Water and nutrient management is fundamentally important to the production of greenhouse vegetable crops. The effective management of these resources helps protect the environment and improve production efficiency.

The Self-Assessment and Best Management Practices (BMPs) in this publication are voluntary tools that can help you:

- scrutinize current use of water and fertilizer at your production facility
- prioritize your water and fertilizer use concerns
- determine where effective improvements can be made – such as increasing water and nutrient efficiency
- document continual improvements.

Use BMPs to manage both the quantity and quality of water in your operation – from source through to pre-irrigation treatment, fertility, distribution, collection, storage, post-irrigation treatment, reuse and discharge.

Implementation of the BMPs provided in this document does not remove the operator's responsibility to ensure compliance with applicable legislation, including municipal and provincial requirements.

The disposal of nutrient feedwater must be managed in accordance with applicable legislation such as the *Ontario Water Resources Act, Environmental Protection Act,* and *Nutrient Management Act.*

Self-Assessment for Greenhouse Vegetable Water and Fertilizer Use

To decide which BMPs to implement in your greenhouse production system, start by completing the Self-Assessment in this publication. It will give you a comprehensive view of your operation.

The Self-Assessment focuses on water and fertilizer management in three areas:

A. Pre-Production Practices – for water and nutrient management *before* water and nutrients enter the production system and greenhouse facility

B. Production Practices – for water and nutrient management *within* the greenhouse facility and *during* crop production

C. Post-Production Practices – for water and nutrient management *outside* the greenhouse facility when water and nutrients are no longer required or usable for production.

Nutrient feedwater – a solution with all essential elements required for healthy plant growth. It consists of various proportions of fertilizers dissolved in water or a blend of fertilizer solutions to provide the nutrient complement required for healthy plant growth.

Leached nutrient feedwater – the nutrient feedwater that has been captured after passing though the growing substrate. It may or may not be recycled. It can also be referred to as leachate or leach.

Fertilizer solution – a stock solution consisting of a single fertilizer, or several compatible fertilizers, dissolved in water.

How the Self-Assessment Works

For most questions, there are four descriptions listed in separate columns. Each column has a number ranking: 4, 3, 2 or 1. (In some instances, fewer than four categories will appear.)

Check the box ☑ that most accurately describes the current situation for your operation.

Practices described under Columns 4 and 3 (on left-hand side of tables) improve nutrient and water use in the greenhouse by reducing the amount of water and nutrients requiring management post-production.

Practices identified in Columns 1 and 2 may be improved by implementing the BMPs referred to by number in the bottom row of each Self-Assessment question. These BMPs are described in tables, starting on page 16.

After completing the Self-Assessment, review the practices you identified as candidates for improvement. Then consider the suitable BMPs that can improve your operation.

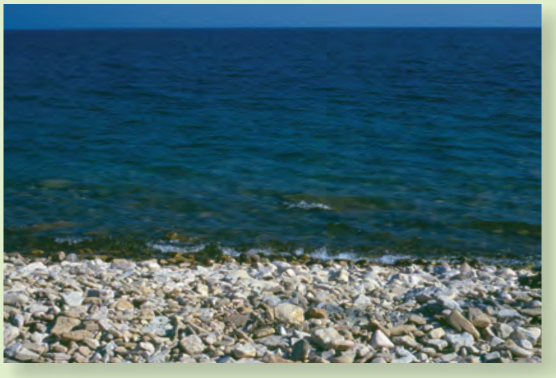
A PRE-PRODUCTION PRACTICES

for water and nutrient management *before* water and nutrients enter the production system and greenhouse facility

Know your water quality before it becomes part of your production system. If you know the possible undesirable attributes and nutrients in your source water, you can take pre-emptive measures to reduce the quantity of water and nutrients that will have to be managed post-production.

A.1 WHAT IS THE MAIN WATER SOURCE FOR YOUR PRODUCTION SYSTEM?

