**DETERMINING ACTUAL ANNUAL WATER USE OF TRICKLE IRRIGATION SYSTEMS**

Knowing the actual annual water use of an irrigation system will help to develop an effective irrigation schedule that meets the climate, crop and soil requirements. Some irrigation licences may state a water withdrawal rate; therefore, the actual annual water use must not exceed the licensed amount. The annual water use is based on peak flow rate and annual crop water requirement which vary depending on:

1. crop type
2. soil type
3. rooting depth
4. irrigation system efficiency
5. climate and field elevation that determine peak ET rates (farms at the bottom of the valleys have higher peak ET rates than those in the same area but at a higher elevation)

**Step 1  Actual Peak Flow Rate**

The actual system flow rate can be determined using meters, water purveyor restrictions, pump information or sprinkler nozzle output.

A **water meter** installed on the irrigation system can be used to determine the system flow rate by measuring the amount of water that passes through the meter during a given time period.

**Water purveyors** supplying irrigation water often allocate a flow rate of the farm based on acreage. Most often, these flow rates are regulated using flow control valves. Contact your water purveyor to find out how much water you are allowed to take if you are on municipal system or an irrigation district.

The **pump curve** can be used to estimate the irrigation system flow rate by using the impeller diameter, the number of revolutions per minute (rpm) of the pump, and the system operating pressure. This method is most reliable for pumps that have a steeper pump curve. Contact your pump supplier for pump curve information. It is a good idea to confirm the pump flow rate determined from a pump curve with one of the other methodologies whenever possible.

The **trickle system output flow rate** can be determined using the emitter flow rate and the number of emitters. For farms using more than one type of emitter for different crops or zones, use the zone with the highest flow rate.

**Step 2  Calculated Annual Water Use**

The calculated annual water use is determined using an estimated value of crop water requirements (Table 1) and irrigation system efficiency factors (Table 2). The estimated annual crop water requirement values in Table 1 are based on data collected over the last 40 years. It is accepted that some years are wetter or drier than others and therefore annual water use varies. Regardless, farmers using a well or other water source should adhere to the calculated annual water requirement figures, and should have the annual withdrawal rate stay within the licensed amount.
Table 1  Estimated Annual Crop Water Requirements for B.C. Locations with Average (3 in or 7.5 cm) Maximum Soil Water Deficit

