Saskatchewan
Ministry of
Health

March 2012

GUIDELINE FOR CONSTRUCTION AND APPROVAL OF PUBLIC WATER SYSTEMS REGULATED UNDER THE HEALTH HAZARD REGULATIONS

Table of Contents

Preamble

These guidelines cover the design of new public water supplies or extensions and replacement of public water supplies regulated by Regional Health Authorities under *The Health Hazard Regulations*. The guide is not intended to be a detailed engineering manual. However, the guide addresses certain aspects pertinent to the design of public water supplies so as to safeguard the public and protect the environment.

This document is intended to describe the minimum criteria acceptable to the Health Region for a new or significantly altered public water supply. It is expected that designers comply with good engineering practice and supply evidence supporting a design, where a design deviates from the typical. It remains the responsibility of the owner and designer to ensure that the water supplied as drinking water is suitable for human consumption regardless of any approval, permit or licence issued by the Regional Health Authority.

Reference Regulations

The Health Hazard Regulations require that the written approval of the health region is obtained prior to establishing, extending, renovating or altering a public water supply.

Section 1 Submission Requirements

Sections 5 of *The Health Hazard Regulations* states:

Approval re public Water supplies
5(1) *No person shall establish, extend, renovate or alter a public water supply unless the owner or operator has obtained written approval to do so from the local authority.*

Method(s) of Achievement – The intent of the above regulatory requirements can be achieved by applying the best management practices below:

All submissions to the Regional Health Authority should include:

- a completed application;
- a plan/map to show where the system is located;
- all supply, transmission, storage, pumping, treatment and distribution works;
- location of any nearby utilities including sanitary sewers, storm sewers, and onsite sewage treatment and disposal systems;
- water quality results;
- information that indicates the source water quantity is sufficient (as applicable);
  - ground water: well log, pump test, hydrogeological report; or
  - surface water: water license;
- proposed treatment (on application form); and
- one complete set of plans.

Where an application is made for approval of a public water supply that serves a rural residential community, a professional engineer of Saskatchewan should make the submission. All plans submitted by a professional engineer must be signed and sealed.

Section 2 Design Considerations

Sections 5 of *The Health Hazard Regulations* states:

Duties of owners, operators of public water supplies

6(1) *The owner or operator of a public water supply shall:*

(a) ensure that the water is potable at the place where it is delivered for use;

(b) locate, construct and operate the public water supply in a manner that will:

(i) reduce the potential of contamination of the water source; and

(ii) prevent the contamination of water within the distribution system, including any place where water is collected, stored or treated;

Treatment of public water supply

8 *If a local authority suspects that a public water supply constitutes a health hazard, the local authority may require the owner or operator to provide ongoing treatment of the kind and to the extent required by the local authority.*

Method(s) of Achievement – The intent of the above regulatory requirements can be achieved by applying the best management practices below:

2.1 General

The facility should be designed for the worst-case conditions that may exist during the life of the facility. It is the responsibility of the owner and designer to ensure that all relevant codes, regulations and legislation are complied with. Particular attention should be paid to occupational health and safety requirements and operator safety.

2.2 Quantities

Water supplied must be of sufficient quantity for sanitary purposes and to satisfy the reasonable expectations of users. The supply must be adequate to meet reasonable peak demands without development of low pressures that could result in health hazards. Water usage from similar facilities may provide valuable information. For a residential situation, 340 L (75 Imperial gallons) per person per day (1020 L or 225 Imperial gallons per household based on triple occupancy) may be adequate as an average flow. Water for fire fighting[1], irrigation, or other purposes is additional to that required for sanitary purposes.

A typical daily water usage rate for a community setting inclusive of all uses is 400 Lpcd (90 igpd). Maximum daily flow can be 150% to 450% or more of the average daily water usage. Systems without sufficient storage may have to design for flows higher than the maximum day demand.

[1] For details regarding fire protection requirements, the designer should refer to the most current Fire Underwriters Survey publication entitled Water Supply for Public Fire Protection.

2.3 Source of Supply

The water supply should be obtained from a source that is likely to produce water of a sufficient quality for consumption after treatment. See Appendix A for the minimum water parameters to be tested. The water should be tested a sufficient number of times to ensure that the results are representative.

Every effort should be made to prevent contamination of the source. The water source should be protected against access by unauthorized persons.

