BMPs FOR SUBSURFACE DRAINAGE

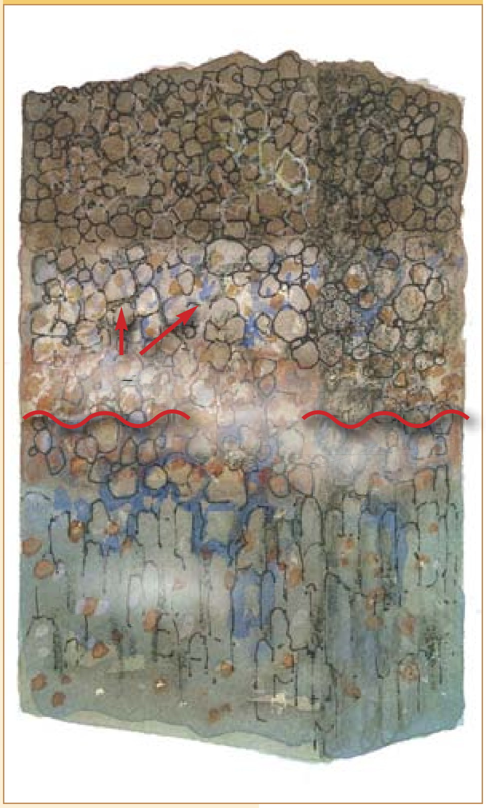
Accurately diagnosing drainage problems is the first task when planning an effective subsurface drainage system. This chapter opens with tips for diagnosing problems and sets out the planning steps for a drainage project. BMPs for design are explained, including drainage coefficient, depth and spacing, drainpipe sizing, layouts and systems, outfall (end pipes), and seepage control. Moving to the installation stage, handy checklists for contractors and landowners are presented for before, during, and after construction. The chapter closes with BMPs for system management, including maintenance and troubleshooting, as well as a brief look at controlled drainage and subirrigation.

The main challenges for subsurface drainage are:

- managing crop inputs and other contaminants
- removing excess water but also conserving water
- managing wet areas, and
- protecting adjacent wetlands.

DIAGNOSING SUBSURFACE DRAINAGE PROBLEMS

CONDITIONS THAT REQUIRE DRAINAGE



In many cases, drainage systems are established or improved due to the limitations of local soil and site conditions. Also, we have a humid climate in Ontario, which means that on average there is a seasonal net surplus of water on most croplands. The growing season (optimum temperatures) is limited, and there is a need to have the soil in a good hydrologic condition for the full growing season.

Soils may need drainage for one or more of the following reasons.

Uneven soil moisture conditions. Soil moisture conditions are not sufficiently uniform for efficient operations on fields with highly variable soil types and slope positions.

Inadequate natural drainage for the crop's sensitivity. Some crops are very sensitive to water ("wet feet"), and easily damaged if roots are in saturated soil – even for a short period of time. Some soils have average natural drainage, but are unsuitable for the crop's needs.

Soils with naturally high seasonal water tables. Found in level-to-depressional topography or where impermeable subsoils limit water infiltration, these soils will benefit from systematic drainage systems. Such soils are referred to as poorly and imperfectly drained soil types on soil maps and reports.

Cropland soils with a drainage class of "poor" require subsurface drainage. Poorly drained soils have a high water table for most of the year. To verify poor drainage, check for a zone of mottles and gley colours in the top 50 cm (20 in.) of the soil profile.

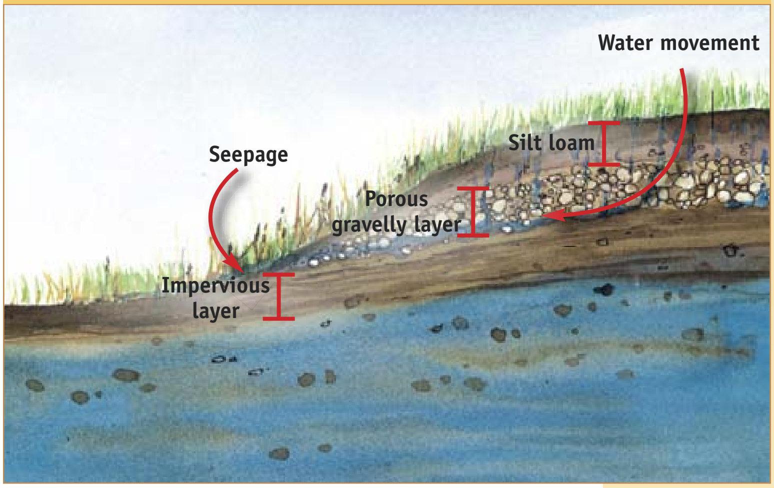
Water will not flow to outlet because land is too flat or natural surface barriers limit movement of water. Such sites are often in depressional areas.

Artificial barriers. Constructed barriers that obstruct or limit the flow of water include roads, fence rows, dams, dikes, bridges, and culverts of insufficient capacity and depth.

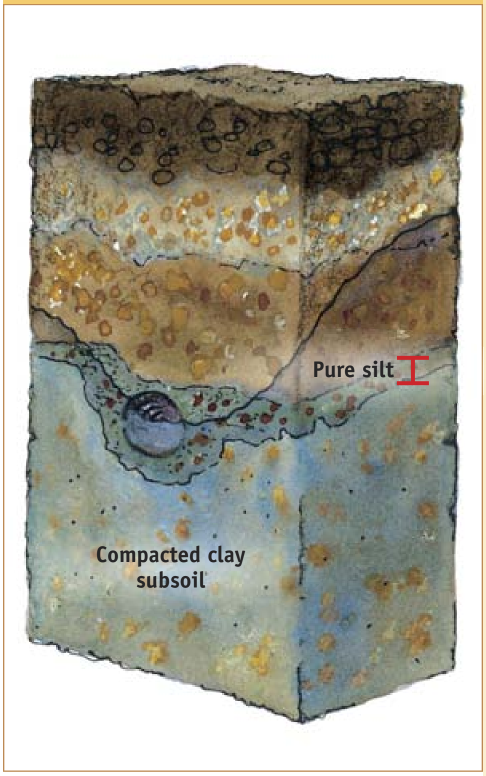
Seepage areas. When water table conditions cause groundwater to be discharged on a sloping field, the soil can be sufficiently saturated to require drainage. **A single seepage area can render a large area of cropland unfit for crop production.**

Impermeable soil materials. Soil layers of low permeability that restrict the downward movement of water trapped in small surface depressions or held in the soil profile may benefit from drainage.

