

CERTIFIED PROFESSIONAL IN STORMWATER QUALITY®

EXAMPLE EXAM QUESTIONS



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CPSWQ EXAMPLE EXAM QUESTIONS COMBINED IMPERIAL AND STANDARD INTERNATIONAL VERSION

ECI has provided the following questions as examples as to what to expect on the Certification Exam for CPSWQ. An answer sheet with a brief explanation is provided after the questions.

Values in italics represent Standard International values. If there are no italics the values are the same in both Imperial and Standard International units.

Example Questions:

1. What is the definition of a stormwater pollutant?
 - a. anything that enhances stormwater runoff and can positively impact water quality
 - b. anything that enhances stormwater runoff and can negatively impact water quality
 - c. anything that contaminates stormwater runoff and can positively impact water quality
 - d. anything that contaminates stormwater runoff and can negatively impact water quality

2. An aerobic environment, by definition is saturated with:
 - a. Oxygen
 - b. Microorganisms
 - c. Light
 - d. Nutrients

3. Which of the following is NOT a stream classification system
 - a. Strahler Stream Order Classification
 - b. Montgomery-Buffington Stream Classification
 - c. Stream Channel Profile and Pattern Classification
 - d. Rosgen Stream Classification

4. What does an Isohyetal Map represent?
- a. An isohyetal map is a map that uses isohyets (lines) to connect points that have the same elevation on the land surface
 - b. An isohyetal map is a map that uses isohyets (lines) to connect points that have the same amount of precipitation over a specific period of time.
 - c. An isohyetal map is a map that uses isohyets (lines) to connect points that have the same amount of rainfall erosivity.
 - d. An isohyetal map is a map that uses isohyets (lines) to connect points that depict the same type of soil.
5. What does the term quantification mean when discussing pollutants?
- a. The calculation of determining the quantity difference of a pollutant before and after construction
 - b. The process of measuring and assessing the amount and type of pollutants in a specific environment
 - c. The effect of a pollutant measured in miles (kilometers) downstream of the source
 - d. The effect of a pollutant measured in time

6. As a SWM designer you have determined that the four and a half ($4 \frac{1}{2}$) acres (*1.82 hectares*) draining to the proposed detention pond needs to be temporarily stabilized prior to construction of the pond. After consulting with the Soils Scientist and Landscape Architect it has been determined that two and a half ($2 \frac{1}{2}$) tons (*5.60 tonnes*) of straw needs to be applied per acre (*hectare*). If one (1) bale of straw weighs 88 pounds (*40.0 kilograms*) how many bales will be required to mulch the area draining to the pond.

- a. 57 straw bales *56 straw bales*
- b. 142 straw bales *141 straw bales*
- c. 256 straw bales *255 straw bales*
- d. 102 straw bales *101 straw bales*

7. After performing sampling data on highway runoff, a discharge concentration of 0.148 mg/l of a pollutant was identified, 0.132 mg/l above the concentration of the pollutant found in the receiving waters. Per regulations the threshold for aquatic life, discharge is restricted to 0.0069 mg/l of the pollutant above background (existing conditions). Using the formula initial pollutant concentration (C_1) * initial discharge volume (V_1) = final pollutant concentration (C_2) * final volume (V_2), how much volume of stream water would be needed to dilute three (3) liters of the discharge to required concentrations.

- a. 22.6 liters
- b. 19.4 liters
- c. 6.8 liters
- d. 16.4 liters

8. The project you are working on will expand an existing paved parking area from 10 acres (*4.05 hectares*) to 12 acres (*4.86 hectares*). Currently there is no treatment of existing parking lot runoff. Local regulations require a “no increase” pre versus post project in TSS loading. You have selected a stormwater wetland to provide for the required TSS removal. A stormwater wetland has a TSS removal rate of 76%. Determine the amount of paving needs to be treated to meet the “no increase” requirement.

- a. 1.34 acres *0.54 hectares*
- b. 2.63 acres *1.07 hectares*
- c. 9.12 acres *3.69 hectares*
- d. 2.00 acres *0.81 hectares*

Questions 9 through 16 are based on the following Scenario

You have just purchased a seventy-five (75) acre (30.35 hectares) parcel of land to develop as town houses with retail/commercial space. The local jurisdiction is requiring that the wooded area of the site to remain undisturbed and ignored when performing calculations for stormwater treatment.

TR-55 Worksheets and Quantification Worksheets can be found at the end of this document.

Site Parameters:

Soils

Groton Soil – Hydrologic Soil Group A

Acton Soil – Hydrologic Soil Group B

Paxton Soil – Hydrologic Soil Group C

RCN Factors – Same in both imperial and standard international

Woods good conditions – A = 30, B = 55, C = 70, D = 77

Meadow – A = 30, B = 58, C = 71, D = 78

Pasture poor condition – A = 68, B = 79, C = 86, D = 89

Farmstead – A = 59, B = 74, C = 82, D = 86

Town Houses – A = 77, B = 85, C = 90, D = 92

Retail/Commercial – A = 89, B = 92, C = 94, D = 95

Newly Graded Areas – A = 77, B = 86, C = 91, D = 94

Isohyetal Value for twenty-four (24) hour storm

2-year storm 3.2 inches (8.128 cm)

10-year storm 5.1 inches (12.954 cm)

100-year storm 7.3 inches (18.542 cm)

Rainfall Distribution – Type 2

Manning's n Values

Sheet Flow Smooth surfaces = 0.011

Sheet Flow Short grass = 0.05

Sheet Flow Dense grass = 0.24

Grass Lined Channel = 0.03

Existing Travel Segments

Segment 1 - 75 feet (*22.86 meters*) of overland flow on a 4.0% slope through dense grass

Segment 2 - 20 feet (*6.10 meters*) of overland flow on a 3% slope through short grass

Segment 3 – 1,500 feet (*457.20 meters*) of shallow concentrated flow through pasture on a 3% slope resulting in a velocity of 2.8 feet per second (*0.85 meters per second*)

Segment 4 - 15 feet (*4.57 meters*) over a paved driveway with a 2% reversed crown resulting in a velocity of 2.9 feet per second (*0.88 meters per second*)

Segment 5 – 3,000 feet (*914.40 meters*) of concentrated flow in a constructed grass lined trapezoidal channel at 2.5% with a bottom width of 4 feet (*1.22 meters*) and side slopes of 3:1. Design flow depth within the swale is 2.0 feet (*0.61 meters*) which results in a flow area of 20.0 square feet (*1.86 square meters*) and a wetted perimeter of 16.64 feet (*5.07 meters*).

Proposed Travel segments

Segment 1 - 35 feet (*10.67 meters*) of overland flow on a 4.0% slope through dense grass

Segment 2 - 24 feet (*7.32 meters*) of overland flow a 3% slope over a reverse crown roadway, resulting in a velocity of 3.5 feet per second (*1.07 meters per second*)

Segment 3 – 2,100 feet (*640.08 meters*) of concentrated flow at 2.5% in a constructed grass lined trapezoidal channel with a bottom width of 4 feet (*1.22 meters*) and side slopes of 3:1. Design flow depth within the swale is 2.0 feet (*0.61 meters*) which results in a flow area of 20.0 square feet (*1.86 square meters*) and a wetted perimeter of 16.64 feet (*5.07 meters*).

1a Factors

60 = 1.333	(33.87)	70 = 0.857	(21.77)	80 = 0.500	(12.70)
61 = 1.279	(32.49)	71 = 0.817	(20.75)	81 = 0.469	(11.91)
62 = 1.226	(31.14)	72 = 0.778	(19.76)	82 = 0.439	(11.15)
63 = 1.175	(29.85)	73 = 0.740	(17.87)	83 = 0.410	(10.41)
64 = 1.125	(28.58)	74 = 0.703	(17.87)	84 = 0.381	(9.667)
65 = 1.077	(27.36)	75 = 0.667	(16.94)	85 = 0.353	(8.966)
66 = 1.030	(26.16)	76 = 0.632	(16.05)	86 = 0.326	(8.280)
67 = 0.985	(25.02)	77 = 0.597	(15.16)	87 = 0.299	(7.595)
68 = 0.941	(23.90)	78 = 0.564	(14.32)	88 = 0.273	(6.934)
69 = 0.899	(22.83)	79 = 0.532	(13.51)	89 = 0.247	(6.274)

Pond and Swamp Adjustment – 1.0

Q _u Existing =	600	(0.230)
Q _u Proposed =	900	(0.385)
V _s / V _r =	0.285	(0.300)

TSS Constant Concentrations

- Forest/Rural Open = 51
- Agriculture/Pasture = 145
- Farmstead (using low density residential) = 70
- High Density Residential = 97
- Commercial = 77

TP Constant Concentrations

- Forest/Rural Open = 0.11
- Agriculture/Pasture = 0.37
- Farmstead (using low density residential) = 0.52
- High Density Residential = 0.24
- Commercial = 0.33

Equations

$$\text{Weighted RCN} - \text{Weighted RCN} = [\text{Total of each (RCN x area)}] / \text{total area}$$

$$\text{Potential Maximum Retention} - S = (1000 / \text{CN}) - 10$$

$$S = [(1000 / \text{CN}) - 10] * 25.4 \text{ (2.54 to convert to centimeters)}$$

$$\text{Peak Flow Rate} - Q = (P - (0.2 * S))^2 / (P + (0.8 * S))$$

$$\text{Acre-Feet of Runoff} = (Q * \text{acres}) / 12 \text{ inches per foot}$$

$$\text{Hectare-Meters of Runoff} = (Q * \text{hectare}) / 100$$

$$\text{Travel Time Sheet Flow} - T_t = ((0.007 * (n * L)^{0.8}) / P_2^{0.5} * s^{0.4})$$

$$T_t = ((0.007 * (n * L)^{0.8}) / P_2^{0.5} * s^{0.4})$$

$$\text{Travel Time Shallow Concentrated Flow} - T_t = L / 3600 * V$$

$$T_t = L / 3600 * V$$

$$r - r = a / p_w$$

$$r = a / p_w$$

$$V - V = (1.49 * r^{2/3} * s^{1/2}) / n$$

$$V = (1.00 * r^{2/3} * s^{1/2}) / n$$

$$\text{Travel Time Channel Flow} - T_t = L / 3600 * V$$

$$T_t = L / 3600 * V$$

$$\text{Peak Discharge} - q_p = q_u * A_m * Q * F_p$$

$$q_p = q_u * A_m * Q * F_p$$

$$V_r - V_r = Q * A_m * 53.33$$

$$V_r = Q * A_m * 1,000$$

$$V_s - V_s = V_r * (V_s / V_r)$$

$$V_s = V_r * (V_s / V_r)$$

$$L - L = [(P * P_j * R_v / 12] * C * A * 2.72$$

$$L = [(P * P_j * R_v / 1,000] * C * A * 10.09$$

$$R_v = 0.05 + (0.009 * I)$$

$$R_v = 0.05 + (0.009 * I)$$

Questions

9: Determine the composite runoff curve number for the construction portion of the site in existing, construction, and proposed conditions.

