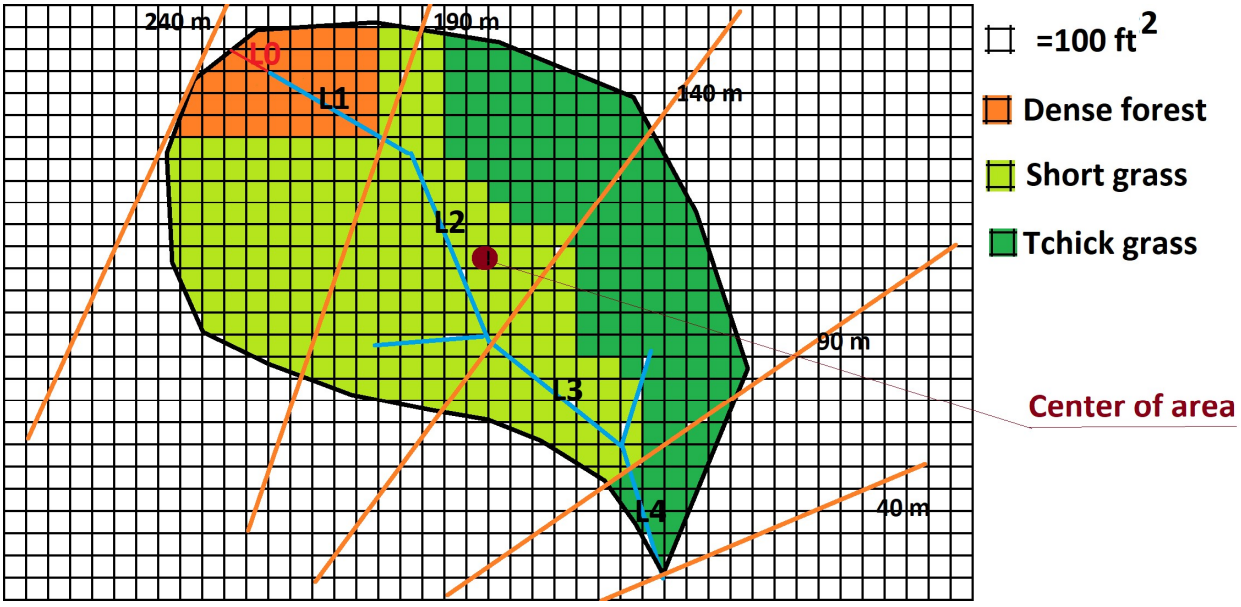
Solution assignment #2

Problem 1



In this problem:

- Lengths are calculated using the fact that the distance between grid points is 10 ft;
- Areas are calculated given that one square is 100 ft^2

Questions

$$L_4 \approx 248\,ft; L_3 \approx 418\,ft; L_2 \approx 342\,ft; L_1 \approx 209\,ft; L_0 \approx 17\,ft$$

$$\text{Channel length } L_c = L_1 + L_2 + L_3 + L_4 \approx 288\,ft$$

$$\text{Watershed length } L = L_c + L_0 = 288\,ft + 17\,ft \approx 305\,ft$$

$$\text{Watershed slope} = \frac{\Delta E}{L} = \frac{(240m - 40m)\dfrac{3.28\,ft}{1m}}{305\,ft} = 2$$

$$L_{ca} \approx 164\,ft$$

Perimeter $P = 770\,ft$

$Area \approx 36449\,ft^2$

$$F_c = \frac{P}{(4\pi A)^{0.5}} = \frac{770\,ft}{(4\pi * 36449\,ft^2)^{0.5}} = 1.6$$

$$A_0 = \pi r_0^2 = \pi\left(\frac{P}{2\pi}\right)^2 = \pi\left(\frac{770}{2\pi}\right)^2 = 47177\,ft^2$$

$$R_c = \frac{A}{A_0} = \frac{36449\,ft^2}{47177\,ft^2} = 0.77$$

Time of concentration

$$T_c = \frac{L_1}{60V_1} + \frac{L_2}{60V_2} + \frac{L_3}{60V_3} + \frac{L_4}{60V_4}$$