<table>
<thead>
<tr>
<th>Location</th>
<th>Water [in]</th>
<th>Location</th>
<th>Water [in]</th>
<th>Location</th>
<th>Water [in]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abbotsford</td>
<td>9</td>
<td>Golden</td>
<td>11</td>
<td>Oliver</td>
<td>24</td>
</tr>
<tr>
<td>Agassiz</td>
<td>4</td>
<td>Grand Forks</td>
<td>11</td>
<td>100 Mile House</td>
<td>17</td>
</tr>
<tr>
<td>Alexis Creek</td>
<td>11</td>
<td>Grandview Flats</td>
<td>18</td>
<td>Osoyoos</td>
<td>25</td>
</tr>
<tr>
<td>Armstrong</td>
<td>12</td>
<td>Grasmere</td>
<td>13</td>
<td>Oyster River</td>
<td>6</td>
</tr>
<tr>
<td>Ashcroft</td>
<td>25</td>
<td>Grindrod</td>
<td>7</td>
<td>Parksville</td>
<td>10</td>
</tr>
<tr>
<td>Aspen Grove</td>
<td>13</td>
<td>Hazelton</td>
<td>2</td>
<td>Pitt Meadows</td>
<td>6</td>
</tr>
<tr>
<td>Barriere</td>
<td>13</td>
<td>Hixon</td>
<td>6</td>
<td>Port Alberni</td>
<td>12</td>
</tr>
<tr>
<td>Baynes Lake</td>
<td>17</td>
<td>Hope</td>
<td>9</td>
<td>Prince George</td>
<td>10</td>
</tr>
<tr>
<td>Campbell River</td>
<td>10</td>
<td>Invermere</td>
<td>17</td>
<td>Princeton</td>
<td>18</td>
</tr>
<tr>
<td>Canal Flats</td>
<td>14</td>
<td>Kamloops</td>
<td>23</td>
<td>Quesnel</td>
<td>9</td>
</tr>
<tr>
<td>Castlegar</td>
<td>21</td>
<td>Kelowna</td>
<td>19</td>
<td>Radium</td>
<td>12</td>
</tr>
<tr>
<td>Cawston</td>
<td>25</td>
<td>Keremeos</td>
<td>23</td>
<td>Riske Creek</td>
<td>16</td>
</tr>
<tr>
<td>Chase</td>
<td>15</td>
<td>Kersley</td>
<td>9</td>
<td>Saanichton</td>
<td>10</td>
</tr>
<tr>
<td>Cherryville</td>
<td>14</td>
<td>Kettle Valley</td>
<td>18</td>
<td>Salmon Arm</td>
<td>13</td>
</tr>
<tr>
<td>Chilliwack</td>
<td>5</td>
<td>Kimberley</td>
<td>17</td>
<td>Smithers</td>
<td>9</td>
</tr>
<tr>
<td>Clinton</td>
<td>17</td>
<td>Ladner</td>
<td>8</td>
<td>Spillimacheen</td>
<td>14</td>
</tr>
<tr>
<td>Cloverdale</td>
<td>7</td>
<td>Langley</td>
<td>6</td>
<td>Sumas</td>
<td>6</td>
</tr>
<tr>
<td>Comox</td>
<td>12</td>
<td>Lilloet</td>
<td>19</td>
<td>Summerland</td>
<td>19</td>
</tr>
<tr>
<td>Creston</td>
<td>16</td>
<td>Lister</td>
<td>16</td>
<td>Terrace</td>
<td>9</td>
</tr>
<tr>
<td>Dawson Creek</td>
<td>7</td>
<td>Lumby</td>
<td>15</td>
<td>Vancouver</td>
<td>11</td>
</tr>
<tr>
<td>Douglas Lake</td>
<td>16</td>
<td>Lytton</td>
<td>25</td>
<td>Vanderhoof</td>
<td>8</td>
</tr>
<tr>
<td>Duncan</td>
<td>9</td>
<td>Malakwa</td>
<td>9</td>
<td>Vernon</td>
<td>16</td>
</tr>
<tr>
<td>Ellison</td>
<td>17</td>
<td>Merritt</td>
<td>21</td>
<td>Walchachin</td>
<td>20</td>
</tr>
<tr>
<td>Fort Fraser</td>
<td>8</td>
<td>Nanaimo</td>
<td>10</td>
<td>Westwold</td>
<td>20</td>
</tr>
<tr>
<td>Fort Steele</td>
<td>10</td>
<td>Natal</td>
<td>10</td>
<td>Williams Lake</td>
<td>13</td>
</tr>
<tr>
<td>Fort St. John</td>
<td>7</td>
<td>Notch Hill</td>
<td>14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: An irrigation system efficiency needs to be applied to the figures to obtain the gross annual requirements.

Table 2  Application Efficiencies of Irrigation Systems

<table>
<thead>
<tr>
<th>Irrigation System Type</th>
<th>Typical Application Efficiency [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trickle</td>
<td>92</td>
</tr>
<tr>
<td>Drip – Subsurface</td>
<td>95</td>
</tr>
<tr>
<td>Microjet</td>
<td>85</td>
</tr>
</tbody>
</table>

A trickle system irrigates less crop area than a sprinkler system because emitters apply water directly to the root zone. The efficiency of a trickle system is also much higher than that of a sprinkler system which adds to water savings. Table 3 provides factors that can be used to adjust the annual crop water requirement values in Table 1.
### Table 3. Crop Adjustment Factors for Trickle Systems

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apples, Cherries – Medium Density</td>
<td>0.90</td>
</tr>
<tr>
<td>Apricots, Peaches, Pears – Medium Density</td>
<td>0.80</td>
</tr>
<tr>
<td>Tree Fruits – High Density</td>
<td>1.00</td>
</tr>
<tr>
<td>Grapes</td>
<td>0.70</td>
</tr>
<tr>
<td>Blueberries</td>
<td>0.80</td>
</tr>
<tr>
<td>Raspberries</td>
<td>0.70</td>
</tr>
<tr>
<td>Strawberries</td>
<td>0.75</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>0.90</td>
</tr>
<tr>
<td>Vegetables</td>
<td>0.80</td>
</tr>
</tbody>
</table>

### Step 3: Actual Annual Water Use

The actual annual water use by an irrigation system can be determined using meter data, pumping information or irrigation system operation information.

