UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2009/2010

SUBJECT NAME	:	HYDROLOGY
SUBJECT CODE	:	BFC 3092
COURSE	:	3 BFF
EXAMINATION DATE	:	NOVEMBER 2009
DURATION	:	2 ½ HOURS
INSTRUCTION	:	ANSWER FOUR (4) QUESTIONS ONLY

THIS PAPER CONSISTS OF **TWENTY ONE (21)** PAGES

Q1 (a) Define hydrologic cycle and discuss the impact of urbanization to the hydrologic cycle.

(5 marks)

(b) A lake has an area of 15 km^2. During a specific month the lake evaporation was 84 mm. During the same month the average inflow to the lake was 1.5 m^3/s and the average outflow from the lake was 1.3 m^3/s. Also, for the same month the water level for the lake was observed to increase by 110 mm. What was the precipitation in mm during that month? State the assumption(s) to substantiate your answer.

(8 marks)

(c) The annual precipitation at station E and the average precipitation at four surrounding stations are given in **Table Q1(b).**

(i) Why is it important to check the consistency of the record for precipitation data?

(2 marks)

(ii) Determine the consistency of record at station E from year 1970 to 1974.

(10 marks)

Table Q1(b): Precipitation data

Year	Four Stations Average	Station E
1970	95	83
1971	91	59
1972	105	85
1973	90	75
1974	88	61
1975	135	158
1976	112	118
1977	81	78
1978	103	118
1979	104	97
1980	93	95

Q2 (a) What are **five (5)** factors affecting evaporation?

(5 marks)

(b) During an isolated storm, a catchment area of 65 hactare produced a mass curve of the average rainfall depth and was recorded as in the **Table Q2(b)**. If the Φ-index was found to be 6.80 mm/hr, estimate the runoff volume of the catchment in cubic meter.

Table Q2(b): Rainfall depth

Time (hour)	0	1	2	3	4	5	6	7
Accumulated Average Rainfall (mm)	0	6.5	17.2	50.9	81.5	93.7	100.0	100.0

(10 marks)

(c) Estimate the potential evapotranspiration, ET, from an area in the month of November by using Penman's Formula. The following data are available:
(Refer to **Figure Q2 (c)(i), Figure Q2 (c)(ii), Table Q2 (c)(i) – Table Q2 (c)(v))**

Latitude	:	32° N
Mean Relative Humidity	:	72 %
Mean monthly temperature of air	:	34° C
Mean observed sunshine hours, n	:	9 hours
Average wind velocity	:	2.5 mile/hour
Reflection Coefficient, r	:	20 %

(10 marks)

Q3 (a) Explain in details how to estimate discharge of a stream at an outlet using Rational method.

(5 marks)

(b) Describe briefly **three (3)** elements that characterize a catchment.

(6 marks)

(c) By refering to **Figure Q3(c)(i) – Figure Q3(c)(v)**, compute the peak run-off, Q_p, for a 10-year storm using Rational Method for a drainage basin of 19 acres and having the following parameters:

Time of concentration:

- Overland: average grass surface, length 250ft and slope 2.5%,
- Shallow concentrated flow: length 500ft and slope 4%,
- Stream: length 800ft, slope 0.39%

Run-off coefficient:

- Asphalt and concrete = 1.1 acre
- Residential Suburban = 7.5 acres
- Unimproved = 10.4 acres

(14 marks)

Q4 (a) Explain briefly unit hydrograph (UH) and the importance of this UH.

(4 marks)

(b) Ordinates of a 4 hour UH and baseflow for a river are given in **Table Q4(b)(i)**. Ordinates of Effective Rainfall Hyetograph (ERH) are also given in **Table Q4(b)(ii)**. Determine the river flow using convolution method.

Table Q4(b)(i): 4-hr UH (unit hidrograph)

Time (hr)	UH ($m^3/s/cm$)	Baseflow (m^3/s)
1200	0	10
1600	37	10
2000	72	11
2400	47	11
0400	40	12
0800	29	12
1200	24	12
1600	14	13
2000	7	13
2400	0	13

Table Q4(b)(ii): Effective Rainfall Hyetograph (ERH)

Time (hr)	4	8	12	16
Rainfall excess (cm)	2.1	3.3	0	4.5

(21 marks)

Q5 (a) Define flood routing and state **four (4)** uses of flood routing.

(6 marks)

(b Explain why the process of flood routing is important in hydrological study. Describe the process of flood routing completely with the aid of sketches.

