The Drinking Water Section develops and provides technical guidelines for the design and construction of water and treatment works projects and drinking water related practices such as bulk water hauling. The technical guidelines are intended primarily for public water system certified operators, engineers, and consultants to help ensure that best engineering and management practices are being followed to help assist in the approval process. The technical information provided in the guidelines includes accepted best practices from Recommended Standards for Water Works and from organizations such as the American Water Works Association. The Drinking Water Section is continuously developing new guidelines and revising existing ones due to the dynamic nature of drinking water delivery and treatment technology and as additional information becomes available. Public comments on the technical guidelines are always encouraged and may be considered for future revisions. Technical Guidance Drinking water must be 'wholesome' and this is defined in law mainly by setting standards for a wide range of substances, organisms and properties of water in regulations. There is an additional requirement to make sure that it does not contain anything else that might be a potential danger to human health, as identified by risk assessment. The standards are set to be protective of public health and the definition of wholesome includes factors that might affect the look, smell or taste of the water which needs to be acceptable to consumers. There is good agreement amongst experts worldwide on the science behind the setting of health based standards for drinking water and this expert evidence is documented by the World Health Organisation in the Guidelines for Drinking Water Quality. You can look up all the background information to standards of water safety here: Guidelines for drinking-water quality: Fourth edition incorporating the first and second addenda (who.int). The legal standards in the UK were based on those which were set in Europe in the Drinking Water Directive 1998 and subsequent revisions, together with national standards set to maintain the high quality of water already achieved. The standards are strict and include wide safety margins. They cover: • micro-organisms • chemicals such as nitrate and pesticides • metals such as lead and copper • the way water looks and how it tastes The full regulations can be found The Water Supply (Water Quality) Regulations 2016 (legislation.gov.uk). An explanation of the organisms and substances tested for regularly can be found in the Chief Inspector's Report. This guide also explains how drinking water is regulated in England and Wales. Parameter: Substance or organism tested for routinely in drinking water. Directive requirements: These are the standards and specifications set in the EU Drinking Water Directive and were adopted into national legislation. National requirements: These are national standards and specifications in the regulations which apply only in the England and Wales. Concentration or value or specification: Maximum or minimum or range allowed in drinking water. Point of compliance: The point where the legal standards apply, normally this is the consumers tap but it may be at the water works. µg/l: Micrograms per litre (parts per billion). mg/l: Milligrams per litre (parts per million). Parameters Concentration or Value maximum) Units of Measurement Point of compliance Enterococci 0 number/100ml Consumers' taps Escherichia coli (E. coli) 0 number/100ml Consumers' taps Table 1: Part I – Directive requirements Parameters Concentration or Value maximum) Units of Measurement Point of compliance Coliform bacteria 0 number/100ml Service reservoirs* and water treatment works Escherichia coli (E. coli) 0 number/100ml Service reservoirs and water treatment works Table 2: Part II – National requirements Note: *Compliance required as to 95% of samples from each service reservoir Parameters Concentration or Value maximum) Units of Measurement Point of compliance Acrylamide 0.10 µg/l (i) Antimony 5.0 µgSb/l Consumers' taps Arsenic 10 µgAs/l Consumers' taps Benzene 1.0 µg/l Consumers' taps Benzo(a)pyrene 0.010 µg/l Consumers' taps Boron 1.0 mgB/l Consumers' taps Bromate 10 µgBrO3/l Consumers' taps Cadmium 5.0 µgCd/l Consumers' taps Chromium 50 µgCr/l Consumers' taps Copper(ii) 2.0 mgCu/l Consumers' taps Cyanide 50 µgCN/l Consumers' taps 1, 2 dichloroethane 3.0 µg/l Consumers' taps Epichlorohydrin 0.10 µg/l (i) Fluoride 1.5 mgF/l Consumers' taps Lead (ii) 10 µgPb/l Consumers' taps Mercury 1.0 µgHg/l Consumers' taps Nickel (ii) 20 µgNi/l Consumers' taps Nitrate (iii) 50 mgNO3/l Consumers' taps Nitrite (iii) 0.50 mgNO2/l Consumers' taps 0.10 Treatment works Pesticides (iv) (v) Aldrin 0.030 µg/l Consumers' taps Dieldrin 0.030 µg/l Consumers' taps Heptachlor 0.030 µg/l Consumers' taps Heptachlor epoxide 0.030 µg/l Consumers' taps other pesticides 0.10 µg/l Consumers' taps Pesticides: Total (vi) 0.50 µg/l Consumers' taps Polycyclic aromatic hydrocarbons (vii) 0.10 µg/l Consumers' taps Selenium 10 µgSe/l Consumers' taps Tetrachloroethene and Trichloroethene (viii) 10 µg/l Consumers' taps Trihalomethanes: Total (ix) 100 µg/l Consumers' taps Vinyl chloride 0.50 µg/l (i) Table 3: Part I – Directive requirements Notes: The parametric value refers to the residual monomer concentration in the water as calculated according to specifications of the maximum release from the corresponding polymer in contact with the water. This is controlled by product specification. See also regulation 6(6) See also regulation 4(2)(d) See the definition of "pesticides and related products" in regulation 2 The parametric value applies to each individual pesticide. "Pesticides: Total" means the sum of the concentrations of the individual pesticides detected and quantified in the monitoring procedure. The specified compounds are: – benzo(b)fluoranthene – benzo(k)fluoranthene – benzo(ghi)perylene – indeno(1,2,3-cd)pyrene. The parametric value applies to the sum of the concentrations of the individual compounds detected and quantified in the monitoring process. The parametric value applies to the sum of the concentrations of the individual compounds detected and quantified in the monitoring process. The specified compounds are: – chloroform – bromoform – dibromochloromethane – bromodichloromethane. The parametric value applies to the sum of the concentrations of the individual compounds detected and quantified in the monitoring process. Parameters Concentration or Value (maximum unless otherwise stated) Units of Measurement Point of compliance Aluminium 200 µgAl/l Consumers' taps Colour 20 mg/l Pt/Co Consumers' taps Iron 200 µgFe/l Consumers' taps Manganese 50 µgMn/l Consumers' taps Odour Acceptable to consumers and no abnormal change Consumers' taps Sodium 200 mgNa/l Consumers' taps Taste Acceptable to consumers and no abnormal change Consumers' taps Tetrachloromethane 3 µg/l Consumers' taps Turbidity 4 NTU Consumers' taps Table 4: National requirements Synopsis Part 4 suggests various treatment options and guidelines to permit a variety of raw water, both groundwater and surface water, to be treated in order to comply with the physical, chemical and microbiological levels recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) and potential pathogenic biota levels required by INAC. Check List Confirm if the water source is the ideal choice before proceeding with the water treatment evaluation. In most cases groundwater will be the best choice of the water source over surface water, unless the groundwater contains high levels of heavy metals or toxins such as arsenic which mandates sophisticated treatment equipment, and operation and maintenance, compared with the surface water option. Determine need and type of treatment from pilot studies, develop protocol for piloting before proceeding with tests, at least two treatment options should be piloted. Plate settlers are the preferred method of clarification; check that hydraulic upflow rate conforms to guidelines based on projected area. Synopsis Part 4 suggests various treatment options and guidelines to permit a variety of raw water, both groundwater and surface water, to be treated in order to comply with the physical, chemical and microbiological levels recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) and potential pathogenic biota levels required by INAC. Check List (Continued) Static mixers are the preferred type of flash mix, provide water flushing feature and include in design provision for minimum flows during early operation of plant. Check detention times at various flow rates. Hydraulic flocculation is the preferred option, include in design for minimum flow conditions during the early years of operation of the plant. Check detention time at various flow rates particularly cold water conditions. Check to ensure flushing lines, drains and sludge disposal features are included in the design for flocculators and clarifiers. Filtration, Slow Sand Filters are the preferred method of filtration if filtration is deemed necessary, followed by rapid rate gravity filters and rapid rate pressure filters. Bag and cartridge filters are suitable on small systems and where the water quality permits their use. Synopsis Part 4 suggests various treatment options and guidelines to permit a variety of raw water, both groundwater and surface water, to be treated in order to comply with the physical, chemical and microbiological levels recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) and potential pathogenic biota levels required by INAC. Check List (Continued) Disinfection: Disinfection is required for all surface water supplies and groundwater under the direct influence of surface water. Chlorine is the preferred disinfecting agent, using sodium or calcium hypochlorite. Check that system capacity can maintain a chlorine residual of 2 mg/L at the design maximum day demand. Include 100% redundancy in the design of the chlorine feed equipment. Review contact time and CT requirements to accomplish the required log inactivation and destruction levels. Confirm that a the design ensures that a chlorine residual will be maintained in the distribution system of at least 0.2 mg/L Review the need for two stage disinfection using UV light and chlorine. Synopsis Part 4 suggests various treatment options and guidelines to permit a variety of raw water, both groundwater and surface water, to be treated in order to comply with the physical, chemical and microbiological levels recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) and potential pathogenic biota levels required by INAC. Check List (Continued) Softening: Review need for softening, confirm if there are other raw water sources available before proceeding with softening. Hardness levels of 250 mg/L or less need not be softened. Where hardness levels exceed this level consider split treatment and blending. Only ion exchange softening should be considered. Check levels of TDS and sodium in treated water following the ion exchange process with respect to health concerns. Check for pre-treatment required particularly if there are high levels of turbidity, iron and manganese in the raw water. Review disposal of spent brine during regeneration. Ensure that there is ample storage space for sodium chloride in the plant design. Ensure that construction materials are compatible with the aggressive nature of salt. Synopsis Part 4 suggests various treatment options and guidelines to permit a variety of raw water, both groundwater and surface water, to be treated in order to comply with the physical, chemical and microbiological levels recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) and potential pathogenic biota levels required by INAC. Check List (Continued) Aeration: Consider aeration for taste and odour removal, air stripping of volatile organics, hydrogen sulphide and pre-oxidation of iron and manganese if the pH of the water permits a weak oxidant. A natural or forced draft air system may be used. All aerators must be housed in a heated and protected enclosure. Noise control features must be included if a forced air system is utilized. Consider range of water temperatures of the water to be treated due to its effect on contaminant removal efficiency. Conduct a pilot study to determine the minimum volumetric air to water ratio if there is limited past performance data available. Use corrosion resistant materials in the construction of all aeration equipment. Synopsis Part 4 suggests various treatment options and guidelines to permit a variety of raw water, both groundwater and surface water, to be treated in order to comply with the physical, chemical and microbiological levels recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) and potential pathogenic biota levels required by INAC. Check List (Continued) Iron and manganese control: Iron