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PUBLIC HEALTH ENGINEERING GUIDELINE:
SMALL WATER SYSTEMS DESIGN GUIDELINES – GROUNDWATER SOURCE

1. INTRODUCTION

These design guidelines provide guidance for small water system owners when they consider starting up a new water system or improving their existing water systems with a ***groundwater source*** from a well. The requirements set out in these guidelines are not exhaustive. Details of any water system must be reviewed based on the specific conditions of each individual site.

1. This guideline co-ordinates with Northern Health's drinking water treatment objectives:

4	log (99.99%) reduction or inactivation of enteric viruses (using *rotavirus* as target)*
3	log (99.9%) reduction or inactivation of protozoan cysts (including *Giardia* and *Crypto*)*
2	treatment processes (multi-barrier approach)*
1	NTU turbidity maximum*
0	*E. coli* and Total Coliforms

* for groundwater at risk of containing pathogens

2. A valid ***Construction Permit*** is required before any work is started on water systems and application by a qualified professional engineer, experienced in the design of small water systems, is recommended. Applications *may* be accepted from a designer who is *not* a qualified professional under the following circumstances:

   - Designer is knowledgeable and experienced in the water supply field
   - Designer accepts legal liability for water supply system design
   - Small water system, serving fewer than 500 persons in any 24-h period
   - Acceptable source water quality, with no unusual chemistry
   - Standard water treatment equipment proposed, and used in a standard way.

The overall process of approving a ***new*** water supply system is outlined in **Figure 3** on page 5. If you have any questions, please contact an Environmental Health Officer (Drinking Water Officer) at your nearest Health Unit.

2. WATER SOURCE

1. The ***groundwater source*** should be located to minimise the risk of potential contamination or interference with neighbouring water wells. The following minimum setbacks are required:
   - 30 m [100 feet] from any open source of contamination (e.g. septic field, cesspool, manure pile) or existing underground fuel storage tank or facility
   - 120 m [400 feet] from any cemetery or dumping ground
   - 3 m [10 feet] from underground infrastructure containing contamination, (e.g. septic tank, sewer line), or other structure such as a shed, used to store anything hazardous
   - 15 m [50 feet] from water supply wells
   - 15 m [50 feet] from streams, lakes and springs
2. Northern Health does ***not*** require prior approval of well location or well depth at this time, but the water system owner should take into account that shallow wells in an unprotected aquifer will usually be at risk of containing pathogens and so require more treatment than deeper, secure wells.

3. Wells must comply with the Ministry of Environment's *Ground Water Protection Regulation*, including well ID plate, secure cap, wellhead drainage and sanitary survey. A copy of the well construction report (driller's log) is required.
4. All wells must be evaluated to see if the ground water is *at risk of containing pathogens*. Shallow wells, dug wells, wells located near surface water, and wells constructed prior to 2005 are more likely to be at risk, but an individual assessment must be made in every case. For small systems, the water system owner usually completes the initial sanitary survey, and this information is reviewed by Northern Health. If it is determined that the well is at risk, then disinfection or corrective measures are mandatory. Properly constructed wells in a deep, confined aquifer may not be at risk of containing pathogens – for these wells, disinfection is ***optional***, but recommended.
5. Chlorination is recommended, even for secure wells, because ground water may contain pathogenic viruses which UV does not inactivate, and to provide a residual disinfectant to protect water in the distribution system (plumbing).
6. The water system owner must arrange to analyse a sample of raw, untreated water from the well for the suite of water quality parameters listed in **Table 1** on page 6. A list of laboratories approved by the BC Provincial Health Officer for drinking water is available from your Environmental Health Officer at the Health Unit, or on-line: using Google, search for EWQA. Select *Enhanced Water Quality Assurance* and then click on *PHO - Approved Laboratory List*.