(8 marks)

(c) A detention pond is designed to reduce the storm water runoff in a new housing area. Determine the effect of storage pond if the inflow hydrograph is listed in Table **Q5(c)(i)**, and the elevation, storage and outflow are listed in Table **Q5(c)(ii)**.
(Use Table Q5(c)(iii) at Appendix 10 and submit it together with the answer papers)

Table Q5(c)(i): Inflow Hydrograph

Time (hr)	0	0.5	1	1.5	2	2.5	3	3.5	4
Q (m^3/s)	1	1.5	2.4	6.5	22	12.5	5	3	1

Table Q5(c)(ii) : Storage and outflow

Elevation (m)	**Storage (m^3)**	**Outflow (m^3/s)**	**2S/Δt-O (m^3/s)**	**2S/Δt+O (m^3/s)**
90	0	0	0	0
91	5152.00	1.57	4.159	7.290
92	10616.00	2.21	9.582	14.010
93	16404.00	2.71	15.515	20.938
94	22528.00	3.13	21.900	28.162
95	28700.00	3.50	28.388	35.389
96	35832.00	3.83	35.979	43.648
97	40642.00	4.14	41.016	49.300
98	50624.00	4.43	51.821	60.677
99	58608.00	4.70	60.424	69.816
100	67000.00	4.95	69.494	79.395

(11 marks)

Q6 (a) List and define **four (4)** parameters of aquifer.

(8 marks)

(b) (i) A tube well penetrates through an artesian aquifer having a permeability of 37 m/day. Find the yield in liters per hour for a drawdown of 3.5 m when the diameter of the well is 25 cm and the thickness of the aquifer is 35.0 m. The radius of influence is 330 m with a zero-drawdown.

(6 marks)

(ii) If the diameter of the well is doubled and other conditions remain the same, find the percentage increase in the yield. Give a brief comment on the results.

(4 marks)

(c) Confined aquifer has a source of recharge as shown in **Figure Q6(c).** The hydraulic conductivity of the aquifer is 50 m/day and its porosity is 0.18. The piezometric head in two wells 1000 m apart is 60 m and 50 m, respectively, from a common datum. The average thickness of the aquifer is 20 m and the average width is 4 km. Determine the rate of flow through the aquifer and the time of travel from the head of the aquifer to a point 5 km downstream (assume no dispersion or diffusion).

(7 marks)

S1 (a) Definisikan kitaran hidrologi dan bincangkan kesan urbanisasi kepada kitaran hidrologi.

(5 markah)

(b) Sebuah tasik mempunyai keluasan 15 km^2. Pada satu bulan tertentu penyejatan di tasik tersebut adalah sebanyak 84 mm. Pada bulan yang sama purata aliran masuk ke dalam tasik adalah 1.5 m^3/s dan purata aliran keluar dari tasik adalah 1.3 m^3/s. Pada bulan tersebut berlaku peningkatan paras air sebanyak 110 mm. Apakah jumlah kerpasan dalam mm bagi bulan tersebut? Nyatakan andaian yang penting dalam menentukan jawapan anda.

(8 markah)

(c) Kerpasan tahunan bagi stesen E dan purata kerpasan bagi empat stesen berhampiran diberikan dalam **Jadual S1(b).**

(i) Mengapa ianya penting untuk memeriksa kekonsistenan rekod bagi data kerpasan?

(2 marks)

(ii) Tentukan kekonsistenan rekod bagi stesen E.dari tahun 1970 hingga 1974.

(10 marks)

Jadual S1(b): Data kerpasan

Tahun	Purata empat stesen	Stesen E
1970	95	83
1971	91	59
1972	105	85
1973	90	75
1974	88	61
1975	135	158
1976	112	118
1977	81	78
1978	103	118
1979	104	97
1980	93	95

S2 (a) Apakah **lima (5)** faktor yang mempengaruhi penyejatan?.

(5 markah)

(b) Dalam satu kejadian hujan ribut, sebuah kawasan tadahan yang berkeluasan 65 hektar menghasilkan lengkung jisim dengan purata kedalaman hujan seperti di dalam **Jadual S2(b)**. Sekiranya indeks-Φ adalah 6.80 mm/jam, anggarkan isipadu airlarian yang berlaku di dalam kawasan tadahan tersebut dalam unit m^3.