and manganese removal will be required if the iron and manganese levels exceed 0.3 mg/L and 0.05 g/L respectively. Recommended oxidizing methods are aeration and the use of strong oxidizers such as sodium hypochlorite. Potassium permanganate, although a strong oxidizer, is not recommended for First Nation iron and manganese removal plants. The pH of the raw water is a significant parameter for the type of treatment selected. Cation ion exchange methods are acceptable if the heavy metals in the raw water do not exceed 0.3 mg/L. Silica sand with a blend of manganese dioxide is an acceptable method of filtration; a minimum cap of 400 mm of anthracite should overlay the silica sand/pyrolucite blend. The filter must act as a contactor and filter based on previous pilot work. Check hydraulic loading rates of filters and backwash rates. Synopsis Part 4 suggests various treatment options and guidelines to permit a variety of raw water, both groundwater and surface water, to be treated in order to comply with the physical, chemical and microbiological levels recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) and potential pathogenic biota levels required by INAC. Check List (Continued) Water Conditioning: Conditioning of water is required if the alkalinity is too low to ensure effective coagulation for subsequent treatment or the water is so aggressive that serious corrosion could occur in the distribution piping or in internal plumbing systems in homes. Conditioning will increase the pH and alkalinity of the water. Where coagulation and flocculation treatment is required the preferred form of conditioning method is with the use of a limestone contactor. Check empty bed contact time and configuration of tank shape, ensure that each contactor has a drain for de-watering. Pre-screening is required for all contactors and a bypass is necessary for blending raw water with conditioned water. Check specifications of lime rock with guidelines. Include provision for an efficient airwash and water backwash to remove inerts and sediments from the contactor basin. Synopsis Part 4 suggests various treatment options and guidelines to permit a variety of raw water, both groundwater and surface water, to be treated in order to comply with the physical, chemical and microbiological levels recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) and potential pathogenic biota levels required by INAC. Check List Water Conditioning: Where water conditioning is required for reducing corrosivity only then alternative treatment solutions should be reviewed such as the addition of sodium hydroxide (caustic soda) or sodium carbonate (soda ash). Arsenic removal: Where levels of arsenic exceed 0.025 mg/L in any one sample in the raw water then an alternative raw water source should be sought. If there is no other source available then arsenic treatment must be applied to reduce the levels below 0.010 mg/L At least two arsenic removal treatment processes must be piloted to determine the optimum form of treatment. Review life cycle costs, and complexity of operation in the review analysis. Ensure that accurate test equipment is available to readily measure and record arsenic levels in the raw and treated water. Synopsis Part 4 suggests various treatment options and guidelines to permit a variety of raw water, both groundwater and surface water, to be treated in order to comply with the physical, chemical and microbiological levels recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) and potential pathogenic biota levels required by INAC. Check List (Continued) Arsenic is most easily removed when it exists in trivalent and pentavalent forms which in turn is related to the pH of the water. Several methods are available however the following methods should be explored: Absorption onto a granular ferric oxide medium, By reverse osmosis, Alum chemical coagulation and sedimentation with preoxidation as necessary, Activated alumina. Consider removal and handling of rejects and waste streams generated from the treatment process both efficiently and safely. Water which is to be delivered to consumers must meet the "Guidelines for Canadian Drinking Water Quality" Latest Edition, published in a booklet by Health Canada. In order to keep interested parties informed of changes to the Guidelines between publication of new editions, a summary table entitled "Summary of Guidelines for Canadian Drinking Water Quality" is updated and published every spring on Health Canada's website . The "Summary of Guidelines for Canadian Drinking Water Quality" supercedes all previous versions, including that contained in the published Health Canada booklet.The design of treatment processes and devices shall depend on an evaluation of the nature and quality of the particular water to be treated, seasonal variations, the desired quality of the finished water and the mode of operation planned. Continuous disinfection is required for all water supplies.Water containing high turbidity may require pretreatment, usually coagulation, flocculation and clarification with the addition of coagulation chemicals. Water containing colour greater than 15 True Colour Units (TCU), or Total Organic Carbon (TOC) in a concentration that it may produce disinfection by-products during disinfection with chlorine may require pre-treatment with the addition of coagulation chemicals.As per Health Canada Guidelines for Canadian Drinking Water Quality - Supporting Documentation on Turbidity - for chemically assisted filtration (i.e., continuous feed of a coagulant with mixing ahead of filtration), source water turbidity levels should be measured at least once per calendar day directly in front of where the first treatment chemical is applied.The above notwithstanding all designs should provide for low mechanical content to the greatest extent possible. For example, water systems and processes based on flow of water by gravity are preferred over pumped or mechanical systems.The design shall prevent cross connections, and common walls, between potable and nonpotable water. Where the drinking water system obtains water from a raw water supply which is groundwater, the treatment process must, as a minimum, consist of disinfection and must be credited with achieving an overall performance that provides at least 2-log (99%) inactivation or removal of viruses before water is delivered to the first consumer. Where the drinking water system obtains water from a raw water supply which is groundwater that is of questionable sanitary quality, the treatment process shall as a minimum, consist of disinfection and must be credited with achieving an overall performance that provides at least 4-log (99.99%) inactivation or removal of viruses before water is delivered to the first consumer. Plants designed for processing groundwater with treatment other than disinfection shall be designed according to the applicable process descriptions noted further in this Section Part 4. The process shall provide a level of treatment which achieves at least 4-log (99.99%) inactivation or removal of viruses. Primary disinfection processes that do not produce a disinfection residual must be followed by a secondary disinfectant. The use of chlorine as secondary disinfection by applying chlorine to provide a residual disinfectant is recommended. Filtration and Disinfection may be required for all surface water, and groundwater under the direct influence of surface water. Disinfection is mandatory and will ideally include two distinct stages, a primary stage using pH UV irradiation to inactivate or destroy bacteria, protozoa and some viruses and a secondary stage using chlorine to complete the destruction of potential pathogens and maintain a working residual in the distribution system. Filtration is required at all treatment plants unless the avoidance criteria for filtration is met as detailed in the Health Canada Guidelines for Canadian Drinking Water Quality - Supporting Documentation on Turbidity. Filtration of a surface water source or a groundwater source under the direct influence of surface water may not be necessary if all of the following conditions are met: Overall inactivation is met using a minimum of two disinfectants: ultraviolet irradiation or ozone to inactivate cysts/oocysts; chlorine (free chlorine) to inactivate viruses; and chlorine to maintain a residual in the distribution system. Disinfection should reliably achieve at least a 99% (2-log) reduction of Cryptosporidium oocysts,* a 99.9% (3-log) reduction of Giardia lamblia cysts and a 99.99% (4-log) reduction of viruses. If mean source water cyst/oocyst levels are greater than 10/1000 L, more than 99% (2-log) reduction of Cryptosporidium oocysts and 99.9% (3-log) reduction of Giardia lamblia cysts should be achieved. Background levels for Giardia lamblia cysts and Cryptosporidium oocysts in the source water should be established by monitoring as described in the most recent "Protozoa" guideline document, or more frequently during periods of expected highest levels (e.g., during spring runoff or after heavy rainfall). Prior to the point where the disinfectant is applied, the number of Escherichia coli bacteria in the source water does not exceed 20/100 mL (or, if E. coli data are not available, the number of total coliform bacteria does not exceed 100/100 mL) in at least 90% of the weekly samples from the previous 6 months. Average daily source water turbidity levels measured at equal intervals (at least every 4 hours), immediately prior to where the disinfectant is applied, are around 1.0 NTU but do not exceed 5.0 NTU for more than 2 days in a 12-month period. Source water turbidity also does not show evidence of protecting microbiological contaminants. A watershed control program (e.g., protected watershed, controlled discharges, etc.) is maintained that minimizes the potential for faecal contamination in the source water. Water treatment facilities designed for processing surface water, and groundwater under the direct influence of surface water shall be designed according to the applicable and/or pertinent treatment process described later in this Part 4. The following minimum level of treatment for microbiological contaminants shall be provided: Potential Pathogen Removal/Inactivation Cryptosporidium 2 log (99%) Giardia 3 log (99.9%) Viruses 4 log (99.99%) Bacteria (E-coli) 100% At least 0.5-log removal or inactivation of Giardia cysts, and 2-log removal or inactivation of viruses must be provided through the disinfection portion of the overall water treatment process. The requirements of the document entitled "Procedure for Disinfection of Drinking Water in Ontario" - Latest Version, Province of Ontario, should be met for determining whether water treatment facilities provide the minimum level of treatment for microbiological contaminants. The document is available in Appendix A. The following treatment processes and devices are included as guidelines that will depend on the nature and quality of the raw water to be treated. Such treatment when selected as the preferred option must ensure that the treated water complies fully with the latest edition of the Guidelines for Canadian Drinking Water Quality and the criteria noted under 4.1 and 4.2 above for microbiological removal or inactivation. The treatment processes addressed in this document are: Clarification Presedimentation Rapid mix Flocculation Sedimentation Plate settlers Filtration Rapid rate gravity filters Rapid rate pressure filters Slow sand filters Direct filtration Disinfection Chlorination Ultraviolet irradiation Softening Aeration Natural draft aeration Force or induced draft aeration Spray aeration Pressure aeration Packed tower aeration Iron and manganese removal Oxidation, detention and filtration Silica sand/manganese coated filter Ion exchange Fluoridation Stabilization Alkali feed Limestone contactor Other treatment Taste & Odour Control Microscreening Arsenic Removal Conventional coagulation employing aluminum or iron salts Adsorption onto a granular ferric oxide bed Adsorption onto an activated alumina Separation by reverse osmosis provide a minimum of one unit each for rapid mix. flocculation and sedimentation; be constructed to permit units to be taken out of service without disrupting operation, and with drains or pumps sized to allow dewatering in a reasonable period of time; provide multiple-stage treatment facilities when required by the reviewing authority; be started manually following shutdown; minimize hydraulic head losses between units to allow future changes in processes without the need for repumping. 