Student Name: SOLUTION FALL 2024

## CE 3354 Engineering Hydrology
## Exam 3, FALL 2024

The exam is to be completed on Blackboard. The questions below are the same as on the Blackboard implementation.

1. What is a hydrograph (as used in this class)?
   - a) A record of rainfall rates (inches/hour) versus time.
   - b) A record of cumulative rainfall depth (inches) versus time.
   - [✓ c)] A record of discharge rate (cubic feet/second) versus time.
   - d) A and B

Google

Chat GPT chooses: C

2. What is excess precipitation?

   a) The amount of precipitation that falls upon a watershed.

   [✓ b)] The amount of runoff that is produced from a watershed.

   c) The equivalent depth of uniformly distributed precipitation.

   d) A and B

class Notes

http:\\ 54.243.252.9/ . . . /13 RationalModified Rational.

Chat GPT also chooses B

Apply water balance

3. Hydrology is

   a) Study of the atmosphere, ocean, and surface waters

   [✓ b)] The study of the occurrence, distribution, and movement of water above, on, and below the surface of the earth

   c) A study of the processes of evaporation, infiltration, and storage

   d) The study of the relationship between rainfall and runoff

Class notes

http://54.243.252.9/ . . . /03-Hydrologic Cycle

Chat GPT also chooses B

4. Rainfall behavior is expressed as a combination of

   [✓ a)] depth or intensity, duration, and probability or frequency

   b) intensity and probability or frequency

   c) duration and probability or frequency

   d) depth and duration

Class Notes

http://54.243.252.9/ce-3354_webroot/. . . . /109-Precipitation

Class

Chat GPT also chooses A

5. An annual recurrence interval of 100-years is equivalent to an Annual Exceedance Probability (AEP) of what percent?

   [✓ a) 1-percent.]

   b) 10-percent.

   c) 50-percent.

   d) 100-percent.

Textbook

Google

Chat GPT also chooses A

6. What is a plotting position?

   a) The multiplicative inverse of relative frequency

   b) An estimate of probability associated with an observation based on its magnitude relative to the arithmetic mean

   [✓ c)] An estimate of probability associated with an observation based on its position within a ranked sample set

   d) Location in a chart of a data pair

Class Notes

http://54.243.252.9/ce-3354-webbook . . . .

. . . lessons/06_Probability Estimation/

Chat GPT also chooses C

7. What is a flood frequency curve?
   - a) A plot of discharge and time
   - [✓ b)] A plot of estimated exceedance probability and discharge
   - c) A plot of the frequency and discharge
   - d) A plot of the discharge magnitude and the Weibull plotting position

Class Notes

http:\\54.243.252.9/ce-3354-webroot/ce-3354-webbook-2024/my3354notes/

_build/html/lessons/07-StreamflowDataModeling

and

... /06-ProbabilityEstimationModeling

Chat GPT chooses B

8. Average Rainfall intensity is

- a) instantaneous rainfall rate
- b) slope of the depth duration curve at a duration of one hour
- [✓ c)] the ratio of accumulated depth to duration
- d) integral of the depth duration curve from 0 to 24 hours

Class Notes

http:// 54.243.252.9/ce-3354-webroot/ce-3354-webbook-2024/

my3354notes/_build/html/lessons/09-Precipitation/

Chat GPT chooses A, if question is modified to averge rainfall intensty

9. In the rational equation, Q = CIA, the intensity, I, is

[✓ a)] the ratio of depth to the time of concentration

b) the ratio of depth to watershed area

c) the ratio of depth to storm duration

d) the ratio of depth to watershed impervious cover

Class Notes

http://54.243.252.9/ . . . /13-RationalModifiedRational . . .

