**Self-Assessment and Best Management Practices**

# for Water and Fertilizer Use in Greenhouse Vegetable Production

Canada

Ontario

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

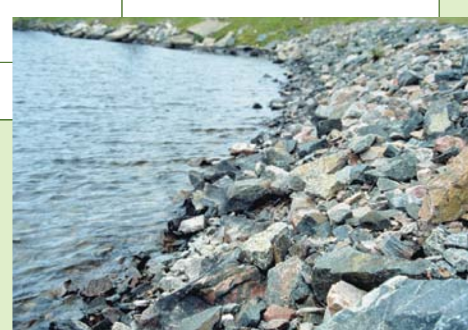
for water and nutrient management *before* water and nutrients enter the production system and greenhouse facility

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<br>Very consistent water quality<br>Potable water<br>☐ Rainwater collected and stored separately | ☐ Well water<br>Generally consistent water quality<br>*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<br>Quality may vary over the year | ☐ Drain<br>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<br>EC <0.5 mS/cm<br>Na <30 ppm<br>Cl <50 ppm<br>$SO_4$ <100 ppm<br>*Note:* Used for all purposes, recommended for hydroponics production | ☐ Class 2<br>EC 0.5–1.0 mS/cm<br>Na 30–60 ppm<br>Cl 50–100 ppm<br>$SO_4$ 100–200 ppm<br>*Note:* Used in agriculture where adequate leach can be maintained | ☐ Class 3<br>EC 1.0–1.5 mS/cm<br>Na 60–90 ppm<br>Cl 100–150 ppm<br>$SO_4$ 200–300 ppm<br>*Note:* Not recommended for salt-sensitive crops such as cucumbers | ☐ Don't know<br>*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<br>Water quality is improved to allow for use on sensitive crops and nutrient feedwater recycling | ☐ No<br>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)<br>☐ suspended solids<br>__________<br>__________ |

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)<br>__________<br>__________ |

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<br><br>*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<br><br>*Note:* Check municipal bylaws | ☐ Discharged into on-site septic system, if permitted<br><br>*Note:* Check municipal bylaws<br><br>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)<br><br>*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<br><br>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<br>Precise delivery of water and fertilizer to individual plant | ☐ In-line drip system<br>Precise delivery of water and fertilizer to crop | ☐ Drip irrigation tape watering<br>Less precision of water and fertilizer delivery to crop<br>Between-plant space is also watered, making it more difficult to control plant growth in early plantings | ☐ Other<br>☐ watering booms<br>☐ spray nozzles<br>☐ misting<br>☐ 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<br>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<br>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<br>(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<br>Poor draining<br>Fine texture<br>Less risk of nutrient leaching | ☐ Clay loam | ☐ Loam and silt loam | ☐ Sands and sandy loam<br>Fast draining<br>Coarse texture<br>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:<br>• tensiometers<br>• weigh scales<br>• water content meters<br>• start trays<br>• leach trays<br>• leach counters – incorporation of leach tray/counter data assists in determining when and how much to irrigate | ☐ Use **one** of the following:<br>• tensiometers<br>• weigh scales<br>• water content meters<br>• start trays<br>• 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<br>All leachate nutrient feedwater is collected (including bag-charging solution) and no nutrient solution leaves the nutrient solution recirculation system | ☐ 75–99<br>Occasionally some leachate nutrient feedwater is removed/ released from the nutrient solution recirculation system | ☐ 50–74<br>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.***