4.3.1.1 Presedimentation Water containing high turbidity may require pre-treatment, usually sedimentation with or without the addition of coagulation chemicals: Basin Design - presedimentation basins must provide arrangements for dewatering and having access for equipment for manually cleaning the basin; Inlet - incoming water shall be dispersed across the full width of the line of travel as quickly as possible; short-circuiting must be prevented; Bypass - provisions for bypassing presedimentation basins shall be included; Detention Time - three hours detention is the minimum period recommended; greater or less detention may be required based on tests performed at the specific location. 4.3.1.2 Rapid Mix Rapid mix shall mean the rapid dispersion of chemicals throughout the water to be treated, usually by violent agitation. The engineer shall submit the design basis for the velocity gradient (G value) selected, considering the chemicals to be added, water temperature, colour and other related water quality parameters. The need for rapid mixing shall be determined from bench scale (JAR) tests or pilot tests; Hydraulic mixing is the preferred method of mixing. Consideration should be given to variable flow over the life of the facility to ensure adequate mixing during low flow conditions; Mixing - the detention period shall be not more than thirty seconds; Location - The rapid mix and flocculation basin shall be as close together as possible. 4.3.1.3 Flocculation Flocculation shall mean the agitation of water at low velocities for long periods of time. Basin Design - inlet and outlet design shall minimize short-circuiting and destruction of floc. A drain and/or pumps shall be provided to handle dewatering and sludge removal; Detention - the flow-through velocity should be not less than 0.15 m/min nor greater than 0.50 m/min with a detention time for floc formation of at least 30 minutes. Bench scale (JAR) testing or pilot plant testing shall be used to determine extended detention time for cold water conditions, i.e. less than 10°C; Equipment - agitators shall be driven by variable speed drives with the peripheral speed of paddles ranging from 0.15 m to 1 m per second; Flocculation - hydraulic flocculation is the preferred method of gentle mixing. Mechanical flocculation may be used only after consultation and approval from the reviewing authority; Piping - flocculation and sedimentation basins shall be as close together as possible. The velocity of flocculated water through pipes or conduits to settling basins shall be not less than 0.15 m nor greater than 0.50 m per second. Allowances must be made to minimize turbulence at bends and changes in direction. Care must be taken to prevent the breaking up of floc, particularly colour floc; Other Designs - baffling may be used to provide for flocculation in small plants only after consultation with the reviewing authority. The design should be such that the velocities and flows noted above will be maintained; Superstructure - a superstructure over the flocculation basins may be required. 4.3.1.4 Sedimentation Sedimentation shall follow flocculation. The detention time for effective clarification is dependent upon a number of factors related to basin design and the nature of the raw water. The following criteria apply to conventional sedimentation units: Detention Time - shall provide a minimum of four hours of settling time. Reduced sedimentation time may also be approved when equivalent effective settling is demonstrated or when overflow rate is not more than 1.2 m/hr. The overflow rate is for turbidity removal. For colour removal the overflow rate should be reduced to 60% of the value given; Inlet Devices - inlets shall be designed to distribute the water equally and at uniform velocities. Open ports, submerged ports, and similar entrance arrangements are required. A baffle should be constructed across the basin close to the inlet end and must project sufficient distance below the water surface to dissipate inlet velocities and provide uniform flows across the basin; Outlet Devices - outlet weirs or submerged orifices shall maintain velocities suitable for settling in the basin and minimize short-circuiting. The use of submerged orifices is recommended in order to provide a volume above the orifices for storage when there are fluctuations in flow. Outlet weirs and submerged orifices shall be designed as follows: the rate of flow over the outlet weirs or through the submerged orifices hall not exceed 250 m3/day/month of the outlet launder; submerged orifices should not be located lower than 1 m below the flow line; the entrance velocity through the submerged orifices shall not exceed 0.15 m per second. Velocity - the velocity through settling basins shall not exceed 0.15 m per minute. The basins must be designed to minimize short-circuiting. Fixed or adjustable baffles must be provided as necessary to achieve the maximum potential for clarification; Overflow - an overflow weir or pipe designed to establish the maximum water level desired on top of the filters should be provided. The overflow shall discharge by gravity with a free fall at a location where the discharge will be noted; Superstructure - a superstructure over the sedimentation basins may be required. If there is no mechanical equipment in the basins and if provisions are included for adequate monitoring under all expected weather conditions, a cover may be provided in lieu of a superstructure; Sludge Collection - hoppers and drains or mechanical sludge collection equipment should be provided; Drainage - basins must be provided with a means for dewatering. Basin bottoms should slope toward the drain not less than 8%; Flushing Lines - flushing lines or hydrants shall be provided and must be equipped with back flow prevention devices acceptable to the reviewing authority; Safety - permanent ladders or handholds shall be provided on the inside walls of basins above the water level. Guard rails must be included. Compliance with other applicable safety requirements, such as Workers Compensation Board, shall be required; Sludge Removal - sludge removal design shall provide that: sludge pipes shall be not less than 75 mm in diameter and so arranged as to facilitate cleaning; entrance to sludge withdrawal piping shall prevent clogging; valves shall be located outside the tank for accessibility; the operator can observe and sample sludge being withdrawn from the unit. Sludge Disposal - facilities are required by the reviewing authority for disposal of sludge. See Part 9. 4.3.1.5 Plate Settlers Proposals for settler unit clarification must include pilot plant and/or full scale demonstration data on water with similar quality prior to the preparation of final plans and specifications for approval. Settler units consisting of variously shaped plates which are installed in multiple layers and at an angle to the flow may be used for sedimentation, following flocculation. 4.3.1.5.1 General Criteria Inlet and Outlet Considerations - design to maintain velocities suitable for settling in the basin and to minimize short-circuiting. Plate units shall be designed to minimize uneven distribution across the units; Drainage - drain piping from the settler units must be sized to facilitate a quick flush of the settler units and to prevent flooding other portions of the plant; Protection from Freezing - although most units will be located within a plant, outdoor installations must provide sufficient freeboard above the top of settlers to prevent freezing in the units. A cover or enclosure is strongly recommended; Application Rates for Plate Settlers - for turbidity removal a maximum plate loading rate of 1.2 m/hr based on 80% of the projected horizontal plate area shall be used. After pre-treatment for colour removal a maximum plate loading rate of 0.3 m/hr based on 80% of the projected horizontal plate area shall be used; Flushing Lines - flushing lines shall be provided to facilitate maintenance and must be properly protected against back flow or back siphonage. Acceptable filters shall include, upon the discretion of the reviewing authority, the following types: Rapid rate gravity filters; Rapid rate pressure filters; Slow sand filtration; Direct filtration; Membrane filtration (see Policy Statements on Reverse Osmosis and Nanofiltration for Public Water Supplies and Microfiltration and Ultrafiltration for Public Water Supplies and Microfiltration and Ultrafiltration for Public Water Supplies at the front of this document); Bag and cartridge filters (see policy statement on Bag and Cartridge Filters for Public Water Systems at the front of this document). The application of any one type must be supported by water quality data representing a reasonable period of time to characterize the variations in water quality. Experimental treatment studies may be required to demonstrate the applicability of the method of filtration proposed. 4.3.2.1 Rapid Rate Gravity Filters 4.3.2.1.1. Pre-treatment The use of rapid rate gravity filters shall require pre-treatment. 4.3.2.1.2. Rate of Filtration The rate of filtration shall be determined through consideration of such factors as raw water quality, degree of pre-treatment provided, filter media, water quality control parameters, competency of operating personnel, and other factors as required by the reviewing authority. In any case, the filter rate must be proposed and justified by the design engineer to the satisfaction of the reviewing authority prior to the preparation of final plans and specifications. 4.3.2.1.3. Number At least two units shall be provided. Where only two units are provided, each shall be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved filtration rate. Where more than two filter units are provided, the filters shall be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service. Where declining rate filtration is provided, the variable aspect of filtration rates, and the number of filters must be considered when determining the design capacity for the filters. 4.3.2.1.4. Structural Details and Hydraulics The filter structure shall be designed to provide for: vertical walls within the filter; no protrusion of the filter walls into the filter media; cover by superstructure; head room to permit normal inspection and operation; minimum depth of filter box of 2.5 m; minimum water depth over the surface of the filter media of 1 m; trapped effluent to prevent back flow of air to the bottom of the filters; prevention of floor drainage to the filter with a minimum 100 mm curb around the filters; prevention of flooding by providing overflow; maximum velocity of treated water in pipe and conduits to filters of 0.6 m per second; clean-outs and straight alignment for influent pipes or conduits where solids loading is heavy, or following lime-soda softening; wash-water drain capacity to carry maximum flow; walkways around filters, to be not less than 600 mm wide; safety handrails or walls around all filter walkways; construction to prevent cross connections and common walls between potable and non-potable water. 4.3.2.1.5. Wash-water Troughs Wash-water troughs shall be constructed to have: the bottom elevation above the maximum level of expanded media during washing; a 50 mm freeboard at the maximum rate of wash; the top edge level and all at the same elevation; spacing so that each trough serves the same number of square metres of filter area; maximum horizontal travel of suspended particles to reach the trough not to exceed 1 m. 4.3.2.1.6. Filter Material The media shall be clean silica sand or other natural or synthetic media free from detrimental chemical or bacterial contaminants, approved by the reviewing authority, and having the following characteristics: a total depth of not less than 600 mm and generally not more than 750 mm; an effective size range of the smallest material no greater than 0.45 mm to 0.55 mm; a uniformity coefficient of the smallest material not greater than 1.65; a minimum of 300 mm of media with an effective size range no greater than 0.45 mm to 0.55 mm, and a specific gravity greater than other filtering materials within the filter; types of filter media: Anthracite - clean crushed anthracite, or a combination of anthracite and other media may be considered on the basis of experimental data specific to the project, and shall have: effective size of 0.45 mm - 0.55 mm with uniformity coefficient not greater than 1.65 when used alone; effective size of 0.8 mm - 1.2 mm with a uniformity coefficient not greater than 1.85 when used as a cap; effective size for anthracite used as a single media on potable groundwater for iron and manganese removal only shall be a maximum of 0.8 mm (effective sizes greater than 0.8 mm may be approved based upon onsite pilot plant studies or other demonstration acceptable to the reviewing authority). Silica Sand - silica sand shall have: effective size of 0.45 mm to 0.55 mm; uniformity coefficient of not greater than 1.65; larger size media may be allowed by the reviewing authority where full scale tests have demonstrated that treatment goals can be met under all conditions. Granular Activated Carbon (GAC) - Granular activated carbon as a single medium may be considered for filtration only after pilot or full scale testing and with prior approval of the reviewing authority. The design shall include the following: the media must meet the basic specifications for filter media as noted under Filter Material, except that larger size media may be allowed by the reviewing authority where full scale tests have demonstrated that treatment goals can be met under all conditions; there must be provisions for a free chlorine residual and adequate contact time in the water following the filters and prior to distribution; there must be means for periodic treatment of filter material for control of bacterial and other growth; provisions must be made for frequent replacement or regeneration. Other Media - other media will be considered based on experimental data and operating experience. Torpedo Sand - a three inch layer of torpedo sand shall be used as a supporting media for filter sand where supporting gravel is used, and shall have: effective size of 0.8 mm to 2.0 mm; uniformity coefficient not greater than 1.7. Gravel - gravel, when used as the supporting media shall consist of cleaned and washed, hard, durable, rounded silica particles and shall not include flat or elongated particles. The coarsest gravel shall be 50 mm in size when the gravel rests directly on a lateral system, and must extend above the top of the perforated laterals. Not less than four layers of gravel shall be provided in accordance with the following size and depth distribution. Size Depth 60 mm to 50 mm 125 mm to 200 mm 50 mm to 20 mm 75 mm to 125 mm 20 mm to 10 mm 75 mm to 125 mm 10 mm to 5 mm 50 mm to 75 mm 5 mm to 2.5 mm 50 mm to 75 mm Reduction of gravel depths and other size gradations may be considered upon justification to the reviewing authority for slow sand filtration or when proprietary filter bottoms are specified. 