AP® Environmental Science
2012 Scoring Guidelines

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Question1

Read the following article from the *Fremont Gazette* and answer the questions that follow.

(a) Identify and describe TWO water-related environmental problems associated with fracking.
(*4 points: 1 point for each identification and 1 point for each description*)

Students may earn a point for either identifying a problem or describing a problem. However, if an issue is identified, it must be linked correctly to its description in order to earn 2 points.

Identification of the problem (2 points maximum)	**Description** (2 points maximum)
Groundwater contamination	• Fracking liquids or chemicals can contaminate drinking water or groundwater. • Liquid waste stored in waste lagoons can leach into groundwater (aquifer). • Drilling can allow methane (or natural gas) to seep into groundwater. • Leaks from the well casings can contaminate the water with either fracking liquids or flowback liquids. • Radioactive isotopes used as tracers in fracking fluids can contaminate groundwater.
Surface water contamination	• Brine (or wastewater) sprayed on roadways can run off and contaminate rivers, streams, and lakes. • Spills of brine (or wastewater) can contaminate rivers, streams, and lakes. • Wastewater disposed of in streams and rivers may contain salts, heavy metals, benzene, and/or other components of fracking liquid.
Excessive water use or consumption	• Considerable amounts of water are used in the fracking process. This can result in overdrafts of aquifers. • Water demands for the fracking process compete with water demands for drinking or irrigation (agriculture).

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Question 1 (continued)

(b) Natural gas is considered to be a better fossil fuel for the environment than coal is. Discuss TWO environmental benefits of using natural gas as a fuel compared to using coal.
(*2 points*)

Benefits of natural gas (must be environmental, not economic) include the following:

- Fewer SO_x are produced, resulting in less acid rain.
- Fewer NO_x are produced, resulting in less acid rain and less photochemical smog.
- Less Hg is released.
- Harmful mining techniques are avoided; for example, no strip mining or mountaintop removal is required.
- Fewer particulates (soot) are released.
- Less CO_2 is produced.

(c) Describe TWO environmental drawbacks, not related to water use, of using the fracking process to extract natural gas from shale.
(*2 points: only the first two descriptions can earn points*)

Environmental drawbacks of fracking include the following:

- Habitat fragmentation/destruction can occur from setting up the drilling site or from building roads.
- Earthquakes can result from the drilling/fracking process.
- Methane can leak (into the atmosphere) during the process, resulting in an increase of greenhouse gases.
- Subsidence of the land can occur once fracking fluids are removed.
- Trucks and drilling equipment consume a nonrenewable fuel and release CO_2 (greenhouse gases) and, potentially, SO_x (which produce acid rain) and NO_x (which produce acid rain and photochemical smog).
- Noise pollution is caused by the drilling rigs and by increased truck traffic.
- Soil salinization or heavy metal contamination can result from the spraying of wastewater.
- The drilling site increases the amount of particulate matter in the air.
- Other appropriate examples may also earn points.

(d) Describe one economic benefit to society of using fracking to extract natural gas from shale.
(*1 point*)

Economic benefits of fracking include the following:

- Development of a domestic energy resource (reducing foreign influences on price).
- Creation of jobs.
- Financial gains to individuals who lease their property to the natural gas companies.

Question 1 (continued)

(e) Nuclear power is an alternative to using natural gas or coal as a fuel for generating electricity. However, there are also problems associated with nuclear power plants. Describe TWO negative environmental impacts associated with nuclear power.
(*2 points*)

Negative environmental impacts of nuclear power include the following:

- Spent nuclear waste (fuel): a storage facility does not exist for high-level waste; waste has to be stored for 10 half-lives in order to be considered safe.
- Thermal pollution from cooling operations (impacting surface waters).
- Nuclear accidents/plant failures: release of radioactive substances, resulting in contamination of soil, water, air, and living organisms.
- Results of mining uranium:
  - Habitat degradation.
  - Radioactive mine tailings.
  - Large amounts of water are used.
  - CO_2 is released during the transportation and enrichment process (from fossil fuels).
- Uranium is a nonrenewable resource.
- Limited life span: plants have to be decommissioned.
- Runoff into surface waters during construction.
- Waste produced during the enrichment process.
- Nuclear energy production is less efficient than a coal-burning power plant; most uranium ends up as waste.