	<u>Existing</u>	<u>Construction</u>	<u>Proposed</u>
a.	74	89	89
b.	60	78	83
c.	67	84	86
d.	76	87	89

10: Using the composite CNs developed in Question 9 for the area of development and the rainfall values provided in the site parameters, calculate the existing storm runoff for the two (2) year, ten (10) year, and one hundred (100) year storm events (ex) and two (2) year, ten (10) year, and one hundred (100) year storm events for construction and proposed (cp) conditions.

		<u>2-year</u>	<u>10-year</u>	<u>100-year</u>
a.	ex	5.33 acre feet	19.84 acre feet	30.75 acre feet
	cp	10.66 acre feet	31.55 acre feet	43.05 acre feet
b.	ex	4.33 acre feet	10.17 acre feet	17.92 acre feet
	cp	8.67 acre feet	16.13 acre feet	25.00 acre feet
c.	ex	3.51 acre feet	13.07 acre feet	20.25 acre feet
	cp	7.02 acre feet	20.78 acre feet	28.35 acre feet
d.	ex	4.81 acre feet	18.02 acre feet	27.75 acre feet
	cp	9.62 acre feet	28.65 acre feet	38.85 acre feet

	<u>2-year</u>	<u>10-year</u>	<u>100-year</u>
a. ex	0.65 hectare meters	2.45 hectare meters	3.80 hectare meters
cp	1.31 hectare meters	3.87 hectare meters	5.32 hectare meters
b. ex	0.53 hectare meters	1.26 hectare meters	2.21 hectare meters
cp	1.07 hectare meters	1.99 hectare meters	3.09 hectare meters
c. ex	0.43 hectare meters	1.61 hectare meters	2.50 hectare meters
cp	0.86 hectare meters	2.54 hectare meters	3.50 hectare meters
d. ex	0.59 hectare meters	2.21 hectare meters	3.43 hectare meters
cp	1.19 hectare meters	3.49 hectare meters	4.80 hectare meters

11: Using the travel time segments found in the site parameters calculate the existing and the proposed time of concentration.

	<u>Existing Tc</u>	<u>Proposed Tc</u>	<u>Existing Tc</u>	<u>Proposed Tc</u>
a.	0.211 hours	0.132 hours	0.209 hours	0.116 hours
b.	0.255 hours	0.158 hours	0.317 hours	0.139 hours
c.	0.143 hours	0.089 hours	0.1435 hours	0.079 hours
d.	0.0.404 hours	0.145 hours	0.406 hours	0.147 hours

12: The local jurisdiction is requiring that peak storm discharge from the site in proposed conditions matches the existing conditions for a 100 year storm. Using the provided site parameters and the calculated values, determine the existing and proposed peak storm discharges.

	Existing	Proposed	Existing	Proposed
a.	227.40 cfs	507.13 cfs	6.37 cm/s	14.24 cm/s
b.	201.24 cfs	421.20 cfs	5.31 cm/s	11.88 cm/s
c.	160.89 cfs	338.09 cfs	4.25 cm/s	9.50 cm/s
d.	221.20 cfs	464.87 cfs	5.84 cm/s	13.05 cm/s

13: Using the values calculated in previous questions determine the storage volume required to store stormwater to allow for peak storm discharge from the site in proposed conditions to match the existing conditions for a 100-year storm.

- | | |
|--------------------|----------------------------------|
| a. 8.51 acre feet | <i>a. 11,121.18 cubic meters</i> |
| b. 7.11 acre feet | <i>b. 9,255.23 cubic meters</i> |
| c. 5.679 acre feet | <i>c. 7,414.12 cubic meters</i> |
| d. 7.80 acre feet | <i>d. 10,194.41 cubic meters</i> |

14: Using the annual rainfall, the annual rainfall correction factor, the pollutant concentrations, and the percent of impervious cover found in the site parameters, determine the difference in annual pollutant loading for total phosphorus under existing and proposed conditions.

- | | |
|-----------------------|--------------------------------|
| a. 47 pounds per year | <i>21.5 kilograms per year</i> |
| b. 56 pounds per year | <i>25.8 kilograms per year</i> |
| c. 37 pounds per year | <i>17.2 kilograms per year</i> |
| d. 51 pounds per year | <i>23.7 kilograms per year</i> |

15: Using the annual rainfall, the annual rainfall correction factor, the pollutant concentrations, and the percent of impervious cover found in the site parameters, determine the difference in annual pollutant loading for total suspended solids under existing and proposed conditions.

- | | |
|---------------------------|---------------------------------|
| a. 21,268 pounds per year | <i>9,833 kilograms per year</i> |
| b. 14,178 pounds per year | <i>6,555 kilograms per year</i> |
| c. 19,496 pounds per year | <i>9,013 kilograms per year</i> |
| d. 17,548 pounds per year | <i>8,033 kilograms per year</i> |

16: You have been provided the following Median Pollutant Removal (%) for total nitrogen for the following treatment practices: Stormwater Wetlands – 30%, Stormwater Wet Ponds – 33%, Stormwater Dry Ponds – 25%, and filtering practices – 38%. If the water quality treatment volume of 40 pounds (*18.14 kilograms*) is collected in the most effective treatment practice, calculate the remaining total nitrogen would be after treatment.

- | | |
|-----------------|-----------------|
| a. 29.8 pounds | 13.50 kilograms |
| b. 19.8 pounds | 9.00 kilograms |
| c. 24.8 pounds | 11.25 kilograms |
| d. 27.28 pounds | 12.38 kilograms |

Questions 17 through 19 are based on the following Scenario

A new commercial site has been required to capture/treat 600 cubic feet (*17 cubic meters*) of storm water runoff. You will be using a Bioretention facility. Assume the following Site Parameters.

Site Soils Report

The project soils report has indicated that the soils are silty sands. Percolation testing was conducted at several areas across the site at varying depths. Percolation rates measured at the surface measured approximately 0.55 inches per hour (*1.4 centimeters per hour*) while testing at depths between two (2) feet (*0.61 meters*) and six (6) feet (*1.83 meters*) below the surface measured consistently at 0.75 inches per hour (*1.8 centimeters per hour*).

Jurisdiction Water Quality BMP Requirements

The jurisdiction in which the project is located requires that Bioretention facilities shall be designed with a minimum surface area such that ponding water be infiltrated within forty-eight (48) hours. In addition, the entire system volume must have a maximum drawdown time of seventy-two (72) hours. In addition, amended planter media shall be used and have a minimum thickness of four (4) feet (*1.22 meters*) to ensure adequate space for plants to take root. If a gravel layer is used, the gravel shall be a minimum of $\frac{3}{4}$ inch (*2 centimeter*) angular stone with a minimum void ratio of 35 percent (%) with a depth of two (2) feet (*0.61 meters*). A perforated underdrain shall be installed at a minimum slope of 0.5 percent (%) if percolation rates are 0.50 inches per hour (*1.3 centimeters per hour*) or less.

The jurisdiction also provides the following BMP sizing calculations.

- t_{ponding}** = required drain time of surface ponding (hours)
- d_p** = selected surface ponding water depth in feet (*meters*) -
- d_{max}** = max depth of surface ponding that can be infiltrated within the required drain time in feet (*meters*)
- p_{design}** = site percolation rates
- l_{media}** = thickness of amended planter media in feet (*meters*)
- n_{media}** = porosity of amended planter media in feet per feet (*meters per meters*) - (assume 30 percent (%) for the referenced questions)
- n_{gravel}** = porosity of gravel layer in feet per feet (*meters per meters*)
- l_{gravel}** = depth of gravel layer in feet (*meters*) - (assume two (2) feet (0.61 meters) for the referenced questions)
- d_{effective}** = total effective storage depth of bio-retention facility in feet (*meters*)
- t_{total}** = the total depth of water that can infiltrate during the required draw down time. (hours)
- A_{req}** = required infiltrating surface area in cubic feet (*cubic meters*)

Equations

$$d_{max} = (P_{design} \times t_{ponding}) / 12$$

$$d_{max} = (P_{design} \times t_{ponding}) / 100$$

$$d_{effective} \geq (d_p + n_{media} \cdot l_{media} + n_{gravel} \cdot l_{gravel})$$

$$d_{effective} \geq (d_p + n_{media} \cdot l_{media} + n_{gravel} \cdot l_{gravel})$$

$$t_{total} = (d_{effective} / P_{design}) \times 12$$

$$t_{total} = (d_{effective} / P_{design}) \times 100$$

$$A_{req} = \text{Req. treatment volume} / d_{effective}$$

$$A_{req} = \text{Req. treatment volume} / d_{effective}$$

Questions

17: Calculate the maximum depth of surface ponding (d_{max}) that can be infiltrated within the required drain time ($t_{ponding}$) based on the site percolation rates (P_{design}).

- | | |
|-------------|-----------------------|
| a. 3.0 feet | <i>a. 0.86 meters</i> |
| b. 2.5 feet | <i>b. 76 meters</i> |
| c. 1.7 feet | <i>c. 0.52 meters</i> |
| d. 2.2 feet | <i>d. 0.67 meters</i> |

18: Using the calculated ponding depth from Question 17, calculate the total effective storage depth of the Bio-retention facility assuming the gravel layer has been installed.

- | | |
|-------------|-----------------------|
| a. 4.7 feet | <i>a. 1.44 meters</i> |
| b. 4.1 feet | <i>b. 1.25 meters</i> |
| c. 3.1 feet | <i>c. 0.94 meters</i> |
| d. 4.2 feet | <i>d. 1.28 meters</i> |

19: Using the calculated ponding depth from Question 17 and the total effective calculated in question 18, does the entire depth of the bioretention system infiltrate in the required drain time?

- a. Yes, the effective drawdown time is 89.4 hours
- b. No, the effective drawdown time is 89.4 hours
- c. Yes, the effective drawdown time is 67.5 hours
- d. No, the effective drawdown time is 67.5 hours

20: Which of the following has not been used as a mitigation of CSO impacts?

- a. Stormwater and sewage pipe combination
- b. Reducing stormwater flows
- c. Retention basins
- d. Screening and disinfection facilities

21: Using the TR-55 Travel Time for sheet flow formula, $T_t = 0.007 * (n * L)^{0.8} / (P2)^{0.5} * S^{0.4}$ ($T_t = 0.093 * (n * L)^{0.8} / P2^{0.5} * S^{0.4}$). Given the following, $n = 0.011$, sheet flow travels 125 feet (*38.10 meters*) along a 1.5% slope, and the 2-year precipitation is 1.4 inches (*35.56 millimeters*) in 24-hours? What is the travel time in minutes for sheet flow across a gravel parking lot?