SIDE SLOPE SEEPAGE



IMPERMEABLE SOIL

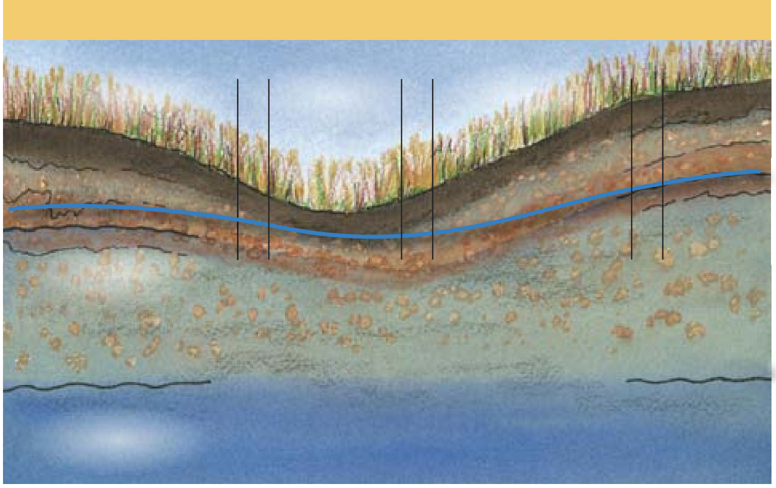


In some cases, subsurface drainage pipes are surrounded by impermeable soils such as heavy clay, pure silts or compacted subsoils.

Look for zones of mottles and gley colours around the existing drainpipe when identifying soil drainage problems.

Recharge areas don't normally require drainage improvements because water naturally moves rapidly to deeper levels.

VISUAL IDENTIFICATION OF DRAINAGE PROBLEMS



In April and May, on imperfectly drained and poorly drained soils, the water table is too high for seedbed preparation. These soils would benefit from subsurface drainage.

Indicators of poor drainage may include:

- uneven crop growth
- uneven crop colour
- water at or near the surface
- water-tolerant vegetation
- soil colours indicating a high water table
- soil colours indicating uneven or long drying period.

Locating Drainage Problems in the Soil Profile

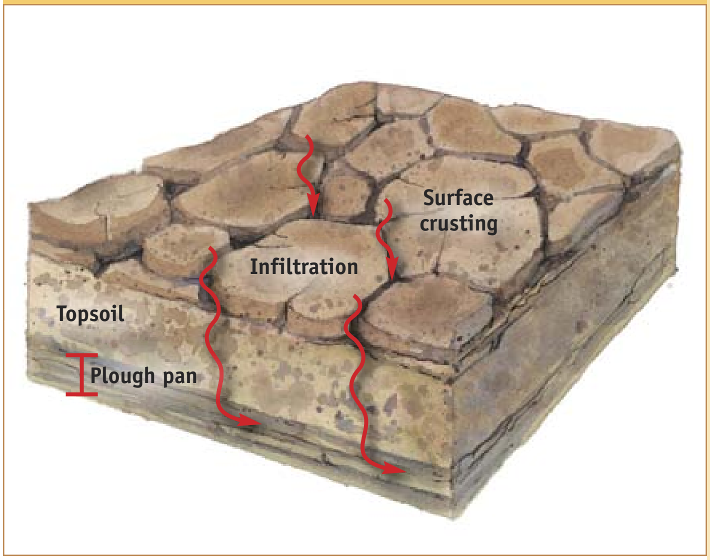
Drainage problems can be found in four places in the soil: at the surface, in the plough layer, in the subsoil, and around the drainpipe itself.

Most surface problems are associated with soil crusting – a sheet of soil that prevents infiltration. Following the rapid wetting and drying of an overworked seedbed, a solid sheet forms (0.2–5 cm or 0.8–2 in. thick) that is tight enough to prevent crop emergence. A track record of poor soil management and few organic matter inputs is most often the cause.

A similar impeding layer at the surface can result from "puddling" caused by a heavy rainfall of large rain droplets. Here the surface is compacted by the droplets, creating a barrier.

✔ **Adopt farming practices that maintain good soil structure and organic matter/crop residue help to prevent crusting.**

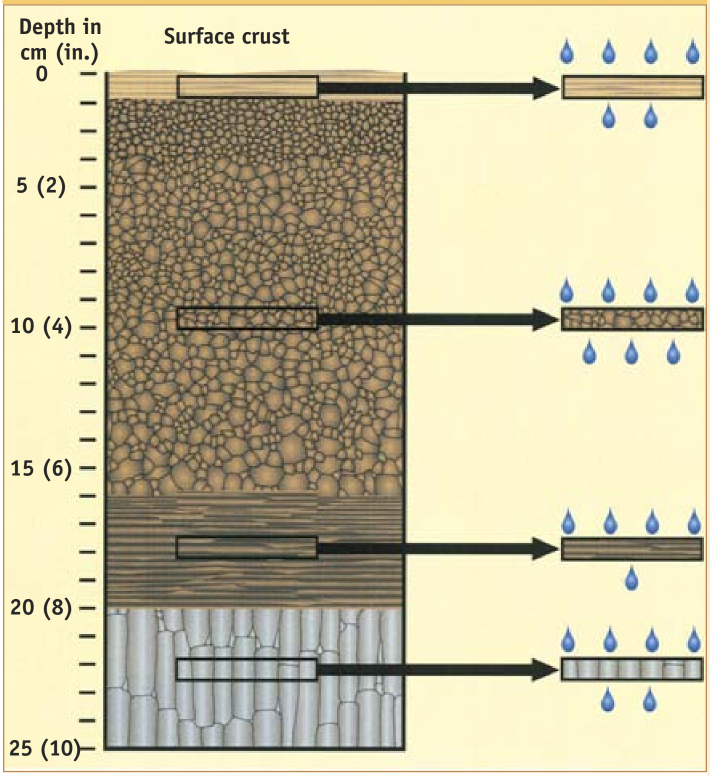
SURFACE STRUCTURE PROBLEMS



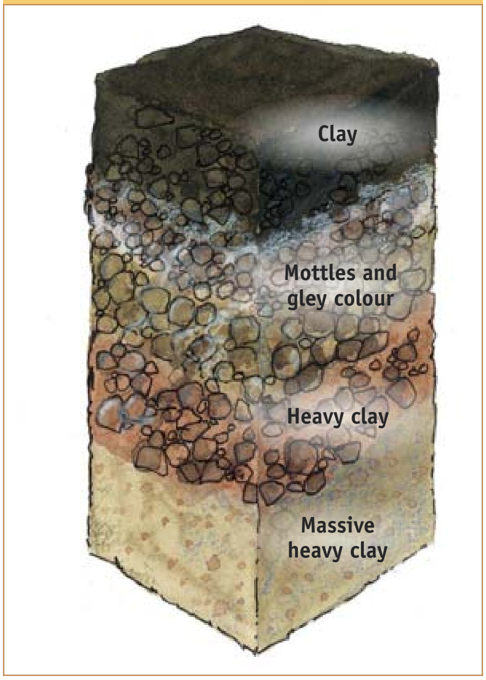
Most plough-layer drainage problems are actually compaction problems. Compaction is the process of increasing soil density by packing soil or smearing particles closer together. It can occur anywhere in the soil profile, but tends to be seen near the surface or at plough depth.