A **water meter** provides accurate information on annual water use. Metered systems are usually on municipal or irrigation district water supplies. Trickle irrigation systems often have flow meters to monitor system performance, but these meters do not provide annual data. The meter reading can be converted into annual water use.

The **pump operating hours** may be determined from information on the hydro bill. The amount of energy used can be converted into operating hours and annual water use.

Trickle systems are more efficient than most other irrigation systems. They also operated more frequently than other systems, usually every day or numerous times every week. The annual water use for each zone should be calculated separately, and then added together to determine the total annual use for the irrigation system.

### Step 4. Compare Calculated and Actual Annual Water Use

If there is a water licence, do Step 4(a), and then Step 4(b) to double-check. If groundwater is used or water is supplied by a purveyor (i.e., no water licence), follow Step 4(b) only.

**4(a)** To conduct a water licence check, the annual water use calculated in inches must be converted to acre-feet in order to be compared to the licensed volumes. The annual water use in acre-feet should not exceed the amount stated on the water licence.

**4(b)** Compare the calculated and actual annual water use. The actual value should not exceed the calculated value by 10%. If the farm obtains water from a surface water source under a water licence, the annual use allowed by the licence cannot be exceeded.

An example is shown below on how to determine the actual annual water use for a trickle system. A blank worksheet is provided at the end for self-evaluation.
Example 1 Trickle Irrigation in Kelowna

Annual Water Use Check - TRICKLE

Question: A high density 14-acre apple orchard in Kelowna has a trickle irrigation system with a flow rate of 58 US gpm. The irrigation system consists of seven zones that have similar flow rates. Each zone operates for 2.5 hours per day. The system operates 100 days during the irrigation season. A meter on the system indicates readings of 4,510,900 US gallons at the start of the year, and 12,116,400 US gallons at the end of the year. The water licence states a water withdrawal rate of 20 acre-feet. Does the annual water use meet the licensed amount and/or the calculated annual irrigation water requirement for Kelowna?

Information:

<table>
<thead>
<tr>
<th>Irrigated area</th>
<th>14 acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water withdrawal amount on water licence (if applicable)</td>
<td>20 ac-ft</td>
</tr>
<tr>
<td>Estimated annual crop water requirement from Table 1</td>
<td>19 in</td>
</tr>
<tr>
<td>Crop adjustment factor from Table 3</td>
<td>1.0</td>
</tr>
<tr>
<td>Application efficiency from Table 2</td>
<td>92 %</td>
</tr>
</tbody>
</table>

Calculation:

Step 1. Determine actual system peak flow rate using one or more of the following methods:

Method 1. Water purveyor restriction or measured flow rate using a meter

Flow rate measured using a meter or provided by district = 6 US gpm

Method 2. Pump peak flow rate

Irrigation pump peak flow rate from pump curve = 7 US gpm

Method 3. Determine flow rate using sprinkler nozzles

Nozzle flow rate from supplier’s tables = 5.7 gph

No. of emitters operating at one time = 756 emitters

\[
\text{Trickle System Output Flow Rate} = \text{Emitter Flow Rate} \times \text{No. of Emitters} \times 0.0167
\]

\[
= 5.7 \times 756 \times 0.0167
= 72.10 \text{ US gpm}
\]

Step 2. Determine calculated annual water use.

\[
\text{Calculated Annual Water Requirement} = \frac{\text{Estimated Annual Crop Water Requirement} \times \text{Crop Adjustment Factor} \times 100\%}{\text{Application Efficiency}}
\]

\[
= 19 \times 1.0 \times 92 \times 100\%
= 20.711 \text{ in}
\]

Step 3. Determine actual annual water use using one or more of the following methods:

Method 1. Metered water use

Meter reading at start of year = 6,089,400 US gal

Meter reading at end of year = 12,116,400 US gal
Equation 4.8
Annual Water Use = [Meter Reading at End of Year – Meter Reading at Start of Year] x [Irrigated Area]

\[
\begin{align*}
\text{Annual Water Use} &= \frac{12,116,400 \text{ US gal} - 4,510,900 \text{ US gal}}{27027 \times 14 \text{ acres}} \\
&= \frac{7605500 \text{ gal}}{27027 \times 14 \text{ in}}
\end{align*}
\]