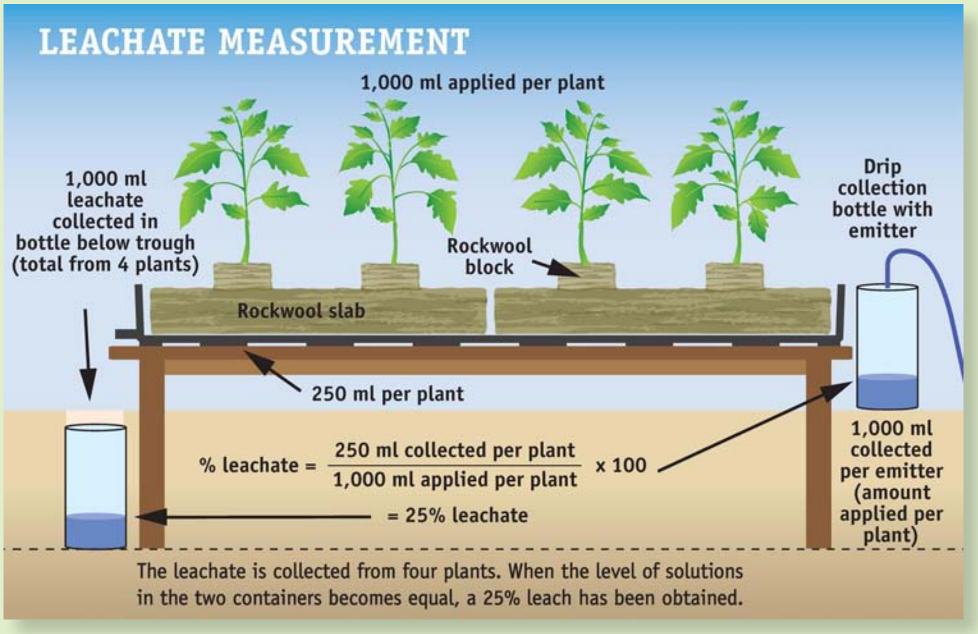

***Water-content meters assess moisture levels in the growing media. This information can be used to target irrigation needs and improve irrigation efficiency.***

| 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.

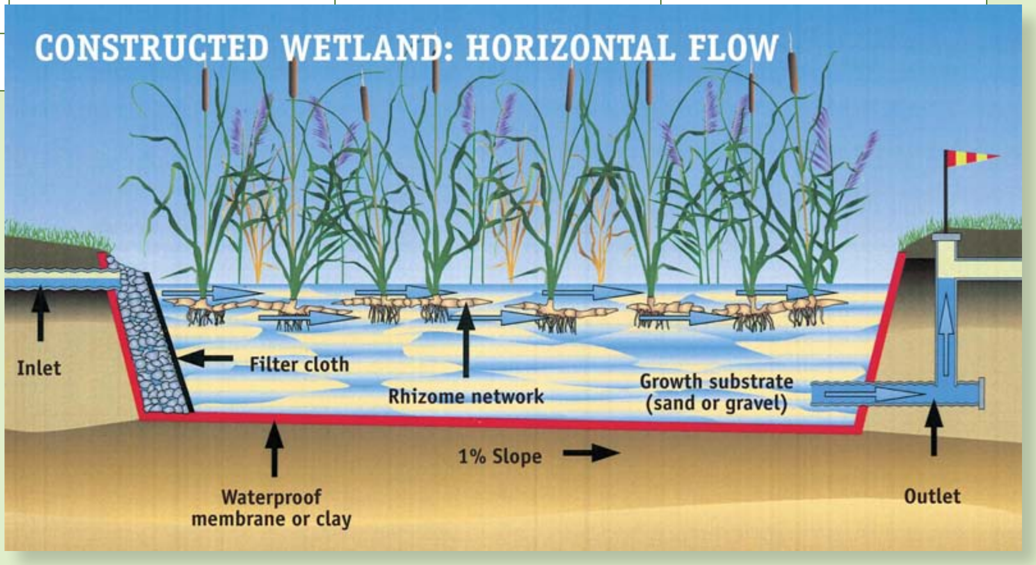
| C.1 WHAT ARE YOUR CURRENT POST-PRODUCTION WASTEWATER MANAGEMENT PRACTICES? | | | |
|---|---|---|---|
| 4 | 3 | 2 | 1 |
| The disposal of leached nutrient feedwater must be managed in accordance with applicable legislation, such as the *Ontario Water Resources Act, Environmental Protection Act,* and *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.***