Jadual S2(b): Kedalaman hujan

Masa (jam)	0	1	2	3	4	5	6	7
Purata Hujan Terkumpul (mm)	0	6.5	17.2	50.9	81.5	93.7	100.0	100.0

(10 markah)

(c) Dengan menggunakan kaedah Penman, anggarkan nilai sejatpeluhan, ET, bagi bulan November bagi sebuah kawasan yang mempunyai data cuaca seperti berikut : (Rujuk ***Figure Q2 (c)(i), Figure Q2 (c)(ii), Table Q2 (c)(i) – Table Q2 (c)(v)***)

Latitud	:	32° N
Kelembapan bandingan purata, RH	:	72 %
Purata suhu angin bulanan	:	34° C
Purata jam sinar matahari, n	:	9 jam
Halaju angin purata, u	:	2.5 batu/jam
Pekali pantulan, r	:	20 %

(10 markah)

S3 (a) Terangkan dengan terperinci bagaimana untuk menganggarkan kadar aliran sebuah sungai pada titik luahan menggunakan kaedah Rasional.

(5 markah)

(b) Huraikan secara ringkas **tiga (3)** elemen yang mencirikan sebuah kawasan tadahan.

(6 markah)

(c) Dengan merujuk ***Figure Q3(c)(i) – Figure Q3(c)(v)***, kirakan kadar alir puncak, Q_p untuk hujan ribut berkala 10 tahun menggunakan kaedah Rasional bagi kawasan tadahan berkeluasan 19 ekar yang mempunyai perincian berikut:

Masa penumpuan:

- *Overland:* Permukaan rumput sederhana, panjang 250 kaki dan cerun 2.5%,
- Aliran cetek tertumpu: panjang 500 kaki and cerun 4%,
- Sungai: panjang 800 kaki, cerun 0.39%

Pekali kadar alir:

- Asfalt dan konkrit = 1.1 ekar
- Perumahan suburban = 7.5 ekar
- *Unimproved* = 10.4 ekar

(14 markah)

S4 (a) Terangkan mengenai Hidrograf Unit dan kegunaannya.

(4 markah)

(b) Data ordinat-ordinat 4 jam dan aliran dasar sungai diberikan dalam **Jadual S5(b)(i)**. Ordinat Hyetograf Hujan Bersih juga diberikan dalam **Jadual S5(b)(ii)**. Dapatkan aliran sungai tersebut menggunakan kaedah konvolusi.

Jadual S5(b)(i): 4-jam (Hidrograf Unit)

Masa (jam)	Hidrograf unit ($m^3/s/cm$)	Aliran Dasar (m^3/s)
1200	0	10
1600	37	10
2000	72	11
2400	47	11
0400	40	12
0800	29	12
1200	24	12
1600	14	13
2000	7	13
2400	0	13

Jadual S5(b)(ii): Ordinat Hyetograf Hujan Bersih

Masa (jam)	4	8	12	16
Hujan bersih (cm)	2.1	3.3	0	4.5

(21 markah)

S5 (a) Berikan definisi penghalaan banjir, dan nyatakan empat kegunaan daripada penghalaan banjir.

(6 markah)

(b) Jelaskan kenapa proses penghalaan banjir adalah penting untuk kajian hidrologi. Dengan bantuan lakaran, huraikan proses penghalaan banjir dengan lengkap.

(8 markah)

(c) Sebuah kolam penyimpanan direkabentuk untuk mengurangkan air larian ribut pada satu kawasan perumahan baru. Tentukan kesan perubahan oleh kolam penyimpanan bilamana hidrograf aliran masuk diberikan dalam **Jadual S5(c)(i)** dan aras takungan, simpanan dan aliran keluar diberikan dalam **Jadual S5(c)(ii)**. (***Gunakan Table Q5 (c)(iii) di Appendix 10 dan hantar bersama kertas jawapan***)

Jadual S5(c)(i): Hidrograf aliran masuk

Masa (jam)	0	0.5	1	1.5	2	2.5	3	3.5	4
Q (m^3/s)	1	1.5	2.4	6.5	22	12.5	5	3	1

Jadual S5(c)(ii) : Simpanan dan aliran keluar

Aras (m)	**Simpanan (m^3)**	**Aliran keluar (m^3/s)**	**$2S/\Delta t$-O (m^3/s)**	**$2S/\Delta t$+O (m^3/s)**
90	0	0	0	0
91	5152.00	1.57	4.159	7.290
92	10616.00	2.21	9.582	14.010
93	16404.00	2.71	15.515	20.938
94	22528.00	3.13	21.900	28.162
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97	40642.00	4.14	41.016	49.300
98	50624.00	4.43	51.821	60.677
99	58608.00	4.70	60.424	69.816
100	67000.00	4.95	69.494	79.395

(11 markah)

S6 (a) Nyatakan dan takrifkan **empat (4)** parameter-parameter akuifer

(8 markah)

(b) (i) Sebuah telaga airbumi menembusi lapisan akuifer artisian yang mempunyai nilai kebolehtelapan 37 m/hari. Tentukan nilai kadaralir yang boleh dihasilkan dalam unit liter per jam akibat penyusutan paras air dalam telaga sebanyaki 3.5 m. Diberi diameter telaga air bumi dan ketebalan lapisan akuifer artisian adalah masing-masing 25 cm dan 35 m. Jejari terpengaruh, R, adalah 330 m dengan penyusutan sifar.

