# RACECOURSE WATER MANAGEMENT:

## BEST PRACTICE GUIDE

RCA

Horse Welfare Board

STRI

# CONTENTS.



# INTRODUCTION.

Water is a precious resource and vital for managing the natural turf on racecourses. This best practice guidance has been produced to provide a thorough overview of:

- How soil and water interact in terms of drainage and irrigation
- Why racecourse turf is irrigated
- Irrigation demands on racecourses and the infrastructure used to water them
- Best practice guidance on managing irrigation on racecourses
- Technical information used to base this best practice on

This guidance document can be read "cover to cover" as part of training staff new to racing and racecourse management. It is also designed to allow experienced Clerks and grounds people to use it as a "look up" refence to refresh their knowledge or seek guidance.

In 2004, a thesis was published by Dr Colin Mumford at Cranford University titled "The optimisation of going management on UK racecourses using controlled water applications". This proposed a model that was subsequently developed to assist in water management for Going. In 2024, a Performance Quality Standard (PQS) for turf horse racing was developed and resulted in a greater use of data measurement needed to enable this process to be simplified and refined for ease of use.

The document aims to provide a detailed yet straightforward best practice guide on soil water relationships and how these relate to plant health and Going manipulation. The guide is supported by leading organisations and practitioners. The reader should be able, with appropriate tools, to refine water applications, thus saving time, money and resource and could improve the racing surface. At the core of the guidance in this document is the need to consider water management on racecourses from not only a turf health and racing standpoint, but also surface consistency and horse welfare. From a horse welfare perspective, a consistent surface around and across the track of the desired Going with strong and healthy turf provides the optimal grassed surface for racing.

This best practice guide was developed by the RCA, HWB and STRI with support from the RCA Ground and Going Group, with funding provided by the Racing Foundation.

# EXECUTIVE SUMMARY.

Key to maintaining racecourse turf is the effective use of water to manage grass health and to create optimal surface performance and consistency of Going. Water however is becoming a scarce resource and so the methods and amounts of water used need to be appropriate for maintaining grass and adjusting Going.

Traditionally, water applications are decided upon based largely on experience and, to some extent, a feel of what's needed and in most cases this has worked well. However, this has led to a potential trend to, at times, apply water more than needed and occasionally inconsistently.

The guide aims to present the principles of water movement in soils and use the data being more actively collected in the 2025 PQS requirements to demonstrate how irrigation requirements can be more accurately calculated. The key is understanding the relationship between the soil moisture and firmness (Going) of a track. Once known and the impact of irrigation on moisture content is understood, then irrigation need can be calculated providing a more objective insight into water demand.

The understanding of soil moisture and the nature of their track will also help track managers to avoid issues sometimes seen. The guidance in this document can be distilled into five golden rules of irrigation that can help enhance your understanding of what your track needs, when and in what quantity:

1. Know you soil types around your track and understand how they react to water inputs.

2. Measure your water content to help inform irrigation requirements, whilst considering whether it is more effective with your soil to maintain a specific level of soil hydration rather than let it dry out too far.

3. When you need to apply water, apply it well ahead of a meeting, ensure it can soak evenly throughout the upper track profile (at least 150 mm).

4. If you need to apply irrigation, make sure it is applied at the right time of day, at the right rate and to the areas that need it, bearing in mind the starting moisture content of the track.

5. Make sure applying water will soften the track. If compaction is the issue, water is not going to be effective and therefore decompactive aeration is a better option.

# WATER IN THE SOIL.

Water has a range of critical functions in soil and in its interaction with plants (Figure 1). For a soil to function effectively there needs to be a balance between air and water in the available spaces in a soil. Management of soil water for horse racing must be mindful that, as well as plant health and surface performance characteristics, having a soil that is not too dry, nor too wet for extended periods is vital for long term soil health.

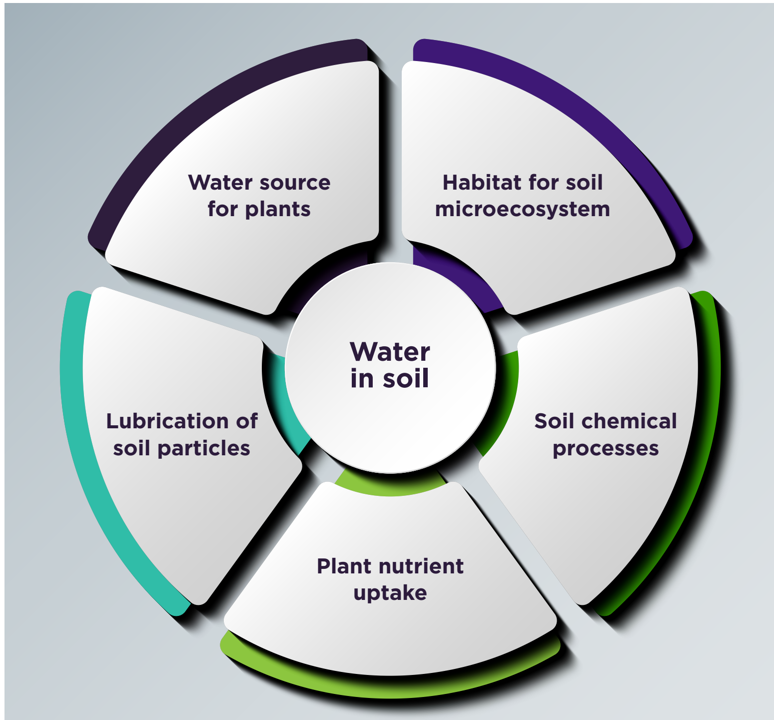



**Figure 1: Key functions of water in soil**

In the following sections, how water moves into, through and is retained in soil, as well as the impact of drainage and soil water monitoring are all discussed. As soil water plays such a key role in directly influencing the racing surface, as well as plant health, it is vital that those involved with the practical management of natural grass horse racing surfaces under-stand the interactions between the makeup of a track, how it deals with water and the impacts water has on soil and surface properties. The key effects of soil water on a racing surface are summarised in Figure 2.

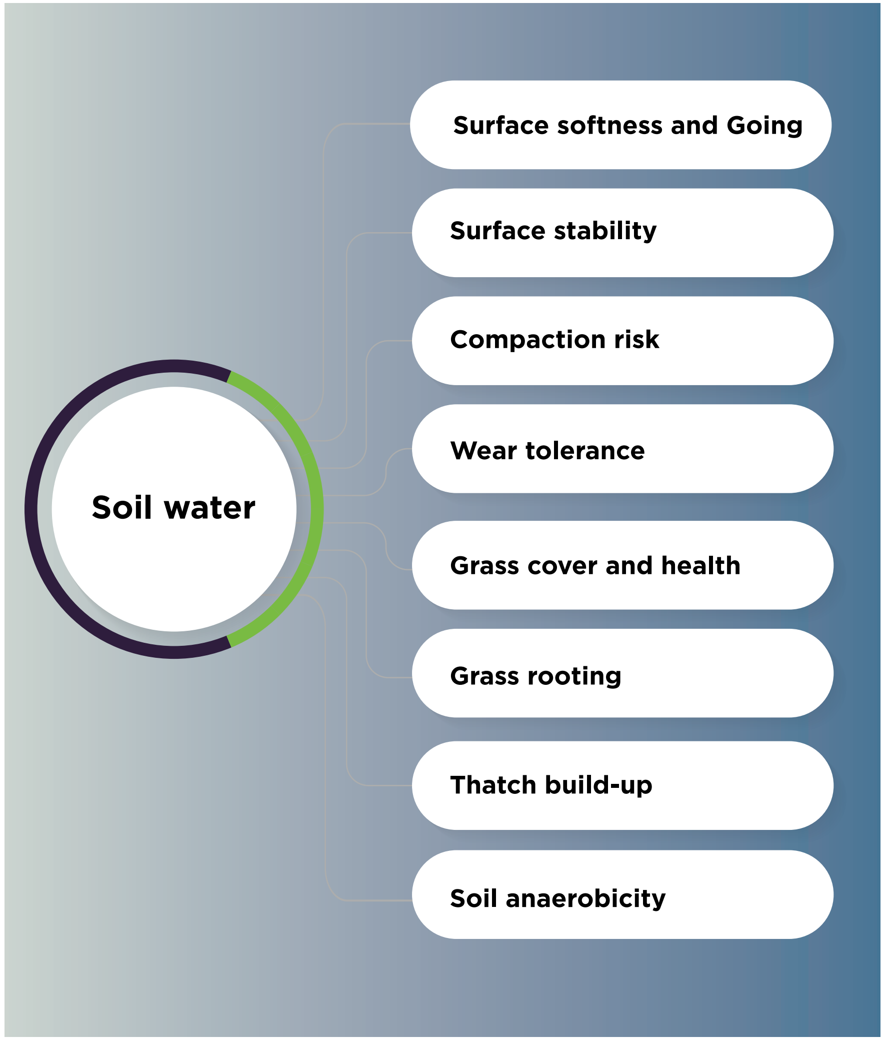



**Figure 2: Surface factors that are affected by soil water content**

The reality of track maintenance is that much of its focus is on the direct and indirect management of soil water. Dealing with excess water in wet weather and maintaining optimum levels in drier periods. Understanding how water interacts with soil is vital in predicting its effects and how to optimise its management.

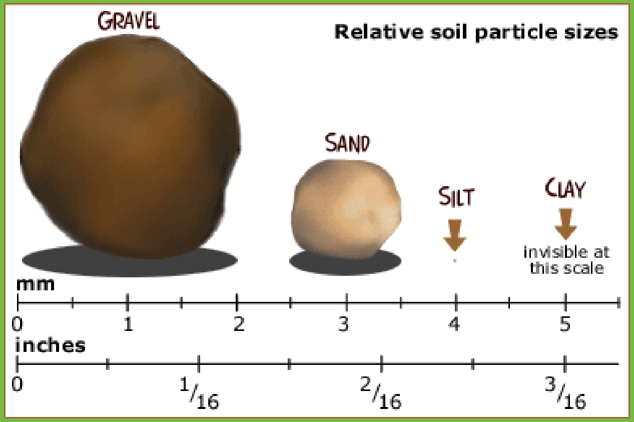
## Pore space, water holding and field capacity.

Soil pores are the gaps between the solid matter that makes up the soil, including soil particles, aggregates and roots. It is these spaces where water, air and soil organisms are found. Soil pores are also the habitat in which roots of grass plants grow, allowing them to exploit the resources in the soil ecosystem.

In terms of soil water content and its location, soil pores are critical and define how soils drain and how much water is retained in dry weather. This is because water can only exploit and travel in spaces between the solid matter in the soil, i.e. soil pores. The relationship between pores and water movement and storage is a critical one. The quantity, size and inter-connectivity of pores determine how easily water will enter a soil, how quickly water will drain through the soil and how much water will be retained. Table 1 summarises the relationship between pores and water movement and storage in soils.

### What are soil particles and aggregates and how do they relate to soil pore space?

Soil particles are individual grains of weathered rock that make up soil. They are classified based on their size as sand grains (largest sizes), silt and clay particles (smallest size). In very sandy soils (those classified as sands), most of the pores are found between individual sand grains. However, in most soils where there is a blend of sand, silt and clay particles they tend to fit together tightly so there are few spaces between individual soil particles. In these soils, pores exist as cracks and fissures between conglomerations of soil particles. These conglomerations are called aggregates and are formed through natural soil processes that arrange the soil, creating what is termed soil structure. It is the soil structure and aggregates that make it up that define the amount and connectivity of porosity/pore space in most natural soils.




**From Nair, P.K.R., Kumar, B.M., Nair, V.D. (2021). Soils and Agroforestry: General Principles. In: An Introduction to Agroforestry. Springer, Cham.**

Pores in soil are not only vital for water movement and air entry, but they also create space to allow soil to deform when a horse's hoof contacts the soil. If a soil is compacted there is less pore space and therefore there is less empty space to allow the soil particles to move into as the hoof contacts the surface, resulting in less hoof penetration and a faster, firmer and less forgiving running surface.

> In terms of soil water content and its location, soil pores are critical and define how soils drain and how much water is retained in dry weather.

