Irrigation
FACTSHEET

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GUIDE TO IRRIGATION SYSTEM DESIGN WITH RECLAIMED WATER

This guide is to provide a reference for the design of irrigation systems in British Columbia using reclaimed water in accordance with the Municipal Sewage Regulation (MSR). Irrigation systems can be used to apply reclaimed water to landscape and agricultural crops in regions with a moisture deficit during the growing season, for frost protection in the spring and fall, and crop cooling purposes during the hot part of the summer. The general philosophy is that the irrigation system shall be designed and operated to make beneficial use of reclaimed water, as opposed to disposal in a watercourse or to ground. This philosophy is necessary to prevent excessive irrigation and subsequent negative impact on the irrigated lands and lands down-gradient from them.

Reclaimed Water Use

Schedule 2 of the MSR outlines the permitted uses and standards for reclaimed water use. The water quality parameters and use categories for irrigation extracted from Schedule 2 of the MSR are shown in Table 1. For a complete Schedule 2 and the appended explanatory notes see the MSR. The two standards for reclaimed water are:

Category 1
"*Restricted Public Access*" – means that the reclaimed water quality is of a quality that the public is to be restricted from having access to the irrigated lands or contact with the reclaimed water both during actual reclaimed water application or use and thereafter.

Category 2
C"*Unrestricted Public Access*" – means that the reclaimed water quality is of sufficiently high quality that public access to areas that are irrigated with reclaimed water or contact with the reclaimed water is allowed as prescribed in the MSR and the Code of Practice for the Use of Reclaimed Water.

Table 1 – Permitted Uses for Irrigation with Reclaimed Water

Excerpted from Schedule 2 of the MSR – Permitted Uses and Standards for Reclaimed Water			
Category 1 - Unrestricted Public Access			
Permitted Uses for Irrigation	Treatment Requirements	Effluent Quality Requirements	Monitoring Requirements
Agriculture Food crops eaten raw Orchards and Vineyards Seed Crops Frost Protection Crop Cooling Pasture (no lag time for - animal grazing) **Urban and Landscape** Parks Playgrounds Cemeteries Golf Courses Road Right of Ways School Grounds Residential Lawns Landscape around buildings Greenbelts	Secondary Chemical Addition Filtration Disinfection Emergency Storage	pH = 6 – 9 $\leq$ 10 mg/L BOD_5 $\leq$ 2 NTU number of fecal coliform organisms $\leq$ 2.2/100ml Provider must demonstrate that reclaimed water does not contain pathogens or parasites at levels that are of concern to health authorities. Levels for metal and nutrient concentrations are governed by crop limitations at various growth stages where applicable.	pH – weekly BOD – weekly Turbidity – continuous Coliform - daily
Category 2 - Restricted Public Access			
Permitted Uses for Irrigation	Treatment Requirements	Effluent Quality Requirements	Monitoring Requirements
Agriculture Commercially processed food crops Trickle/Drip for Orchards and Vineyards Fodder and Fibre Nursery and Sod farms Silviculture Pasture (with a 6 day lag time for milking animals and 3 days for other cattle grazing) Spring Frost Protection **Urban and Landscape** Parks Golf Courses School Grounds	Secondary Disinfection Remote areas of parks, school grounds during vacation periods, and golf courses can be considered under the restricted access category provided a minimum of 60 days storage is provided, concerns of local health authorities are resolved, the manager is satisfied that access is controlled and the use is approved in writing by the manager and health.	pH = 6 – 9 $\leq$ 45 mg/L BOD_5 $\leq$ 45 mg/L TSS number of fecal coliform organisms $\leq$ 200/100ml Levels for metal and nutrient concentrations are governed by crop limitations at various growth stages where applicable. Setback from a potable well must be > 30 m. Spray drift must not exceed boundaries of property where reclaimed water is being applied and drift must not reach areas that are accessible to the public	pH – weekly BOD – weekly TSS – daily Coliform - weekly

System Selection

Various types of irrigation systems can be selected for use with reclaimed water. For reclaimed water use allowing unrestricted public access any type of sprinkler or drip system can be used on agricultural crops. Pop-up sprinkler and spray heads or drip/trickle systems may be used on turf and landscape areas. For reclaimed water that has a restricted public access designation, sprinkler irrigation systems may be used on forage crops but only trickle or drip systems may be used for orchard or vineyard crops. Vegetable crops must be irrigated with subsurface drip systems.