✔ **Consider a range of BMPs, including tillage at proper soil moisture conditions, use of deep-rooted crops, and mulch tillage to reduce the impact of compaction on soil structure.**

PLOUGH-LAYER PROBLEMS



SUBSOIL PROBLEMS



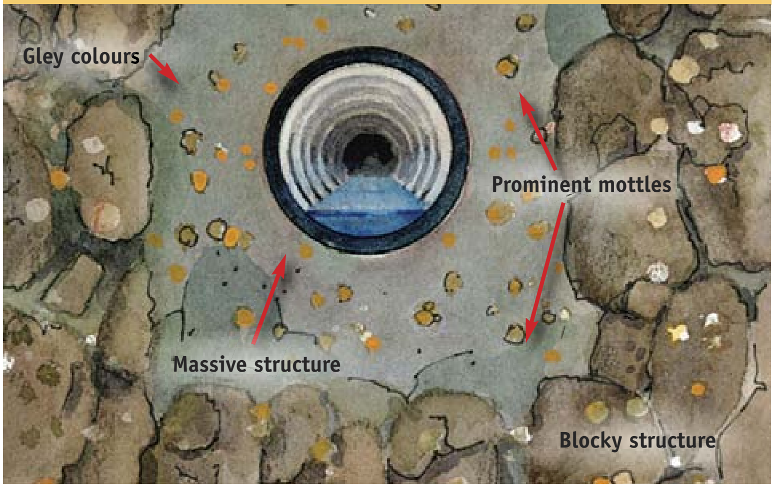
Subsoils can be impermeable and cause surface drainage problems. Impermeable subsoils are usually:

- heavy clays – soils with high clay contents and low natural permeability
- massive soils – clay, usually poorly drained soils, with massive structure where there are few connected macropores to aid drainage
- compacted soils – some glacial till soils were smeared and compacted during deposition
  - more common near the Canadian Shield.

Other soils have naturally high water tables, and so cannot store additional water.

✔ Have the problem properly evaluated by a licensed drainage contractor to determine course of action.

PROBLEMS AROUND THE DRAINPIPE



When water can neither permeate the soil around the drainpipe nor enter the drainpipe, it's known as *entrance resistance*. This can artificially elevate the water table. When operating in saturated soils, drainage equipment can sometimes smear soil. Gley colours and mottles around the drain indicate a problem.

✔ Avoid installing subsurface drainage in saturated soils if at all possible.

STEPS FOR PLANNING A SUBSURFACE DRAINAGE SYSTEM

Begin by determining the feasibility of the project. Your investigation should provide a clear understanding of the problem, the types of crops to be grown, which drainage designs will work, an estimate of the cost and value of expected benefits, and the impacts of the project. This information can often be obtained from a reconnaissance of a small problem area.

✔ Hire a professional licensed drainage contractor to conduct more detailed examinations and surveys that determine the size of the area, the drainage pattern, and special features where riparian vegetation, wetlands, or rock outcrops exist.

Environmental considerations must be a part of the cropland drainage planning process – including habitat enhancement or mitigation where needed.

INFORMATION REQUIRED TO PLAN A SUBSURFACE DRAINAGE PROJECT

STEP	INFORMATION NEEDED
1. RECONNAISSANCE	• nature and extent of drainage problem • location and condition of existing drainage system if one already exists • feasibility of outlet on neighbour's property – if necessary • whether activities or conditions on neighbouring property contribute to drainage problem • location of any utilities or pipelines
2. PROBLEM ANALYSIS	• watershed area • suitability of outlet • suitability of grades for mains • drainage system design
3. DETAILED SURVEY AND CHECKING FOR LEGAL OUTLET	• survey information to size watershed, to size field to drain, and to verify the presence of a legal outlet • estimate of surface runoff and water volumes/rates of subsurface flow through drains
4. DESIGN OPTIONS AND COSTS	• consideration and cost of any regulatory or municipal bylaw requirements (e.g., proper outlet, protection of wetlands, habitat, utilities and pipelines) • this step embraces all technical, environmental management, regulatory and economic information to help you make the best business decision
5. APPROVALS AND FUNDING	• compliance with any regulatory or municipal bylaw requirements

BMPs FOR SUBSURFACE DRAINAGE DESIGN

The intent of subsurface drainage is to remove only the necessary quantity of water that will ensure adequate cropland access and improved crop performance. Beyond that, it's important to conserve water to support crop growth during dry periods.

Drainage systems require proper planning, design, installation and maintenance. Design is critical. Improper design can lead to poor performance, failure, or repeated repair. Most drainage projects are designed by licensed professional contractors.

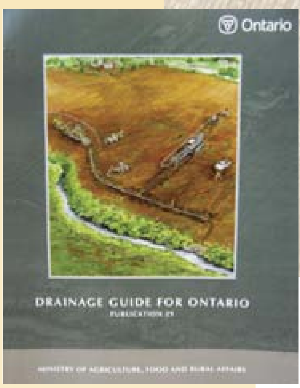
As a landowner, you will want to work closely with the contractor in the reconnaissance, surveying and design of your drainage project.

All subsurface drainage design should be conducted by trained and licensed professional drainage contractors.

Design factors include:

- drainpipe location
- spacing
- depth
- alignment
- materials
- outlets
- correct drainage coefficient for crops grown and soil type.

Design procedures must account for site factors (soil type, depth to water table, hydraulic conductivity) and the variability of soils and drainage requirements across the area to be drained.



For more detailed information on drainage design principles and practices, see OMAFRA Publication 29, *Drainage Guide for Ontario*. For more information on subsurface drainage and the Agricultural Tile Drainage Installation Act, check the Drainage page on the OMAFRA website, http://www.omafra.gov.on.ca/english/landuse/drainage.htm

DRAINAGE COEFFICIENT

The drainage coefficient or drainage rate is a design standard that reflects the amount of water that can be drained from a watershed in a 24-hour period. It is the physical capacity of the drainage system, and more specifically the main collectors. The coefficient is expressed in units of mm/24 hr (in./24 hr), i.e., surface equivalent. It does not reflect the soil's ability to transmit the water.

Part of the decision process is to ensure the soil and drainage system are balanced with the appropriate drainage coefficient needed for the crops to be grown. In some cases, expectations may have to be adjusted, as some soils will not allow gravitational water to move at the rate needed to protect the proposed crop.

The most common drainage coefficient used in Ontario is 12 mm/day (0.5 in./day) for cash crops on average soils. In other words, a drainage system designed to a 12 mm drainage coefficient would be capable of removing 12 mm of excess water from the entire subsurface-drained area over a 24-hour period.

If there is a heavier rain and more than 12 mm/24 hr needs to be removed, it would take longer to remove the excess water. Higher drainage coefficient rates are sometimes used for crops that are more susceptible to damage from excess moisture.

✔ Determine the drainage coefficient for your soil type and crop needs.

Check the *Drainage Guide for Ontario* for more information on drainage rate and other design ratings based on mapped soil series.

To protect crops, a subsurface drainage system must be able to remove excess water from the upper portion of the active root zone 24–48 hours after a rain.