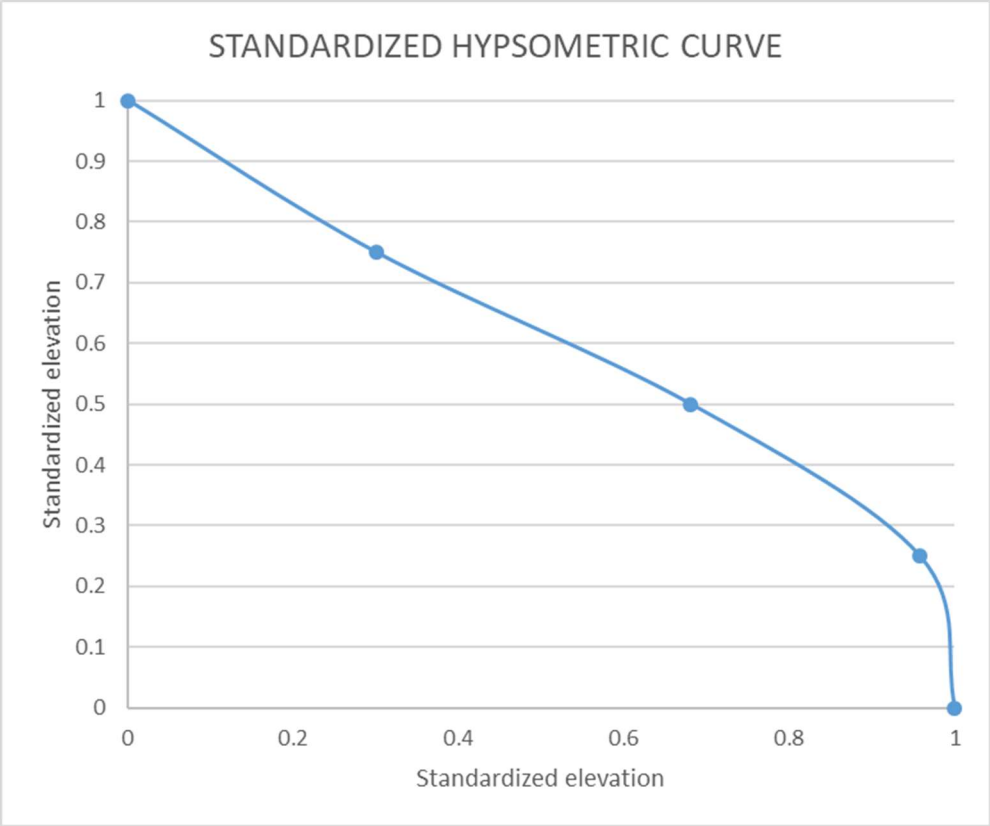
$$V_i = k_i\sqrt{S_i}$$

i	Land use	L_i (ft)	Altitude of the starting point	Altitude of the end point	SLOPE $\frac{\Delta E_i}{L_i}$	k_i	Vi (ft/s)	Tc (min)
4	dense forest	59	225	190	1.984714	2	2.817597	0.346392
3	light grass	99	190	140	1.657613	6	7.7249	0.21346
2	light grass	81	140	90	2.030819	6	8.550408	0.157411
1	thick grass	49	90	40	3.323158	4.5	8.203289	0.100266

$$T_c = 0.34\,\text{min} + 0.21\,\text{min} + 0.15\,\text{min} + 0{,}1\,\text{min} = 0.81\,\text{min}$$

Hypsometric curve derivation

Hi	Hi+1	Area(boxes)	Area (sq. ft)	Area above Hi	Standardized elevation	Standardized area
40	90	15.31567	1531.567	36159.18	0	1
90	140	100.0924	10009.24	34627.61	0.25	0.957644
140	190	137.6715	13767.15	24618.37	0.5	0.680833
190	240	108.5122	10851.22	10851.22	0.75	0.300096
240		0	0	0	1	0



Problem 2

1a) Runoff calculation for the initial conditions:

Land use=100% herbaceous forest in fair condition: CN=71

$$S = \frac{1000}{CN} - 10 = \frac{1000}{71} - 10 = 4.08in$$

$$I_a = 0.2S = 0.2 * 4.08in = 0{,}81in$$

$$V_Q = P - S\left(1.2 - \frac{S}{P + 0.8S}\right) = 6.35in$$

1b) Runoff calculation after urbanisation:

Land use=15 ha of herbaceous forest in fair condition (CN=71) and 10ha of residential areas, ¼ acre lots (CN=75). We need to find a weighted CN $CN_w = \frac{10}{25} * 75 + \frac{15}{25} * 71 = 72.6$

$$S = \frac{1000}{CN_w} - 10 = \frac{1000}{72.6} - 10 = 3.77in$$
$$I_a = 0.2S = 0.2 * 4.08in = 0.75in$$
$$V_Q = P - S\left(1.2 - \frac{S}{P + 0.8S}\right) = 6.56in$$

The percent increase in runoff is $100\frac{6.56in - 6.35in}{6.35in} = 3.28\%$

2) offsetting urbanisation with parks:

To offset urbanisation, X ha of parcs (CN=61) are built, leaving 15-X ha of forest. The weighted CN is

$$CN_w = \frac{15 - X}{25} * 71 + \frac{X}{25} * 61 + \frac{10}{25} * 75 = 42.6 - 0.40X + 30 = 72.6 - 0.40X$$

To offset urbanisation, the value of CN should be the same as before urbanisation, i.e. 71:

$$CN_w = 72.6 - 0.40X = 71 \Rightarrow X = 4ha$$

3) Calculation of runoff after disconnection of 100% of impervious areas

First, let's calculate the new CN of urban areas:

$$\text{Soil group} = B \Rightarrow CN_p = 61$$
$$f = 0.38$$
$$R = 1$$
$$CN = CN_p + f(98 - CN_p)(1 - 0{,}5R) = 68.03$$

Calculation of the weighted CN for the whole area:

$$CN_w = \frac{10}{25} * 68.03 + \frac{15}{25} * 71 = 69.83$$

$$S = \frac{1000}{CN_w} - 10 = \frac{1000}{69.83} - 10 = 4.32in$$
$$I_a = 0.2S = 0.2 * 4.08in = 0.86in$$
$$V_Q = P - S\left(1.2 - \frac{S}{P + 0.8S}\right) = 6.20in$$

The percent change in runoff is $100\frac{6.20in - 6.35in}{6.35in} = -2.4\%$

4) Are parks needed to offset urbanisation?

Given that the runoff is below the runoff in the initial conditions, no additional measure is needed to offset urbanisation.