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Question 2

The Fremont School District uses oil to heat school buildings. Go Green! is a new project the district will implement. The superintendent has declared that the district will dedicate itself to reducing its carbon footprint. In addition to taking serious energy-conservation measures, the district is planning to help offset its carbon dioxide emissions by raising money to help conserve a portion of a large tract of forest land adjacent to the high school campus.

(a) Describe one alternative energy source that would reduce the carbon footprint of the school district. Discuss one environmental benefit (other than reduced CO_2 emissions) and one environmental drawback of using the alternative source instead of fuel oil.
(*3 points*)

One point can be earned for describing an alternative energy source that would reduce the carbon footprint. One point can be earned for identifying an environmental benefit of the alternative source. One point can be earned for identifying an environmental drawback of using the alternative energy source. Acceptable examples include, but are not limited to, the following:

	Description	**Environmental benefits/drawbacks**
Wind	Turbines are used to capture energy from wind to produce electricity.	<u>Benefits</u> • Minimal habitat disruption/alteration. • Used in agricultural areas where habitat destruction is already complete. • Land may also be used to raise livestock/grow crops. • Produces no air pollution. <u>Drawbacks</u> • Often requires a large expanse of land/habitat. • Turbines are unsightly. • Sound/vibration is annoying. • Turbines kill/affect migration of birds/bats. • Requires toxic materials for production.
Nuclear	Uranium/plutonium/nuclear fission is used to create steam to rotate turbines to produce electricity.	<u>Benefits</u> • Produces little/no air pollution (other than mining and reprocessing). • Reservoirs (for coolant water) provide recreational opportunities. <u>Drawbacks</u> • Creates potential for radiation leaks/accidents. • Unsafe storage of nuclear wastes.

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Question 2 (continued)

	Description	**Environmental benefits/drawbacks**
Solar	Passive solar: south-facing windows or a solar sunspace can be used to capture sunlight to heat the school.	Benefits • Produces no air pollution. • Requires little/no disruption of land/habitat. Drawbacks • Could make school too warm in summer. • May require removal of trees to allow sunlight to enter. • Birds may fly into windows.
	Active solar: a collector is used to absorb solar radiation and transfer the heat to a fluid that is pumped through the device: • Fluid is used to heat water in a hot water tank, or • Air/water can be used directly for space heating.	Benefits • Produces little/no air pollution. • Requires little/no disturbance of habitat. Drawbacks • Materials for panel need to be mined, causing habitat destruction/water pollution. • Collectors are unsightly. • May require removal of trees to allow sunlight to enter.
	Photovoltaic: photovoltaic/solar cells are used to convert energy from (photons of) light to electricity.	Benefits • Requires little/no disruption of land/habitat (especially if panels are installed on rooftops). • Produces little/no air pollution. Drawbacks • Photovoltaic cells are unsightly. • Materials for cells must be mined, causing habitat destruction/water pollution. • Requires toxic materials in production of cells and storage batteries. • Requires disposal of toxic materials in batteries/used panels.
Geothermal	Conventional: • Fluid naturally heated underground is used directly as a source of heat, or • Steam is used to rotate a turbine to produce electricity.	Benefits • Requires little/no disruption of land/habitat. • Small-scale heat pump systems produce no air pollutants. Drawbacks • Systems are noisy. • Releases unpleasant odor (from H_2S). • Can cause land subsidence.
	Heat pump: pipes are used to transfer heat into the ground in the summer (to cool the school) and out of the ground in the winter (to heat the school).	Benefits • Requires little/no disruption of land/habitat. • Produces little/no air pollution. Drawbacks • Energy must be used to pump fluid, with the associated ecological impact, depending on the source of the energy.