The irrigation system types that are commonly used for reclaimed water application are:

- **Handline** – Aluminum pipes that are moved by hand from one set to the next. Lateral pipe sizes are commonly in the 2" to 3" range.
- **Wheelmove** – Heavy gauge 4" or 5" aluminum pipe mounted on wheels with a motorized mover located at the center of the lateral. Lateral lengths are generally ¼ of a mile. Generally used for forage systems.
- **Solid Set Sprinkler** – Laterals are permanently installed underground or on a trellis. Lateral spacing is matched to sprinkler performance. Microsprinkler systems will have the laterals spaced closer together while the larger more conventional sprinklers can be spaced up to 60 feet apart. These systems are often used on nurseries and horticulture systems such as tree fruits, grapes and vegetables. In tree fruits the sprinklers can be installed either overtree or undertree.
- **Pop-up Sprinkler or Spray Systems** – These systems consist of sprinklers (rotors) and spray heads located inside a case that is installed at ground level. When the system is turned on the head pops up above ground to irrigate.
- **Stationary Gun** – Gun systems are referred to as high volume sprinklers with flow rates that exceed 100 gpm, usually in the 150 – 350 gpm range. Flow rates can go as high as 1000 gpm. Stationary guns are mounted on tripods and must be moved by hand.
- **Travelling Gun** – Gun systems that are mounted on a travelling machine. A 2" - 5" hard or soft hose is attached to the gun cart to supply irrigation water.
- **Center Pivot** – A lateral mounted on a truss system that travels in a circle about a pivot point. Sprinkler sizes can range from spray heads to larger conventional sprinklers. Sprinklers can be mounted at the truss or on dropper tubes.
- **Drip Systems** – Emitters are installed on low density polyethylene tubing to reduce the flow rate at the emission point to 2 – l/hr. Drip systems can be suspended on a trellis, laid on the ground or buried below ground.
- **Trickle Systems** – Trickle systems use emitters that apply water in a spray pattern to enhance the moisture distribution through the soil profile.

System management is also a major consideration. The application rate of stationary guns is usually very high, requiring the system to be moved every four to six hours if the available soil water storage capacity is not to be exceeded. These systems are not considered to be practical unless there is sufficient labour available at all times.

Some systems may be better suited to certain crops than others. Travelling gun and center pivot systems can irrigate mature corn crops much easier than handline or wheelmove systems. For tree and vine crops drip/trickle irrigation or solid set sprinklers are the best choices.