**Table 1: Relationship between soil pores on water movement and storage in soils.**

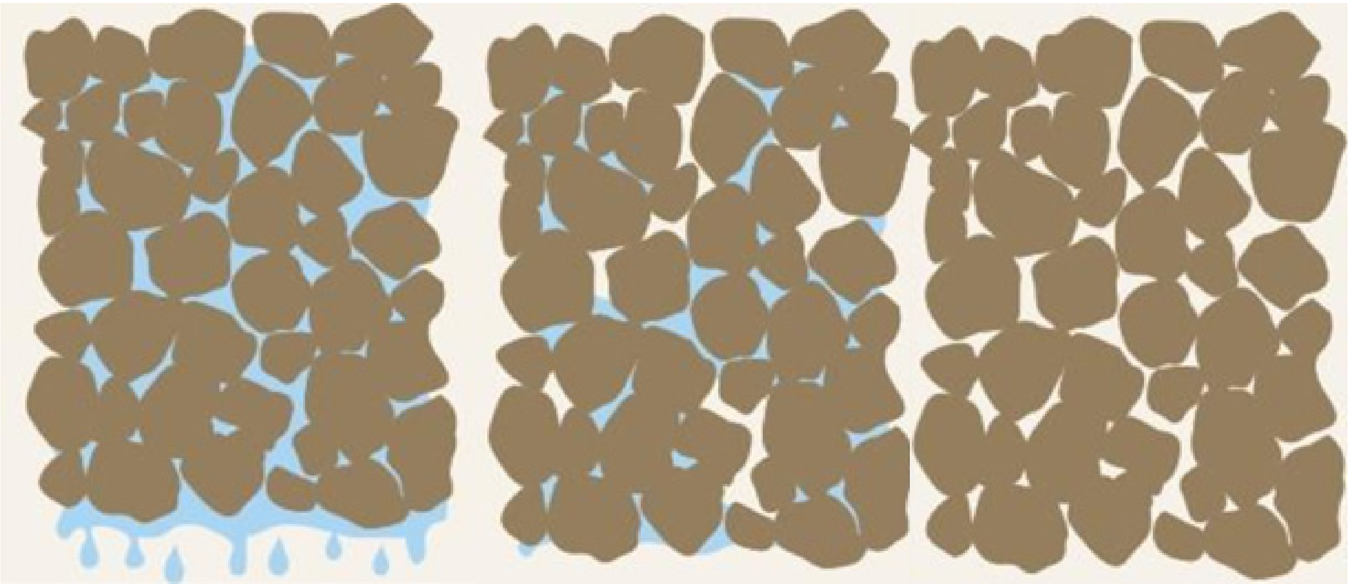
| SOIL PORE CHARACTERISTICS | EFFECT ON WATER MOVEMENT AND STORAGE |
|---|---|
| **Pore size** | **Large pores**<br>• Often referred to as macroporosity and is measured as air-filled porosity (i.e. pores that under normal conditions are filled with air).<br>• Easy for water to enter these pores and so they are very important for drainage and the transmission of water deeper in the soil.<br>• Often the result of physical processes such as freeze-thaw of soil and biological processes such as root growth, burrowing of soil organisms and formation of aggregates.<br>**Small pores**<br>• Often referred to as microporosity and is measured as capillary porosity, i.e. pores that under normal conditions are filled with water with that water being held in place by capillary forces.<br>• Difficult for water to enter small pores so they are less useful for drainage but very useful for water retention as water cannot easily escape from them, so they form a reservoir for water for plants and the soil ecosystem.<br>• Present to some extent in all soils but can be the dominant pore type in compacted soils or finer textured soils (clay and silt rich soils). |
| **Quantity of pores** | **More pores**<br>• More pores mean more potential for optimal air:water balance in soil.<br>• The blend of pore size will determine the net effect of the pore space on water retention and drainage.<br>**Less pores**<br>• Fewer pores indicates poor soil structure and reduced drainage potential.<br>• Less pore space is a key indicator of soil compaction. |
| **Pore interconnectivity** | **Highly connected pores**<br>• For water to access soil pores and to travel deeper into the soil profile it is vital that pores are connected to the surface.<br>• Highly interconnected pores are found in well-structured soils that are not overly compact and results in greater potential for water entry into and movement downwards in soils, as well as increased opportunity for water storage.<br>**Less connected pores**<br>• Poor pore connectivity is often associated with poorly structured and compacted soils.<br>• Less well-connected soil pores are associated with limited potential for drainage. |

## What are water holding and field capacities and how do they relate to pore space?

Water holding capacity and field capacity define the same characteristic of soil (Figure 3). They measure the amount of water held in a soil once gravity has pulled out all the water it can do. In other words, it is the maximum storage of water once drainage has stopped. What remains can then be divided into water that will be available for extraction by turf (available water content) and that which is unavailable to turf because it is tightly held in the smallest pores and as water films around soil particles. As the grass plant removes water from the soil's storage this is called soil water deficit.

The size and amount of pore space in a soil determines the following:

- How much water will be held in the soil – the greater the proportion of large pores, the lower the water holding capacity, whereas the greater the proportion of small pores, the more water can be retained.
- How quickly water can enter the soil and recharge the water holding capacity – more small pores will recharge more slowly compared to a soil with more large pores, but in the latter the overall storage capacity will be lower.



| Saturation | Field capacity | Permanent wilt point |
|---|---|---|
| Soil pores all filled with water and drainage is actively happening. | Gravity has pulled all water out the soil and drainage stops. Water that is left is in capillary pores. | No available water for plants and soil will be dry with only limited water films present. |

**Figure 3: An example of a soil at saturation, field capacity and permanent wilt point (no available water for plant growth) (Source: ADHB).**

When racecourse ground staff manage the soil of their tracks, they are often managing the pore space within it. Pores are so vital for how soils absorb and hold onto water that it is critical to understand the key relationships. Later in the guidance, the effect of different soil types on pore space and water dynamics will be discussed.

## Key terminology – infiltration, drainage, percolation and hydraulic conductivity.

Sometimes the terminology around water in soils can be confusing and therefore it is important to clearly define what these terms mean. Below are some commonly used soil science terminology for how water moves through soils:

- **Infiltration** – this defines the ability of a soil surface to accept water, i.e. the rate at which water will enter into a soil. It is typically measured in mm/hr.
- **Drainage** – this defines the capability of a soil to get rid of excess water as it drains through a soil under gravity. More specifically, it is the volume of water that can drain through a soil in a given time period and often measured as the flow rate at a drainage pipe outlet.
- **Percolation** – this term describes the process of water movement through the soil profile once it has infiltrated through the surface. Percolation rate quantifies the volume or depth of water that travels through a soil in a given time period. It is often measured in the field by digging a soil pit which is filled with water and the time taken for a known volume of water to drain away measured and typically reported in mm/hr.
- **Hydraulic conductivity** – this is the scientific parameter which defines and characterises the flow rate of water through a soil. It is often measured as saturated hydraulic conductivity, i.e. the flow rate of water through a soil when it is saturated. This is because saturating a soil creates a standard and repeatable test condition that can be compared both over time and between soils. It can be measured in the field but is typically measured in the laboratory and reported in mm/hr.


## Infiltration, measurement and what it means.

Infiltration capacity/rate of a soil defines the ability for water to enter soil. This is vital for preventing ponding of water on a racing surface. It is also often used as a metric for drainage potential of a soil. Infiltration rate is often used to inform turf managers, agronomists and consultants on the potential for a racing surface to be able to withstand rainfall.

Infiltration rate is directly related to the pore space of a soil (total amount, size distribution and interconnectivity). The smaller the average pore size of a soil, the harder it is for water to enter the soil and therefore drain through it. This will then result in a surface that will be at higher risk of water ponding and which will tend to soften down and remain softer for longer with rainfall and/or irrigation inputs. Soils with a larger average pore size tend to have greater infiltration rates as it is easier for water to enter the soil and drain downwards under gravity. However, the larger pore size also means that the soil will have a lower field capacity, i.e. less potential to hold on to water after drainage has stopped.

All the work carried out to date shows clearly that wetter soils, i.e. those that tend to hold onto water more readily, will tend to be softer and have softer Going. Understanding infiltration rate and any causes for poor infiltration are vital for promoting a racing surface that is both resilient to heavy rainfall, but that also accepts water inputs for managing plant health and going modification.

### Measuring soil infiltration and hydraulic conductivity

There are a number of measurement methods that have been devised over the years by soil and sports surface scientists for measuring both water infiltration and soil hydraulic conductivity. These are summarised in Table 2.

**Table 2: Measurement methods for water infiltration and hydraulic conductivity.**

| PARAMETER AND MEASUREMENT TYPE | DESCRIPTION | PRO'S AND CON'S |
|---|---|---|
| **Field measurement of infiltration** | Direct surface measurement using ring infiltrometer inserted into surface. Rings inserted into the ground and water flow rate into the surface is measured. Other surface measurements such as disc infiltrometer can't cope with typical height of sward on a racecourse.  | **Pro's**<br>• Direct measurement that relates to the conditions at the time of testing.<br>• Provides a visible indicator of drainage potential of a soil.<br>**Con's**<br>• High height of cut can make assessment difficult to carry out.<br>• Takes considerable time (potentially 1 hr+ to test a location).<br>• Needs a lot of logistical support to transport equipment and a plentiful source of water at the assessment site.<br>• Can be affected by seasonal or weather effects (for example unusually dry soils).<br>• Can be unduly affected by recent surface maintenance such as aeration. |
| **Field measurement of hydraulic conductivity** | Typically aiming to measure saturated flow of water through a soil. The main methods for field assessment are the Guelph Permeameter and double ring infiltrometer.  | **Pro's**<br>• Direct measurement under conditions at time of test.<br>**Con's**<br>• Time consuming and needs a lot of logistical support on site to complete assessment.<br>• Some methods require turf layer to be removed. |
| **Infiltration and hydraulic conductivity on soil cores** | Typically carried out on intact cores removed from the racing surface, often at several depths to give surface infiltration and soil hydraulic conductivity.  | **Pro's**<br>• Quick to take samples.<br>• Sampling needs much less logistical support than field measurements.<br>**Con's**<br>• Relies on soil samples to be undisturbed during sampling and transit.<br>• Relatively small sample volume means any unusual soil features can unduly affect soil results.<br>• Needs multiple replicate samples to be analysed from an area. |

STRI's approach over recent years has been to take intact core samples for laboratory analysis of water infiltration and hydraulic conductivity. It is felt this gives a good balance between accuracy of reading and repeatability, whilst being practical to carry out and causing minimal disruption to the racing surface or track maintenance operations.

Typical infiltration rates of a range of soil types are given in Table 3. There is a clear trend for sandier soils to naturally have greater water infiltration rates, loamy soils (those with a mixture of sand, silt and clay particles) are intermediate and silt and clay soils tend to have naturally low infiltration values. It is important to note that actual rates from racecourses will be affected by usage, management, weather, profile build-up and presence of drainage infrastructure, so the values in Table 3 should be treated as indicative only.

Infiltration and hydraulic conductivity measurement, along with other assessment such as penetrometer and soil water content readings are very useful for characterising the condition of a racetrack soil and its ability to cope with water inputs and how it will hold onto water or allow it to drain away. This is why the PQS system for natural turf horse racetracks includes infiltration measurements as a key characteristic

**Table 3: Typical water infiltration rates for different soil types, taken from Brouwer, C., Prins, K., Kay, M., & Heibloem, M. (1986). Irrigation Water Management: Irrigation Methods. Training manual no. 5. Food and Agriculture Organization of the United Nations, Rome.**

| SOIL TYPE | INFILTRATION RATE (MM/HOUR) |
|---|---|
| **Sand** | Greater than 30 |
| **Sandy loam** | 20–30 |
| **Loam** | 10–20 |
| **Clay loam** | 5–10 |
| **Clay** | 1–5 |

for measurement. The winter minimum threshold for intact core samples has been set to 5 mm/hr, whilst for summer conditions the ideal minimum threshold is 20 mm/hr with an acceptable minimum threshold of 15 mm/hr.

## Measuring water content and what does it mean?

Measuring water infiltration and hydraulic conductivity are important for assessing the potential for a soil to drain and hold water but can be time consuming and resource intensive if

“The winter minimum threshold for intact core samples has been set to 5 mm/hr, whilst for summer conditions the ideal minimum threshold is 20 mm/hr with an acceptable minimum threshold of 15 mm/hr.

trying to do it in the field, whilst for samples taken from the field there is a delay for the analysis to be carried out in the laboratory. However, it is often critical to be able to measure the water content in the soil at a given moment in time and for this reading to be instantaneous and to inform maintenance in the run up to a meeting or during adverse weather. This data can be used to inform turf managers on a range of soil water management issues (Figure 4).