4.3.2.1.7. Filter Bottoms and Strainer Systems Departures from these standards may be acceptable for high rate filters and for proprietary bottoms. Porous plate bottoms shall not be used where iron or manganese may clog them. The design of manifold-type collection systems shall; minimize loss of head in the manifold and laterals; ensure even distribution of wash-water and even rate of filtration over the entire area of the filter; provide the ratio of the area of the final openings of the strainer systems to the area of the filter at about 0.003; provide the total cross-sectional area of the laterals at about twice the total area of the final openings; provide the total cross-sectional area of the manifold at 1-1/2 to 2 times the total area of the laterals; lateral perforations without strainers shall be directed downward. 4.3.2.1.8. Surface Wash or Subsurface Wash Surface or subsurface wash facilities are required except for filters used exclusively for iron or manganese removal, and may be accomplished by a system of fixed nozzles or a revolving-type apparatus. All devices shall be designed with: a provision for water pressures of at least 310 kPa; a properly installed vacuum breaker or other approved device to prevent back siphonage if connected to the treated water system; rate of flow of 4.9 m/hr of filter area with fixed nozzles or l.2 m/hr with revolving arms; air wash can be considered based on experimental data and operating experiences. 4.3.2.1.9. Air Scouring Air scouring can be considered in place of surface wash: air flow for air scouring the filter must be 0.9 to 1.5 m3/min/m2 when the air is introduced in the under-drain; a lower air rate must be used when the air scour distribution system is placed above the under-drains; a method for avoiding excessive loss of the filter media during backwashing must be provided; air scouring must be followed by a fluidization wash sufficient to restratify the media; air must be free from contamination; air scour distribution systems should be placed below the media and supporting bed interface; if placed at the interface the air scour nozzles shall be designed to prevent media from clogging the nozzles or entering the air distribution system; piping for the air distribution system shall not be flexible hose which will collapse when not under air pressure and shall not be a relatively soft material which may erode at the orifice opening with the passage of air at high velocity; air delivery piping shall not pass down through the filter media nor shall there be any arrangement in the filter design which would allow short circuiting between the applied unfiltered water and the filtered water; consideration should be given to maintenance and replacement of air delivery piping; the back-wash water delivery system must be capable of 40 m/hr; however, when air scour is provided the back-wash water rate must be variable and should not exceed 30 m/hr unless operating experience shows that a higher rate is necessary to remove scoured particles from filter media surfaces; the filter under-drains shall be designed to accommodate air scour piping when the piping is installed in the under-drain; the provisions of the section describing "Back-wash" shall be followed. 4.3.2.1.10. Appurtenances the following shall be provided for every filter: influent and effluent sampling taps; an indicating loss of head gauge; an indicating rate-of flow metre. A modified rate controller which limits the rate of filtration to a maximum rate may be used. However, equipment that simply maintains a constant water level on the filters is not acceptable, unless the rate of flow onto the filter is properly controlled. A pump or a flow metre in each filter effluent line may be used as the limiting device for the rate of filtration only after consultation with the reviewing authority; where used for surface water, provisions for filtering to waste with appropriate measures for back-flow prevention. It is recommended the following be provided for each filter: a continuous recording turbidimeter on each filter effluent line; wall sleeves providing access to the filter interior at several locations for sampling or pressure sensing; a 25 mm to 40 mm pressure hose and storage rack at the operating floor for washing filter walls; additional continuous monitoring equipment to assist in the control of coagulant dose may be required by the reviewing authority. 4.3.2.1.11. Back-wash Provisions shall be made for washing filters as follows: a minimum rate of 37 m/hr, consistent with water temperatures and specific gravity of the filter media. A rate of 50 m/hr or a rate necessary to provide for a 50% expansion of the filter bed is recommended. A reduced rate of 24 m/hr may be acceptable for full depth anthracite or granular activated carbon filters; filtered water provided at the required rate by wash-water tanks, a washwater pump, from the high service main, or a combination of these; wash-water pumps in duplicate unless an alternate means of obtaining wash-water is available; not less than 15 minutes wash of one filter at the design rate of wash; a wash-water regulator or valve on the main wash-water line to obtain the desired rate of filter wash with the wash-water valves on the individual filters open wide; a rate-of-flow indicator, preferably with a totalizer, on the main washwater line, located so that it can be easily read by the operator during the washing process; design to prevent rapid changes in back-wash water flow; back-wash shall be operator initiated. Automated systems shall be operator adjustable. 4.3.2.1.12. Miscellaneous Roof drains shall not discharge into the filters or basins and conduits preceding the filters. 4.3.2.2 Rapid Rate Pressure Filters The normal use of these filters is for iron and manganese removal. Pressure filters shall not be used in the filtration of surface or other polluted water. 4.3.2.2.1. General Minimum criteria relative to rate of filtration, structural details and hydraulics, filter media, etc., provided for rapid rate gravity filters also apply to pressure filters where appropriate. 4.3.2.2.2. Rate of Filtration The rate shall not exceed 7.2 m/hr except where in plant testing as approved by the reviewing authority has demonstrated satisfactory results at higher rates. 4.3.2.2.3. Details of Design The filters shall be designed to provide for: loss of head gauges on the inlet and outlet pipes of each battery of filters; an easily readable metre or flow indicator on each battery of filters. A flow indicator is recommended for each filtering unit; filtration and back-washing of each filter individually with an arrangement of piping as simple as possible to accomplish these purposes; minimum side wall shell height of 1.5 m. A corresponding reduction in side wall height is acceptable where proprietary bottoms permit reduction of the gravel depth; the top of the wash-water collectors to be at least 450 mm above the surface of the media; the under-drain system to efficiently collect the filtered water and to uniformly distribute the back-wash water at a rate not less than 40 m/hr; back-wash flow indicators and controls that are easily readable while operating the control valves; an air release valve on the highest point of each filter; an accessible manhole to facilitate inspection and repairs for filters 900 mm or more in diameter. Sufficient handholds shall be provided for filters less than 900 mm in diameter. Manholes should be at least 600 mm in diameter where feasible; means to observe the waste-water during back-washing; construction to prevent cross-connection. 4.3.2.3 Slow Sand Filters The use of these filters shall require prior engineering studies to demonstrate the adequacy and suitability of this method of filtration for the specific raw water supply. For conditions not included in this guideline, or at the direction of the reviewing authority, engineering studies should include operation of a pilot plant in order to determine the suitability of the proposed sand and to establish the required frequency of cleaning. The pilot plant should use the same sand as proposed for the full scale plant and the period of operation should include seasons with poor water quality conditions. 4.3.2.3.1. Quality of Raw Water Slow sand gravity filtration shall be limited to water having maximum turbidities of 10 NTU's and maximum colour of 15 TCU; turbidity values must not be attributable to colloidal clay. Raw water quality data must include examinations for algae. These conditions pertain to raw water without coagulation pre-treatment. Slow sand gravity filtration with coagulation pre-treatment (enhanced treatment) should have influent water to the filter with a maximum turbidity of 2 NTU and a maximum colour of 15 TCU. 4.3.2.3.2. Number At least two units shall be provided in order to allow operation flexibility unless waived by the reviewing authority. 4.3.2.3.3. Structural Details and Hydraulics Slow sand gravity filters shall be so designed as to provide: a cover, unless it can be demonstrated that it is not a problem for filter cleaning or operation of the plant; headroom to permit normal movement by operating personnel for scraping and sand removal operations. A minimum 2 m headroom is suggested; adequate access hatches and access ports for handling of sand and for ventilation, easy access at grade shall be provided; filtration to waste or to the inlet side of other filters during ripening process; an overflow at the maximum filter water level that can be used for removal of scum and floating matter from the water when necessary; protection from freezing unless it can be demonstrated that freezing is not a problem for filter cleaning or operation of the plant; provision to drain off supernatant water prior to filter cleaning. (The drain inlet should be adjustable so that it is located near the top level of the sand over the full range of sand depths). The drain shall be constructed to not allow short circuiting of raw or pre-treated water to the filter under-drain; the walls of the filter box shall be configured to prevent short circuiting of flow between the media and the walls; provisions to permit filtered water (from another filter unit) to flow slowly upwards at a maximum rate of 0.1 m/hr from the bottom, through the gravel and sand bed, during start-up operation after sand cleaning; provisions for a temporary hose connection between the outlet of the pretreatment unit or raw water source and the outlet side of filters to permit water to flow slowly upwards from the bottom, through the drainage system and the gravel and sand bed, during plant start-up operation; provisions for draining each filter tank; a continuous, relatively uniform flow of water through the filter; a valve to control rate of raw water into the supernatant water reservoir; a valve capable of accurately controlling the rate of filtration; an effluent pipe designed to maintain the water level above the top of the filter sand; construction to prevent cross connections, and common walls, between potable and non-potable water. 