HYDROBULL No 2
A TECHNICAL BULLETIN from HYDROGOLD
INT'L WATER MANAGEMENT CONSULTANTS
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HYDROBULL is a technical bulletin covering issues related to water.
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DETERMINING PEAK APPLICATION

This is the second of the 3 basic irrigation parameters:

- Area of Coverage - The area watered by (in this case) the sprinklers
- Peak Application - The maximum application (precipitation) for the hottest period
- Watering Window - The time period during which the irrigation occurs

The irrigation system is designed for a Peak Application (Precipitation) which is the depth of water that is required per irrigation cycle during (typically) the hottest part of the year.

This article explains how to determine the Peak Application and its importance.

1 EVAPOTRANSPIRATION (ET) & REFERENCE EVAPOTRANSPIRATION (ETo)

EvapoTranspiration (ET) is the combined amount (depth) of water loss from ***Evapo***ration directly from the ground surface ***plus*** the ***Transpiration*** from the plant.

Transpiration is the evaporation from the plant surface (mostly from the leaves but also stems, flowers and roots). It is like the breathing of humans.

Reference EvapoTranspiration (ETo) is the ET for a nominated species of turf grass.

Rather than determine the ET for each plant, a reference ET (ETo) is determined. Then a crop factor (see following) is applied to determine the ET for each particular plant species.

ET is a linear measurement (eg, 6 mm per day) or 1.65 inches per week). An ET of 6 mm is the same as 6 L/m^2. (For the metric-dyslexic, the imperial measurement system does not have such a simple conversion example - but that is why most of the world is metric!)

2 CROP FACTOR

The Reference ET (ETo) is the ET for a particular species of turf grass. Depending on the crop (eg, the variety of turf grass), the ET for a specific plant may be different from ETo.

ET = ETo * k

Where:

ET	= EvapoTranspiration for a specific plant
ETo	= Reference ET
k	= Crop Factor (for that specific plant)

For example…

Assuming an ETo of 6.0 mm per day and a Crop Factor (k) of 1.2…
Then ET (for that plant) would be 7.2 (=6.0 * 1.2) mm per day.

3 PEAK APPLICATION

The application (sometimes called precipitation) is the depth of water applied by the irrigation system. We normally measure this in terms of mm per day (or inches per week).

Typically the application is the same as the ET for that plant; but there may be some adjustment made for:

- The Type of Soil
- Quality of Turf Required
- Water Conservation Strategies

We design for the Peak Application so that the irrigation system can supply sufficient water in the worst case (typically the hottest days).

4 THE IMPORTANCE OF DETERMINING THE CORRECT PEAK APPLICATION

Looks are deceiving. The choice of the Peak Application may not seem that important.

Example 1

The decision to go from a 5 mm application to a 6 mm application (only 1 mm) means a 20% increase in the required flow from the pump station (all other factors being equal).

That is, the pump station would increase from (say)
100 L/s (360 m^3/h or 1,587 USGPM) to
120 L/s (432 m^3/h or 1,904 USGPM).

Further to that, the mainline sizes would need to be increased and there are likely to be design considerations for the Irrigation Control System.

Example 2

In a hot desert situation, the difference between 10 and 15 mm per day would be a huge 50% increase in the pump station size.

But more importantly, ***if the ET was 15 mm per day and the system was only designed for 10 mm per day, the result is an irrigation system that will not work.*** That is, it would not keep the turf in good condition.

5 HOW DOES HYDROGOLD DETERMINE ETo?

In determining the Reference ET (ETo), we take several factors into account:

Latitude	The degrees north of south of the equator determine the daylight hours and solar radiation intensity.
Altitude	This determines the atmospheric pressure (marginal impact)
Temperature	Hotter temperatures increase ET
Humidity	Lower humidity increases ET
Wind Speed	Higher Wind increases ET

ETo can be calculated by the Penman-Monteith formula. A modified form of this equation is used by weather stations to calculate ET.

