HUNTER WATER

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Best Practice Sporting Fields

A guide for turf surfaces in the Lower Hunter

Book 4: Irrigation

AgEnviro Solutions

PEAK WATER CONSULTING

Cover Picture: Irrigation at Ulinga Sporting Complex.

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Brief biographies for authors and reviewers are contained in Appendix A of Book 1.

INTRODUCTION

As outlined in the previous book, the myth that all fields require an automatic irrigation system and sports field drainage is untrue for the Lower Hunter. There are many sporting fields with low levels of wear in the Lower Hunter that perform well despite not having an automatic irrigation system.

The lifecycle cost to install irrigation and drainage in all the existing sporting fields in Lake Macquarie City Council for example would be around $33 million over 20 years and increase potable water use by 320 ML pa. Instead, best practice involves installing irrigation only at the sites where these works are needed to meet the playing surface benchmarks described in Table 3.1 (Book 1).

For greenfield (new) sites, a holistic and integrated approach involves consideration of soils, turf, irrigation and drainage to meet the playing surface benchmarks described in Table 3.1 of Book 1. This may entail the provision of irrigation infrastructure according to best practice to meet these benchmarks.

This book focusses on best practice elements for irrigation design, installation, maintenance and scheduling. The decision on whether to install an irrigation system at a facility is part of the strategic planning process and is discussed further in Book 5. Drainage and the management of excess water is covered Book 3.

Figure P.1: This field has reasonable turf cover despite not having an automatic irrigation system.

CHAPTER 10: WATER SUPPLY

The water supply is a critical element of any irrigation system. Ideally, where available, (provided it is of suitable quality), non-potable water would be used for turf and landscape irrigation. This approach reduces demands on the overall potable water supply and provides a water source that is not subject to the same water restrictions. Each site will have different requirements and considerations. Regardless of the water source, there are many factors to consider such as those listed below.

Licensing and approvals

Irrigation systems using **potable water from the Hunter Water network** require approval via a Technical Assessment. Design plans need to be submitted showing irrigation demands and the connection point (including water meter and backflow prevention). This is to ensure the Hunter Water infrastructure can meet the projected demands and that public health is protected through appropriate backflow prevention. Information on backflow prevention requirements for irrigation systems can be obtained from Hunter Water's backflow prevention standard (available on Hunter Water's website).

Irrigation systems **drawing or proposing to draw upon groundwater** may require several licences, including a Works Approval, Water Use approval and a Water Allocation License (WAL). Groundwater is regulated by both Water NSW and the Natural Resources Access Regulator (NRAR).

Harvested stormwater and Recycled Water schemes may require multiple approvals depending on the project. These may include Council, NSW Health, NSW Department of Planning, Industry & Environment (DPIE), Hunter Water and/or IPART under the Water Industry Competition Act.

Licensing requirements, agency names and responsibilities can change over time. As such, it is the responsibility of the project manager to ensure licensing and approval requirements are met.

Water quantity

The quantity of water available (e.g. pressure, flow rate and yield), coupled with the irrigation demands play a crucial role in determining whether storage is required and the size of storage needed. Water balance modelling is generally needed to perform these calculations and should be based on:

- historical weather data from a nearby station that has conditions similar to the site being examined
- at least 10, but preferably 20 years of daily weather observations and NOT based on daily averages (using daily averages typically results in annual irrigation and peak demand being massively underestimated)
- daily time steps within the water balance model, with the information from monthly water balances typically providing unreliable outputs.

Water quality

Water quality includes the chemical, physical and biological properties of the irrigation water. This can impact on:

- public health
- soil health, including the soil chemistry, soil structure and the infiltration rate of the soil
- turf performance and health
- environmental health
- longevity and materials used for irrigation infrastructure (e.g. pumps, pipes, sprinklers, filters etc).

A key consideration that is often overlooked is the implications of water chemistry on the clay soils in turf cricket wickets. Water quality testing is crucial as this will heavily influence numerous elements of the irrigation system and how it is managed to optimise turf performance (Table 10.1).

Table 10.1: Potential impact of water quality on irrigation (Connellan 2013, p.46)[20]

Water Quality Property	Irrigation System Implications
Chemical	Management of the irrigation system and scheduling (salinity, nutrients) Selection of irrigation system materials and equipment Irrigation system design parameters (hydraulics) Runoff and drainage water impact on environment
Physical	Selection of materials and equipment (e.g. pumps, emitters) Filtration requirements Servicing/maintenance requirements and budgets
Biological	Filtration and disinfection requirements Turf disease management Servicing/maintenance requirements and budgets

Table 10.2 presents indicative limits for various water quality parameters to avoid problems when using non-potable water for irrigation (Connellan 2013)[20]. It is important to note that these values are a guide only as the requirements at a specific site depend on several factors (Connellan 2013)[20]. A non-potable water source that may be suitable at one site, may not be suitable at another due to differences in soil properties, such as soil texture and structure, chemistry as well as the turf variety. Furthermore, non-potable water sources can vary dramatically in their quality, including over time (e.g. groundwater quality can deteriorate during drought).

