# CE420 IRRIGATION AND DRAINAGE

## HOMEWORK # 3

1. Determine the water-application efficiency, the water-storage efficiency, and the water-distribution efficiency for the following conditions:
   Stream of 125 lt/s delivered to the field for 6 hr.
   Runoff averaged 70 lt/s for 3.0 hr
   Depth of root zone was 2.0 m.
   Depth of penetration varied linearly from 2.0 m at one end to 1.0 m at the other end of the field.

2. A stream of 315 lt/s was diverted from the river and 150 lt/s were delivered to the field. An area of 4 ha was irrigated in 8 hr. The root zone depth was 1.6 m. The runoff averaged 65 lt/s for 3 hr. The depth of water penetration varied linearly from 1.6 m at the head of the field to 1.0 m at the end of the field. Determine the water conveyance efficiency, the water application efficiency, the water storage efficiency, and the water distribution efficiency.

3. An irrigation discharge of 4 $m^3/s$ is diverted from a river into a main canal. Of this amount, only 3 $m^3/s$ is delivered to the farms. The surface runoff over the irrigated are is approximately 0.7 $m^3/s$. The deep percolation to groundwater is 500 lt/s. Determine the water conveyance efficiency, and the water application efficiency.

4. An irrigation project is planned in an arid zone. The maximum water requirements of crops are estimated in August during which no precipitation is observed. The mean river discharge is 15 $m^3/s$. Of this amount, $Q_{ir}$ discharge is diverted to irrigate the project area as shown in Figure 1. The areal distribution of crops k values to be used in the Blaney-Criddle equation are given below for August with $t=35^0C$. Take e=60%. The area is located on $38^0$ latitudes in northern hemisphere.

a) Determine the design irrigation discharge of the project area ($Q_{ir}$)
b) Determine the section dimensions of the trapezoidal main canal at point A with $S_0$= 0.0008, z = 1.5, n = 0.016 and b = 1.8 m. Consider $u_{min}$= 0.5 m/s.

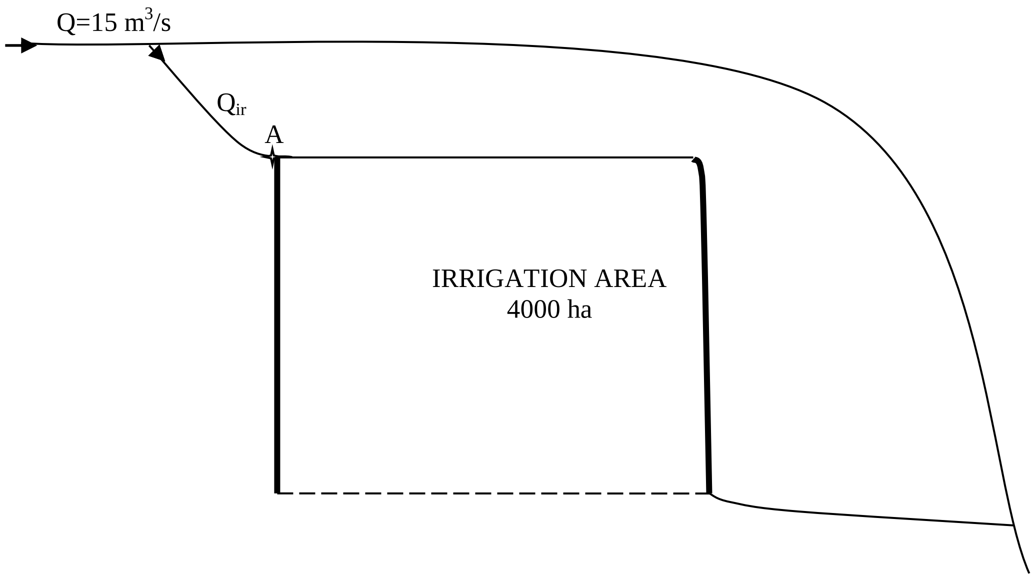
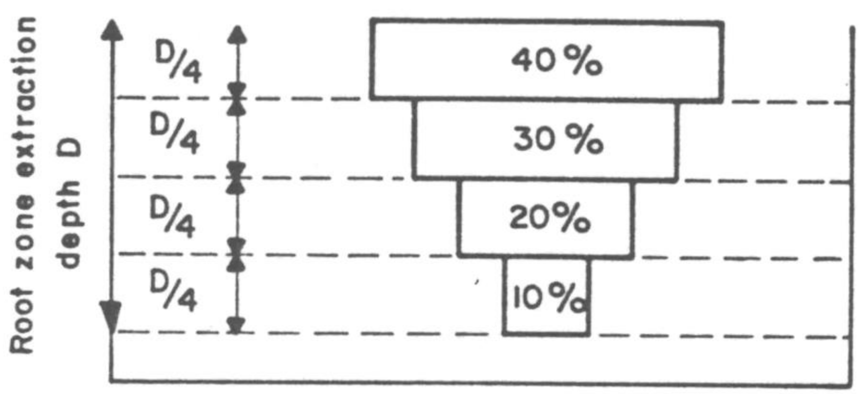



Figure 1. Definition sketch for problem 4.

| Crop Type | Areal distribution (%) | $k_1$ | $k_2$ |
|---|---|---|---|
| Crop 1 | 30 | 0.70 | 1.2 |
| Crop 2 | 30 | 0.75 | 1.1 |
| Crop 3 | 40 | 0.60 | 0.8 |

5. Field capacity (*FC*) and the permanent wilting point (*PWP*) of sandy loam soil are 0.31 and 0.12 respectively. Determine the total available water for cotton whose average rooting depth during the grooving season is 100 cm, is planted in this soil. If the root of this crop is distributed with the conventional root distribution given in the figure below, determine the values of Readily Available Water (*RAW*) for each root zone. Also determine the irrigation frequency (*T*), and the duration of water application ($t_a$) if the infiltration capacity of sandy loam is 7 mm/hr, deep percolation losses are 15%, and the daily average moisture consumption of the crop is 9 mm/day.