# Best Management Practices for Water and Fertilizer Use

## 12 Steps to Improved Water and Fertilizer Use

1. Complete an Environmental Farm Plan and the Self-Assessment (see pg. 3).
2. Map all water, wastewater and movement of that water on and off your property.
3. Review all fertilizer and chemical storage and mixing areas to ensure proper containment and separation from floor drains.
4. Identify areas on your property where current practices impact surface water or groundwater, and take steps to eliminate these impacts.
5. Monitor, calculate, and record your current water and fertilizer use per unit area.
6. Establish short- and long-term water and fertilizer conservation goals.
7. Implement BMPs to help meet your water and fertilizer conservation goals.
8. Determine water and fertilizer reuse, storage, and disposal options. Consult with appropriate regulatory agencies, including municipal and provincial governments, and local conservation authority.
9. Implement necessary treatment options for reuse or discharge. Consult with appropriate regulatory agencies, including municipal and provincial governments, and local conservation authority.
10. Monitor and document new practices and processes. Upgrade technologies where applicable. Adjust your plan where appropriate.
11. Develop contingency plans to manage water and wastewater, and to address spills to the environment.
12. Know and comply with all local, provincial, and federal bylaws and regulations.

## Guiding BMP Principles

- Keep clean water clean.
- Know your water quantity and quality throughout the system.
- Manage water and nutrient inputs efficiently.
- Close production system to collect and reuse leached nutrient feedwater.
- Prevent discharge of leached nutrient feedwater and other wastewaters.

*Note:* Each greenhouse operation is unique, and not all BMPs in the following pages will suit the circumstances and goals of every operation.

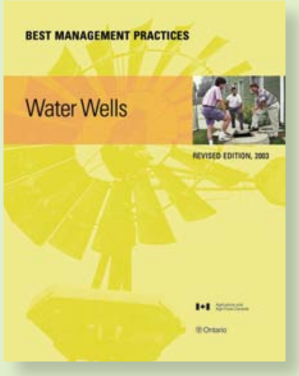
## A PRE-PRODUCTION BEST MANAGEMENT PRACTICES

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

| GUIDING PRINCIPLES | GENERAL BMP | SPECIFIC BMPs | DETAILS |
|---|---|---|---|
| KEEP CLEAN WATER CLEAN | **1.** Capture and store rainwater for use in irrigation | Divert to cistern, storage tank, or lined pond | Use roof and eaves to collect rainwater<br>Store in cistern, storage tank, or lined pond |
| | **2.** Keep stored municipal water clean | Use anti-backflow devices<br>Use leak-proof storage tanks | |
| | **3.** Construct storm water management ponds or basins, where practical, to reduce sediment loads to surface water | Construct berms<br>Use pond liners | Use berms to prevent unwanted runoff entering pond<br>Use liners (e.g. synthetic liner, clay) to reduce loss and prevent contamination of the stored water |
| | **4.** Maintain all wells to minimize nutrients and pesticides reaching groundwater | Inspect and monitor wells<br>Protect wells<br>Maintain minimum separation distances<br>Decommission abandoned wells | Test water regularly<br>Construct berm around well<br>Follow Environmental Farm Plan guidelines for separation distances from contaminant sources<br>See BMP book: *Water Wells* |

***This greenhouse under construction features downspouts to direct rainwater to storm water retention pond.***

***Store clean water in durable, waterproof storage tanks.***




***See Best Management Practices book* Water Wells *for more information about well protection and maintenance.***

## A PRE-PRODUCTION BEST MANAGEMENT PRACTICES

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

| GUIDING PRINCIPLES | GENERAL BMP | SPECIFIC BMPs | DETAILS |
|---|---|---|---|
| KNOW YOUR WATER QUANTITY AND QUALITY THROUGHOUT THE SYSTEM | **5.** Take samples throughout the year or when changing water sources to identify chemical makeup and manage the water accordingly for optimal crop production | Test water for:<br>• macronutrients<br>• micronutrients<br>• other components | • N, P, K, Mg, S, Ca<br>• Mn, Mo, Cu, Cl, B, Zn, Fe<br>• EC, pH, bicarbonates, Na, Si<br>(see pg. 4 for legend)<br><br>Use acid treatment to lower pH<br>Undertake desalinization to remove ions in order to improve water quality<br>Adjust nutrient solution following treatment<br>*Note:* **Pretreatment systems may generate a waste by-product that may be subject to MOE requirements for disposal or discharge** |
| PREVENT DISCHARGE OF LEACHED NUTRIENT FEEDWATER AND OTHER WASTEWATERS | **6.** Map all water and wastewater and movement of that water on and off your property | Draw a diagram of all water and wastewater inputs and outputs | These may include, but are not limited to:<br>• inputs from municipal water, wells, surface water, and storm water recapture<br>• outputs from wastewater (regardless of how infrequent), excess leached nutrient feedwater, irrigation water, floor drains, tile drains, filter backwash, boiler blowdown, washwaters, greenhouse washdown, and any septic waste<br>• outputs from storm water, including outdoor catch basins and roof gutters |