Therefore, when considering or using non-potable water sources it is crucial to:

- get independent professional advice from a multi-disciplinary team, including certified professional soil scientists, turf and water quality specialists
- have a regular monitoring program (including turf and soil health) to identify potential problems or issues early
- have an adaptive management program to adjust water sources (and their mix) along with irrigation scheduling should issues arise
- allow for specific irrigation and soil chemistry management measures (e.g. leaching of harmful salts and/or the addition of calcium)

Table 10.2: Guidelines for water quality for irrigation use (Connellan 2013, p.52)[20]

Water Quality Parameter	Preferred range or limit	Reference/sources
pH	6.0 to 8.0	Various. pH depends on multiple water quality properties, soil conditions and site requirements
Salinity – EC	< 0.28 dS/m	ANZECC (1992)[21]
Salinity – TDS	<175 mg/L	ANZECC (1992) [21]
Alkalinity (CaCO3 equiv.)	<100 mg/L	Handreck (2008) [22]
Bicarbonate	<90 mg/L	Handreck and Black (2001) [23]
Chloride (overhead sprinklers)	<100 mg/L	Handreck and Black (2001) [23]
Sodium (overhead sprinklers)	<70 mg/L	Handreck and Black (2001) [23]
Boron	<0.5 mg/L	Handreck (2008) [22]
Sodium adsorption ratio (SAR)	<6	Neylan (2003) [24]
Total Suspended Solids (TSS) *	<50 ppm	Burt and Styles (1994) [25]

* For micro-irrigation and drip systems

Water budget

The amount of water required (water budget) at a site will depend on several factors, such as: soil profile, turf cultivar, foot traffic, irrigation system efficiency, weather conditions, irrigation management practices and microclimate to name a few. The independent expert (often a certified professional soil scientist) should be able to provide detailed information on the water requirements for the proposed field.

Detailed water balance modelling is often required to determine the reliability of an intermittent water sources such as stormwater. If non-potable water sources are being considered, then water quality will also need to be examined during the planning stage. The water quality of non-potable water sources will affect the overall water budget as additional irrigation management measures may be needed to protect soil and turf health (e.g. leaching of sodium from the soil).

Costs and budgets

Contrary to popular belief, automatic irrigation systems are not cheap, and just because they “work”, doesn’t mean they are efficient or effective. The capital, maintenance and water costs for irrigation systems are discussed further in Book 5. Where non-potable water sources are being considered, funding will be needed for monitoring and maintenance of treatment systems and water quality. The amount of funds required is very site and situation specific and is a key component in the detailed planning required for non-potable sources.

CHAPTER 11: IRRIGATION DESIGN AND INSTALLATION

Automatic irrigation systems can be used to meet the turf watering requirements during periods when inadequate rainfall occurs. They can also be used to wash some chemicals off the leaf or into the soil after application. An irrigation system that adheres to best practice will need to be designed by an independent qualified irrigation designer to a performance standard that at a minimum ensures:

- the irrigation system has sufficient water supply (both quantity and quality) to maintain turf and soil health (Chapter 10)
- water is applied evenly
- minimal water is overthrown onto adjacent areas
- specialised areas within the field (e.g. turf cricket wickets) are on their own stations/zones and receive minimal overthrow from surrounding sprinklers
- irrigation is shut off during and following rainfall events
- irrigation is shut off if a major leak or break occurs.

Each of these aspects of design are discussed in this chapter, along with irrigation system installation. Irrigation system maintenance and irrigation scheduling are discussed in Chapter 12.

Choosing an irrigation designer

A key step in designing best practice irrigation systems is to ensure the irrigation designer and the lead consultant/designer are independent of any organisation that may potentially be involved in the construction phase of the project. It is recommended that the irrigation designer be engaged directly to avoid situations where the irrigation system performance (efficiency, effectiveness, lifecycle cost) is compromised.

The selection of an independent irrigation designer, involves considering, for example:

- irrigation industry recognition and accountability: Member of industry bodies such as Irrigation Australia Limited (IAL) or the American Society of Irrigation Consultants (ASIC)
- broader industry involvement: Member of relevant professional industry bodies beyond the irrigation industry, e.g. Australian Water Association, Australian Sports Turf Managers Association, NSW Sports Turf Association, etc
- technical skills and qualifications: Irrigation design for turf and open spaces requires skills and knowledge across soils, plant water use, hydraulics and irrigation equipment. Industry certification (e.g. Certified Irrigation Designer) is one way of having these skills verified and acknowledged.

Irrigation systems must apply water evenly

To prevent water wastage and/or under irrigation it is crucial that irrigation systems apply water evenly. There are various parameters that can be used to define evenness of watering, with these detailed in Table 11.1. These parameters can be measured in the field using catch can tests or evaluated using specialised analysis software and tools combined with laboratory test results of sprinkler nozzles.

Table 11.1: Parameters used to express or define the evenness of watering for an irrigation system

Term	Explanation
Coefficient of Uniformity (CU) or J.E. Christiansen's Uniformity	Measures how evenly water is applied across the irrigated area. Expressed as a percentage between 0 and 100%, with perfectly even watering having a value of 100% Calculated from the total variation of applied water at each location in the test area compared to the overall average
Distribution Uniformity (DU)	Measures how evenly water is applied across the irrigated area. Expressed as a percentage between 0 and 100%, with perfectly even watering having a value of 100% Calculated by comparing the average from the lowest 25% of measurements in the test area to the overall average. The lowest 25% is called the Lower Quartile (DULQ) and is the most commonly used in Australia.
Scheduling Coefficient (SC)	Is a measure of how much additional water must be applied overall to ensure each contiguous area receives enough water. It identifies how much less water the driest areas are getting. For example, the site receives 10 mm on average, but the driest areas only receive 5 mm, then the SC is 2.0 (as the driest areas are getting half the water). Typically, for turf the SC is defined as the driest 5% contiguous area, so if the sprinklers were laid out on a 10m x 10m grid (so $100m^2$), then the SC 5% would refer to the driest $5m^2$. The major difference between the SC and DULQ is that the DULQ treats all the lowest values as a group of numbers regardless of their location, so it has no spatial element. By contrast, the SC uses a contiguous area or "dry spot".