4	3	2	1
☐ Municipal Very consistent water quality Potable water ☐ Rainwater collected and stored separately	☐ Well water Generally consistent water quality *Note:* Depending on the geographic location and well depth, it may have high electrical conductivity (EC), sulphate, iron, or bicarbonates	☐ Pond/lake/river or stream Quality may vary over the year	☐ Drain Highly variable water quality
BMPs: 1–4 (pg. 16), 6 (pg. 17), 9, 10, 12, 14 (pp. 18–20)			



Water from the Great Lakes is low in dissolved salts and generally has a low EC. High EC waters require treatment before use in greenhouse vegetable operations to reduce dissolved salts that could cause poor plant growth.

The water from drainage channels (e.g. municipal drains) is highly variable and unsuitable for irrigation in greenhouse vegetable operations.

A.2 WHAT IS YOUR WATER QUALITY CLASS?

4	3	2	1
☐ Class 1 EC <0.5 mS/cm Na <30 ppm Cl <50 ppm SO_4 <100 ppm *Note:* Used for all purposes, recommended for hydroponics production	☐ Class 2 EC 0.5–1.0 mS/cm Na 30–60 ppm Cl 50–100 ppm SO_4 100–200 ppm *Note:* Used in agriculture where adequate leach can be maintained	☐ Class 3 EC 1.0–1.5 mS/cm Na 60–90 ppm Cl 100–150 ppm SO_4 200–300 ppm *Note:* Not recommended for salt-sensitive crops such as cucumbers	☐ Don't know *Note:* Requires a water analysis

BMP: 5 (pg. 17)

SYMBOL	NAME
B	Boron
Ca	Calcium
Cl	Chloride
Cu	Copper
EC	Electrical conductivity
Fe	Iron
K	Potassium
Mg	Magnesium
Mn	Manganese
Mo	Molybdenum
N	Nitrogen
Na	Sodium
P	Phosphorus
S	Sulphur
SO_4	Sulphate
Zn	Zinc

Water from relatively clean sources such as drilled wells often requires some form of treatment. Media filters and other technologies will remove impurities such as iron and sulphur prior to use.

A.3 DO YOU TREAT WATER BEFORE IRRIGATION?

☐ Yes Water quality is improved to allow for use on sensitive crops and nutrient feedwater recycling	☐ No Water quality is in Class 2 or higher, or level of some elements is too high for economical treatment options

BMPs: 5 (pg. 17), 18 (pg. 21), 27 (pg. 25)

A.4 IF YOU ARE NOT ON MUNICIPAL WATER, FOR WHICH UNDESIRABLE WATER QUALITY PARAMETERS DO YOU TREAT?

4	3	2	1
☐ All undesirable chemical and physical parameters	☐ Water quality parameters identified in column 2, plus iron and/ or sulphate	☐ Water quality parameters identified in column 1, plus bicarbonates	☐ Other (list) ☐ suspended solids __________ __________

BMPs: 5 (pg. 17), 17, 18 (p. 21)

A.5 DO YOU USE ANY OF THE FOLLOWING PRE-TREATMENT TECHNOLOGIES?

4	3	1
☐ Reverse osmosis (RO)	☐ Specific ion filters/ Oxygenation	☐ Other (list) __________ __________

BMPs: 5 (pg. 17), 17, 18 (p. 21)

Complete a water analysis on the backwash/reject solution. The results can help prevent the discharge of unwanted nutrients to surface waters.

Reverse osmosis will remove salts (nitrates, sulphates, carbonates etc.), pathogens, and other micro-organisms from irrigation water.

A.6 DO YOU CONDUCT A COMPLETE WATER ANALYSIS ON THE BACKWASH/REJECT SOLUTION FROM PRE-TREATMENT SYSTEMS (SAND FILTER, RO) BEFORE DISPOSAL?

4	1
☐ Yes, tested before disposal	☐ No, not checked before disposal

BMPs: 27 (pg. 25), 31, 32 (pg. 27)

A.7 WHAT HAPPENS TO THE BACKWASH/REJECT SOLUTION?