- a. 0.01 minutes
- b. 1.23 minutes
- c. 2.46 minutes
- d. 4.92 minutes

22. Using the TR-55 Travel Time for shallow concentrated flow formula, $T_t = L / (3,600 * V)$ ($T_t = L / (3,600 * V)$). Given the following, 200 feet (60.96 meters) of curb flow at 2.00% to a curb cut, and then 400 feet (121.92 meters) of shallow grass channel flow at 2.00% to the outlet, resulting in velocities of 2.25 feet per second (0.69 meters per second) on unpaved surfaces and 2.85 feet per second (0.87 meters per second) on paved surfaces. What is the travel time in minutes for shallow concentrated flow across along the curb and shallow grass swale to the outlet?
- a. 4.44 minutes
 - b. 4.20 minutes
 - c. 3.51 minutes
 - d. 3.92 minutes
23. Using the TR-55 Travel Time for channel flow formulas, $r = a / Pw$, $V = (1.49 * r^{2/3} * s^{1/2}) / n$, and $T_t = L / (3,600 * V)$ ($r = a / Pw$, $V = (1.00 * r^{2/3} * s^{1/2}) / n$, and $T_t = L / (3,600 * V)$). Given the following, 1,500 feet (457.20 meters) of grassed swale flow at 3.00%, grassed swale with an 8 foot (2.44 meters) bottom width, 3:1 side slopes, and 1 foot (0.31) flow depth and a channel n factor of 0.03 (0.03). What is the travel time in minutes for channel flow in the grass swale?
- a. 3.96 minutes
 - b. 4.50 minutes
 - c. 2.70 minutes
 - d. 3.60 minutes

24. Soils with similar profiles and characteristics are grouped together in a naming convention called soil taxonomy., Which of the following is at the base of the Soil Taxonomy Pyramid?
- a. Series
 - b. Family
 - c. Subgroup
 - d. Order
25. Porosity is defined as?
- a. the quantification of a soil's void space to hold/store water
 - b. the ability of water to flow through the available interconnected soil voids
 - c. the process of water soaking into the soil surface
 - d. the fraction of pore volume in a rock or material occupied by water
26. Which of the following is not considered a depositional environment?
- a. Continental
 - b. Transitional
 - c. Marine
 - d. Volcanic

27. Before designing management practices and site features to limit stormwater issues and the transportation of pollutants within a project site and offsite, a Certified Professional should conduct which of the following?
- a. review historic site soils and topographic information only to identify geomorphic landforms
 - b. review current site soils and topographic information only to identify geomorphic landforms
 - c. review both current and historic site soils and topographic information to identify geomorphic landforms
 - d. None of the above
28. Sediment traps perform best when a holistic approach is taken to managing construction stormwater runoff. Which of the following is not something a Certified Professional should consider when designing sediment traps:
- a. Divert runoff from undisturbed areas away from the trap using temporary diversions
 - b. Increase velocity in channels to ensure stormwater reaches treatment practices quickly
 - c. Stabilize areas surrounding the sediment trap and the trap itself using vegetation or geotextiles
 - d. Minimize site disturbance and incorporate site stabilization efforts upstream of sediment trap to minimize erosion and subsequent loading into the trap

29. A sediment basin consists of four stages or zones. Which of the following is NOT a stage or zone?.
- standing pool
 - stormwater storage
 - auxiliary storage
 - freeboard
30. A common definition of Non-Point Pollution (NPS) is which of the following:
- NPS pollution is caused by direct stormwater discharge moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, streams, wetlands, coastal waters, and ground waters
 - NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, streams, wetlands, coastal waters, and ground waters
 - NPS pollution is caused by rainfall or snowmelt moving over the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, streams, wetlands, coastal waters
 - NPS pollution is caused by direct stormwater moving over the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, streams, wetlands, coastal waters

31. Which of the following documents does not provide safety instructions for each procedure and site location.
- a. Job Task Analysis (JTA) is a systematic process used to break down a job into specific duties, tasks, and steps, identifying the knowledge, skills, and abilities (KSAs) needed for successful performance.
 - b. Job Hazard Analysis (JHA): A JHA focuses on methods to eliminate, reduce, or protect against hazards that are potentially inherent in each job. A JHA should be developed during the pre-planning phase of a project, and all field personnel should review the JHA for the tasks to be conducted prior to undertaking field work. The JHA should specify the type of personal protective equipment (PPE) that is to be worn and under what conditions it is required.
 - c. Site Hazard Analysis (SHA): A SHA documents traffic safety and other potential hazards around the site to ensure that all field personnel who visit are aware of hazards and understand the requirements for traffic navigation, safe parking, and sampling routines. The SHA should document other site hazards including any physical hazards (e.g. railroad crossings or buried electrical wiring), hazards associated with weather (e.g. extreme heat/cold, heavy rain) and biological hazards (e.g. wild animals).
 - d. All of the above

32. Field data should be submitted to the sampling leader as soon as possible after undertaking the work. In general, a review of project data is carried out to confirm that the sampling and analysis protocols were followed. This review should be carried out by the sampling leader or another experienced analyst. Which is not part of the data that should be reviewed as soon as possible for typos, unrealistic results, or obvious errors?
- Look for obvious deviations in the data, for example, when a result is greatly larger or smaller than that of previous data.
 - Examine field reports to check holding times and flag any that exceed recommended times.
 - Check for suspect data, such as the concentration of dissolved phosphorus exceeding that of total phosphorus.
 - Review the original field data sheets to make sure they show the expected results.
33. Surface Water Pollution Modeling typically uses which of the following inputs:
- Meteorological data, Hydrologic data, Hydraulic data, and Climate data
 - Meteorological data, Hydrologic data, Hydraulic data, and Land use data
 - Meteorological data, Pollution Concentration data, Hydraulic data, and Land use data
 - Meteorological data, Hydrologic data, Previous model data, and Land use data

34. Major Pollutant Source Area Considerations include all but the following
- a. Land uses, including agriculture, commercial, industrial, residential, roads, highways, open space, and recreation
 - b. Soil Types and Predominant Pollutant Types
 - c. Population, zoning, and available funding for Stormwater Control
 - d. Water Cycle Alteration and Available Land for Stormwater Controls
35. What is a passive method of stream restoration?
- a. Natural Stream Channel Design
 - b. Legacy Sediment Removal
 - c. Regenerative Stormwater Conveyances
 - d. Riparian Corridor Protection
36. Which of the following methods are considered hard shoreline stabilization approaches?
- a. Seawalls and revetments
 - b. Beach nourishment and living shorelines
 - c. Bioengineering and re-vegetation
 - d. Live staking and brush layering

37. As a Certified Professional, what general techniques can be used to help communities increase their resiliency to impacts from climate change?
- a. Increase Storage Volumes, Bypass and Flow-through Options for Extreme Events Management
 - b. Groundwater Separation Considerations
 - c. Updated floodplain mapping, land use planning, drought management planning
 - d. Maintaining Vegetative Controls and Bioengineered Shorelines

CPSWQ ANSWER SHEET WITH ANNOTATED ANSWERS

Question 1: The correct answer is d.

- a. Is incorrect because pollutants typically do not enhance water quality
- b. Is incorrect because pollutants typically do not enhance water quality
- c. Is incorrect because pollutants typically do not positively impact water quality

Question 2: The correct answer is a. An aerobic condition means that oxygen is present (saturated in the aquatic system)

b., c., and d. are incorrect because while microorganisms, light, and nutrients in the aquatic system may show that the aquatic system is in good health, oxygen is the determinant factor if the system is aerobic or anaerobic

Question 3: The correct answer is c. The other three answers are common methods used when classifying streams. Stream channel profile and pattern characteristics may be used within the other methods but is not a method of classifying streams.

Question 4: The correct answer is b.

- a. Is incorrect because a map that uses isohyets (lines) to connect points that have the same elevation on the land surface is a contour map
- c. Is incorrect because a map that uses isohyets (lines) to connect points that have the same amount of rainfall erosivity is an isoerodent map.
- d. Is incorrect because a map that uses isohyets (lines) to connect points that depict the same type of soil is a soils map.

Question 5: The correct answer is b.

- a. Is incorrect because the calculation of the difference is a pollutant loading calculation performed on both before and after construction quantities of the pollutant of concern
- c. Is incorrect because this is a spatial characteristic
- d. Is incorrect because this is a temporal characteristic

For Questions 6 through 8, the following annotated answers show the required calculation steps performed to achieve the answer. If you calculate a different answer, please verify that you used the proper data as provided in the question.

Question 6:

Step 1 - Collect the data

Area to be temporarily stabilized	4.5 acres	<i>1.82 hectares</i>
Amount of straw to be applied	2.5 tons/acre	<i>5.60 tonnes/hectare</i>
Weight of straw bale	88 pounds	<i>40 kilograms</i>

Step 2 - Determine the total weight of straw to be applied

$$4.5 \text{ acres} * 2.5 \text{ tons} = 11.25 \text{ tons} \quad 1.82 \text{ hectares} * 5.60 \text{ tonnes} = 10.19 \text{ tonnes}$$

Step 3 - Determine the number of bales in a ton (tonne)

$$2000 \text{ pounds per ton} / 88 \text{ pounds per bale} = 22.73 \text{ straw bales per ton}$$

$$1000 \text{ kilograms per tonne} / 40 \text{ kilograms per bale} = 25 \text{ straw bales per tonne}$$

Step 4 – Determine the total number of bales required

$$4.5 \text{ acres} * 22.73 \text{ straw bales/ton} * 2.5 \text{ tons/acre} = 255.71 \text{ bales USE } \mathbf{256 \text{ bales}}$$

$$1.82 \text{ hectares} * 25 \text{ straw bales/tonne} * 5.60 \text{ tonnes/hectare} = 254.8 \text{ bales USE } \mathbf{255 \text{ bales}}$$

Step 5 – Check the number of bales against the total weight required

$$256 \text{ bales} * 88 \text{ pounds} = 22,528 \text{ pounds} / 2000 \text{ pounds/ton} = 11.26 \text{ tons}$$

$$255 \text{ bales} * 40 \text{ kilograms} = 10,200 \text{ kilograms} / 1000 \text{ kilograms/tonne} = 10.20 \text{ tonnes}$$

Question 7:**Step 1 - Collect the data**

$C_1 = 0.148$ mg/l of the pollutant in the highway stormwater discharge

0.132 mg/l of the pollutant above the receiving waters

0.0069 mg/l of the pollutant permitted above background (existing condition)

$V_1 =$ three (3) liters discharge to be treated

Step 2 - Determine receiving water background (existing) concentration

$$0.148 \text{ mg/l} - 0.132 \text{ mg/l} = 0.016 \text{ mg/l}$$

Step 3 - Determine threshold effect mg/l allowed

$$C_2 = 0.016 \text{ mg/l} + 0.0069 \text{ mg/l} = 0.0229 \text{ mg/l}$$

Step 4 - Determine V_2 using the formula $C_1 * V_1 = C_2 * V_2$

$$0.148 \text{ mg/l} * 3 \text{ liters} = 0.0229 \text{ mg/l} * V_2$$

$$0.444 = 0.0229 \text{ mg/l} * V_2$$

$$19.39 \text{ liters} = V_2$$

Step 5 - Determine volume of stream water required to dilute solution to the required concentration

$$19.39 \text{ liters} - 3 \text{ liters} = \mathbf{16.39 \text{ liters}}$$

Question 8

Step 1 - Collect the data

- 10 acres (*4.05 hectares*) existing parking lot
- 12 acres (*4.86 hectares*) proposed parking lot
- 76% TSS removal rate for stormwater wetlands

Step 2 – Determine increase in parking lot

- 12.0 acres - 10.0 acres = 2 acres
- 4.86 hectares – 4.05 hectares = 0.81 hectares*

Step 3 – Determine acres of pavement to be treated

- Acres of pavement to be treated = 2 acres / 76% (0.76)
- Acres of pavement to be treated = 2.63 acres**
- Acres of pavement to be treated = 0.81 hectares / 76% (0.76)*
- Acres of pavement to be treated = 1.07 hectares***

For Questions 9 through 16, the following annotated answers show the required calculation steps performed to achieve the answer. If you calculate a different answer, please verify that you used the proper data as provided in the question or in the Site Parameters provided.