### How can soil water be measured?

There are a range of methods that have been developed over decades of research. The simplest and still the most accurate method is to directly measure the amount of water in a soil. To do this, soil samples of known volume are taken and the water evaporated off and the weight difference before and after evaporation calculated as a percentage. This can be reported as gravimetric water content (i.e. the percentage of weight of water lost) or as volumetric water content (i.e. the percentage of the volume of water lost). The latter is often more relevant as it is measured on a scale that is compatible with irrigation calculations. This is because it allows the depth of water in a known volume of soil to be calculated. This can be useful as the difference between the reading and a target value or between two readings taken at different times allows the depth of water lost from the soil to be calculated and this replaced by irrigation inputs.


**Figure 4: Benefits of soil water measurement in turf racetrack management**

However, taking soil samples and drying them is not an instantaneous measurement and can be time consuming. To overcome this, soil water sensors have been developed to allow instantaneous measurement of volumetric soil water content. Over the decades a range of measurement methods have been developed, but the one that is most commonly used is Time Domain Reflectometry or TDR. TDR probes are generally robust, reliable and give a good indication of soil water content across a range of different soil types. For further details on how TDR probes operate see "What is TDR and how does it work?" opposite.

There are a range of soil TDR probes that are commonly used on sports surfaces for measuring volumetric soil water content (Table 4). Many of the systems are designed for portable handheld readings which offer the greatest flexibility for taking readings as part of routine monitoring or spot checks before or after irrigation. Readings are easy to take and quick to carry out making this type of sensor very handy and useful to use,

There are systems designed for installation into the soil to give continuous monitoring, but there are risks and issues with these systems that need to be considered given the potential for a sensor to come into contact with a horse's hoof. It may be possible to use these systems in representative areas off the racing surface, but these areas would need to be managed in the same way as the main racing surface. These issues and risks on permanently installed systems often means that portable systems are used on racecourses.

## What is TDR and how does it work?

TDR (Time Domain Reflectometry) is a soil water sensing method that measures the dielectric constant of a soil. The dielectric constant value is related to the density of the soil and the amount of water in the pore space between solid matter.

How does a TDR sensor take a reading? All TDR sensors operate along the same lines. An electrical signal is sent into the soil and the time taken for that signal to be picked up by the receiver is related to the amount of water present in the soil pore space. This is used to calculate the volume of water inside a given volume of soil, in other words to measure the volumetric water content of a soil.

**Table 4: Soil TDR probes used on sports surfaces for measuring volumetric soil water content.**

## SYSTEMS AND EXAMPLES

## PRO'S AND CON'S

### Two pronged portable TDR systems

Examples:

FieldScout TDR 250 and TDR 350 Soil Moisture Meters


**Pro's**

- Low cost and robust.
- Can have different length of sensor prongs installed to allow greater depths and volumes of soil to be measured.
- Can often have other readings taken at the sand time such as soil or surface temperature and soil electrical conductivity.

**Con's**

- Uses an assumed volume for taking the reading therefore under certain soil conditions readings can be prone to greater risk of reduced accuracy.
- Affected by soil salinity (or high concentrations of dissolved salts in the soil such as fertilisers).

### Four pronged portable TDR systems

Examples:

ML3 ThetaKit Soil Moisture Meter


POGO Pro+

**Pro's**

- Low cost and robust.
- Takes reading from a defined volume of soil (determined by the triangular arrangement of outer prongs) giving slightly better standard accuracy compared to some other TDR probes.

**Con's**

- Some systems can be more expensive than some of the other simpler TDR sensors.
- Some units are more prone to soil salinity or dissolved salt effects than others.
- Some systems require annual subscriptions

### TDR systems designed for burial

Example:

Soil Scout Wireless Soil Moisture Sensor


**Pro's**

- Continuous readings.
- Newer systems are wireless.
- Can be integrated into the Internet of Things.
- Can be installed at different depths in the soil.
- Can have multiple sensors installed around an area to understand consistency across an area of turf.

**Con's**

- Unsuitable for installation in the main racing surface due to risk of horses coming into contact with sensor.
- Risk of damage when carrying out deep decompaction work.
- Can be expensive and requires annual subscriptions.

Handheld TDR systems tend to either have a dedicated reader unit that displays the measured values or uses an app on a Bluetooth enabled smart phone or tablet. A number of the systems offer GPS logging to allow readings to be mapped to help visualise differences across an area. This can be especially useful when determining particularly wet or dry areas to allow targeted maintenance operations.

How important is it to be able to measure the water content of my soils around my track? Very important! Being able to measure how much water is in a soil takes the guesswork out of managing soil drainage and irrigation. Understanding consistency of soil water content and surface performance both across and around a racetrack is a key part of the natural grass PQS. Measuring soil water content allows more informed decisions to be made regarding wet areas of the track and the need for and effectiveness of irrigation for maintaining grass health and for modifying Going.

## Impact of compaction on water movement and holding.

Soil compaction is the compression of a soil which changes the structure of the pore space within the soil profile. Compaction pushes soil particles closer together both changing the balance of large pores that are so important for drainage and small pores associated with water retention, whilst often reducing the total amount of pores present in the soil. In other words, the soil becomes denser with a greater tendency to hold water and have fewer pores filled with air at field capacity through which water can flow downwards in the soil. The effect of compaction on the physical structure of soil is highlighted in Figure 5. The net result is that compacted soils tend to have poorer drainage in wet weather and be firmer in dry weather (due to less pores to allow hooves to penetrate the surface deeper meaning there is less cushioning in the surface).

## Can I compare readings from one sensor to another?

A question that often gets asked is "can I compare readings from one sensor to another?". In theory yes, especially when calibrated for the soil on site. However, each system may use different standard calibrations in the calculation of the result, which means that readings can vary from each other slightly. However, they should all react in the same way to differences in soil water content, it is just that the reading from one sensor compared to another may be slightly different.

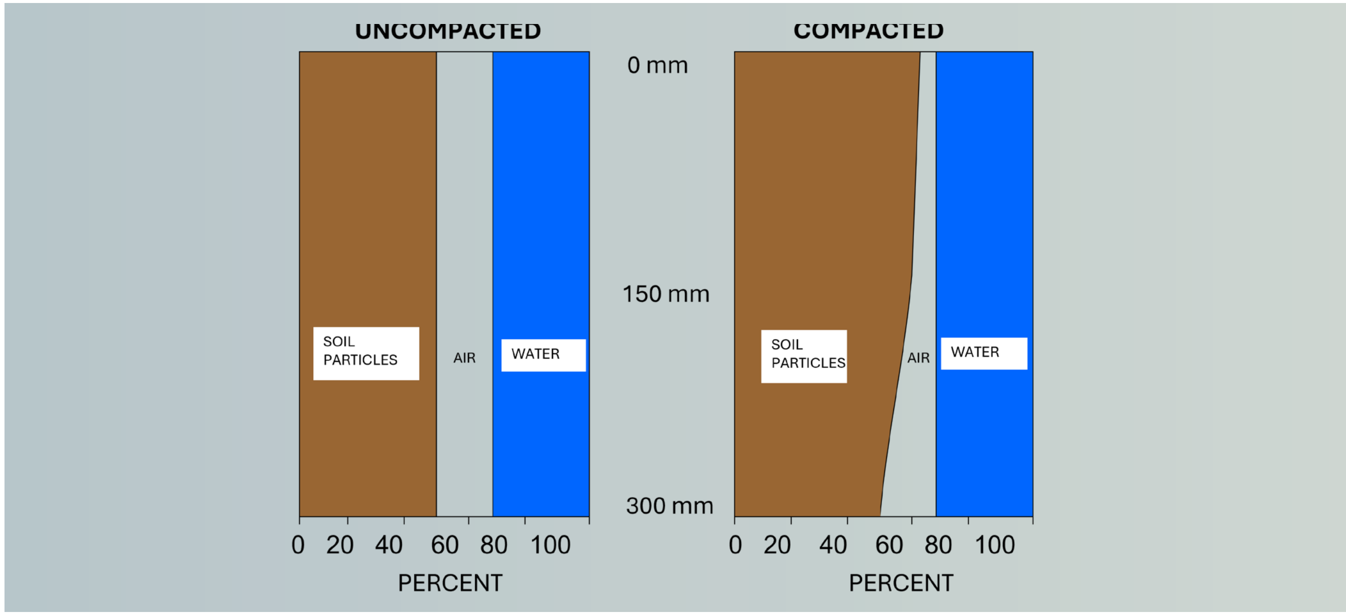



**Figure 5: Effect of compaction on the volumetric composition of soil over depth based on compaction forces from the top down.**

## What conditions favour soil compaction?

There are several factors that work together to determine the level of compaction and compaction risk of a soil:

- **Force applied to a soil** – this is determined by the weight and contact footprint of an object trafficking over the surface. The heavier and/or smaller the contact footprint, the greater the potential to cause compaction. This is why most tractors and other equipment used on a racetrack have floatation or turf tyres which are designed to spread the load over a greater surface area reducing vertical force applied to the soil surface.
- **Soil type** – some soil types are more prone to compaction. Sandy soils often have better drainage and are less reliant on soil structure for drainage and are therefore at lower risk of compaction. Finer textures soils such as those with higher proportions of silts and clays are at higher risk of compaction. This is because these soils are more compressible, have a greater abundance of small pores and therefore tend to hold onto water for longer.
- **Soil water content** – water acts like a lubricant in the soil and when a compressive force is applied it is easier for soil particles to move against each other when wet, resulting in them being able to be pushed closer together reducing the size of pores and/or the total amount of pore space.

When carrying out any maintenance operation on a turf racetrack, it is vital that the risk of compaction is assessed. A wet fine textured soil subjected to heavy weights is at very high risk of compaction. It is also important to understand that compaction can build over time and in of itself helps to create conditions that favour further compaction.

How does a soil become compacted? Compaction is caused by pushing the solid matter in the soil (soil particles) closer together. This happens when weight (and therefore compressive force) is applied to the turf and soil surface. This is often in the form of vehicle traffic (tractors, irrigators and mowers), as well as use of the racing surface by horses. These are the main contributors to compaction on a natural turf racetrack.

A key result of compaction is a change in the water retention and drainage of a soil. Compaction results in more water retentive surfaces (they have greater field capacity) but that also have less drainage potential meaning they are less able to cope with wet weather. The net result is a wetter soil in winter and firmer soil in dry weather. An additional risk, especially in silt rich soils, is that when wet (at or near saturation) and when trafficked, the fine silts can be brought upwards in the soil profile and this can further reduce drainage and cause long-term water retention issues that can be difficult to resolve.

> “The key to managing compaction is to prevent it occurring in the first place.

The key to managing compaction is to prevent it occurring in the first place. Prevention is more effective than correcting a problem that has manifested. This means ensuring soils are not worked or run on when very wet and that all efforts are taken to reduce ground pressure and spread wear across the surface, However, compaction often occurs through use and maintenance of turf surfaces, so dealing with its effects early on will result in the most robust and resilient racing surface possible. If a soil has become compacted, the main way to resolve the issue is to carry out decompactive operations using tools such as punch type decompactive aerators such as using a Verti-Drain or Terraspike. Linear decomp-active aeration, using machines such as the Verti-Quake or Shockwave, is also possible and can be popular as it is quicker to carry out than punch type aeration. Examples of different types of decompactive aerators are shown in Figure 6.


**Figure 6: Examples of decompactive aerators often used on natural turf horse racetracks.**

## How does track drainage work, but what will it not do?

Drainage is an important characteristic of soils and racing surfaces, as it defines the ability of a natural turf surface to be able to cope with wet weather and to get rid of excess water. Drainage is defined by two key processes, namely infiltration (water movement into the soil surface) and percolation/hydraulic conductivity (water movement through the soil profile). On racecourses, drainage relates to the natural water movement through the soil, as well as installation of infrastructure to assist with either water entry into the ground (irrigation, aeration) or its movement into an outlet and away from site (drainage). This is important as it can significantly improve how the racing surface reacts to heavy or persistent rainfall, its aim being to avoid the surface becoming excessively soft.

> Drainage does not “dry out soils” – installed drainage is about providing an outlet for excess water to escape from a soil.