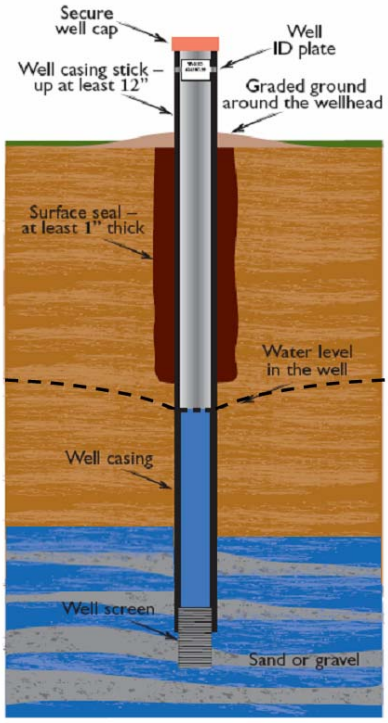

Figure 1. Typical Well

3. PUMPING

1. Backup equipment should be available.
2. A positive pressure [min. 140 kPa (20 psi)] must always be present in the distribution system.

4. FILTRATION

1. Filtration is always recommended, but may not be necessary if turbidity is acceptable (< 1 NTU).
2. A 1 micron (µm) **absolute** filter or membrane filter is needed if filtration is used to reduce the levels of protozoan cysts (*Crypto* and *Giardia*).
3. Disinfection (chlorination) of water is always recommended in addition to filtration.

5. ULTRA VIOLET TREATMENT

1. Ultra-violet (UV) treatment is effective at inactivating or killing pathogenic bacteria, protozoan cysts, and many viruses. Not all pathogenic viruses are inactivated by UV.
2. The UV unit must be certified to meet the NSF 55 Class A standard; this means that the equipment will have a minimum UV dose of 40 mJ/cm^2 at the alarm set point, with built-in sensors and automatic shut off when the dose rate is not achieved.
3. Raw water to be disinfected should have UV Transmittance (UVT) of more than 80%.
4. If the UVT in the raw water is low due to high organic content (TOC), an appropriate ***activated carbon filter*** can usually improve the water quality to the extent that UV treatment is possible. This is not commonly necessary for groundwater sources.
5. Maximum flow rate must be determined and the unit properly sized to meet the demand. In general, a single tap could discharge as much as 8 litres (2 gallons) per minute of water.

6. The safety features that are provided in the UV system should be listed; some of these features may be built-in but some may be external components that have to be installed. Provide a schematic diagram showing all ***mandatory*** features:
    - Flow restriction device
    - UV lamp intensity sensor (mostly built-in)
    - UVT sensor (mostly built-in)
    - Automatic solenoid shut-off when the dose rate is not met or when the unit is unplugged
    - System failure alarms (list the alarms).
7. The assembly ***should*** include the following monitoring devices:
    - Flow meter
    - Pressure gauge at the downstream end of the UV unit.
8. The UV system should usually be installed after the pressure tank or in such a way that the raw water supply pump will be shut off when flow to the UV unit is shut off.
9. A 5 micron filter is required ***before*** the UV unit to protect it.
10. Bypass of the treatment unit is **not** allowed.
11. Whenever the UV unit is not operational, water should not be used for domestic purposes.
12. Chlorination of water is recommended **in addition** to UV treatment, to deal with pathogenic viruses and as part of the multi-barrier approach to drinking water security.

6. Disinfection (Chlorination)

1. Chlorination is effective at killing or inactivating pathogenic bacteria and viruses, but not protozoan cysts.
2. When used for primary disinfection, a 'concentration-time' of at least 12 min·mg/L should be provided. As a general rule, a residual "free chlorine" level of 1 mg/L for 20 minutes in a tank or pipe is recommended.
3. Adequate mixing should be provided; there should be sufficient storage time before the water is used and sufficient distance from the first user in the distribution system.
4. The amount of chlorine added should be metered with a chemical injection pump wired to come on when the well pump is engaged.
5. A chlorine meter or test kit that can measure down to 0.1 mg/L and up to at least 5 mg/L of free chlorine should be available and used on site.

