3- MORE BLUE WITH LESS WATER. IMPROVING THE EFFICIENCY OF IRRIGATION SYSTEMS AND STEPS TO TAKE ON DEFECTIVE STABLISHED IRRIGATION SYSTEMS

By Tomás Brzobohatý & Rafael Diaz

1.LACK OF PROFESSIONALIZATION OF THE SECTOR

In many cases, professional through the irrigation chain (engineer companies, installers, contractors maintenance companies, municipality technicians, end users etc.) are not totally professionalized added to the lack of professional training, have given rise to a plague of inefficient irrigation systems.

These installers and end users have assumed that the high consumption of their irrigation systems was something normal derived from the high water needs of a lawn, accepting with resignation in some cases the high economic cost of its maintenance, and in many other cases, interrupting irrigation, with the consequent deterioration of its lawns.

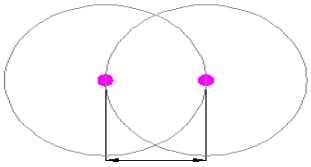
It is important that the entire chain is professionalized since the lack of excellence in any of the steps (design, installation, products, and maintenance) would result in an inefficient irrigation system, ruining the good work of the rest of the chain.

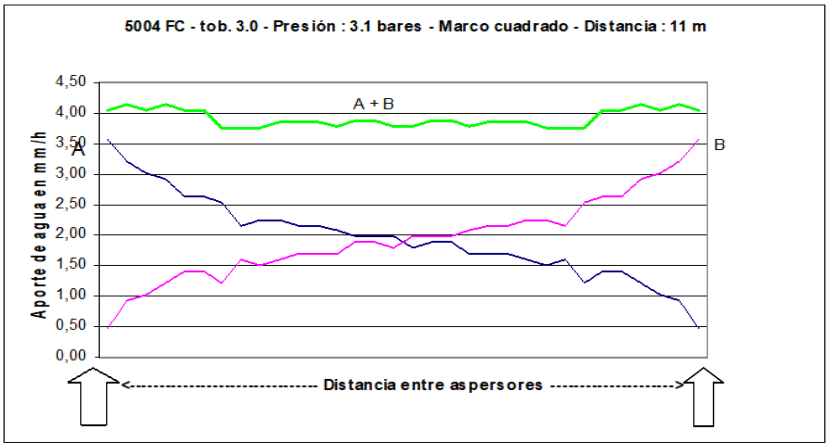
Investments in educating the installers and end users is required. In case of public procurement, a minimum standard on professionals qualification and water efficiency of the solutions shall be required and enforced from the companies bidding for projects

2. *NEW IRRIGATION SYSTEMS*

a. Design

Solapamiento.





Take as a reference the following Uniform Coefficient

Table 11.5. Performance rating categories for sprinklers and sprays

	Field distribution uniformity (DU_{LQ}) performance rating categories for sprinkler and spray irrigation equipment				
	Excellent	Very good	Good	Fair	Poor
Fixed spray	0.75	0.65	0.55	0.50	0.40
Sprinklers (gear and impact drive)	0.80	0.70	0.65	0.60	0.50

Source: GreenCO and Wright Engineers (2008)

Type of zone	Emission uniformity (EU) performance rating categories for microirrigation systems		
	Excellent	Very good	Good
Microspray	0.80	0.70	0.60
Drip – standard	0.80	0.70	0.65
Drip – pressure-compensating	0.95	0.90	0.85

Source: GreenCO and Wright Engineers (2008)

https://books.google.es/books?id=6M4w6zPETNYC&dq=spray+distributor+uniformity+good+poor&hl=es

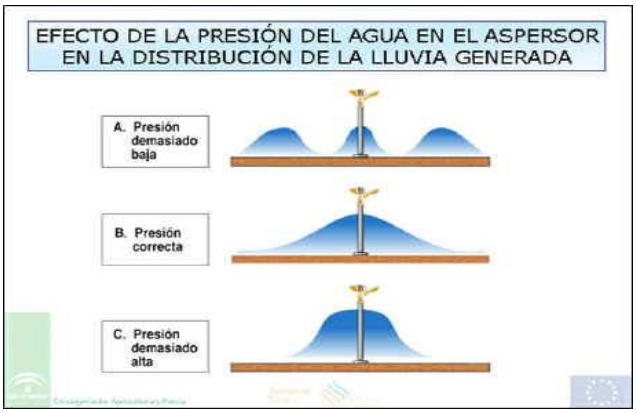
The following is a guide;

New irrigation systems:	DU should be >85%	
Existing systems:	If DU < 75%	System should be repaired
Existing systems:	If DU < 60%	System should be replaced.