When discussing drainage of natural soils, there are a number of facts that need to be considered:

- **Gravity –** water drains through a soil by gravity pulling it downwards. This takes place in larger (macropores) which are normally filled with air (air-filled porosity). If gravity can’t pull the water out, it will be retained within the soil.
- **Drainage provides outlets for water –** most installed drainage systems don’t “pull water” out of the soil, but rather provide outlets for excess water to be pulled by gravity out of the soil and into some kind of drainage network to move the water away.
- **Drainage does not “dry out soils” –** installed drainage is about providing an outlet for excess water to escape from a soil. Once a soil has reached field capacity, no further drainage will occur and the only way a soil will lose water is through evaporation from the surface and transpiration (the loss of water through the normal operation of plant leaves).
- **Vertical movement –** because the main force associated with drainage is gravity, the vast majority of water movement is downward. Water does not move easily laterally within a soil and when it does this is localised and

occurs very slowly. Unless capillary drainage is installed, drains provide somewhere for water to vertically drain into. This is vital to consider when planning spacings between drainage elements.

- **Preferential flow –** most drainage systems work by creating preferential flow paths for water to get it away from the surface and into a pipe drainage system. Often, they are designed to have parts of the system that are open on the surface and then connect into a pipe system beneath. This allows water building up at or close to the turf surface to enter the drainage network and flow away without the need for it to have to infiltrate and percolate through the soil.

- **Soil texture and structure –** these characteristics determine the pore space in a soil. As discussed, this is the natural interconnected network of spaces in a soil through which water may flow. Finer textured soils (those dominant in clay and silt) or those that are compacted will have far less potential for water to infiltrate and percolate due to the size of their pore space, and therefore drainage will need to be installed at closer spacings and with a more intensive design.

Natural or installed drainage can be very important at helping a soil to cope with heavy rainfall. However, the best way to achieve consistent drainage is to prevent compaction and promote the formation of natural soil structure. This will ensure that as much of the soil as possible is able to achieve the optimal air:water balance for a particular soil type (water flow versus water retention). Sometimes installing drainage does not lead to significant improvements often because it is mistakenly believed that drainage "pulls water from a soil". It provides an outlet for water, but water still needs to be able to reach the drainage system before it can be gotten rid of. Sometimes, drainage infrastructure is not the answer whereas focusing on soil health and structure is the optimal way to achieve long lasting wet weather resilience.

## Impact of different soil types to moisture content and soil strength and softness.

Soil type (often described by its texture) is critical to determining the performance of a racing surface. This is because it is the very foundation of the racetrack and its characteristics influence every aspect of both the growing environment for the grass and how the racing surface deals with water. Figure 7 describes the composition and soil water relationship between a range of soil types ranging from sands through to loams, clay and silt dominant soils. What is clear is that as the texture of the soil becomes finer (more dominant in clay and silt), the airspace that can be used for drainage decreases and the amount of water held in the soil (available and unavailable water) increases. In short, finer textured soils drain more slowly and have slower drainage and will therefore be more prone to becoming soft when wet and, likewise, firm when dry.

"What is clear is that as the texture of the soil becomes finer, the airspace that can be used for drainage decreases and the amount of water held in the soil increases.

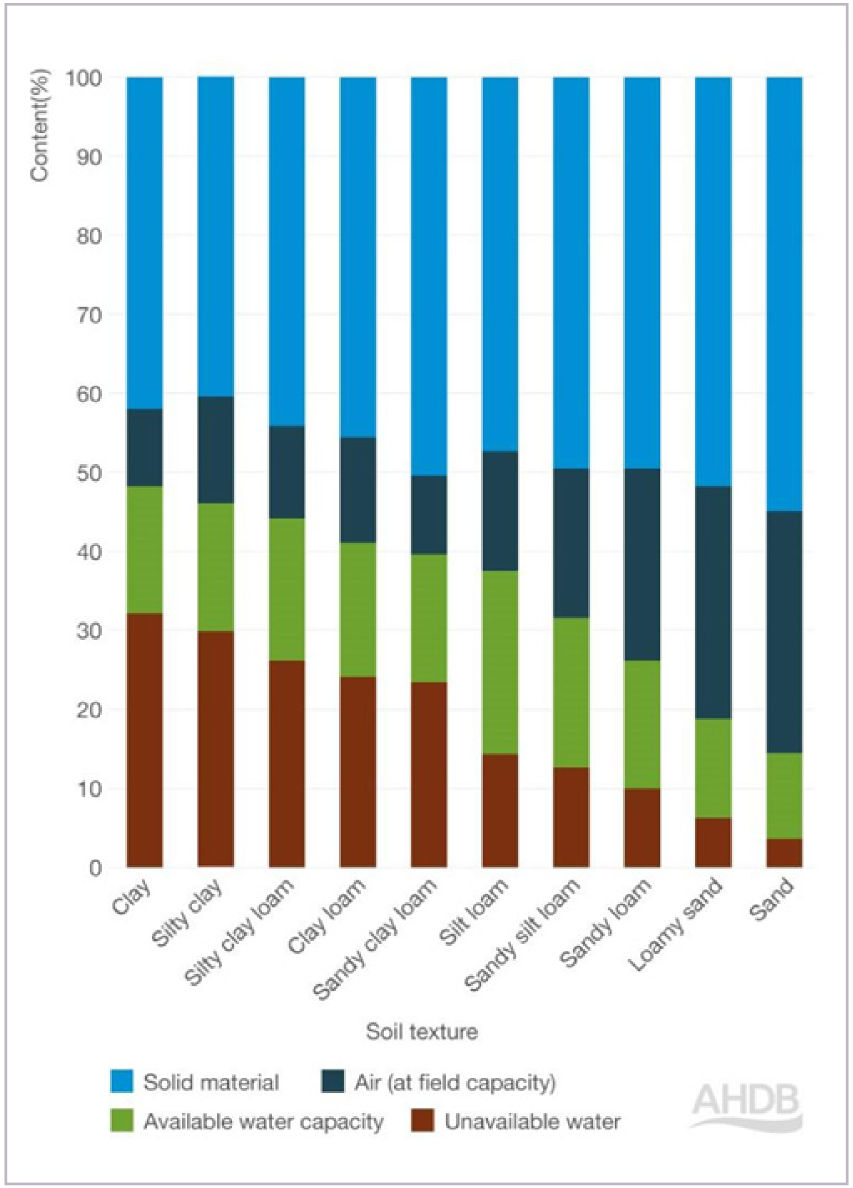
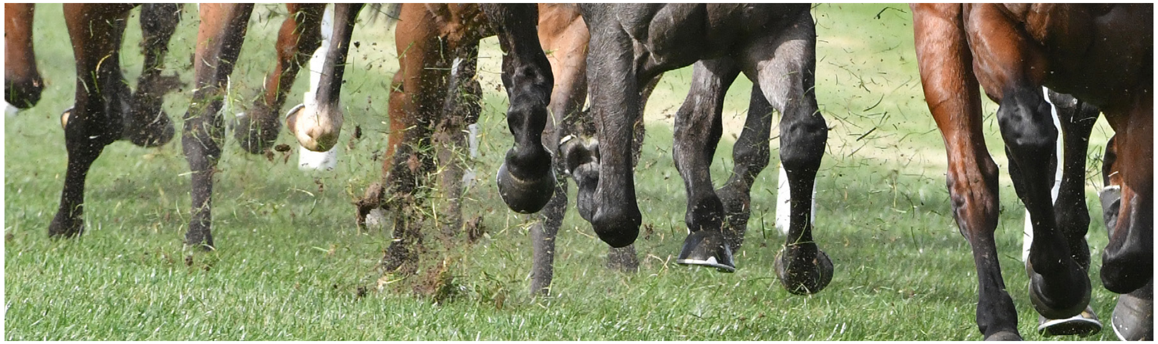



**Figure 7: Effect of soil type on composition and air:water balance (AHDB (2024) Principles of Soil Management. Coventry, UK. Pp20)**



Soil strength is an important characteristic of a horse racing surface (further detail on what this is can be found in the call out box "What is soil strength?"). Soil strength is determined by a range of factors, some of the most important being soil type, soil water content, soil porosity/compaction and grass root development. Wetter soils tend to have lower soil strength, whereas drier soils have greater soil strength. Likewise, less compact soils have less soil strength whereas more compact soils have greater soil strength. To achieve optimum soil strength for horse racing, there needs to be a balance between:

- **Soil compaction** – there needs to be enough compaction (or optimum porosity) to allow good hoof penetration but enough friction between soil particles for the hoof to act against when kicking off.

- **Soil water content** – there needs to be enough water to allow the hoof to penetrate into the soil but not too much as to create too deep a hoof print (which leads to increase fatigue) or over lubricate the soil reducing soil strength so the footing of the horse is less stable. Likewise, it is important that there is enough soil water to allow penetration of the hoof as this provides cushioning (shock absorption) and the hoof more gently decelerates as it enters the soil profile. Not enough water will result in plenty of soil strength but not enough hoof penetration and therefore less cushioning.

- **Grass rooting** – roots act like natural reinforcement for the soil and help to strengthen the soil whilst still allowing hoof penetration. If grass cover or rooting is poor then soil strength will be reduced, potentially creating greater and more severe divoting, leading to less stable footing for the horse.

## What is soil strength?

Soil strength describes the ability of a soil to be cohesive and hold together when compressed and/or subject to applied forces. This is an important characteristic for natural grass horse racetracks as it determines how stable the footing is for horses running over the ground or jumping. The ideal racing surface is one which provides good cushioning (shock absorption) whilst being stable and providing the horse's hoof with sufficient footing to allow a natural action when either running or jumping.

Soil strength is often measured as both the ability of a soil to resist compaction and to withstand shear forces (such as those created when a hoof contacts the surface through all phases of a horse's stride). Shear is often measured as either the resistance to divotting (linear shear) or as rotational shear.

Any soil characteristic that affects compaction risk, porosity and water retention will affect soil strength. Soil texture and structure play a critical role in determining soil strength:

- **Heavier textured soils** – tend to be more dense (more prone to compaction) and when drier can be very strong. However, these same soils when wet can have significantly lower soil strength due to their greater field capacity and therefore water retention (the water acting as a lubricant reducing soil strength).
- **Sandier textured soils** – have naturally lower soil strength but are less prone to change when conditions are either drier or wetter. In other words, sandier soils tend to be more consistent and less extreme when it comes to wetting up or drying out. However, sands often need moderate water content to provide strength.

## What are wetting agents and how do they work?

Wetting agents are a group of chemical compounds that can help to allow water to enter and move through soil, whilst some can help water to be held in freer draining soils. Some come from synthetic chemistry whereas others are from natural plant extracts or synthesised naturally occurring molecules.

Wetting agents are a group of compounds that are also known as surfactants. They all have the ability to reduce the soil water surface tension (reducing the stickiness of water in soil) which means that water molecules are less cohesive with each other allowing them to move into and through smaller pores in the soil than they normally would.

Some wetting agents are designed to focus on allowing water to enter and drain from smaller pores than would normally be possible under natural conditions. This means that treated soils temporarily have lower field capacities. This can be very useful when either trying to get more water to penetrate into a soil or help get rid of water that would otherwise be held in the soil pores, thereby creating more air-filled pore space. It is important to note that applying wetting agents won't typically allow more water to drain from a soil if the limiting factor is an outlet for water to escape. To get the best from them in winter conditions, there needs to be drainage infrastructure to give an outlet for water that may be held in the soil to escape.

There are other wetting agents whose formulation allows part of the molecule to bind to organic matter or other soil components, whilst the other part is highly attracted to water. This dual effect means that these compounds are really good at grabbing hold of water and helping it to be held in the soil. This is particularly useful in more free draining soils or in dry weather when irrigating to get the best effect of allowing water into the soil and then being held.

Wetting agents are commonly used in many sports surface turf maintenance programmes. They can be just as useful for horse racetracks, albeit they would need to be applied over a much greater surface area. However, the benefits they can have in both wet and dry weather can be remarkable and as the effects of climate change become ever stronger, these types of tools will be of even greater use with managing, at times, challenging soil conditions.