Project proponents should contact the Saskatchewan Watershed Authority to ensure that the appropriate approvals are received for the source water removals.

Wells

Wells must be located to conform to the requirements of the ***Ground Water Regulations***, unless the requirements are waived by the Saskatchewan Watershed Authority. Some of these requirements include using a registered drill rig, obtaining a permit for ground water exploration, submitting a well drillers report, obtaining a license for water use and installing a meter.

Wells should be constructed according to "AWWA Standard for Water Wells" (A100-06) and the publication "Landowners Guide to Water Well Management" (available from the Saskatchewan Watershed Authority). New wells that are part of a Public Water Supply must be constructed to prevent the entry of surface water, dirt or other materials in the casing; and not be located in a pit or basement. In addition, proper separation distance should be maintained between the well and any possible sources of contamination.

The reliable yield of the source should be adequate to supply the design maximum day demand. After construction, new wells should be shock chlorinated and meet acceptable bacteriological quality requirements prior to usage for human consumption.

Potential sources of contamination must be more than 30 m (100 ft) from the water source unless other setbacks apply (i.e. set-backs for onsite wastewater systems are specified in the Saskatchewan Onsite Wastewater Disposal Guide).

Surface Water Abstraction

The reliable yield of the source should be adequate to supply the design maximum day demand during a moderate drought in the summer. It is also recommended that the intake structure should be able to withdraw from more than one level. Intakes must be accessible in all seasons of usage and be suitably anchored and marked, if they may interfere with other users.

Impounding Reservoirs

Any earth storage facility for raw water should be designed to minimize contact between the water and organic materials such as grass, peat, trees, etc and avoid shallow water areas and embankment erosion.

2.4 Pumping Stations & Water Treatment Facilities

Pumping facilities and water treatment plants must be designed to maintain the sanitary quality of the pumped water and prevent unauthorized entry. Interior finishes shall be durable and easily cleaned. Subsurface pits or pump rooms and other inaccessible installations should be avoided. No pumping station or water treatment plant should be subject to flooding. A standby pump should normally be provided. Standby power should be considered in situations where a power failure could produce complete pressure loss in areas of the distribution system.

The floor of every water treatment plant or pumphouse shall be designed so that drainage occurs only into the floor drains or sumps. Every drainline from a treatment component to a sanitary sewer shall have a trap that contains water and the pipe shall have adequate backflow prevention. Piping systems within pumping stations and water treatment facilities shall be designed to avoid cross connections.

Except for small facilities with no treatment or distribution system, all public water supplies must have a water meter installed sufficient to measure the volume of water treated. It is also highly recommended that water treatment facilities are designed to include sampling points to allow for water to be sampled prior to and after all treatment units.

2.5 Finished Water Storage

Finished water storage must be adequately protected from contamination. Storage structures must have a cover that is watertight, opaque and vermin proof. Manholes to these structures must be framed at least 15 cm (6 inches) above the ground or floor surface at the opening and the cover must be watertight and extend down around the frame at least 5 cm (2 inches). The floor shall slope away from reservoir openings. Manhole covers outside of a building must be lockable. An overflow, which is not directly connected to a sewer or storm drain, shall be provided on all water storage devices. Overflows should be constructed to prevent the entry of birds, bugs and rodents. Venting of storage structures must not be by open construction between the sidewall and the roof or by an overflow, but by special vent structures, which will exclude birds, vermin, and dust.

Designers should ensure that the storage is sufficient for balancing, emergency use, and fire protection. It is recommended that either 455 L (100 gallons)/dwelling unit or one average day's volume, whichever is greater, be provided for emergency standby storage. Additional storage may be required for balancing fluctuations in domestic demand and for fire protection.

Hydropneumatic tanks are acceptable as a means of providing pump control but are not a means to provide balancing, emergency and fire protection storage. Hydropneumatic tanks shall be constructed to comply with NSF 61.

Steel storage tanks and paintings and coatings for steel storage tanks shall comply with the AWWA standards for steel tanks (D100, D102, D103 or D104).

2.6 Transmission and Distribution

It is recommended that watermains be looped wherever economically feasible to minimize contamination risks and service disruption during repair of breaks or watermain flushing. However, if dead ends or low points are present, flushouts or hydrants must be provided for flushing purposes. In addition, measures must be taken to prevent freezing of watermains and services if the system is intended for year round use.

Pipe materials shall meet the requirements of a relevant standard (NSF 61, AWWA C906).

