THE FIELD

How you manage crops in the field directly affects water quantity and quality. This chapter will help you develop a water management plan that:

- ▶ will help sustain ideal soil moisture levels
- ▶ keeps ground water impacts to a minimum
- ▶ reduces soil erosion, by managing overland runoff.

But first, back to basics: how water moves (or doesn't move) through a field, and the influences of soil types, seasons, cropping practices, and drainage on its movement. You need to be aware of these interrelationships before you can develop an effective plan.

Throughout the remaining chapters, we'll be referring you to other booklets in the Best Management Practices series that address related topics – soil, nutrient, crop, manure, and woodlot and wildlife habitat management. In them are more background and best management practices to help you protect your soil and water resources.

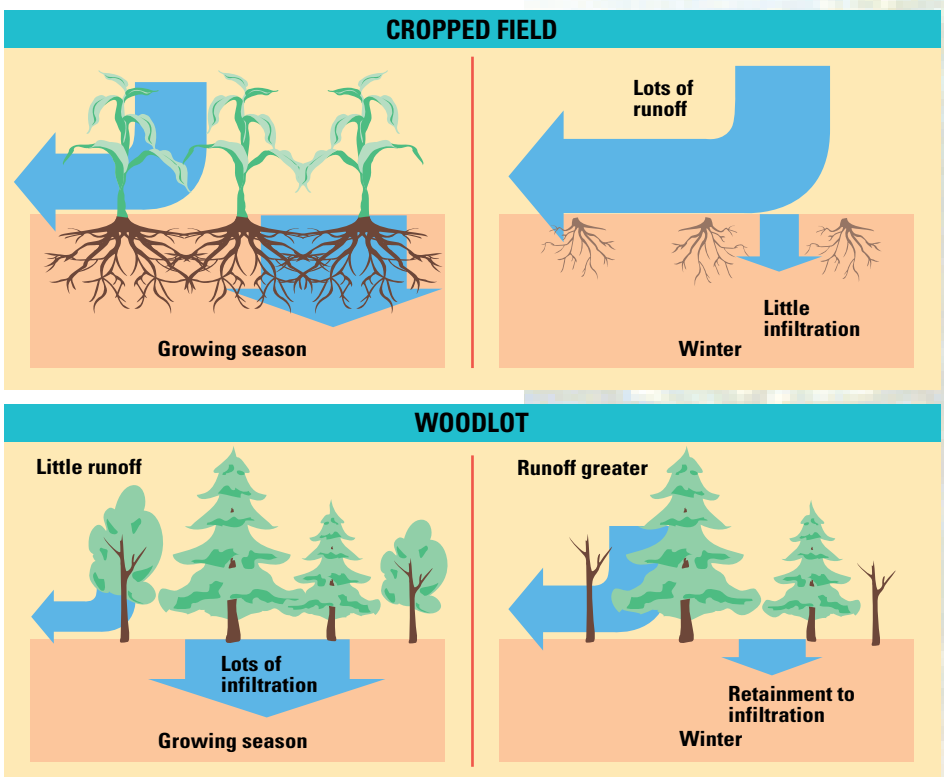
Typically, when water falls on a bare field, 66% is evaporated back to the atmosphere, 25% runs off to ponds, watercourses, lakes, and other depressional areas, and the remaining 9% infiltrates the soil.

PATHWAYS OF WATER

Prior to agricultural settlement, the Ontario landscape was covered in forest, wetlands, and natural meadow. Clearing and logging made farming viable. But they also increased the amount of surface runoff from farm fields.