REMINDER: - The local jurisdiction is requiring that the wooded area of the site to remain undisturbed and ignored when performing TR-55 calculations for stormwater treatment.

Question 9:

You will be using the Weighted RCN equation, $RCN = [\text{Total of each area (RCN} \times \text{area)}] / \text{total area}$, to determine the answer.

Step 1 – Collect the Data. Since the jurisdiction requires the woods to remain, the area of woods on Groton soil, 25 acres (10.12 hectares), will be removed from the calculations reducing the total area to 50 acres (20.23 hectares).

Existing Conditions

Meadow – 20 acres (8.09 hectares),

RCN 58 (Acton = Hydrologic group B)

Pasture in poor condition – 25 acres (10.12 hectares),

RCN 86 (Paxton = Hydrologic group C)

Farmstead – 5 acres (2.02 hectares),

RCN 82 (Paxton = Hydrologic group C)

Construction Conditions

Newly Graded Areas – 20 acres (8.09 hectares),

RCN 86 (Acton = Hydrologic group B)

Newly Graded Areas – 30 acres (12.14 hectares),

RCN 91 (Paxton = Hydrologic group C)

Proposed Conditions

Town Houses – 20 acres (8.09 hectares),

RCN 85 (Acton = Hydrologic group B)

Town Houses – 20 acres (8.09 hectares),

RCN 90 (Paxton = Hydrologic group C)

Retail/Commercial – 10 acres (4.05 hectares),

RCN 94 (Paxton = Hydrologic group C)

Step 2 – Plug the data into the Weighted RCN equation

Weighted RCN = [Total of each (RCN x area)] / total area

Existing Conditions

Weighted RCN = [(20 * 58) + (25 * 86) + (5 * 82)] / 50

Weighted RCN = [1,160 + 2,150 + 410] / 50

Weighted RCN = 3,720 / 50

Weighted RCN = 74.4

Rounded to the nearest whole number - **Weighted RCN = 74**

*Weighted RCN = [(8.09 * 58) + (10.12 * 86) + (2.02 * 82)] / 20.23*

Weighted RCN = [469 + 870 + 166] / 20.23

Weighted RCN = 1,505 / 20.23

Weighted RCN = 74.4

*Rounded to the nearest whole number - **Weighted RCN = 74***

Construction Conditions

$$\text{Weighted RCN} = [(20 * 86) + (30 * 91)] / 50$$

$$\text{Weighted RCN} = [1,720 + 2,730] / 50$$

$$\text{Weighted RCN} = 4,450 / 50$$

$$\text{Weighted RCN} = 89.0$$

Rounded to the nearest whole number - **Weighted RCN = 89**

$$\text{Weighted RCN} = [(8.09 * 86) + (12.14 * 91)] / 20.23$$

$$\text{Weighted RCN} = [696 + 1,105] / 20.23$$

$$\text{Weighted RCN} = 1,801 / 20.23$$

$$\text{Weighted RCN} = 89.0$$

Rounded to the nearest whole number - **Weighted RCN = 89**

Proposed Conditions

$$\text{Weighted RCN} = [(20 * 85) + (20 * 90) + (10 * 94)] / 50$$

$$\text{Weighted RCN} = [1,700 + 1,800 + 940] / 50$$

$$\text{Weighted RCN} = 4,440 / 50$$

$$\text{Weighted RCN} = 88.8$$

Rounded to the nearest whole number - **Weighted RCN = 89**

$$\text{Weighted RCN} = [(8.09 * 85) + (8.09 * 90) + (4.05 * 94)] / 20.23$$

$$\text{Weighted RCN} = [688 + 728 + 381] / 20.23$$

$$\text{Weighted RCN} = 1,797 / 20.23$$

$$\text{Weighted RCN} = 88.8$$

Rounded to the nearest whole number - **Weighted RCN = 89**

Question 10:

You will be using the following equations to determine the answer

Potential Maximum Retention – $S = (1000 / CN) - 10$

$(S = [(1000 / CN) - 10] * 25.4$ (2.54 to convert to centimeters),

Peak Flow Rate – $Q = (P - (0.2 * S))^2 / (P + (0.8 * S))$, and

Acre-Feet of Runoff = $(Q * acres) / 12$ inches per foot

*Hectare-Meters of Runoff = $(Q * hectare) / 100$*

Step 1 - Collect the data

Calculated CN from Question 9

Existing = 74

Construction = 89

Proposed = 89

Rainfall values

2-year storm 3.2 inches (8.13 cm)

10-year storm 5.1 inches (12.95 cm)

100-year storm 7.3 inches (18.54 cm)

Step 2 – Calculate the Potential Maximum Retention value for each storm

<u>Existing</u>	<u>Construction and Proposed (same CN)</u>
$S = (1000 / 74) - 10$	$S = (1000 / 89) - 10$
$S = 13.514 - 10$	$S = 11.235 - 10$
$S = 3.514$ inches	$S = 1.235$ inches
$S = [(1000 / 74) - 10] * 2.54$	$S = [(1000 / 89) - 10] * 2.54$
$S = [13.514 - 10] * 2.54$	$S = [11.235 - 10] * 2.54$
$S = 3.514 * 2.54$	$S = 1.235 * 2.54$
$S = 8.926$ centimeters	$S = 3.137$ centimeters

Step 3 – Calculate the Peak Flow Rate for each storm

Existing 2 year

$$Q = (3.2 - (0.2 * 3.514))^2 / (3.2 + (0.8 * 3.514))$$

$$Q = (3.2 - 0.703)^2 / (3.2 + 2.811)$$

$$Q = 2.497^2 / 6.011$$

$$Q = 6.235 / 6.011$$

$$Q = 1.04 \text{ inches}$$

$$Q = (8.128 - (0.2 * 8.926))^2 / (8.128 + (0.8 * 8.926))$$

$$Q = (8.128 - 1.785)^2 / (8.128 + 7.141)$$

$$Q = 6.343^2 / 15.269$$

$$Q = 40.234 / 15.2691$$

$$Q = 2.64 \text{ centimeters}$$

Existing 10 year

$$Q = (5.1 - (0.2 * 3.514))^2 / (5.1 + (0.8 * 3.514))$$

$$Q = (5.1 - 0.703)^2 / (5.1 + 2.811)$$

$$Q = 4.397^2 / 7.911$$

$$Q = 19.334 / 7.911$$

$$Q = 2.44 \text{ inches}$$

$$Q = (12.954 - (0.2 * 8.926))^2 / (12.954 + (0.8 * 8.926))$$

$$Q = (12.954 - 1.785)^2 / (12.954 + 7.141)$$

$$Q = 11.165^2 / 20.095$$

$$Q = 124.747 / 20.095$$

$$Q = 6.21 \text{ centimeters}$$

Existing 100 year

$$Q = (7.3 - (0.2 * 3.514))^2 / (7.3 + (0.8 * 3.514))$$

$$Q = (7.3 - 0.703)^2 / (7.3 + 2.811)$$

$$Q = 6.597^2 / 10.111$$

$$Q = 43.520 / 10.111$$

$$Q = 4.30 \text{ inches}$$

$$Q = (18.542 - (0.2 * 8.926))^2 / (18.542 + (0.8 * 8.926))$$

$$Q = (18.542 - 1.785)^2 / (18.542 + 7.141)$$

$$Q = 66.757^2 / 25.683$$

$$Q = 280.797 / 25.683$$

$$Q = 10.93 \text{ centimeters}$$

Construction and Proposed 2year

$$Q = (3.2 - (0.2 * 1.235))^2 / (3.2 + (0.8 * 1.235))$$

$$Q = (3.2 - 0.247)^2 / (3.2 + 0.988)$$

$$Q = 2.953^2 / 4.188$$

$$Q = 8.720 / 4.188$$

$$Q = 2.08 \text{ inches}$$

$$Q = (8.128 - (0.2 * 3.137))^2 / (8.128 + (0.8 * 3.137))$$

$$Q = (8.128 - 0.627)^2 / (8.128 + 2.510)$$

$$Q = 7.501^2 / 10.638$$

$$Q = 56.265 / 10.638$$

$$Q = 5.28 \text{ centimeters}$$

Construction and Proposed 10 year

$$Q = (5.1 - (0.2 * 1.235))^2 / (5.1 + (0.8 * 1.235))$$

$$Q = (5.1 - 0.247)^2 / (5.1 + 0.988)$$

$$Q = 4.853^2 / 6.088$$

$$Q = 23.552 / 6.088$$

$$Q = 3.87 \text{ inches}$$

$$Q = (12.954 - (0.2 * 3.137))^2 / (12.954 + (0.8 * 3.137))$$

$$Q = (12.954 - 0.627)^2 / (12.954 + 2.510)$$

$$Q = 12.3273^2 / 15.464$$

$$Q = 151.955 / 15.464$$

$$Q = 9.83 \text{ centimeters}$$

Construction and Proposed 100 year

$$Q = (7.3 - (0.2 * 1.235))^2 / (7.3 + (0.8 * 1.235))$$

$$Q = (7.3 - 0.247)^2 / (7.3 + 0.988)$$

$$Q = 7.053^2 / 8.288$$

$$Q = 49.745 / 8.288$$

$$Q = 6.00 \text{ inches}$$

$$Q = (18.542 - (0.2 * 3.137))^2 / (18.542 + (0.8 * 3.137))$$

$$Q = (18.542 - 0.627)^2 / (18.542 + 2.510)$$

$$Q = 17.915^2 / 21.052$$

$$Q = 320.947 / 21.052$$

$$Q = 15.25 \text{ centimeters}$$

Step 4 - Calculate the storm runoff in acre feet (hectare meters) for each storm using the Acre-Feet of Runoff = $(Q * \text{acres}) / 12$ inches per foot (*Hectare-Meters of Runoff = $(Q * \text{hectare}) / 100$*) equation.