All distribution lines should be sized based on hydraulic requirements with regards to future maintenance and current pressure requirements. The system should provide at least 140 kPa (20 p.s.i.) at ground level at all points in the water distribution system. Watermains should normally be 15 cm (6 inches) in diameter or greater where fire protection is provided.

Watermain valves should be provided to isolate reasonably sized sections of the system for repair or maintenance. It is recommended that they be placed on property lines, if possible, to make them easier to locate.

Tank loading facilities shall:

- have no backflow to the water supply;
- have a piping arrangement that shall prevent contamination from being transferred from a hauling vessel to others using the station; and
- not allow the hoses to be contaminated by contact with the ground.

Cross-Connection and Backflow Prevention
Cross connections to contaminated water sources must be prevented within the water treatment plant.

In the distribution system, backflow prevention devices (i.e. premise isolation) are to be installed, especially at services that are likely sources of contamination such as hospitals, service stations, and chemical operations, etc. Where premise isolation occurs, a means of addressing thermal expansion should be considered within the premise.

Cross connection of watermains with any sanitary or storm sewer or other source of non-potable water is prohibited. See Appendix D for assistance.

2.7 Treatment

Log removals are determined using methodologies acceptable to the Local Authority. Procedures such as described or referenced in Saskatchewan Environment’s “A Guide to Water Works Design” and the Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Mangers’ “Recommended Standards for Waterworks” are generally acceptable. Any treatment unit that is used to achieve log removals shall not be bypassed during the production of water. See Appendix B for the required log removals.

The health region should be consulted prior to construction to ensure that the appropriate level of treatment has been constructed.

Selection of a suitable treatment process should always be based upon local conditions and desires. Raw water quality and variability, treatment objectives (both health related and aesthetic), costs, operational requirements, and other factors should all be weighed for a variety of options. The overall goal of the new plant must be to provide water that is safe (i.e. as free as possible from possible pathogenic organisms and levels of chemical parameters that does not result in an unacceptable health risk) for human consumption at all times and locations where potable water is required and in a quantity that is sufficient to meet the needs of users.

All chemicals shall meet the appropriate ANSI/AWWA standards and/or ANSI/NSF Standard 60 or other standards considered equivalent by the Local Authority.

The following information describes the usage of typical treatment units. Where the design criteria are given, these may be used as typical values and designers are responsible to ensure that the proposed system will function as desired.

- Tray Aeration: 0.7 to 3.4 L/s per m^2 of total tray area.
- Rapid Mix: detention time not to exceed 30 seconds.
- Flocculation: detention time generally between 30 to 60 minutes.
- Settling: detention time of at least 3 hours. If tube settlers are used, a detention time of 2 hours may be sufficient.
- Filtration:
  - Slow sand: filtration rate between 0.04 to 0.42 m/h (0.01 to 0.14 gpm/ft^2).
  - Rapid sand (Gravity or Pressure Filtration): filtration rate between 5 to 12.5 m/h (1.7 to 4.2 gpm/ft^2) with a backwash rate of between 37 and 56 m/h (12-19 gpm/ft^2).
  - Membrane: A professional engineer must design larger systems. Smaller Point-of-Use or Point-of-Entry units shall be certified to an appropriate NSF standard.
  - Cartridge:
    - Should be designed to manufacturer's specifications.
    - Should be certified to an appropriate NSF standard.
    - Should include more than one cartridge and be graded to a final cartridge that is 1 micron absolute.
  - Filtration Media:
    - Manganese Greensand
      - Requires continuous or periodic application of potassium permanganate.
    - Anthracite Coal
      - Typical filter media (note: does not perform chlorine, taste & odour removal like activated carbon).
    - Filter Sand (a variety of types/sizes is available)
      - Typical filter media.
    - Garnet
      - Typical filter media.
- Granular Activated Carbon Contactors:

- Typical design based on 5 to 25 minutes Empty Bed Contact Time.
- No credit for Giardia or Cryptosporidium removal.
- Should be located near the end of treatment but before chlorination.
- May be used at filtration rate of 5 to 12.5 m/h (1.7 to 4.2 gpm/ft^2).

2.7.1 Disinfection

Disinfecting agents commonly used in water treatment are chlorine, chlorine compounds, ultraviolet light and ozone. Other methods of disinfection will be considered if an applicant provides sufficient evidence to support their use.