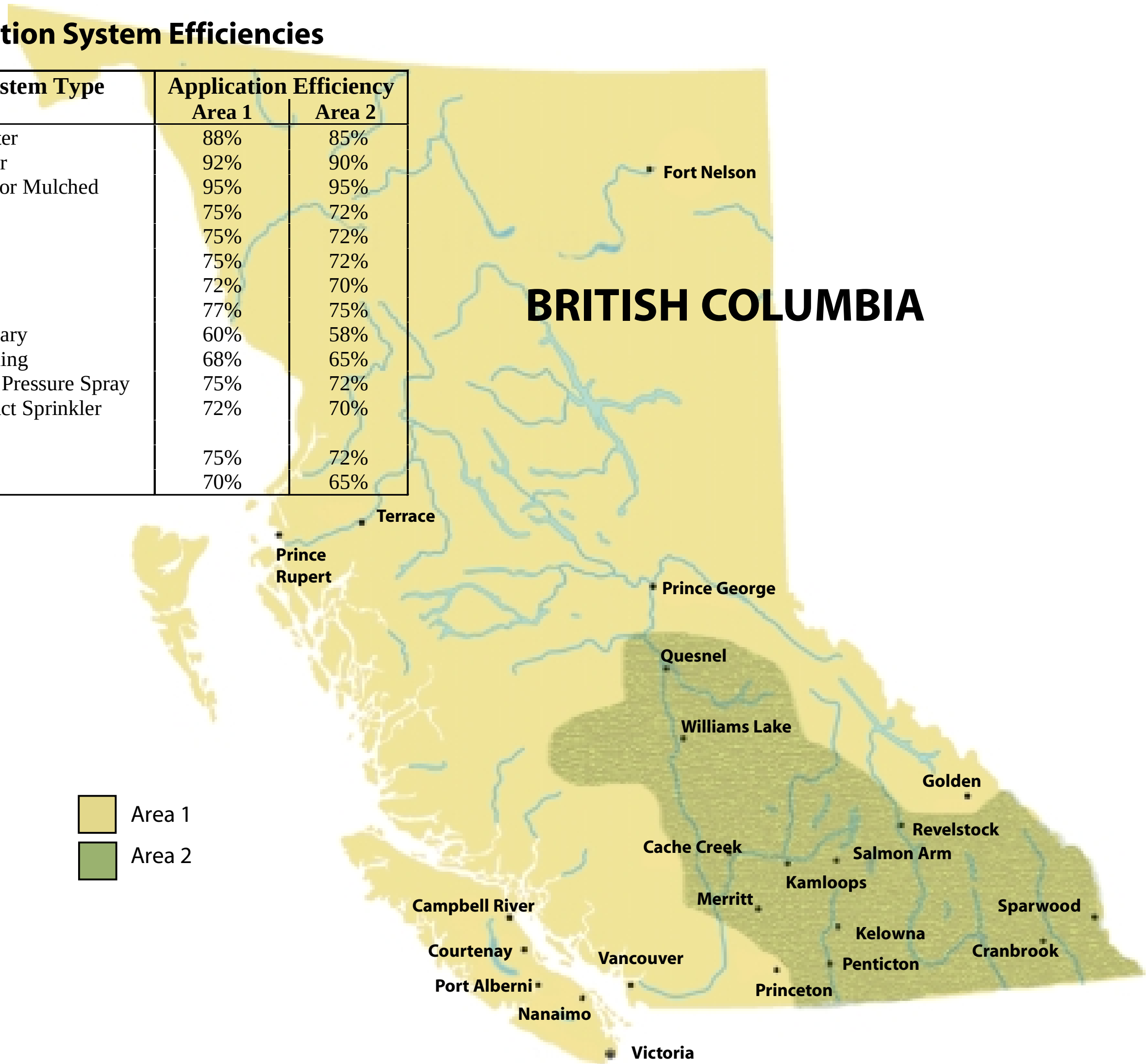
Application Efficiency

Irrigation system efficiency should be considered when selecting a system for reclaimed water application. The range of application efficiencies can vary quite dramatically depending on system type, crop irrigated, climate, and weather conditions at the time of irrigation. Table 2 provides a guide as to the maximum irrigation application efficiencies that are possible for the areas shown in Figure 1. Actual efficiencies may be less depending on system design, maintenance and operation. Efficient systems will require more land base for reclaimed water application than inefficient systems.

Further information on irrigation system selection and design can be found in the B.C. Sprinkler Irrigation Manual and the B.C. Trickle Irrigation Manual available from the Irrigation Industry Association of British Columbia.

Table 2 Irrigation System Efficiencies

Irrigation System Type	Application Efficiency	
	Area 1	Area 2
Trickle Spray Emitter	88%	85%
Trickle Drip Emitter	92%	90%
Trickle Subsurface or Mulched	95%	95%
Handmove	75%	72%
Wheelmove	75%	72%
Solid set undertree	75%	72%
Solid set overtree	72%	70%
Microsprinkler	77%	75%
Giant Gun - Stationary	60%	58%
Giant Gun - Travelling	68%	65%
Center Pivot - Low Pressure Spray	75%	72%
Center Pivot - Impact Sprinkler	72%	70%
Landscape		
Rotary Sprinklers	75%	72%
Spray Heads	70%	65%



Irrigation Design Considerations

The objective, when designing an irrigation system for the application of reclaimed water, is to ensure that the crop water consumption is maximized. The amount applied must not exceed the soil limitations that exist. For sprinkler irrigation systems the soil texture and corresponding water holding capacity will determine the rate and amount of water that can be applied during an irrigation interval. Irrigation applications in excess of the soil's infiltration rate will cause surface run off. Exceeding the soil water holding capacity will cause percolation out the bottom of the soil profile to groundwater. Each irrigation application must therefore be matched to the water holding capacity of the soil within the plant's rooting depth. The maximum soil water deficit (MSWD) is a term used to describe the maximum amount of water that can be stored by the soil within the plant's rooting depth. See the B.C. Sprinkler Irrigation Manual for further information on MSWD.

Design Application Rates

The rate that water infiltrates into the soil surface is determined by soil texture, soil structure, ground slope and type of ground cover. The irrigation system design application rate must be limited to the infiltration capability of the soil. (See B.C. Sprinkler Irrigation Manual). For reclaimed effluent systems where the ground slope exceeds 20%, the irrigation system application rate should be less than 75% of the maximum allowable design application rates. A drip system may be a viable alternative in these situations.

Evapotranspiration Rates

The irrigation system must be designed using the process outlined in the B.C. Sprinkler Irrigation Manual or the B.C. Trickle Irrigation Manual. Peak E.T. values should be used to ensure that the irrigation system is capable of supplying the daily crop water needs during the peak of the season.

Determining Reclaimed Water Irrigation Requirements in British Columbia

A reclaimed water system usually generates the same volume of water annually. An increase in reclaimed water supply will be gradual as the population of the service area slowly increases. However the amount of water required by a crop will vary from one season to another. In wetter seasons irrigation will be less frequent as it will take longer for the MSWD to be depleted. Hot dry seasons will allow more frequent irrigation applications as the MSWD will be depleted more quickly. To determine the land base that can be irrigated on an average year, the average seasonal irrigation requirement must be determined. Determining the land base using average seasonal irrigation requirements will ensure that for most years there is sufficient land available. The ***average seasonal irrigation requirement*** is used to determine the land base area needed to accept the annual amount of reclaimed water produced each year. In drier years more can be applied and on wetter years less. Storage will be required to buffer the climatic variations, and to carry over the excess effluent from wetter seasons to drier seasons. (See next section on storage calculation.)

In the late 70's and early 80's the Air Management Branch, British Columbia Ministry of Environment did an analysis of the average seasonal irrigation requirement for 78 locations in British Columbia. The values shown in Table 5 are calculated based on empirical relationships developed from average seasonal irrigation requirements reported by Coligado, Baier and Sly in the Agriculture Canada series of bulletins entitled "Risk Analysis of Weekly Climatic Data for Agricultural and Irrigation Planning". These values, when adjusted for leaching requirement and irrigation system application efficiency, should be used for determining the crop land area required for the application of reclaimed water.

