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Continuing Education Course #032
Stormwater Retention Pond Recovery Analysis

1. One of the main purposes of a retention pond is:
- a. prevent erosion
- b. collect and treat "the first flush" of polluted stormwater
- c. divert stormwater runoff to a wetland
- d. evaporate stormwater from the pond

2. Several types of retention ponds are used in sandy soils, including those listed below, except:
- a. combined retention and detention ponds
- b. off-line retention ponds
- c. closed basin (100% capture) ponds
- d. concrete structures
- e. existing natural depressions

3. Which of the following two retention ponds provides the most effective pollution control system (most effective retention and treatment):
- a. off-line retention pond
- b. wet retention pond with bleed-down orifice

4. If at the beginning of a storm event a retention pond contains some of the runoff from the preceding storm, then its effectiveness will be:
- a. increased
- b. unchanged
- c. reduced

5. The simplified infiltration analysis presented in this course may not be applicable where the soil and/or groundwater conditions are as described in one of the items below:
- a. sandy soil with groundwater at less than 2 feet below pond bottom
- b. soil consists of clayey sands and clays and the groundwater level occur at more than 10 feet below pond bottom
- c. fine sand aquifer with groundwater at 5 feet and aquifer base at more than 10 feet below pond bottom
- d. soil consist of silty sand and groundwater is at less than 10 feet below pond bottom

6. For the purposes of the analytical approach presented in this course, it is assumed that the subsurface conditions (aquifer system below the retention pond) are:
- a. stratified and non-homogeneous
- b. layered and anisotropic
- c. homogeneous and isotropic
- d. non-homogeneous and anisotropic

7. For a typical stormwater retention pond in a shallow aquifer system, the groundwater mounding portion of the infiltration is controlled primarily by:

- a. vertical flow
- b. horizontal flow
- c. diagonal flow
- d. capillary suction

8. Unsaturated flow follows Darcy's law just as saturated flow does, but which two of the parameter pairs listed below are variable:
- a. coefficient of permeability and seepage gradient
- b. soil porosity and depth to water table
- c. soil porosity and seepage length
- d. soil density and depth to water table

9. The second stage of seepage starts when the wetting front reaches the water table. The following statements are all true, except:
- a. the effective capillary suction potential at the wetting front disappears
- b. the pressure head is approximately equal to the seepage path length
- c. the vertical infiltration begins to add water to the water table
- d. horizontal groundwater seepage in the saturated aquifer begins
- e. storage in the unsaturated portion above the water table begins
- f. vertical coefficient of permeability becomes zero

10. The retention pond recovery analysis presented in this course may not be applicable where the soil conditions consist of thick surficial deposits of clayey sands and clays and/or groundwater levels that occur at more than 10 feet below pond bottom.
- a. True
- b. False

11. For the unsaturated analysis portion of the methodology presented in this course the infiltration equation developed by Green and Ampt was utilized.
- a. True
- b. False

12. For the unsaturated analysis, experiments by Bodman & Coleman indicate that the transmissive zone for sand is about 30% of full saturation.
- a. True
- b. False

13. The saturated flow beneath a typical stormwater retention pond is governed in part by the transmissive characteristics of the shallow aquifer, available lateral seepage gradients and pond geometry.
- a. True
- b. False

14. Recharge from the pond and into the groundwater aquifer creates a groundwater mound beneath the pond and its vicinity, which begins to rise under the pond and spreads laterally around the pond.
- a. True
- b. False

15. Once the groundwater mound intersects the pond bottom the infiltration into the soil will be governed by the unsaturated seepage with a gradient of 1.0.
- a. True
- b. False

16. The rate of water level decline in the pond is directly proportional to the rate of groundwater mound recession in the saturated aquifer.

- a. True
- b. False

17. For a successful design of stormwater retention ponds, only the saturated seepage analysis must be accounted for.

- a. True
- b. False

18. The two phase analytical approach presented in this course includes both unsaturated and saturated infiltration. The hydraulic conductivity value for the two phases of the analysis is not the same. Unsaturated infiltration is concerned with vertical flow while the groundwater mound is mainly influenced by horizontal flow. Which of the following statements correctly explains the reason for the difference in hydraulic conductivity value?