In practice, no irrigation system can apply water with perfect uniformity. As such, some additional water needs to be applied to ensure the irrigation requirements are met for sections of the site that are receiving less water.

If the irrigation system applies water unevenly then the turf manager is forced to make a compromise on how the field is watered. If the turf manager elects to schedule according to the needs of:

- drier areas: the wetter areas will receive far too much water and experience the many issues related to overwatering such as increased likelihood of turf disease, waterlogging and increased soil compaction
- wetter areas: the drier areas will receive far too little water and experience the many issues related to under watering such as thin cover, turf stress and soils becoming water repellent
- "the middle ground": creates issues for both the wetter and drier areas, particularly if the irrigation system applies water very unevenly and the soil is prone to becoming water repellent.

The effects of uneven irrigation are most pronounced during dry periods when deficiencies in the irrigation system are not masked by regular rainfall (Figure 11.1).

Figure 11.1: Two aerial images showing the impact of uneven water distribution on turf performance (Nearmaps images).

However, on well-draining sites that are overirrigated, uneven watering may not always be visually obvious. This is shown in Figure 11.2, where the system applied water very unevenly (Distribution Uniformity 71%, Scheduling Coefficient 1.6). A detailed performance assessment of the system identified water use could be reduced by 30% with relatively minor changes to the irrigation system (sprinkler nozzles and pump) to apply water more evenly.

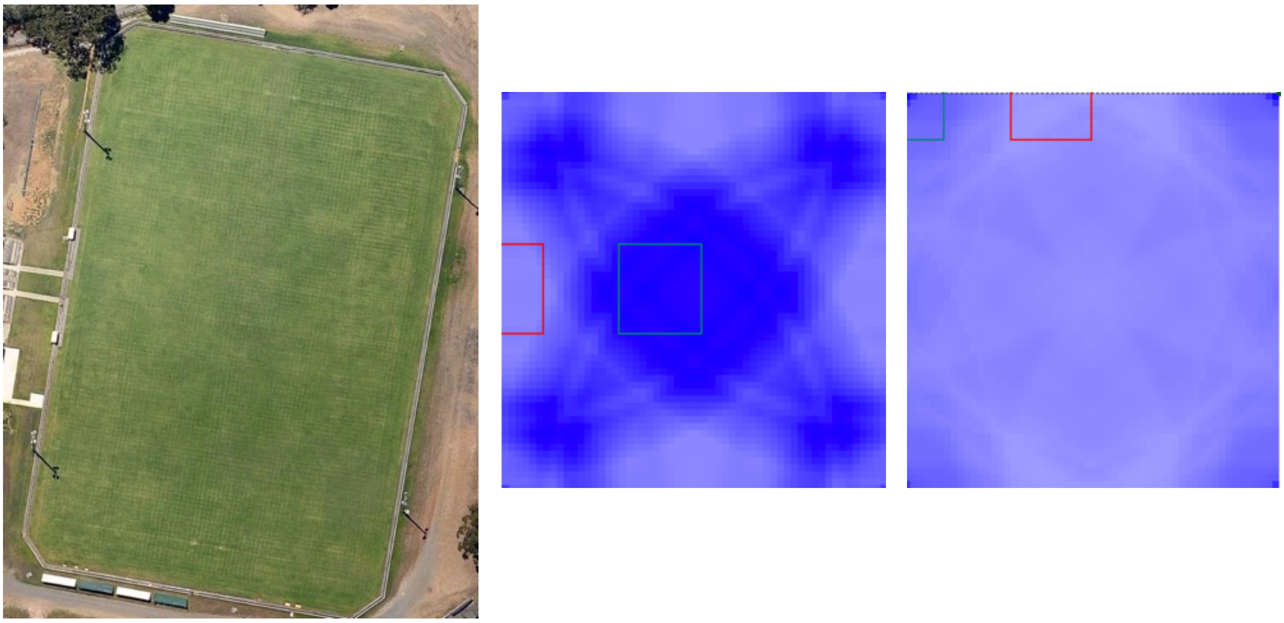

Figure 11.2: Uneven water distribution is not always obvious from the turf appearance (Nearmaps image). Detailed analysis found this irrigation system applies water unevenly (left densogram). By making improvements to the irrigation system, more even irrigation can occur (right densogram) and water savings achieved.

The myth of head-to-head coverage

One of the most quoted irrigation "industry standards" is that sprinklers need to throw "head-to-head" (i.e. water from one sprinkler reaches the next sprinkler). Rex Sullings of Aqueduct Consultancy assessed the performance of more than 100 combinations of sprinklers using head-to-head spacing and found less than 10% applied water evenly. Therefore, if design and construct systems were all installed to the "industry standard" of "head-to-head coverage", then over 90% would be inefficient in their application of water.[26]

Design to a performance standard

Instead of designing to the outdated industry dictum of "head to head" coverage, best practice irrigation design for sports fields involves designing to meet best practice performance standards for evenness of application, pressure variation and application rate (Table 11.2). In addition to the parameters in Table 11.2, the irrigation design should ensure that the amount of overthrow onto adjacent areas is less than 2% of the water applied to the target area.