To determine the average seasonal irrigation requirement the crop rooting depth and available water storage capacity of the soil must be known.

Crop Rooting Depth

Plants derive most of their water requirements from the upper portions of the root zone. For most plants the effective rooting depth is less than the maximum depth of the plant's root development. The effective rooting depth is dependent on soil texture, subsoil formations, water table limitations, cultural practices and soil fertility.

The rooting depths in Table 3 can be used providing the water table depth and soil conditions do not limit the crop rooting depth.

Soil Texture

Soil texture has important influences on the selection of crops, choices on farming practices, planning of the distribution system and the irrigation system type to be used. Soil texture also governs the water holding capacity and infiltration rate of the soil. The soils to be irrigated require a thorough investigation and attention in developing irrigation plans. The texture of the soil is determined by the content of sand, silt and clay. (See Figure 1)

Available Water Storage Capacity

Forms of soil moisture are classified as hygroscopic water, gravity water and capillary water. Hygroscopic water is taken into the pores of soil mineral particles or attached as thin films to their surfaces. It is not available to plants. Gravity water is readily taken down through pore spaces in the soil by the force of gravity. Capillary water is held in the small pores by capillary forces and is the principal source of water used by plants. The AWSC is the amount of water stored in the soil between field capacity and the permanent wilting point. The capacity of the soil to store water depends on the soil texture and structure. To approximate the AWSC of a soil it is necessary to determine the texture of the soil. Table 4 provides a guide to AWSC for various soil textures.

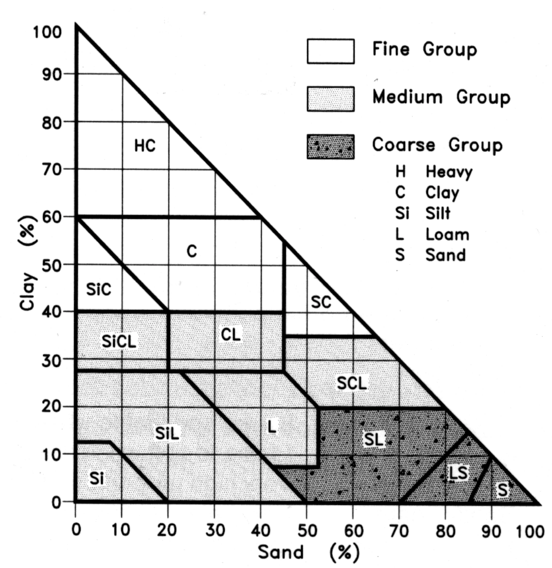


Figure 1 Soil Texture Triangle

Table 3 Effective Rooting Depths for Various Crops

Shallow 0.45 m (1 ½ ft)	**Medium Deep** 0.90 m (3 ft)	**Deep** 1.20 m (4 ft)
Blueberries	Brussels Sprouts	Alfalfa
Cucumber	Cereals	Asparagus
Cabbage	Red Clover	Field Corn
Ladino Clover	Corn (Sweet)	Grapes
Lettuce	Eggplant	Raspberries
Pasture Species	Kiwifruit	Tree Fruits
Potatoes	Peppers	
Tomatoes	Squash	
Strawberries	Tree Fruits (smaller root stocks)	

(from B.C. Sprinkler Irrigation Manual)

Table 4 Guide to AWSC for Soil Textures

Soil Texture	**AWSC**	
	mm/m	**in./ft.**
Sand	85	1.0
Loamy Sand	100	1.2
Sandy Loam	125	1.5
Fine Sandy Loam	140	1.7
Loam	175	2.1
Silt Loam	210	2.5
Clay Loam	200	2.4
Clay	200	2.4

(from B.C. Sprinkler Irrigation Manual)

Table 5 Availability Coefficient

Crop	**Availability Coefficient Maximum percent**
Peas	35
Potatoes	35
Tree Fruits	40
Grapes	40
Tomatoes	40
Forages	50
Other Crops	50

(from B.C. Sprinkler Irrigation Manual)

Moisture Availability Coefficient

Water is not equally available to plants over the AWSC soil moisture range. Different crops will have varying capabilities of drawing moisture out of the soil. Only a portion of the AWSC is readily available to the plant. Table 5 provides a guide to the availability coefficient that should be used. Allowing the soil moisture to deplete below levels that are determined by the availability coefficient may result in reduced water use and reduced yields.

Maximum Soil Water Deficit

The maximum soil water deficit (MSWD) is a term used to describe the maximum amount of water that can be stored by the soil within the plant's rooting depth. The following example illustrates how to calculate MSWD.

Maximum Soil Water Deficit Calculation

An alfalfa crop is growing in a deep loam soil.
Calculate the MSWD.