7. Chemical Conditioning

1. Ground water often contains chemicals such as calcium, magnesium, iron, manganese, or sulphide that, while they are not dangerous to human health at normal levels, do affect the taste, odour, and suitability of water for other domestic purposes. In many cases, the aesthetic quality of the finished water can be greatly improved by using filters and ion-exchange resins tailored to the particular water quality issues in the source ground water. Oxygenation or pre-oxidation may also be beneficial for anoxic water from deep wells in confined aquifers. Treatment for these aesthetic parameters is generally ***optional***.
2. Ground water may occasionally contain naturally-occurring chemicals which are hazardous to human health, such as arsenic, lead, or uranium. In other cases, human activities, past or present, may have contaminated ground water with a variety of agricultural or industrial chemicals. In all cases, refer to the ***Guidelines for Canadian Drinking Water Quality*** for advice on the acceptable levels of these parameters. When specific parameters exceed the maximum acceptable concentration in the Canadian guidelines, treatment to reduce the levels of health-based parameters is usually ***mandatory***.

A "typical" treatment train conforming to steps 4 (Filtration), 5 (UV), 6 (Chlorination), and 7 (Chemical Conditioning) is presented in **Figure 2** below. This is a robust approach that works in many instances, but, the actual treatment train should always be tailored to the specifics of the source water chemistry. The specific ***sequence*** of treatment units depends on the water chemistry, and needs to be carefully considered by the water treatment system designer.

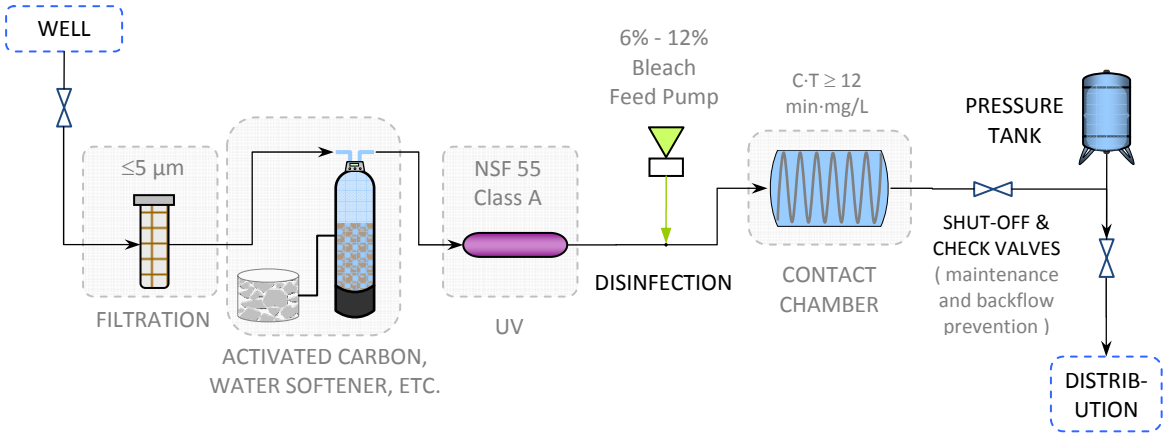

Figure 2. (EXAMPLE ONLY) **Typical Small Water System Ground Water Treatment Train**

8. PERMITTING

1. Under the *Drinking Water Protection Act*, every water system requires an **Operating Permit** before providing water service to users.
2. If this is a <u>new</u> water system, contact your local Environmental Health Officer to obtain the separate **Water System Application**.
3. A **Construction Permit** from Northern Health is required for commissioning of a new water system and also for every structural or mechanical change to an existing water system that may occur over time, but not including routine maintenance.
4. Construction, installation, alteration or extension of any part of a water supply system without a valid Construction Permit is an offence under **s45** of the Act.
5. Complete the submission package checklist included in your ***Waterworks Construction Permit Application***, to avoid delays due to incomplete documentation.
6. Allow 30-60 days lead time from the time an application with complete information is accepted to when your construction permit is issued.