The performance standards in Table 11.2 can be used to assess the performance of both existing systems and new designs.

Table 11.2: Irrigation design rating matrix for sports field and open space turf Irrigation systems (Rex Sullings and Dr Paul Lamble).

Rating	Scheduling Coefficient [1]	Coefficient of Uniformity (%)	Distribution Uniformity (%)	Application Rate (mm/hr) [2]	Pressure Variation (%)
Best Practice	< 1.25	> 85	> 80	> 10.0	< 5
Average	1.25 – 1.35	80 – 85	75 – 80	7.5 – 10.0	5 – 12
Poor	1.35 – 1.45	75 – 80	70 – 75	5.0 – 7.5	12 – 20
Very Poor	> 1.45	< 75	< 70	< 5.0	> 20

Table Notes:

1. Scheduling Coefficient (SC) in this table uses the driest 5% contiguous area and the irrigation designer should be clear on what contiguous area (e.g. 5%) has been used to determine the SC. The irrigation designer should also detail the parameters (e.g. sprinkler spacing, nozzle, operating pressure) and the software used in the analysis.
2. The application rate applies to sports turf situations where slopes are relatively low and infiltration rates are relatively high. In other situations, a lower application rate may be needed to avoid surface water run-off. The common industry practice of using the saturated hydraulic conductivity of the soil (see Book 3) to guide irrigation application rates is inappropriate, as irrigation is used when the soil is dry, not saturated.

Other critical elements of best practice irrigation design

In addition to the core design standards above, there are numerous other elements of best practice irrigation design which are critical to maximise the efficiency and effectiveness of the irrigation system. These include:

- installing part circle sprinklers around the perimeter of the irrigated area and turf wicket tables
- ensuring specialist areas within the field (e.g. turf cricket wickets) have their own stations/zones and receive minimal overthrow from surrounding sprinklers
- pump systems are pressure actuated start (i.e. pump starts and stops automatically based on pressure) rather than being turned on/off by the irrigation controller
- sufficient pressure contingency allowance in the pump selection to ensure effective operation of the irrigation system, especially at changeover between zones/stations
- where practical within site constraints, sprinklers of different arcs (e.g. half, quarter and full circle sprinklers) operate on separate valves. This particularly applies to gear drive rotors

- there is adequate and suitable water supply and that water quality implications for turf and soil health have been considered (Chapter 10)
- ensuring the water supply and system hydraulics are able to meet watering requirements under peak demand conditions (e.g. hot dry weather) as this is when irrigation will be most needed
- where practical, areas with differing watering requirements are irrigated as separate zones/stations
- ensuring the system can apply a minimum of 5 mm over the entire irrigated area within the available watering time. This will be dictated by site operational requirements and local conditions, with the watering window typically varying from:
  - 4 hours (e.g. 1 am to 5 am) for heavily used, wind prone, publicly accessible sites
  - 8 hours (e.g. 9pm to 5 am) for less exposed areas, but a longer run time may need to be used on fields where lower application rates are needed
- having sensors to automatically shut-down the system in adverse conditions. These sensors can include, but are not limited to:
  - rain sensors, especially ones that allow adjustment to activate at a specific rainfall depth
  - soil moisture sensors (correctly positioned and wired, with readings interpreted correctly)
  - wind sensors (particularly critical on sites using recycled water)
  - on site weather stations, particularly if microclimate is crucial at a site
  - flow sensors for shut down in response to burst pipes, fittings or sprinklers.

Elements of best practice irrigation management that can shape design and product specification decisions include:

- programmable delays to irrigation (e.g. 5 days) following sensor activation
- central irrigation control systems (and their controllers) that use supporting information and management tools, such as weather forecasts, virtual weather stations, soil moisture levels and water use reporting. These can influence the type and location of hardware required in a design (e.g. irrigation controllers, water meters etc).

Design and construct results in poorer irrigation outcomes

Many organisations issue tenders requesting contractors provide a quote to "design and construct" an irrigation system. A comparison of 11 sports field irrigation systems in the Lower Hunter showed those installed using a "design and construct" process:

- used about 30% more water annually than those installed following a professional design
- take 250% more time (i.e. 2.5 times the total run time) to apply the required water than those following a professional design. As such, they are more prone to losses from wind drift in adverse conditions and are incapable of meeting irrigation demand in spells of hot, dry weather.

Table 11.3: Performance Comparison for Design & Construct versus Professional Design for the irrigation system installed at 11 sites (Lamble 2019)[27].

Item	Design & Construct	Professional Design	Improvement from Professional Design
Cumulative water use across all sites (ML pa)	60	43	28%
Cumulative run time across all sites to apply 5mm (hours)	167	59	64%

In addition, the design and construct approach results in a large variety of components over time, which creates ongoing maintenance problems as equipment gets replaced with whatever is available rather than the appropriate part. Of the 11 systems assessed in this study, there were different types of controllers (8), sprinklers (9), valves (5) and pumps (7).