DRAINAGE DEPTH AND SPACING

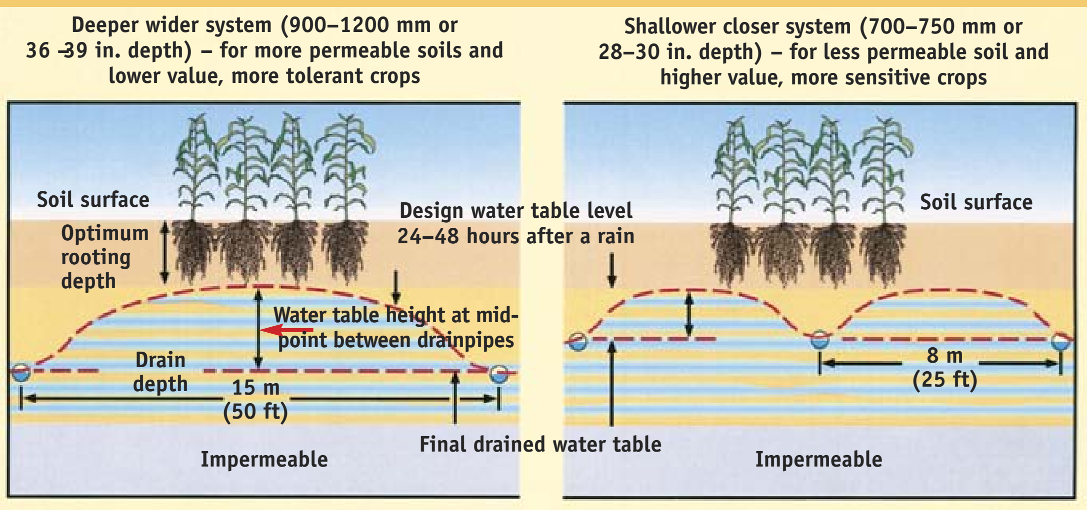
Place 100 mm (4 in.) laterals deep enough to prevent damage from tillage operations and from the weight of the equipment. A minimum cover depth of 600 mm (24 in.) is recommended. See the *Drainage Guide for Ontario* for more information.

Laterals' depth and spacing are linked, and should be selected jointly. Laterals must be shallow enough to provide timely drainage, deep enough to remove only excess water from the root zone, and spaced appropriately to get uniform drainage at the soil surface. The goal is to remove only the water that will impede proper crop growth.

Check the *Drainage Guide for Ontario* for recommended depth and spacing criteria related to the individual soil series as mapped and published in regional and county soil survey reports.

Main and sub-main drains must be deep enough to provide an easy connection point and a good outlet for lateral drains. Also, the maximum depth at which drains can be laid to withstand trench loading varies with the width of the trench and the crushing strength of the pipe to be used. Typical depths of header mains are 90–120 cm (36–48 in.) deep, but can be deeper as dictated by topography. A header main is there for the primary purpose of transporting water to the outlet.

SPACING AND DEPTH OPTIONS FOR DRAINPIPES



SIZING DRAINPIPE

The maximum amount of water a drainpipe can carry (its flow capacity) depends on the pipe's inside diameter, the installation grade, and the pipe surface roughness.

In the farm drainage industry, a more common way of reflecting drainpipe capacity is the area that can be drained through a particular diameter of drainpipe.

The following table shows how the capacity of a drainpipe to drain land is affected by size, material (roughness), and grade.

DRAINPIPE MATERIAL	GRADE OF DRAINPIPE	DRAINAGE COEFFICIENT	DESIGN CAPACITY
150 mm (6 in.) CORRUGATED PLASTIC PIPE	0.2% slope 0.2 m per 100 m slope (0.2 ft per 100 ft slope)	12 mm/day (1/2 in./day)	3.8 ha (9.3 ac)
The above row shows the capacity of a 150 mm diameter, corrugated plastic drainpipe with a grade of 0.2% to remove 12 mm of water from 3.8 ha of land in 24 hours.			
150 mm (6 in.) SMOOTH WALL e.g., clay, concrete	0.2% slope 0.2 m per 100 m slope (0.2 ft per 100 ft slope)	12 mm/day (1/2 in./day)	5.8 ha (14.3 ac)
The above row shows the capacity of a 150 mm diameter, smooth wall (clay, concrete) drainpipe with the same 0.2% grade. It has the capacity to remove 12 mm water from 5.8 ha of land in 24 hours – approximately 50% more capacity than a corrugated plastic tubing drainpipe of the same size and slope.			
150 mm (6 in.) CORRUGATED PLASTIC PIPE	0.4% slope 0.4 m per 100 m slope (0.4 ft per 100 ft slope)	12 mm/day (1/2 in./day)	5.3 ha (13.1 ac)
The above row shows the effect of increasing slope. While the pipe material and diameter are identical to the first row, the grade is now 0.4% instead of 0.2%. This changes the drainpipe's capacity to 5.3 ha. More slope, more capacity.			
200 mm (8 in.) CORRUGATED PLASTIC PIPE	0.2% slope 0.2 m per 100 m slope (0.2 ft per 100 ft slope)	12 mm/day (1/2 in./day)	7.6 ha (18.9 ac)
The above row shows the effect of increasing the diameter of the drainpipe. While the pipe material and grade are identical to the first row, the size is now 200 mm diameter instead of 150 mm. Capacity of the 200 mm corrugated plastic pipe is 7.6 ha – twice that of the 150 mm.			

Choosing the correct size of drainpipe is extremely important for main collector drains. Too small and the system does not function properly; too large adds cost to the system. A licensed drainage contractor can provide this information, or consult Publication 29, *Drainage Guide for Ontario* for the capacities of all sizes of drainpipe for different grades, drainage coefficients, and material.

Besides flow capacity, drainage systems should be designed to meet or exceed a certain minimum velocity of flow so that "self-cleaning" or "self-scouring" takes place.

LAYOUTS AND SYSTEMS

When selecting a layout pattern for a particular field or topography, there are a number of targets to aim for.

✔ Orient lateral drains nearly parallel to the field's contours, crossing the slope – not straight up and down. This way, water flowing downslope can be intercepted by laterals and the system will function more effectively and produce more uniform results.

✔ Orient lateral drains askew to tillage and planting pattern. This ensures that tracking of heavy equipment will be across the drainpipe and not lengthwise, thus reducing potential for damage and providing better traction for machinery. Also, tillage or row planting can alter the flow path of surface water. An askew pattern of drainage will ensure that gravitational water will be better intercepted by laterals and that drainage will be more uniform.