Question 2 (continued)

	Description	**Environmental benefits/drawbacks**
Biomass	Wood, charcoal, manure, garbage, plants, or crop residue are burned to produce electricity/heat.	Benefits • Burning garbage uses waste materials that would otherwise require destruction of habitat when placed in landfills. • Plants used for fuels can be grown on marginal land. Drawbacks • Requires destruction of habitat/biodiversity for fuel wood/plantations/monoculture crop production. • Causes increased soil erosion/water pollution in deforested areas. • Land could instead be used for growing (food) crops. • Depletes soil nutrients in plantations/agricultural areas. • Can produce air pollutants (e.g., CO).
	Solid biomass is converted to natural gas (biogas) via use of anaerobic bacteria/digester.	Benefits • Uses animal waste products that could otherwise pollute waterways or groundwater. • Converts animal waste products that could otherwise pollute waterways/groundwater. • Captures methane that would otherwise contribute to global climate change. Drawbacks • Produces unpleasant odor. • Could potentially leak methane (a greenhouse gas). • Manure could otherwise be used to replenish soil nutrients.
Hydropower	Flowing water is used to rotate turbines to create electricity.	Benefits • Hydroelectric dam/reservoir may provide flood control. • Reservoir provides recreational opportunities (e.g., boating, fishing). • Reservoir provides reliable water source for irrigation and drinking. • Produces little/no air/water pollution. Drawbacks • May cause displacement of people/animals living in area flooded by dam. • Can cause water loss via evaporation from reservoir. • Dam prevents/interferes with fish migration. • Soils saturated by/plants killed by flooding can produce methane (a greenhouse gas). • Can result in seismic activity beneath reservoir. • Causes habitat alteration/destruction (via flooding of habitat above dam, or alteration of water temperature/silt deposition in river below dam).

Question 2 (continued)

(b) Identify TWO ecological benefits provided by intact forest ecosystems (other than reducing CO_2 levels in the atmosphere).
(*2 points: 1 each for identifying two ecological benefits*)

Intact forest ecosystems:

- Provide homes/shelter (students may say "habitat") for organisms
- Provide food for organisms
- Maintain biodiversity
- Moderate/regulate (local) climate
- Produce oxygen
- Purify water
- Purify air
- Reduce soil erosion
- Absorb/store/regulate water
- Moderate stream temperature
- Moderate stream flow
- Aid in nutrient cycling
- Aid in soil formation

(c) Use the assumptions below to answer the questions that follow. For each calculation, show all work.

The biomass of the forest increases at an annual rate of 2.7×10^5 kg/ha.
The forest biomass is 50 percent carbon by mass.
Each year the district uses 3.0×10^5 gallons of fuel oil for heating and hot water.
10 kg of CO_2 is produced when 1 gallon of fuel oil is burned.
1.0 kg of CO_2 contains 0.27 kg of carbon.
The cost of putting 1 ha of the forest into conservancy is $12,000.

(i) Calculate the mass of carbon, in kg, that is accumulated and stored in 1.0 ha of forest in one year.
(*1 point for a correct answer*)

$$1 \text{ ha} \times \frac{2.7 \times 10^5 \text{ kg}}{\text{ha}} \times 0.5 = 1.35 \times 10^5 \text{ kg}$$

(ii) Calculate the mass of carbon, in kg, that is emitted by the school as a result of its fuel-oil consumption in one year.
(*2 points: 1 point for the correct setup and 1 point for the correct answer*)

$$3.0 \times 10^5 \text{ gal} \times \frac{10 \text{ kg } CO_2}{\text{gal}} \times \frac{0.27 \text{ kg C}}{\text{kg } CO_2} = 8.1 \times 10^5 \text{ kg}$$