(6 markah)

(ii) Sekiranya garispusat telaga ini dua kali ganda dan lain-lain keadaan masih sama, tentukan peratusan perubahan di dalam kadaralir yang dihasilkan. Berikan komen mengenai jawapan tersebut.

(4 markah)

(c) Akuifer terkurung mempunyai sumber air sebagaimana ditunjukkan dalam ***Figure* Q6(c).** Pekali kebolehtelapan akuifer adalah 50 m/hari dan keliangan adalah 0.18. Turus piezometer dalam dua telaga berjarak 1000 m di antara kedua-duanya ialah 60 m and 50 m. Purata kedalaman akuifer terkurung ialah 20 m dan purata lebar akuifer ialah 4 km. Tentukan aliran melalui akuifer dan masa yang diperlukan untuk perjalanan sejauh 5 km ke bahagian bawah. (andaikan tiada serakan menegak atau serakan mendatar).

(7 markah)

APPENDIX 1

FINAL EXAMINATION

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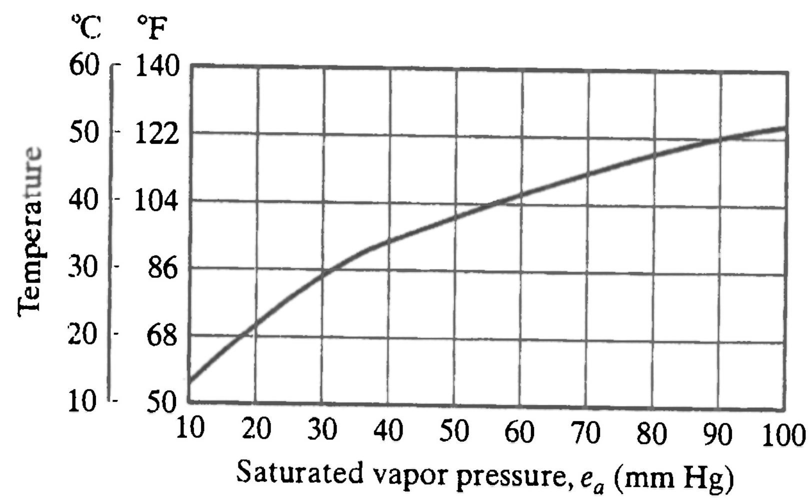

FIGURE Q2(c)(i) : Relation between saturated vapor pressure and temperature.

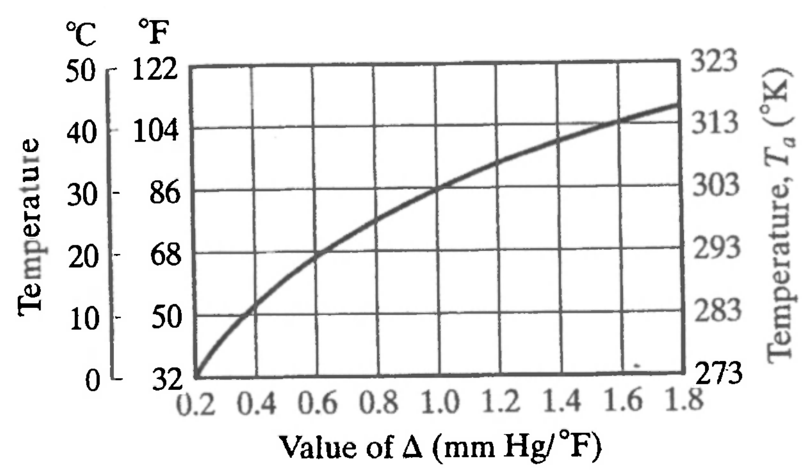

FIGURE Q2(c)(ii) : Temperature versus Δ relation for use with the Penman equation.