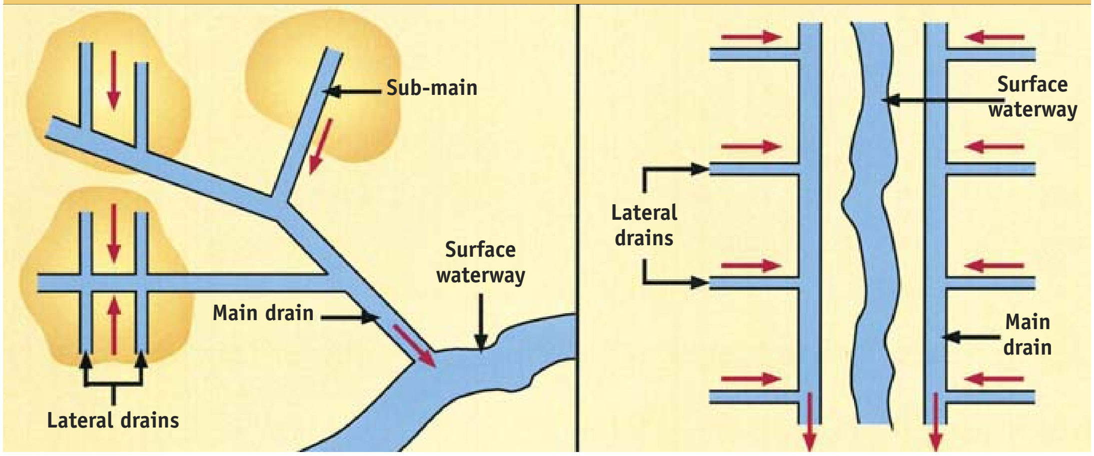
✔ Minimize the number of short lateral drains to reduce costs. Each lateral requires excavation to start installation and a connection to the header main.

✔ Balance the number and size of header mains for capacity and to reduce costs.

✔ Minimize number of outlets to reduce costs and maintenance.

Usually, not all of these objectives can be attained at the same time. A well-designed system will balance function with cost. Communication between the landowner and licensed drainage contractor is a must. Remember, a drainage system lasts a lifetime, and a little extra cost in the beginning is often an excellent investment in the long run.

RANDOM DRAINAGE SYSTEM

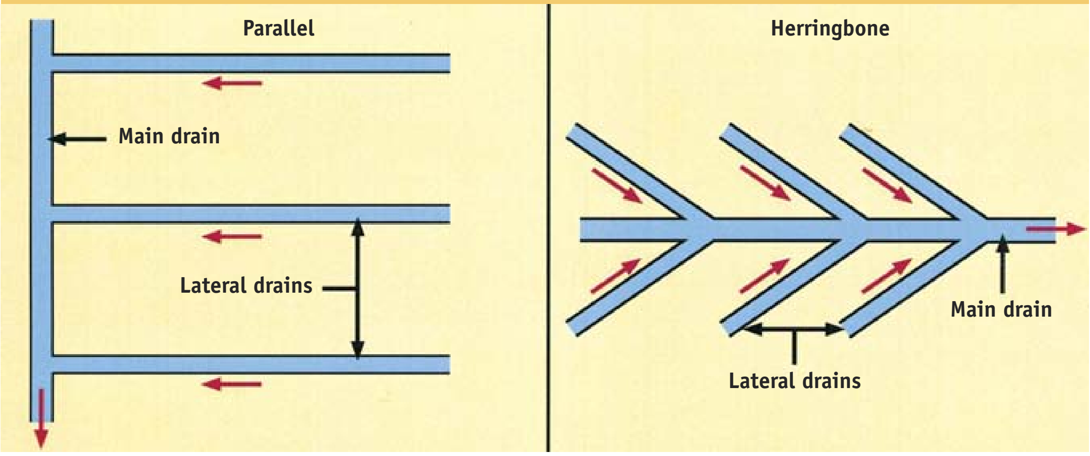


RANDOM SYSTEMS (SITE-SPECIFIC)

The main drain is generally placed near the lowest natural depression, and smaller drainpipes branch off to drain the wet areas.

Because such drains often become outlets for a more complete system established in the higher areas of the field, the depth, location, and capacity of the random lines should be considered as part of a complete drainage system.

SYSTEMATIC DRAINAGE SYSTEM



SYSTEMATIC SYSTEMS

Systematic patterns drain larger areas. There are two types: parallel and herringbone.

The parallel field drainage pattern consists of laterals that are perpendicular to the main drain or sub-main. In most cases, the laterals run parallel to a field boundary. Variations of this system are often used with other patterns.

The herringbone field drainage pattern consists of laterals that enter the main drain at an angle, generally from both sides. This system can be used in place of the parallel pattern. It can also be used where the main is located on the major slope and the lateral grade is obtained by angling the laterals across slope. This pattern may be used with other patterns in laying out a composite system in small or irregular areas.

The option of choosing the type of system layout is only available in new systems, or with complete system replacements.

✔ Align laterals across the slope and across the planting direction, which ensures that the general movement of both surface water and groundwater is across the lateral drainpipe.

This improves the potential to capture the water for drainage, and makes drainage more uniform. Herringbone systems can more easily achieve these objectives than parallel systems. However, in general, herringbone systems cost more to install, as usually there are more mains to install and more tap connections to be made to the main.

OUTFALL – END PIPE

The end pipe is a length of rigid non-perforated pipe that connects the main drain to a drainage channel or natural watercourse. It must be sufficiently large to:

- carry the water discharge from the main drain
- not cause any flow restrictions
- not cause any erosion
- remain stable in the bank.

End pipes are installed at the same elevation and slope as the main drain. They are simply a secure connection of the main drain to the surface water body.

The bottom of an end pipe should be located 300 mm (12 in.) above the normal water level in a receiving drainage channel or natural watercourse.

The discharging water may cause erosion in the receiving drainage channel or natural watercourse.

✔ Install an apron of rock riprap to prevent erosion.

✔ Equip all end pipes with rodent grates to prevent unwanted entry by animals.

✔ Inspect end pipes each spring to ensure proper functioning and that no debris is blocking them.

Drainage inlets are discussed in the previous chapter on page 26. For detailed information on sizing and construction, see the *Drainage Guide for Ontario*.

Proper placement and design of outfalls and end pipes are key drainage BMPs.

CONSTRUCTION CHALLENGES

Sedimentation – Drainpipe Plugging

Fine and very fine sands and silts are not sticky, which means it's easier for them to move through the orifices and into subsurface drainpipe.

✔ Evaluate whether special protection such as filters or envelopes may be required.

Consider different filter or envelope materials with specific pore sizes (e.g., very fine sands, 0.10–0.05 mm diameter) to ensure sediment or sand doesn't enter the drainpipe in these soils.

Filter materials known as non-woven geotextiles or woven filter cloth (sock) are widely used as pre-wrapped synthetic drain envelopes. These materials can be made from polyester, polypropylene, polyamide, polystyrene, and nylon. Filter materials may reduce sediment loading in drainpipe; however, no textile is suitable for all problem soils.

✔ Talk to manufacturers to see what envelopes may best suit your soil conditions. Consider providing them with a soil sample.

Ochre, an iron oxide, affects about 2% of cropland drainage systems in Ontario. It occurs in two soil conditions: acidic sands and poorly drained sands.

Ochre accumulates through chemical or microbiological processes, or both. It's a natural condition usually found where new land – sandy in nature with high organic matter – is cleared and drained. Recognized by brilliant red deposits at drain outfalls, iron ochre can seal drain openings very quickly.