## A PRE-PRODUCTION BEST MANAGEMENT PRACTICES
for water and nutrient management before water and nutrients enter the production system and greenhouse facility

| GUIDING PRINCIPLES | GENERAL BMP | SPECIFIC BMPs | DETAILS |
|---|---|---|---|
| PREVENT DISCHARGE OF LEACHED NUTRIENT FEEDWATER AND OTHER WASTEWATERS | 7. Select or alter site to reduce infiltration of leached nutrient feedwater into groundwater | Assess site features | Consider depth to water table and bedrock<br>Know off-site water sources – monitor incoming water quality and quantity from adjacent areas |
| | | Modify site | Compact soil beneath production areas, cover ground with impermeable surface, or use subsurface drains to capture and collect |
| | 8. Select or alter the site to minimize runoff to surface water | Assess site features | Consider slope, distance to surface water<br>Monitor incoming water quality and quantity from adjacent areas |
| | | Modify site | Construct berm or protect site from runoff |
| MANAGE WATER AND NUTRIENT INPUTS EFFICIENTLY | 9. Replenish irrigation ponds during high flows to avoid water removal during periods of low flow | Schedule during high water conditions | Harvest water after peak flows for best quality and minimal impact on habitat |
| | 10. Construct permanent water storage | Ensure storage is designed and sized with sufficient capacity to allow for variability in water quantity and quality | Use lined ponds, lined/treated concrete reservoirs, or heavy-duty plastic cisterns if treated surface water is used for irrigation system or other purposes |

***Modify site to reduce the risk of groundwater contamination. The ground is leveled, compacted, and prepared for installation of groundsheet plastic cover.***

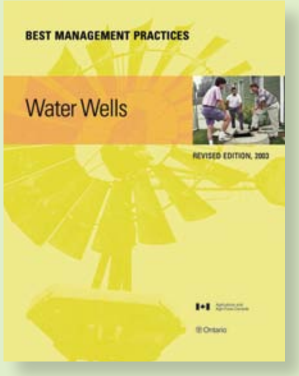
## A PRE-PRODUCTION BEST MANAGEMENT PRACTICES

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

| GUIDING PRINCIPLES | GENERAL BMP | SPECIFIC BMPs | DETAILS |
|---|---|---|---|
| MANAGE WATER AND NUTRIENT INPUTS EFFICIENTLY | **11.** Obtain a Permit to Take Water (PTTW) from MOE if you take more than 50,000 L on any day from a surface water or groundwater source | Monitor and keep records for PTTW | Install water meters and other devices strategically to monitor volume used<br>Test wells for sustainable pumping rates, drawdown and yield before using a well as your water source<br>Pump water for 24 hours to test yield and water table drawdown; pumping pump-test water into municipal drains may require a permit, so contact town/municipality<br>See BMP book: *Water Wells* |
| | **12.** Create a contingency plan to deal with issues of threatened water availability | Develop a low-water contingency plan | Ensure your plan includes: alternative water sources, logistics for delivery, backup storage, and water-efficient BMPs |
| | **13.** Hire an engineer familiar with irrigation methods to design your system | Hire an irrigation consultant | Get professionally designed irrigation system with optimal uniformity and efficiency, and able to optimize timing of irrigations |

***Store irrigation water in leak-proof containers such as above-ground, lined storage tanks.***

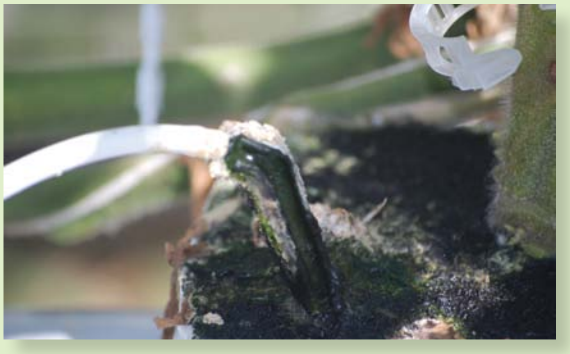
***See Best Management Practices book* Water Wells *for information on measuring yield and water table drawdown.***