4	3	2	1
☐ Stored, followed by appropriate approved disposal method *Note:* Discharges to surface water and groundwater must be done in accordance with an Environmental Compliance Approval from MOE	☐ Discharged into the municipal sanitary sewer system, if permitted *Note:* Check municipal bylaws	☐ Discharged into on-site septic system, if permitted *Note:* Check municipal bylaws Check with MOE to determine if approval is required (if system is >10,000 L/day)	☐ Disposed directly into surface water (municipal drain, pond, lake, stream, wetland) *Note:* Discharges to surface water and groundwater must be done in accordance with an Environmental Compliance Approval from MOE

BMPs: 6 (pg. 17), 28–32 (pp. 25–27)

This below-ground reservoir can store fresh water, nutrient feedwater, or disinfected or treated leached nutrient feedwater.

A.8 IF YOU ARE TAKING 50,000 LITRES OR MORE OF WATER ON ANY DAY FROM A GROUND-WATER OR SURFACE WATER SOURCE, DO YOU HAVE A VALID PERMIT TO TAKE WATER (PTTW)?

4	3	2	1
☐ Not applicable (take less than 50,000 L/day, or under someone else's PTTW)	☐ Yes PTTW number: ________	☐ PTTW application in process	☐ No, but I should have a PTTW

BMP: 11 (pg. 19)

The Permit to Take Water process is in place to manage shared water resources effectively and to prevent interference with any public or private interest in any water.

B PRODUCTION PRACTICES

for water and nutrient management *within* the greenhouse facility and *during* crop production

Maintaining water quality and minimizing unnecessary nutrient applications within the greenhouse facility during crop production cycles will reduce the quantity of water and nutrients that must be managed post-production.

B.1 WHAT IRRIGATION SYSTEM DO YOU USE IN YOUR GROWING SYSTEM?

4	3	2	1
☐ Drip system Precise delivery of water and fertilizer to individual plant	☐ In-line drip system Precise delivery of water and fertilizer to crop	☐ Drip irrigation tape watering Less precision of water and fertilizer delivery to crop Between-plant space is also watered, making it more difficult to control plant growth in early plantings	☐ Other ☐ watering booms ☐ spray nozzles ☐ misting ☐ hand-watering

BMPs: 13 (pg. 19), 16 (pg. 20), 19 (pg. 22)

Advanced irrigation-control technology such as variable-speed soft-start irrigation pumps will improve irrigation water efficiency.

B.2 WHAT GROWING MEDIA DO YOU USE IN YOUR PRODUCTION SYSTEM?

4	3	2
☐ Bag culture/ Nutrient Film Technique (NFT)	☐ Pot culture	☐ In-ground

BMP: 23 (pg. 23)

B.3 DO YOU OPERATE A CLOSED OR OPEN GREENHOUSE SYSTEM WITH RESPECT TO WATER AND NUTRIENTS? IF YOU ARE OPERATING A CLOSED SYSTEM, HOW ARE YOU COLLECTING LEACHED NUTRIENT FEEDWATER?

☐ Closed system in a closed system, leached nutrient feedwater is mostly contained within the greenhouse facility and is not lost to surface water or groundwater			☐ Open system in an open system, leached nutrient feedwater is discharged to surface water or groundwater
4	**3**	**2**	**1**
☐ Raised trough system	☐ On-the-ground system	☐ In-the-ground system	*Note:* Any discharge to surface water and groundwater must be done in accordance with an Environmental Compliance Approval from MOE

BMPs: 7, 8 (pg. 18), 16 (pg. 20), 26 (pg. 24), 27 (pg. 25)

A cucumber crop grown on bag culture in a trough system is an example of a closed system. Water and nutrients are used efficiently by recycling them within the system.

Inert substrates such as these rockwool slabs will not interfere with water quality.

B.4 IF YOU ARE GROWING IN SOILLESS SUBSTRATE, WHICH ONE DO YOU USE?

4	3	2
☐ Inert (e.g. rockwool, foam)	☐ Organic-based: pre-treated if appropriate (e.g. washed coco-coir)	☐ Organic-based: untreated if appropriate (e.g. coco-coir)

BMP: 23 (pg. 23)

B.5 HOW DO YOU DISPOSE OF THE LEACHED NUTRIENT FEEDWATER AFTER THE FIRST WATERING (BAG CHARGE)?