Method 2. Pump water use
Pump horsepower from supplier’s table = - 15 hp
Energy consumption for entire year from hydro bill = - 16 KWh
Pump flow rate from pump curve = - 17 US gpm

Equation 4.9(a)
Pump Power = Pump Horsepower x 0.746 KW/hp

\[
\begin{align*}
Pump Power &= - 13 \text{ hp} \times 0.746 \text{ KW/hp} \\
&= - 18 \text{ KW}
\end{align*}
\]

Equation 4.9(b)
Pump Operating Hours = \frac{KWh for Entire Year}{Pump Power}

\[
\begin{align*}
Pump Operating Hours &= \frac{- 16 \text{ KWh}}{- 18 \text{ KW}} \\
&= - 0.944 \text{ hr}
\end{align*}
\]

Equation 4.9(c)
Annual Water Use = Pump Operating Hours x Pump Flow Rate x 0.0022

\[
\begin{align*}
\text{Annual Water Use} &= - 19 \text{ hr} \times - 17 \text{ US gpm} \times 0.0022 \\
&= - 0.614 \text{ acres}
\end{align*}
\]

Method 3. Sprinkler system annual water use
Number of zones = 7 21 zones
Operating hours per zone per day = 2.5 22 hr/zone/d
Number of operating days per year = 100 23 d

Equation 4.11(a)
Annual Water Use = Zone Flow Rate x No. of Zones x Operating Hours x No. of Days x 0.0022

\[
\begin{align*}
\text{Annual Water Use} &= \frac{72 \text{ US gpm} \times 7 \text{ zones} \times 2.5 \text{ hr/zone/d} \times 100 \text{ d}}{14 \text{ acres}} \\
&= 19.8 \text{ in}
\end{align*}
\]
If there is a water licence, go to Step 4(a), and do Step 4(b) to double-check. If groundwater is used or water is supplied by a purveyor (no water licence), follow Step 4(b) only.

Step 4(a). Calculate the annual water use and compare it with the water licence withdrawal.

**Equation 4.12**

\[
\text{Annual Water Use [ac-ft]} = \frac{\text{Annual Water Use [in]} \times \text{Irrigated Area [acres]}}{12 \text{ [in/ft]}}
\]

\[
= \frac{20.1 \text{ in} \times 14 \text{ acres}}{12 \text{ in/ft}}
\]

\[
= 23.5 \text{ ac-ft}
\]

Is 23.5 ac-ft less than 20 ac-ft? 
- Yes: Water withdrawal not exceeded
- No: Refer to the B.C. Irrigation Management Guide

Step 4(b). Calculate percent difference of annual water use. Use the metered water use if available because it is the most accurate method.

**Equation 4.5**

\[
\text{Percent Difference} = \left(\frac{\text{Actual Annual Water Use}}{\text{Calculated Annual Water Use}}\right) \times 100\%
\]

\[
= \frac{20.7 \text{ in}}{20.1 \text{ in}} \times 100\%
\]

\[
= 97.26\%
\]

Is 97.26% less than 110%? 
- Yes: annual water use not exceeded by more than 10%
- No: Refer to the B.C. Irrigation Management Guide
### Annual Water Use Check - TRICKLE

#### Information:
1. Irrigated area: 
2. Water withdrawal amount on water licence (if applicable): ac-ft
3. Estimated annual crop water requirement from Table 1: in
4. Crop adjustment factor from Table 3: 
5. Application efficiency from Table 2: %

#### Calculation:

**Step 1.** Determine actual system peak flow rate using one or more of the following methods:

- **Method 1.** Water purveyor restriction or measured flow rate using a meter
  - Flow rate measured using a meter or provided by district: US gpm
- **Method 2.** Pump peak flow rate
  - Irrigation pump peak flow rate from pump curve: US gpm
- **Method 3.** Determine flow rate using sprinkler nozzles
  - Nozzle flow rate from supplier's tables: gph
  - No. of emitters operating at one time: emitters