At present there are no long-term solutions. If you encounter ochre:

► plan to replace or abandon the original system when it fails
► flush drainpipe with high-pressure water to provide temporary relief.

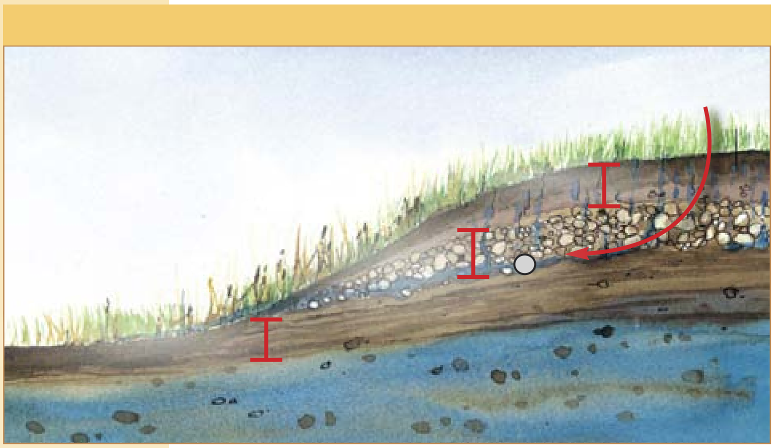
Connecting Old Drainage System to New System

If existing lateral drainpipes are relatively new, clean and not full of sediment, they are probably working. They can be hooked into the new subsurface drainage system.

However, if they are full of sediment, then relieve with crushed stone. Do not directly connect the two systems, as the old system may add excessive sediment.

SEEPAGE CONTROL

Interceptor drains are installed at right angles to the flow of groundwater to intercept subsurface flows. This drainage is applicable to broad, flat areas that are wet due to seepage from adjoining highlands, springs, seepage lines at two different layers of soil, etc.



Subsurface drains for interception of seepage must be located properly to correct wet areas usually found downslope from the seepage line. The seepage line can be located by digging test holes upslope from the wet area. The interceptor lines should be placed upslope from the wet area on the seepage line, and across the slope on grades slightly off-contour. Water is captured and drained away before it reaches the surface.

BMPs FOR INSTALLING SUBSURFACE DRAINAGE

BEFORE CONSTRUCTION

All agricultural subsurface drainage systems must be installed in accordance with the Agricultural Tile Drainage Installation Act. The act requires that each drainage contractor hold a valid business licence to install subsurface drainage systems on agricultural land, that each tile drainage machine be licensed, and that each operator of a drainage machine be licensed. These regulations do not apply to landowners installing subsurface drains on their own farm with their own equipment.

Review the Construction section of OMAFRA Publication 29, *Drainage Guide for Ontario.* It defines the minimum standard for workmanship, materials, and methods of construction acceptable for the installation of subsurface drains.

A list of drainage contractors is available from your nearest OMAFRA Resource Centre and the Land Improvement Contractors' of Ontario (LICO) website: www.drainage.org

BMP CHECKLIST FOR LANDOWNERS

Landowner Checklist – Before Construction

✔ Seek professional advice to verify that subsurface drainage will be a good investment.

✔ Have the soil examined if there's some doubt of its drainage properties – ensure soil is suitable for a subsurface drainage system.

✔ Discharge water at a location where collected water can be legally discharged without adversely affecting downstream landowners, e.g., natural watercourses, agreement drains, municipal drains

- determine whether a satisfactory outlet is available for the proposed work on your property
- if not, negotiate agreements, in writing, with neighbours and other parties to obtain authority to enter their property
- if this does not work out, consider a petition for a municipal drain under the Drainage Act – see section 7.

✔ Check with your local Conservation Authority regarding regulatory requirements.

✔ Visit the municipal office to ensure municipal drain requirements will be met.

✔ Ensure financing is in place to complete the project.

✔ Locate existing drainage plans of the farm.

✔ Obtain a plan for the entire farm, even though only a part is to be drained.

Coordinating your crop rotation to allow subsurface drainage installation in the summer or early fall (e.g., after winter wheat) has many advantages. Most drainage is installed with plough machines. When soil is dry (not saturated), you'll have the least amount of compaction and the greatest amount of soil fracturing. At the same time, some topsoil will fall into the fractures. This will optimize your drainage system's potential in both the short and long term.

✔ Plan with consideration for drainage of upslope watersheds or neighbouring farms' drainage flow.

✔ Make the contractor aware of the location of telephone, gas and oil lines, water lines, septic beds, hydro lines, and other buried utilities. Remember to "call before you dig."

✔ Arrange mutual agreements and easements (hydro and other utilities) in advance.

✔ Ensure that the contractor is aware of the location of manure storages and transfer systems so that the requirements for distance separation under the Nutrient Management Act can be accounted for when designing the drainage system.

✔ Point out the location of existing subsurface drainage to the contractor.

✔ To avoid the risk of soil compaction, install subsurface drains in the summer or fall whenever possible

- crop damage can be as little as 10% when subsurface drains are constructed through crops with care
- make use of strategic crop rotation planning, e.g., field to be drained is planted in wheat or hay
- construction should be in reasonably dry soil so its structure is not destroyed and drainability is not impaired – if the field is dry enough to work, it's dry enough to install subsurface drains.

Landowners who are doing their own installations near wetlands or regulated areas should contact their local Conservation Authority to determine whether regulations apply or approvals are required.

✔ Remove obstructions to construction such as fences, trees, etc.

- check with local municipality regarding tree-cutting bylaw requirements before removing trees.

✔ Decide on the point of delivery of drainage materials ahead of time.

✔ Plan a rotation one or two years in advance for the field to be drained

- use soil and cropland BMPs to improve soil conditions that will assist cropland drainage performance.

✔ Ensure that the subsurface drainage contractor:

- holds the proper and relevant licences
- carries adequate insurance
- has checked with local Conservation Authority to determine whether any CA regulations apply
- has been provided with the necessary permits to do the work.

Landowners should know the exact location of subsurface drainpipes on their property. This will help with subsequent monitoring, maintenance, and new installations.

Landowner Checklist – During Construction

✔ Monitor and inspect the work to ensure it's proceeding according to the agreed-upon plan.

✔ Consult OMAFRA's drainage inspector for advice if needed – call your nearest OMAFRA Resource Centre or the Agricultural Information Call Centre. See back cover.

Landowner Checklist – After Construction

✔ Keep a record of the work done:

- obtain and retain a copy of the cropland drainage plan as constructed by contractor
- ensure the contractor has prepared a plan of the subsurface drainpipe locations with any changes and problem areas noted on it that may affect future maintenance
- in the absence of a proper plan, obtain an aerial photograph of the work area.

✔ File the plan at the municipal office where required. This creates a permanent record, which helps locate the lines for future subsurface drainage repair or improvements.

✔ Keep a copy of the drainage plan, aerial photograph and any mutual agreement under the Drainage Act, with the deed to the property

- keep copies of municipal drain reports and plans.