Chat GPT

Chooses C (which is incorrect as applied in drainage engineering)

10. The rational runoff coefficient for a 300 X 200-meter property with a slope of 3% is 0.35. The rainfall intensity is 116 mm/hr. The peak discharge from this property is anticipated to be about

a) 2200 $\frac{m^3}{hr}$

[✓ b)] 2400 $\frac{m^3}{hr}$

c) 3800 $\frac{m^3}{hr}$

d) 7000 $\frac{m^3}{hr}$

Calculaton

$Q_p = CIA\left(\frac{1}{360}\right)$

; $A$ (hectares) $= \frac{(300m \times 200m)}{10{,}000} = 6$ ha

; $I\left(\frac{mm}{hr}\right) = 116$

; $C = 0.35$

$Q_p = (0.35)(116)(6)\left(\frac{1}{360}\right) = 0.676\ m^3/sec * \frac{3600\ sec}{hr} = 2436\frac{m^3}{hr}$

BEST ANSWER IS $\boxed{B}$

Chat GPT

Also chooses B; but supplied arithmetic is nonsensical.

11. A 3.2-inch storm is uniformly distributed over a 95 acre watershed. The NRCS Curve Number for the watershed is CN = 78. The anticipated watershed runoff is about

    a) 8.0 acre-feet

    b) 9.0 acre-feet

    [✓ c)] 10.0 acre-feet

    d) 11.0 acre-feet

CALCULATION

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

$$= \frac{(3.2 - 0.2(2.82))^2}{(3.2 + 0.8(2.82)}$$

$$= \frac{6.948}{5.456} = 1.273 \text{ in}$$

$$CN = \frac{1000}{S+10} \leftarrow \text{SOLVE FOR } S$$

$$S + 10 = \frac{1000}{CN}$$

$$S = \frac{1000}{CN} - 10$$

$$= \frac{1000}{78} - 10 = 2.82$$

$$Q \cdot 95\text{acres} = 1.273\text{in}\,(95\text{acres})$$

$$= 120.97 \text{ acre-in} \frac{1\text{ft}}{12\text{in}}$$

$$= 10.08 \text{ acre-ft}$$

Choose (c)

12. A 3.5 acre drainage area receives a rainfall intensity of 0.5 in/hour; the peak runoff from the area is 500 gallons per minute. What is the runoff coefficient?

    (A) 0.11

    (B) 0.31

    [✓ (C) 0.64]

    (D) 0.86

Calculation

$Q_P = CIA$ Solve for $C$

$$\frac{500\,gal}{min} \cdot \frac{1\,ft^3}{gal} \cdot \frac{1\,min}{60\,sec} = 1{,}114\ ft^3/sec$$

$$C = \frac{Q}{iA} = \frac{1{,}114\ ft^3/sec}{\frac{0.5\,in}{hr} \cdot 3.5\,acres} = 0{,}636$$ Choose C

13. A residential lot of 0.37 acres contains a house that occupies 0.05 acres, and a driveway that covers 0.035 acres. The runoff coefficients are 0.50 for the undeveloped portions of the lot, 0.85 for the house, and 0.90 for the driveway. The peak discharge from the lot during a storm event with rainfall intensity of 0.5 inches per hour is

    (A) 0.085 $\text{ft}^3$/sec

    [✓ (B)] 0.110 $\text{ft}^3$/sec

    (C) 0.250 $\text{ft}^3$/sec

    (D) 0.320 $\text{ft}^3$/sec

Calculation

Composite C

$$(0.85)(0.05) \leftarrow \text{House}$$
$$(0.90)(0.035) \leftarrow \text{Driveway}$$
$$\underline{(0.50)(0.305)} \leftarrow \text{All else}$$

$$\frac{\Sigma CA}{\Sigma A} \quad \frac{0.2265}{0.37 \text{ acres}} = 0.612 \leftarrow \bar{C}$$

$$q_p = \bar{C} i A$$
$$= (0.61)(0.5 \text{ in/hr})(0.37 \text{ acres}) = 0.11325 \text{ ft}^3/\text{sec}$$

Choose (B)