APPENDIX 2

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Table Q2 (c)(i) : Values of temperature-Dependent Coefficient B for use in the Penman Equation

T_a (°K)	B (mm H_2O/day)	T_a (°F)	B (mm H_2O/day)
270	10.73	35	11.48
275	11.51	40	11.96
280	12.40	45	12.45
285	13.20	50	12.94
290	14.26	55	13.45
295	15.30	60	13.96
300	16.34	65	14.52
305	17.46	70	15.10
310	18.60	75	15.65
315	19.85	80	16.25
320	21.15	85	16.85
325	22.50	90	17.46
		95	18.10
		100	18.80

Note : $B = \sigma T_a$ where σ is the Boltzmann constant, 2.01 x 10^{-9} mm/day
and T_a = °C + 273° = °K

Table Q2 (c)(ii): Mean Monthly Values of Possible Sunshine Hours, D

North Latitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0°	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1
10°	11.6	11.8	12.1	12.4	12.6	12.7	12.6	12.4	12.9	11.9	11.7	11.5
20°	11.1	11.5	12.0	12.6	13.1	13.3	13.2	12.8	12.3	11.7	11.2	10.9
30°	10.4	11.1	12.0	12.9	13.7	14.1	13.9	13.2	12.4	11.5	10.6	10.2
40°	9.6	10.7	11.9	13.2	14.4	15.0	14.7	13.8	12.5	11.2	10.0	9.4
50°	8.6	10.1	11.8	13.8	15.4	16.4	16.0	14.5	12.7	10.8	9.1	8.1

APPENDIX 3

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Table Q2 (c)(iii) : Properties of Water in Traditional U.S. Units

Temperature	Vapor pressure		
(°F)	in Hg	mb	psi
32	0.18	6.11	0.09
40	0.25	8.36	0.12
50	0.36	12.19	0.18
60	0.52	17.51	0.26
70	0.74	24.79	0.36
80	1.03	34.61	0.51
90	1.42	47.68	0.70
100	1.94	64.88	0.95

Table Q2 (c)(iv) : Properties of Water in SI Units

Temperature	Vapor pressure		
(°C)	mm Hg	mb	g/cm^2
0	4.58	6.11	6.23
5	6.54	8.72	8.89
10	9.20	12.27	12.51
15	12.78	17.04	17.38
20	17.53	23.37	23.83
25	23.76	31.67	32.30
30	31.83	42.43	43.27
35	42.18	56.24	57.34
40	55.34	73.78	75.23
50	92.56	123.40	125.83
60	149.46	199.26	203.19
70	233.79	311.69	317.84
80	355.28	473.67	483.01
90	525.89	701.13	714.95
100	760.00	1013.25	1033.23

APPENDIX 4

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Table Q2 (c)(v) : Tabulated Values of R, Mean Monthly Intensity of Solar Radiation on a Horizontal

	Latitude (degree)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
North	60	1.3	3.5	6.8	11.1	14.6	16.5	15.7	12.7	8.5	4.7	1.9	0.9
	50	3.6	5.9	9.1	12.7	15.4	16.7	16.1	13.9	10.5	7.1	4.3	3
	40	6.0	8.3	11.0	13.9	15.9	16.7	16.3	14.8	12.2	9.3	6.7	5.5
	30	8.5	10.5	12.7	14.8	16.0	16.5	16.2	15.3	13.5	11.3	9.1	7.9
	20	10.8	12.3	13.9	15.2	15.7	15.8	15.7	15.3	14.4	12.9	11.2	10.3
	10	12.8	13.9	14.8	15.2	15.0	14.8	14.8	15.0	14.9	14.1	13.1	12.4
	0	14.5	15.0	15.2	14.7	13.9	13.4	13.5	14.2	14.9	15.0	14.6	14.3
South	10	15.8	15.7	15.1	13.8	12.4	11.6	11.9	13.0	14.4	15.3	15.7	15.8
	20	16.8	16.0	14.6	12.5	10.7	9.6	10.0	11.5	13.5	15.3	16.4	16.9
	30	17.3	15.8	13.6	10.8	8.7	7.4	7.8	9.6	12.1	14.8	16.7	17.6
	40	17.3	15.2	12.2	8.8	6.4	5.1	5.6	7.5	10.5	13.8	16.5	17.8
	50	17.1	14.1	10.5	6.6	4.1	2.8	3.3	5.2	8.5	12.5	16	17.8
	60	16.6	12.7	8.4	4.3	1.9	0.8	1.2	2.9	6.2	10.7	15.2	17.5