# CURRENT METHODS OF IRRIGATION AND STRATEGIES.

### Why do racecourses need to irrigate?

Irrigation is applied to racecourses for plant health and to assist in modifying surface performance or Going. All grasses require a minimum level of soil moisture (albeit slightly different target ranges for each grass species and soil type) to take up nutrients and achieve basic plant health and growth functions. In drought conditions, supplementing water lost in evapotranspiration is a key objective. However, irrigation is mostly applied to bring the soils to the required firmness for the code of racing, i.e. to help the course achieve its optimal Going. There is a strong relationship in most soils that the wetter the soil, the softer it is. Accurate application based on knowing how a track responds to irrigation is essential to achieving the desired racing conditions and avoiding wasting the valuable resource of water.

## Systems and effectiveness.

Any system applying water to a racecourses needs to be able to apply large volumes of water quickly and evenly. This is primarily to ensure the track remains consistent for racing. There are a number of different systems used for this purpose. The most commonly used systems are as follows:

- **Installed pop-ups** – where an irrigation nozzle is located underground and "pops-up" under supplied water pressure and rotates to give coverage. Typically installed so the spray from one pop-up reaches its neighbours in what is termed "head to head coverage".
- **Travelling overhead booms** – where water is supplied to a wheeled boom and sprayed through nozzles providing coverage across the width of the boom. The boom is pulled slowly along by a motorised hose reel that winds back up pulling the boom. There are pegs with rollers that are used on bends to allow the boom to travel round the bend.
- **Tow lines** – are an older and more basic system of interconnected surface laid pipes with irrigation heads at intervals.
- **Other forms of irrigation** – some courses have no installed systems and rely on rainfall and top up with bowsers fitted with spreader plates or with an attached rain gun.

## What makes up an irrigation system?

All installed systems will have the components shown in Figure 8. To supply sufficient irrigation water, the infrastructure is run at high pressures (up to 10 bar) and utilises large pumps and pipe sizes. All systems should be regularly serviced and extreme caution employed when using or repairing any system, ensuring that staff strictly following the onsite health and safety and risk management procedures. Pop-up systems are computer controlled so can be run automatically if needed. This is achieved through the use of solenoid valves which are used to turn on and off the desired irrigation heads. These can be controlled by mobile phone apps and will often have links to a weather station to help with irrigation scheduling.


**Figure 8: Schematic of a typical racecourse irrigation system**

## Installed pop-up irrigation.

Pop-up irrigation is where the heads are located on the edge of the track, preferably on both outer edges at distances apart equivalent to the throw of the sprinkler. Many will have individual control or be grouped in blocks. Controlled by a computer, digital decoder and solenoid value. When the computer transmits a digital signal, the target sprinkler (or block) decoder recognises the code and opens the solenoid valve allowing water to flow to the sprinkler. As the water in the ring main is under pressure, the pop-up sprinkler head lifts above the turf surface and rotates to cover the ground under a user defined arc of coverage. Most modern systems use large multi-nozzle gear-driven sprinklers, although some impact type heads are still found. It is possible with this type of system to have fully remote phone-based operation and links to weather systems. This type of irrigation system is the ultimate to controlling a watering programme but needs careful use.

**The advantages** of this type of system are:

- Targeted irrigation can be applied at any time of the day.
- Systems are designed for precise and automated control and low rates of water can be applied.
- Coverage can be good if the system is set up correctly.
- There is no heavy equipment on the racecourse.
- No staff time required except for checks to the system.

**The disadvantages** are:

- The ability to cover very wide areas and bends uniformly, as throw is typically limited to 30 m.
- On course infrastructure, such as rail legs, can disrupt the flow.
- Wind can impact evenness of spread.
- The system being in the ground means it is easy to miss over or under application.
- Very expensive to install and needs regular checks to ensure good coverage and function.

## Overhead booms.

These are systems utilised in agriculture and have been modified for turf use. At present, these systems are the main method of applying water to racecourses. The system consists of a connection to the pumped ring main or moveable connection to a water source to a hose reel. This connects to the boom that will vary in width from 20-40 m. The boom is unwound from the reel to typically a 200+ m distance down the centre of the track. On bends, pins fitted with rollers are inserted into the ground to guide the hose and boom around the bend.

The reel is powered by onboard generators and the amount of water required to be applied is programmed in. This determines the speed of travel of the boom but will be dependent on the available pressure and flow rate from the pumped system. The boom is slowly pulled to the reel, and a switch stops the system at a predetermined point. The system can easily deliver large volumes of water to a surface quickly and, with multiple units (providing the water supply is adequate), can give the BHAGI stipulated 12 mm per day to the racing line within a working day. In some settings a single large volume impact nozzle is used giving an arc of coverage. These are less uniform on coverage but lighter in weight. There are high pass systems that hydraulically lift the boom over jumps.

**The advantages** are:

- Ability to quickly apply large volumes of water.
- Systems are relatively robust and when a coarse water droplet is used can be resistant to wind effects.
- Application can easily be visually checked for accuracy.

**The disadvantages** are:

- Heavy infrastructure needed on the track creating localised compaction.
- The ability to apply high volumes means the amount/weight of water hitting the surface is very high, potentially impacting surface soil structure.
- Heavier applications may also drain through faster reducing the effect of the application in manipulating Going.
- Require very large ring mains and pump stations aimed at delivering high pressure and flow rates.
- Leaks in connectors can lead to wet spots on the track and need to continually monitor for repositioning.
- The reel will pull the boom towards it and needs to be strongly anchored. Typically, this is with a tractor but also with ground anchors inserted into the track, which often move and disturb the track surface.


## Other systems.

### Tow lines

These are mobile pipeline systems with sprinklers set at intervals. These are still seen on racecourses but, due to the high labour requirement of set up, are now less used. The pipework is in sections with flexible couplers to make long runs. The pipes would be connected into a manual ring main and run for a time to irrigate. There are no control systems meaning it is difficult to get a good idea of the level of application. They have the advantage of being light and so have less compacting impact than other systems, but setting up and moving is very slow and will require vehicles on the racing surface. They would be effective where ring mains are sub-sized as the flow and pressure requirement will be lower than required by other methods.

### Manual systems

Some tracks still have no installed system or ring main and so water is applied by bowser and spreader plate, water bar or water cannon. Given the size areas that may need irrigating, this approach is not able to apply enough water to a track fast enough to meet the BHAGI requirements. For example, to water a 30 m strip of track 200 m long to provide 12 mm of water would require 72 tons of water or 6 bowser loads. The weight on the track is large as the water is transported to the track by bowser.

A modification of this system is where there is a ring main with reasonable pressure, a tractor mounted pump and spreader plate is connected to the ring main and water applied as the tractor travels over the turf surface. This avoids transporting water to the track but is very inefficient and will require multiple passes resulting in compaction.

### Ring mains

The key part of any system is the method used to supply water to the location of the irrigator. This is normally achieved by a large ring main and/or multiple loops or branches for complicated tracks. These are carefully specified systems of reducing pipe sizes away from the irrigation pump. This maintains the correct flow and pressure at most points of a system. Each drop in pipe size will typically reduce the pipe volume by 50% and therefore at a tee, both branches will receive similar flow and pressure. The use of a ring main has benefits as it allows pressure to equalise around the system, so each sprinkler will receive a similar flow and pressure and hence application rate.

Racecourse ring mains are massive, often utilising 180 to 225 mm or larger diameter pipes and are easily capable of applying 1000 $m^3$ water per day. Most ring mains are retained at operation pressure during the watering season, although some will be primed prior to use. Pressurised systems will require a network of pipes without leaks or weak joints that risk pipe or joint failure. The pressures used will be very high and so connecting into a pressurised system must be risk assessed and only competent grounds team members undertake the task.

### Pump systems

Most racecourses will have a relatively modern pump or pump set. The pump will be of sufficient size and pressure to power the system. Modern systems will typically have multiple pumps in tandem and control systems that allow variable speed of operation as the demand increases. This allows a primed system (kept at pressure) to be maintained and as water is used the pump will maintain this pressure. Older systems may not have this level of control and the pump “kicks in” as required. This can send a shock down the system (pipe hammer) that in time may lead to increased risk of pipe/joint rupturing.

### Water supply

The ability to supply enough water to a course is critical and requires large supply reservoirs and the ability to fill them. Other methods of supply would be from adjacent steams or boreholes. Typically, most water sources, except rainwater harvesting, will need permissions and abstraction licenses from the Environment Agency. Rainwater harvesting systems are not able to supply total demand but can be very useful to help mitigate against dry weather or to reduce the amount of water needed to be abstracted. A downside of these systems is the need to have a very large storage capacity to make the capture of water worthwhile for when the water is needed.

As the implications of Climate Change are becoming further understood, there is increasing risk or extreme weather occurring, be it rainfall or drought. This highlights the need for racecourses to develop strategies of water use that reduce the level of water application or to increase water harvesting strategies. This is about building water resilience into racecourses so that they can deal with prolonged wet weather and drought as best as possible.

## Evapotranspiration and health needs.

Evapotranspiration is a very important pathway for loss of water from a turf surface (Figure 9). It is how a soil dries down beyond the potential of gravity to pull water from the soil, as the water is lost through grass plant extraction (Figure 10). It is a seasonal process as it is biologically controlled and is greatest during periods of strong growth coupled with higher air temperatures.

## Evapotranspiration.

Evapotranspiration (ET) is the biological and hydrological process where water is lost from a grassed surface by two processes:

1. **Evaporation** – water lost directly from the soil surface. It is reduced by having full grass canopy but is greater on worn areas where more soil surface is exposed. This is determined by temperature and wind flow, where water is lost from a wet surface to the drier air and is faster as the temperature increases. In a turf setting and especially with a longer grass height, this is relatively low due to the humidity held at the plant base and soil surface preventing the transfer of vapour to the air.
2. **Transpiration** – water lost from plant leaves as they carry out gaseous exchange. Is also used to help pull water up from the roots to the leaf tips (the latter being important for nutrient uptake from roots to growing regions of the grass plant). This is a biological process where a plant draws water from the soil by the roots and is lost from the leaf. The process is essential for plant health and transport of nutrients and molecules around the plant. If water is limited, then the leaves wilt as this process is disrupted. Transpiration is temperature dependent but will occur for cool season grasses between 5 and 28 degrees Celsius (dependent on species and cultivar).

Evapotranspiration is measured as mm of water lost and is directly equivalent to rainfall or irrigation that needs to be applied to replace lost water.

