frequently under water to location in a flood prone area, the hydrant should be relocated.

For additional information on fire hydrants, refer to AWWA Standard Methods C502 (Dry Barrel) and C503 (Wet Barrel).

Resources –

AWWA Manual M17 on Fire Hydrants: <http://www.awwa.org/bookstore/product.cfm?id=30017>

AWWA Conducting Hydrant Flow Tests: <http://www.awwa.org/bookstore/product.cfm?id=65050>

19.0 Valve Maintenance

A small water system may have a limited watermain network, and every valve may have to be operable to isolate a break in the system. If a valve does not work when needed, the entire system may need to shut down. All valves in the water distribution system should be exercised at least once a year. At the same time the valve should be inspected and records updated accordingly. Implementing a valve maintenance program extends valve life and results in long term savings to the system.

19.1 Components of a Valve Maintenance Program

- ❑ An updated system map indicating the location and identification (numbering) of all valves.
- ❑ Documentation for each valve, indicating type, date of last exercise, number of turns to close, and a record of maintenance work for each valve. Records should indicate whether the valve is right hand or left hand closing, and whether the valve is normally open or normally closed. See sample Valve Operation Worksheet.
- ❑ A schedule for regular exercise and routine maintenance.

19.2 Components of a Routine Valve Inspection

- ❑ Verify the accuracy of the location of the valve boxes on the system map and update map where necessary.
- ❑ Remove valve box cover and inspect stem and nut for damage or obvious leakage.
- ❑ Close the valve fully and record the number of turns to the fully closed position (always close the valve slowly to prevent water hammer).
- ❑ Record whether the valve is right hand or left hand closing.
- ❑ To determine if a valve is closed, an aquaphone, or simply an ear to the gate key, can be used.
- ❑ Record condition of valve and any maintenance that is required. Any valve that does not completely open or close should be replaced.
- ❑ Clean the valve box cover seat.
- ❑ Replace any missing valve box covers.
- ❑ **Place the valve in its operating position (open or closed) when inspection is complete.**

Automatic air release, vacuum breaker, or pressure-reducing valves should be inspected at least every six months. These valves will usually have an O&M manual, which describes how they are to be inspected and maintained. Manual air releases should be opened and flushed to remove accumulated air, at least twice per year. Air locks in water lines will interfere with the capacity of the line to convey water.

20.0 Cross Connections and Backflow Prevention

Small water systems may be more vulnerable to backflow situations than larger systems because they do not always have the luxury of continuous positive pressure with an emergency backup power supply. Small systems on hilly terrain may be particularly vulnerable to negative pressures when heavy water use in the lower elevations may siphon water away from the higher elevations.

A few examples of residential cross connections include:

- ❑ A flexible hose connected to a water tap and submerged in non-potable water (e.g. sink);
- ❑ A garden hose submerged in a pesticide or herbicide mixture;
- ❑ A piped connection providing potable feed water to appliances (dishwasher); and
- ❑ Connections between firefighting equipment and the potable water system.

Operators should be constantly aware of possible operational conditions that may cause a cross connection and backflow situation.

- ❑ Was power to the pump off?
- ❑ Was the pump out of service?
- ❑ Was there a major line break in the system?
- ❑ Was there a major water draw for fire fighting purposes?

Unsatisfactory bacteriological test result may be an indication of cross connection problems and should not be dismissed as sample collection error or a problem with the laboratory.

Cross connections must either be physically disconnected (air gap) or have an approved backflow prevention device installed to protect the public water system. There are five types of approved devices:

1. Air gap
2. Atmospheric vacuum breaker
3. Pressure vacuum breaker
4. Double check valve
5. Reduced pressure principle backflow preventer

The backflow prevention device, or method appropriate for a particular cross connection situation, is based on the degree of hazard.

Backflow prevention should be done in accordance with the provincial plumbing code, and WCS AWWA Cross Connection Control Manual or CSA B64.10-01 Manual for the Selection and Installation of Backflow Prevention Devices.

Resource –

US EPA Cross connection Control Manual: <http://www.epa.gov/safewater/crossconnection.html>

21.0 Leak Detection Program

Leak detection programs are an effective way to reduce operating and maintenance costs and should be carried out on a regular basis.

Depending upon size and complexity of the water system various components of the program could include the following:

- ❑ **Water Audit.** Compare the volume produced to the volume sold and used for other metered and un-metered purposes (flushing, fire fighting, etc.).
- ❑ **Visual Inspection.** During routine distribution maintenance and system checks, look for standing water in low areas. If fluoride is used in the system, test standing water for fluoride to determine if it a pipeline leak.
- ❑ **Audible Inspections.** Listening devices can be placed on hydrants, valve stems, or directly over a water line, to determine if there are leaks. These devices can be as simple as a metal rod, or more sophisticated, such as a hydro-phonic probe and amplifier, or a computerised noise correlator.