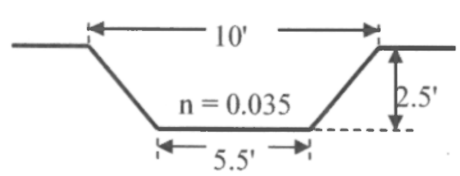

FIGURE Q3(c)(i) : Cross section of stream

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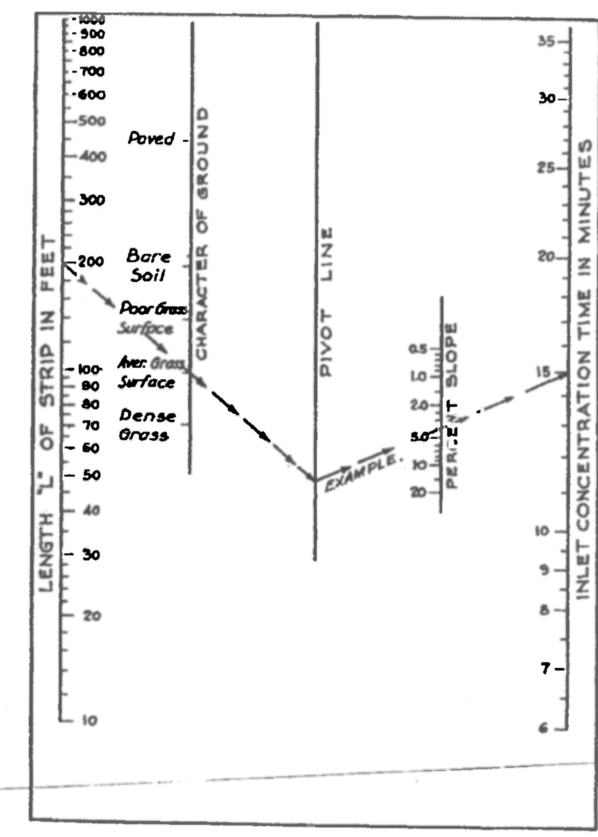

Figure C-2 Nomograph for overland flow time. *(Courtesy of E. Seeley, Data Book for Civil Engineers, Vol. 1, John Wiley & Sons, Inc.)*

FIGURE Q3(c)(ii): Nomograph for overland flow time

APPENDIX 6

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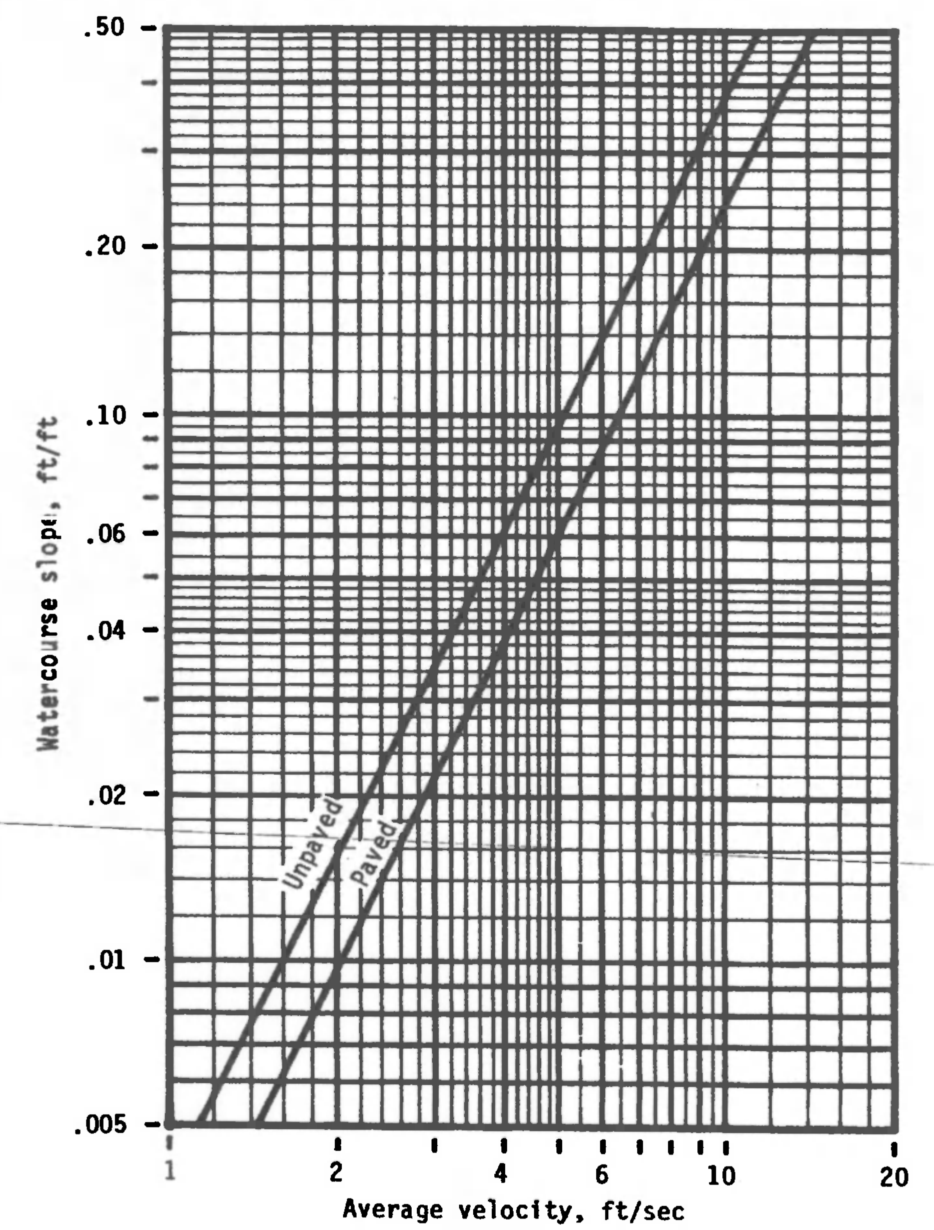