Free residual chlorination is the method of disinfection most commonly practiced. A minimum contact time (T) (T equals storage volume divided by peak *hourly* flow) and minimum level of free chlorine residual (C) is required to produce a CT (product of C and T) of 30 min•mg/L unless detailed calculations showing the calculated CT of the system are provided (following USEPA's Disinfection Profiling and Benchmarking Guidance Manual method). This level of CT will generally be sufficient to ensure adequate destruction of viruses and bacteria. If inactivation of *Giardia lamblia* cysts are required, higher levels of CT are required. Consideration must be given to pH, ammonia, taste producing substances, temperature, bacteriological quality and other pertinent factors when determining CT. At pH levels above 9, CT has to be increased substantially. It should be noted that storage tanks that utilize a common inlet and outlet pipe do not provide contact time for disinfection to occur.

The capacity of chlorination equipment must be capable of maintaining adequate chlorine residuals when maximum flow rates coincide with anticipated maximum chlorine demands. The equipment must also operate accurately over the entire anticipated flow rates.

If gas chlorine is used, a separate room must be provided including fan ventilation from floor level to an approved area, viewing window, exterior light and fan switches, chained storage of cylinders, chlorine container repair kit, breathing apparatus, emergency eye wash facilities, chlorine leak monitoring and alarm equipment.

If powdered chlorine is used, storage facilities should preclude contact with moisture or organic materials and should be mechanically vented to an approved area.

Where methods of disinfection other than chlorination are employed, contact time and disinfectant concentrations must be sufficient to provide adequate disinfection. It should be possible to confirm the dosage of the disinfectant being applied to the water.

If a distribution system is present, the water quality following any treatment and disinfection must produce a minimum free chlorine residual of 0.1 mg/L or a total chlorine residual of 0.5 mg/L throughout the distribution system.

If needed to ensure reliable, effective and continuous disinfection, additional facilities such as standby equipment, flow pacing, residual monitoring, automated recording and controlling equipment and alarms should be provided.

2.8 Operational

A chlorine test kit (DPD) suitable for measuring both free and total chlorine residual over a range of 0 to 2.0 mg/L, should be provided when chlorine is used. Test kits with either a scale or digital readout are far better than those which rely on visual colour comparison, particularly for measurements below 0.5 mg/L, and should be utilized.

A turbidimeter is recommended for public water supplies that are designed to reduce turbidity.

Manuals detailing the installation and operation of all devices installed must be provided to the operator and made available to the Regional Health Authority upon their request. The operator is responsible to ensure that all treatment equipment is operated and maintained as recommended by the manufacturer.

The public water supply owner and installer are responsible to ensure that all new and repaired tanks, water mains, wells, etc. are disinfected (and pressure tested if applicable) before use according to the AWWA Standards or an equivalent methods considered equivalent by the local authority.

APPENDIX A

WATER SOURCE MONITORING – APPROVAL OF NEW SOURCES

Minimum Untreated Water Source Quality Parameters To Be Analyzed

Source Water: Surface Water

Microbiological
Total Coliform
Escherichia Coli

Physical/Chemical
Total Dissolved Organic Carbon
Turbidity
General chemicals
Alkalinity (as CaCO3)
Bicarbonate
Calcium
Carbonate
Chloride
Hardness (as CaCO3)
Magnesium
Nitrate
Potassium
Sodium
Sulphate
Health and Toxicity
Aluminum
Arsenic
Barium
Boron
Copper
Cadmium
Chromium
Iron
Lead
Manganese
Selenium
Uranium
Zinc

Source Water: Shallow Wells, Deep Wells and Springs

Microbiological
Total Coliform
Escherichia Coli

Physical/Chemical
Total Dissolved Organic Carbon
Turbidity
General chemicals
Alkalinity (as CaCO3)
Bicarbonate
Calcium
Carbonate
Chloride
Conductivity
Fluoride
Hardness (as CaCO3)
Magnesium
Nitrate
Sodium
Sulphate
Total Dissolved Solids
Health and Toxicity
Aluminum
Arsenic
Barium
Boron
Copper
Cadmium
Chromium
Iron
Lead
Manganese
Selenium
Uranium
Zinc