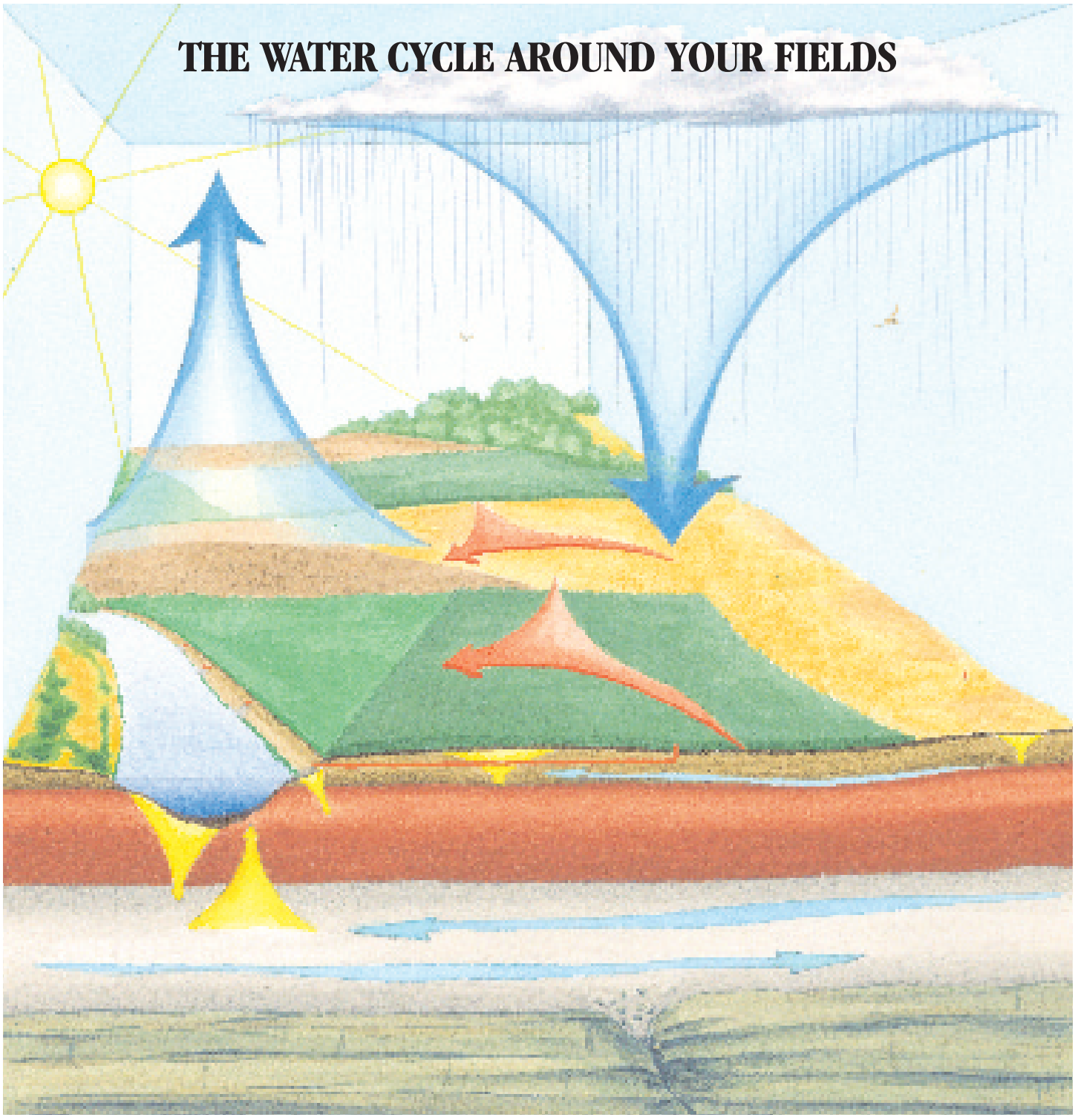
Runoff can carry with it sediment, nutrients, and pesticides, and is of particular concern when we look at the cycle of water in the field.

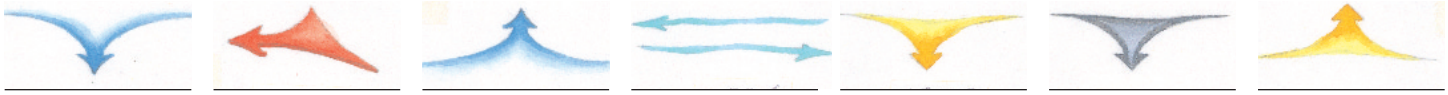
Water movement will vary, according to the season.



Regardless of season, there is more runoff from one hectare of a cropped field without residue management than from one hectare of woodlot. In a woodlot, more water infiltrates or is stored as snow.

THE WATER CYCLE AROUND YOUR FIELDS





Precipitation | **Runoff** | **Evaporation and Transpiration** | **Ground water flow** | **Infiltration (uncontaminated)** | **Infiltration (potentially contaminated)** | **Ground water recharge**

In your fields, precipitation can: be stored as snow or ice, be stored in the soil to be used by crops, evaporate at the soil surface, infiltrate the soil, or, if precipitation exceeds the soil's infiltration capacity, run off overland. The proportion of water in any of these areas depends on soil conditions, the length and degree of slope, time of year, and how you manage the fields.

Runoff is of particular concern, since it can potentially take soil and crop inputs in the soil (such as phosphates from applied commercial fertilizers or manure, and some pesticides) with it to pollute surface water.