The overall process of approving a ***new*** water supply system is outlined in **Figure 3** below. For ***existing*** water systems, the existing Operating Permit continues in force, so there is no need for a Water System Application, but most of the Construction Permit steps are identical. If you have any questions, please contact your local Environmental Health Officer.

Construction Permit (CP) *contact NH Public Health Engineer (PHE)*		**Operating Permit (OP)** *contact Environmental Health Officer (EHO)*
Steps		
1. IDEA – the owner identifies a need for potable water supply.		
2. SOURCE – the owner decides on a proposed source of water for the system – usually surface water from a lake or stream, or groundwater from a well.	⇦	Owner should contact the EHO to advise on required analyses, sampling protocols, etc.
3. SAMPLES – the owner collects a first sample of water from the source for a complete suite of physical-chemical and bacteriological analyses – this allows an appropriate treatment system to be designed.		At this time, the owner needs to complete a **WATER SYSTEM APPLICATION**
4. DESIGNER – the owner hires a water system design specialist or professional engineering firm.		
5. DRAWINGS – the designer or owner prepares 1. regional location plan, 2. site plan, and 3. treatment system schematic to explain the proposed water system design.		
6. **CONSTRUCTION PERMIT APPLICATION** – the designer or owner applies to Northern Health PHE for a permit for construction of waterworks, together with all construction plans, equipment specifications, and a copy of the source water chemical analyses.		
7. **APPROVAL OF SOURCE** – the EHO reviews the source water chemistry and decides whether it is acceptable. A preliminary assessment of whether the well is ***at risk of containing pathogens*** will also be made and recorded. if treatment is required, reviews proposal in consultation with PHE.	⇦	
8. CONSTRUCTION PERMIT REVIEW – PHE reviews the application against regulatory requirements and Northern Health policy. Allowing for design modifications, this step usually requires 30-60 days.		
CONSTRUCTION PERMIT ISSUED – PHE issues construction permit, with conditions. 		
9. CONSTRUCTION * – installation of treatment, distribution, and storage facilities as per Construction Permit.	⇦	EHO may optionally inspect the works during construction
10. DISINFECTION – following construction, all new or altered works must be disinfected, with lab results from confirmatory samples sent to DWO.	⇨	EHO receives confirmation that the new equipment and distribution pipes are free of bacterial contamination
END OF CONSTRUCTION PERMIT PROCESS		**OPERATIING PERMIT ISSUED – EHO issues operating permit, with conditions.**

The Operating Permit (OP) process for a Water System can move forward in ***parallel*** with the Construction Permit process. For a ***new*** water system, the OP will not usually be issued until the CP process is completed. Key elements in the OP include:

- OPERATOR TRAINING – consistent with the level of complexity of the water system
- ROUTINE SAMPLING – locations, parameters and frequency
- CONTINGENCY & EMERGENCY RESPONSE PLAN

* Permits and approvals from other government agencies may be required before construction may begin.

Figure 3. The Process of Permitting a New Groundwater-Source Water System

Table 1. Required Groundwater Source Water Quality Parameters

Core Parameters	*Guideline*
☑ ***E. Coli***	***[none detected]***
☑ **Total Coliforms**	***[none detected]***
☑ HPC (1)	[~ 100-500 CFU/mL]
☑ Alkalinity	[~30-500 mg/L]
☑ Chloride	[250 mg/L]
☑ Colour	[15 TCU]
☑ Electrical Conductivity	[~800 µS/cm]
☑ **Fluoride**	**[1.5 mg/L]**
☑ Hardness	[~250 mg/L]
☑ Langelier Saturation Index	[~ -2 to +2]
☑ **Metals Scan**	**[varies]** (2)
☑ Nitrogen: (3)	
Ammonia	[~ 1.5 mg/L]
Organic N	[~ 0.5 mg/L]
Nitrate	**[10 mg/L]**
Nitrite	**[1 mg/L]**
☑ Odour	[Describe]
☑ pH	[6.5 – 8.5]
☑ Sulphate	[500 mg/L]
☑ Total Dissolved Solids (TDS)	[~ 500 mg/L]
☑ Total Organic Carbon (TOC)	[2.5 mg/L]
☑ **Turbidity**	**[1-5 NTU]**