## How much water is lost from a grass racing surface per month?

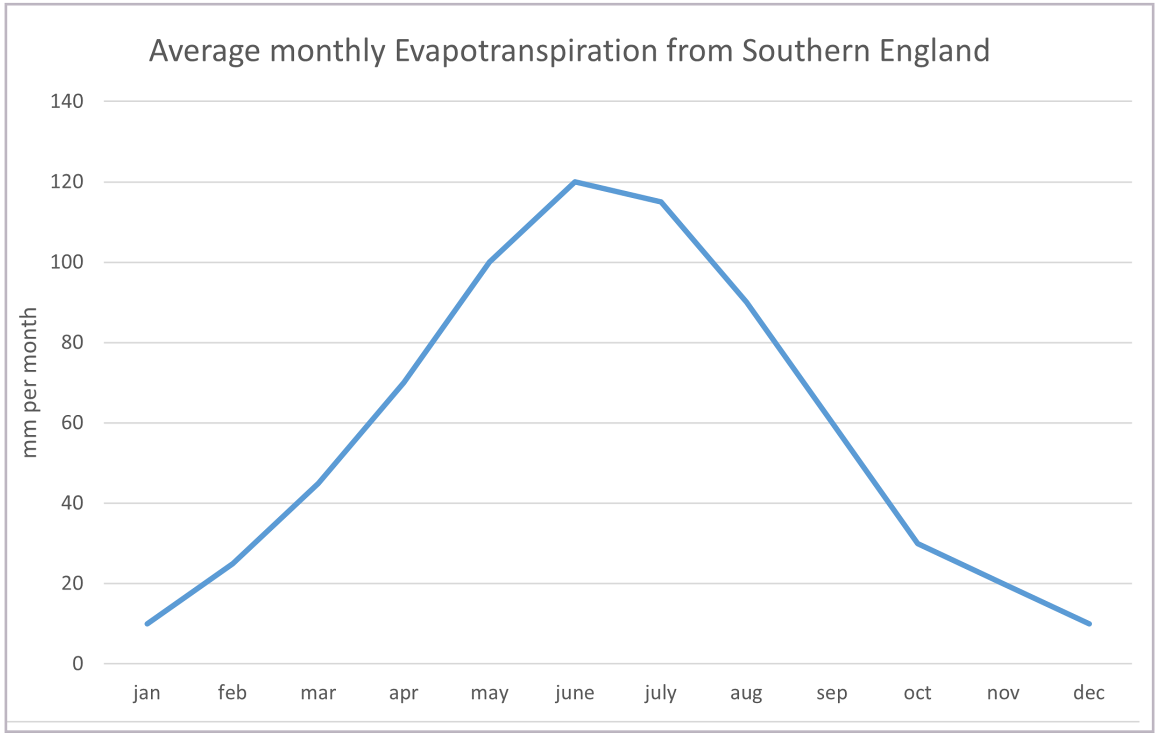



**Figure 9: Monthly average ET rate for Southern England**

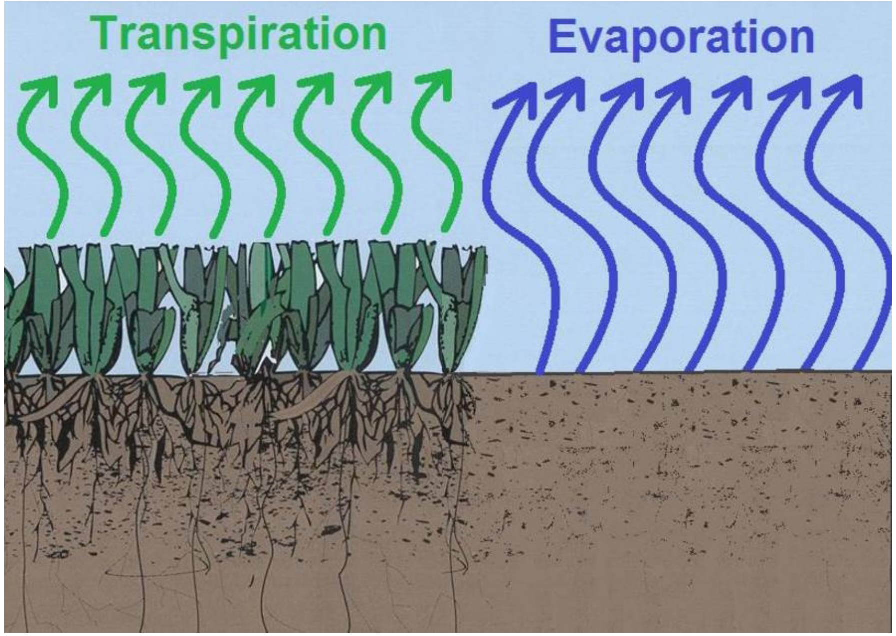



**Figure 10: Evapotranspiration from racecourse turf (credit to USGA)**

In the UK, the highest rate of ET for a long grass turf sward would be around 6-7 mm but more typically around 3-5 mm per day. This means to retain the same moisture content in a profile, the same mm of irrigation should applied. In the racecourse setting where meetings occur frequently, there is a benefit of adopting this strategy to maintain the desired Going. This would be achieved by recording the daily losses and replacing on a 3-5 day watering strategy rather than daily applications. The key is to know the daily ET rate for the racecourse and most sites will have this information from the on-site weather stations.

“In the UK, the highest rate of ET for a long grass turf sward would be around 6-7 mm but more typically around 3-5 mm per day.

However, there is a grass health and species concern where tracks are heavily watered to maintain Going (rather than applying to replace ET losses). Keeping a soil wetter than needed is likely to increase the risk of invasion by less desirable grass species such as meadow-grasses. Rooting depth can also decrease since the grass does not need to search for water as it is always present in the surface layer of the track profile.

When not having to water to achieve a specific Going, the best practice approach is to apply a water deficit strategy. This should be coupled with a record of moisture content to control applications of water to just meet turf needs and performance.

## Using water to manipulate Going, the relationships.

Irrigation has historically been used to manage the Going of a surface. There is a clear relationship between soil moisture and firmness and hence Going. The higher the soil moisture content, the softer a surface will be. However, the specifics and detail will differ depending on soil type, soil compaction/bulk density, the ratio of the macro and capillary pores (drainage potential) and % organic matter. Seasonal effects also need to be considered as the amount of irrigation needed to create a change in Going may be different.

### Water moisture deficit management strategies.

A water deficit is where the amount of water lost from a soil is greater than that replaced through rainfall or irrigation, and a soil will become drier. For simplicity, it is expressed in mm and is directly equivalent to mm applied irrigation or rainfall. It is also important to note that approximately 1 mm of applied irrigation or rainfall will wet 4 mm depth of soil, which is based on typical soil porosity values.

Strategies used for managing water deficit include replacing the lost moisture each day or every few days. This assumes the desired moisture content for health or Going has been achieved and this approach might be used running up to a race meeting.

Another strategy, particularly used for soil and plant health, is to allow a deficit to build up and only replace to a percentage of the loss (e.g. 80%). This slowly and controllably dries a soil until a point where the moisture content reaches the lowest desirable level. To reset the soil moisture to a specific level, irrigation would be needed as below:

ET deficit – irrigation – rainfall = irrigation needed (mm)

This process could be used to control dry down of a soil to reach target moisture contents for health or Going.

If a record of Going/firmness and moisture is recorded over time, it would be possible to create a moisture versus Going graph to better inform the level of irrigation needed to manipulate Going. If this was linked with data on the quantity of irrigation applied and the resultant change in soil moisture content, once any drainage has stopped, then it would be possible to broadly predict typical changes in soil water content for a given irrigation depth applied.

As an example, Figure 11 shows how this might work. If the moisture content was measured at 35% and deemed to be too firm for racing at good to firm, to soften the ground to good would require an increase in soil moisture of 5%, whilst 10% to go to good to soft. If it was then known that 5 mm of irrigation changed the moisture content by 10% then in our analogy the change from good to firm, to good to soft would need 5 mm of water applied. This is somewhat academic and needs to integrate with the experience and site-specific knowledge of the track team. However, there are occasions where the level of water thought to be needed to make the desired change is in excess of the amount really needed, so having a data driven calculation can help refine actual needs.

The 2006 thesis by Dr Colin Mumford (The optimization of going management on UK racecourses using controlled water applications; Cranfield University at Silsoe, December 2006) indicated a similar process of measuring moisture and Going could lead a track-based model for Going manipulation. This was proposed at a time when little data was collected, or relationships were determined. With a PQS approach being more widely used, these data collected will allow relationships between irrigation, soil moisture and Going to be developed. However, it should be noted each soil type and track will have differing relationships and indeed moisture may not be the key driving factor to make the greatest change in Going. In many soils, compaction may be the key to adjusting Going and therefore applying water will be less effective than using a decompactive aerator such as a Verti-Drain or Terraspike.

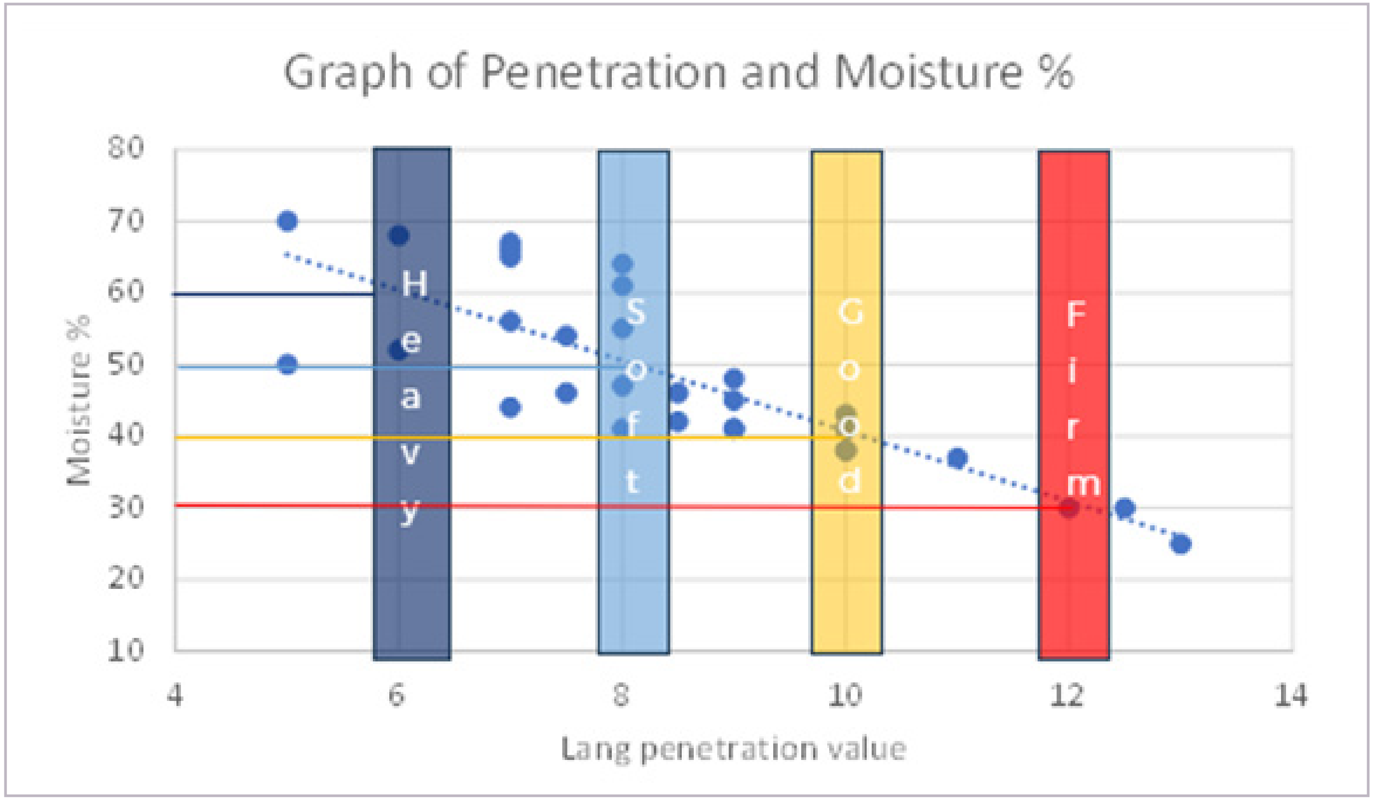



Figure 11: Graph showing live data of moisture vs lang penetrometer value and related to Going

# MANAGING IRRIGATION.

## Introduction.

Irrigation strategies on racecourse are most commonly based on experience. This will work well in ideal conditions but can be challenging when identifying the level of irrigation needed to reach an ideal Going after long dry periods or even following some rainfall. This can lead to incorrect applications resulting in surface inconsistencies and excess water use.

With the increased use of moisture meters and installed moisture sensors, it is possible with recorded data to be more precise on irrigation requirements, in support of the experience and feel a track surface is presenting. This section gives a guide to developing and using moisture relationship for your racecourse to support irrigation practice.

## Create a Going to moisture relationship for your racecourse.

Following the principles above, a Going to moisture relationship could be developed. This could be developed using the data collected by your agronomist but will take years to gather enough data, as the greater the amount of data the better the relationship will be produced. Therefore, the track will need some tools to speed this process up. A moisture meter is key and there are a number of different types available, with some recording data, measuring at different depths and some logging readings made. There are some that can log and transmit data to allow graphs and maps to be produced. At the time of production, the Delta-T theta probe, Soil Scout TDR 350 and the Pogo were common types used and deemed accurate.

To be able to use data to characterise a surface and inform maintenance processes, it will be necessary for tracks to invest in objective tools that measure firmness or penetration and shear. This could be the GoingStick (recording the penetration and shear values separately), Clegg impact hammer, Longchamps penetrometer, Lang penetrometer or Vienna surface tester. Alternatively, Going measured by the Clerks stick or adjusted Going Allowance could be used but makes creating of numerical models of how a track reacts more difficult.

## Managing your track water content with facts.

The moisture meter is a vital tool in water management. It allows users to accurately monitor soil and track performance and predict when moisture or aeration is needed.

It is difficult to accurately determine if water is needed visually or by feel and, in certain conditions, the soil moisture may be very different to the feel.

With data on soil moisture, Going and surface firmness collected over a wide range of track and weather conditions, it becomes easier to accurately determine the amount of water required rather than an estimate based on experience. This potentially leads to better track consistency and potential savings in water, time and energy.