Rooting Depth - From Table 3 - Alfalfa crop = 1.2 m

Soil Storage - From Table 4 – Loam soil = 175 mm/m

Availability Coefficient – From Table 5 = 0.5

AWSC = 1.2 m x 175 mm/m = 210 mm.

MSWD = AWSC x Availability Coefficient

= 210 mm x 0.50 = 105 mm

Average Seasonal Irrigation Requirement

The MSWD can now be used to determine the average seasonal irrigation requirement (IR) from Table 6 for many locations throughout British Columbia. Care should be taken to ensure that the location of the reclaimed water use site is close to where the weather station data will have been taken. Changes in elevation, northern versus southern exposure can make a significant difference.

For example: If reclaimed water were to be used to irrigate alfalfa in a loam soil near Kamloops, (along the Thompson River or in the valley bottom) the average seasonal irrigation requirement will be:

MSWD = 100 mm

Table 6 - Kamloops for 100 mm MSWD the IR
= 379 mm (14.9 in).

Table 6 Average Seasonal Irrigation Requirements in British Columbia

	Irrigation Requirement (IR) for MSWD of					
Location	13 mm (0.5 in)	25 mm (1 in)	50 mm (2 in)	75 mm (3 in)	100 mm (4 in)	125 mm (5 in)
Abbotsford	206 mm (8.1 in)	174 mm (6.9 in)	123 mm (4.8 in)	94 mm (3.7 in)	64 mm (2.5 in)	41 mm (1.6 in)
Aberfeldie	247 (9.7)	219 (8.6)	173 (6.8)	145 (5.7)	118 (4.6)	93 (3.7)
Agassiz	195 (7.7)	157 (6.2)	100 (3.9)	69 (2.7)	35 (1.4)	14 (0.6)
Alberni	286 (11.3)	261 (10.3)	219 (8.6)	190 (7.5)	164 (6.5)	139 (5.5)
Alta Lake	208 (8.2)	176 (6.9)	125 (4.9)	95 (3.8)	66 (2.6)	43 (1.7)
Ashcroft	424 (16.7)	407 (16.0)	370 (14.6)	340 (13.4)	314 (12.4)	289 (11.4)
Baldonnel Ft. St. John	246 (9.7)	218 (8.6)	172 (6.8)	144 (5.7)	117 (4.6)	92 (3.6)
Babine Lake	206 (8.1)	173 (6.8)	122 (4.8)	93 (3.7)	63 (2.5)	40 (1.6)
Barkerville	230 (9.1)	201 (7.9)	154 (6.1)	125 (4.9)	98 (3.8)	73 (2.9)
Beatton River	208 (8.2)	175 (6.9)	124 (4.9)	95 (3.8)	66 (2.6)	43 (1.7)
Big Creek	256 (10.1)	229 (9.0)	184 (7.2)	155 (6.1)	129 (5.1)	104 (4.1)
Bralorne	263 (10.4)	237 (9.3)	193 (7.6)	164 (6.5)	138 (5.4)	113 (4.5)
Carmi	238 (9.4)	210 (8.3)	163 (6.4)	135 (5.3)	108 (4.2)	83 (3.3)
Chilliwack	195 (7.7)	160 (6.3)	104 (4.1)	74 (2.9)	42 (1.6)	20 (0.8)
Comox	251 (9.9)	224 (8.8)	178 (7.0)	150 (5.9)	123 (4.9)	98 (3.9)
Cowichan Lake	276 (10.9)	251 (9.9)	207 (8.2)	179 (7.0)	153 (6.0)	127 (5.0)
Cranberry (Valemont)	275 (10.8)	250 (9.8)	207 (8.1)	178 (7.0)	152 (6.0)	127 (5.0)
Cranbrook	350 (13.8)	329 (12.9)	289 (11.4)	260 (10.3)	235 (9.3)	209 (8.2)
Creston	359 (14.1)	338 (13.2)	299 (11.8)	270 (10.6)	245 (9.6)	219 (8.6)
Cumberland	276 (10.9)	251 (9.9)	207 (8.2)	179 (7.0)	153 (6.0)	128 (5.0)
Dease Lake	206 (8.1)	174 (6.8)	122 (4.8)	93 (3.7)	63 (2.5)	40 (1.6)
Dog Creek	233 (9.2)	204 (8.0)	157 (6.2)	128 (5.0)	100 (4.0)	76 (3.0)
Dome Lake	235 (9.2)	206 (8.1)	159 (6.3)	130 (5.1)	103 (4.1)	79 (3.1)
Fauquier	282 (11.1)	257 (10.1)	214 (8.4)	186 (7.3)	160 (6.3)	135 (5.3)
Fernie	233 (9.2)	204 (8.0)	156 (6.2)	128 (5.0)	100 (4.0)	76 (3.0)
Ft. Nelson	205 (8.1)	173 (6.8)	121 (4.8)	92 (3.6)	62 (2.4)	39 (1.5)
Ft. St. James	233 (9.2)	204 (8.0)	157 (6.2)	128 (5.0)	101 (4.0)	76 (3.0)