Question 2 (continued)

(iii) Calculate the number of hectares of forest the school district needs to conserve in order to offset the carbon released in one year by the school burning its fuel oil.
(*2 points: 1 point for the correct setup and 1 point for the correct answer*)

$$\frac{8.1 \times 10^5 \text{ kg}}{1.35 \times 10^5 \text{ kg/ha}} = 6 \text{ ha}$$

(iv) Calculate the amount of money the school district must raise for the conservation project.
(*1 point for a correct answer*)

$$6 \text{ ha} \times \frac{\$12{,}000}{\text{ha}} = \$72{,}000$$

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Question 3

The active ingredients in many pesticides are chemical compounds that kill organisms such as insects, molds, and weeds. Proponents claim that the use of pesticides improves crop yields and thus protects land and soil by reducing the conversion of forests and wetlands to cropland. Opponents of pesticide use claim that pesticides degrade water and soil quality and that other modern agricultural techniques and practices are responsible for the improved crop yields in recent years.

(a) Design a laboratory experiment to determine whether or not a new pesticide (product X) is toxic to minnows, a type of small fish. For the experiment you design, be sure to do all of the following.

(i) State the hypothesis.
(*1 point*)

A correct hypothesis includes the following:

- The hypothesis must predict a relationship between product X and minnow health.
- The prediction must indicate a specific direction of change for each variable, such as:
  - An increase in product X concentration will result in increased minnow mortality.
  - Does decreasing exposure to product X result in increased survivorship of minnows?
- Students may also state a null hypothesis in which they predict no relationship between product X and minnow health, such as:
  - Changing the concentration of product X has no effect on minnow health.
  - Increasing exposure to product X does not change minnow mortality.

(ii) Describe the method you would use to test your hypothesis.
(*1 point*)

A point is earned for a correct method that indicates the manipulation of the independent variable (product X). *Note:* The method must include a minimum of three experimental groups, one of which is not exposed to product X.

(iii) Identify the control.
(*1 point*)

A point is earned for the identification of an experimental group without the presence of product X as the control.

(iv) Identify the dependent variable.
(*1 point*)

A point is earned for the identification of a measure of minnow health as the dependent variable.

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Question 3 (continued)

(b) Describe experimental results that would lead you to reject your hypothesis in part (a)(i). (Be specific.)
(*1 point*)

A point is earned for a correct description of experimental results that include minnow health measurements that contradict the prediction in the hypothesis stated in part (a)(i). *Note:* A point can be earned with an incorrectly stated hypothesis in (a)(i), if the results described correctly contradict the statement in (a)(i).

(c) One strategy for dealing with agricultural pests is integrated pest management (IPM).

(i) Describe IPM. As part of your description, include TWO specific pest-control approaches that are part of IPM.
(*3 points: 1 point for a description of IPM and 1 point each for including two specific pest-control approaches that are part of IPM*)

One point can be earned for a description of IPM that demonstrates an understanding of one of the following:

- IPM uses a combination of biological, chemical, and physical (two of the three) means to control pests.
- IPM is used to reduce or eliminate the use of pesticides.
- IPM is used to reduce pest populations to acceptable or tolerable levels.

One point can be earned for each of two specific pest-control approaches that are part of IPM (only the first two approaches mentioned can earn points):

- Introduce, attract, or create habitat for the predators of pests.
- Introduce parasites that feed on pests.
- Introduce diseases or disease-carrying bacteria to kill pests.
- Vacuum pests from crops.
- Rotate crops.
- Plant multiple crops simultaneously (e.g., polyculture, intercropping).
- Adjust the planting times of crops.
- Use pheromones to attract pests to traps.
- Spray crops with hot water to scald pests.
- Introduce sterile males into pest populations to decrease their reproductive success.
- Use narrow-spectrum, or less persistent pesticides.
- Spray crops with soap solutions.
- Use noise to repel pests.
- Cultivate pest-resistant genetically modified crops.
- Use physical barriers to prevent pests from reaching crops.
- Other appropriate examples may also earn points.