Often the moisture meter could be used ahead of an irrigation cycle and a period after to determine the effect of the application against the known desirable targets.

The moisture meter is also useful to check the moisture through the profile depth to confirm a uniformity of the profile or where water is being held. This can directly inform track management strategies.

The process is to take data from a range of repeated places around the track. At each location, the average of a number of readings should be recorded, being careful to reject any widely variable reading where a tine hole, filled divot or drain line may skew the result. The intention is to get a fair and representative understanding of the racing surface. The data "pairs" should be taken together. The estimated Going or that recorded from the objective device in the case of the GoingStick or VST should be taken.

Once a fair dataset is created then a graph of moisture versus "firmness" could be developed and a best fit line calculated to give a trend. If the graph has widely variable data points, then it might be due to differing soil types or compaction and therefore other parameters or areas should be evaluated. Your agronomist would be able to assist with this.

The Going value should be added, as has been done in Figure 11, and then the moisture values for the particular Going can be understood. With this information it would be possible to determine the % change required to change Going (Figure 12).

> "With this information it would be possible to determine the % change required to change Going.

Using the moisture meter before and after irrigation (leave at least 12 hours before taking readings, but ideally 24 hours), record the average moisture content change for a mm irrigation application (Figure 13). This is best recorded over time and in different moisture situations. It may be the case that in a dry setting, it takes more irrigation to wet a soil for an increase in moisture content of 10% than in a soil nearing field capacity.

It is important to note that in soil types, such as very sandy soils, the relationships particularly of penetration versus moisture content may not be strong and so it would be very unreliable to assume a moisture content will be the sole determinant of Going or that a certain level of water application will result in a desired change in Going. In these circumstances the following example might be applicable:

If a GoingStick records a Going level of good and the moisture content is low, then the actual Going declaration is likely to be slightly firmer and the opposite if the moisture is high. Experience would then dictate if watering were necessary and how much but could be related to monitoring the change in moisture content pre and post soaking in after irrigation.

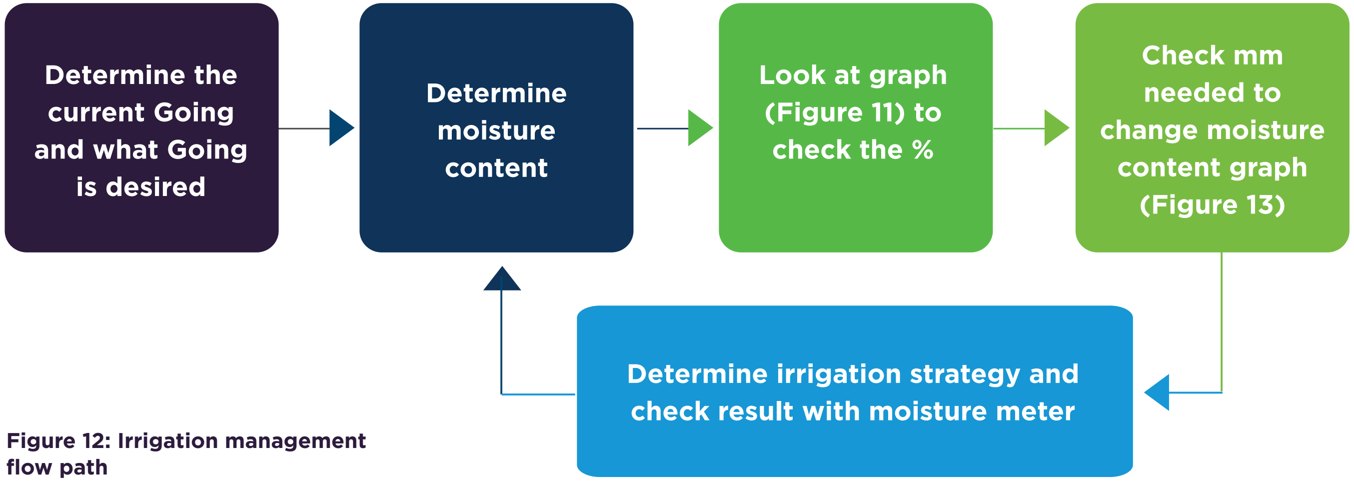



**Figure 12: Irrigation management flow path**

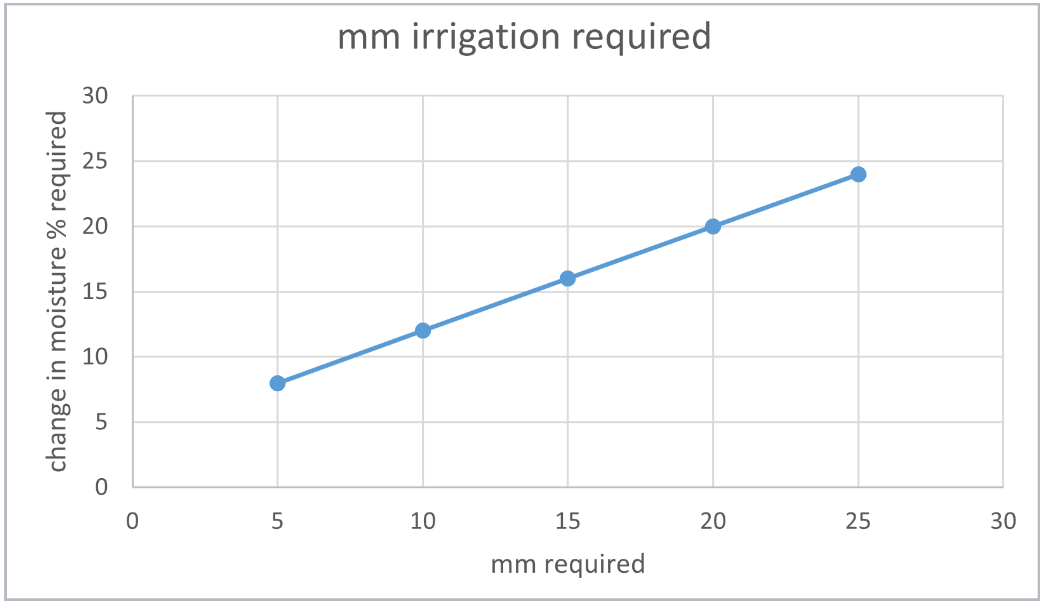



**Figure 13: Indicative graph of mm irrigation required to change moisture content %**

## How much water do I need to change Going and for health of plant and soil?

Irrigation is most commonly used to soften a surface and generally well-founded experience-based decisions are often made as to the amount required. However, it is possible to be more precise in the amount needed to achieve a particular goal using the moisture versus Going method and potentially a water deficit ET programme detailed above.

It is important to note that, the amount of irrigation required to change Going may vary at different times of year. For example, a clay-based track that has cracked in the summer will need significantly more irrigation to modify moisture levels than a track without major cracks. This is due to the irrigation initially being needed to rehydrate the lower profiles. To some extent, a guide could be gained by monitoring the ET and water deficit as this could indicate initial volumes needing to be applied to rehydrate the soil.

Also, irrigation effectiveness may be different depending on the level of water filling of macro and capillary pores. Indeed, if a soil compacts during a season and macropores are reduced in volume, then less water may be required to achieve a desired moisture content and hence Going. This is a key premise of understanding how your individual track performs over a season and then applying data and science to provide the right amount of water.

The key to understanding the soil moisture relationships is to understand how irrigation or rainfall amounts impact the track moisture content. This is easily assessed by measuring the moisture content of sample areas pre and post rainfall and or irrigation. If the mm applied is known, the change in moisture % per mm applied can be recorded and over time an average calculated. There are risks at the ends of the moisture spectrum and in sandier soils as how the profile holds and transmits water can be quite different to typical tracks.

There is a key difference between the moisture content grass requires versus that needed for all Going categories. For a ryegrass/meadow-grass sward on a sandy soil, then good plant health is achieved at soil moisture contents of 20-30% and slightly higher for clays. Above this level, grasses will actively grow but the rate of organic matter breakdown can decline resulting in excess soil organic matter (thatch) accumulation. Agronomically, at higher moisture contents meadow-grasses are favoured and can quickly dominate a sward.

In contrast, the moisture contents for ideal Going for both Flat (30-40% typically) and Jump (40-50% typically) codes is much higher than that needed for plant health and therefore runs the risk of organic matter increase and meadow-grass development leading to soft and lush grasses. This means that a one size fits all irrigation policy is not going to be suitable. There needs to be an appreciation of the nuance associated with managing track water contents at levels that meet both agronomic and performance targets.

### Soil moisture for plant health and Going.

Soil moisture levels for plant health and Going will differ, with higher levels being required for Going than plant health. Maintaining the soil moisture for Going season long could change the grass species negatively and increase compaction. Soil type will also impact the "ideal" moisture ranges.

**Plant Health**

- Sandy soil minimum 15%, clay soils minimum 25%.

**Going (good)**

- Sandy Soils 35-45%, clays soils 40-50%

## What ground changes occur over a racing season in relation to moisture management?

During a racing season, racing and management activities will tend to compact soils. To recap, this is the process whereby the air volume of the soil is reduced as compared to other components (soil and water) which are not compressible. The organic matter in the soil may also be tightened up and drain less well restricting infiltration of water into the track and increasing water retention. The amount to which compaction happens will vary from code to code, number of runners and use.

The ET rate will differ through a season in response to prevailing weather conditions and the potential for turf growth. Typically, at the start and end of a season, soil will tend to have higher moisture contents, but growth potential of turf is lessened resulting in lower ET rates and less potential to dry down a track. Care is then needed in applying the correct level of irrigation at these times, especially at the end of a season as the consequence of overwatering can impact Going for a long time (reduced drying down potential of turf as growth and transpiration are reduced). Figure 14 summarises the relationship between existing soil water content and ET conditions for how a track dries and how it reacts to irrigation inputs.

### The impact of surface use on compaction for differing codes of racing.

A **Chase track** typically will have less runners than a **Hurdle track** and the level of compaction would be higher than the more churned surface of a hurdle track. This is further mitigated in most situations by the ability to move a Hurdle running line more than the commonly fixed Chase jumps.

A **Flat track** where the running line would be moved over a season but typically always return to lines that had "recovered". would be likely to be compacted. The level of compaction will be greatest on lines that are heavily used. This can be mitigated with regular decompactive aeration.

| | |
|---|---|
| **High moisture, High ET**<br><br>Soil is slowly drying but highly manageable to adjust Going with water inputs. | **High moisture, Low ET**<br><br>Soil wet and very difficult to reduce moisture, especially if Going is too soft. Be cautious of any irrigation inputs, especially risk of rainfall. Penetrant wetting agents may assist, as would drainage systems. |
| **Low moisture, High ET**<br><br>Soil is drying out quickly, therefore need to apply more water than ET to achieve Going change. May need wetting agents and surface management to adjust Going. | **Low moisture, Low ET**<br><br>Easy to adjust soil moisture to increase moisture content. Risk of over watering as soil would be slow to reduce. |

**Figure 14: The effect of different soil moisture and ET scenarios on how a track dries and how this relates to irrigation inputs**

**Using ground manipulation rather than water.**

In the last few years, the understanding that firmness and compaction are key issues on our heavily raced surfaces and the greater availability of aerators such as the Verti-Drain has allowed alternative methods to adjust Going. In particular, the Verti-Drain type action of a tine being able to be inserted and heaved is useful to fracture and loosen slightly an overtight soil.

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Typically, a surface will tighten in the upper layers and if the upper "cushion" layer can be loosened over the firmer base layer then a horse will gain both cushioning and energy return and the surface will be less jarring. The process involves shallow Verti-Drain with a significant heave in the two weeks or so before a meeting if required. This needs careful management as surface damage and heave should be monitored. Monitoring penetration and soil moisture values will help in assessing the requirement, intensity and frequency of soil decompaction.

It is also important to monitor deeper compaction with the track profile, as this may not directly affect Going, but in wetter periods of the year can affect how much water a track holds. If there are deep compaction layers, this can result in a softer surface due to its greater water retention.

After use of the Verti-Drain or similar decompactive tools, it is important to note that a track may need more water applying than normal to achieve the desired Going. This is due to:

- Held water being released when the soil is decompacted.
- Greater abundance of voids in the soil that then need to be rehydrated.
- Preferential flow down tine holes so more water is needed to get an even rewetting of the track.

