HELP HANDBOOK FOR **PRESUD** (PREssurized SUBunit Design) PROGRAM APPLIED TO SUBUNIT OF DRIP IRRIGATION

In order to work with PRESUD it will be necessary, first **to download and install the 32 or 64 bit MATLAB compiler** depending on the type of computer available. The download can be done at http://crea.uclm.es/crea/descargas/matlab.php?s=aspersionygoteo

Also it is possible download and install the compiler for Windows MCR_R2016a(9.0.1) (not the most recent) in the link https://es.mathworks.com/products/compiler/matlab-runtime.html

The first step is to activate the **"start"** button and then the **"default values"** button, which will load a set of typical values for the variables.

After entering all data, activate the "**Calculate**" button.

PRESUD calculates the solution that makes the average flow rate by the set of emitters on the subunit equal to the average flow of drippers, defined as data.

To visualize the graphic representation of the emitter discharge and pressure distribution on of the subunit, activate the "**Figures**" button

Additional clarifications:

1. It is necessary to select if paired lateral or manifold pipe is used (Fig. 1) or is fed by one end

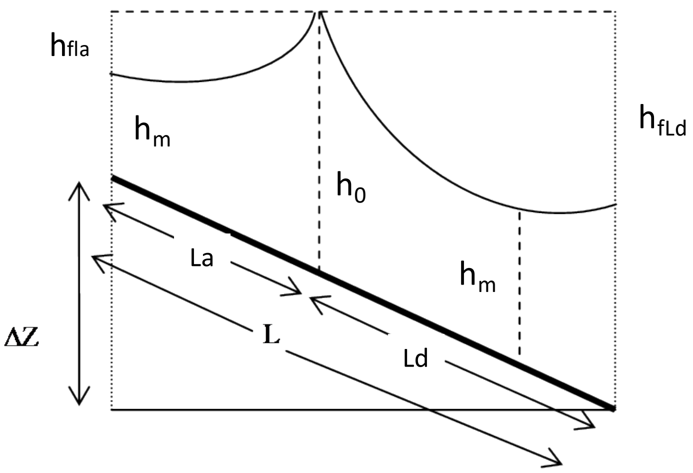


Fig. 1. Diagram of a paired lateral pipe.

Both feeding of paired **lateral or manifold pipe** could be done: a) by an equidistant point between two emitters or two laterals, b) next to one emitter or lateral, c) by the exact point (" theoretical point ") that makes the pressure difference (ho - hm) equal in the ascending and descending part; d) by another distance set by the user that is not equidistant between two emitters or laterals.

2. The general emitter equation is expressed as $q = K H^x$, where q = emission flow rate ($L h^{-1}$); K = emission coefficient; H pressure head at the emitter inlet (m); x= emission exponent ($0 < x < 1$). Known the values of q, H and x, PRESUD calculates the K value.
3. The head losses of a singular element or device of a pipe are estimated by its equivalent length, which is that length of pipe that has the same frictional head losses as the singular element. Therefore, the equivalent lengths of the connection of a emitter to the lateral (normally between 0.15 and 1.0 m), and from a lateral to the manifold (usually between 0.15 and 0.60 m) are requested.
4. Lo y So are the distances from the origin of the lateral or the manifold to the first emitter or lateral (m) respectively. Necessary data only when the pipe is fed from one end
5. The plants spacing is necessary to calculate the number of drippers per plant (
6. Gross annual irrigation water requirement (R_g) are calculated as

$$N_b = N_n / Ea$$

Where, N_n is the net annual irrigation water requirement (in m^3/ha); E_a the general application efficiency in the subunit, calculated as:

$$Ea = EU_q / Tr$$

Where, EUq is the emission uniformity of the irrigation system, calculated as $EUq = q_{25}/q_a$, being q_{25} mean of 25% emitters with lower flow values and q_a the mean of all emitter flow values, Tr = the transpiration ratio in peak period (Table 1) (Keller and Bliesner 1990). This represents the estimation of additional water that must be applied for unavoidable losses due to percolation outside the root zone in drip irrigation

Table 1. Tr values based on soil texture and root depth

Root depth	Soil texture			
	Very thick	thick	medium	fine
< 0.8 m	1.10	1.10	1.05	1.00
0.8 to 1.50 m	1.10	1.05	1.00	1.00
> 1.50 m	1.05	1.00	1.00	1.00