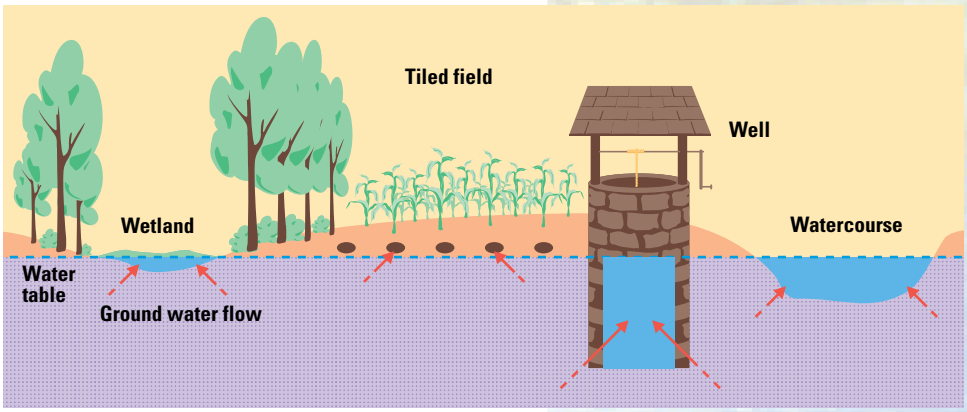
Sandy and gravelly soils, soils with a high water table, and shallow soils over bedrock are vulnerable to ground water contamination by nitrate-nitrogen and some pesticides that leach through the soil. Best management practices will help you control runoff and preserve soil and water quality.

THE FIELD

GROUND WATER AND YOUR SOIL

Water enters soil through pores and cracks or holes and tunnels created by dead plant material, earthworms, insects, and animals. How much water enters will depend on your field's natural characteristics and your management choices.

Water moves down slowly in fine-textured soils, making them more sensitive to runoff and surface water contamination. Downward movement is faster in coarser-textured soils, which can lead to a greater potential for ground water contamination.



Ground water can resurface in drains, watercourses, wetlands, or other low areas on and off the farm, or may be drawn back up to the surface through wells.

Several natural characteristics affect the amount of water in soils, namely: soil type and structure, slope, depth to water table, precipitation, season, and weather.

Management practices also affect soil moisture content. Soils with high amounts of crop residue will allow more infiltration and higher soil moisture. The same is true for soils with high organic matter content.

NATURAL CHARACTERISTICS	MANAGEMENT IMPACTS
• soil type and structure	• residue management practices
• slope	• cropping practices, including type, rotation, cover crops, and direction relative to slope
• wetness of the soil depth to water table	• compaction
• amount and intensity of precipitation	• organic matter levels
• time of year	• other management practices, such as: strip cropping, terraces, windbreaks
• weather (freezing/thawing,wetting/drying)	

The type of soil determines how much water is held in your soil, and how much is available for use by your plants.

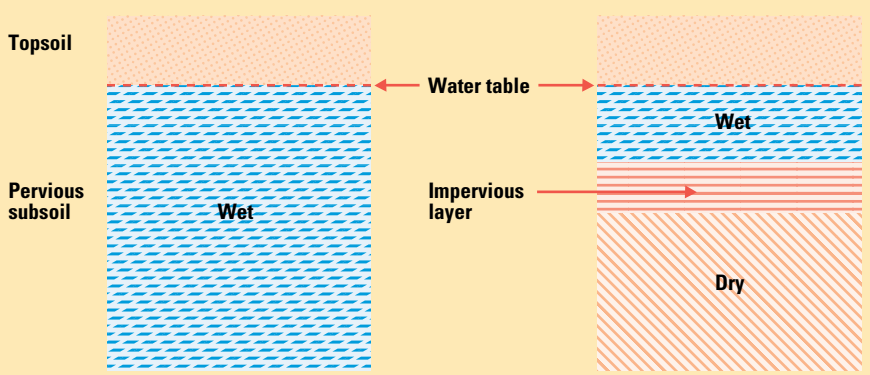
THE FIELD

Your soil's water-holding capacity will also depend on the amount of organic matter and the number of soil layers. Many of Ontario's soils are stratified, that is, they have layers of various-textured soils overlying each other. These features will significantly affect your field's wetting and drying characteristics.

In uniform soils the water table will move up and down with the seasons. If a layer of soil occurring naturally or caused by cultivation restricts water movement, a perched water table may be present. Knowing your soil types is the first step to maintaining and improving them, and managing water effectively.

SOIL TYPE	RATE OF WATER MOVEMENT INTO SOIL		mm OF WATER AVAILABLE IN A METRE OF SOIL	
	ON BARE SOIL	ON CROPPED SOIL	IN SATURATED SOIL	AVAILABLE TO PLANTS
sand	fast	fast	100	75
silt loam	medium	fast	267	167
loam	medium	fast	283	167
clay loam	medium	medium	317	167
clay	slow	slow	325	117

STRATIFIED SOILS' EFFECTS ON WATER TABLE



THE FIELD

SURFACE WATER

Monoculture, specialized livestock production, a decrease in forage-based cropping systems, and large equipment can contribute to soil compaction, which reduces water's ability to percolate through your soil. This can result in excess surface water in your fields.