A lower value of Distribution Uniformity (DU >65%) should be used for spray systems as the performance of these applicators or heads is not to the same standard as sprinklers (Connellan, 2004).

http://www.geoffconnellan.com.au/sites/default/files/Dload1GC2004EvaluateUrbanIrrigation.pdf

- In the irrigation system water speed < 1,5 m/s (exception for forced diameters calculation)
- Pressure loss < 6% (exception for short lengths)
- Assure all emitters count on right pressure



- In any case assure pressure differences between first at last emitter is no higher than 20% of emitter nominal pressure (it means precipitation is not more than10% different)
- As far as possible use sprinklers and emitters with seal valves and with internal pressure regulators. In case of dripline use self-compensating emitters.

- In case of subsurface drip irrigation use dripline with anti-root intrusion defending system. For not total coverage turf areas use mulching.
- Design with Master Valves and with control systems with intelligent flow control (in case of leak the system cancels just the defective station). Besides control systems with intelligent flow management can calculate the water use per station (important to follow up them)
- The system shall the administrator to adjust the irrigation intensity as smoothly as possible. Remote control of irrigation on the level of irrigation section is desirable so that a section specific plan can be set up. For such solution, a wireless valves controlling system shall be installed to prevent possible problems with electricity cables and tedious and costly service and repair.
- As far as possible use triangle grids.
- Use emitter with right flows according to soil infiltration and slopes

https://www.ranchowater.com/DocumentCenter/View/235/Water-Using-Technology---Landscape-Water-Use-Efficiency

All the below devices should be mandatory.

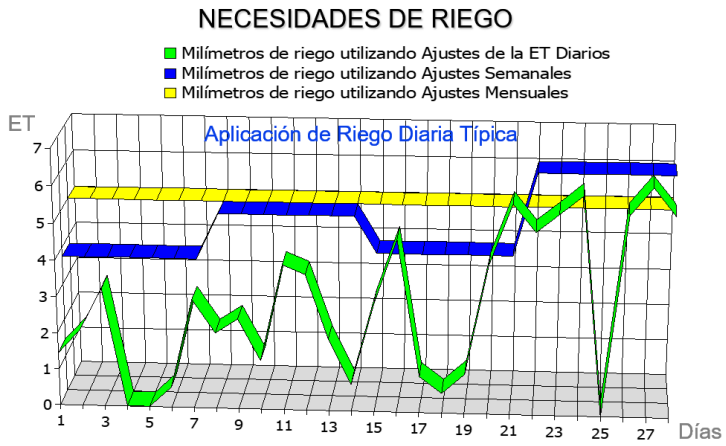
Process or Equipment Alternatives	Water-Savings Potential
Water budgets	**Medium**
Rain-sensing devices on controllers	**Low-Medium**
Smart controllers	**Medium**
Matched-precipitation-rate sprinklers	**Medium**
Low-pressure irrigation systems	**High**
Anti-drain check-valves	**Low-Medium**

b. Installation and products.

- Step by step irrigation installers, contractors should be officially certified or at least they should prove a minimum skill.
- Installers and contractor should be extremely respectful of designs (models, distances, nozzles, etc.)
- If possible, prepare soil with organic amendments to increase water retention rate.
- Installed only top-quality products. Ask for quality certificates
- Assure the right pressure according to emitter type at station valve point.

c. Maintenance and management

- In case of subcontracting irrigation maintenance to private companies, water saving should be a priority in the contract and water waste should be penalized.
- As far as possible irrigate according to in situ real needs (as many irrigation calendars as different weather days). Consider ETP, weather and soil sensors, etc. In any case, if it is not possible, at least set an irrigation calendar per month. The information on watering needs and recommended irrigation intensity shall be automated by specifically developed models as much as possible. Still, the final decision shall be up to the administrator.



- Stop irrigation when wind is > 20 km/h
- Set irrigation times according to soil type and slope.