## B PRODUCTION BEST MANAGEMENT PRACTICES
for water and nutrient management within the greenhouse facility and during crop production

| GUIDING PRINCIPLES | GENERAL BMP | SPECIFIC BMPs | DETAILS |
|---|---|---|---|
| KNOW YOUR WATER QUANTITY AND QUALITY THROUGHOUT THE SYSTEM | **14.** Keep records of measurements of volume of water used for irrigation and other purposes – and its corresponding analysis where possible | Install sensors<br>Calibrate output | Involves water meters, pressure sensors<br>Use bucket under emitter<br>(see Leachate Measurement diagram on pg. 12) |
| | **15.** Optimize water efficiency based on monitoring and record-keeping | Create management zones based on similar irrigation and climate needs | Group plants by size and cultivar, for example |
| CLOSE PRODUCTION SYSTEM TO COLLECT AND REUSE LEACHED NUTRIENT FEEDWATER | **16.** Design your operation to collect and recycle leached nutrient feedwater within your operation where practical | Monitor<br>Conduct routine maintenance<br>Repair fertigation system components | Install monitoring equipment – e.g. pressure gauges, EC, and pH meters<br>Routinely check all components<br>Test output for uniformity<br>Monitor and clean nozzles<br>Clean/replace filters |

***Water content meters can provide feedback that will improve irrigation efficiency.***



***Clean nozzles: application rates must be uniform to attain even production and reduce waste.***

***Create management zones by crop type, stage or size to manage inputs more efficiently.***

***In closed production systems, use reliable techniques to monitor the quality and quantity of recycled water. Use the information to treat effectively.***

## B PRODUCTION BEST MANAGEMENT PRACTICES

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

| GUIDING PRINCIPLES | GENERAL BMP | SPECIFIC BMPs | DETAILS |
|---|---|---|---|
| CLOSE PRODUCTION SYSTEM TO COLLECT AND REUSE LEACHED NUTRIENT FEEDWATER | **17.** Treat reused water for plant pathogens<br>**18.** Consult qualified person to assist in design, setup, and safety<br>(17 and 18 are continued on next page) | Ultra-violet (UV) – irradiation | Kills most pathogens at prescribed rates<br>Requires pre-filtration of water |
| | | Pasteurization | Kills most pathogens at prescribed temperatures<br>Requires pre-filtration and acidification of water |
| | | Reverse osmosis (RO) | Removes ions and pathogens<br>Produces large volumes of filtrate (brine) solution<br>Requires pre-filtration of water |
| | | Ultra-filtration | Removes most pathogens (due to membrane technology)<br>Requires high maintenance<br>Requires pre-filtration of water |

*Use UV treatment systems to kill pathogens and other micro-organisms.*

*Heat disinfection will also kill pathogens and bacteria.*

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

## B PRODUCTION BEST MANAGEMENT PRACTICES

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

| GUIDING PRINCIPLES | GENERAL BMP | SPECIFIC BMPs | DETAILS |
|---|---|---|---|
| CLOSE PRODUCTION SYSTEM TO COLLECT AND REUSE LEACHED NUTRIENT FEEDWATER | (17 and 18 are continued from previous page)<br>**17.** Treat reused water for plant pathogens<br>**18.** Consult qualified person to assist in design, setup and safety | Slow sand | Filters out particulate matter and houses microbes that will suppress pathogens<br>May require post-treatment |
| | | Lava rock | Provides habitat for pathogen-reducing microbes (due to porous medium)<br>Will not kill all pathogens<br>May require post-treatment |
| | | Ozonation | Is a potent oxidant<br>Requires pre-filtration of water |
| | | The following treatment options for reused water are also available but have potential risks for operator, plant and aquatic toxicity:<br>• hydrogen peroxide<br>• chlorination<br>• chlorine dioxide<br>• copper ionization | |
| MANAGE WATER AND NUTRIENT INPUTS EFFICIENTLY | **19.** Look for a system that suits your operation and a design that offers optimal uniformity and efficiency, and is able to optimize timing of irrigations | Hire an irrigation consultant | |