The poor performance of “design and construct” systems reflects the major compromises in quality, such as:

- sprinklers spaced too far apart so the watering is very uneven
- sprinkler position determined by pacing or measuring tapes rather than accurate tools such as survey standard GPS systems
- running the system at very low pressure to reduce the size of the pump and pipework or not installing a pump at all and running the system on the available mains pressure
- undersized pipes, creating large differences in operating pressures, causing uneven watering
- storage tanks (if used) being undersized, and mains water connections and supply being too small (sized to a budget rather than practicality) so the system quickly runs out of water
- not installing conduit for irrigation control cabling, reducing the effective life of the system
- no half circle sprinklers around the perimeter of the site, with these areas underwatered
- pipes installed too close to the surface so the field can’t be effectively aerated
- lack of care and attention to detail in the installation, such as sprinklers not set at correct angle and/or height, trenches not appropriately backfilled and compacted, large items of excavated waste debris such as concrete, bricks, tree roots placed in trenches as backfill
- not disposing of surplus spoil, leaving it in a pile with inadequate environmental controls

Some pictorial examples are provided in Figures 11.3a and 11.3b.

Figure 11.3a: Examples of poor installation practices including lack of coverage and sprinklers spaced too far apart (upper picture) and low operating pressure (lower pictures).

Figure 11.3b: Examples of poor installation practices including inappropriate material used as backfill around sprinklers and in trenches (left) and pipe installed at shallow depth preventing aeration (right)

Ensure the system is accurately installed by licensed personnel and contractors

Licensing

Best practice requires the irrigation system is installed by licensed personnel and entities. NSW Fair Trading (part of NSW Department of Customer Service) is the regulatory authority for plumbing, draining and gasfitting work in NSW. At the date of publication of these guidelines, the NSW Fair Trading Website[28] states:

- "*A licence is required for all specialist work, regardless of cost*"
- "*Plumbing, draining and gasfitting work is Specialist Work and includes many categories of work*", one of these is Water plumbing – urban irrigation
- "*Work of irrigation includes the construction, alteration, extension, disconnection, removal, maintenance, repair, renewal or clearing of any pipes, fittings or equipment of any irrigation system communicating (or intending to communicate) directly or indirectly with any water main, and the connection of the system to a water main*".

At-least two types of licences will be required from a potential irrigation contractor:

- Contractor licence – which is required to contract for and advertise to do work. This must be held by the entity tendering for the work
- Individual licence – which is required for the individual who will oversee and sign off on the work.

TIP: Before seeking quotations from any potential irrigation contractors, check that the entities you are proposing to get quotes from have a contractor's licence. This can be done online through the Service NSW Contractor and Tradesperson License Register.

TIP: In any quotation ask the tenderer to supply the licence details for their contractor licence and individual licences for the work. These can then be checked to ensure they are current before evaluating their quotation.

Best practice irrigation installation

Irrigation systems that are well installed can apply water evenly. Furthermore, they are easy to service and maintain.

Best practice irrigation installation involves:

- obtaining all required permits and approvals prior to connecting the system to the water supply
- accurately setting out the location of sprinkler heads and installing heads accurately to the set-out position. For sports fields and larger open spaces, use survey standard GPS equipment. Best practice irrigation installation is to minimise the differences in spacing between sprinklers. Some of the best performing irrigation installers have less than 4% difference between the largest and smallest spaces in the main sprinkler grid.
- pump systems are pressure actuated start (i.e. pump starts and stops automatically based on pressure levels) rather than being turned on/off by the irrigation controller
- ensuring all sprinklers are at the correct height, plumb to vertical and have the correct arc
- ensuring the required backflow prevention devices are installed and operating correctly
- adjusting irrigation system settings (e.g. pump set points, valve pressure regulators and flow controls) to ensure the sprinkler operating pressure is within 20 kPa of the design pressure
- not adjusting the overall spacing of sprinklers across the site. Only adjust the perimeter sprinklers where minor adjustments to the overall sprinkler grid are required
- adjusting the arc of coverage (where required) to avoid over spray onto non target areas. The interference screw should NOT be used to reduce the range of throw of any sprinkler
- bedding the pipes in 100mm of suitable soil/sand and not using waste debris (e.g. concrete, bricks, tree roots etc) as backfill in trenches
- ensuring sufficient depth of coverage over all pipework (minimum 450mm for main lines, 350mm for laterals), so the field can be aerated without damaging pipes
- ensuring all irrigation trenches are backfilled in a manner that does not allow them to function as pseudo slit drains, which then result in localised waterlogging or flooding of valve boxes
- enclosing all control cabling in dedicated cable conduit
- ensuring appropriate earthing and surge protection for decoder systems
- ensuring adequate spare wires for conventionally wired systems (minimum of 2 spare wires each for both “active” and “common” wires)
- placing the main line pipes and valve enclosures (valve boxes) the maximum practical distance from the playing surfaces on all fields
- ensuring all valve boxes and pipes are not installed at excessive depths (i.e. depth should be less than 800mm deep) as this increases the maintenance costs and disruption for repairs to valves, sprinklers and fittings
- all valve box supports should be on a solid base such as paving slabs and concrete “C” sections, not bricks and gravel. Subsided or collapsed valve boxes and surrounds create an uneven surface and increase the risk of injuries to users
- all main line fittings should be electrofusion welded fittings, with threaded fittings only to be used for joining solenoid and isolation valves
- managing spoil according to good environmental practice. Cleaning up at completion of works
- checking all sprinkler arcs and pressures during the commissioning process
- providing accurate work as executed drawings.

Figure 11.4: Irrigation installation examples. Electrofusion fittings for connection to the irrigation main line, paving slabs and c-sections for valve box supports (left) and valve boxes wrapped in geofabric (right)

The accuracy of installation for sprinklers affects irrigation system efficiency and can vary dramatically across sites. A study of irrigation installations (Lamble and Sullings 2016)[29] found that:

- 90% of sprinkler heads were within 27cm of the set-out position for the most accurate installation. That distance roughly trebled to 78cm for the least accurate installation. In all cases, the set out was completed by the designer with a survey standard GPS (+/-50mm accuracy)
- irrigation efficiency decreased from design to installation by ~6% for the least accurate installation
- work processes and methods during the installation influenced the accuracy achieved.