TEXTURA DEL SUELO	PLUVIOMETRIAS MAXIMAS : mm/h							
	Pendiente 0 a 5%		Pendiente 5 a 8%		Pendiente 8 a 12%		Pendiente + 12%	
	Veg	Des	Veg	Des	Veg	Des	Veg	Des
Suelos arenosos gruesos	50	50	50	37	37	25	25	12
Suelos arenosos gruesos sobre subsuelos compactos	44	37	32	25	25	19	19	10
Suelos limosos arenosos uniformes	44	25	32	20	25	15	19	10
Suelos limosos arenosos sobre subsuelos compactos	31	19	25	12	19	10	12	8
Suelos limosos	25	12	20	10	15	8	10	5
Suelos limosos sobre subsuelos compactos	15	8	12	6	10	4	8	3
Suelos muy arcillosos o arcillo limosos	5	4	4	2	3	2	2	1

- Increase irrigation frequency as far as
    - Less soil depth
    - Less root system depth
    - More sandy soil
    - Higher ETP
    - Lower water quality

d. Water

Recycled water: the reuse of wastewater is a desirable practice. However, the potential for water savings represented by the reuse of wastewater is limited because urban consumption rarely exceeds 15% of total water consumption. "La utilización de aguas no potables para

riego." Jesús de Vicente Sánchez, Cordinador de la Comisión del Agua de la Asociación Española de Parques y Jardines Públicos".

Madrid as an example:

https://www.canaldeisabelsegunda.es/-/reutilizacion-una-nueva-oportunidad-para-el-agua

Reclaimed water produced by Canal Isabel II, irrigates 323 parks and green areas in the region, in addition to 11 golf courses. In total, just over 2800 hectares of land.

3. ESTABLISHED IRRIGATION SYSTEMS

a. Irrigation Audits.

https://ag.umass.edu/landscape/fact-sheets/role-of-irrigation-audit-in-water-conservation

keeping irrigation systems functioning properly is key to conserving water. One tool to help determine if irrigation systems are working adequately is an irrigation audit.

A typical irrigation audit will include many of the following procedures:

i. Visual inspection of irrigation system

An irrigation auditor observes each zone in a sprinkler system and the landscape surrounding sprinkler heads to identify sources of inefficient water use:

- Broken, damaged, or leaking heads.
- Improperly positioned sprinklers watering streets and sidewalks.
- Sprinkler heads too low or off vertical.

- Sprinkler heads improperly spaced or arranged in pentagon patterns instead of water-conserving triangle or square patterns (Whiting et al, 2003).
- Misting around sprinkler heads (excessive water pressure) or large water droplets falling close to heads (low water pressure); and poor system design features (no automatic or manual shut-off during rainy weather, non-uniform sprinkler heads used).

ii. Evaluation of distribution uniformity (DU)

While many of the problems described above affect DU, a catch can test is routinely used to quantify whether irrigation water is being uniformly applied to the landscape. To perform a catch can test, an auditor places collection containers in a grid pattern on the surface of an irrigated zone, runs the irrigation system through a typical timed cycle, and collects and records the amount of water in each catch container. The data gathered is then used to identify areas of over- and under-irrigation (relative to the targeted application amount); results of a catch can test may also be correlated to observations of plant health in the test area.

iii. Determination of precipitation rate

Data from a catch can test is also used to determine the rate at which water is applied by the irrigation system. Since individual site conditions, specifically water pressure and sprinkler head spacing, may alter a system's performance, using catch can test results is more accurate than relying on the system manufacturer's performance specifications (TAES, accessed May 2006). Knowing the rate of application is important for developing appropriate irrigation schedules

iV. Determination of landscape's watering needs

An evaluation of the landscape features present at a site provides a great deal of information about that site's water requirements. Factors to consider in developing a watering schedule include:

- The types of plants present and the depth of their roots.
- Whether they are growing in sun or shade, on flat areas or slopes.
- The presence or absence of a thatch layer in turf.
- Whether or not non-turf plantings are mulched.
- Soil texture and structure; and evidence of compaction and drainage problems.
- Actual ongoing soil moisture measurements, weather measurements, EVP calculations and data evaluation

V. Review and development of irrigation schedule

An irrigation auditor will review a site's current irrigation schedule (amount of water applied and the interval between watering events), and make recommendations based on catch can test results, soil conditions, and plant water requirements, considering local climate and rainfall patterns (TAES, accessed May 2006). Because an irrigation audit is only a tool, audit

recommendations must be put into practice for water conservation to be realized.