For micro sprinkler irrigation add 0.05 to Tr in humid climates and 0.10 in arid climates to account for evaporation losses

7. Pump efficiency corresponding to the overall performance of the pump + engine + variable speed driver. The recommended real value after the energy audits carried out at more than 30 pumping stations in Castilla-La Mancha is between 65 and 70%
8. . It is necessary to make a previous selection of the pipe diameters for the lateral (including emiters) and manifold. Lateral and manifold prices will appear when the pipe diameter is selected. This data (Table 2) may be modified by the user
9. In the block called "**Regulation**", it is possible to select the option where the program calculate the necessary pressure at the inlet ("**pre-dimensioned or Predim**.") or the user can enter a specific inlet pressure data at ("**Yes**")

Tabla 2. Average prices of different manufacturers and distributors in Spain

Material	Lateral diameter (mm) PE 0.25 MPa	Lateral pipe, included emitter (€ m^{-1})					Manifold pipe PE 0.4 MPa	
		Emission exponent (x)	Emitters spacing (s) (m)				Diameter (inner) (mm)	Price (€ m^{-1})
			0.5	0.75	1.0	1.25	32(28)	0.32
PE	16 (13.6)	0.1	0.20	0.18	0.16	0.14	40(35.2)	0.48
		0.5	0.175	0.16	0.145	0.13	50(44)	0.75
		0.9	0.125	0.12	0.115	0.11	63(55.4)	1.20
	17.5 (15.6)	0.1	0.25	.022	0.20	0.19	75(66)	1.75
	20 (17.4)	0.1	0.29	0.26	0.25	0.24	90(79.2)	2.6

10. The emission uniformity (EU) in the subunit can be estimated as

$$EU = \left(1 - \frac{1{,}27 CV_{qmf}}{\sqrt{e}}\right)\frac{q_m}{q_a}100$$

Where: CV_{qmf} = Coefficient of variation of emitter manufacturer; q_m = minimum emitter flow in the subunit due to the pressure; q_a = mean of all emitter flow values in the subunit due to variations in pressure; e = number of emitters per plant

11. The emission uniformity in the irrigation subunit can also be estimated with the Christiansen Uniformity Coefficient CU (Christiansen 1942) defined as

$$CU = \left(1 - \frac{\sum_{i=1}^{n} | q_i - q_a |}{q_a\, n}\right)100$$

Where q_i is the flow rate of each emitter and n the number of emitters in the irrigation subunit

12. The coefficient of variation of flow rate CVq) in the subunit defined as

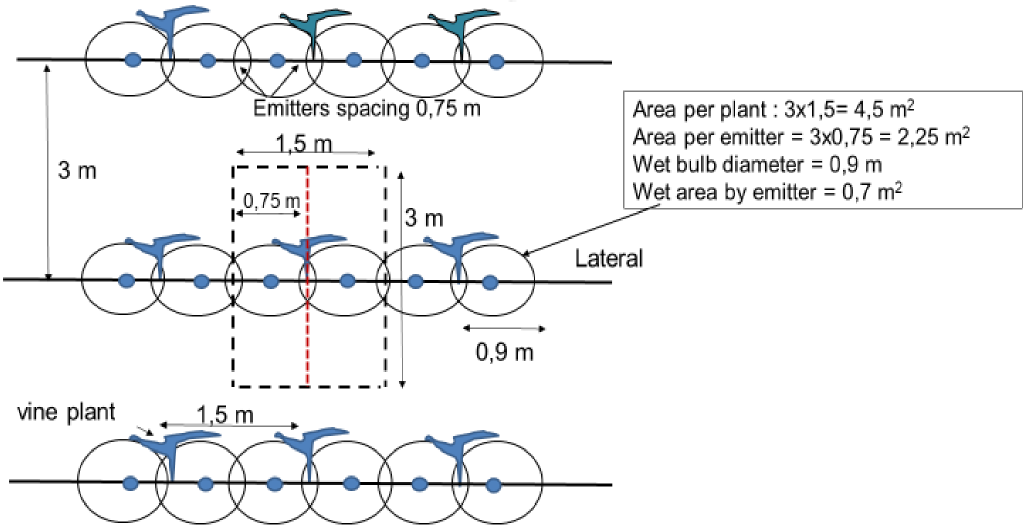
$$CV_q \cong \sqrt{CV_{qmf}{}^2 + x^2\, CV_h{}^2}$$

Where: CV_{qmf}= manufacturer coefficient of variation of the emitters; CV_h= coefficient of variation of emitter flow due to pressure variation ($CV_h = D_h\, h_a^{-1}$), where D_p= standard deviation of the emitter flow due to the variation in pressure, h_a= average emitter pressure in the subunit; x emission exponent.