Techniques to minimise surface disturbance during installation

Traditionally, irrigation pipework has been installed using chain trenchers. This leaves a trench to be backfilled and the grass to grow over (Figure 11.5).

Figure 11.5: Installation of irrigation pipework using a chain trencher

In recent times, some contractors have used a plough to “plough in” pipework (Figure 11.6). Ploughing minimises the amount of the disturbance of the playing surface and the amount of excavated material as the only areas to be excavated are the locations of the sprinklers and the start and end of the pipe run (Figure 11.6).

Figure 11.6: Installation of irrigation pipework using a plough

Ploughing is commonly undertaken for irrigation laterals, but it can be done for mainlines (depending on pipe sizes). Poly pipe up to 63mm nominal diameter can often be ploughed in, with larger pipes requiring bigger machinery, which is more expensive and less readily available. Hence, in many cases, irrigation laterals are ploughed while main lines are trenched as the mains have larger pipe sizes and cable conduit. If it is intended to plough in main lines, then the cable conduit should also be ploughed in, and this can be done at the same time (depending on the pipe sizes and machinery).

Ploughs can be used under a variety of soil conditions but may be poorly suited on sites with rocky material.

CHAPTER 12: IRRIGATION MAINTENANCE AND OPERATION

Irrigation system maintenance

Irrigation systems are not static infrastructure, with both electrical and hydraulic components requiring regularly servicing. Best practice irrigation maintenance involves implementing a proactive, preventative maintenance regime with sufficient operational budget to ensure repairs are carried out promptly.

As irrigation systems primarily operate at night, regular visual checks are required to make sure sprinklers are operating correctly. Flow monitoring systems will not detect faults such as sprinklers not rotating, being too low, not plumb to vertical or incorrect arcs. More regular inspections are required if the system doesn't automatically send alerts or if flow monitoring is not used.

Elements of best practice irrigation maintenance includes:

- detailed check of all components at-least annually. A sample maintenance checklist is provided in Appendix A
- rectify identified defects promptly to ensure the system is operating correctly for as much of the irrigation season as possible
- using flow monitoring tools to rapidly identify system faults and breaks, repairing if these arise
- visual check of sprinklers at the start of the irrigation season in September and then every 2 months during the irrigation season (which includes winter if oversowing with ryegrass). Sensors should also be checked for correct operation.
- when replacing defective sprinklers, replace the old sprinkler with the same make/model and nozzle.
    - if the same sprinkler is no longer available, use the current, equivalent model from the same manufacturer and replace all the sprinklers on the same lateral (zone) at the same time
    - if a large number of sprinklers require replacement, obtain independent, professional advice from a Certified Irrigation Designer. They have the analysis tools to select the most appropriate sprinkler and nozzle given the current system hydraulics and performance. Be wary of advice and "free samples" from sales representatives. Some product catalogues provide charts with "equivalent" sprinklers and nozzles. These sprinklers are usually equivalent only in flow rate or radius of throw. They are very rarely equivalent in performance and evenness of coverage for a given spacing or operating pressure
- use data loggers on water meters to monitor water usage and peak flow rates. These can yield valuable information when trouble-shooting irrigation system faults as well as being a useful reporting tool.

Common irrigation system maintenance issues include:

- heads that are too low
- leaks at sprinklers and valves
- heads with incorrectly adjusted arcs (i.e. throw onto surrounding areas)
- sprinklers with excessive misting

Pictorial examples are presented in Appendix B.

Irrigation system scheduling

It is a popular misconception that sports field turf areas in the Lower Hunter require 25 mm of irrigation per week. This “rule of thumb” is also used in areas that have very different climate such as South Australia, Western Australia and it has even been applied to irrigated pastures feeding dairy cattle in northern Victoria.

During the drought of 2019-20, there was only 5mm of rainfall recorded over a 10-week period from mid-November until mid-January 2020. Over this time, the reference evapotranspiration was 440mm (approx. 7mm/day), which is consistent with the hot conditions experienced. As a result of water restrictions, irrigation was limited to approximately 10 mm/week for the driest areas. Figure 9.1 shows three kikuyu fields that were doing well during this period of hot weather and limited water availability. These examples demonstrate that turf fields can do well on much less water than 25 mm/week, even under severe conditions.

Figure 12.1: These sporting fields were doing well during the 2019-20 drought with limited irrigation. Photos taken 15th January 2020 prior to breaking rains.

Graeme Logan, head curator at Bankwest Stadium in Sydney has an adaptive approach to irrigation scheduling and management. He reviews water applications weekly and relates this to how much the system delivers and the moisture in the profile. He knows how much water (depth in mm and volume in kL) the irrigation system will apply for a given run time. Soil moisture sensors are used as a guide rather than driving the irrigation system, to get the optimum moisture level in the profile for the firmness of playing surface (Logan, pers comm 2021).

Graeme's key message is: "*Be prepared to change your mindset. Don't follow a program because it has always been done that way. Look at the conditions, usage, etc and adjust. Be willing to constantly adjust*".