SOLUTION FOR BIG CITIES MANAGIG MANY GREEN AREAS IN ORDER TO SIMPLIFY AND OPTIMIZE MAINTENANCE THANKS TO THE NEW TECHNOLOGIES CENTRALIZED AND INTEGRATED SYSTEMS (SMART CITIES ETC.)

Irrigation Central Control Systems: Intelligent irrigation systems managed by an intelligent software using weather stations, weather forecasts, different kind of sensors, etc. This this type of system has shown to save up to 30-40% of irrigation water.

Anyway, if we compare these systems with an orchestra, this intelligent Irrigation System is similar to the orchestra director. A key member but music will not sound well as far as musicians are not well tuned (right irrigation design, right installation, right quality products, right configuration of emitters right maintenance, etc.)

Maintenance (it is another topic covered later so just two comments)

- ✓ Use a water smart irrigation professional/company to maintenance the irrigation system
- ✓ The maintenance of green areas at municipalities should be focus on water savings not just on economic decisions.

OTHERS

We consider the following:

surface plant Cover 25-40%: Low plant density

Surface plant Cover 40-70%: Medium plant density

Surface plant Cover 65% in advance: High density plant

APPENDIX

Irrigation of parks, gardens, and green sports areas accounts for almost 60% of water consumption in cities in arid and semi-arid climates.

https://www.upm.es/?id=e5e8efe4f3256710VgnVCM10000009c7648a__&prefmt=articulo&fmt=detail

Efficiency and Uniformity

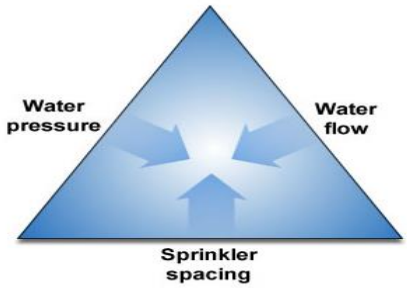
A good irrigation is the efficient application of the right amount of water at right time in the right place.

Efficiency = 100 – Percolating (deep drainage) – Evaporation – Runoff

CU(Zone) = 100 x ($V_{25\%}/V_{average}$) $V_{25\%}$= Average of 25% containers with less water

CU (Zone) it also known as DU

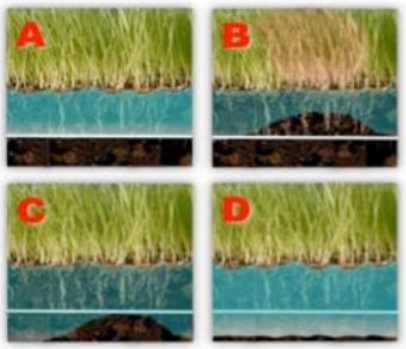
Regardless of any other factor, good uniformity provides a sound foundation for overall irrigation system efficiency. As the following figure shows, a balance is required among the below physical properties affecting distribution uniformity.



Important components of efficient irrigation.

https://floridawaterstar.com/technicalmanual/irrigation/uniformity.html

Relation between Efficiency and Uniformity.



1- The irrigation water applied is both uniform and efficient (the goal).
2- While efficient in terms of conservative water use, the irrigation was not uniform. Under-watering areas in the root zone will result in plant quality decline (leading to pest and weed invasion, or “dry spots”).
3- The common cure the “dry spots” is watering longer. This leads to non uniformity and inefficiency due to over watering some areas

4- (D)Uniform but inefficient due to overwatering, resulting in drainage below the root zone (which, with time, can result in plant loss as well as the transport of excess nutrients, fertilizers and pesticides that harm the environment).
https://www.huntingtonbeachca.gov/files/users/public_works/IrrigationP2.pdf