Hydrogold has developed a spreadsheet to determine ETo based on several climate inputs. The spreadsheet has both a tabular and graphic output (data is for Beijing):

MONTHLY CLIMATE DATA - TABULAR FORMAT		
Lattitude	Degrees	39
	Minutes	56
	Decimal	39.9
Altitude (Elevation Above Sea Level)	m	54
Crop Factor - Applied to ETo	Coeff.	1.2

Includes Penman-Monteith calculation for Eto and irrigation application based on:

Lattitude (to determine daylight hours and solar radiation)
Altitude
Crop Factor
Temperature (Average High, Average & Average Low)
Humidity (Average)
Wind Speed (Average)

Description	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
** Temperature - Highest Recorded	Celsius	12.0	17.0	27.0	32.0	37.0	40.0	40.0	41.0	33.0	28.0	23.0	18.0		29.0
Temperature - Average High	Celsius	1.0	3.0	11.0	19.0	25.0	29.0	30.0	29.0	25.0	18.0	9.0	2.0		16.8
Temperature - Average	Celsius	(3.0)	0.0	6.0	13.0	20.0	24.0	26.0	25.0	20.0	13.0	5.0	(1.0)		12.3
Temperature - Average Minimum	Celsius	(8.0)	(5.0)	0.0	8.0	13.0	18.0	22.0	20.0	15.0	8.0	0.0	(5.0)		7.2
** Temperature - Lowest Recorded	Celsius	(17.0)	(15.0)	(8.0)	(1.0)	3.0	8.0	17.0	12.0	2.0	(2.0)	(12.0)	(14.0)		(2.3)
Relative Humidity - Average	%	42.5	42.5	46.0	48.0	55.5	63.0	75.5	76.5	67.5	61.5	56.5	49.5		57.0
Wind Speed - Average	km/h	14.0	19.0	12.0	14.0	12.0	12.0	8.0	8.0	8.0	9.0	19.0	14.0		12.4
** Precipitation - Average	mm	5.1	5.1	7.6	17.8	33.0	78.7	223.5	170.2	58.4	17.8	10.2	2.5	630	52
** No of Rainy Days	No	5	5	5	7	9	12	16	15	11	7	6	4	102	9
Temperature - Average - Previous Month	Celsius	(1.0)	(3.0)	0.0	6.0	13.0	20.0	24.0	26.0	25.0	20.0	13.0	5.0		
Temperature - Average - Next Month	Celsius	0.0	6.0	13.0	20.0	24.0	26.0	25.0	20.0	13.0	5.0	(1.0)	(3.0)		
Day of Year for middle of month	No	15	46	74	105	135	166	196	227	258	288	319	349		
Sunlight Duration (Daylight Hours)	h/day	9.6	10.7	11.9	13.2	14.4	15.0	14.8	13.8	12.5	11.2	10.0	9.4		12.2
Nightime Hours	h/day	14.4	13.3	12.1	10.8	9.6	9.0	9.2	10.2	11.5	12.8	14.0	14.6		11.8
Clear-Sky Solar Radiation	$MJ/m^2/day$	11.3	15.3	20.5	26.0	29.8	31.4	30.6	27.5	22.5	16.9	12.3	10.2		21.2
Net Solar or Net Shortwave Radiation	$MJ/m^2/day$	8.8	11.9	15.9	20.2	23.1	24.4	23.8	21.4	17.6	13.3	9.6	8.0		16.5
Net Radiation	$MJ/m^2/day$	1.2	4.4	8.5	13.2	16.9	19.2	19.7	17.1	12.0	6.7	2.4	0.6		10.2
Reference EvapoTranspiration (ETo)	mm/day	1.4	2.0	2.8	4.7	5.8	6.6	6.2	5.5	4.3	2.8	2.1	1.3	1,385	110.0
Application Based on ETo & Crop Factor	mm/day	1.7	2.4	3.3	5.6	7.0	7.9	7.5	6.6	5.1	3.4	2.5	1.6		4.5
	mm/month	51.2	67.1	103.0	168.4	215.6	238.1	231.4	204.3	154.1	105.2	75.7	49.8	1,664	139