13. Maximum pressure difference between two emitters of the irrigation subunit (Δh, as % of the average pressure)
14. Maximum difference in flows between two emitters of the irrigation subunit (Δq, as % of average flow)
15. Graphs of pressures and flows distribution in the emitters of the subunit

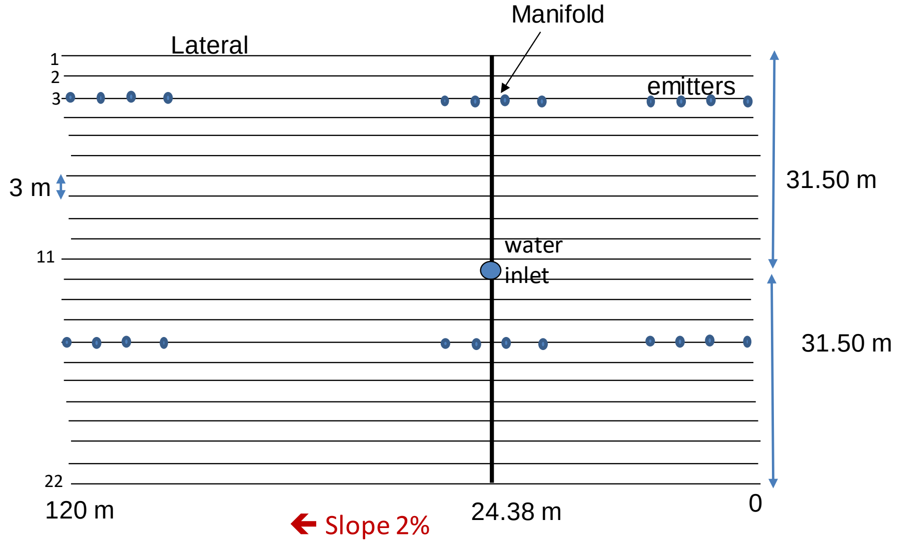
Example of PRESUD tool for subunit drip irrigation design

Example of 0.76 ha (120 m x 63m) of vineyard at 3m x 1,5m (22 lines of 120m vine plant) using emitters of q_a = 2 L h^{-1}, working to a pressure of 10m



Example of PRESUD tool for subplot drip irrigation design

Example of 0.76 ha (120 m x 63m) of vineyard at 3m x 1,5m (22 lines of 120 m vine plant) using emitters of q_a = 2 L h^{-1}, working to a pressure of 10 m