4.3.2.3.4. Rates of Filtration The permissible rates of filtration shall be determined by the quality of the raw water and shall be on the basis of experimental data derived from the water to be treated; without coagulation pre-treatment, the nominal rate may be 0.1 to 0.3 m/hr at design maximum day demand. During filter cleaning operations, the filtration rate may be temporarily increased in the operating filter(s), but should not exceed 0.4 m/hr; without coagulation pre-treatment the nominal rate may be somewhat higher when demonstrated to the satisfaction of the approving authority; with coagulation pre-treatment the maximum permissible rate of filtration shall be 0.1 m/hr at design maximum day demand unless it can be demonstrated that frequency of cleaning can be met with a higher filtration rate. During filter cleaning operations, the filtration rate may be temporarily increased in the operating filter(s), but should not exceed 0.2 m/hr; at design maximum day demand the time period between scraping should be at least one month during the worst water quality conditions. 4.3.2.3.5. Under-drains each filter unit shall be equipped with a main drain and an adequate number of lateral under-drains to collect the filtered water. The underdrains shall be so spaced that the maximum velocity of the water flow in the under-drain will not exceed 0.25 m per second. The maximum spacing of laterals shall not exceed 1 m if pipe laterals are used; the lateral drains should consist of slotted PVC pipe covered with layers of gravel of successively diminishing grain size to prevent the intrusion of filtering medium. The pipe must be CSA certified for potable water use; the slot size and diameter of pipe is to be compatible with overlying gravel materials and specified flow rate and velocity. 4.3.2.3.6. Filter Material The filtering material shall meet the requirements of the most current issue of AWWA B100 Filtering Material including all the testing requirements; the initial thickness of the filter sand should be 1.2 m. This thickness shall be reduced to not less than 0.4 m after removing the upper sand layers during filter cleaning; without pre-treatment, the effective diameter of the filter media, d10, should be between 0.15 mm and 0.35 mm and will be determined by pilot testing. With pre-treatment, the effective diameter of the filter media, d10, should be between 0.30 mm and 0.35 mm; the uniformity coefficient should not exceed 3.0. A coefficient of less than 2.0 is preferable; the filter sand should be hard and durable, rounded, free from clay, loam, and organic matter; the sand should not contain more than 2% of calcium and magnesium, calculated as carbonates. 4.3.2.3.7. Filter Gravel the support gravel shall meet the requirements of the most current issue of AWWA B100 Filtering Material including all testing requirements; the filter sand shall be underlain by graded support gravel layers to prevent migration of the filter sand; the support gravel system shall be built of various layers ranging from fine grain at the top to coarse grain at the bottom; each gravel layer shall be graded such that the 10% and 90% passing diameters shall differ by a factor of not more than 1.41; the upper layer of gravel must be selected with a d10 value more than four times greater than the d15 value of the coarsest filtration sand and less than four times greater than the d85 value of the finest filtration sand proposed to be used; each successive gravel layer shall be graded so that the d10 particle diameters are not more than four times smaller than those of the layer immediately below; the diameter of the smallest particle within the last gravel layer shall be at least two times greater than the slot size opening in the under-drainage system; the thickness of each gravel layer shall be at least three times the diameter of the largest stone in its grading, but for practical purposes a minimum thickness of the layers shall be 50 mm to 70 mm for the finer material and 80 mm to 120 mm for the coarser gravel; the support gravel shall be hard, rounded, with a specific gravity of at least 2.5, and should be free from silt, clay loam, and organic impurities of all kinds. 4.3.2.3.8. Depth of Water on Filter Beds outlet controlled - the rate of filtration is regulated by a valve on the outlet. The depth of water on filter beds should be regulated to provide a relatively constant positive water head in the system of 2 m. This is the preferred mode of operation; inlet controlled - the rate of filtration is regulated by a valve on the filter inlet. This mode of operation will be approved on a site - specific basis only. Initially the level of supernatant water will be low, but with time it will gradually rise to compensate for the increase in filter resistance. The final water depth should be 1.5 to 2 m. 4.3.2.3.9. Control Appurtenances Turbidity test equipment must also be provided for measurement of raw water turbidity. The following shall be provided for each filter unit: sampling taps for raw and filtered water, and also for settled water where coagulation pre-treatment is provided; flow metre with rate-of-flow indicator, totalizer, and a signal suitable for input to an electronic recording device; filter level site gauges which indicate filter head loss (for use during normal operation) and level of water in the sand (for use in back-filling and draining operations); a continuous monitoring turbidimeter on the filter effluent, with a means to record results electronically. 4.3.2.3.10. Ripening Slow sand filters shall be operated to waste after scraping or rebedding during a ripening period until the filter effluent turbidity falls to consistently below 5 NTU. 4.3.2.4 Direct Filtration Direct filtration, as used herein, refers to the filtration of a surface water following chemical coagulation and possibly flocculation but without prior settling. The nature of the treatment process will depend upon the raw water quality. A full scale direct filtration plant shall not be constructed without prior pilot studies which are acceptable to the reviewing authority. In-plant demonstration studies may be appropriate where conventional treatment plants are converted to direct filtration. Where direct filtration is proposed, an engineering report shall be submitted prior to conducting pilot plant or inplant demonstration studies. 4.3.2.4.1. Filtration filters shall be rapid rate gravity filters with dual or mixed media. The final filter design shall be based on the pilot plant or in-plant demonstration studies and all portions of Section 4.3.2.1 "Rapid Rate Gravity Filters". Pressure filters or single medium sand filters shall not be used; a continuous recording turbidimeter shall be installed on each filter effluent line and on the composite filter effluent line; additional continuous monitoring equipment such as particle counting or streaming current metering to assist in control of coagulant dose may be required by the reviewing authority. 4.3.2.5 Siting Requirements See Section 2.20.

4.3.3.1 General Disinfection is required for all raw water supplies, regardless of source. The required amount of primary disinfection needed shall be specified by the reviewing authority. Continuous disinfection is required for all water supplies. Consideration must be given to the formation of disinfection byproducts (DBP) when selecting the disinfectant. Disinfection shall be accomplished using chlorine or ultraviolet light or if considered necessary by both. Chlorine is the preferred disinfecting agent and may be introduced into the water supply using either sodium or calcium hypochlorite. If calcium hypochlorite is used then the tablet form is preferred. (See Part 5 for further details of disinfecting agents). 4.3.3.2 Chlorination Equipment 4.3.3.2.1. Type Hypochlorite feeders of the positive displacement type or in tablet form must be provided depending on the hypochlorite selected (see Part 5). 4.3.3.2.2. Design Capacity The chlorination system must be able to provide a free chlorine residual of at least 2 mg/L once all demands are met after a contact time of at least 30 minutes under anticipated maximum chlorine demand conditions. The initial chlorine metering pumps should be designed for twice the maximum demand that will be achieved at the plant five years following pump installation. Every five years the feeder pumps should be replaced with pumps of higher capacity to meet twice the maximum day demand that will be reached five years after installation. The capacity of the replacement feeder pumps would increase until the plant design capacity has been reached. This will allow the pumps to operate more effectively during the low flows the plant will experience during the initial years of plant operation. The replacement of the feeder pumps every five years with greater capacity pumps must be included in maintenance cost estimates for treatment facilities (See Section 1.1.5). 4.3.3.2.3. Standby Equipment Where chlorination is required for protection of the supply, standby equipment of sufficient capacity shall be available to replace the largest unit. Spare parts shall be made available to replace parts subject to wear and breakage. 4.3.3.2.4. Injector/Diffuser The chlorine solution injector/diffuser must be compatible with the point of application to provide a rapid and thorough mix with all the water being treated. The centre of a pipeline is the preferred application point. 4.3.3.3 Contact Time and Point of Application Due consideration shall be given to the contact time of the disinfectant in water with relation to pH, ammonia, taste-producing substances, temperature, bacterial quality, disinfection byproduct formation potential and other pertinent factors. The disinfectant should be applied at a point which will provide adequate contact time after mixing. All basins (contact chambers) used for disinfection must be designed to minimize short circuiting. Additional baffling can be added to new or existing basins to minimize short circuiting and increase contact time; At plants treating surface water, provisions shall be made for applying the disinfectant to the filtered water, and water entering the distribution system; As a minimum, at plants treating groundwater, provisions shall be made for applying the disinfectant to the water entering the distribution system; The amount of contact time provided will depend on the type of disinfectant used along with the parameters mentioned in 4.3.3.3 (a). As a minimum, for surface water and groundwater under the direct influence of surface water, the system must be designed to meet the CT standards noted in Appendix A of the guidelines. Disinfection for groundwater is required for all potable public water systems. Further guidance is provided in the USEPA Guidance Manual for the Surface Water Treatment Rule, March 1991 Edition, the USEPA "Disinfection Profiling and Benchmarking Guidance Manual", August 1999, and the Ministry of Environment Document "Procedure for Disinfection of Drinking Water in Ontario", which is provided in Appendix A; Provisions should be made for applying chlorine as a secondary disinfectant to the water entering the distribution system.

4.3.3.4 Residual Chlorine Free residual chlorination is the preferred practice. The overall waterworks should be capable of achieving, at all locations within the distribution system, a free chlorine residual of at least 0.2 milligrams per litre. Higher residuals may be required depending on pH, temperature and other characteristics of the water;

4.3.3.5 Testing Equipment Chlorine residual test equipment recognized in the latest edition of Standard Methods for the Examination of Water and Wastewater shall be provided and should be capable of measuring residuals to the nearest 0.01 milligrams per litre. It is recommended that all systems, as a minimum, use an instrument using the DPD colorimetric method with a digital readout and a self-contained light source; Automatic chlorine residual recorders should be provided where the chlorine demand varies appreciably over a short period of time; All treatment plants having a capacity of 2 ML/day or greater should be equipped with recording chlorine analyzers monitoring water entering the distribution system; All surface water treatment plants must have equipment to measure chlorine residuals continuously entering the distribution system; Systems that rely on chlorination for inactivation of bacteria or other microorganisms present in the source water shall have continuous chlorine residual analyzers and other equipment that automatically shut down the facility when chlorine residuals are not met unless otherwise approved by the reviewing authority. 4.3.3.6 Chlorinator Piping 4.3.3.6.1. Cross-connection Protection The chlorinator water supply piping shall be designed to prevent contamination of the treated water supply by sources of questionable quality.