4	3	1
☐ 100% collected and recycled	☐ A portion is collected and recycled and a portion is disposed	☐ None collected

BMPs: 26 (pg. 24), 28 (pg. 25)

B.6 IF YOU ARE GROWING IN SOIL, WHAT IS THE SOIL TEXTURE? ☐ NOT APPLICABLE

4	3	2	1
☐ Clay Poor draining Fine texture Less risk of nutrient leaching	☐ Clay loam	☐ Loam and silt loam	☐ Sands and sandy loam Fast draining Coarse texture Greater risk of nutrient leaching

BMPs: 6 (pg. 17), 19 (pg. 22), 20, 21 (pg. 23)

B.7 HOW DO YOU MIX/PREPARE FERTILIZER FOR YOUR FERTIGATION SYSTEM?

4	3
☐ Use multi-head single fertilizer injector	☐ Use A–B tank system (recipe-based)

BMP: 24 (pg. 23)

Multi-head injector systems allow managers to match nutrient application to crop needs, according to results of weekly solution analysis.

B.8 WHAT IS YOUR FERTILIZER QUALITY?

4	3	2	1
☐ Greenhouse-grade, micronutrients all chelated	☐ Greenhouse-grade, some micronutrients are chelated and some unchelated	☐ Greenhouse-grade, all micronutrients unchelated	☐ Field- or agriculture-grade
BMPs: 20, 24 (pg. 23), 25 (pg. 24)			

Using field-grade fertilizers is not advised. Greenhouse-grade fertilizers are easily soluble and have fewer contaminants that could block emitters.

Irrigation monitoring and control systems, such as this pressure regulator and filter with pressure gauges, improve water efficiency for each greenhouse zone.

B.9 HOW DO YOU DECIDE WHEN TO BEGIN AND END AN IRRIGATION CYCLE?

4	3	2	1
☐ Use a **combination** of the following: • tensiometers • weigh scales • water content meters • start trays • leach trays • leach counters – incorporation of leach tray/counter data assists in determining when and how much to irrigate	☐ Use **one** of the following: • tensiometers • weigh scales • water content meters • start trays • solar radiation to initiate system	☐ System initiated by time and/or visual clues in consideration of light, relative humidity, and media moisture	☐ System initiated by time with no consideration of media, light etc.
BMPs: 22, 24 (pg. 23)			

B.10 WHAT PERCENTAGE OF YOUR LEACHED NUTRIENT FEEDWATER IS RECIRCULATED?			
4	**3**	**2**	**1**
☐ 100 All leachate nutrient feedwater is collected (including bag-charging solution) and no nutrient solution leaves the nutrient solution recirculation system	☐ 75–99 Occasionally some leachate nutrient feedwater is removed/ released from the nutrient solution recirculation system	☐ 50–74 The nutrient feedwater used to charge the bags is released, and occasionally some of the leached nutrient feedwater is removed/released from the recirculation system	☐ Less than 50
BMPs: 16 (pg. 20), 26 (pg. 24), 27 (pg. 25)			