Question 3 (continued)

(ii) Identify one environmental benefit of using IPM.
(*1 point: only the first benefit mentioned can earn a point*)

Note: The benefit must be environmental; economic and societal benefits are not acceptable:

- Reduces the introduction of pesticides into areas other than farmland (e.g., runoff, overspray).
- Reduces incidental killing of non-targeted organisms (e.g., bees, spiders, ladybugs, birds).
- Reduces soil compaction by pesticide application equipment.
- Reduces CO_2 emissions from pesticide production and application equipment.
- Reduces erosion.
- Reduces bioaccumulation/biomagnification of pesticides.
- Reduces genetic resistance to pesticides.
- Other appropriate examples may also earn points.

(d) Describe TWO agricultural practices, other than those involving pest control, that increase crop yields.
(*2 points: 1 point for each correct practice described; only the first two practices mentioned can earn points*)

The following are acceptable with a suitable description of the practice or how the results of the practice would increase crop yields:

- Develop and plant high-yielding varieties of crops.
- Plant high-yielding genetically modified varieties of crops.
- Plant monocultures (monocropping).
- Plant polycultures.
- Rotate crops.
- Intercropping (alley cropping).
- Use irrigation systems.
- Apply fertilizers.
- Amend soil with organic material (e.g., compost, manure, mulch).
- Keep land in constant production (multiple cropping).
- Use modern farm equipment (e.g., tractors, harvesters).
- Grow crops in greenhouses.
- Grow crops hydroponically.
- Terracing of slopes.
- Contour plowing.
- Plant windbreaks or shelterbelts.
- Plow or till soil.
- Till soil with lower frequency (low-till or no-till).
- Slash and burn farming practices.
- Plant cover crops.
- Other appropriate examples may also earn points.

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Question 4

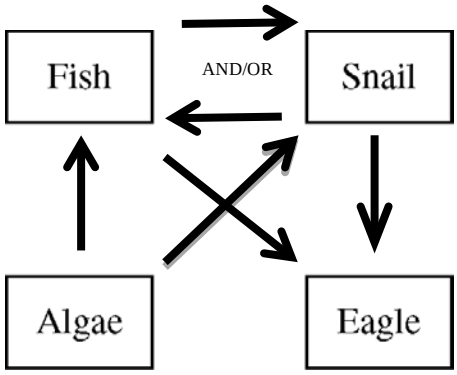
Wetlands were once considered to be wastelands. Over 50 percent of the United States original wetlands have been destroyed.

(a) Describe TWO characteristics that are used by scientists to define an area as a wetland.
(*2 points: 1 point for each characteristic; only the first two characteristics mentioned can earn points*)

- Soil covered/saturated/submerged/inundated/flooded with water (for all or part of the year) OR shallow/standing water with emergent vegetation.
- Plants/vegetation have adaptations that allow them to live under these conditions (are water tolerant).
- Characteristic (hydric) soils.

(b) Wetlands are highly productive ecosystems with complex food webs.

(i) Complete the diagram of the wetland food web below by drawing arrows that show the direction of energy flow.
(*2 points: Three arrows are required. ALL boxes must have at least one connecting arrow, and no points are earned if ANY arrows are incorrect. One point can be earned for at least two correct arrows indicating a food chain, and 1 additional point can be earned for creating a food web connecting two food chains that share a species in common*)



(ii) Explain why it takes many hectares of wetland to support a pair of eagles.
(*2 points: 1 point for each correct explanation*)

- To support a pair of eagles, there must be a large amount of biomass at lower trophic levels.
- Less energy is available at each successive trophic level, because as energy moves up the food chain, much of it is:
  - lost as heat (10 percent rule) or lost as metabolic work; or,
  - transformed into a less usable form/becomes less organized (second law of thermodynamics).
- Some biomass is not digestible at the next trophic level (e.g., cellulose, chitin). *Note:* Students may use a trophic pyramid diagram, but it must be accompanied by an explanation in order to earn credit.