- a. soil is compacted in the vertical direction
- b. water infiltrates vertically at the surface
- c. horizontal layering of the soil
- d. effects of acid rain

19. The unsaturated hydraulic conductivity, Kvu, is normally less than the saturated hydraulic conductivity, Kvs. Typically, for natural fine sand aquifer systems, the correlation between these two values is:

- a. Kvu= 1/2 Kvs
- b. Kvu= 1/8 Kvs
- c. Kvu= 2/3 Kvs
- d. Kvu= 1/3 Kvs

20. For the following soil testing and permeability testing results, calculate the weighted average horizontal hydraulic conductivity, Kh. Assume the effective aquifer for this retention pond extends from 1 foot to 18 feet below ground surface. Select the closest value listed below:

Soil type	Depth Interval (ft)	Measure Kh (ft/day)	Estimated Kh (ft/day)
Fine Sand	0.0 – 6.5	15.5	
Slightly Silty Fine Sand	6.5 – 11.3		5.0
Clayey Fine Sand	11.3 – 18.0		2.0
Clay	18.0 – 25.0		0.01

- a. Average Kh = 13.2 ft/day
- b. Average Kh = 7.2 ft/day
- c. Average Kh = 5.8 ft/day
- d. Average Kh = 4.5 ft/day

Question 21 Given:
Elevation of water at end of storm (start of recovery) = 224.0 ft
Elevation of pond bottom = 218.0 ft
Average length of pond = 450 ft
Average width of pond = 225 ft
Aquifer base elevation = 200.0 ft
Design groundwater level (normal seasonal high) = 220.0 ft

Average horizontal hydraulic conductivity, Kh = 20 ft/day
Effective storage coefficient for saturated flow = 0.20
h_c = 3.0 ft.
H_T = 4.0 ft
F_y = 3.0 ft/4.0 ft = 0.75

21. For a wet retention pond that has no outfall (closed basin) and the given data, calculate the time of recovery for 1 foot drop of water in the pond after the storm event. Select the closest value listed below:

- ○ a. total recovery time = 1.6 days
- ○ b. total recovery time = 2.2 days
- ○ c. total recovery time = 3.5 days
- ○ d. total recovery time = 5.4 days

Question 22 Given:
Elevation at high water level = 62.0 ft
Elevation of pond bottom = 59.0 ft
Aquifer base elevation = 35.0 ft
Design groundwater level (normal seasonal high) = 52.0 ft
Average vertical hydraulic conductivity, Kvs = 12.0 ft/day
Effective storage coefficient for unsaturated flow = 0.30

22. For a dry retention pond and the given data, calculate the time of unsaturated infiltration only. Select the closest value listed below:

- ○ a. total recovery time = 6.3 hours
- ○ b. total recovery time = 12.2 hours
- ○ c. total recovery time = 32.0 hours
- ○ d. total recovery time = 58.3 hours

Question 23 Given:
Elevation at high water level = 180.0 ft
Elevation of pond bottom = 175.0 ft
Design groundwater level (normal seasonal high) = 145.0 ft
Average vertical hydraulic conductivity, Kvs = 1.0 ft/day

23. For a dry retention pond built in clayey fine sand soils and the data given below, calculate the time of recovery using unsaturated infiltration only. Select the closest value listed below:

- ○ a. total recovery time = 66.0 hours
- ○ b. total recovery time = 92.2 hours
- ○ c. total recovery time =180.0 hours
- ○ d. total recovery time =250.3 hours

Question 24 Given:
Pond volume at high water level = 270,400 ft^3
Elevation at high water level = 156.0 ft
Elevation of pond bottom = 152.0 ft
The pond is circular in shape
Aquifer base elevation = 105.0 ft
Design groundwater level (normal seasonal high) = 148.0 ft
Average horizontal hydraulic conductivity, Kh = 15.0 ft/day
Average vertical hydraulic conductivity, Kvs = 10.0 ft/day

Effective storage coefficient for unsaturated flow = 0.18
Effective storage coefficient for saturated flow = 0.30

Calculated:

Calculated unsaturated infiltration volume = 48,672 ft^3
Calculated unsaturated time of infiltration = 2.59 hours
Calculated elevation of water for start of saturated flow = 155.28 ft
Calculated H_T value = 7.28 ft
$h_c = H_T F_y$

24. For the given pond and aquifer data and the given time and volume of unsaturated infiltration, calculate the water elevation of the pond after a total of 3 days (72 hours) of recovery. Remember to subtract the unsaturated infiltration time from the total infiltration time. Use the dimensionless curve graphs included on **Figures 6 – 9**. Select the closest value listed below:

- a. water elevation after 3 days = 45.0 ft
- b. water elevation after 3 days = 103.5 ft
- c. water elevation after 3 days = 153.1 ft
- d. water elevation after 3 days = 182.5 ft

Question 25 Given:

Pond volume at high water level = 500,000 ft^3
Elevation at high water level = 5,130.0 ft
Elevation of pond bottom = 5,127.0 ft
Average vertical hydraulic conductivity, Kvs = 0.7 ft/day

25. For the given pond and aquifer data, calculate the time of pond recovery, assuming the depth to groundwater level is greater than 50 feet and all infiltration recovery will occur through unsaturated infiltration. Select the closest value listed below:

- a. 3.4 days
- b. 4.3 days
- c. 6.4 days
- d. 35.7 days