Figure 4-10 Average velocities for estimating travel time for shallow concentrated flow. *(Courtesy of Soil Conservation Service, Technical Release 55.)*

FIGURE Q3(c)(iii): Average velocity (ft/sec)

APPENDIX 7

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C-1
c, Runoff Coefficient

Character of Surface	Runoff Coefficients
Pavement	
Asphalt and concrete	0.70 to 0.95
Brick	0.70 to 0.85
Roofs	0.75 to 0.95
Lawns, sandy soil	
Flat (2 percent)	0.05 to 0.10
Average (2 to 7 percent)	0.10 to 0.15
Steep (> 7 percent)	0.15 to 0.20
Lawns, heavy soil	
Flat (2 percent)	0.13 to 0.17
Average (2 to 7 percent)	0.18 to 0.22
Steep (> 7 percent)	0.25 to 0.35
Composite c-values:	
Business	
Downtown	0.70 to 0.95
Neighborhood	0.50 to 0.70
Residential	
Single Family	0.30 to 0.50
Multi-units, detached	0.40 to 0.60
Multi-units, attached	0.60 to 0.75
Residential (suburban)	0.25 to 0.40
Apartment	0.50 to 0.70
Industrial	
Light	0.50 to 0.80
Heavy	0.60 to 0.90
Parks, cemeteries	0.10 to 0.25
Playgrounds	0.20 to 0.35
Railroad yards	0.20 to 0.35
Unimproved	0.10 to 0.30

Note: The ranges of c values presented are typical for return periods of 2–10 years. Higher values are appropriate for larger design storms. Suggested multiplier factors for larger design storms are

Storm	Multiplier
25-year	1.15
50-year	1.20
100-year	1.25

Note: Adjusted n-value cannot exceed 1.00.

Figure C-1 Values of c, runoff coefficient. *(Courtesy of ASCE & Water Environmental Federation, Design and Construction of Urban Stormwater Management Systems.)*

FIGURE Q3(c)(iv): Typical coefficients for use with the Rational Method

APPENDIX

FINAL EXAMINATION

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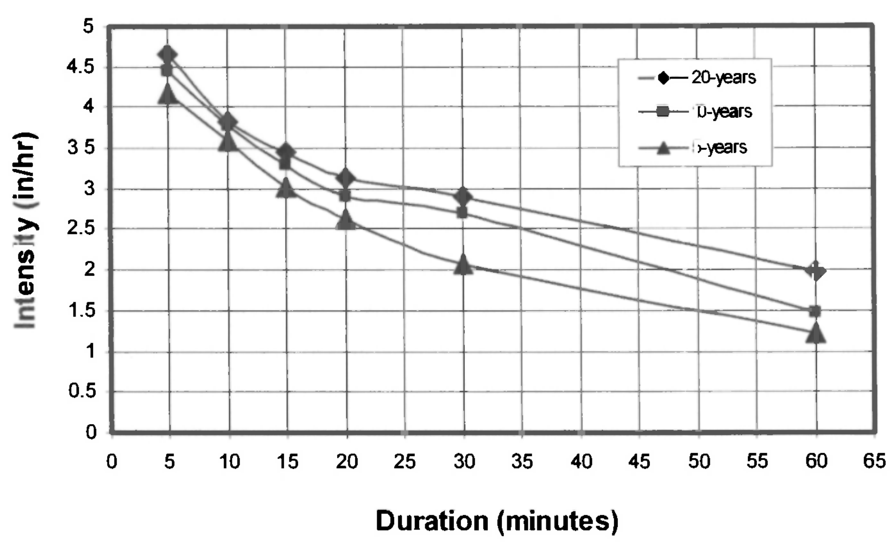