Root zone distribution pattern of corn in sandy loam

## SOLUTION

**1)** $$E_a = 100\left(\frac{W_d - (R_f + D_f)}{W_d}\right) \quad ; \quad D_f = 0$$

$W_d$ = 125 l/s x 6 h x 3600s/h = 2700000 lt = 2700 $m^3$

$R_f$ = 70 l/s x 3 h x 3600 s/h = 756000 lt = 756 $m^3$

$$E_a = 100\left(\frac{2700 - 756}{2700}\right) = 72\%$$

$$E_s = 100\frac{W_s}{W_n}$$ ; $W_s$ = (2 +1)/2 = 1.5 , $W_n$ = 2

$$E_s = 100\,\frac{1.5L}{2.0L} = 75\%$$

$$E_d = 100\left(1 - \frac{y}{d}\right)$$ , y = 0.5 m, d = 1.5 m $\Rightarrow$ $E_d = 100\left(1 - \frac{0.5}{1.5}\right) = 66.7\%$

**2)** $W_d$ = 150 l/s , $W_i$ = 315 l/s, $\Rightarrow$ $E_c = 100\frac{W_d}{W_i} = 100\frac{150}{315} = 47.6\%$

$$E_a = 100\left(\frac{W_d - (R_f + D_f)}{W_d}\right)$$

$W_d$ = 150 l/s x 8 h x 3600 h/s x 1/1000 $m^3$/l = 4320 $m^3$

$R_f$ = 65 l/s x 3 h x 3600 h/s x 1/1000 $m^3$/l = 702 $m^3$

$D_f$ = 0

$$E_a = 100\left(\frac{4320 - 702}{4320}\right) = 83.75\%$$

$$E_s = 100\frac{W_s}{W_n} = 100\frac{1.3}{1.6} = 81.25\%$$

$$E_d = 100\left(1 - \frac{y}{d}\right) = 100\left(1 - {}^{0.3}\!/_{1.3}\right) = 76.92\%$$

**3)** $W_i$ = 4 $m^3$/s

$W_d$= 3 $m^3$/s

$R_f$ = 0.7 $m^3$/s

$D_f$ = 500 l/s

$$E_c = 100\frac{3}{4} = 75\%$$

$$E_a = 100\left(\frac{3(0.7+0.5}{3}\right) = 60\%$$

**4)** $u = 25.4kf$ ; $k = k_1 k_2$ , $f = \left[\frac{1.8t+32}{100}\right]P$ ,  E = 60%

**a)**

| | AUGUST | | |
|---|---|---|---|
| | **Crop1** | **Crop2** | **Crop3** |
| $\mathbf{k_1}$ | 0.7 | 0.75 | 0.6 |
| $\mathbf{k_2}$ | 1.2 | 1.1 | 0.8 |
| **k** | 0.84 | 0.825 | 0.48 |
| **P** | 9.47 | | |
| **t ($^0$C)** | 35 | | |
| **f** | 9.0 | | |
| **U (mm/m)** | 192 | 188.5 | 109.7 |
| **%A** | 30 | 30 | 40 |
| **CIR (mm/m)** | 57.6 | 56.6 | 43.9 |
| **TDR=CIR/E** | 96 | 94.3 | 73.2 |
| **TDR (mm/m)** | 263.5 | | |
| $\mathbf{q_{max}}$ **(lt/s/ha)** | 0.984 | | |

F = 1.122

$$Q = A \cdot F \cdot q_{max} = 4000 \cdot 1.22 \cdot 0.984 = 4414.6 l/s = 4.42 m^3/s$$

**b)** At Point A $\Rightarrow$ Q= 4.42 $m^3$/s

$S_0$ = 0.0008, z=1.5, n = 0.016, b =1.8m

$$Q = \frac{1}{n} R^{2/3} A S_0^{1/2} \Rightarrow \; AR^{2/3} = \frac{nQ}{\sqrt{S_0}} = \frac{0.016 \cdot 4.42}{\sqrt{0.0008}} = 2.5$$

$$A = (b + zy)y = (1.8 + 1.5y)y$$

$AR^{2/3}$ = 2.5

b = 1.8 m  $\Rightarrow$ y ≈1.5 m.

**5)** FC= 0.31
PWP =0.12
AW= (FC-PWP) x D
AW = (0.31-0.12) x D = 0.19 x 100 = 19 cm
RAW = 0.75X AW

| **Root Zone** | **D(cm)** | **% Root** | **AW (mm)** | **RAW (mm)** |
|---|---|---|---|---|
| 1 | 25 | 40 | 47.5 | **89.06** |
| 2 | 25 | 30 | 47.5 | 118.75 |
| 3 | 25 | 20 | 47.5 | 178.125 |
| 4 | 25 | 10 | 47.5 | 356.25 |

$$T = \frac{RAW_{min}}{u_{c,daily}} = \frac{89.06}{9} = 9.9 days \approx 10 days$$

$$t_a = \frac{u_{c,daily} \times T}{(1 - \%percolation) \times f} = \frac{9 \times 10}{(1 - 0.15) \times 7} = 15.1 hrs \approx 15 hrs$$