Document any leak repairs and ensure adequate disinfection is achieved.

At minimum, record the following:

- ❑ repair date;
- ❑ location of repair;
- ❑ size of line and pipe material;
- ❑ disinfection method and flushing procedures;
- ❑ chlorine residual testing results;
- ❑ bacteriological sampling results; and
- ❑ estimated volume of water lost due to the leak and during repair, including any flushing.

Resource –

Detecting Leaks in Water-Distribution Pipes: http://irc.nrc-cnrc.gc.ca/pubs/ctus/40_e.html

22.0 Water Quality Monitoring Program

A water quality monitoring program must be tailored to each system by looking at the unique elements of the system, the water quality challenges the system faces and regulatory requirements.

Some benefits of implementing a thorough monitoring program include:

- ❑ reducing risk to public health by early detection and mitigation of declining or unacceptable water quality;
- ❑ supporting due diligence and increasing public trust;
- ❑ maximizing the efficiency of treatment processes at the treatment facility; and
- ❑ guiding operation and maintenance activities to address water quality in the distribution system.

Include the following steps when developing a monitoring program.

22.1 Determine Monitoring Parameters

As a minimum, water quality parameters required by regulation as well as those stipulated by the Office of Drinking Water must be monitored to ensure regulatory compliance. Monitoring some parameters that are non-regulatory (pH, turbidity, alkalinity, etc.) may provide the operator with a better understanding of what is affecting water quality within the distribution system and for optimising treatment system operation.

22.2 Determine Monitoring Locations

The locations at which various parameters are monitored should be based on regulatory requirements, historical data (consistent poor water quality results and customer complaints), distribution system size and characteristics, consumer distribution and operational requirements. Establish locations that have good representation of the distribution system based on distance or travel time from the treatment facility.

22.3 Determine Monitoring Frequency

The frequency of monitoring should allow the system to meet regulatory requirements, allow timely detection of acute changes in the water quality that may affect public health or aesthetics, and provide data required to operate and maintain the system. Examine the flows in the distribution (i.e., low flow areas), seasonal variability and vulnerability to assist in determining the appropriate monitoring frequency. Based on the chosen monitoring frequency, the collection of samples should be spread out evenly over time.

It is recommended for most systems, and required by regulation for larger water systems, that continuous on-line monitoring of both chlorine residual and turbidity take place.

22.4 Determine Sampling Techniques

For manual sampling, all staff should be properly trained in aseptic techniques to prevent sample contamination. Where possible, dedicated sampling stations should be used for manual sample collection to avoid contamination. The operator should possess the proper tools for field measurements (i.e. nephelometer for turbidity measurements).

22.5 Manage and Report Monitoring Data

Develop a data management system that will record all the water quality data, allow access by many parties, but can only be edited by select staff. Using the data management system the operator can then prepare reports to demonstrate regulatory compliance. Computerized data should have appropriate backup measures in place (printed hard copies, back up CD). Certain reporting will be required through regulation and a water system's operating licence. For other data, water quality monitoring forms should be developed. See sample Water Quality Log Card.

22.6 Include Event-Driven Monitoring in the Program

There are a number of events such as watermain breaks, hydrant use, and power outages, which should trigger monitoring in the distribution system and may help identify localized problems before they become a system-wide concern. Customer inquiries should also trigger monitoring; the inquiry should be investigated until a resolution is found. Samples should be obtained upstream and downstream of the event location.

22.7 Develop Response Procedures for Monitoring Results

Develop and document response procedures for water quality monitoring results that are outside of normal or acceptable limits. Regulatory requirements for reporting abnormal results must be included. The system should have a response procedure based on two occurrences:

- ❑ when monitoring results **approach** an unacceptable level; and
- ❑ when monitoring results **reach** an unacceptable level.