Existing 2 Year

$$\text{Acre Feet of Runoff} = (1.04 * 50) / 12$$

$$\text{Acre Feet of Runoff} = 52 / 12$$

$$\text{Acre Feet of Runoff} = \mathbf{4.33}$$

$$\text{Hectare-Meters of Runoff} = (2.64 * 20.23) / 100$$

$$\text{Hectare-Meters of Runoff} = 53.41 / 100$$

$$\text{Hectare-Meters of Runoff} = \mathbf{0.53}$$

Existing 10 Year

$$\text{Acre Feet of Runoff} = (2.44 * 50) / 12$$

$$\text{Acre Feet of Runoff} = 122.00 / 12$$

$$\text{Acre Feet of Runoff} = \mathbf{10.17}$$

$$\text{Hectare-Meters of Runoff} = (6.21 * 20.23) / 100$$

$$\text{Hectare-Meters of Runoff} = 125.63 / 100$$

$$\text{Hectare-Meters of Runoff} = \mathbf{1.26}$$

Existing 100 Year

$$\text{Acre Feet of Runoff} = (4.30 * 50) / 12$$

$$\text{Acre Feet of Runoff} = 215.00 / 12$$

$$\text{Acre Feet of Runoff} = \mathbf{17.92}$$

$$\text{Hectare-Meters of Runoff} = (10.93 * 20.23) / 100$$

$$\text{Hectare-Meters of Runoff} = 221.11 / 100$$

$$\text{Hectare-Meters of Runoff} = \mathbf{2.21}$$

Construction and Proposed 2 Year

$$\text{Acre Feet of Runoff} = (2.08 * 50) / 12$$

$$\text{Acre Feet of Runoff} = 104.00 / 12$$

$$\text{Acre Feet of Runoff} = \mathbf{8.67}$$

$$\text{Hectare-Meters of Runoff} = (5.28 * 20.23) / 100$$

$$\text{Hectare-Meters of Runoff} = 106.81 / 100$$

$$\text{Hectare-Meters of Runoff} = \mathbf{1.07}$$

Construction and Proposed 10 Year

$$\text{Acre Feet of Runoff} = (3.87 * 50) / 12$$

$$\text{Acre Feet of Runoff} = 193.50 / 12$$

$$\text{Acre Feet of Runoff} = \mathbf{16.13}$$

$$\text{Hectare-Meters of Runoff} = (9.83 * 20.23) / 100$$

$$\text{Hectare-Meters of Runoff} = 198.94 / 100$$

$$\text{Hectare-Meters of Runoff} = \mathbf{1.99}$$

Construction and Proposed 100 Year

$$\text{Acre Feet of Runoff} = (6.00 * 50) / 12$$

$$\text{Acre Feet of Runoff} = 300.00 / 12$$

$$\text{Acre Feet of Runoff} = \mathbf{25.00}$$

$$\text{Hectare-Meters of Runoff} = (15.25 * 20.23) / 100$$

$$\text{Hectare-Meters of Runoff} = 308.51 / 100$$

$$\text{Hectare-Meters of Runoff} = \mathbf{3.09}$$

Question 11:

You will be using the following formulas to determine the answer.

$$\text{Travel Time Sheet Flow} - T_t = ((0.007 * (n * L)^{0.8}) / P_2^{0.5} * s^{0.4})$$

$$T_t = ((0.093 * (n * L)^{0.8}) / P_2^{0.5} * s^{0.4})$$

$$\text{Travel Time Shallow Concentrated Flow} - T_t = L / 3600 * V$$

$$T_t = L / 3600 * V$$

$$r - r = a / p_w$$

$$r = a / p_w$$

$$V - V = (1.49 * r^{2/3} * s^{1/2}) / n$$

$$V = (1.00 * r^{2/3} * s^{1/2}) / n$$

$$\text{Travel Time Channel Flow} - T_t = L / 3600 * V$$

$$T_t = L / 3600 * V$$

Step 1 - Collect the data

Existing Travel Segments

Segment 1 - 75 feet (22.86 meters) of overland flow on a 4.0% slope through dense grass. Mannings n value = 0.24. P₂ = 3.2 inches (81.28 millimeters)

Segment 2 - 20 feet (6.10 meters) of overland flow on a 3% slope through short grass. Mannings n value = 0.05. P₂ = 3.2 inches (81.28 millimeters)

Segment 3 – 1,500 feet (457.20 meters) of shallow concentrated flow through pasture on a 3% slope resulting in a velocity of 2.8 feet per second (0.85 meters per second)

Segment 4 - 15 feet (4.57 meters) over a paved driveway with a 2% reversed crown resulting in a velocity of 2.9 feet per second (0.88 meters per second)

Segment 5 – 3,000 feet (914.40 meters) of concentrated flow in a constructed grass lined trapezoidal channel at 2.5% with a bottom width of 4 feet (1.22 meters) and side slopes of 3:1. Design flow depth within the swale is 2.0 feet (0.61 meters) which results in a flow area of 20.0 square feet (1.86 square meters) and a wetted perimeter of 16.64 feet (5.07 meters).

Proposed Travel segments

Segment 1 - 35 feet (*10.67 meters*) of overland flow on a 4.0% slope through dense grass

Segment 2 - 24 feet (*7.32 meters*) of overland flow a 3% slope over a reverse crown roadway, resulting in a velocity of 3.5 feet per second (*1.07 meters per second*)

Segment 3 – 2,100 feet (*640.08 meters*) of concentrated flow at 2.5% in a constructed grass lined trapezoidal channel with a bottom width of 4 feet (*1.22 meters*) and side slopes of 3:1. Design flow depth within the swale is 2.0 feet (*0.61 meters*) which results in a flow area of 20.0 square feet (*1.86 square meters*) and a wetted perimeter of 16.64 feet (*5.07 meters*).

Step 2 – Calculate the time of travel for existing conditions

Segment 1 (overland)

$$T_t = ((0.007 * (0.24 * 75)^{0.8}) / 3.2^{0.5} * 0.04^{0.4})$$

$$T_t = (0.007 * 18.0^{0.8}) / 1.789 * 0.276$$

$$T_t = (0.007 * 10.098) / 0.494$$

$$T_t = 0.071 / 0.494$$

$$T_t = 0.144 \text{ hours}$$

$$T_t = ((0.093 * (0.24 * 22.86)^{0.8}) / 81.28^{0.5} * 0.04^{0.4})$$

$$T_t = (0.093 * 5.486^{0.8}) / 9.016 * 0.276$$

$$T_t = (0.093 * 3.903) / 2.488$$

$$T_t = 0.363 / 2.488$$

$$T_t = 0.146 \text{ hours.}$$

Segment 2 (overland)

$$T_t = ((0.007 * (0.05 * 20)^{0.8}) / 3.2^{0.5} * 0.03^{0.4})$$

$$T_t = (0.007 * 1.0^{0.8}) / 1.789 * 0.246$$

$$T_t = (0.007 * 1.000) / 0.440$$

$$T_t = 0.007 / 0.440$$

$$T_t = 0.016 \text{ hours}$$

$$T_t = ((0.093 * (0.05 * 6.1)^{0.8}) / 81.28^{0.5} * 0.030^{0.4})$$

$$T_t = (0.093 * 0.305^{0.8}) / 9.016 * 0.246$$

$$T_t = (0.093 * 0.387) / 2.218$$

$$T_t = 0.036 / 2.218$$

$$T_t = 0.016 \text{ hours.}$$

Segment 3 (shallow concentrated)

$$T_t = 1,500 / 3,600 * 2.8$$

$$T_t = 1,500 / 10,080$$

$$T_t = 0.149 \text{ hours}$$

$$T_t = 457.20 / 3,600 * 0.85$$

$$T_t = 457.20 / 3,060$$

$$T_t = 0.149 \text{ hours}$$

Segment 4 (shallow concentrated)

$$T_t = 15 / 3,600 * 2.9$$

$$T_t = 15 / 10,440$$

$$T_t = 0.001 \text{ hours}$$

$$T_t = 4.57 / 3,600 * 0.88$$

$$T_t = 4.57 / 3,168$$

$$T_t = 0.001 \text{ hours}$$

Segment 5 (concentrated flow)

Cross sectional area is given as 20 square feet (*0.09 square meters*)

Wetted perimeter is given as 16.5 feet (*5.02 meters*)

$$\text{Calculate the hydraulic radius} = r = 20 / 16.64 \qquad r = 1.86 / 5.07$$

$$r = 1.202 \qquad r = 0.367$$

Channel slope is given at 2.5%

Mannings n is given at 0.03

Calculate the velocity of flow

$$V = (1.49 * 1.202^{2/3} * 0.025^{1/2}) / 0.03$$

$$V = (1.49 * 1.130 * 0.158) / 0.03$$

$$V = 0.266 / 0.03$$

$$V = 8.867$$

$$V = (1.00 * 0.367^{2/3} * 0.025^{1/2}) / 0.03$$

$$V = (1.00 * 0.513 * 0.158) / 0.03$$

$$V = 0.081 / 0.03$$

$$V = 2.700$$

Length is given at 3,000 feet (*914.40 meters*)

Calculate the time of travel

$$T_t = 3,000 / 3,600 * 8.867$$

$$T_t = 3,000 / 31921.20$$

$$T_t = 0.094 \text{ hours}$$

$$T_t = 914.40 / 3,600 * 2.700$$

$$T_t = 914.40 / 9720$$

$$T_t = 0.094 \text{ hours}$$

Step 3 - add the total time of travel from each segment to determine the time of concentration under existing conditions.