Example of PRESUD tool for subplot drip irrigation design

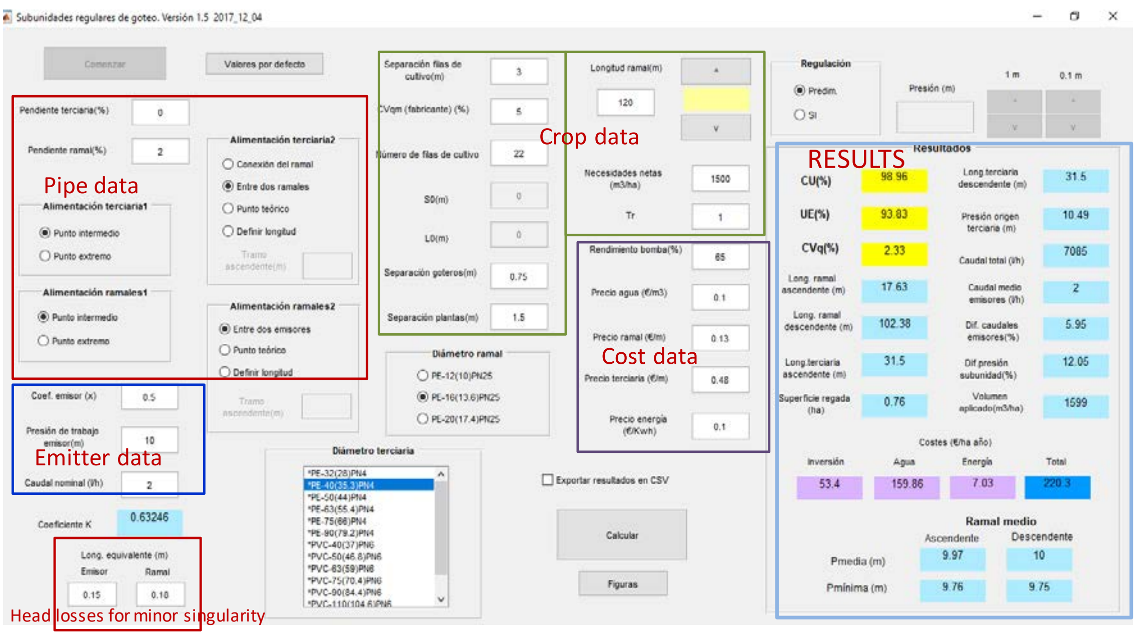
Example of 0.76 ha (120 m x 63m) of vineyard at 3m x 1,5m (22 lines of 120 m vine plant) using emitters of $q_a = 2\ L\ h^{-1}$, working to a pressure of 10 m

DATA used

Manifold slope	0 %	Manifold inlet	Between tow laterals	Lateral length	120 m
Latera slope	2%	lateral inlet	Between tow emitters	Net crop irrigation water requirement	1500 $m^3\ ha^{-1} year^{-1}$
Manifold inlet	paired manifold	Distance between to lines of plants	3 m	Transpiration relationship	Tr = 1
lateral inlet	paired lateral	CV_{qmf} Coefficient	5 %	Pumping efficiency	65 %
emission exponent (x)	0.5	Distance from the inlet point to the firs lateral	0	Water rate	0.1 € m^{-3}
Working pressure	10 m	Distance from the inlet point to the firs emitter	0	Lateral rate	0.13 € m^{-1}
emission rate	2 L h^{-1}	Spacing between emitters	0.75 m	Manifold rate	0.48 € m^{-1}
Equivalent length for minor singularity	emitter =0.15m lateral = 0,18m	Spacing between plants	1.5 m	Energy rate	0.1 € kWh^{-1}

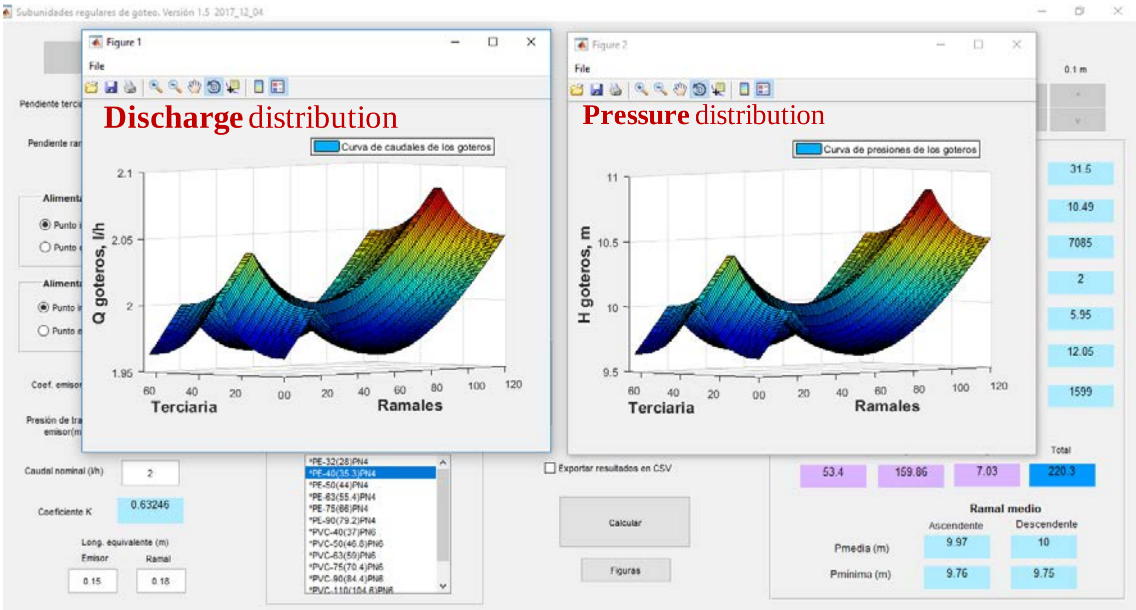
Example of PRESUD tool for subplot drip irrigation design