Question 4 (continued)

(c) Describe TWO economic benefits (other than those related to water quality) that wetlands provide.
(*2 points: 1 point for each economic benefit LINKED to each description; only first two descriptions provided can earn points*)

Acceptable benefits include, but are not limited to, the following:

Benefit	Description
Recreation/aesthetic uses	• Provide revenue/profits/jobs from tourism • Provide revenue from permits/hunting/fishing licenses
Nurseries for fish and shellfish species/areas for aquaculture	• Provide fish/shellfish for sale by commercial fishers
Absorption of excess water	• Reduces cost of flood damage to property (roads, buildings, other infrastructure, crops) • Reduces insurance costs
Storm protection	• Reduces cost of hurricane/tsunami damage • Reduces insurance costs
Protection of biodiversity	• Provides jobs in conservation/biological resources management
Carbon sequestration/sink	• Reduces cost of mitigating effects of climate change
Methane collection	• Provides revenue
Provide water supply (particularly during periods of drought)	• Supports revenue from agricultural crops • Lowers costs for irrigation • Reduces the need to build costly dams
Used for agriculture	• Commercial species/trade (such as wild rice, cranberries, blackberries, blueberries)
Shoreline stabilization/erosion protection	• Reduces financial loss associated with rising sea level (agriculture/development) • Reduces insurance costs
Extraction of products (fossil fuels, phosphate/fertilizer, peat, gravel, building materials, minerals, wood/timber)	• Revenue/profits from sale/trade
Recharge ground water	• Reduces cost of water treatment (infrastructure/transportation/desalination/reverse osmosis)

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Question 4 (continued)

(d) Describe one specific human activity that degrades wetlands.
(*1 point: only the only first description provided can earn points*)

- Converting to other uses (draining/filling)
  - Agriculture
  - Buildings/infrastructure/development
- Runoff/urban storm water drainage
  - Sediment
  - Chemical pollutants: fertilizer, pesticides, heavy metals, oil
  - Sewage
  - Litter/trash/solids
- Disposing of waste such as dumps/landfills/livestock waste (e.g., hog lagoons)
- Overharvesting/poaching
  - Commercial fishing
  - Recreational hunting and fishing
- Logging/deforestation/removal of trees to allow alternative use of the wetland or for sale of timber
- Recreational vehicles
  - Disturb sediment/bottom
  - Damage aquatic vegetation
  - Injure/kill organisms
  - Produce noise pollution
- Water diversion
  - Damming/levees/building barriers to control/change water flow/levels
  - Diking/building barriers to control rising sea level
  - Use for water supply (irrigation, municipal, industrial)
- Dredging/channelization for navigation
- Anthropogenic acid precipitation from fossil fuel (coal) burning
- Oil spills from tankers/drilling platforms/transportation
- Waste disposal/habitat destruction associated with recreational activities
  - Fishing and hunting activities
- Mining for minerals, fossil fuels, building materials, or peat
- Draining to reduce mosquito populations/malaria
- Human-induced sea level rise (climate change)
- Conversion to commercial aquaculture facilities
- Introduction of invasive species

(e) Wastewater treatment plants perform some of the same water-quality improvement functions that natural wetlands perform. Explain how wetlands perform the equivalent of

(i) primary treatment, and
(*1 point: only the first explanation provided can earn points*)

Physical/mechanical removal/trapping of sediment/solids/objects/particulates through processes such as settling, sedimentation, filtering, and screening.

Question 4 (continued)

(ii) secondary treatment
(*1 point: only the first explanation provided can earn points*)

Biological/bacterial/microbial removal of waste through breakdown, decomposition, and aerobic respiration/consumption.