Segment 1 - 0.144 hours	<i>Segment 1 - 0.146 hours</i>
Segment 2 - 0.016 hours	<i>Segment 2 - 0.016 hours</i>
Segment 3 - 0.149 hours	<i>Segment 3 - 0.149 hours</i>
Segment 4 - 0.001 hours	<i>Segment 4 - 0.001 hours</i>
Segment 5 - <u>0.094 hours</u>	<i>Segment 5 - <u>0.094 hours</u></i>
Tc 0.404 hours	Tc 0.406 hours

Step 4 - Calculate the time of travel for proposed conditions

Segment 1 (overland)

$$T_t = ((0.007 * (0.24 * 35)^{0.8}) / 3.2^{0.5} * 0.04^{0.4})$$

$$T_t = (0.007 * 8.40^{0.8}) / 1.789 * 0.276$$

$$T_t = (0.007 * 5.488) / 0.494$$

$$T_t = 0.038 / 0.494$$

$$T_t = 0.077 \text{ hours}$$

$$T_t = ((0.093 * (0.24 * 10.67)^{0.8}) / 81.28^{0.5} * 0.04^{0.4})$$

$$T_t = (0.093 * 2.561^{0.8}) / 9.016 * 0.276$$

$$T_t = (0.093 * 2.122) / 2.488$$

$$T_t = 0.197 / 2.488$$

$$T_t = 0.079 \text{ hours.}$$

Segment 2 (shallow concentrated)

$$T_t = 24 / 3,600 * 3.5$$

$$T_t = 24 / 12,600$$

$$T_t = 0.002 \text{ hours}$$

$$T_t = 7.32 / 3,600 * 1.07$$

$$T_t = 7.32 / 3,852$$

$$T_t = 0.002 \text{ hours}$$

Segment 3 (concentrated flow)

Cross sectional area is given as 20 square feet (*0.09 square meters*)

Wetted perimeter is given as 16.5 feet (*5.02 meters*)

$$\text{Calculate the hydraulic radius} = r = 20 / 16.64 \qquad r = 1.86 / 5.07$$

$$r = 1.202 \qquad r = 0.367$$

Channel slope is given at 2.5%

Mannings n is given at 0.03

Calculate the velocity of flow

$$V = (1.49 * 1.202^{2/3} * 2.5^{1/2}) / 0.03$$

$$V = (1.49 * 1.130 * 0.158) / 0.03$$

$$V = 0.266 / 0.03$$

$$V = 8.867$$

$$V = (1.00 * 0.367^{2/3} * 2.5^{1/2}) / 0.03$$

$$V = (1.00 * 0.513 * 0.158) / 0.03$$

$$V = 0.081 / 0.03$$

$$V = 2.700$$

Length is given at 2,100 feet (*640.08 meters*)

Calculate the time of travel

$$T_t = 2,100 / 3,600 * 8.867$$

$$T_t = 2,100 / 31,921$$

$$T_t = 0.066 \text{ hours}$$

$$T_t = 640.08 / 3,600 * 2.700$$

$$T_t = 640.08 / 9720$$

$$T_t = 0.066 \text{ hours}$$

Step 5 - add the total time of travel from each segment to determine the time of concentration under proposed conditions.

Segment 1 - 0.077 hours	<i>Segment 1 - 0.079 hours</i>
Segment 2 - 0.002 hours	<i>Segment 2 - 0.002 hours</i>
Segment 3 - <u>0.066 hours</u>	<i>Segment 3 - <u>0.066hours</u></i>
Tc 0.145 hours	Tc 0.147 hours

Question 12:

You will be using the following formula to determine the answer

$$\text{Peak Discharge} - q_p = q_u * A_m * Q * F_p \quad (q_p = q_u * Km^2 * Q * F_p)$$

Step 1 – Collect the Data

Drainage area -	50 acres	(20.23 hectares)
Runoff curve number existing –	74	(74)
Runoff curve number proposed –	89	(89)
Time of concentration existing –	0.404 hours	(0.406 hours)
Time of concentration proposed –	0.145 hours	(0.147 hours)
Rainfall distribution –	2	(2)
Pond/swamp Factor –	1.0	(1.0)
Rainfall for 100-year storm -	7.3 inches	(185.42 mm)
I_a existing -	0.703	(17.87)
I_a proposed	0.247	(6.274)
Existing Q_{100}	4.30 inches	(109.30 mm)
Proposed Q_{100}	6.00 inches	(152.50 mm)
Existing Q_u	600	0.230
	900	0.385

Step 2 – Convert the area into square miles (square kilometers)

$$50 \text{ acres} / 640 = 0.078 \text{ square miles}$$

$$20.23 / 100 = 0.2023 \text{ square kilometers}$$

Step 3 – Compute I_a / P

Existing

$$0.703 / 7.3 = 0.096 \quad 17.87 / 185.42 = 0.096$$

Proposed

$$0.247 / 7.3 = 0.034 \quad 6.274 / 185.42 = 0.034$$

Step 4 – From Unit Peak Discharge Table (table can be found in the General Principles Review Manual). For this sample problem and on the exam this value has/will be provided.

Existing

$$T_c = 0.404 \text{ hours, } I_a/p = 0.096 \text{ (use } I_a/P \text{ of 0.10)}$$

$$q_u = 600$$

$$T_c = 0.406 \text{ hours, } I_a/p = 0.096 \text{ (use } I_a/P \text{ of 0.10)}$$

$$q_u = 0.24$$

Proposed

$$T_c = 0.145 \text{ hours, } I_a/p = 0.034 \text{ (use } I_a/P \text{ of 0.10)}$$

$$q_u = 900$$

$$T_c = 0.147 \text{ hours, } I_a/p = 0.034 \text{ (use } I_a/P \text{ of 0.10)}$$

$$q_u = 0.385$$

Step 5 – Calculate the q_p

Existing

$$q_p = 600 * 0.078 * 4.30 * 1.0$$

$$q_p = \mathbf{201.24 \text{ cfs}}$$

$$q_p = 0.240 * 0.2023 * 109.30 * 1.0$$

$$q_p = \mathbf{5.31 \text{ cms}}$$

Proposed

$$q_p = 900 * 0.078 * 6.00 * 1.0$$

$$q_p = \mathbf{421.20 \text{ cfs}}$$

$$q_p = 0.385 * 0.2023 * 152.50 * 1.0$$

$$q_p = \mathbf{11.88 \text{ cms}}$$

Question 13:

You will be using the following equations to determine the answer.

$$V_r = Q * A_m * 53.33$$

$$V_r = Q * A_m * 1,000$$

$$V_s = V_r * (V_s / V_r)$$

$$V_s = V_r * (V_s / V_r)$$

Step 1 – Collect the Data

Drainage area -	0.078 mi ²	<i>0.2023 km²</i>
Rainfall distribution –	2	2
Design storm -	100-year	<i>100-year</i>
Peak inflow q _i (proposed q _p)–	421.20 cfs	<i>11.881 cms</i>
Peak outflow q _o (existing q _p) –	201.24 cfs	<i>5.31 cms</i>
Q ₁₀₀ –	6.00 inches	<i>152.50 mm</i>

Step 2 – Calculate q_o / q_i

$$201.24 / 421.20 = 0.48 \qquad 5.31 / 11.88 = 0.45$$

Step 3 – From Graphical Detention Basin Storage Estimation Table (table can be found in the General Principles Review Manual) determine the value of V_s / V_r. For this sample problem and on the exam this value has/will be provided.

$$0.285 \qquad 0.300$$

Step 4 – Calculate V_r

$$V_r = 6.00 * 0.078 * 53.33$$

$$V_r = 24.96 \text{ acre feet}$$

$$V_r = 152.50 * 0.2023 * 1,000$$

$$V_r = 30,850.75 \text{ cubic meters}$$

Step 5 – Calculate the V_s

$$V_s = 24.96 * 0.285$$

$$V_s = 7.11 \text{ acre feet}$$

$$V_s = 30,850.75 * 0.300$$

$$V_s = 9,255.23 \text{ cubic meters}$$

Question 14:

You will be using the following equations to determine the answers.

Simple Method Pollutant Loading formula

$$L = [(P * P_j * R_v / 12] * C * A * 2.72$$

$$L = [(P * P_j * R_v / 1,000] * C * A * 10.09$$

Rv formula

$$R_v = 0.05 + (0.009 * I)$$

$$R_v = 0.05 + (0.009 * I)$$

Step 1 – Collect the Data

Annual rainfall (P) = 35 inches

889 millimeters

Rainfall correction factor (P_j) = 0.9 (0.9)

Percent impervious (I) =

Forest = 2%

Meadow = 2%

Pasture = 2%

Farmstead = 40%

Town Houses = 65%

Retail/Commercial = 85%

Flow weighted pollutant concentration for TP

Forest/Rural Open = 0.11

Agriculture/Pasture = 0.37

Farmstead (using low density residential) = 0.52

High Density Residential = 0.24

Commercial = 0.33

Total site area =	75 acres	20.23 hectares
Existing woods (to remain)	25 acres	10.12 hectares
Existing meadow	20 acres	8.09 hectares
Existing pasture	25 acres	10.12 hectares
Existing farmstead	5 acres	2.02 hectares
Proposed high density residential	40 acres	16.19 hectares
Proposed commercial	10 acres	4.05 hectares

Step 2 – Calculate R_v values for different land uses,

Woods = 2%

$$R_v = 0.05 + (0.009 * 2) \qquad R_v = 0.05 + (0.009 * 2)$$

$$R_v = 0.068 \qquad R_v = 0.068$$

Meadow = 2%

$$R_v = 0.05 + (0.009 * 2) \qquad R_v = 0.05 + (0.009 * 2)$$

$$R_v = 0.068 \qquad R_v = 0.068$$

Pasture = 2%

$$R_v = 0.05 + (0.009 * 2) \qquad R_v = 0.05 + (0.009 * 2)$$

$$R_v = 0.068 \qquad R_v = 0.068$$

Farmstead = 40%

$$R_v = 0.05 + (0.009 * 40) \qquad R_v = 0.05 + (0.009 * 40)$$

$$R_v = 0.410 \qquad R_v = 0.410$$

Town Houses = 65%

$$R_v = 0.05 + (0.009 * 65) \qquad R_v = 0.05 + (0.009 * 65)$$

$$R_v = 0.635 \qquad R_v = 0.635$$

Retail/Commercial = 85%

$$R_v = 0.05 + (0.009 * 85) \qquad R_v = 0.05 + (0.009 * 85)$$

$$R_v = 0.815 \qquad R_v = 0.815$$

Step 3 – Calculate the TP pollutant loading for different land uses in existing conditions

Woods

$$L = [(35 * 0.9 * 0.068 / 12) * 0.11 * 25.00 * 2.72$$

$$L = 0.1785 * 0.11 * 25.00 * 2.72$$

$$L = 1.34 \text{ pounds per year}$$

Meadow

$$L = [(35 * 0.9 * 0.068 / 12) * 0.37 * 20.00 * 2.72$$

$$L = 0.1785 * 0.37 * 20.00 * 2.72$$

$$L = 3.59 \text{ pounds per year}$$

Meadow Comparison as Rural Open (do not use to calculate final answer)

$$L = [(35 * 0.9 * 0.068 / 12) * 0.11 * 20.00 * 2.72$$

$$L = 0.1785 * 0.11 * 20.00 * 2.72$$

$$L = 1.07 \text{ pounds per year A difference of 2.52 pounds of TP per year}$$

Pasture

$$L = [(35 * 0.9 * 0.068 / 12) * 0.37 * 25.00 * 2.72$$

$$L = 0.1785 * 0.37 * 25.00 * 2.72$$

$$L = 4.49 \text{ pounds per year}$$

Farmstead

$$L = [(35 * 0.9 * 0.410 / 12) * 0.52 * 5.00 * 2.72$$

$$L = 1.0763 * 0.52 * 5.00 * 2.72$$

$$L = 7.61 \text{ pounds per year}$$

Woods

$$L = [(889 * 0.9 * 0.068 / 1000) * 0.11 * 10.12 * 10.09$$

$$L = 0.054 * 0.11 * 10.12 * 10.09$$

$$L = 0.61 \text{ kilograms per year}$$

Meadow

$$L = [(889 * 0.9 * 0.068 / 1000) * 0.37 * 8.09 * 10.09]$$

$$L = 0.054 * 0.37 * 8.09 * 10.09$$

$$L = 1.63 \text{ kilograms per year}$$

Meadow Comparison as Rural Open (do not use to calculate final answer)

$$L = [(889 * 0.9 * 0.068 / 1000) * 0.11 * 8.09 * 10.09]$$

$$L = 0.054 * 0.11 * 8.09 * 10.09$$

$$L = 0.49 \text{ kilograms per year A difference of 1.14 kilograms of TP per year}$$