** These values are not used in the ET Calculation but included to give a better overall view of the climate

MONTHLY CLIMATE DATA - GRAPHICAL FORMAT

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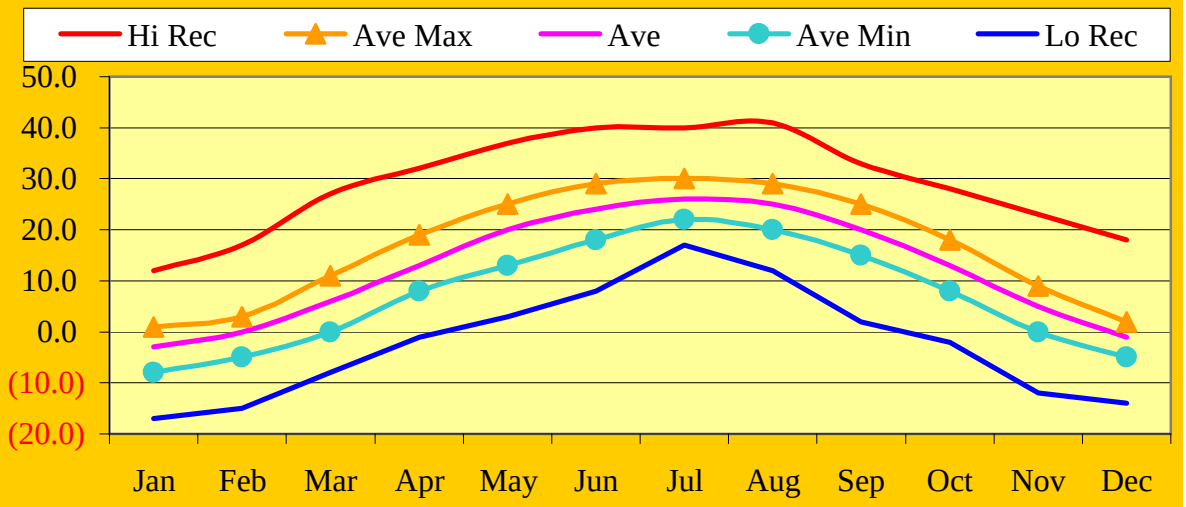
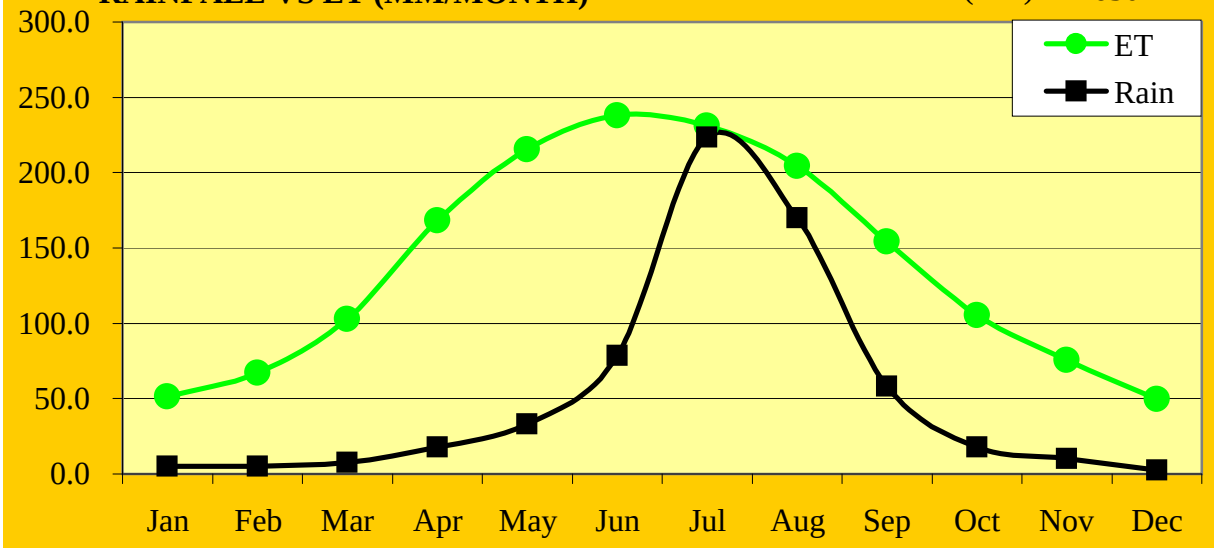
TEMPERATURE (CELSIUS)