The procedures must incorporate the appropriate corrective actions to be taken, including internal and external communication protocols. All contact information should be readily available in a single location. Co-ordinate procedure documentation with the system's Emergency Response Plan. ***The Office of Drinking Water should be notified, as soon as practical, of any contamination event or other major problem, upset, bypass condition, main break or malfunction that may adversely affect public health or the environment, and appropriate remedial actions should be immediately taken.***

22.8 Establish Partnerships

The system should develop partnerships that will help contribute to the maintenance of acceptable water quality in the distribution system, including:

- ❑ Office of Drinking Water (through local Drinking Water Officer)
- ❑ Regional Health Authority and Manitoba Health
- ❑ Fire Department
- ❑ Manitoba Conservation
- ❑ Building and plumbing inspection departments
- ❑ Laboratories
- ❑ Consultants, contractors, and equipment suppliers
- ❑ Emergency response groups

22.9 Maintain and Update the Monitoring Program

To maintain the program, the system owner should ensure that staff receives appropriate training and maintains proficiency. Instrument replacement and upgrades should be done on a regular basis, as well as calibration of the instruments. Regularly review the program as to how it meets the system's needs and expand the program as the system expands.

Resource -

Office of Drinking Water "Operations and Monitoring":

<http://www.gov.mb.ca/waterstewardship/odw/reg-info/operations-monitor/index.html>

WATER QUALITY LOG CARD

PARAMETER: _____

Location: _____ Month/Year: _____

Day	Raw Water Measurement (units: _____)	Measurement leaving WTP (units: _____)	Measurement in Distribution System (units: _____)	Notes or Comments
1 st				
2 nd				
3 rd				
4 th				
5 th				
6 th				
7 th				
8 th				
9 th				
10 th				
11 th				
12 th				
13 th				
14 th				
15 th				
16 th				
17 th				
18 th				
19 th				
20 th				
21 st				
22 nd				
23 rd				
24 th				
25 th				
26 th				
27 th				
28 th				
29 th				
30 th				
31 st				

23.0 Emergency Planning

An emergency plan is needed so that when an emergency occurs, it can be handled quickly, efficiently, and professionally. Emergency situations would include power outages, equipment failure, loss of pressure in the distribution system, or a suspected contamination event. The emergency plan should be specific to each system and the best person to develop an emergency plan is the operator. The emergency plan should outline what action will be taken and by whom.

Any emergency plan should be written down and stored in a binder so it can regularly be updated. More than one person should be familiar with the plan and it should be readily accessible. An Emergency Plan should be reviewed and tested periodically.

At minimum, an Emergency Plan should contain the following elements as applicable to each system:

- The following contact names and telephone numbers;
 - Water system personnel and water system owner(s),
 - Local Drinking Water Officer,
 - Local Public Health Inspector,
 - Provincial 24-hour emergency response number,
 - Local and Municipal emergency services (Police, Fire, EMS),
 - Current chemical suppliers,
 - Laboratories,
 - Utilities (Telephone, Hydro, etc.),
 - Contractors who would be readily available for making repairs beyond the capability of the operator (Plumbers, Electricians, Excavators, etc.),
 - Well drillers,
 - Equipment suppliers and spare parts, pipe sections and pipe repair parts,
 - Additional help and volunteers, and
 - Neighbouring water systems for emergency support;
- Arrangements for obtaining emergency power;
- Arrangements for obtaining an alternative source of potable water;
- An up-to-date distribution map showing wells/intake, pumping facilities, storage facilities, line sizes, valves, hydrants, and blow-offs;
- Procedure for notifying the public and media, including a sample Boil Water notice; and
- Emergency disinfection procedures for wells, water lines and storage facilities.

Resources -

INAC Emergency Response Planning Guide:

http://www.ainc-inac.gc.ca/H2O/cokit/appc_e.html

Office of Drinking Water "Operations and Monitoring":

<http://www.gov.mb.ca/waterstewardship/odw/reg-info/operations-monitor/index.html>

24.0 Additional Resources

24.1 Standards

Office of Drinking Water Home Page:

- http://www.gov.mb.ca/waterstewardship/drinking_water/index.html

A summary of the Guidelines for Canadian Drinking Water Quality is available through Health Canada:

- http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/doc_sup-appui/sum_guide-res_recom/index_e.html

The Ten State Standards (used by the Office of Drinking Water as the basis for the engineering review and approval of water systems) are available from Health Education Services:

- <http://www.hes.org/>

AWWA Standards are available through the AWWA web site:

- <http://www.awwa.org/bookstore/Category.cfm?cat=ALLSTD>

The NSF (National Sanitation Foundation) certifies drinking water chemicals and water treatment units:

- <http://www.nsf.org>

24.2 Information

Manitoba Water & Wastewater Association:

- <http://www.mwwa.net/>

Western Canada Water & Wastewater Association:

- <http://www.wcwwa.ca/>

Western Canada Section American Water Works Association:

- <http://www.wcsawwa.net/>

USEPA Small Systems Documents:

- <http://www.epa.gov/safewater/smallsys/ssinfo.htm>

Health Canada Water Quality and Health:

- http://www.hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/index_e.html

British Columbia Water & Wastewater Association – Best management Practices

- <http://www.bcwwa.org/BMP/index.php>

24.3 Other Examples of Manuals

Example of a Groundwater Manual:

- <http://water.montana.edu/training/gw/default.htm>

Example of some Drinking Water Manuals:

- <http://oregon.gov/DHS/ph/dwp/manuals.shtml>

Example of a Small Water System Management Program Guide:

- <http://www4.doh.wa.gov/dw/publications/publications.cfm?action=pubdetail&type=subject&PubId=123>

Example of a Small Water System Manual:

- <http://www.bcwwa.org/BMP/index.php>

Example of a Preventative Maintenance Manual:

- <http://www.epa.gov/safewater/smallsys/4x6final.pdf>

APPENDICES

SI System Prefixes

mega, M	= 1,000,000
kilo, k	= 1,000
hecta, h	= 100
deca, da	= 10
deci, d	= 0.1
centi, c	= 0.01
milli, m	= 0.001
micro, μ	= 0.000001

Areas

Rectangle

$A = lw$

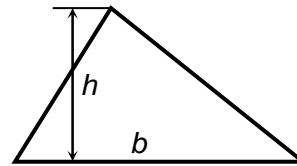
Where: $A = \text{Area, m}^2$
 $l = \text{length, m}$
 $w = \text{width, m}$



Triangle

$A = (bh)/2$

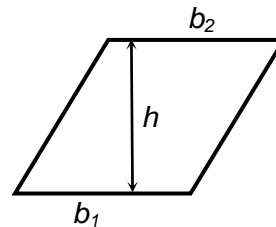
Where: $A = \text{Area, m}^2$
 $b = \text{base, m}$
 $h = \text{height, m}$



Trapezoid

$A = ((b_1+b_2)h)/2$

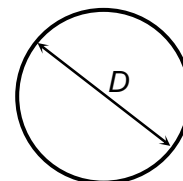
Where: $A = \text{Area, m}^2$
 $b_1 = \text{smaller base, m}$
 $b_2 = \text{larger base, m}$
 $h = \text{height, m}$



Circle

$A = \pi r^2$ Or, $= (\pi D^2)/4$

Where: $A = \text{Area, m}^2$
 $\pi = 3.14$
 $r = \text{radius, m}$
 $D = \text{Diameter, m}$



Volumes

Rectangular Prism

$V = lwh$

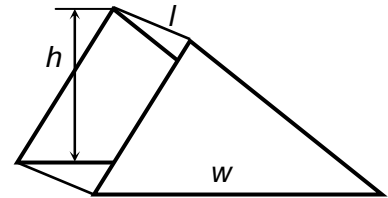
Where: $V = \text{Volume, m}^3$
 $l = \text{length, m}$
 $w = \text{width, m}$
 $h = \text{height, m}$



Triangular Prism

$V = (bh) (l) / 2$

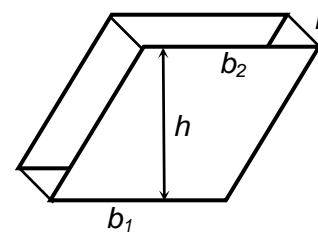
Where: $V = \text{Volume, m}^3$
 $b = \text{base, m}$
 $h = \text{height, m}$
 $l = \text{length, m}$



Trapezoidal Prism

$V = ((b_1+b_2)h)/2$

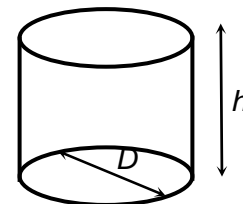
Where: $V = \text{Volume, m}^3$
 $b_1 = \text{smaller base, m}$
 $b_2 = \text{larger base, m}$
 $h = \text{height, m}$



Cylinder

$V = (\pi)D^2(h) / 4$

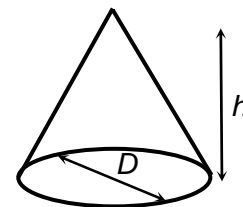
Where: $V = \text{Volume, m}^3$
 $\pi = 3.14$
 $D = \text{Diameter, m}$
 $h = \text{height, m}$



Cone

$V = (\pi)D^2(h) / 12$

Where: $V = \text{Volume, m}^3$
 $\pi = 3.14$
 $D = \text{Diameter, m}$
 $h = \text{height, m}$