APPENDIX B
TREATMENT STANDARDS

Source | Usage	**Non-Contact**				**Contact**				**Oral Consumption**			
Quality Concern?	None	Bacteria[1]	Protozoa[2]	Chemical[3]	None	Bacteria[1]	Protozoa[2]	Chemical[3]	None	Bacteria[1]	Protozoa[2]	Chemical[3]
Surface Water[6]	NT[5]	NT	NT	NT	NT[5]	T2, D1	NT	NT	T2, D1[5]	T2, D2	T3, D2	R1
Ground Water	NT	NT	NT	NT	NT	T1, D1	NT	NT	NT	T2, D2	GUDI[7]	R1
Distribution System	NT	D3	D3	NT	D3	D3	D3	NT	D3	D3	D3	NT

Treatment	
D1	Chlorination or other disinfection
D2	4-log inactivation of viruses
D3	Secondary disinfectant
T1	Filtration for aesthetic purposes should be considered in cases where turbidity is high.
T2	Processes (e.g. filtration) effective for maintaining turbidity less than 1.0 NTU. In some cases (i.e. some ground waters) the water may not require treatment to maintain the turbidity below 1.0 NTU
T3[4]	3-log Cryptosporidium, 3-log Giardia
R1	Treatment effective at lowering the level of chemical to below the acceptable level as determined through risk assessment
NR/NT	No treatment requirements

Notes

* All significant distribution systems require secondary disinfection. Primary and secondary disinfection are often completely separate treatment processes and provide different outcomes. The former is intended to provide disinfection before the water is delivered to the first consumer and the latter ensures maintenance of a disinfectant residual throughout the distribution system.

* When more than one treatment option results from the table, the highest level should be selected. E.g.. Ground water where both bacteria and protozoa are suspected and the water will be used for human consumption would require T2, D2. In addition, the requirements are additive. E.g.. Oral consumption of surface water from a distribution system where protozoa and chemicals are present would be T3, D2, R1, and D3.

1	Bacterial concerns are identified via bacteriological testing or the presence of poor infrastructure. Bacterial indicators can also be used to indicate the presence of viruses.
2	Protozoa concerns are identified by a wellhead/watershed assessment based on the discretion of the Local Authority. In most cases it is safe to assume that protozoa are present in surface water and high risk potentially GUDI wells.
3	Chemical concerns are identified by testing for health and toxicity testing, which may be required by the Local Authority. This category encompasses all chemical-related health concerns (e.g. arsenic, selenium, lead, etc). All water systems should supply water that when used under typical usage pattern does not cause acute or chronic health issues due to the chemical constituents.
4	Raw water monitoring (E.Coli.) of 1/month for 24 months or 2/month for 12 months can be used to determine if additional treatment is required (adopted from USEPA Long Term 2 Enhanced Surface Water Treatment Rule: A quick reference guide for schedule 4 systems). If the E.Coli limit is exceeded, Cryptosporidium testing is required for 12 to 24 months. If any Cryptosporidium is discovered, up to 5.5 log inactivation of Cryptosporidium is necessary.
5	Situation is highly unlikely to occur. Significant raw water information should be collected and analysed to determine this.
6	Generally, surface water can be assumed to contain bacteria, viruses, and protozoa.
7	Ground water that falls in this category would be considered under the direct influence of surface water and surface water treatment requirements should apply for new systems.

APPENDIX C
LOG CREDITS

The following treatment technologies can achieve varying degrees of Cryptosporidium and Giardia inactivation/removals when operated properly. Health Canada shows these removal/inactivation rates as:

Technology	Crypto Credit	Giardia Credit[c]	Virus Credit
Conventional Filtration[a]	3.0 Log	3.0 Log	2.0 Log
Direct Filtration[a]	2.5 Log	2.5 Log	1.0 Log
Slow Sand or Diatomaceous Earth Filtration[a]	3.0 Log	3.0 Log	2.0 Log
Micro and Ultra Filtration, Nanofiltration and Reverse Osmosis	Removal efficiency demonstrated through challenge testing[d]	Removal efficiency demonstrated through challenge testing[d]	No credit for micro and ultrafiltration; for nanofiltration, reverse osmosis the removal efficiency is demonstrated through challenge testing

a Conventional/direct/slow sand/diatomaceous earth filtration should be followed by free chlorination to obtain additional virus credit.
b Micro- and ultrafiltration should be followed by free chlorination for the inactivation of viruses.
c Depending on (oo)cyst levels in source water, additional treatment is required using UV light, ozone, chlorine, or chlorine dioxide.
d Certification by ANSI or NSF for treatment objectives can be used as a surrogate to determine this.