Table 6 Average Seasonal Irrigation Requirements in British Columbia

	Irrigation Requirement (IR) for MSWD of					
Location	13 mm (0.5 in)	25 mm (1 in)	50 mm (2 in)	75 mm (3 in)	100 mm (4 in)	125 mm (5 in)
Germansen Landing	221 (8.7)	190 (7.5)	142 (5.6)	113 (4.4)	85 (3.3)	61 (2.4)
Golden	285 (11.2)	261 (10.3)	218 (8.6)	189 (7.5)	164 (6.4)	138 (5.4)
Hedley	382 (15.0)	362 (14.3)	324 (12.8)	295 (11.6)	269 (10.6)	244 (9.6)
Hope	204 (8.0)	171 (6.7)	120 (4.7)	90 (3.6)	60 (2.4)	37 (1.5)
Horsefly Lake	196 (7.7)	161 (6.3)	106 (4.2)	76 (3.0)	44 (1.7)	22 (0.9)
Hudson Hope	232 (9.1)	203 (8.0)	155 (6.1)	127 (5.0)	99 (3.9)	75 (3.0)
Joe Rich Creek	271 (10.7)	245 (9.7)	201 (7.9)	173 (6.8)	147 (5.8)	122 (4.8)
Kamloops	486 (19.2)	471 (18.6)	436 (17.2)	406 (16.0)	379 (14.9)	354 (13.9)
Kaslo	250 (9.8)	222 (8.8)	177 (7.0)	148 (5.8)	122 (4.8)	97 (3.8)
Kelowna	425 (16.7)	407 (16.0)	370 (14.6)	341 (13.4)	315 (12.4)	289 (11.4)
Keremeos	485 (19.1)	470 (18.5)	434 (17.1)	404 (15.9)	377 (14.9)	352 (13.9)
Kimberly	349 (13.7)	328 (12.9)	289 (11.4)	260 (10.2)	234 (9.2)	209 (8.2)
Kleena Kleene	288 (11.3)	263 (10.4)	221 (8.7)	192 (7.6)	166 (6.6)	141 (5.6)
Lytton	449 (17.7)	433 (17.0)	397 (15.6)	367 (14.4)	341 (13.4)	315 (12.4)
McBride	311 (12.3)	288 (11.3)	247 (9.7)	218 (8.6)	193 (7.6)	167 (6.6)
McCulloch	245 (9.7)	218 (8.6)	172 (6.8)	143 (5.6)	117 (4.6)	92 (3.6)
Merritt	403 (15.9)	384 (15.1)	347 (13.7)	317 (12.5)	292 (11.5)	266 (10.5)
Nanaimo	247 (9.7)	219 (8.6)	174 (6.8)	145 (5.7)	118 (4.7)	94 (3.7)
New Hazelton	217 (8.5)	186 (7.3)	137 (5.4)	108 (4.3)	79 (3.1)	56 (2.2)
Okanagan Centre	385 (15.2)	366 (14.4)	328 (12.9)	299 (11.8)	273 (10.8)	248 (9.8)
Oliver	504 (19.9)	490 (19.3)	455 (17.9)	425 (16.7)	398 (15.7)	373 (14.7)
150 Mile House	257 (10.1)	231 (9.1)	186 (7.3)	157 (6.2)	131 (5.2)	106 (4.2)
Pemberton Meadows	290 (11.4)	265 (10.4)	223 (8.8)	194 (7.6)	169 (6.6)	143 (5.6)
Penticton	452 (17.8)	436 (17.2)	400 (15.7)	370 (14.6)	344 (13.5)	318 (12.5)
Powell River	221 (8.7)	190 (7.5)	142 (5.6)	113 (4.4)	85 (3.3)	61 (2.4)
Prince George	218 (8.6)	188 (7.4)	138 (5.5)	122 (4.4)	84 (3.3)	58 (2.3)
Princeton	398 (15.7)	279 (14.9)	342 (13.5)	312 (12.3)	287 (11.3)	261 (10.3)