Best practice irrigation scheduling and management involves:

- scheduling using science and data, not common rules of thumb such as the "25 mm per week". This means irrigation frequency and run times need to account for:
  - site soils (infiltration rates, soil depth, soil texture and structure) and moisture levels
  - turf water requirements (wear from foot traffic, turf recovery, growth rates and weather conditions)
  - the performance of the irrigation system (application rates and evenness of watering – enough water needs to be applied to the driest areas without overwatering)
- setting run times based on the required irrigation depth (e.g. 5mm) for each irrigation station at a site rather than using the same run-time for all stations (e.g. 30 minutes per zone)
- using tools such as weather forecasts and projected rainfall such as those provided by the Bureau of Meteorology and central control systems to avoid irrigation immediately prior to or after forecast rainfall (especially if rainfall of 10 mm or more is forecast)
- using weather observations (e.g. rainfall, ET) from the Bureau of Meteorology, on-site weather stations, rain gauges and sensors (e.g. soil moisture sensors) and/or virtual weather stations in central control systems to guide irrigation scheduling
- adapting irrigation schedules to seasonal conditions
- managing risks if the weather turns (e.g. using light rather than heavy irrigation events towards the end of the irrigation season to avoid saturating the soil profile)
- avoiding general irrigation between mid-March and mid-September as much as practicable (subject to weather conditions and horticultural practices such as ryegrass oversowing)
- ensuring equipment is regularly serviced, calibrated and maintained, especially if using soil moisture sensors or evapotranspiration to drive irrigation schedules. It is common for over irrigation to occur because sensors have not been calibrated, regularly serviced or checked
- using central irrigation control systems to monitor and manage multiple controllers and sites. Ensure alerts are turned on for sensor activation and flow monitoring faults. Promptly rectify alarm faults.

Determining the performance of an existing irrigation system can be undertaken through a comprehensive performance assessment. This performance assessment can also identify efficiency improvement options and is more comprehensive than catch can tests.

Catch can tests (also termed irrigation audits) can be used to measure how much and how evenly water is applied to the field by the existing irrigation system in its current condition. It is important to complete a full maintenance check and rectify defects prior to performing the catch can test. Catch can tests must be conducted under low wind conditions (<10 km/hr) and use a minimum 3 representative areas with a grid of at-least 25 cans in each area. It is crucial to note that a catch can test only gives the performance of the system under the conditions in which the test was conducted. Catch can tests cannot assess or compare options for improving the irrigation system.

Site soils and irrigation management

The role of site soils in managing and scheduling irrigation is often underestimated. While it is widely understood that soil properties affect the frequency, depth and required rate of irrigation, many guides only provide parameters for available water and infiltration in relation to soil texture. Such an approach ignores the pivotal role of soil structure in irrigation management. The irrigation regime on a sandy loam will be dramatically different depending on whether it is well-structured or poorly structured with the poorly structured soil needing shallower and more frequent irrigation.

An assessment of existing site conditions (e.g. turf variety, wear levels and carrying capacity) combined with a detailed site soil survey can provide the information required for irrigation scheduling. As soil characteristics can vary widely across a site, it is crucial that the survey takes sufficient measurements (at-least 40 holes per hectare). Furthermore, it is recommended that the soil survey be undertaken by Certified Professional Soil Scientist.

Irrigation scheduling and management with non-potable supplies

Using non-potable water sources for irrigation needs to account for managing soil and turf health. Without intervention, the soil chemistry will change over time to reflect the chemistry of the irrigation water. Therefore, the chemical composition of the irrigation water and the soil needs to be regularly monitored. Soil structure, infiltration rate and turf health can all be adversely affected by changes in soil chemistry (e.g. pH, calcium, sodium levels etc). When there is a lack of rainfall, additional irrigation may be required to leach harmful cations out of the root zone. This enables both the turf and soil to be maintained in a healthy state.

Using technology and data

The management of the irrigation system requires good information and data. Sensors are a vital part of this equation. However, they do require regular checking and maintenance and irrigation systems should not be “left to their own devices” with total reliance on the sensor to drive the irrigation system.

Maitland Council have been using a POGO™ to map soil moisture levels across their fields to gain a better understanding of how soil moisture levels behave across their sites. They have related this information to playing surface conditions and now have a much greater understanding of the wetting and drying cycles for their fields. Furthermore, they have found the POGO™ to be an invaluable tool in managing irrigation at higher profile sites or in situations where there is less resilience in the system regarding under or over watering. With the data they have gathered, they have adjusted their irrigation schedules across and within their sites to reflect the distribution of soil moisture in the profile.

The distribution and amount of rainfall from any single rainfall event can vary dramatically. This is shown graphically in Figure 12.2 from two different 24-hour rainfall events (radar data from the Bureau of Meteorology). Tipping bucket rain gauges (linked to a data logger and/or website) provide a very cost-effective means of collecting rainfall data across many sites that are spatially distant from each other. This enables the irrigation manager to effectively adjust irrigation schedules based on rainfall received in a specific area (or a specific site).