However, with a shallow Verti-Drain this will be relatively minimal.

### Large applications versus “drizzle”.

The amount of water applied in each application will have a direct impact on how water will percolate through or remain within a soil profile. It is important to consider that water has a weight, so when a large application is made it will be heavier than a light one. This means that an application of 10 mm irrigation/$m^2$ will weigh 10 kg/$m^2$ and an application of 2 mm equates to 2 kg of water per $m^2$. This will “push” through a profile more quickly and may not achieve the wetting of the soil block as effectively. It is likely that water drains through macropores and only partially fills the capillary pores. Also, the rate per hour is important due to the force of impact of the water hitting the surface and compacting it over an extended period of time.

“The amount of water applied in each application will have a direct impact on how water will percolate through or remain within a soil profile.

In practice, larger volumes are used to allow a one pass operation and to reduce equipment traffic on the surface, as well as being time efficient. But it is important to consider the actual need for water application, as per the calculations given earlier in the chapter, to reduce the above concerns and save water and energy associated with the application.

Ideally, a series of light applications would be made to achieve the desired moisture content and hence Going, but realistically this could only be achieved by pop-up systems. In this case, water will percolate more slowly and have increased potential to fill the capillary pores and hence the soil block and influence soil moisture. Additionally, if aeration holes are present, applying more but lighter applications slightly lowers the risk of water bypassing the soil block down a tine hole, as the surface tension of the water at low volumes will hold up in the profile better.

| VOLUME OF APPLICATION | DISADVANTAGE | ADVANTAGE |
|---|---|---|
| **Heavy application (>8 mm)** | Weight of water can drain through profiles faster making the application less effective. | Gets large volumes on more quickly with less runs of heavy equipment. |
| **Light application (<4 mm)** | More runs or cycles of irrigation to achieve same effect. Small amounts may wet the upper profile only leading to potential slippiness. | Wets profiles more effectively if repeated. Effective with installed systems. |

## Why pre-race irrigation is perceived to produce poorer racing surfaces.

It is important to note that irrigated ground is not generally favoured by the racing world. There is no real reason why this is any different than a rainfall event when considering the rates of water percolation through a profile or moisture content. In addition, the soil profile is not impacted any differently. The key difference is the speed and volume with which water reaches the soil. For example, applications of over 5 mm from a boom irrigator over the typical time period it is applied are significant, being equivalent to a rainfall rate in excess of 35 mm/hr or in other words a severe storm. This can lead to two main risks:

- **Deadening of the surface** – occurs when the upper macropores in the upper profile are filled and do no empty before racing starts.
- **Increases in slipping** – occurs due to the upper soil profile comprising a relatively shallow depth of wet thatch and soft soil over a harder soil beneath. This results in poor hoof penetration and reduced resistance to the motion of the horse and therefore greater risk of slipping, especially on bends.

The risk and extent of deadening and slipping will greatly depend on the soil type or profile condition but bear in mind many tracks may only drain slowly and may not drain to field capacity for many hours.

There is always a risk that a water application before a meeting may result in a wet upper profile, especially in a thatch layer and be drier below, risking the creation of slippery surface conditions. The aim of all irrigation to a racecourse is to achieve a thorough and even soil moisture content throughout the profile. This plays a critical role in reducing the risk of a slippery surface.

## Environmental cost of irrigation.

Inevitably irrigation of racecourses requires a huge resource in terms of amount of water applied, energy, staffing and machinery demands. As a guide, to deliver the BHAGI 12 mm per day application over a 30 m width and a 1.5 mile round track, around 1000 $m^3$ of water is required. This is equivalent to around 7000 persons daily usage. This volume would be categorised as high and, depending on the water source, would need abstraction licenses from the Environment Agency. As water is a limited resource in the UK, it is likely legislation will be enacted in the future to force high volume users to reduce water usage. Consider current water sourcing and usage now and act upon global risks such as climate change will help in formulating water resilience strategies at racecourses.

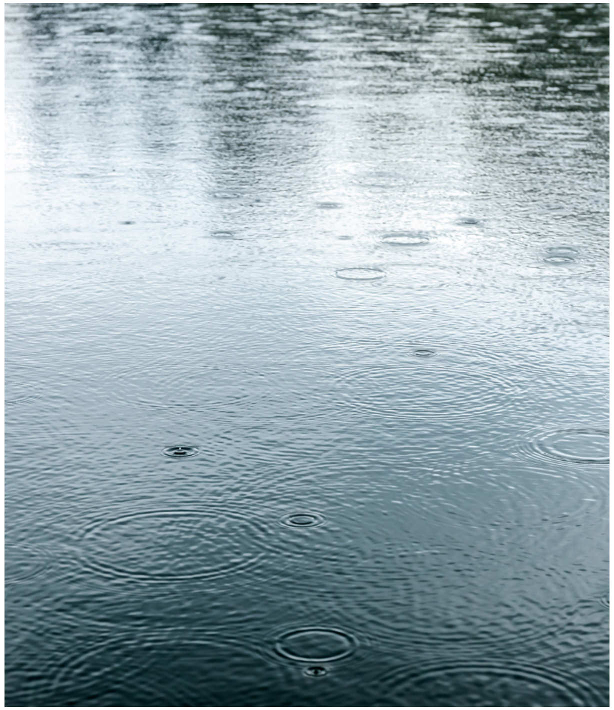
> “As water is a limited resource in the UK, is likely legislation will be enacted in the future to force high volume users to reduce water usage.

In the UK water sources are from the mains network, borehole, surface water features (rivers and lakes), rainwater harvesting and recycled treated grey and black water. Coastal desalination is being investigated. The first three sources will be licensed and, whilst at present are relatively generous, could be restricted in the future as greater pressure is placed on water resources. Undoubtedly, the future of irrigation sources would be to combine sources, but some sources such as rainwater harvesting and its associated storage come with high initial infrastructure costs. The concept of rainwater harvesting is simple as it involves capturing rain falling onto the site before it enters the soil or ground water and store it. This requires infrastructure and the ability to store enough water to help meet irrigation needs in dry periods.

To meet current, let alone future challenges, racecourse managers need to use all the following to help enhance water resilience:

- Improved irrigation accuracy.
- Accurate assessment of need.
- Using all available monitoring and predictive tools to help inform decisions made.
- Utilise products available to help reduce need or maximise benefits from either rainfall or irrigation, such as wetting agents.
- Look at all possible sources of water and their storage for when irrigation is needed.

This is a step change and may be forced onto racecourses, so it is better to plan and act now before it is legislated for. As this guidance has shown, water management is key to producing consistent and high-performance racing surfaces,. Without it, managing a racecourse becomes more challenging and being able to hold meetings becomes less certain.



# BEST PRACTICE GUIDANCE.

**The do's and don'ts of water management on the racecourse.**

Don't forget that whilst we can start to utilise data and testing to help inform our irrigation decisions, the feel and knowledge of how a track performs versus the amount of irrigation needed is priceless.

## Do’s

- Apply water to meet the needs of the track for health and racing based on good knowledge, data and experience.
- Remember applying water has a significant cost of a finite resource and the energy and time to apply, use it wisely.
- Balance the time savings, compaction of applying a larger application against the benefit of lighter more frequent applications.
- Factor in evapotranspiration to watering need.
- Use a moisture meter to inform irrigation need.
- Ask yourself the question, “Do I need to manipulate ground rather than try to use excess irrigation to change Going?”
- Utilise wetting agents to assist in wetting profiles.
- If possible, irrigate at night/early in morning or evening to use water as efficiently as possible.
- Consider the viability of managing water contents for plant health during drier periods and boosting water content to meet Going requirements.

## Don’ts

- Don’t overwater as this is environmentally costly and can result in detrimental surface changes such as increases in less desirable grasses.
- Don’t try and modify Going by adding a lot of water just before a meeting, apply it earlier and let it soak in, otherwise a deadened or slippery surface can result.
- Don’t assume that water distribution from an irrigation system is even and consistent, check it and calibrate the irrigator if necessary.
- Where possible avoid irrigating when windy.
- If using boom or surface mounted irrigation, try to move where it sits or travels on the turf. This is to help manage and prevent compaction, which may create inconsistencies in the running surface.

## Best practice guidance for using water to manage Going.

This section condenses the information discussed above to a step by step guide. Note that some soils may respond less predictably to water application in delivering the desired Going.

### Step 1: understand soil moisture and the soil profile.

Collect data of Going (ideally using a numeric data collection) and soil moisture over time to create a Going to soil moisture graphical relationship, as per the information in *Water in the Soil* section. This will provide greater accuracy over time and ideally where a track had differing soil types or construction, a graph for each.

### Step 2: Understand the level of irrigation needed to change a moisture content.

Take moisture readings before and 24 hours after an irrigation cycle and note the change in moisture content for the amount of moisture applied. Repeat over a number of soil moistures and over the season to give an average % soil moisture change for a mm of irrigation applied.

### Step 3: Irrigate.

Using the information iabove record the moisture content and refer to the Going/moisture graph. Identify where the moisture needs to be to achieve the desired Going and hence the change needed. Refer to the mm applied data/ knowledge and calculate the level of mm of irrigation required.

### Step 4: Check.

Confirm the easing of the ground meets requirements and if the moisture content is roughly in line with expectations. Record in the Going and moisture data.

This process will take time to identify the parameters but in practice the point of needing to apply irrigation will be simple and potentially less time consuming than over applying water. It may require support and guidance from your agronomist to help in setting this up.

## Surface suitability.

Water applications have the ability to soften areas where an over firm surface, such as a bend, may not have grip and lead to slippage or a chase jump where there is “jarring” and may result in falls or injuries. It is very important however to understand the processes and potential consequences of such operations.

Water percolates through a soil at differing rates depending on soil layers and type, as well as organic matter levels. It is easy to apply incorrect levels (mm) of water and create a wet upper surface in the thatch and soil layers that runs the risk of shearing off and being more slippery than the original issue of an over firm surface. As a generalised “rule of thumb”, 1 mm of water applied will soak in 4 mm and then move through the soil profile. This is based on the natural porosity of typical racecourse soils, with the understanding that the more water that lands on the surface, the greater the throughflow of water there will be until the soil reaches its peak drainage capacity. Inputs of water are often needed to maintain specific water levels in the soil, with greater amounts of water needed in freer draining soils and less in heavier textured track profiles,

The process for suitability of a racing surface is to confirm there is no significant shear weakness and this can be assessed with the GoingStick. A soil slab can be removed and moisture taken down the profile. There will be a gradual drop in moisture content in a profile but sudden changes in the upper 100 mm should be noted and acted upon. It is difficult to be precise on the level of water needed, but an application and then let it drain for 24 hours and then check the moisture again is potentially the easiest route.

There is great risk in adjusting a section of track too close to a race meeting, as water may not percolate deep enough and risk producing a slippery surface. Under these circumstances, there may be benefit in manipulating the surface Going with shallow Verti-Draining or sanding rather than using irrigation.

## Autumn/winter irrigation and its impact.

Jump racing codes, when racing commences in September (and even in October), may find the Going too firm for many Yards and Novice horses. There is a valid perception that good Going may be too firm in this circumstance. The key reason is dry soils from the summer not wetting down consistently due to insufficient rainfall. There may also be a degree of soil tightness or compaction. Therefore, the initial process to ease ground and reduce jarring would be Verti-Draining.

Undoubtedly gentle prolonged rainfall is the ideal. This allows the larger macropores and cracks (seen in dry clay soils) to fill and swell and gradually soak into the capillary pores. However, irrigation is often the only resort to avoid a meeting being cancelled. It is important to bear in mind the challenge of heavier applications of water and difficulties of getting the water to soak in rather than drain through. Also, large deep cracked surfaces will require vast quantities of water to fill and swell and probably should have been prevented by low level irrigation to keep cracking to a beneficial micro level. The use of preventive wetting agents to minimise soil drying or curatively to aid with rewetting can be highly beneficial.

The application of irrigation in autumn and winter can be successful but could over wet the surfaces, partly due to low evaporation rates and not taking account of soil moisture at the start of irrigation. The worst-case scenario is a soft wet surface at the season start resulting in deep surface damage that renders a racing "lane" potentially not able to be reused at the end of the season due to poor recovery.

The key is therefore to understand your track soil profile, moisture content at varying Going description, using surface manipulation and soil management to reduce jarring and create an ideal surface.

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