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14. In an area with a composite runof coeflicient of 0.65, the surface runoff flows toward a steet from the land on both sides. The watershed area extends to 100 ft on eaoh side of the street centerline. The street has curb-and-gutter, and there is a curb inlet (or basin) on both sides of the street The capacity of the curb inlet to pick up runoff from the gutter is 10 cfs (any more than this will just run past the opening). City policy is to design the street drainage system to acoommodate a 6.8-in/hr rainfall. The distance (ft) between the inlets along the sheet should be most nearly:

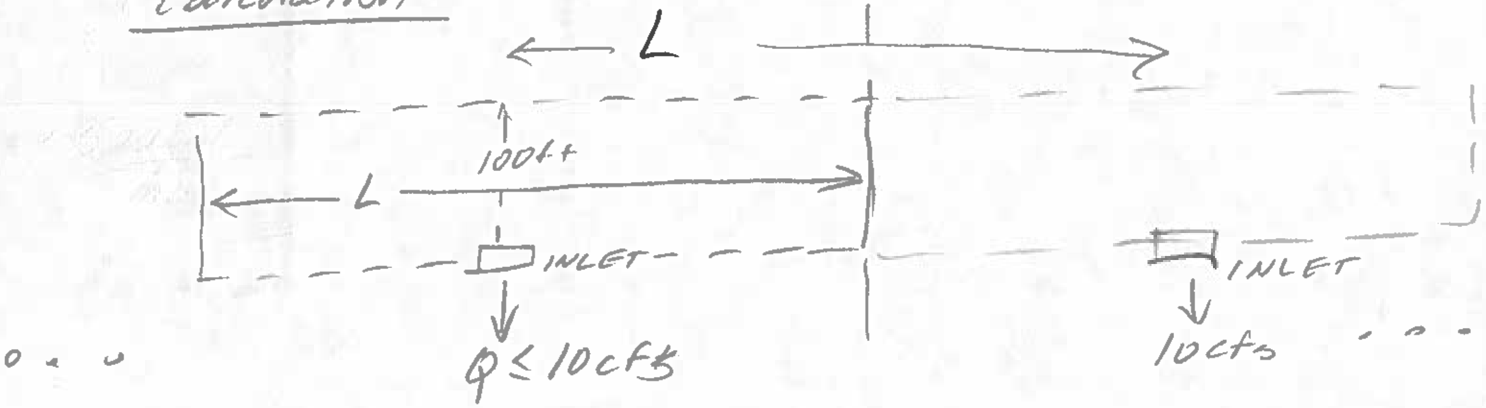
    a) 230 feet

    b) 490 feet

    c) 640 feet

    [✓ d) 980 feet]