Pasture

$$L = [(889 * 0.9 * 0.068 / 1000) * 0.37 * 10.12 * 10.09]$$

$$L = 0.054 * 0.37 * 10.12 * 10.09$$

$$L = 2.04 \text{ kilograms per year}$$

Farmstead

$$L = [(889 * 0.9 * 0.410 / 1000) * 0.52 * 2.02 * 10.09]$$

$$L = 0.328 * 0.52 * 2.02 * 10.09$$

$$L = 3.48 \text{ kilogram per year}$$

Step 4 – Calculate total TP pollutant loading in existing conditions

$$1.34 + 3.59 + 4.49 + 7.61 = 17.03 \text{ pounds per year}$$

$$0.61 + 1.63 + 2.04 + 3.48 = 7.76 \text{ kilograms per year}$$

Step 5 – Calculate the TP pollutant loading for different land uses in existing conditions

Woods

$$L = [(35 * 0.9 * 0.068 / 12) * 0.11 * 25.00 * 2.72$$

$$L = 0.1785 * 0.11 * 25.00 * 2.72$$

$$L = 1.34 \text{ pounds per year}$$

High density residential

$$L = [(35 * 0.9 * 0.635 / 12) * 0.24 * 40.00 * 2.72$$

$$L = 1.667 * 0.24 * 40.00 * 2.72$$

$$L = 43.53 \text{ pounds per year}$$

Commercial

$$L = [(35 * 0.9 * 0.815 / 12) * 0.33 * 10.00 * 2.72$$

$$L = 2.139 * 0.33 * 10.00 * 2.72$$

$$L = 19.20 \text{ pounds per year}$$

Woods

$$L = [(889 * 0.9 * 0.068 / 1000) * 0.11 * 10.12 * 10.09$$

$$L = 0.054 * 0.11 * 10.12 * 10.09$$

$$L = 0.61 \text{ kilograms per year}$$

High density residential

$$L = [(889 * 0.9 * 0.635 / 1000) * 0.24 * 16.19 * 10.09$$

$$L = 0.508 * 0.24 * 16.19 * 10.09$$

$$L = 19.92 \text{ kilograms per year}$$

Commercial

$$L = [(889 * 0.9 * 0.815 / 1000) * 0.33 * 4.04 * 10.09$$

$$L = 0.652 * 0.33 * 4.05 * 10.09$$

$$L = 8.79 \text{ kilograms per year}$$

Step 6 – Calculate total TP pollutant loading in proposed conditions

$$1.34 + 43.53 + 19.20 = 64.07 \text{ pounds per year}$$

$$0.61 + 19.92 + 8.79 = 29.30 \text{ kilograms per year}$$

Step 7 – Calculate the TP pollutant loading difference between existing and proposed conditions

$$64.07 \text{ pounds per year} - 17.03 \text{ pounds per year} = 47.04 \text{ pounds per year}$$

Use 47 pounds per year

$$29.30 \text{ kg per year} - 7.76 \text{ kg per year} = 21.54 \text{ kilograms per year}$$

Use 21.5 kilograms per year

Question 15:

You will be using the following equations to determine the answers.

Simple Method Pollutant Loading formula

$$L - L = [(P * P_j * R_v / 12] * C * A * 2.72$$

$$L = [(P * P_j * R_v / 1,000] * C * A * 10.09$$

Rv formula

$$R_v = 0.05 + (0.009 * I)$$

$$R_v = 0.05 + (0.009 * I)$$

Step 1 – Collect the Data

Annual rainfall (P) = 35 inches

889 millimeters

Rainfall correction factor (P_j) = 0.9 (0.9)

Percent impervious (I) =

Forest = 2%

Meadow = 2%

Pasture = 2%

Farmstead = 40%

Town Houses = 65%

Retail/Commercial = 85%

Flow weighted pollutant concentration for TSS

Forest/Rural Open = 51

Agriculture/Pasture = 145

Farmstead (using low density residential) = 70

High Density Residential = 97

Commercial = 77

Total site area =	75 acres	20.23 hectares
Existing Woods (to remain)	25 acres	10.12 hectares
Existing meadow	20 acres	8.09 hectares
Existing pasture	25 acres	10.12 hectares
Existing farmstead	5 acres	2.02 hectares
Proposed high density residential	40 acres	16.19 hectares
Proposed commercial	10 acres	4.05 hectares

Step 2 – Calculate R_v values for different land uses,

Woods = 2%

$$R_v = 0.05 + (0.009 * 2) \qquad R_v = 0.05 + (0.009 * 2)$$

$$R_v = 0.068 \qquad R_v = 0.068$$

Meadow = 2%

$$R_v = 0.05 + (0.009 * 2) \qquad R_v = 0.05 + (0.009 * 2)$$

$$R_v = 0.068 \qquad R_v = 0.068$$

Pasture = 2%

$$R_v = 0.05 + (0.009 * 2) \qquad R_v = 0.05 + (0.009 * 2)$$

$$R_v = 0.068 \qquad R_v = 0.068$$

Farmstead = 40%

$$R_v = 0.05 + (0.009 * 40) \qquad R_v = 0.05 + (0.009 * 40)$$

$$R_v = 0.410 \qquad R_v = 0.410$$

Town Houses = 65%

$$R_v = 0.05 + (0.009 * 65) \qquad R_v = 0.05 + (0.009 * 65)$$

$$R_v = 0.635 \qquad R_v = 0.635$$

Retail/Commercial = 85%

$$R_v = 0.05 + (0.009 * 85) \qquad R_v = 0.05 + (0.009 * 85)$$

$$R_v = 0.815 \qquad R_v = 0.815$$

Step 3 – Calculate the TSS pollutant loading for different land uses in existing conditions

Woods

$$L = [(35 * 0.9 * 0.068 / 12) * 51 * 25.00 * 2.72$$

$$L = 0.1785 * 51 * 25.00 * 2.72$$

$$L = 619.04 \text{ pounds per year}$$

Meadow

$$L = [(35 * 0.9 * 0.068 / 12) * 145 * 20.00 * 2.72$$

$$L = 0.1785 * 145 * 20.00 * 2.72$$

$$L = 1,408.01 \text{ pounds per year}$$

Meadow Comparison as Rural Open (do not use to calculate final answer)

$$L = [(35 * 0.9 * 0.068 / 12) * 51 * 20.00 * 2.72$$

$$L = 0.1785 * 51 * 20.00 * 2.72$$

$$L = 495.23 \text{ pounds per year A difference of 912.78 pounds of TSS per year}$$

Pasture

$$L = [(35 * 0.9 * 0.068 / 12) * 145 * 25.00 * 2.72$$

$$L = 0.1785 * 145 * 25.00 * 2.72$$

$$L = 1,760.01 \text{ pounds per year}$$

Farmstead

$$L = [(35 * 0.9 * 0.410 / 12) * 70 * 5.00 * 2.72$$

$$L = 1.0763 * 70 * 5.00 * 2.72$$

$$L = 1,024.64 \text{ pounds per year}$$

Woods

$$L = [(889 * 0.9 * 0.068 / 1000) * 51 * 10.12 * 10.09$$

$$L = 0.054 * 51 * 10.12 * 10.09$$

$$L = 281.21 \text{ kilograms per year}$$

Meadow

$$L = [(889 * 0.9 * 0.068 / 1000) * 145 * 8.09 * 10.09$$

$$L = 0.054 * 145 * 8.09 * 10.09$$

$$L = 639.15 \text{ kilograms per year}$$

Meadow Comparison as Rural Open (do not use to calculate final answer)

$$L = [(889 * 0.9 * 0.068 / 1000) * 51 * 8.09 * 10.09$$

$$L = 0.054 * 51 * 8.09 * 10.09$$

L = 224.80 kilograms per year A difference of 414.35 kilograms of TSS per year

Pasture

$$L = [(889 * 0.9 * 0.068 / 1000) * 145 * 10.12 * 10.09$$

$$L = 0.054 * 145 * 10.12 * 10.09$$

L = 799.53 kilograms per year

Farmstead

$$L = [(889 * 0.9 * 0.410 / 1000) * 70 * 2.02 * 10.09$$

$$L = 0.328 * 70 * 2.02 * 10.09$$

L = 467.97 kilogram per year

Step 4 – Calculate total TSS pollutant loading in existing conditions

$$619.04 + 1,408.01 + 1,760.01 + 1,024.64 = 4,811.70 \text{ pounds per year}$$

$$281.21 + 639.15 + 799.53 + 467.97 = 2,187.86 \text{ kilograms per year}$$

Step 5 – Calculate the TSS pollutant loading for different land uses in existing conditions

Woods

$$L = [(35 * 0.9 * 0.068 / 12) * 51 * 25.00 * 2.72$$

$$L = 0.1785 * 51 * 25.00 * 2.72$$

$$L = 619.04 \text{ pounds per year}$$

High density residential

$$L = [(35 * 0.9 * 0.635 / 12) * 97 * 40.00 * 2.72$$

$$L = 1.667 * 97 * 40.00 * 2.72$$

$$L = 17,592.85 \text{ pounds per year}$$

Commercial

$$L = [(35 * 0.9 * 0.815 / 12) * 77 * 10.00 * 2.72$$

$$L = 2.139 * 77 * 10.00 * 2.72$$

$$L = 4,479.92 \text{ pounds per year}$$

Woods

$$L = [(889 * 0.9 * 0.068 / 1000) * 51 * 10.12 * 10.09$$

$$L = 0.054 * 51 * 10.12 * 10.09$$

$$L = 281.21 \text{ kilograms per year}$$

High density residential

$$L = [(889 * 0.9 * 0.635 / 1000) * 97 * 16.19 * 10.09$$

$$L = 0.508 * 97 * 16.19 * 10.09$$

$$L = 8,049.58 \text{ kilograms per year}$$

Commercial

$$L = [(889 * 0.9 * 0.815 / 1000) * 77 * 4.04 * 10.09$$

$$L = 0.652 * 77 * 4.05 * 10.09$$

$$L = 2,051.56 \text{ kilograms per year}$$

Step 6 – Calculate total TP pollutant loading in proposed conditions

$$619.04 + 17,592.85 + 4,479.92 = 22,691.81 \text{ pounds per year}$$

$$281.21 + 8,049.58 + 2051.56 = 10,382.35 \text{ kilograms per year}$$

Step 7 – Calculate the pollutant loading for difference between existing and proposed conditions

$$22,691.81 \text{ lbs. per year} - 4,811.70 \text{ lbs. per year} = 17,880.11 \text{ pounds per year}$$