***Ozonation uses ozone, an oxidant with twice the effect of chlorine, to destroy pathogens and other microbes.***

***Slow sand filtration systems are designed to remove particulates and microbes. Sand filters are easy to establish and operate.***

## B PRODUCTION BEST MANAGEMENT PRACTICES
for water and nutrient management within the greenhouse facility and during crop production

| GUIDING PRINCIPLES | GENERAL BMP | SPECIFIC BMPs | DETAILS |
|---|---|---|---|
| MANAGE WATER AND NUTRIENT INPUTS EFFICIENTLY | **20.** Keep inventory of fertilizers | Maintain an inventory of the amount of fertilizer (e.g. ammonium nitrate) purchased and used, and location of storage | Use your inventory to help assess efficiency |
| | **21.** Sample, test, and record fertilizer solutions | Analyze water sources and nutrient feedwater throughout year or when changes are made – identify its chemical makeup, EC, pH, and manage accordingly | Test feed solution for macronutrients, micronutrients or other components |
| | **22.** Schedule irrigation | Monitor plant and atmospheric data | Collect growth environment and plant moisture data for irrigation scheduling |
| | **23.** Match substrate stability to cropping cycle length | Conduct tests and trials | Verify substrate type is suitable for operation by conducting trials |
| | **24.** Crop nutrient management | Choose the right form | Use water-soluble fertilizers<br>Should be good quality – containing no additional by-products or contaminants |
| | | Apply the right rate | Match nutrient needs to crop type and growth stage – consult Ministry of Agriculture and Food and the Ministry of Rural Affairs crop production guidelines for more information<br>Select fertilizer sources and adjust rates to account for remaining nutrients and limiters (sulphates, chlorides, sodium) in recycled irrigation water or available in growing substrates – this applies to all macronutrients and micronutrients |
| | | Apply at the right time | Match nutrient needs to crop type, growth stage, and greenhouse climate conditions |

***Reduce nutrients in the leached nutrient feedwater by:***

- ***matching fertilizer rates to meet crop requirements***
- ***adjusting fertilizer rates to account for fertilizers in growing substrates***
- ***selecting fertilizer sources to account for limiters (chlorides, sulphates, sodium)***
- ***accounting for nutrients remaining in recycled irrigation water.***

***Lower nutrient feedwater concentrations of boron and molybdenum can increase opportunities for approved land application.***

## B PRODUCTION BEST MANAGEMENT PRACTICES

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

| GUIDING PRINCIPLES | GENERAL BMP | SPECIFIC BMPs | DETAILS |
|---|---|---|---|
| PREVENT DISCHARGE OF LEACHED NUTRIENT FEEDWATER AND OTHER WASTEWATERS | **25.** Reduce impact from spills | Equip all water-taking systems with anti-backflow devices to prevent unintentional contamination of the water source | Install a permanent anti-backflow device on the water supply line |
| | | Use high-density polyethylene or stainless-steel containers designed for the purpose of fertilizer solution storage | Store fertilizer to prevent contamination of nearby surface water or groundwater |
| | | Ensure that secondary containment around concentrated fertilizer storages is in place | Note that size should be 110% of storage volume |
| | | Have a written and posted contingency plan for spills of bulk fertilizer | Keep plan readily accessible for staff<br>Inform staff of contingency plan |
| | | Clean up any fertilizer spills immediately | Use appropriate technology and techniques to clean up solution spills (e.g. spill kits with portable barrier) |
| | **26.** Capture, collect, and store leached nutrient feedwater solutions | Ensure no floor drains lead to the outside environment from any fertilizer or pesticide storage or mixing areas | Close off floor drains or direct them to a separate isolated containment |
| | | Use high-density polyethylene containers, lined concrete, lined steel-clad | Ensure correct container size for the volume generated by your specific operation |

*Use of technologies such as variable-speed soft-start irrigation pumps improves precision of irrigation scheduling.*

*Anti-backflow devices prevent contamination of the fresh water supply, which could be municipal water or well water. A restricted-flow valve controls the maximum flow rate to the greenhouse operation so as to minimize strain on the municipal supply system.*