May require …	**Guideline**
☐ UV Transmittance (UVT) (4)	[~80%]
☐ **Disinfection By-Products (DBPs)** (5)	
THMs	**[0.100 mg/L]**
HAAs	**[0.080 mg/L]**
☐ Tannins & Lignins (6)	[~ 0.400 mg/L]
☐ Iron & Sulphate Bacteria (7)	[presence]
☐ Sulphide (8)	[0.050 mg/L]
☐ **Hydrocarbons** (9)	
Benzene	**[0.005 mg/L]**
Toluene	**[0.024 mg/L]**
Ethylbenzene	**[0.002 mg/L]**
Xylenes	**[0.300 mg/L]**

General Comments

1. The sampler must make arrangements for receiving and shipping of chemical/physical sample bottles and coolers with an accredited private lab. *Northern Health* may accept bacteriological samples only.
2. Analysis of additional parameters may be required based on the results of the initial analysis and on potential impact by nearby sources of contamination. The required parameters should be confirmed with *Northern Health* before sampling.
3. The analytical detection limit must be *less than 10% of the Guideline for Canadian Drinking Water Quality* where applicable. Other analyses must provide sufficient information to reasonably assess the water suitability for domestic use and to determine what, if any, treatment might be needed. Analyses must be conducted in accordance with the methods prescribed in *Standard Methods* (latest edition).
4. Analyses should be for total or closely equivalent concentrations, to represent potential quality problems.
5. A copy of all analytical results must be sent to the *Northern Health* Officer responsible for the water system.

Notes

(1) May be omitted if bacterial growth is not found during Total Coliform test – lab to note "*Other bacterial growth not present*".

(2) *Total metals* required. *Dissolved metals* optional, but recommended if turbidity is elevated. Scan to include both high and low level metals: *Aluminum (if coagulant used)*, ***Antimony (0.006)***, ***Arsenic (0.010)***, ***Barium (1)***, ***Boron (5)***, ***Cadmium (0.005)***, *Calcium (~100)*, ***Chromium (0.050)***, *Copper (1)*, *Iron (0.300)*, ***Lead (0.010)***, *Magnesium (~30)*, *Manganese (0.050 - **0.500**)*, *Phosphorus*, *Potassium*, ***Selenium (0.010)***, *Sodium (20-200)*, ***Uranium (0.020)***, *Zinc (5)* [expand scan if zone is mineralised to include ***Mercury (0.001)***].

(3) Required for source water characterisation. If all are < 1 mg/L as N, later samples may be analysed for **Total N** only.

(4) Required if UV disinfection is being considered as part of the water treatment process. The test must be conducted on a RAW, UNFILTERED water sample. [Modified version of *Standard Method* 5910B where the sample is not filtered or pH adjusted.]

(5) Required if chlorination is used or proposed and TOC>2.5 mg/L. For new sources, specify "*DBP **formation potential***". Different DBPs are required for chlorine dioxide or ozone disinfection.

(6) Required for TOC>2.5 mg/L and/or Colour>15 TCU.

(7) Required if bacterial regrowth is suspected in well or distribution piping. Contact laboratory for sampling procedure.

(8) Required if unsatisfactory odour is suspected. Analyse on site or preserve sample. Contact laboratory for sampling procedure.

(9) Required if hydrocarbon/gasoline type contamination is suspected. Contact laboratory for sampling procedure.

Colours: **red → health parameter**, violet → aesthetic, black → treatment options