Calculation



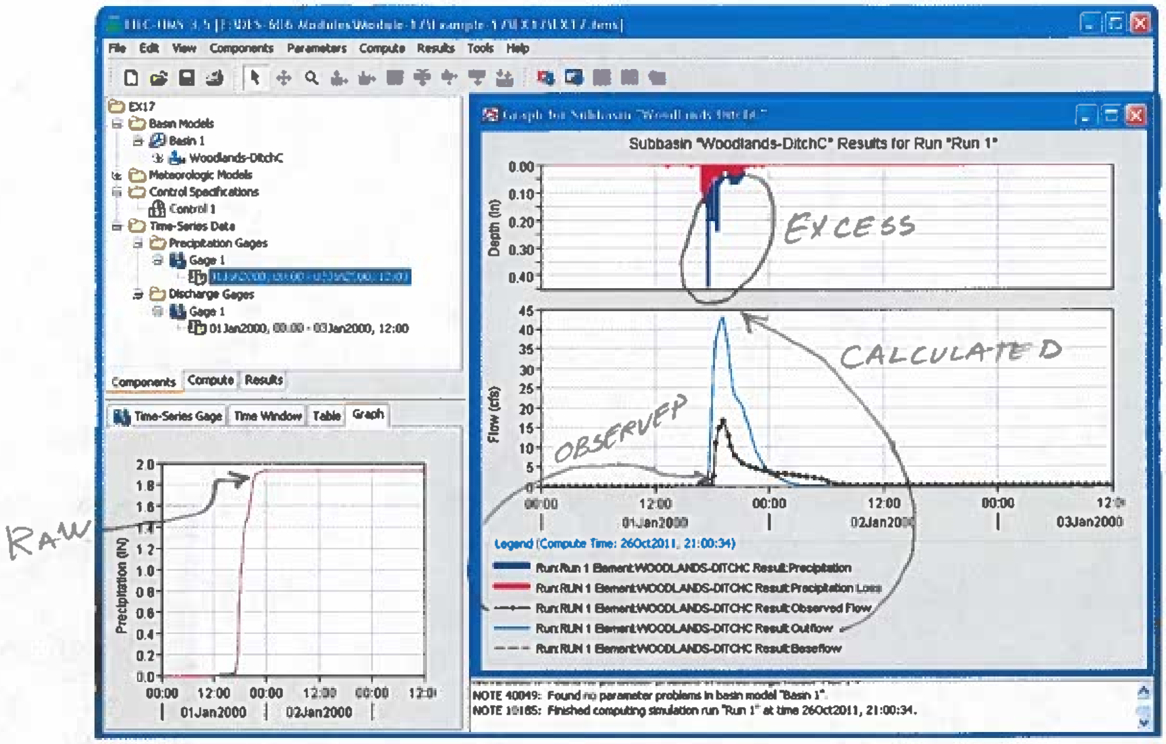
$$Q = CiA = (0.65)(6.8\,\text{in/hr})\frac{(100)(L)}{43560} \leq 10\,\text{cfs.}$$

Solve for L

$$L \leq \frac{10(43560)}{(100)(6.8)(0.65)} = 985\,\text{ft}$$

Assuming want to minimize inlets (cause they cost $)
best answer is Ⓓ

Figure 1 is a screen capture of a HEC-HMS model run.



```
NOTE 40049:  Found no parameter problems in basin model "Basin 1".
NOTE 10185:  Finished computing simulation run "Run 1" at time 26Oct2011, 21:00:34.
```

Figure 1: HEC-HMS Model Run for Woodlands-Ditch C sub-basin.

15. Which value below is the best estimate of the **COMPUTED** peak discharge for the Woodlands-DitchC sub-basin based upon Figure 1?

    a) 0.5 inches

    b) 1.9 inches

    c) 19 cubic feet per second

    [✓ d)] 44 cubic feet per second

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16. Which value below is the best estimate of the **OBSERVED** peak discharge for the Woodlands-DitchC sub-basin based upon Figure 1?

    a) 0.5 inches

    b) 1.9 inches

    [✓ c) 19 cubic feet per second]

    d) 44 cubic feet per second

SEE "OBSERVED" PRIOR PAGE

17. Which value below is the best estimate of the total **RAW** input precipitation for the Woodlands-DitchC sub-basin based upon Figure 1?

    a) 0.5 inches

    [✓ b) 1.9 inches]

    c) 19 cubic feet per second

    d) 44 cubic feet per second

SEE 'RAW" PAGE 15

18. Which value below is the best estimate of the total **EXCESS** input precipitation for the Woodlands-DitchC sub-basin based upon Figure 1?

   [✓ a) 0.5 inches]

