AP® ENVIRONMENTAL SCIENCE
2014 SCORING GUIDELINES

Question 2

Fremont Water Data
The shopping center's parking lot is 200 meters long and 100 meters wide.
Fremont has an area of 10 km^2.
Impervious surfaces cover 20 percent of Fremont's area.
The FWTP typically treats 5,000 m^3 of domestic sewage per day.
The FWTP has the capacity to treat 10,000 m^3 of combined sewage and storm water per day.

(a) Identify TWO specific pollutants in storm-water runoff that degrade the quality of surface water.
(2 points: 1 point for each bulleted pollutant)

- Nitrogen/nitrates/NO_3^-
- Phosphorus/phosphates/PO_4^{3-}
- Fertilizers
- Pesticides/herbicides
- Silt/sediment/soil
- Pathogens (two specific pathogens can each earn 1 point):
  - *E. coli*/coliform bacteria
  - *Salmonella*
  - *Cryptosporidium*
- Ammonia/nitrogenous wastes
- Animal feces
- [Road] salts
- Motor oil
- Grease
- Antifreeze
- Rubber (tire residue)
- Gasoline
- Trash (e.g., plastics, garbage, cigarette butts)
- Detergents
- Sulfuric/nitric acid from acid rain
- Mercury from contaminated rainfall

Question 2 (continued)

(b) Calculate the volume of water (in m^3) that runs off the Shoppes at Fremont parking lot after a 5 cm rainfall event. Assume that all the water that falls on the parking lot runs off.
(2 points: 1 point for a correct setup and 1 point for the correct answer)

$[200\ \text{m} \times 100\ \text{m} = 20{,}000\ \text{m}^2 \text{ or } 2 \times 10^4\ \text{m}^2]$

$\left[5\ \text{cm} \times \frac{1\ \text{m}}{100\ \text{cm}} = 0.05\ \text{m}\right]$

$200\ \text{m} \times 100\ \text{m} \times 0.05\ \text{m} = 1{,}000\ \text{m}^3 \text{ or } 1 \times 10^3\ \text{m}^3$

(Note: Units are not required in the answer; however, students must show the calculation in order to receive credit for the correct answer.)

(c) Calculate the volume of storm-water runoff (in m^3) generated in all of Fremont by the 5 cm rainfall event. Assume that only the impervious surfaces generate runoff.
(2 points: 1 point for a correct setup and 1 point for the correct answer)

$\left[5\ \text{cm} \times \frac{1\ \text{m}}{100\ \text{cm}} = 0.05\ \text{m}\right]$

$\left[10\ \text{km}^2 \times \frac{1 \times 10^6\ \text{m}^2}{1\ \text{km}^2} = 10{,}000{,}000\ \text{m}^2 \text{ or } 1 \times 10^7\ \text{m}^2\right]$

$0.05\ \text{m} \times 1 \times 10^7 \text{m}^2 \times 0.20 = 100{,}000\ \text{m}^3 \text{ or } 1 \times 10^5\ \text{m}^3$

OR

$5\ \text{cm} \times \frac{1\ \text{m}}{100\ \text{cm}} \times 10\ \text{km}^2 \times \frac{1 \times 10^6\ \text{m}^2}{1\ \text{km}^2} \times 0.20 = 100{,}000\ \text{m}^3 \text{ or } 1 \times 10^5\ \text{m}^3$

(Note: Units are not required in the answer; however, students must show the calculation in order to receive credit for the correct answer.)

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Question 2 (continued)

(d) Assume that all the runoff that you calculated in part (c) is captured by the storm sewers in one day. Calculate the volume of untreated water (in m^3) that bypasses the plant as a result of the storm. (Note that the plant still receives 5,000 m^3 of domestic sewage per day.)

(1 point for the correct answer, with work shown)

$$100{,}000\ m^3 + 5{,}000\ m^3 - 10{,}000\ m^3 = 95{,}000\ m^3$$

OR

$$[10{,}000\ m^3 - 5{,}000\ m^3 = 5{,}000\ m^3]$$

$$100{,}000\ m^3 - 5{,}000\ m^3 = 95{,}000\ m^3$$

(e) Describe TWO ways that the volume of storm-water runoff can be reduced.

(2 points: 1 point for each description of a strategy for reducing storm-water runoff)

- Decreasing area covered by impervious surfaces would increase infiltration of storm water
- Increasing area covered by trees/vegetation would increase infiltration/allow for greater uptake of storm water
- Creating basins/ponds to hold storm water
- Creating wetlands to absorb storm water
- Installing rain barrels, cisterns, or other devices to hold storm water
- Using green roofs or rooftop gardens to use rainwater
- Contour farming/terracing to allow water to infiltrate soil

(f) Describe one environmental problem (other than pollution from runoff and from untreated sewage) that results from having extensive paved areas.

(1 point can be earned for a description of an environmental problem)

- Habitat destruction/biodiversity loss caused by the removal of vegetation (or other plausible description of a mechanism for habitat destruction/biodiversity loss)
- Habitat fragmentation caused by roads dividing habitat into smaller areas
- Microclimate caused by paved surfaces absorbing heat/solar energy and releasing heat [at night]
- Flooding/bank erosion/turbidity/loss of aquatic organisms caused by excessive runoff into surface waters
- Groundwater depletion because water runs off rather than infiltrating soil/recharging aquifers
- Drying of soil/subsidence/formation of sinkholes because water runs off instead of infiltrating soil
- Erosion caused by flooding/excessive runoff
- Flooding caused by excessive runoff/lack of infiltration of storm water