Conversions

Inches	Millimetres	Miles	Kilometres	Feet	Metres
1	25.4	1	1.609	1	0.305
0.039	1	0.621	1	3.281	1
Yards	Metres	Square Feet	Square Metres	Square Yards	Square Metres
1	0.914	1	0.093	1	0.836
1.094	1	10.764	1	1.196	1
Cubic Feet	Cubic Metres	Cubic Yards	Cubic Metres	Pounds	Kilograms
1	0.028	1	0.765	1	0.454
35.315	1	1.308	1	2.205	1
Imp. Gallons	Litres	Ounces	Grams	US Gallons	Litres
1	4.546	1	28.350	1	3.785
0.220	1	0.035	1	0.264	1
Psi	ft head water	Psi	kPa	Grains	mg/L or ppm
1	2.31	1	6.895	1	17.1
0.433	1	0.145	1	0.0585	1

Examples of Chemical Calculations

The following are some examples for calculating chemical concentrations and feed flow rates. Chlorine has been used as an example, but any chemical can be substituted here.

Chlorine concentrations can be expressed as a percent (%), or in parts-per-million (ppm), where 1% = 10,000 ppm. Chlorine concentration can also be expressed as mg/L, where 1.0 mg/L = 1 ppm = 0.0001%.

Chemical Feed Equation:

$$\begin{array}{ccccccc} C_F & \times & Q_F & = & C_S & \times & Q_S \\ \text{Feed Concentration} & & \text{Feed Flow} & & \text{System Chlorine Dose} & & \text{Flow} \\ \text{mg/L or ppm} & & \text{Lpm} & & \text{mg/L or ppm} & & \text{Lpm} \end{array}$$

Example 1:

Feed solution: 12% sodium hypochlorite

Desired chlorine dosage: 1.0 mg/L = 1.0 ppm

System flow: 600 Litres per minute (Lpm)

Find: **At what flow rate should the pump be set?**

Equation: $C_F \times Q_F = C_S \times Q_S$

Where; $C_F = (12\%) \times (10,000 \text{ ppm} / \%) = 120,000 \text{ ppm}$

$Q_F = \text{unknown}$

$C_S = 1.0 \text{ mg/L} = 1.0 \text{ ppm}$

$Q_S = 600 \text{ Lpm}$

Solution:

$$\begin{aligned} Q_F &= (C_S \times Q_S) / C_F \\ &= (1.0 \text{ ppm} \times 600 \text{ Lpm}) / 120,000 \text{ ppm} \\ &= 0.005 \text{ Lpm} = 0.3 \text{ L/hr.} = 7.2 \text{ Lpd} \end{aligned}$$

In this example, 7.2 litres per day of 12% sodium hypochlorite must be injected into the system to achieve a 1.0 ppm continuous dose in the effluent water.

Example 2:

If the hypochlorinator has a constant feed rate, then another method to achieve a desired chlorine dosage rate is to proportion the ratio of chlorine to water in the solution tank. This is illustrated in the following example.

Feed solution: 12% sodium hypochlorite = 120,000 ppm
Desired chlorine dosage: 0.5 mg/L = 0.5 ppm
System flow: 600 Litres per minute (Lpm)
Feed pump rate: 1.6 Litres per hour (Lph)
Find: What should be the ratio of chlorine to water in the solution tank?

Equation: $C_F \times Q_F = C_S \times Q_S$
Where;
 $C_F = \text{unknown}$
 $Q_F = 1.6 \text{ Lph} = 38.4 \text{ Lpd}$
 $C_S = 0.5 \text{ mg/L} = 0.5 \text{ ppm}$
 $Q_S = 600 \text{ Lpm} = 864,000 \text{ Litres per day (Lpd)}$

Solution:
 $C_F = (C_S \times Q_S) / Q_F$
 $= (0.5 \text{ ppm} \times 864,000 \text{ Lpd}) / 38.4 \text{ Lpd}$
 $= 11,250 \text{ ppm}$

To calculate chlorine to water ration, the following equation is used

$$(\text{Feed conc.}) \times (? \text{ Litres solution}) = (\text{Cl}_2 \text{ conc.}) \times (1 \text{ Litre of Cl}_2)$$

Thus; $(11,250 \text{ ppm}) \times (? \text{ Litres solution}) = (120,000 \text{ ppm}) \times (1 \text{ Litre of Cl}_2)$

$$(? \text{ Litres solution}) = 10.66 \text{ Litres}$$

Therefore, a solution mix of 9.66 litres of water and 1 litre of chlorine for a total of 10.66 litres of solution fed at a rate of 1.6 Lph will result in a free chlorine residual of 0.5 mg/L.

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