Example of 0.76 ha (120 m x 63m) of vineyard at 3m x 1,5m (22 lines of 120 m vine plant) using emitters of $q_a = 2\ L\ h^{-1}$, working to a pressure of 10 m



RESULTS of PRESUD tool for subplot drip irrigation design

Example of 0.76 ha subplot (120 m x 63m) of vineyard at 3m x 1,5m (22 lines of 120 m vine plant) using emitters of q_a = 2 L h^{-1}, working to a pressure of 10 m, and with slope 2% in lateral and 0% in manifold



RESULTS of PRESUD tool for subplot drip irrigation design

Example of 0.76 ha subplot (120 m x 63m) of vineyard at 3m x 1,5m (22 lines of 120 m vine plant) using emitters of q_a = 2 L h^{-1}, working to a pressure of 10 m, and with slope 2% in lateral and 0% in manifold

CU	98.96 %	Descending manifold length	31.50 m
UE	93.83%	Pressure in subplot inlet	14.9 m
CV_q	2.33 %	Total inlet flow rate	7085 L h^{-1}
Ascending lateral length	17.63 m	Average emitter discharge	2 L h^{-1}
Descending lateral length	102.38 m	Maximum discharge variation between emitter	5.95%
Ascending manifold length	31.50 m	Maximum pressure variation in the subplot	12.05 %
Irrigated area	0.76 ha	Total applied volume	1599 m^{-3} ha^{-1}

Example of PRESUD tool for subplot drip irrigation design

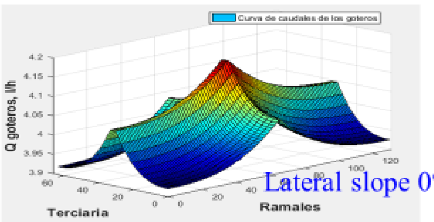
Example of 0.76 ha subplot (120 m x 63m) of vineyard at 3m x 1,5m (22 lines of 120 m vine plant) using emitters of q_a = 2 L h^{-1}, working to a pressure of 10 m, and with slope 2% in lateral and 0% in manifold

Additional RESULTS

TOTAL COSTS in the irrigated subplot	(€ ha^{-1} $year^{-1}$)
Investment	53.40
Water	159.86
Energy	7.03
TOTAL	**220.30**

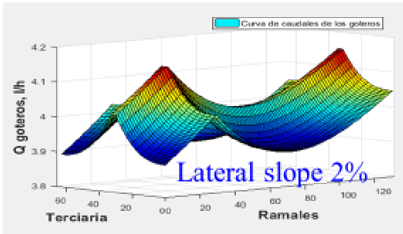
	Working conditions of the middle lateral	
	Ascending lateral	Descending lateral
Average pressure (m)	9.97	10
Minimum pressure (m)	9.76	9.75

Example of 0.76 ha subunit (120 m x 63m) of vineyard at 3m x 1,5m (22 lines of 120 m vine plant) using emitters of q_a = 2 L h^{-1}, working to a pressure of 10 m, and with different slope in lateral and 0% in manifold

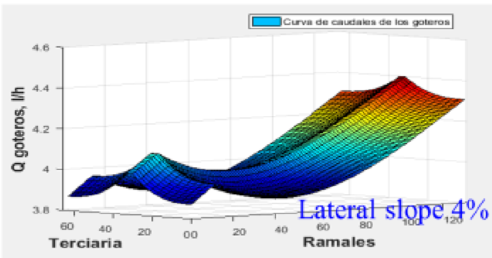


CU %	99.3
UE %	94.4
CV_q %	2.3
C_T (€ ha^{-1} $year^{-1}$)	219.3

Discharge distribution



CU %	98.9
UE %	93.8
CV_q %	2.3
C_T (€ ha^{-1} $year^{-1}$)	220.3



CU %	96.54
UE %	91.1
CV_q %	3.0
C_T (€ ha^{-1} $year^{-1}$)	224.8