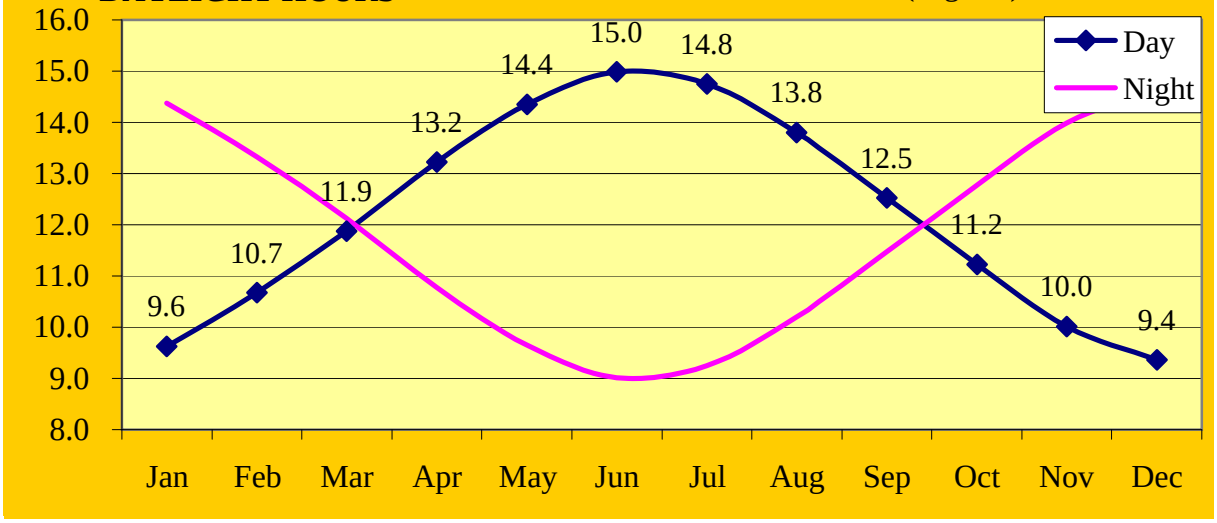
RAINFALL VS ET (MM/MONTH)

Total Annual Rainfall (mm) = 630



DAYLIGHT HOURS

Lattitude (degrees) = **39.9**



6 HOW WILL YOU DETERMINE ETo, ET & PEAK APPLICATION?

Sometimes, particularly in western countries, you are likely to have access to ET data from the government body responsible for meteorological records, often for free (but not in Singapore!). In any case, sometimes ET data is not available (especially on international projects).

You could find the Penman-Monteith equation on the web; in fact, several versions of them. Then you could put it all in a spreadsheet and test it as Hydrogold have done. Most likely will take you several days to do that. If you have the time, it will be a good education for you.

Or you could choose not to re-invent the wheel and get a copy of our spreadsheet from our web site at a nominal charge. Check out the link http://www.hydrogold.com/shop_et.html to get a copy of our spreadsheet for a nominal fee.

IN SUMMARY…

The correct Peak Application is a critical irrigation parameter. It should be determined by an agronomist or perhaps the supplier of the turf. However, many smaller projects do not have an agronomist available and rely on the advice of their Irrigation Consultant. Rely on Hydrogold's advice gained from world-wide experience in all climates.

The wide expanses of irrigated turf on the Rodney Wright designed Belle Mare Plage Links Course in Mauritius (irrigation designed by Hydrogold)…