   b) 1.9 inches

   c) 19 cubic feet per second

   d) 44 cubic feet per second

SEE CIRCLED "EXCESS" PG 15

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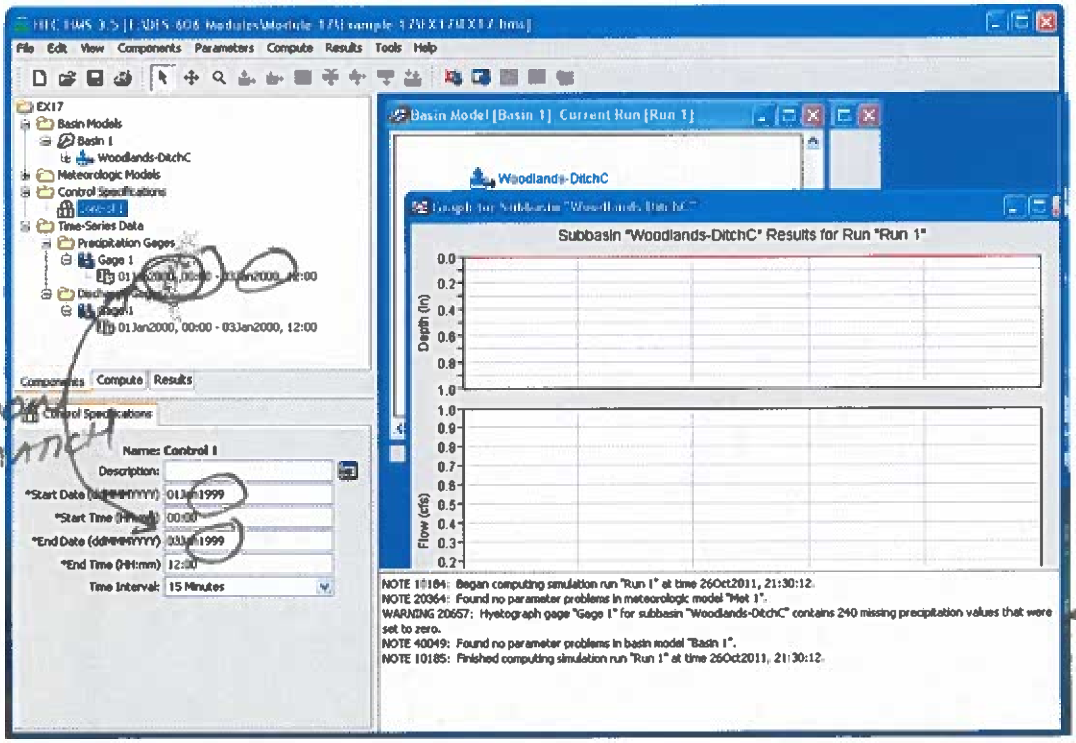
19. Figure 2 is a screen capture of a HEC-HMS model run. The model appears to have successfully run, but when the output graph is selected there in no hyetograph nor hydrograph displayed.



Name: Control 1

Description:

*Start Date (ddMMMYYYY): 01Jan1999

*Start Time (HH:mm): 00:00

*End Date (ddMMMYYYY): 03Jan1999

*End Time (HH:mm): 12:00

Time Interval: 15 Minutes

```
NOTE 10184:  Began computing simulation run "Run 1" at time 26Oct2011, 21:30:12.
NOTE 20364:  Found no parameter problems in meteorologic model "Met 1".
WARNING 20657:  Hyetograph gage "Gage 1" for subbasin "Woodlands-DitchC" contains 240 missing precipitation values that were
set to zero.
NOTE 40049:  Found no parameter problems in basin model "Basin 1".
NOTE 10185:  Finished computing simulation run "Run 1" at time 26Oct2011, 21:30:12.
```

TIME WINDOW MISMATCH

Figure 2: HEC-HMS Model Run for Woodlands-Ditch C sub-basin.

What is a likely explanation for the unanticipated output?

MISSING PRECIP VALUES "CAUSED" BY TIME WINDOW MISMATCH; PRECIP TIME WINDOW ONE YEAR LATER THAN CONTROL TIME WINDOW

Figure 3 is a schematic diagram of a creek that penetrates a 3-meter thick confined aquifer. During a long drought the flow in the creek **decreases** by 1.1 cubic meters per second between two gaging stations along the creek located 6 kilometers apart. On the west side of the creek the hydraulic head contours are parallel to the creek and the levels decrease moving **towards** from the creek at a rate of 0.0003 m/m. The head contours on the east side of the creek are also parallel to the creek and the levels decrease moving **away** from the creek at a rate of 0.0007 m/m.