This guide is intended to reach the point A

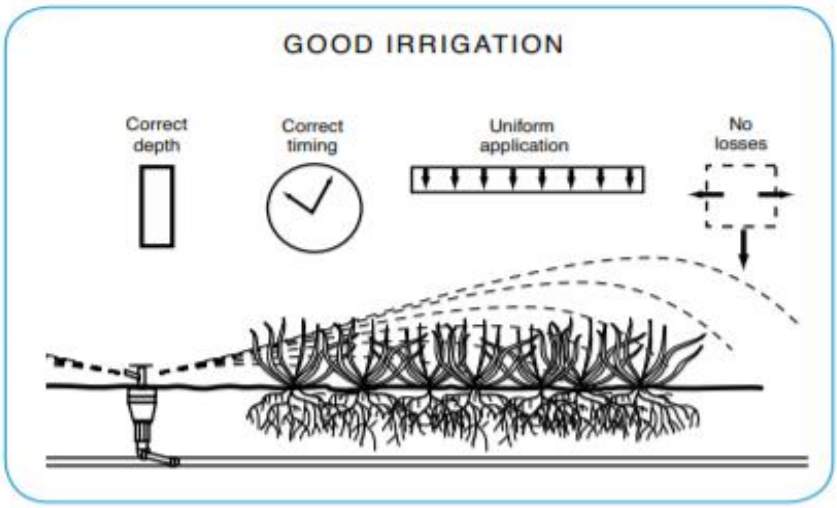
KEY ASPECTS OF EFFICIENT WATER MANAGEMENT

Best Practice Water Management Irrigation. Aim: Effective, efficient and sustainable	
Requirement	**Task/input**
1. System – hardware	Irrigation Design
2. Functioning system	Maintenance – Monitoring & repair
3. Know performance	Uniformity & Precipitation Test: DU & PR
4. Irrigation schedule	Site properties System performance
5. Operate system - Efficiency	Weather, plant, soil moisture
6. Reporting – Efficiency	Consumption Irrigation Index

To achieve overall efficiency of irrigation water use, it is necessary to effectively apply the water to the plant root zone (Application Efficiency) and to time the application so that appropriate soil moisture levels are maintained (Scheduling Efficiency). Efficient irrigation can be described in terms of the following four principles:

1. The amount of water applied should be appropriated to the plants needs and soil properties.

2. Water should be applied effectively and uniformly across the designed irrigation segment (hidrozone) respecting the plants needs and soil conditions.
3. Water should be applied to the plant root zone without wastage through runoff, deep drainage, and other water loss sources such as wind drift and evaporation.
4. The timing of water application should suit the plant



https://www.clearwatervic.com.au/user-data/research-projects/swf-files/bpg-final.pdf

Basic Principles of Water-Wise Landscaping

A blueprint for designing and maintaining a water-efficient landscape can be summed up in 8 steps:

1. **Group Plants According to Water Needs** - Separation of natives, low-water-use shrubs, trees, and thirsty turfgrass into different "hydrozones" allows for more efficient irrigation scheduling, view the document Site Plan With Hydrozones (PDF).
2. **Use Native and Low-Water-Use Plants** - Perennials, shrubs, trees, and groundcovers that are naturally adapted to our Mediterranean

climate can add tremendous color and beauty to the landscape. Once established, these plants survive with little or no water other than rainfall.

3. **Limit Turf Areas to Those Needed for Practical Purposes** - Lawns require the greatest share of landscape irrigation water. By limiting turf to areas used for recreation and other functional purposes, you can reserve the rest of the landscaped area for alternative plants and hardscape features. Use our Cash for Grass rebate incentive to replace your existing lawn areas.
4. **Use Efficient Irrigation Systems** - Well-designed and -installed systems, automatic shutoff valves, rain sensors, and regular maintenance of drip lines and sprinkler heads are essential components of efficient irrigation.
5. **Schedule Irrigation Wisely** - Infrequent, deep watering is generally the best strategy. Early morning is the best time to avoid evaporation loss. Use a standard controller's multiple start time feature to minimize run times and eliminate runoff. Adjust schedule at least monthly to match the changing weather by using our free Sprinkler Times tool or consider using a weather-based "Smart" controller.
6. **Make Sure Soil is Healthy** - Healthy soil amended with organic matter such as compost helps plants retain moisture and resist evaporation. Compacted soil should be aerated occasionally.
7. **Remember to Mulch** - A layer of mulch over the soil around plants will reduce evaporation and inhibit the growth of water-stealing weeds.
8. **Provide Regular Maintenance** - Repair leaks in hoses, drip lines, and sprinkler heads. Control weeds and minimize the use of fertilizer. Hire a Qualified Water Efficient Landscaper (QWEL).

https://www.cityofnapa.org/587/8-Basic-Principles-of-Water-Wise-Landsca