✔ Watch for erosion of the drainpipe trench following rain events over the first two years.

✔ Mark the outlets, and check them each spring for possible erosion, discharge volume and clarity.

BMP CHECKLIST FOR CONTRACTORS

Contractor Checklist – Before Construction

✔ Contact the local Conservation Authority or check their website to find out if any portion of the property is regulated. If it is regulated, find out if approval is required to install the subsurface drainage system.

✔ Ensure landowner has obtained all licences, permits and easements prior to moving onto the site.

✔ Ensure that the final plan has been agreed upon by landowner.

✔ Notify landowner where and when design changes may have to occur during construction.

✔ Inspect the site with the owner to ensure adequate outlets are available, utilities have been located, and possible problems identified (e.g., the soil is not drainable)

- inspect the soil profile to below drain depth
- advise the owner regarding necessary notices to third parties.

✔ Agree with the owner on the financial costs, and how and to whom the costs are to be paid.

✔ Determine whether there is an adequate outlet.

✔ Review Occupational Health and Safety Act requirements for health and safety on the job site, and remind workers of them.

Conservation Authority regulations may apply to some cropland, e.g., where wetlands or floodplains occur. Prior to undertaking any drainage work, contractors should contact the local CA or check the CA website to find out if any portion of the property is regulated, and if approvals are required.

Contractor Checklist – During Construction

✔ Comply with applicable legislation.

✔ Adhere to Occupational Health and Safety Act requirements on the job site.

✔ Follow all safety procedures.

✔ Keep casual observers away from construction operations.

✔ Erect safety barriers to prevent public access to the work.

✔ Restrict all machine and truck movement on the field to designated paths.

✔ Do not backtrack plough trenches to compress them: it may damage drainpipes and affect drainability.

✔ Inspect all cropland drainage materials before installation to ensure they're free from defects and meet approved quality standards for their intended purpose.

✔ Store drainage materials so they won't be damaged before installation.

✔ Check existing drainage systems for agronomic and hydraulic efficacy.

✔ Don't connect drainpipes that appear to be polluting.

✔ Minimize the number of outlets to reduce system maintenance.

✔ Maintain and operate the installation equipment so drainpipe is installed in accordance with the designed grade and depth.

Provide a copy of the plan to the landowner.

Contractor Checklist – After Construction

✔ Ensure the following information is on the plan to be left with the landowner:

- date of construction
- name of the contractor
- alterations to the original plan
- drainpipe type, size, footage, and materials
- details of construction problems
- location of utilities, sand pockets, springs, etc. that may affect future maintenance
- suggestions for future work additions.

BMPs FOR MANAGING SUBSURFACE DRAINAGE SYSTEMS

INSPECTION AND MAINTENANCE

Annual maintenance and good soil management practices are your best insurance for the successful long-term operation of your drainage system.

✔ Adopt soil management BMPs – cropland drainage system performance may be hindered by poor practices.

✔ Check outlets regularly

- make more thorough inspections in the spring or late fall when the soil is wet and the subsurface drainpipes are running
- mark locations in need of repair or maintenance
- make sure outlet marker is still in place and clearly visible.

✔ Schedule maintenance or repair work when field conditions are drier.

✔ Keep up a preventative maintenance program, including:

- keeping a plan of the cropland drainage system
- cleaning surface inlets and outlets
- repairing the outfall.

Cropland drainage systems require routine monitoring to ensure that the entire system is performing the expected function of safely conveying water to a proper outlet.

✔ Make routine, periodic inspections of drainage system components to ensure minimal environmental impact.

PROBLEM VERIFICATION

In practice, you will notice the inefficiency of a drainage system when water stands on the field for a long time, and in spring when the topsoil remains wet too long. Isolated wet spots in the field, surface wash-ins, and blowouts along the installed drainpipe are indications of drain problems.

The value of a proper drainage plan or aerial photograph of the system becomes very apparent when maintenance is needed.

For more information on drainage system maintenance and management, please refer to:

► OMAFRA factsheets, *Operating and Maintaining a Tile Drainage System*, Order no. 10-091, *Drain Problems*, Order no. 84-017, *Maintenance of the Drainage System,* Order no. 87-062 and *Management of Drained Fields,* Order no. 90-156

► the OMAFRA Drainage website http://www.omafra.gov.on.ca/english/landuse/drainage.htm

► your local Conservation Authority.

TROUBLESHOOTING

Diagnosing and troubleshooting drainage problems is an ongoing process that's both simple and complicated, and requires the landowner to pay attention to changes in the field drainage conditions.

Take note of changes to the wetness of a field or specific location, or to the uniformity of crop growth. After a rain, the soil will change colour as it dries and usually forms a pattern. Pay attention to these details. If the pattern changes, there may be a problem.

Some problems are very obvious in the form of easily visible wash-ins or washouts or water bubbling to the surface. These are abrupt changes. Other problems occur over time, e.g., iron ochre, tree roots, partial collapse of a plastic drainpipe. These are identified by changing conditions.

In most cases, a standard approach to fully identify and diagnose the problem is to expose the drainpipe on the downflow side of the wet area. Excavate the soil covering the drainpipe in the upstream direction until the problem is found. Diagnose and repair.

The following chart lists the most common drainage problems that you might encounter and what to look for.

TROUBLESHOOTING SUBSURFACE DRAINAGE

ITEM	WHAT TO LOOK FOR (SYMPTOM)	POSSIBLE CAUSES	PREVENTATIVE MEASURES	CORRECTIVE MEASURES
BLOCKED PIPE	• water bubbling to surface like a spring above the drainpipe • holes in soil above drainpipe • water not draining • trees close to drainpipes	• collapsed or crushed drainpipe • damaged or poorly installed drainpipe connection • sediment buildup or blockage in drainpipe • tree roots in drainpipe • dead animal blocking drainpipe	• ensure proper design, depth, location, and installation • avoid travelling over drainpipes with heavy equipment in wet conditions • do not plant water-loving trees within 30 m (100 ft) of drainpipe – all other trees, 15 m (50 ft) • install/repair rodent guards at outlets	• repair immediately, and replace damaged drainpipe • use rigid or double-wall drainpipes under high-traffic areas • relocate/resize drainpipe • remove problem tree(s) • use non-perforated drainpipe along problem tree • use high-pressure water system to clean out line • install/repair rodent guards at outlets
BLOWOUTS AND CAVE-INS	• similar to blocked drainpipe except water will go back down hole as well as come out	• poor design, inadequate grade, undersized drainpipes • drainpipe slope changes from steep to flatter, causing pressure buildup	• ensure drainpipe is properly sized to handle flows • use a relief well in the design or use larger-diameter drainpipe	• replace drainpipe with larger diameter • if high pressures persist, vent as necessary – relief well
		• partial collapse of drainpipe resulting in flow restriction and pressure buildup • faulty connections	• avoid travelling over drainpipes with heavy equipment in wet conditions • ensure proper installation	• replace damaged drainpipe • repair poor or damaged connections
		• too much surface water diverted to subsurface system		• make use of flow restrictors on surface inlets
HIGH TRAFFIC AREA	• drainpipes under laneways • water not draining	• compaction • crushed drainpipe	• use rigid drainpipe beneath traffic area	• replace drainpipe if necessary