4.3.3.6.2. Pipe Material See Part 5 for further details. 4.3.3.7 Housing See Part 5 for further details. 4.3.3.8 UV Disinfection UV (ultraviolet light) disinfection may be considered as an alternative primary disinfectant if accepted by the reviewing authority. In order to be acceptable, the UV system must meet the following minimum requirements: The specific UV equipment to be used (exact size and model number) must have been independently validated to demonstrate its effectiveness; The design should include standby unit(s) and standby power to ensure that all water receives UV treatment at all times; water that has not been UV treated shall not be fed into the distribution system; The UV dose shall be based on the quality of the water to be disinfected, taking into account lamp aging and fouling. The minimum UV dose shall be 40 mJ/ cm^2 at maximum flow; Instrumentation to continuously monitor and record the performance of the UV system, including UV sensors and flow meters for each unit must be provided; The design shall allow periodic replacement of lamps and sensors, and repairs. Spare parts shall be available to ensure that the equipment can be maintained and kept in service; Lamp cleaning methods should be considered in the design and selection of equipment. NOTE: In the near future the USEPA will be publishing UV dosage tables and a UV Guidance Manual for UV disinfection of drinking water. 4.3.3.9 Other Disinfecting Agents Proposals for use of disinfecting agents other than those listed shall be approved by the reviewing authority prior to preparation of final plans and specifications. Although disinfecting agents other than chlorine are available, each can have shortcomings when applied to a small community water supply. Only ion-exchange softening will be considered and where approved by the reviewing authority. Consideration must be taken into account for the disposal of brine wastes in accordance with the reviewing authority. 4.3.4.1 Cation Exchange Process Alternative water sources should be investigated when the sodium content and dissolved solids concentration is of concern with respect to health (low sodium diets). 4.3.4.1.1. Pre-treatment Requirements Iron, manganese, or a combination of the two, should not exceed 0.3 mg/L in the water as applied to the ion exchange resin. Pre-treatment is required when the content of iron, manganese, or a combination of the two is one milligram per litre or more. Water having 5 NTU's or more turbidity should not be applied directly to the cation exchange softener. 4.3.4.1.2. Design The units may be of pressure or gravity type, of either an upflow or down-flow design. Automatic regeneration based on volume of water softened should be used unless manual regeneration is justified and is approved by the reviewing authority. A manual override shall be provided on all automatic controls. 4.3.4.1.3. Exchange Capacity The design capacity for hardness removal should not exceed 46 kg/m^3 when resin is regenerated with 0.14 kg of salt per kg of hardness removed. 4.3.4.1.4. Depth of Resin The depth of the exchange resin should not be less than 1 m. 4.3.4.1.5. Flow Rates The rate of softening should not exceed 17 m/hr and the backwash rate should be 14-20 m/hr of bed area. Rate-of-flow controllers or the equivalent must be installed for the above purposes. 4.3.4.1.6. Freeboard The freeboard will depend upon the size and specific gravity of the resin and the direction of water flow. Generally, the wash-water collector should be 600 mm above the top of the resin on down-flow units. 4.3.4.1.7. Under-drains and Supporting Gravel The bottoms, strainer systems and support for the exchange resin shall conform to criteria provided for rapid rate gravity filters. 4.3.4.1.8. Brine Distribution Facilities should be included for even distribution of the brine over the entire surface of both upflow and down-flow units. 4.3.4.1.9. Cross-connection Control Backwash, rinse and air relief discharge pipes shall be installed in such a manner as to prevent any possibility of back-siphonage. 4.3.4.1.10. Bypass Piping and Equipment A bypass must be provided around softening units to produce a blended water of desirable hardness. Totalizing metres must be installed in the bypass line and on each softener unit. The bypass line must have a shut-off valve and should have an automatic proportioning or regulating device. In some installations, it may be necessary to treat the bypassed water to obtain acceptable levels of iron and/or manganese in the finished water. 4.3.4.1.11. Additional Limitations Silica gel resins should not be used for water having a pH above 8.4 or containing less than six milligrams per litre of silica and should not be used when iron is present. When the applied water contains a chlorine residual, the cation exchange resin shall be a type that is not damaged by residual chlorine. Phenolic resin should not be used. 4.3.4.1.12. Sampling Taps Smooth-nose sampling taps must be provided for the collection of representative samples. The taps shall be located to provide for sampling of the softener influent, effluent and blended water. The sampling taps for the blended water shall be at least 6 m downstream from the point of blending. Petcocks are not acceptable as sampling taps. Sampling taps should be provided on the brine tank discharge piping. 4.3.4.1.13. Brine and Salt Storage Tanks Salt dissolving or brine tanks and wet salt storage tanks must be covered and must be corrosion-resistant; The make-up water inlet must be protected from back-siphonage. Water for filling the tank should be distributed over the entire surface by pipes above the maximum brine level in the tank. The tanks should be provided with an automatic declining level control system on the make-up water line; Wet salt storage basins must be equipped with manholes or hatchways for access and for direct dumping of salt from truck or railcar. Openings must be provided with raised curbs and watertight covers having overlapping edges similar to those required for finished water reservoirs; Overflows, where provided, must be protected with corrosion resistant screens and must terminate with either a turned down bend having a proper free fall discharge or a self-closing flap valve; Two wet salt storage tanks or compartments designed to operate independently should be provided; The salt shall be supported on graduated layers of gravel placed over a brine collection system; Alternative designs which are conducive to frequent cleaning of the wet salt storage tank may be considered.

4.3.4.1.14. Salt and Brine Storage Capacity Total salt storage should have sufficient capacity to store in excess of 1-1/2 carloads or truckloads of salt, and provide for at least 30 days of operation. 4.3.4.1.15. Brine Pump or Eductor An eductor may be used to transfer brine from the brine tank to the softeners. If a pump is used, a brine measuring tank or means of metering should be provided to obtain proper dilution. 4.3.4.1.16. Waste Disposal Suitable disposal must be provided for brine waste (see Part 9). Where the volume of spent brine must be reduced, consideration may be given to using a part of the spent brine for a subsequent regeneration. 4.3.4.1.17. Construction Materials Pipes and contact materials must be resistant to the aggressiveness of salt. Plastic and red brass are acceptable piping materials. Steel and concrete must be coated with a non-leaching protective coating which is compatible with salt and brine. 4.3.4.1.18. Housing Bagged salt and dry bulk salt storage shall be enclosed and separated from other operating areas in order to prevent damage to equipment. 4.3.4.2 Water Quality Test Equipment Test equipment for alkalinity, total hardness, carbon dioxide content, and pH should be provided to determine treatment effectiveness. Aeration may be used to help remove offensive tastes and odours due to dissolved gases from decomposing organic matter, or to reduce or remove objectionable amounts of carbon dioxide, hydrogen sulfide, etc. and to introduce oxygen to assist in iron and/or manganese removal. The packed tower aeration process is an aeration process applicable to removal of volatile organic contaminants. 4.3.5.1 Natural Draft Aeration Design shall provide: Perforations in the distribution pan 5 mm to 12 mm in diameter, spaced 25 to 75 mm on centres to maintain a 150 mm water depth; For distribution of water uniformly over the top tray; Discharge through a series of three or more trays with separation of trays not less than 300 mm; Loading at a rate of 2.5 to 12.5 m/hr of total tray area; Trays with slotted, heavy wire (12 mm openings) mesh or perforated bottoms; Construction of durable material resistant to aggressiveness of the water and dissolved gases; Protection from loss of spray water by wind carriage by enclosure with louvers sloped to the inside at an angle of approximately 45 degrees; Protection from insects by 24-mesh screen. 4.3.5.2 Forced or Induced Draft Aeration Devices shall be designed to: Include a blower with a weatherproof motor in a tight housing and screened enclosure; Insure adequate counter current of air through the enclosed aerator column; Exhaust air directly to the outside atmosphere; Include a down-turned and 24-mesh screened air outlet and inlet; Be such that air introduced in the column shall be as free from obnoxious fumes, dust and dirt as possible; Be such that sections of the aerator can be easily reached or removed for maintenance of the interior or installed in a separate aerator room; Provide loading at a rate of 2.5 - 12.5 m/hr; Insure that the water outlet is adequately sealed to prevent unwarranted loss of air; Discharge through a series of five or more trays with separation of trays not less than 150 mm or as approved by the reviewing authority; Provide distribution of water uniformly over the top tray; Be of durable material resistant to the aggressiveness of the water and dissolved gases. 4.3.5.3 Spray Aeration Design shall provide: A hydraulic head of between 1.5 m to 8 m; Nozzles, with the size, number and spacing of the nozzles being dependent on the flow rate, space, and the amount of head available; Nozzle diameters in the range of 25 mm to 40 mm to minimize clogging; An enclosed basin to contain the spray. Any openings for ventilation, etc. must be protected with a 24-mesh screen.

4.3.5.4 Pressure Aeration Pressure aeration may be used for oxidation purposes only if pilot plant study indicates the method is applicable; it is not acceptable for removal of dissolved gases. Filters following pressure aeration must have adequate exhaust devices for release of air. Pressure aeration devices shall be designed to: Give thorough mixing of compressed air with water being treated; Provide screened and filtered air, free of obnoxious fumes, dust, dirt and other contaminants. 4.3.5.5 Packed Tower Aeration Packed tower aeration (PTA) which is also known as air stripping involves passing water down through a column of packing material while pumping air counter-currently up through the packing. PTA is used for the removal of volatile organic chemicals, trihalomethanes, carbon dioxide, and radon. Generally, PTA is feasible for compounds with a Henry's Constant greater than 100 (expressed in atm mol/mol) - at 12EC, but not normally feasible for removing compounds with a Henry's Constant less than 10. For values between 10 and 100, PTA may be feasible but should be extensively evaluated using pilot studies. Values for Henry's Constant should be discussed with the reviewing authority prior to final design. 4.3.5.5.1. Process Design Process design methods for PTA involve the determination of Henry's Constant for the contaminant, the mass transfer coefficient, air pressure drop and stripping factor. The applicant shall provide justification for the design parameters selected (i.e. height and diameter of unit, air to water ratio, packing depth, surface loading rate, etc.). Pilot plant testing may be required. The pilot test shall evaluate a variety of loading rates and air to water ratios at the peak contaminant concentration. Special consideration should be given to removal efficiencies when multiple contaminations occur. Where there is considerable past performance data on the contaminant to be treated and there is a concentration level similar to previous projects, the reviewing authority may approve the process design based on use of appropriate calculations without pilot testing. Proposals of this type must be discussed with the reviewing authority prior to submission of any permit applications; The tower shall be designed to reduce contaminants to below the maximum contaminant level (MCL) and to the lowest practical level; The ratio of the column diameter to packing diameter should be at least 7:1 for the pilot unit and at least 10:1 for the full scale tower. The type and size of the packing used in the full scale unit shall be the same as that used in the pilot work; The minimum volumetric air to water ratio at peak water flow should be 25:1. The maximum air to water ratio for which credit will be given is 80:1; The design should consider potential fouling problems from calcium carbonate and iron precipitation and from bacterial growth. It may be necessary to provide pre-treatment. Disinfection capability shall be provided prior to and after PTA; The effects of temperature should be considered since a drop in water temperature can result in a drop in contaminant removal efficiency; Redundant capacity may be required by the reviewing authority. 4.3.5.5.2. Materials of Construction The tower can be constructed of stainless steel, concrete, aluminium, fibreglass or plastic. Uncoated carbon steel is not recommended because of corrosion. Towers constructed of light-weight materials should be provided with adequate support to prevent damage from wind; packing materials shall be resistant to the aggressiveness of the water, dissolved gases and cleaning materials and shall be suitable for contact with potable water. 4.3.5.5.3. Water Flow System water should be distributed uniformly at the top of the tower using spray nozzles or orifice-type distributor trays that prevent short circuiting. For multi-point injection, one injection point for every 190 cm^2 of tower crosssectional area is recommended; a mist eliminator shall be provided above the water distributor system; a side wiper redistribution ring shall be provided at least every 3 m in order to prevent water channelling along the tower wall and short circuiting; sample taps shall be provided in the influent and effluent piping; the effluent sump, if provided, shall have easy access for cleaning purposes and be equipped with a drain valve. The drain shall not be connected directly to any storm or sanitary sewer; a blow-off line should be provided in the effluent piping to allow for discharge of water/chemicals used to clean the tower; the design shall prevent freezing of the influent riser and effluent piping when the unit is not operating. If piping is buried, it shall be maintained under positive pressure; the water flow to each tower shall be metered; An overflow line shall be provided which discharges 300 mm to 350 mm above a splash pad or drainage inlet. Proper drainage shall be provided to prevent flooding of the area; butterfly valves may be used in the water effluent line for better flow control, as well as to minimize air entrainment; means shall be provided to prevent flooding of the air blower; the water influent pipe should be supported separately from the tower's main structural support.