Table 6 Average Seasonal Irrigation Requirements in British Columbia

	Irrigation Requirement (IR) for MSWD of					
Location	13 mm (0.5 in)	25 mm (1 in)	50 mm (2 in)	75 mm (3 in)	100 mm (4 in)	125 mm (5 in)
Quesnel	231 (9.1)	202 (7.9)	154 (6.1)	126 (4.9)	98 (3.9)	74 (2.9)
Revelstoke	211 (8.3)	180 (7.1)	129 (5.1)	100 (3.9)	71 (2.8)	48 (1.9)
Rossland	289 (11.4)	265 (10.4)	222 (8.8)	194 (7.6)	168 (6.6)	143 (5.6)
Saanichton	274 (10.8)	249 (9.8)	205 (8.1)	177 (7.0)	151 (5.9)	125 (4.9)
Salmon Arm	308 (12.1)	285 (11.2)	243 (9.6)	215 (8.5)	189 (7.5)	164 (6.5)
Saltspring Island	269 (10.6)	243 (9.6)	199 (7.9)	171 (6.7)	145 (5.7)	120 (4.7)
Shawnigan Lake	317 (12.5)	295 (11.6)	254 (10.0)	225 (8.9)	200 (7.9)	174 (6.9)
Sinclair Pass	212 (8.4)	181 (7.1)	131 (5.2)	102 (4.0)	73 (2.9)	49 (1.9)
Smithers	235 (9.3)	206 (8.1)	159 (6.3)	131 (5.1)	103 (4.1)	79 (3.1)
Summerland	423 (16.7)	405 (16.0)	369 (14.5)	339 (13.4)	313 (12.3)	288 (11.3)
Tappen	335 (13.2)	314 (12.3)	273 (10.8)	245 (9.6)	219 (8.6)	194 (7.6)
Tatlayoko Lake	289 (11.4)	265 (10.4)	222 (8.7)	193 (7.6)	168 (6.6)	142 (5.6)
Telkwa	222 (8.7)	192 (7.5)	143 (5.6)	114 (4.5)	86 (3.4)	62 (2.5)
Terrace	199 (7.9)	166 (6.5)	113 (4.4)	83 (3.3)	52 (2.1)	30 (1.2)
Vananda	214 (8.4)	182 (7.2)	133 (5.2)	104 (4.1)	75 (2.9)	51 (2.0)
Vancouver Airport	239 (9.4)	210 (8.3)	164 (6.4)	135 (5.3)	108 (4.3)	83 (3.3)
Vanderhoof	227 (8.9)	197 (7.8)	149 (5.9)	121 (4.8)	93 (3.7)	69 (2.7)
Vavenby	308 (12.1)	284 (11.2)	243 (9.6)	214 (8.4)	189 (7.4)	163 (6.4)
Vernon Coldstream	328 (12.9)	306 (12.1)	266 (10.5)	237 (9.3)	212 (8.3)	186 (7.3)
Victoria	358 (14.1)	338 (13.3)	299 (11.8)	270 (10.6)	244 (9.6)	219 (8.6)
Westwold	381 (15.0)	362 (14.2)	232 (12.7)	294 (11.6)	269 (10.6)	243 (9.6)
White Rock	216 (8.5)	185 (7.3)	136 (5.3)	107 (4.2)	78 (3.1)	55 (2.2)
Williams Lake	208 (8.2)	176 (6.9)	126 (4.9)	96 (3.8)	67 (2.6)	44 (1.7)
Wistaira	226 (8.9)	196 (7.7)	148 (5.8)	120 (4.7)	92 (3.6)	68 (2.7)

Calculation of the Leaching Requirement

In order to prevent salt accumulation in the soil, it is necessary in the design of an irrigation system using reclaimed water to allow a net leaching of water through the soil profile. The seasonal LEACHING REQUIREMENT can be approximated using the technique outlined in the Food and Agriculture Organization of the United Nations publication "Guide for Predicting Crop Water Requirements". The leaching requirement (LR) is expressed as a fraction of the irrigation requirement.

$$LR = \frac{EC_{irr}}{4}$$

where: EC_{irr} is the electrical conductivity of the irrigation water expressed in mmhos.

Data on the electrical conductivity of irrigation waters in British Columbia is available from the Agriculture Canada publication "Suitability for Irrigation of Water from Lakes and Streams in the Southern Interior of British Columbia". Electrical conductivity of sewage effluent would have to be determined by laboratory analysis. Unless the electrical conductivity of the effluent exceeds 1.0 mmhos, an assumed leaching requirement of 20% (LR = 0.2) is sufficient.

An example of the leaching requirement calculation can be considered using a hypothetical electrical conductivity of the irrigation effluent water EC_{irr} = 1.2 mmhos.

Therefore the leaching requirement can be calculated as:

$$LR = \frac{EC_{irr}}{4} = \frac{1.2}{4} = 0.3$$

Calculation of the average seasonal irrigation requirement including the need for leaching water (IR_o) is done as follows:

$$IR_o = \frac{IR}{1-LR}$$

If this effluent was to be used to grow alfalfa on a loam soil in the Kamloops area (see earlier example) then the average seasonal irrigation requirement including leaching will be:

$$IR = 379 \text{ mm}$$

$$IR_o = \frac{379}{1-0.3} = 541 \text{ mm}$$

Application Efficiency

The irrigation system application efficiency accounts for water losses due to spray drift and evaporation from the crop and soil surface. The efficiency varies due to the sprinkler type, nozzle size and operating pressures, prevalent wind, temperature and humidity conditions. The application efficiencies shown in Table 2 can be used in the calculation below.