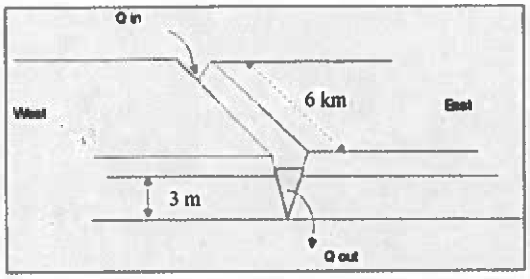
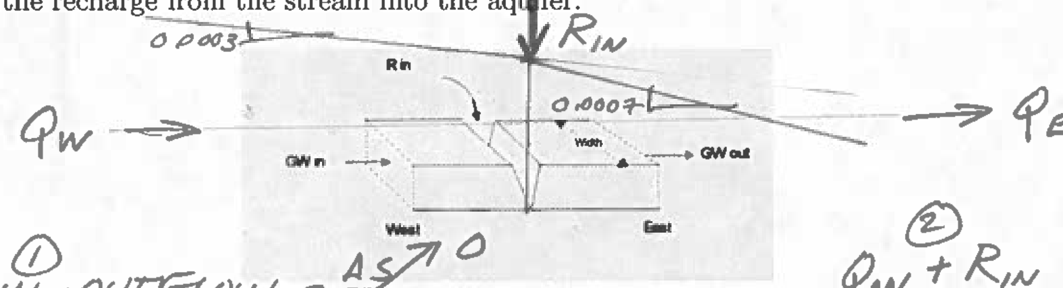


Figure 3: Dog Run Creek Schematic

20. Figure 4 is a representative sketch of a water balance where the term $R_{in}$ represents the recharge from the stream into the aquifer.



① INFLOW − OUTFLOW = $\frac{\Delta S}{\Delta t} \to 0$

Figure 4: Dog Run Water Balance

② $Q_W + R_{IN} = Q_E$

OR

$Q_W + R_{IN} - Q_E = 0$

Which expression best represents the water balance for the **aquifer** in the vicinity of the creek?

a) $Q_{WEST} - R_{RIVER} - Q_{EAST} = 0$

[✓ b)] $Q_{WEST} + R_{RIVER} - Q_{EAST} = 0$

c) $Q_{EAST} - R_{RIVER} = Q_{EAST}$

d) $R_{RIVER} + Q_{WEST} = Q_{WEST}$

21. Which value using Darcy's Law and the water balance is the best estimate the hydraulic conductivity of the aquifer in Figures 3 and 4?

    a) $0.105 \frac{m}{sec}$
    [✓ b)] $0.153 \frac{m}{sec}$
    c) $0.250 \frac{m}{sec}$
    d) $0.302 \frac{m}{sec}$

CALCULATION

$$R_{IN} = Q_E - Q_W = 1,1\ m^3/s$$

$$= KA\frac{\Delta h}{\Delta x_E} - KA\frac{\Delta h}{\Delta x_W} = KA\left(\frac{\Delta h}{\Delta x_E} - \frac{\Delta h}{\Delta x_W}\right)$$

$$1,1\,m^3/s = K(3m)(6000\,m)(0.0007 - 0,0003)$$

$$K = \frac{1,1\,m^3/s}{(3m)(6000\,m)(0.0004)} = 0.153\ m/sec$$

CHOOSE Ⓑ

22. During a drought period the following declines in the water table were recorded in an unconfined aquifer.

Table 1: Water Table Declines

| Area | Size (mi2) | Decline (ft) | $\forall_{AQUIFER}$ DEWATERED |
|---|---|---|---|
| A | 14 × $\left(\frac{640\,ac}{mi^2}\right)$ | × 2.75 | = 24,640 ac-ft |
| B | 7 × (640) | × 3.56 | = 15,948 ac-ft |
| C | 28×(640) | × 5.42 | = 97,126 ac-ft |
| D | 33×(640) | × 7.78 | = 164,314 ac-ft |
| | | $\Sigma$ $3.016 \cdot 10^5$ | |