FIGURE Q3(c)(v): Intensity-Duration-Frequency (IDF) curve

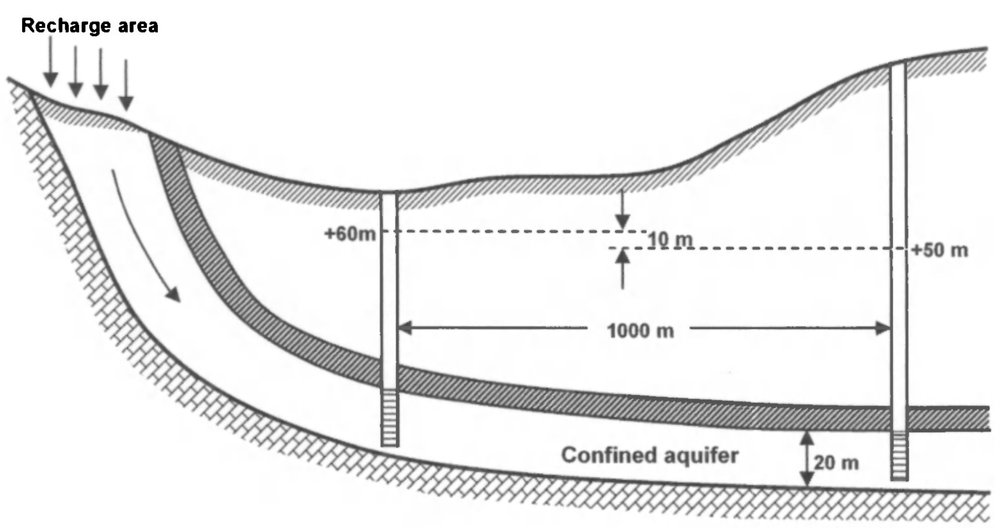

FIGURE Q6(c): Confined aquifer

APPENDIX 9

FINAL EXAMINATION

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Equations:

$$P_a = \frac{M_a}{M_o} P_o$$

$$I - O = \Delta S/\Delta t$$

$Q_p = A \times C \times i$ (for English Unit)

Where: Q_p = ft³/s or cfs/s
A = acre
C = runoff coefficient
i = in/hr

$Q_p = \frac{1}{360} \times C \times i$ (for International Unit)

Where: Q_p = m³/s
A = ha
C = runoff coefficient
i = mm/hr

$$E = 0.35(e_a - e_d)(1 + 0.0098\,u_2)$$

$$H = R(1-r)(0.18 + 0.55(n/D)) - \sigma T_a^4 (0.56 - 0.092 e_d^{0.5})(0.1 + 0.9(n/D))$$

$$ET = \frac{\Delta H + 0.27\,E}{\Delta + 0.27}$$

$$f = f_c + (f_0 - f_c)e^{(-kt)}$$

$$\text{Index } \phi = \frac{P - R}{t_e}$$

$$F = [f_c t + \frac{(f_o - f_c)}{K}(1 - e^{(-kt)})]_b^a$$

$$R_h = \frac{e_d}{e_a}$$

$$(I_1 + I_2) + \left(\frac{2S_1}{\Delta t} - O_1\right) = \left(\frac{2S_2}{\Delta t} + O_2\right)$$

$$Q_n = P_n U_1 + P_{n-1} U_2 + P_{n-2} U_3 + \ldots P_1 U_{(n-m+1)}$$

$$H^2 - h^2 = \frac{Q}{\pi K} \ln\left(\frac{R}{r}\right)$$

$$S = \rho g b\,(\alpha + \eta\beta) = \gamma_w b\,(\alpha + \eta\beta)$$

$$H - h = \frac{Q}{2\pi b K} \ln\left(\frac{R}{r}\right)$$

$$S_y = \frac{1}{A}\frac{dv}{dh}$$

$$S_s = \frac{S}{b} = \gamma_w[(1-\eta)\alpha + \eta\beta]$$

APPENDIX 10

FINAL EXAMINATION

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COURSE : 3 BFF
SUBJECT : HYDROLOGY
SUBJECT CODE : BFC 3092

Name : ____________________

Matric No. : ____________________

Table Q5(c)(iii).: Flood routing calculation

No.	Time (hour)	I (m^3/s)	$I_1 + I_2$ (m^3/s)	$2S/\Delta t - O$ (m^3/s)	$2S/\Delta t + O$ (m^3/s)	O_2 (m^3/s)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						

Direction: Stop calculating when values of O_2 come out down