4.3.5.5.4. Air Flow System the air inlet to the blower and the tower discharge vent shall be downturned and protected with a non-corrodible 24-mesh screen to prevent contamination from extraneous matter. It is recommended that a 4-mesh screen also be installed prior to the 24-mesh screen on the air inlet system; the air inlet shall be in a protected location; an air flow meter shall be provided on the influent air line or an alternative method to determine the air flow shall be provided; a positive air flow sensing device and a pressure gauge must be installed on the air influent line. The positive air flow sensing device must be a part of an automatic control system which will turn off the influent water if positive air flow is not detected. The pressure gauge will serve as an indicator of fouling buildup; a backup motor for the air blower must be readily available. 4.3.5.5.5. Other Features that shall be provided: a sufficient number of access ports with a minimum diameter of 600 mm to facilitate inspection, media replacement, media cleaning and maintenance of the interior; a method of cleaning the packing material when iron, manganese, or calcium carbonate fouling may occur; tower effluent collection and pumping wells constructed to clearwell standards; provisions for extending the tower height without major reconstruction; an acceptable alternative supply must be available during periods of maintenance and operation interruptions. No bypass shall be provided unless specifically approved by the reviewing agency; disinfection application points both ahead of and after the tower to control biological growth; disinfection and adequate contact time after the water has passed through the tower and prior to the distribution system;

4.3.5.5.5. Other Features that shall be provided: a sufficient number of access ports with a minimum diameter of 600 mm to facilitate inspection, media replacement, media cleaning and maintenance of the interior; a method of cleaning the packing material when iron, manganese, or calcium carbonate fouling may occur; tower effluent collection and pumping wells constructed to clearwell standards; provisions for extending the tower height without major reconstruction; an acceptable alternative supply must be available during periods of maintenance and operation interruptions. No bypass shall be provided unless specifically approved by the reviewing agency; disinfection application points both ahead of and after the tower to control biological growth; disinfection and adequate contact time after the water has passed through the tower and prior to the distribution system; adequate packing support to allow free flow of water and to prevent deformation with deep packing heights; operation of the blower and disinfectant feeder equipment during power failures; adequate foundation to support the tower and lateral support to prevent overturning due to wind loading; fencing and locking gate to prevent vandalism; an access ladder with safety cage for inspection of the aerator including the exhaust port and de-mister; electrical inter-connection between blower, disinfectant feeder and well pump. 4.3.5.5.6. Environmental Factors the applicant must contact the appropriate air quality office to determine if permits are required under the Clean Air Act; noise control facilities should be provided on PTA systems located in residential areas. 4.3.5.6 Other Methods of Aeration Other methods of aeration may be used if applicable to the treatment needs. Such methods include but are not restricted to spraying, diffused air, cascades and mechanical aeration. The treatment processes must be designed to meet the particular needs of the water to be treated and are subject to the approval of the reviewing authority. 4.3.5.7 Protection of Aerators All aerators except those discharging to clarification plants shall be protected from contamination by birds, insects, wind borne debris, rainfall and water draining off the exterior of the aerator. 4.3.5.8 Disinfection Groundwater supplies exposed to the atmosphere by aeration must receive chlorination as the minimum additional treatment. 4.3.5.9 Bypass A bypass should be provided for all aeration units except those installed to comply with maximum contaminant levels. 4.3.5.10 Corrosion Control The aggressiveness of the water after aeration should be determined and corrected by additional treatment, if necessary. 4.3.5.11 Quality Control Equipment should be provided to test for DO, pH and temperature to determine proper functioning of the aeration device. Equipment to test for iron, manganese, and carbon dioxide should also be considered. Iron and manganese control, as used herein, refers solely to treatment processes designed specifically for this purpose. The treatment process used will depend upon the character of the raw water. The selection of one or more treatment processes must meet specific local conditions as determined by engineering investigations, including chemical analyses of representative samples of water to be treated, and receive the approval of the reviewing authority. It may be necessary to operate a pilot plant in order to gather all information pertinent to the design. Consideration should be given to adjusting pH of the raw water to optimize the chemical reaction. Testing equipment and sampling taps shall be provided as outlined in Part 2. 4.3.6.1 Removal by Oxidation, Detention and Filtration 4.3.6.1.1. Oxidation Oxidation may be aeration, as indicated in Section 4.3.5, or by chemical oxidation with chlorine with due consideration to the raw water pH, the total organic carbon in the raw water, and the potential formation of THM's. 4.3.6.1.2. Detention Reaction - a minimum detention time of 30 minutes for iron and 60 minutes for manganese (depending on raw water pH) shall be provided following aeration to ensure that the oxidation reactions are as complete as possible. This minimum detention may be omitted only where a pilot plant study indicates no need for detention. The detention basin may be designed as a holding tank without provisions for sludge collection but with sufficient baffling to prevent short circuiting; Sedimentation - sedimentation basins shall be provided when treating water with high iron and/or manganese content, or where chemical coagulation is used to reduce the load on the filters. Provisions for sludge removal shall be made. 4.3.6.1.3. Filtration Filters shall be provided and shall conform to the applicable section in this part of the guidelines. 4.3.6.2 Removal by Silica Sand/Manganese Coated Media Filtration This process consists of a continuous chlorine or other approved oxidizing agent to the influent of a silica sand/manganese coated media filter. Due consideration must be taken into account of the formation of THM's. a sodium hypochlorite solution shall be applied as far ahead of the filter(s) as is practical and to a point immediately before the filter(s); the silica/manganese dioxide blend should be a minimum of 300 mm in depth, with at least 20% manganese dioxide material included; an anthracite media cap of at least 400 mm or more as required by the reviewing authority shall be provided over the silica sand/manganese coated media; the media bed will act as a combined contactor and filtration bed. The contact time shall be determined by pilot plant studies; normal filtration rate is 7.2 m/hr; normal wash rate is 20 - 24 m/hr with manganese green-sand and 37-49 m/hr with manganese coated media; air washing shall be provided; sample taps shall be provided: prior to application of oxidizer; immediately ahead of filtration; at the filter effluent; should be provided at points between the anthracite media and the manganese coated media. 4.3.6.3 Removal by Ion Exchange This process of iron and manganese removal should not be used for water containing more than 0.3 milligrams per litre of iron, manganese or combination thereof. This process is not acceptable where either the raw water or wash water contains dissolved oxygen or other oxidants. Fluoridation shall be applied to a community water system if a referendum or plebiscite has been held in the community and the majority of eligible voters have voted to have it included as a prophylactic in the public water system. Fluoride when introduced into the water system has been found to have beneficial effects on children in their teeth and bone forming years. 4.3.7.1 Fluoride dosage Accurate dosage of the fluoride ion is important and should be based on seasonal influences with approximately 0.7 mg/L of fluoride ion being added during the summer months and a maximum of 1 mg/L of fluoride ion being added during the other three seasons. 4.3.7.2 Fluoride Chemicals The following three chemicals are considered suitable as commercially available feed chemicals for the application of fluoride: Sodium fluoride (NaF); Sodium silicofluoride (Na_2SiF_6); Hydrofluosilicic Acid (H_2SiF_6); Consideration must be taken into account of the following parameters when selecting the appropriate chemical: the purity of the chemical, the percentage of fluoride ion in each kilogram of chemical, the solubility of the chemical in the solution water and the comparative costs. All or any of the above chemicals when added to a public water supply will tend to depress the pH and increase the aggressive nature of the water. This is particularly important for many west coast water where the water is only lightly buffered. Therefore consideration should be taken into account with due regard to corrosion on distribution piping (old asbestos cement piping) and domestic plumbing before proceeding with fluoridation or selecting the appropriate chemical to apply fluoridation. 4.3.7.3 Fluoride feed equipment See Part 5 for further details of feed equipment for fluoride systems. 4.3.7.4 Other Standards For other guidelines on fluoridation systems see the April 1999 Fluoridation Design Manual for Water Systems in B.C. Region. 4.3.8. Stabilization Water that lacks alkalinity for coagulation treatment or is unstable, aggressive and/or corrosive due to previous or subsequent treatment shall be conditioned to improve coagulation or stabilized to reduce corrosion effects 4.3.8.1 Alkali Feed Water with low alkalinity or pH should be treated with percolating lime rock contactors or the application of an alkali chemical, such as sodium hydroxide (caustic soda) or sodium carbonate (soda ash). See below for details of limestone contactors and Part 5 for sodium hydroxide and sodium carbonate systems. 4.3.8.2 Limestone Contactor Limestone contactors may be required prior to pre-treatment of the raw water (primary limestone contactor) to provide sufficient alkalinity for coagulation, or after the chlorine contact tank (secondary limestone contactor) for corrosion control. The following general design guidelines are provided for both limestone contactors, followed by special provisions for the primary and secondary limestone contactors. 4.3.8.2.1. General Limestone Contactor Design Guidelines Contact Time - the required contact time is dependent on the quality of limestone used, and the pH and alkalinity of the raw water or filtered water; Tank Design - the tank geometry will minimize the wall area to tank volume ratio and minimize short circuiting. The inlet, outlet, and flow through the contactor shall be designed to provide uniform flow through all of the limestone and to prevent short-circuiting; Access - the limestone contactor shall be open at the top, or provided with sufficient access points to allow observation of the top of the limestone, and the easy installation and removal of limestone and internal components such as piping and valves; Bypass - provisions for bypassing the limestone contactor shall be included; Drainage - contactor tanks must be provided with a means for dewatering. The contactor's floor should slope toward the drain at not less than 50 mm in 5 metres (1% slope). 4.3.8.2.2. Special Considerations for Primary Limestone Contactor Pre-screening - a basket strainer shall be provided capable of preventing an accumulation of debris that cannot be removed by backwashing. Provide the ability to modify the size of screen openings after plant start-up if required; Contact Time - a minimum 60 minute actual contact time is recommended. Testing shall be used to confirm the contact time required to increase the raw water alkalinity to an amount needed for adequate coagulation to occur. As an allowance of a safety factor, the contact time determined by the test shall be increased by 10%. An actual contact time of less than 60 minutes may be considered by the reviewing authority based on test results. The testing shall use the same limestone as proposed for the full scale limestone contactor. Limestone Backwash - a water flushing system shall be provided to dislodge sediment that may accumulate in the limestone and remove and dispose of it; the limestone contactor bypass shall include a throttling valve and required piping and fittings to allow the operator to blend limestone treated water with raw water; The limestone shall be thoroughly washed at the treatment plant site prior to being placed into the contactor tanks. 4.3.8.2.3. Special Considerations for Secondary Limestone Contactor Contact Time - a minimum 60 minute actual contact time is recommended. Testing shall be used to confirm the contact time required to increase the raw water alkalinity to an amount needed for adequate corrosion control to occur. As an allowance of a safety factor, the contact time determined by the test shall be increased by 10%. An actual contact time of less than 60 minutes may be considered by the reviewing authority based on test results. The testing shall use the same limestone as proposed for the full scale limestone contactor. 4.3.8.2.4. Limestone The following specifies requirements for the supply, installation and testing of limestone for the limestone contactor(s): the limestone shall yield results similar to the test results used to determine the contact time. The consultant's specifications shall require certification of dissolution performance; the limestone must comply with the latest issue of ANSI/NSF 60 Drinking Water Treatment Chemicals - Health Effects; the material provided and installed shall be high calcium content limestone with greater than 95% calcium carbonate ($CaCo_3$) and have a high rate of dissolution. Impurities such as aluminum (A1) and iron (Fe) shall be kept to a minimum. Testing shall demonstrate that the limestone will not increase aluminum, iron, and heavy metal concentrations in the treated water to concentrations above the Canadian Drinking Water Guidelines; the limestone shall have an effective size, d_{10}, of between 6 mm and 8 mm. The uniformity coefficient shall be 2 to 3. The maximum diameter of the limestone shall be 32 mm. The limestone gradation must be determined by using the latest issue of ASTM, Standard Test. 4.3.8.3 Other Treatment Other treatment for controlling corrosive water by the use of calcium hydroxide, sodium hydroxide and sodium carbonate may be used where necessary. Any proprietary compound must receive the specific approval of the reviewing authority before use. Chemical feeders shall be as required in Part 5. Unstable water resulting from the bacterial decomposition of organic matter in water (especially in dead end mains), the biochemical action within tubercles, and the reduction of sulfates should be prevented by the maintenance of a free and/or combined chlorine residual throughout the distribution system.