Leaving surface water unmanaged can lead to rill and gully erosion. Erosion affects your water quality because it can transfer high sediment loads to watercourses. That sediment will include topsoil, chemicals, nutrients, and bacteria.

Some of the ways excess surface water can be removed are:

- natural or constructed channels
- infiltration to ground water or a tile drainage system
- surface inlets into a tile drainage system
- evaporation and transpiration.

Remember that any method you use to remove surface water will have implications for land and nearby watercourses.

Tillage practices affect the volume of surface runoff. Working your field in wet conditions, or leaving it bare of residue or other vegetation, will reduce your soil's ability to accept water.

Too often, surface runoff is left unmanaged and can result in high sediment loads to the watercourse. High sediment loads can destroy fish habitat.

Tillage practices should be adopted that allow as much infiltration as possible. No-till retains maximum amounts of crop residue on the soil surface to buffer raindrop and runoff impacts.

CHEMICAL MOVEMENT

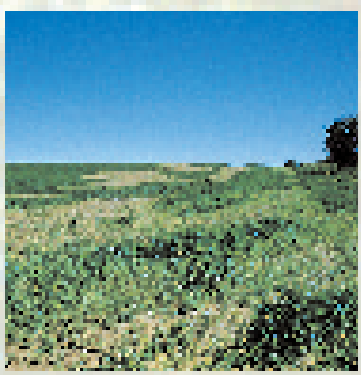
Any chemicals you apply to a field may be:

- intercepted by plants or residue
- attached to soil particles
- dissolved in water
- drained into ground or surface waters
- decomposed or vaporized
- taken up and used by plants.

The factors that help decide where chemicals go in the field include:

- solubility – how easily a chemical dissolves in water to become a solution
- persistence – how long it takes a chemical to break down
- adsorption – the ability of a chemical to attach itself to soil particles.

The following table provides ratings for the solubility, persistence, and adsorption of common chemicals used in field crop production. Clearly, a chemical that is highly soluble, persistent, and has strong adsorption potential is most likely to get into surface water.



Over-application of atrazine can reduce crop yields.

THE FIELD

SOLUBILITY, PERSISTENCE, AND ADSORPTION POTENTIAL OF CROP PROTECTION CHEMICALS

CHEMICAL	SOLUBILITY	PERSISTENCE	ADSORPTION POTENTIAL
2,4-D	low	low	moderate
Atrazine	low	high	moderate
Cyanazine	moderate	low	strong
Diazinon	low	low	strong
Linuron	low	high	strong
Metolachlor	high	high	strong
Metribuzin	high	moderate	weak

A chemical spill during mixing and filling operations, or excessive application, not only reduces your land's ability to grow crops, but will also directly impact ground and surface water.

Time of year influences the movement of crop protection chemicals into surface water. After 15 years of sampling, Atrazine was recorded in numerous surface water samples. Listed in the following table is a breakdown of when these samples were taken.

TIME OF YEAR	% CHEMICAL LOAD MEASURED	REASON
JANUARY - APRIL	54	high precipitation and snowmelt
MAY - AUGUST	32	period of pesticide use
SEPTEMBER - DECEMBER	14	less runoff pesticides not being applied pesticide adsorption

Times of heavy rainfall and drought can lead to periods of water surplus and shortage. You can remove excess water through tile and surface drainage (such as grassed waterways) in ways that reduce erosion and flooding. Water conservation and irrigation can be used to make up for a lack of water.

SUBSURFACE DRAINAGE

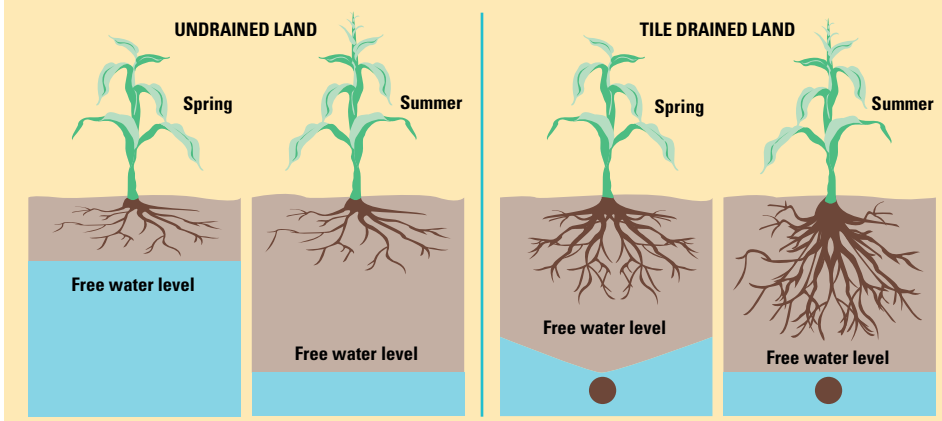
Through most of the year, Ontario farmland has a surplus of water falling on it. Subsurface or tile drainage is a proven method of removing excess water and is a best management practice in crop production. If you have capital available, tile drainage is a sound investment. The following table presents some points to consider:

THE FIELD

TILE DRAINAGE

ADVANTAGES	DISADVANTAGES
• reduces surface runoff of contaminated water	• can increase risk of nutrient flow through tile to watercourses
• reduces soil compaction	• might increase springtime flooding downstream
• increases crop yields	• can damage wetlands or destroy small wetlands
• enhances timing of field operations	• disrupts the flow of ground water to watercourses
• can extend growing season	• high capital costs
• can provide more crop options for rotation	• some maintenance requirements

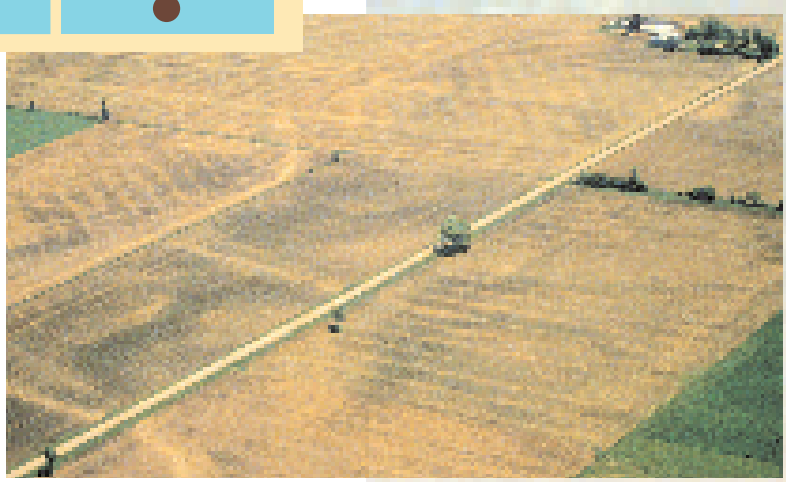
CROP ROOT DEVELOPMENT ON DRAINED VERSUS UNDRAINED LAND



A low water table in the spring allows maximum root growth. In the drier summer months, the crop will better withstand droughts and support yields.

New systems are being designed so that tile drains can do double duty as drainage and irrigation systems. By controlling the tile outlet, water can be released or held in the tile, depending on crop needs. Nutrients contained in the water are also available to the crop.

Aerial view of land drying over tile drains.



THE FIELD

BEST MANAGEMENT PRACTICES

NUTRIENT MANAGEMENT

A sound nutrient management program will maintain or increase yields while saving you money and protecting the environment. We urge you to read *Nutrient Management* and *Livestock and Poultry Waste Management* for more details. Here is a snapshot of best management practices:

- consider risks to water resources before application
  - make sure crops can use fertilizers or manures at time of application. (Coarse-textured soil can't absorb them in the fall; excessively drained or shallow soils on fractured bedrock need extra care.)
- consider cover crops to use nutrients in periods when potential leaching is greatest, or on extensively drained fields
- consider cultivation to break up preferential flow paths on the soil surface and within the soil before applying liquid fertilizer or liquid manure
- monitor irrigation and tile systems carefully, especially if applying fertilizers or manures
- rotate crops to use residual nutrients
- don't store manure in field if it can threaten water resources
- avoid winter manure application, especially on sloping land
- don't apply manure on saturated soils
- test your soil for nutrient levels before planting (or a minimum of every 3 years)
  - soil test for phosphorus and potassium
  - for corn, soil test for nitrogen levels as near as possible to nitrogen application
- test manures for nutrient values
- apply fertilizers at rates recommended for crop production in Ontario
  - base fertilizer rates on soil tests, and on what the plant can use
  - set realistic yield goals
  - account for contributions from manure, cover crops, previous crops, and other applied wastes such as sewage sludge
  - time your fertilizer application to maximize crop uptake and growth
- apply fertilizer in a band after crop is established
- consider using inter-row cultivation to help control weeds
- calibrate manure applicators and spread uniformly.

THE FIELD

BEST MANAGEMENT PRACTICES
PEST MANAGEMENT

Adopting an Integrated Pest Management system for your operation will help you use chemicals efficiently and effectively, while protecting your water quality. The IPM program considers weed, insect, and disease control.

The booklets, *Field Crop Production* and *Horticultural Crops,* outline more fully what's involved. In this booklet, "The Barn and other Farm Buildings" chapter reviews pesticide mixing, storage, and disposal.

In addition to the recommendations there, remember to evaluate the types of soils on your property, and assess the vulnerability of your water supplies.

BEST MANAGEMENT PRACTICES
IRRIGATION MANAGEMENT

If you're planning an irrigation system, bear in mind:

- the effects on crop production
- the amount of water needed
- sources of water (distance, suction height)
- water quality
- impacts on water source
- laws affecting water taking.