The following formula can be used to calculate the average seasonal irrigation requirement including the application efficiency (IR_{Tot}).

$$IR_{Tot} = \frac{IR_o}{AE}$$

Continuing the earlier example, the alfalfa crop in the Kamloops area with an effluent electrical conductivity of 1.2 mmhos is irrigated with a wheelmove system. From Table 2 an irrigation application efficiency of 72% is determined. The IR_{Tot} is then calculated as:

$$IR_{Tot} = \frac{541}{0.72} = 751 \text{ mm}$$

Storage

Reclaimed water storage is required for three conditions:

§ Irrigation Purposes – for times when the method of application is not continuous. In the case of irrigation, storage will be required during the non growing season. Schedule 7, note 6 of the MSR outlines design standards and storage requirements for the use of reclaimed water with irrigation. The methodology for determining storage capacity is provided here.

§ Normal Balancing (Seasonal) Storage – for times when normal reclaimed water production exceeds reclaimed water usage (particularly for the winter non-irrigation season).

§ Emergency Storage – for times when reclaimed water usage is inadvertently interrupted.

Irrigation Storage

For irrigation the storage facility must be large enough to contain the design average daily reclaimed water flow occurring outside the annual normal irrigation period. The normal irrigation period is defined as the number of days in the year when irrigation is required due to a climatic moisture deficit occurring during the growing season. It is estimated from the length of the normal growing season, climatic trends, the annual climatic moisture deficit and knowledge of irrigation periods in British Columbia. Table 7 provides information on the normal growing season, climatic moisture deficit and estimated normal irrigation period for various regions in the province of British Columbia.

Wet Climates

The storage facility may also have to take into account an allowance for cumulative volumes of reclaimed water due to reduced irrigation because of wet weather. If the average seasonal irrigation requirements are used to determine the irrigation area this will not be necessary. If the land base area is not sufficient to accommodate the average seasonal irrigation requirement, the cumulative volume of 5 years of wet weather for a 5 year return period should be added to storage.

Restricted Public Access

In addition, for restricted public access the number of irrigation days may be reduced due to the grazing of animals or harvesting of crops. See schedule 7, item 6.3b of the MSR. If the irrigated site is large enough to allow for the rotation of irrigation applications to accommodate the requirements for restricted public access there will not be additional implications on storage. If not the reduced number of irrigation days due to cattle grazing or irrigation system management must be subtracted from the normal irrigation period shown in Table 7.

Frost Protection

The use of reclaimed water for frost protection will not effect the storage size calculation. While frost protection is an acceptable use and may allow for reclaimed water use earlier in the spring or later in the fall than normal irrigation, frosts cannot be predicted in advance and can therefore not be relied upon every year.

Example Storage Calculation

Reclaimed water is to be used for irrigation of agricultural crops from a development in the South Okanagan. The average daily reclaimed water flow is 100,000 gallons per day. *What storage size is required if there is no alternative discharge?*

From Table 7, the normal irrigation period for Osoyoos
= 150 days.

The storage facility must therefore store:
365 days – 150 days = 215 days of effluent.

$$\frac{215 \text{ days x } 100{,}000 \text{ gallons/day}}{325830 \text{ gallons/ ac- ft}} = 66 \text{ acre feet.}$$

Table 7 Guide to the Normal Irrigation Period for B.C. Locations

Location	*Normal Growing Season (days)	*Climatic Moisture Deficit (mm)	+Normal Irrigation Period (days)
Abbotsford	169	98	140
Armstrong	119	387	120
Ashcroft	143	395	150
Big Creek	41	235	90
Comox	179	174	140
Cranbrook	91	353	110
Creston	148	287	140
Dease Lake	44	81	90
Duncan	164	304	140
Elko	131	200	120
Fernie	98	128	110
Ft. Nelson	104	24	100
Ft. St. James	76	124	90
Ft. St. John	55	34	90
Golden	103	359	100
Grand Forks	121	441	140
Greenwood	90	420	100
Hedley	148	399	150
Heffley Creek	108	327	120
Kamloops	152	444	140
Kelowna	151	350	140
Keremeos	184	427	160
Kimberley	92	377	110
Lytton	185	427	160
Okanagan Centre	170	354	140
Oliver	137	498	140
Osoyoos	179	391	150
Penticton	142	421	140
Prince George	78	68	90
Princeton	99	414	90
Quesnel	98	165	90
Revelstoke	140	176	110
Saanichton	226	202	140
Salmon Arm	147	282	120
Smithers	52	180	90
Steveston	172	177	140
Summerland	174	382	140
Terrace	155	29	90
Valemont	73	234	75
Vernon	153	295	140
Westwold	90	377	110
Williams Lake	101	157	100

* From RAB Technical Paper 1 - Climatic Capability Classification for Agriculture in British Columbia
Normal Growing Season is taken as the Frost Free Period

+ Estimated from Normal Growing Season and the Climatic Moisture Deficit

References

The following manuals should be used as a reference for the design of irrigation systems.

The B.C. Sprinkler Irrigation Manual	From: Irrigation Industry Association of British Columbia
The B.C. Trickle Irrigation Manual	Irrigation Industry Association of British Columbia
B.C. Frost Protection Guide	B.C. Ministry of Agriculture and Food
Chemigation Guidelines for British Columbia	B.C. Ministry of Agriculture and Food

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