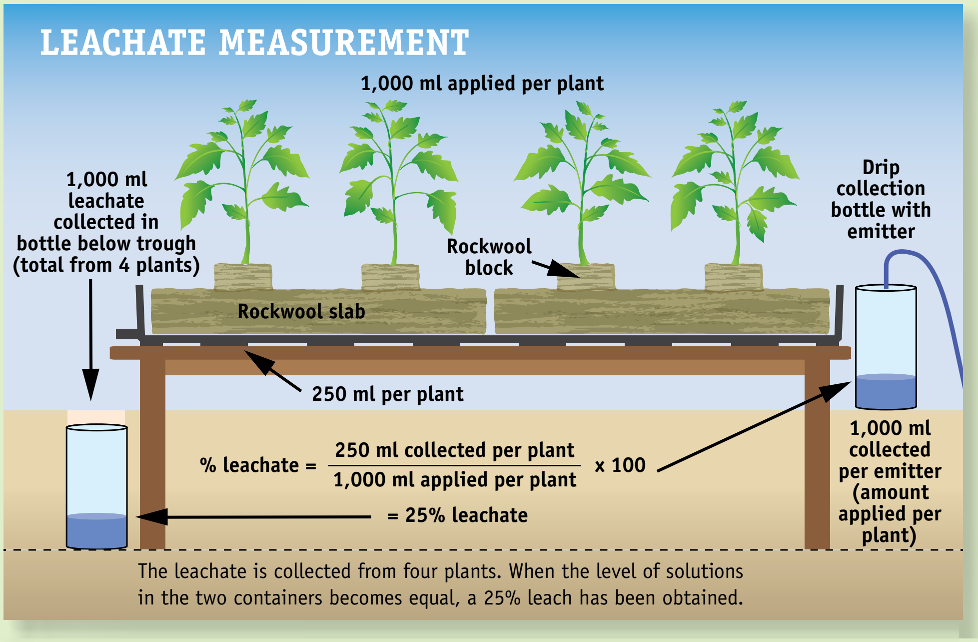
In closed systems, the leached nutrient feedwater is recirculated. This drastically reduces the volume of water and amount of fertilizer used, and the volume of leached nutrient feedwater to store and treat.

Water-content meters assess moisture levels in the growing media. This information can be used to target irrigation needs and improve irrigation efficiency.

B.11 HOW IS PRECISION FERTIGATION USED IN YOUR PRODUCTION SYSTEM?			
4	**3**	**2**	**1**
☐ Use automated feedback system to alter water application to meet plant needs and minimize overwatering	☐ Use real-time weather information to alter water application and improve water use	☐ Monitor water use with respect to the predicted weather conditions (light, temperature etc.)	☐ None, do not use precision fertigation
BMPs: 14, 15 (pg. 20)			

B.12 HOW FREQUENTLY DO YOU COMPLETE A NUTRIENT FEEDWATER ANALYSIS AND USE RESULTS TO ADJUST ITS NUTRIENT COMPOSITION?

4	3	2	1
☐ Weekly	☐ Every 2 weeks	☐ Once a month	☐ Once a year or never
BMP: 21 (pg. 23)			



This is a simple visual technique to monitor the volume of irrigation applied and to determine the percent leachate achieved. Monitor levels during the course of the irrigation cycle to determine when adequate leach is obtained during the course of the day. Electronic leach counters can also be used.

Weekly analysis of nutrient feedwater provides timely information for adjusting its nutrient composition.

Pathogens can thrive in recycled, leached nutrient feedwater. Test frequently to reduce the risk of injury from diseases such as Fusarium root rot, and to confirm that the disinfection system is operating properly.

B.13 HOW FREQUENTLY DO YOU TEST NUTRIENT FEEDWATER FOR MICROBIAL POPULATIONS (E.G. PLANT PATHOGENS)?

4	3	2	1
☐ Quarterly or more frequently	☐ Once a year	☐ When problems occur	☐ Never
BMP: 17 (pg. 21)			

B.14 ON WHAT CRITERIA DO YOU BASE YOUR DECISION TO REMOVE LEACHED NUTRIENT FEEDWATER FROM THE PRODUCTION CYCLE AND DISCHARGE IT?			
4	**3**	**2**	**1**
☐ Poor plant performance and high EC/SO_4/Cl/Na/microbial numbers based on water analysis and monitoring	☐ After a specific time period (e.g. 4–6 weeks), following water analysis	☐ After a specific time period (e.g. 4–6 weeks) with no water analysis or occasionally when capacity is reached	☐ Routine discharge, with no water analysis
BMP: 21 (pg. 23)			

C POST-PRODUCTION PRACTICES

for water and nutrient management *outside* the greenhouse facility when water and nutrients are no longer required or usable for production

Leached nutrient feedwater used in production that no longer meets the requirements for crop production (e.g. higher levels of SO_4, Cl, or Na) needs to removed from the production system.