The type of system you choose will in part depend on:

- slope
- soils
- crops
- energy requirements
- wind action
- methods of application (sprinkler, trickle, surface, or subirrigation).

Choose an irrigation system that gets as much water back to the plant as is needed and minimizes water losses to evaporation and/or runoff.

It's a good idea to do a cost-benefit analysis before you buy. Remember to factor in:

- expected yield increase based on crops to be grown
- water demands of soil and crop
- annual operating costs (including energy, materials, labour, maintenance, and annual depreciation).

Some best management practices for irrigation include:

- scheduling irrigation to maximize energy and water conservation
- being conscious of water table levels and the effect your actions have on them
- moisture-testing soil to ensure crops do need water
- if fertilizers are being applied, making sure the job's done safely and only when necessary
- installing an anti-backflow device, such as a check valve.

THE FIELD

BEST MANAGEMENT PRACTICES

DRAINAGE MANAGEMENT

Drainage works are a large capital investment. Management of an artificial drainage system requires effective:

- **planning** of the system prior to construction, and
- **maintenance,** i.e. inspection and repair.

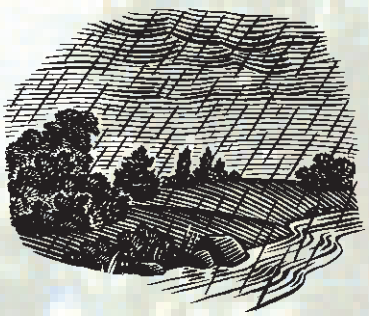
In this section, we'll look at the overall picture, then specifically at tile outlets, surface inlets, tile lines, surface drainage systems, and runoff management.

For more information, read Ontario Ministry of Agriculture and Food Publication 73, *Handbook of Drainage Principles.*

PLANNING A SUBSURFACE DRAINAGE SYSTEM

Here are some determining factors in your choice of system:

- crop types
- soil types and topography
- availability of an outlet
- system design
- location of manure, chemical, and fuel storage areas
  - all drains, including surface inlets, should be located away from contaminant sources.



Also,

- don't use your drains to discharge contaminated wastes
- keep a detailed record of all drainage works you install, and update the record as you make changes
- if you're planning to buy a farm, get a record of any tile drainage and then investigate the system
  - consider both water flow and water quality.

Finally, remember that not all land should be drained. If you have significant wetlands or other sensitive areas, the damage done to the environment may outweigh the benefits of a larger land base. (The next chapter on wetlands outlines your legal responsibilities vis-à-vis wetlands.)

THE FIELD

MAINTENANCE

Properly installed subsurface drains are low-maintenance. Regular visual inspections of your fields, tile lines, and outlets will show you whether water is draining properly. Key times for inspecting are:

- springtime
- after heavy rains
- the first few years after installation.

Licensed drainage contractors assist landowners with planning and installing tile drainage systems.

TILE OUTLETS

A good outlet will consist of a rigid pipe with a hinged rodent gate and be properly protected with rip rap that has filter cloth underlay. Your pipes should not in any way obstruct channel flow.

Ensure there is an adequate clearance between the tile outlet and the receiving drain or stream bottom.

Marking outlets with stakes or posts will make outlets easy to find.

Your maintenance program should include a regular inspection at the drain outlet:

- ensure it's clear of debris and sediment
- check quality of discharged water
- check that the pipe is not damaged by ice
- check that the rodent gate is working properly
- keep the rip rap in good condition, and replace any material that may have moved.

A properly installed tile outlet.

THE FIELD

SURFACE INLETS

There are three basic types of inlets:

- ► concrete, steel, and plastic catchbasins
- ► perforated vertical pipe intakes
- ► blind inlets.

Maintaining surface inlets includes:

- ► inspecting all surface entry points
  - ▷ look for washouts around the inlet and repair immediately
- ► clearing the inlet of trash and debris
- ► removing soil as often as needed, if catchbasin is designed with a sump to trap sediment
  - ▷ especially important in newer drains located on highly erodible soils
- ► not spreading manure close to open inlets
  - ▷ incorporate manure as soon as possible.

If you have a terrace system, where sediment may be trapped on the field adjacent to inlets, you should develop a long-term plan to minimize impacts.

Sediment removal may be necessary periodically with bulldozers or other equipment.

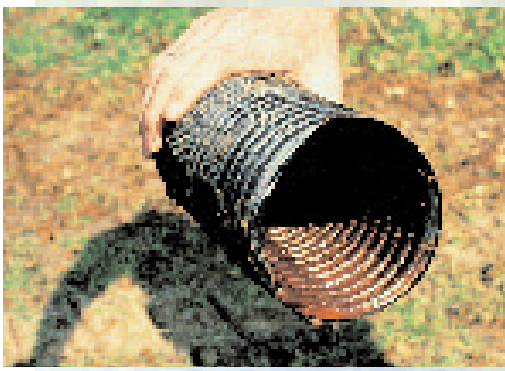
The most effective means to reduce this sedimentation is adopting conservation cropping and tillage.