The total volume of water removed from storage in this aquifer during the time period was $5.7385 \times 10^4$ acre-feet. Which value below is the best estimate the specific yield of this aquifer, for the data provided?

a) 0.09

b) 0.10

c) 0.15

[✓ d) 0.20]

$$\forall_{PUMP} = S_y \forall_{AQUIFER-DEWATERED}$$

$$S_y = \frac{\forall_{PUMP}}{\forall_{AQUIFER-DEWATER}} = \frac{5.7385 \cdot 10^4\ ac\text{-}ft}{3.0165 \cdot 10^5\ ac\text{-}ft} = 0{,}19$$

Closest is (d) (0.20)

Choose D

23. Three wells monitor an aquifer as shown in Figure 5. The head in each well is listed in table 2 below.

Table 2: Monitoring Well Locations and Head

| Area | Size (mi2) | Decline (ft) | |
|---|---|---|---|
| Well ID | X | Y | Head |
| #1 | 10 | 90 | 93.2 |
| #2 | 20 | 5 | 88 |
| #3 | 90 | 95 | 90 |

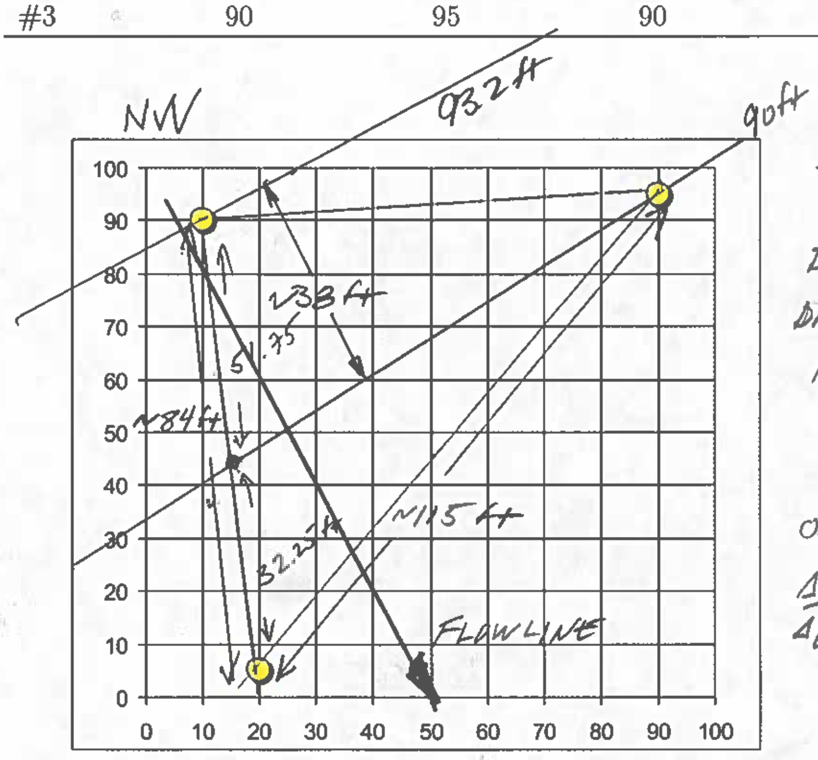


Figure 5: Map of well locations for Table 2

$\frac{M \to L}{H \to L} = \frac{90-88}{93.2-88} = 0.384$

DIST H→L ≈ 84 ft

DIST M→L ON H→L LINE ≈ (0.384)(84) = 32.25 ft

ON FLOWLINE:

$\frac{\Delta h}{\Delta L} = \frac{93.2-90}{38 \text{ ft}} = 0.084$

CHOOSE A

Which value(s) below best represent the magnitude and direction of the hydraulic gradient in this aquifer.