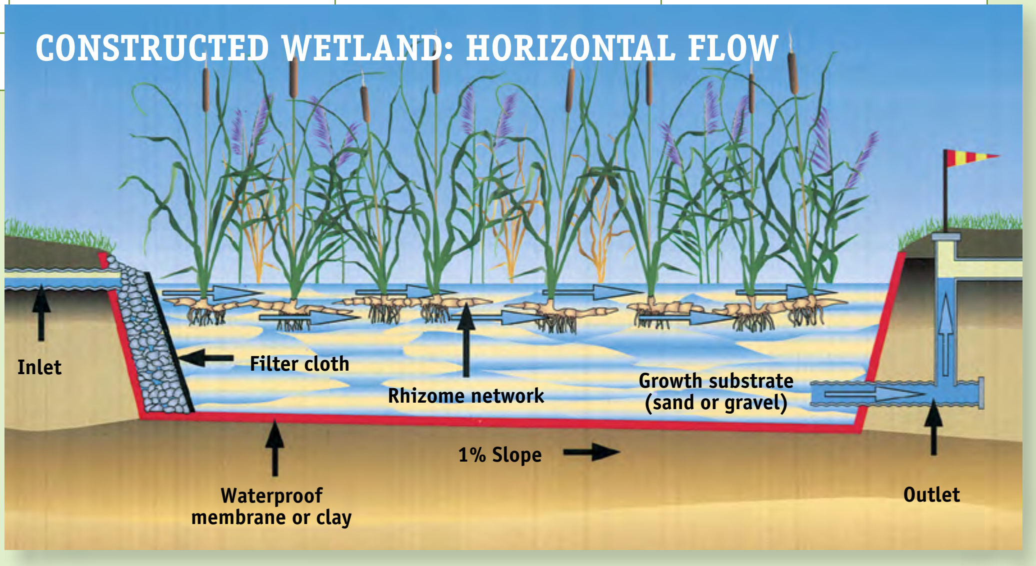
C.1 WHAT ARE YOUR CURRENT POST-PRODUCTION WASTEWATER MANAGEMENT PRACTICES?			
4	3	2	1
The disposal of leached nutrient feedwater must be managed in accordance with applicable legislation, such as the *Ontario Water Resources Act, Environmental Protection Act,* and *Nutrient Management Act.*			
☐ Leached nutrient feedwater (kept separate from storm water), other greenhouse wastewater sources (such as boiler blowdown, washing from floors, equipment and containers), and any other water used within the greenhouse not directly involved in irrigating or fertilizing the crop are stored separately, and disposal is managed in accordance with applicable legislation	☐ Leached nutrient feedwater, storm water, and other wastewater from the greenhouse facility are combined and stored in pond with no off-site discharge	☐ Leached nutrient feedwater, storm water, and other wastewater from the greenhouse facility are combined, stored in pond, and allowed to discharge off-site periodically	☐ No methods employed to prevent leached nutrient feedwater from going off-site into surface water or groundwater
BMP: 28 (pg. 25)			

Reduce the volume of leached nutrient feedwater requiring treatment by storing storm water separately.

Some storm water will require treatment. All storm water discharging off-site from storm water management facilities to other than an engineered and approved storm sewer that is not a combined sewer must be managed in accordance with applicable legislation such as the **Ontario Water Resources Act, Environmental Protection Act,** *and* **Nutrient Management Act.**

C.2 HOW DO YOU MANAGE LEACHED NUTRIENT FEEDWATER?

4	3	2	1
The disposal of leached nutrient feedwater must be managed in accordance with applicable legislation, such as the *Ontario Water Resources Act, Environmental Protection Act,* and *Nutrient Management Act.*			
☐ All leached nutrient feedwater is captured and stored for future treatment and reuse in the facility	☐ Some leaves but is treated, stored, and/or land-applied	☐ Store, treat discharge	☐ Direct discharge off-site
BMPs: 29–31 (pp. 25–27)			



Constructed wetlands are designed to remove nutrients, solids, and pathogens from leached nutrient feedwater.