Regular maintenance of your tile drainage system will help to ensure it works properly year after year.

THE FIELD

TILE LINES

As with tile outlets and surface inlets, regular inspections are an excellent early-warning system to help you troubleshoot. In the next chart, you'll see that some of the problems are a result of poor planning.



Red organic matter, "iron ochre", is occasionally a problem in tile drains.

TROUBLESHOOTING TILE LINES

ITEM	WHAT TO LOOK FOR	POSSIBLE CAUSES	SOME REMEDIAL ACTIONS
• blow-outs, wash-ins, and other broken tile	• holes in soil above or around tile lines • water not draining	• defects in tile • high pressures in drains • faulty connections • shallow cover over drain – collapsed by equipment • damaged tile	• repair immediately • replace damaged tile • if high pressures persist, vent as necessary • relocate drain where sufficient cover can be achieved
• tree roots	• tile line near trees • water not draining	• roots of some tree species can clog drain • problem is greatest in continuous flowing tile	• replace plugged section • consider solid tile in problem area • rotary cutters
• sediment & mineral deposit	• decreased flow capacity • excess sediment in tile	• lack of filter	• filter may eliminate most sediment • high-pressure cleaners (but watch for additional sediment)
• iron ochre	• reddish/orange slime or discoloration at outlet • crusting over of joints or perforations of tile • gelatinous growth inside tile	• soil microbes in oxygen-deprived conditions • usually in an area that hasn't been drained before	• no guaranteed solutions • consult experienced drainage contractor or engineer • replace tile
• damage to soil structure	• water ponding above drain	• compaction by farm equipment, cultivation, or livestock • tile installed in too wet conditions • excess manure application, which seals soil	• install rigid pipe under laneways or traffic areas • restrict livestock from drained areas when ground is saturated • change tillage and cropping if plough pans or layers are noticed • apply manure at proper rates, and when land is suitable • stay off wet soils

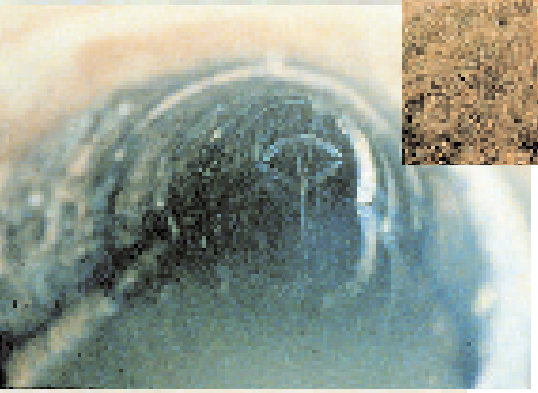
Continues on next page...

THE FIELD

TROUBLESHOOTING TILE LINES... continued

ITEM	WHAT TO LOOK FOR	POSSIBLE CAUSES	SOME REMEDIAL ACTIONS
• grassed waterways	• erosion damage at channel centre, tile exposed	• tile drain too close to channel centre	• move drain (or preferably, plan in advance and locate drain away from channel centre)
• loss of organic soils*	• excessive drying of organic soils where thick organic layer is underlain by a shallow impermeable soil (silty clay, clay, marl or non-waterbearing sand)	• organic soils have been exposed to oxygen • drain installed close to underlying impermeable soils	• install drain sufficiently above underlying soils so that water can be retained, or added to the root zone system, i.e. subirrigation • in some cases, getting soils to accept water again will be impossible
• poor water quality**	• odours or solid waste in drain	• manure, milkhouse, septic or other wastes	• take immediate action: locate source and eliminate if possible
• manure leaching	• manure leaching through soil	• poorly timed manure application; direct flow paths from root or worm tunnels are present	• improve timing of manure application; break up flow paths prior to application

***Draining organic soils (peat or muck) takes special care. Before you begin draining organic (peat or muck) soils:**
▶ consult a local drainage expert
▶ consider the environmental impacts: these soils are often in areas close to wetlands.
****Refer to *Livestock and Poultry Waste Management, Nutrient Management,* and the "Barn and other Farm Buildings" chapter of this booklet.**



Sediment buildup in a tile drain can be eliminated through proper planning and installation.

A well-constructed and maintained municipal drain.

A tile blowout or wash-in indicates immediate attention is needed to repair the tile drain.

THE FIELD

SURFACE DRAINAGE SYSTEMS ON THE FIELD

There are times when water collects and flows on the surface of fields. Managing your surface water in a manner that reduces erosion and the transportation of sediment, nutrients, and chemicals is an important aspect of your field management.