**Equation 4.4**

\[
\text{Trickle System Output Flow Rate} = \text{Emitter Flow Rate} \times \text{No. of Emitters} \times 0.0167
\]

\[
= 8 \text{ gph} \times 9 \text{ emitters} \times 0.0167
= 10 \text{ US gpm}
\]

**Step 2.** Determine calculated annual water use.

**Equation 4.7**

\[
\text{Calculated Annual Water Requirement} = \text{Estimated Annual Crop Water Requirement} \times \text{Crop Adjustment Factor} \times 100\%
\]

\[
= 3 \text{ in} \times 5 \%
= 11 \text{ in}
\]

**Step 3.** Determine actual annual water use using one or more of the following methods:

- **Method 1.** Metered water use
  - Meter reading at start of year: US gal
  - Meter reading at end of year: US gal

**Equation 4.8**

\[
\text{Annual Water Use} = \frac{\text{Meter Reading at End of Year} - \text{Meter Reading at Start of Year}}{27027 \times \text{Irrigated Area}} \times 100\%
\]

\[
= \frac{13 \text{ US gal} - 12 \text{ US gal}}{27027 \times 1 \text{ acres}}
= 14 \text{ in}
\]
Method 2. Pump water use

- Pump horsepower from supplier’s table: 15 hp
- Energy consumption for entire year from hydro bill: 16 KWh
- Pump flow rate from pump curve: 17 US gpm

\[ \text{Pump Power} = \text{Pump Horsepower} \times 0.746 \text{ KW/hp} \]
\[ = 13 \text{ hp} \times 0.746 \text{ KW/hp} \]
\[ = 18 \text{ KW} \]

\[ \text{KWh for Entire Year} = \frac{\text{Pump Operating Hours}}{\text{Pump Power}} \]
\[ = \frac{16 \text{ KWh}}{18 \text{ KW}} \]
\[ = 19 \text{ hr} \]

\[ \text{Annual Water Use} = \text{Pump Operating Hours} \times \text{Pump Flow Rate} \times 0.0022 \]
\[ = 19 \text{ hr} \times 17 \text{ US gpm} \times 0.0022 \]
\[ = 20 \text{ in} \]

Method 3. Sprinkler system annual water use

- Number of zones: 21 zones
- Operating hours per zone per day: 22 hr/zone/d
- Number of operating days per year: 23 d

\[ \text{Annual Water Use} = \text{Zone Flow Rate} \times \text{No. of Zones} \times \text{Operating Hours} \times \text{No. of Days} \times 0.0022 \]
\[ = 10 \text{ US gpm} \times 21 \text{ zones} \times 22 \text{ hr/zone/d} \times 23 \text{ d} \times 0.0022 \]
\[ = 24 \text{ in} \]
Answer:

If there is a water licence, go to Step 4(a), and do Step 4(b) to double-check. If groundwater is used or water is supplied by a purveyor (no water licence), follow Step 4(b) only.

Step 4(a). Calculate the annual water use and compare it with the water licence withdrawal.

**Equation 4.12**

\[
\text{Annual Water Use [ac-ft]} = \frac{\text{Annual Water Use [in]} \times \text{Irrigated Area [acres]}}{12 \text{ in/ft}}
\]

\[
\begin{align*}
\text{Annual Water Use [ac-ft]} & = \frac{10, 20 \text{ or } 24 \text{ in} \times 1 \text{ acres}}{12 \text{ in/ft}} \\
& = \frac{25 \text{ ac-ft}}{}
\end{align*}
\]

Is \(25\) ac-ft less than \(2\) ac-ft? 

- Yes: Water withdrawal not exceeded
- No: Refer to the B.C. Irrigation Management Guide

Step 4(b). Calculate percent difference of annual water use. Use the metered water use if available because it is the most accurate method.

**Equation 4.5**

\[
\text{Percent Difference} = \left(\frac{\text{Actual Annual Water Use}}{\text{Calculated Annual Water Use}}\right) \times 100\%
\]

\[
\begin{align*}
\text{Percent Difference} & = \frac{10, 20 \text{ or } 24 \text{ in}}{11 \text{ in}} \times 100\% \\
& = 26\% \\
\end{align*}
\]

Is \(26\%\) less than \(110\%\)?

- Yes: Annual water use not exceeded by more than \(10\%\)
- No: Refer to the B.C. Irrigation Management Guide