[✓ a)] $\frac{\Delta h}{\Delta L} \approx 0.084; NW to SE$

b) $\frac{\Delta h}{\Delta L} \approx 0.384; NW to SE$

c) $\frac{\Delta h}{\Delta L} \approx 0.084; NE to SW$

d) $\frac{\Delta h}{\Delta L} \approx 0.384; NW to SE$

(IF USE SPREADSHEET GET $\frac{\Delta h}{\Delta L} = 0.0709$ )

24. An unconfined aquifer is 300 feet deep, and has a hydraulic conductivity of 0.5 feet per day. A one-foot diameter well is drilled into the aquifer an pumped at a rate of 50 gallons per minute. The well's radius of influence is 1000 feet. After pumping has continued long enough for equilibrium to be established, the depth of water in the well is

a) 190 feet

[✓ b) 220 feet]

c) 240 feet

d) 270 feet

CALCULATION (COURSE NOTES)

$$q = \frac{\pi K (h_2^2 - h_1^2)}{\ln(\frac{r_2}{r_1})}$$

ALGEBRA

$$h_1^2 = h_2^2 - \frac{q \ln(\frac{r_2}{r_1})}{\pi K}$$

$$= (300)^2 - \frac{(9625)\ln(\frac{1000}{.5})}{\pi (0.5 ft/d)}$$

$$= 43425.7 ft^2$$

$$h_1 = \sqrt{43425.7 ft^2}$$

$$= 208.4 ft$$

$r_1 = 0.5 ft$

$r_2 = 1000 ft$

$h_2 = 300 ft$

$h_2^2 =$

$h_1^2 = ?$

$h_1 = ?$

$K = 0.5 ft/d$

$$q = \frac{50 gal}{min} \cdot \frac{1440 min}{d} \cdot \frac{ft^3}{7.48 gal}$$

$$= 9625 ft^3/d$$

[✓ B] is closest

208 − 190 = 18

→ 220 − 208 = 12
closest

25. Figure 6 depicts a concrete dam that impounds water as shown. The standing water depth is 1.5 meters. The soil layer under the reservoir is underlain by a highly porous sand layer. The sand layer at the bottom of the soil profile has horizontal drainage and zero pore pressure. The water level of the reservoir is constant. The total surface area of the reservoir pool is 1000 m$^2$, and the hydraulic conductivity of the soil layer is $4.7\times10^{-6}$ mm/sec. The loss from seepage through the soil layer per year is

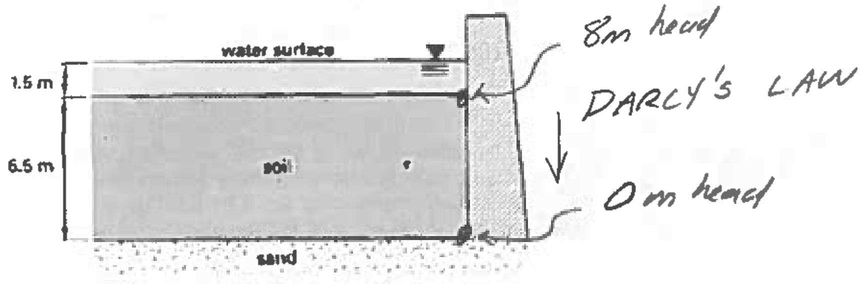


Figure 6: Debris trap (dam) with 6.5 meters of sediment above a sand layer

(A) 1.1 cubic meters

(B) 2.8 cubic meters

(C) 34 cubic meters

[✓ (D) 180 cubic meters]

CALULATION

TREAT SOIL AS A POROUS COLUMN; HEADS ARE GIVEN

$$q = KA\frac{\Delta h}{\Delta L} = K(1000 m^2)\frac{(8m - 0m)}{(6.5m)}$$

$$K = 4.7\cdot10^{-6} mm/sec \cdot \frac{m}{1000 mm} \cdot \frac{86400 sec}{day} \cdot \frac{365 day}{yr}$$

$$= 1.48\cdot10^{-1} m/yr$$

$$q = (1.48\cdot10^{-1} m/yr)(1000m^2)\frac{(8m)}{(6.5m)} = 182.4 m^3/yr$$ CHOOSE D