4.3.8.4 Control Laboratory equipment shall be provided for determining the effectiveness of stabilization treatment. Provision shall be made for the control of taste and odour at all surface water treatment plants. Chemicals shall be added sufficiently ahead of other treatment processes to assure adequate contact time for an effective and economical use of the chemicals. Where severe taste and odour problems are encountered, in-plant and/or pilot plant studies are required. Acceptable treatment processes for taste and odour control are as follows: Chlorination Granular Activated Carbon Aeration 4.3.9.1 Flexibility Plants treating water that is known to have taste and odour problems should be provided with equipment that makes several of the control processes available so that the operator will have flexibility in operation. 4.3.9.2 Chlorination Chlorination can be used for the removal of some objectionable odours. Adequate contact time must be provided to complete the chemical reactions involved. Excessive potential trihalomethane production through this process should be avoided by adequate bench-scale testing prior to design. 4.3.9.3 Granular Activated Carbon Replacement of anthracite with GAC may be considered as a control measure for geosmin and methyl isoborneol (MIB) taste and odours from algae blooms. Demonstration studies performed by the Consulting Engineer may be required by the reviewing authority. See Section 4.3.2.1.6 (Filter Material) for application within filters. 4.3.9.4 Aeration See Section 4.3.5. 4.3.9.5 Other Methods The decision to use any other methods of taste and odour control should be made only after careful laboratory and/or pilot plant tests and approval by the reviewing authority. A microscreen is a mechanical supplement of treatment capable of removing suspended matter from the water by straining. It may be used to reduce nuisance organisms and organic loadings. It shall not be used in place of: Filtration, when filtration is necessary to provide a satisfactory water; or Coagulation, in the preparation of water for filtration. 4.3.10.1 Design Give due consideration to: Nature of the suspended matter to be removed; Corrosiveness of the water; Effect of chlorination, when required as pre-treatment; Duplication of units for continuous operation during equipment maintenance; Automated backflushing operation when used in conjunction with microfiltration treatment; Provide: A durable, corrosion-resistant screen; By-pass arrangements; Protection against back-siphonage when potable water is used for washing; Proper disposal of wash waters (See Section 9). 4.3.11.1 General Arsenic removal, as used herein, refers to treatment processes specifically related to reducing levels of arsenic below 0.025 mg/L in the treated water and preferably below 0.010 mg/L. Where raw water systems exceed 0.025 mg/L of arsenic then every effort should be made to locate an alternative raw water source or, if there is no other source available in the localized area then a treatment strategy must be planned to effectively reduce the total arsenic level to preferably below 0.010 mg/L. 4.3.11.2 Pilot Plant A pilot plant will be necessary to determine the optimum form of treatment to be applied to site specific water, a complete protocol of the pilot work must be developed and submitted to the reviewing authority before the pilot work and testing commences. All pilot work and testing will be done in-situ close by the actual source of the raw water. 4.3.11.3 Treatment Aqueous arsenic solutions are generally most prevalent in the trivalent and pentavalent states, each species in turn predominating as a function of the pH of the water. The trivalent species predominates as a weak acid in the pH range of 2 to 9, while the pentavalent species occurs as a strong acid. The disassociation properties and the pH of the treated water are therefore important criteria in the conventional coagulation process in the selection of the appropriate treatment process. The following treatment processes may be considered for the removal of arsenic: Conventional coagulation employing aluminum or iron salts; Adsorption onto a granular ferric oxide bed; Adsorption onto an activated alumina; Separation by reverse osmosis. Not all the above treatment options are pH dependent, but where they are, consideration should be given to raising or depressing the pH of the raw water to suit the selected process with the appropriate chemical. 4.3.11.4 Rejects and Waste Streams Adsorption media once spent will be replaced and not generated, the spent material shall be disposed of in suitable landfills with the approval of the reviewing authorities. Backwash streams or rejects from RO systems may be discharged to the sewer or to septic tanks with the approval of the reviewing authority. 4.3.11.5 Treatment Criteria The selected treatment option shall take into consideration the required complexity of operation, the capital costs, operation and maintenance costs and the life cycle costs. A minimum of two treatment processes shall be piloted following a desktop study which identifies the pilot program and the protocol to follow. 4.3.11.6 Testing Equipment Analytical testing equipment and proper laboratory procedures shall be included in the pilot plant and final prototype to accurately measure the levels of arsenic in the raw and treated water. The Design Guidelines for Drinking-Water Systems were prepared under the guidance of the Ontario Ministry of the Environment (MOE) Drinking Water Technical Working Group with the assistance of XCG Consultants Ltd. in association with Hydromantis Inc. This document underwent review by various branches of the Ontario Ministry of the Environment and the following stakeholders and reviewers. Ministry of the Environment Drinking Water Technical Working Group: George Lai, M.Eng., P.Eng., Standards Development Branch, MOE Janusz Budziakowski, M.Sc., P.Eng., Safe Drinking Water Branch, MOE Tony Edmonds, Ph.D., Ontario Clean Water Agency Judith Patrick, Standards Development Branch, MOE Stakeholders and Reviewers William B. Anderson, Ph.D., Academia (University of Waterloo) Steve Burns, P.Eng., Ontario Water Works Association Karu Chinniah, M.Sc., P.Eng., Alberta Environment Robert Dumancic, M.A. Sc., P.Eng., Standards Development Branch, MOE Andrew Farr, P.Eng., Association of Municipalities of Ontario Bill Hargrave, Ph.D., P.Eng., Consulting Engineers of Ontario Rod Holme, P.Eng., Engineering Advisor Danny Hui, P.Eng., Ministry of Municipal Affairs and Housing Terry Lang, C.E.T., Ontario Water Works Equipment Association Tony Lotimer, M.Sc., P.Geo., Ontario Water Works Association Edmond Lui, P.Eng., Safe Drinking Water Branch, MOE Gord Robb, C.E.T., Ontario General Contractors Association Joe Rybak, P.Eng., Ontario Clean Water Agency Pervez Sunderani, P.Eng., Alberta Environment Carl Vreugde, B.A., Ontario Water Works Equipment Association Alex Vukosavljevic, B.A., Operators (City of Toronto) Robert Walton, P.Eng., Ontario Municipal Water Association Roland Welker, M. A. Sc., P.Eng., Municipal Engineers Association Matt Uza, B. A. Sc., Land and Water Policy Branch, MOE Historical Note Since the establishment of the Ontario Water Resources Commission under the Ontario Water Resources Act (1956), the commission engineers used the Ten States Standards for Water Works as the reference design guidelines for sanitary engineering practice. These publications were prepared, edited and published, approximately every five years, by the Great Lakes Upper Mississippi River Board of State Public Health Engineers and Great Lakes Board of Public Health Engineers. The commission engineers had also developed and applied internal advisory water works design guidelines based primarily on the Ten States Standards and included design, construction and operational experience specific to Ontario. This practice has continued after the establishment of the Ministry of the Environment in 1973. The Province of Ontario joined the Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers and the Ten States Standards Water Supply Committee in 1977. Over the years, engineering design criteria based on generally accepted good engineering practice in Ontario have been developed and the following ministry guidelines were published: Guidelines for the Design of Water Treatment Works (1982) Guidelines for Water Distribution Systems (1979, 1985) Guidelines for Water Storage Facilities (1979, 1985) Guidelines for Servicing in Areas Subject to Adverse Conditions (1985) Guidelines for Water Supply for Small Residential Developments (1985) Guidelines for Seasonally Operated Water Supply Systems (1985) These guidelines have been revised and updated based on Ontario-specific engineering practice, the latest Ten States Standards (Recommended Standards for Water Works, 2003) and other relevant North American design guidelines and published as the Design Guidelines for Drinking-Water Systems (2008). Preamble The Ontario Ministry of the Environment (ministry) Design Guidelines for Drinking-Water Systems is intended for an audience that includes engineers who are responsible for designing drinking-water systems, ministry engineers responsible for reviewing and approving the designs of such systems, and the municipalities/owners of the drinking-water systems. It is intended that this Design Guidelines document be used with professional judgment and experience in the design of drinking-water systems and in the engineering review of applications for approval of such systems. The ministry recognizes that the choice of drinking-water system designs may be influenced during the planning stages by sustainability issues, such as the cost to design and build drinking-water systems as well as the ongoing cost to operate, maintain, rehabilitate and replace infrastructure. Designers should note that the ministry has a number of specific guidelines and/or procedures which relate to drinking-water systems that may affect design. Such specific guidelines and procedures take precedence over these Design Guidelines. Similarly, the use of actual site-specific data is encouraged. Wherever possible, designers are encouraged to use actual data derived from the drinking-water system monitoring records and operational studies. Actual data can be compared to the typical values provided in these Design Guidelines for comparison and consideration. As well, it should be noted that this Design Guidelines document provides design guidance related to established technologies. The fact that other technologies or equipment are not mentioned in the Design Guidelines should not be construed as precluding their use. It is not the intention of the ministry to stifle innovation. The ministry will approve drinking-water system works designs if the applicant and designer can demonstrate that the works will have a reasonable and substantial chance of success for the particular application. However, drinking-water system works designs using new and innovative technologies and equipment would be approved only where operational reliability and effectiveness of the works has been demonstrated with a suitably-sized prototype unit operating at its design load in the conditions suitable for the particular application. Finally, it must be emphasized that this document contains design guidelines. Legislation, including legislated standards and regulations, takes precedence over the Design Guidelines and must be followed. Readers are cautioned to obtain their own legal advice and guidance in this respect.