The technology log removal credits are based on optimised equipment. Optimised equipment performs adequate turbidity removal that in turn has been related to filter effluent turbidity. The credits discussed above are only valid if the following turbidity levels are achieved.

Technology	Turbidity requirement
Conventional Filtration (turbidity after each filter ≤0.3 NTU)	≤ **0.3 NTU** in at least 95% of the measurements made, or at least 95% of the time each calendar month, and shall not exceed 1.0 NTU at any time.
Direct Filtration (turbidity after each filter ≤0.3 NTU)	≤ **0.3 NTU** in at least 95% of the measurements made, or at least 95% of the time each calendar month, and shall not exceed 1.0 NTU at any time.
Slow Sand or Diatomaceous earth filtration (turbidity after each filter ≤ 1.0 NTU)	≤ **1.0 NTU** in at least 95% of the measurements made, or at least 95% of the time each calendar month, and shall not exceed 3.0 NTU at any time.
Micro and ultra filtration, nanofiltration and reverse osmosis (turbidity after each filter ≤ 0.1 NTU)	less than or equal to **0.1 NTU** in at least 99% of the measurements made, or at least 99% of the time each calendar month, and shall not exceed 0.3 NTU at any time. If membrane filtration is the sole treatment technology employed, some form of virus inactivation should follow the filtration process.

Conventional filtration is defined as a treatment train containing the following optimised and functioning processes: coagulation-flocculation-sedimentation-filtration.

Direct filtration is defined as a treatment train containing the following optimised and functioning processes: coagulation-flocculation-filtration.

In addition, UV disinfection can provide a 3-log inactivation of Cryptosporidium and Giardia but only if operated properly. It is highly recommended that all UV devices incorporate an intensity sensor.

Chlorination, chlorine dioxide, and ozone can be effective means of inactivating Giardia but not Cryptosporidium under certain conditions. For example, temperature, pH, residual, contact time and other factors influence the amount of inactivation that occurs.

Cartridge filters that are certified to remove cysts can be assigned a maximum of 2-log credit for Giardia and Cryptosporidium removal. Cartridge filters that each are certified to remove cysts and used in series receive a maximum of 2.5-log credits for the complete cartridge treatment train.

APPENDIX D

CONSIDERATIONS GOVERNING THE SEPARATION OF SEWERS AND WATER LINES

Ground water may enter a water distribution system when negative internal/positive external pressures occur. The entry of ground water may be through leaks or breaks in piping, vacuum-air relief values, blow-offs, fire hydrants, meter systems, outlets, etc. Therefore the relative location of sewer lines and water lines and the types of material used for each system are important considerations in designing a water distribution system to minimize the possibility of contamination entering the water piping.

Parallel Installation

Under normal conditions, water lines should be laid with at least 2.5 metres horizontal separation from any sanitary or storm sewer.

Under unusual conditions (such as excessive rock, severe dewatering problems, congestion due to other utilities), a water line may be laid closer to a sewer line provided that the elevation of the crown of the sewer is at least 0.5 metres below the invert of the water line. The separation distance should be undisturbed native material or compacted backfill.

Where unusual conditions exist and the vertical separation cannot be obtained, the sewer should be constructed of materials and joints equivalent to water line construction.

Wherever possible these separation practices should also be applied to water service connections.

Crossings

Under normal conditions water lines should cross over sewer lines with sufficient vertical separation to allow for proper bedding and structural support of both lines.

Where it is not possible for the water line to cross over the sewer line, a water line may be laid below a sewer line provided that:

a) a vertical separation of at least 0.5 metres between the invert of the sewer line and the crown of the water line is maintained;
b) adequate structural support for the sewer line is present to prevent excessive deflection of joints and settling; and
c) the lengths of water line are centered at the point of the crossing so that the joints are equidistant and as far as possible from the sewer line.

There may be cases where local conditions do not permit the above guidelines to be met. In these cases, a number of factors can be considered when laying the water and sewer lines. This list of factors can be considered for guidance. This list is not all-inclusive:

a) Materials, types of joints and identification for water and sewer pipes and manholes (e.g. designed not to leak);
b) Soil conditions, undisturbed native soil, backfilling and compaction techniques;
c) Service and branch connections; and
d) Location of ground water table.

APPENDIX E
REFERENCES

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