TROUBLESHOOTING SUBSURFACE DRAINAGE				
ITEM	**WHAT TO LOOK FOR (SYMPTOM)**	**POSSIBLE CAUSES**	**PREVENTATIVE MEASURES**	**CORRECTIVE MEASURES**
SEDIMENT AND DEPOSITS FROM UNSTABLE SOILS	• decreased flow capacity causing areas of field to drain more slowly than normal • excess sediment in drainpipe	• no envelope on drainpipe	• verify presence of problem soils • use filter cloth • design with self-cleaning (steeper) grade	• replace with envelope-wrapped drainpipe • use high-pressure cleaning equipment to remove sediment
QUICKSAND	• soil is saturated at depth or near surface and will not settle	• upward pressure from groundwater in fine and very fine sand and silty soils	• install drainpipe when dry • install on solid bedding	• replace drainpipe in area of quicksand
IRON OCHRE	• reduced drainage each year in low area of field • reddish-orange slime at outlet • crusting around drainpipe when dug up • gelatinous growth in drainpipe	• natural condition of low-lying area of field triggered by installation of drainpipe and introducing oxygen	• very difficult to identify ahead of time • consider controlled drainage during growing season and flooding drainpipe in non-growing season to slow down action	• replace drainpipe • consider controlled drainage during growing season and flooding drainpipe in non-growing season to slow down action
DAMAGE TO SOIL STRUCTURE	• water ponding above drainpipe, yet soil somewhat dry underneath surface layer	• compaction layer • drainpipe installed in wet conditions	• stay off wet soils • modify axle weights • vary tillage depth • reduce tillage passes	• introduce deep-rooted crops into rotation • add organic matter
EROSION IN GRASSED WATERWAY CHANNEL	• drainpipe exposed in bottom of grassed waterway	• drainpipe too close to channel centre • prolonged flow in grassed waterway	• offset drainpipe from centre of grassed waterway	• install new drainpipe away from channel centre • install larger drainpipe to reduce length of time of overland flow
TREE ROOTS	• drainpipes near trees • water not draining • land wetter than other areas of the field	• some species more problematic than others • more acute in continuous flowing drainpipe	• route drainpipe 30 m (100 ft) from water-loving trees, and at least 15 m (50 ft) from all other trees <u>or</u> install sacrificial drainpipe next to tree • use non-perforated drainpipe within 15 m (50 ft) of tree	• reroute drainpipe beyond crown of trees • replace plugged areas • consider non-perforated drainpipe in problem areas • remove problem trees

TROUBLESHOOTING SUBSURFACE DRAINAGE

ITEM	WHAT TO LOOK FOR (SYMPTOM)	POSSIBLE CAUSES	PREVENTATIVE MEASURES	CORRECTIVE MEASURES
LOSS OF ORGANIC SOILS	• reduced depth of organic soil • mineral soil layer exposure • black and discoloured snow	• organic soils over-exposed to oxygen • drainpipe installed too close to an underlying impermeable mineral soils	• install subsurface drainpipes in organic soils and above mineral soils • manage high water levels in non-growing season to avoid wind erosion and oxidation of soil	• change cropping system or land use – less tillage, more vegetative cover
POOR QUALITY WATER (FARMSTEAD LOCATION)	• odours or solid waste in drainpipe at outfall • odours or solid waste in drainpipe dug up just downslope from farmstead	• manure storage, milking centre, septic or other wastes	• keep drainpipes away from source of contamination (vice-versa also true)	• take immediate action – locate source and eliminate connection • reroute drainpipe away from source
POOR QUALITY WATER AT OUTLET PIPE (FIELD LOCATION) – NON-POINT SOURCE	• odours, unusual brown discolouration, or manure in outflow • fish kills • excessive algae • excessive sediment	• poorly timed applications of crop inputs, e.g., manure, sewage biosolids, fertilizer, herbicides • untimely rainfall after application • excessive application rates • soil cracks or worm tunnels • accidental spill in field	• reduce application rates • pre-till to break flow-paths • split applications • improve application timing • apply manure when drainpipes not flowing • develop emergency response plan • consider installing in-line viewing stations for visual check of water quality flowing in drainpipe – same unit can also be used to stop flow in some instances if needed • check outlet pipe each spring, before and after major rain events, when applying manure etc.	• reduce application rates • pre-till to break flow-paths • split applications • improve application timing • apply manure when drainpipes not flowing

As with pipe outlets and surface inlets, regular inspections are an excellent early-warning system to help you troubleshoot.

Drainpipe blowout.

A 100 mm (4 in.) drainpipe containing 20 mm (3/4 in.) of sediment will have its discharge reduced to 80% of capacity. With 30 mm (1 in.) of sediment, the capacity is reduced to 65%.

Drainpipes near treed fencerows are at risk of being clogged by roots of fast-growing trees such as poplar, willow, elm and soft maple.

CONTROLLED DRAINAGE AND SUBIRRIGATION

In specific conditions, a subsurface drainage system can be used to maintain soil moisture at levels that meet crop requirements throughout the growing season.

Controlled drainage uses water table level-control devices and drainpipes to hold back some of the water that would normally drain to an outlet. By doing so, more water is made available for plant growth by capillary action and for a longer period of time. Under normal drainage conditions, the water table over time is lowered to the bottom of the drainpipe. With the control devices, the lowering of the water table is managed to a strategic depth conducive to root development and crop growth. Without additional rain, the water table will continue to lower because of evapotranspiration and normal deep percolation.

Controlled drainage may also be used to hold back soil water in non-cropping seasons (winter). It has been successfully used in muck soils to reduce soil loss in the non-growing season.

Subirrigation adds another dimension to the system. The water table is maintained at the optimum location for plants to use by adding water to the drainage system, usually with pumps, or in some instances by gravity. Hence, a water supply is required to make this system function. The water supply can be a separate source such as a river, stream or well, or it could be water that was captured from the drainage system and stored for irrigation.

For both practices, soil water contaminants may be withheld or allowed to be processed to other less environmentally harmful forms. (For example, nitrate is converted to nitrogen gas through denitrification.)

Research continues to evaluate the effectiveness and conditions under which these technologies may be used. Site conditions must be appropriate – such as flat terrain, proper drainpipe spacing, and an impermeable layer at or below but near the drainpipe depth – to make effective use of this emerging technology.

Controlled drainage has not been extensively tested in Ontario. Site requirements are often too limiting: there are few sites with the precise soil and slope requirements to make controlled drainage effective. Normal subsurface drainage design in Ontario – with shallow drainpipe depths – approximates the same intended effect of controlled drainage.

Controlled drainage and subirrigation show promise where soil and site conditions are suitable and the water supply is adequate.