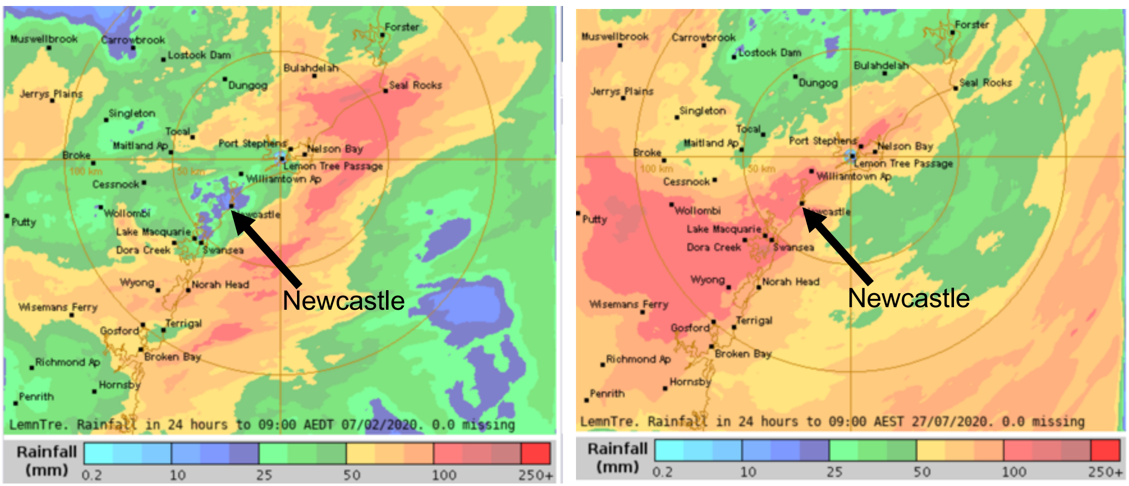

Figure 12.2: Radar images showing a wide variation in 24 hour rainfall for two separate rainfall events in the Hunter and Central Coast on 7th February 2020 (left) and 27th July 2020 (right). Bureau of Meteorology[30]

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FIGURE AND TABLE CREDITS

Dr Paul Lamble (Peak Water Consulting): Cover Photo, Figures 11.1, 11.2 (densograms), 11.3, 11.4, 11.5, 11.6, Appendix B – Low pressure photos. Tables 11.1, 11.2

Dr Mick Battam (AgEnviro Solutions): Figures P.1, 12.1

Geoff Connellan (Reference 20 above): Table 10.1, 10.2

Nearmaps: Figures 11.1, 11.2 (aerial image)

Rex Sullings (Aqueduct Consultancy): Tables 11.1, 11.2, Appendix B photographs and diagram.

David McKechnie: Figure 11.3 – pipe installation

Bureau of Meteorology: Figure 12.2

APPENDIX A. IRRIGATION INSPECTION CHECKLIST

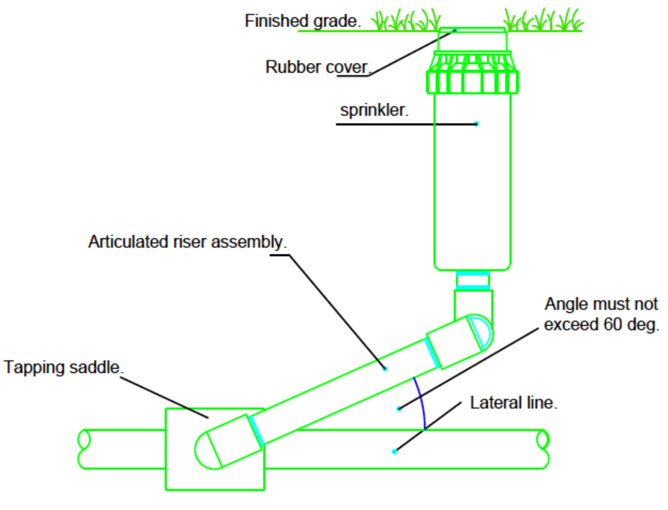
The irrigation inspection should include the following checks as a minimum:

- visual inspection of all sprinkler heads for leaks, uniform sprinkler throw, upright (i.e. plumb), broken or sunken sprinkler heads, rotating, correct arc and trajectory. To rectify these faults:
    - replace damaged/broken heads with the same make, model and nozzle as the existing
    - adjust sprinklers that are too low, not plumb to vertical, incorrect arcs
- check valve boxes, tank surrounds and visible pipework for leaks
- check the pump station or mains connection are operating at a pressure stated in the design specifications
- check pressures on sprinkler heads (at-least first and last head on each station/zone). Adjust flow control or pressure regulator at solenoid valve to achieve design pressure
- testing of the backflow prevention device by a backflow prevention accredited licensed plumber in line with Hunter Water requirements
- check filters and disinfection units are operating correctly and are cleaned as required
- testing controller is operating properly and that the back-up battery is working
- check programming in central control system aligns with programming in field controllers
- where valve boxes are at the surface grade, check they are flush with the surface and undamaged. Adjust valve box levels and replace lids as required
- where valve boxes are buried, check for subsidence and/or collapsed boxes. Repair and/or replace boxes as required and topdress subsided areas
- test the system sensors are working properly and within their calibrated levels of accuracy
- ensure broken hardware (sprinklers, valve components) or pipe items are repaired or replaced with the same or equivalent updated models that meet original specifications, so the entire system continues to perform as designed.

APPENDIX B: COMMON IRRIGATION MAINTENANCE ISSUES

Pictures of common irrigation maintenance issues are presented below.

Heads that are too low (located well below grade)



Sprinkler Assembly
NOT TO SCALE.

Schematic of sprinkler assembly showing correct height for sprinklers.

The top of the rubber cap should be level with the soil surface.

Examples of leaks at valves

Heads with incorrectly adjusted arcs of coverage.

Examples of sprinklers leaking from riser seal or from below the sprinkler.

Heads with excessive misting

Low pressure (well below manufacturer’s recommended minimum)

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