## C POST-PRODUCTION BEST MANAGEMENT PRACTICES

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

| GUIDING PRINCIPLES | GENERAL BMP | SPECIFIC BMPs | DETAILS |
|---|---|---|---|
| | | 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.* | |
| KNOW YOUR WATER QUANTITY AND QUALITY THROUGHOUT THE SYSTEM | **27.** Monitor water quantity and quality | Have your leached nutrient feedwater analyzed for nutrient concentrations and know the volumes in order to design the best system for your operation | Analysis of leached nutrient feedwater and environmental quality goals will assist in determining reused water treatment option<br>Test water for macronutrients, micronutrients or other components – consult Ministry of Agriculture and Food and the Ministry of Rural Affairs production guidelines for more information |
| PREVENT DISCHARGE OF LEACHED NUTRIENT FEEDWATER | **28.** Collect and store separately leached nutrient feedwater from other greenhouse wastewaters | Leached nutrient feedwater storage should be designed to contain total volume of leached nutrient feedwater produced, and to ensure that the stored waters do not reach surface water or groundwater resources | |
| | **29.** Pre-treat leached nutrient feedwater or other post-production water | Drain inlet inserts (a storm water BMP) | Removes debris and prevents some sediment from entering drainpipe |
| | | Sedimentation (recycling) ponds | Removes sand and silt |
| | | Sand filters – fast | Removes particulates |
| | | Sand filters – slow | Removes particulates and some pathogens |

***Leached nutrient feedwater is nutrient-rich and should be collected and stored separately from other greenhouse wastewaters.***

## C POST-PRODUCTION BEST MANAGEMENT PRACTICES

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

| GUIDING PRINCIPLES | GENERAL BMP | SPECIFIC BMPs | DETAILS |
|---|---|---|---|
| | | 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.* | |
| PREVENT DISCHARGE OF LEACHED NUTRIENT FEEDWATER | **30.** Removal of nutrients from leached nutrient feedwater (continued on next page) | Bio-filter | Reduces N, but may not meet required environmental standards |
| | | Inorganic filter | Reduces P, but may not meet required environmental standards |
| | | Constructed wetland | Reduces N and P, but may not meet required environmental standards<br>Reduces some pathogens, but may not meet required environmental standards |
| | | Vegetated filter strips | Reduces some N, P and sediment, but may not meet required environmental standards |
| | | Bio-retention swales | Reduces some N, P and sediment, but may not meet required environmental standards |
| | | Bio-retention basins | Reduces some N, P and sediment, but may not meet required environmental standards<br>Reduces some pathogens, but may not meet required environmental standards |

***With due regard to current regulations (such as the* Ontario Water Resources Act *and* Nutrient Management Act*) and nutrient management BMPs, leached nutrient feedwater can be land-applied to local field crops.***

## C POST-PRODUCTION BEST MANAGEMENT PRACTICES

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

| GUIDING PRINCIPLES | GENERAL BMP | SPECIFIC BMPs | DETAILS |
|---|---|---|---|
| | | 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.* | |
| PREVENT DISCHARGE OF LEACHED NUTRIENT FEEDWATER AND OTHER WASTEWATERS | (continued from pg. 26)<br>**30.** Removal of nutrients from leached nutrient feedwater | Buffer strips | Reduces sediment, but may not meet required environmental standards<br>Reduces some N and P, but may not meet required environmental standards |
| | | Grassed waterways | Reduces sediment, but may not meet required environmental standards<br>Consider agronomic principles, soil characteristics, and application regulations, but may not meet required environmental standards |
| | **31.** Alternative use of leached nutrient feedwater | Land application | Allows nutrients to be used by crops<br>Consider agronomic principles and soil characteristics<br>Ensure plant pathogens will not affect receiving crops |
| | **32.** Disposal of leached nutrient feedwater | Municipal sewer where municipal bylaw permits | Contact your municipality to ensure bylaw compliance |

***Constructed wetlands will reduce particle and nutrient levels of post-production wastewaters.***

## FOR MORE INFORMATION

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Email: ag.info.omafra@ontario.ca
Web: www.ontario.ca

See especially: *Growing Greenhouse Vegetables in Ontario,* No. 836

**BEST MANAGEMENT PRACTICES**

The BMP Series of publications has many booklets on related topics.

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