The following sections list a number of structural runoff management techniques, and cropping and tillage management techniques that reduce runoff impacts.

STRUCTURAL PRACTICES

BEST MANAGEMENT PRACTICE	DESCRIPTION	BENEFITS & CONSIDERATIONS
terrace	• construct earthen berms to shorten slope lengths	• holds water and soil on the field • releases water slowly to a stable outlet through tile drains or grassed waterways
water and sediment control basin (where terraces aren't practical)	• build short earthen embankments across draws or gullies	• will act like terraces to pond water on the field and release it slowly • reduces downslope erosion and flooding impacts, and controls soil erosion • settles some eroding materials out
diversion	• build channels and berms across slopes to intercept and carry runoff water to a stable outlet	• reduces erosion • allows water to move off field at a flatter grade in a controlled manner, thereby reducing sheet erosion downslope
grassed waterway	• develop properly sized and shaped channel with protective vegetation	• transports surface runoff safely
drop pipe inlet	• install a large diameter pipe or pipes to convey water down steep slopes or high drops	• conveys water safely
rock chute spillway	• construct rock chute underlaid with filter cloth to accommodate anticipated flows	• conveys water safely

THE FIELD

▲ Prefabricated vertical pipe intakes virtually eliminate plugging and are best suited to cropland conservation systems. Orifices used to regulate flows reduce tile requirements and costs.

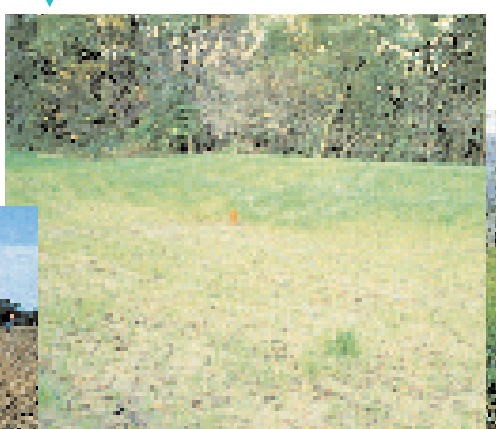
▼ A diversion is an earthen embankment combined with a grass channel that diverts water from a certain area.

▲ A water and sediment control basin assists other conservation practices by controlling surface runoff along drainageways.

▲ A grassed waterway includes shaping and seeding an overland drainageway to carry runoff safely.

Refer to the Best Management Practices booklet, *Field Crop Production*, "Non-Tillage Options", for details on these alternatives and others. Best management practices for watercourses are found on page 75 in this booklet.

Shown below is a drop pipe inlet used with a short earthen dam built across a natural drainageway. Water is released underground to a stable outlet. ▼



▲ A narrow-based terrace outlets surface runoff to a tile drainage system.

▲ Rock underlain with filter cloth carries excess surface water safely to watercourse.

THE FIELD

CROPPING AND TILLAGE MANAGEMENT

BEST MANAGEMENT PRACTICE	DESCRIPTION	BENEFITS & CONSIDERATIONS
residue management	• no-till, mulch-till, and ridge-till that leave at least 30% of previous year's crop residue	• protects soil from raindrop impact • limits downslope movement by reducing runoff • cost savings from reduced number of passes across field • reduced chemical loss to water • improved long-term soil and crop productivity • reduced soil compaction and crusting • improved soil conditions
contour farming	• carry out all field operations on a level or nearly level contour	• creates a series of small dams to slow runoff
contour strip cropping	• alternate strips of row crops, small grains, and forages on the contour level	• close-growing crops act as vegetated filters that reduce erosion • results in greater water infiltration
buffer strip cropping	• use in combination with contour farming on longer slopes • permanent strips of grass or forage break up the slope	• slows water flow by increasing infiltration • grass acts as vegetated filter to reduce soil movement
cover crops	• plant oats, oilseed radish, wheat, rye, vetch, or clover where annual crop doesn't cover sufficiently	• reduces soil erosion • provides buffer for raindrop impact • improves water infiltration • improves soil tilth and fertility
rotations	• change crops grown in a given field year-by-year	• improves soil tilth and fertility • reduces erosion • improves water infiltration • also assists in herbicide and nutrient management programs
pasture management	• use efficiently: assess pasture for food, water, and herd size • rejuvenate vegetation as required • erect fences to keep livestock from watercourses	• improves livestock performance • requires more management • improves downstream water quality • helps prevent stream contamination by manure, soil erosion, and degradation • reduces manure handling
marginal and fragile land retirement	• retire fields where farming is unprofitable and risk to the environment is great • leave to pasture, permanent grasses, or plant trees	• benefits environment • reduces risk of soil erosion • increases small farm yield averages • increases net profitability of operation