Use 17,880 pounds per year

$$10,382.35 \text{ kg per year} - 2,187.86 \text{ kg per year} = 8,194.49 \text{ kilograms per year}$$

Use 8,194 kilograms per year

Question 16:**Step 1 – Collect the Data**

TN collected = 40 pounds *18.14 kilograms*

Stormwater Wetlands – 30%

Stormwater Wet Ponds – 33%

Stormwater Dry Ponds – 25%

Filtering Practices – 38%

Step 2 – Determine the most effective treatment. Since Filtering Practices removes 38% and the other treatments remove a lower percentage Filtering Practices are the most effective for removal of total nitrogen

Step 3 - Calculate the removal of total nitrogen

$40 * 0.38 = 15.2$ pounds removed

$18.14 * 0.38 = 6.89$ kilograms removed

Step 4 - Calculate the remaining total nitrogen

$40 - 15.2 = 24.8$ pounds remain

$18.14 - 6.89 = 11.25$ kilograms remain

For Questions 17 through 19, the following annotated answers show the required calculation steps performed to achieve the answer. If you calculate a different answer, please verify that you used the proper data as provided in the question or in the Site Parameters provided.

Question 17

You will be using the d_{max} equation, $d_{max} = (P_{design} * t_{ponding}) / 12$

($d_{max} = (P_{design} * t_{ponding}) / 100$), to determine the answer.

Step 1 – Collect the Data

Required volume of stormwater runoff capture = 600 cubic feet (*17 cubic meters*)

Surface percolation rate = 0.55 inches per hour (*1.4 centimeters per hour*)

Two (2) feet (*0.61 meters*) to six (6) feet (*1.83 meters*) = 0.75 inches per hour (*1.8 centimeters per hour*)

Required ponding time = 48 hours

Required maximum drawdown time = 72 hours

Planting media porosity = 30%

Planting media minimum thickness = 4 feet (*1.22 meters*)

Minimum gravel void ratio (if used) = 35%

Gravel depth (if used) = 2 feet (*0.61 meters*)

Minimum underdrain slope(if used) = 0.5%

Step 2 – Calculate ponding depth. Since the ponding is affected by the surface infiltration rate P_{design} will be the surface rate.

$$d_{max} = (0.55 * 48) / 12$$

$$d_{max} = (26.4) / 12$$

$$d_{max} = \mathbf{2.20 \text{ feet}}$$

$$d_{max} = (1.4 * 48) / 100$$

$$d_{max} = (67.2) / 100$$

$$d_{max} = \mathbf{0.67 \text{ meters}}$$

Question 18

You will be using the $d_{\text{effective}}$ equation, $d_{\text{effective}} \geq (d_p + n_{\text{media}} \cdot l_{\text{media}} + n_{\text{gravel}} \cdot l_{\text{gravel}})$ ($d_{\text{effective}} \geq (d_p + n_{\text{media}} \cdot l_{\text{media}} + n_{\text{gravel}} \cdot l_{\text{gravel}})$), to determine the answer.

Step 1 – Collect the Data

Required volume of stormwater runoff capture = 600 cubic feet (*17 cubic meters*)

Surface percolation rate = 0.55 inches per hour (*1.4 centimeters per hour*)

Two (2) feet (*0.61 meters*) to six (6) feet (*1.83 meters*) = 0.75 inches per hour (*1.8 centimeters per hour*)

Required ponding time = 48 hours

Required maximum drawdown time = 72 hours

Planting media porosity = 30%

Planting media minimum thickness = 4 feet (*1.22 meters*)

Minimum gravel void ratio (if used) = 35%

Gravel depth (if used) = 2 feet (*0.61 meters*)

Minimum underdrain slope(if used) = 0.5%

Calculated ponding depth from Question 17 = 2.2 feet (*0.67 meters*)

Step 2 – Calculate the effective storage depth

$$d_{\text{effective}} \geq (2.2 + 30\% \cdot 4 + 35\% \cdot 2)$$

$$d_{\text{effective}} \geq (2.2 + 1.2 + 0.7)$$

$$d_{\text{effective}} \geq 4.1 \text{ feet}$$

$$d_{\text{effective}} \geq (0.67 + 30\% \cdot 1.22 + 35\% \cdot 0.61)$$

$$d_{\text{effective}} \geq (0.67 + 0.366 + 0.214)$$

$$d_{\text{effective}} \geq 1.25 \text{ meters}$$

Question 19

You will be using the total time, $t_{total} = (d_{effective}/P_{design}) * 12$ ($t_{total} = (d_{effective}/P_{design}) * 100$), to determine the answer.

Step 1 – Collect the Data

Required volume of stormwater runoff capture = 600 cubic feet (*17 cubic meters*)

Surface percolation rate = 0.55 inches per hour (*1.4 centimeters per hour*)

Two (2) feet (*0.61 meters*) to six (6) feet (*1.83 meters*) = 0.75 inches per hour (*1.8 centimeters per hour*)

Required ponding time = 48 hours

Required maximum drawdown time = 72 hours

Planting media porosity = 30%

Planting media minimum thickness = 4 feet (*1.22 meters*)

Minimum gravel void ratio (if used) = 35%

Gravel depth (if used) = 2 feet (*0.61 meters*)

Minimum underdrain slope(if used) = 0.5%

Calculated ponding depth from Question 17 = 2.2 feet (*0.67 meters*)

Calculated effective storage depth from Question 18 = 4.1 feet (*1.25 meters*)

Step 2 - Determine the effective drain time. Since the ponding is affected by the subsurface infiltration rate P_{design} will be the subsurface rate.

$$t_{total} = (4.1/0.75) * 12$$

$$t_{total} = 5.47 * 12$$

$$t_{total} = 65.64 \text{ hours}$$

$$t_{total} = (1.25/1.8) * 100$$

$$t_{total} = (0.694) * 100$$

$$t_{total} = 69.4 \text{ hours}$$

Step 3 – Compare calculated effective drain time to required drain time

Since the effective drawdown times vary slightly due to rounding and the number of decimal points used the $t_{total} = 65.64$ hours and $t_{total} = 69.4$ hours have been averaged to 67.5 hours.

The maximum drawdown time is 72 hours; thus, the calculated total drawdown time is adequate for the entire bioretention system.

Question 20: The correct answer is a. Combining stormwater and sewage systems will lead to an increased CSO problem, not a reduction in the CSO problem

- b. Is incorrect because many communities have implemented low impact development / green infrastructure techniques in an attempt to reduce stormwater runoff into the collection system and thus effectively reduce the number of CSO events.
- c. Is incorrect because retention basins or large concrete tanks have been constructed to collect, hold, and sometimes treat CSO discharges. While each facility is unique, a typical facility operation is as follows. Flows from the overloaded sewers are pumped into a basin that is divided into compartments. The first flush compartment captures and stores flows with the highest level of pollutants from the first part of a storm. The flows from this compartment are stored and sent to the wastewater treatment plant when there is capacity in the interceptor sewer after the storm. The second compartment is a treatment or flow-through compartment. The flows are disinfected by injecting sodium hypochlorite, or bleach, as they enter this compartment. It then takes about 20 to 30 minutes for the flows to move to the end of the compartment. During this time, bacteria are killed, and large solid materials settle out. At the end of the compartment, any remaining sanitary trash is skimmed off the top and the treated flows are discharged into the river or lake.

- d. Is incorrect because screening and disinfection facilities, also known as flow through facilities are used in some municipalities to treat CSO events. They use fine screens to remove solids and sanitary trash from the combined sewage. Flows are injected with sodium hypochlorite for disinfection and mixed as they travel through a series of fine screens to remove debris. The fine screens have openings that range in size from 4 to 6 mm, or a little less than ¼ inch. The flow is sent through the facility at a rate that provides enough time for the sodium hypochlorite to kill bacteria. All of the materials removed by the screens are then sent to the wastewater treatment plant through the interceptor sewer.

For Questions 21 through 23, the following annotated answers show the required calculation steps performed to achieve the answer. If you calculate a different answer, please verify that you used the proper data as provided in the question or in the Site Parameters provided.

Question 21:

Step 1 – Collect the Data

N Factor	0.011	<i>0.011</i>
Sheet flow distance =	125 feet	<i>38.10 meters</i>
Slope =	1.5%	<i>1.5%</i>
24 hour 2 Year rainfall =	1.4 inches	<i>35.56 millimeters</i>

Step 2 – Determine the travel time in hours

$$T_t = (0.007 * (n * L)^{0.8}) / (P^{2^{0.5}} * S^{0.4})$$

$$T_t = (0.007 * (0.011 * 125)^{0.8}) / (1.4^{0.5} * 0.015^{0.4})$$

$$T_t = (0.007 * (1.375)^{0.8}) / (1.183 * 0.186)$$

$$T_t = (0.007 * 1.290) / 0.220$$

$$T_t = 0.009 / 0.220$$

$$T_t = 0.041$$

$$T_t = (0.093 * (n * L)^{0.8}) / (P^{0.5} * S^{0.4})$$

$$T_t = (0.093 * (0.011 * 38.10)^{0.8}) / (35.56^{0.5} * 0.015^{0.4})$$

$$T_t = (0.093 * (0.419)^{0.8}) / (5.963 * 0.186)$$

$$T_t = (0.093 * 0.499) / 1.109$$

$$T_t = 0.046 / 1.109$$

$$T_t = 0.041$$

Step 3 – Convert hours to minutes

Minutes = hours * 60
 Minutes = 0.041 * 60
Minutes = 2.46

*Minutes = hours * 60*
*Minutes = 0.041 * 60*
Minutes = 2.46

Question 22:

Step 1 – Collect the Data

Curb flow =	200 feet	<i>60.96 meters</i>
Curb slope =	2.00%	2.00%
Curb velocity	2.85 cfs	0.87 m/s
Grass channel flow =	400 feet	<i>121.92 meters</i>
Grass channel Slope =	2.00%	2.00%
Grass channel velocity	2.25 cfs	0.69 m/s

Step 2 – Determine the travel time along the curb in hours

$$T_t = L / (3,600 * V)$$

$$T_t = 200 / (3,600 * 2.85)$$

$$T_t = 200 / 10,260$$

$$T_t = 0.02$$

$$T_t = L / (3,600 * V)$$

$$T_t = 60.96 / (3,600 * 0.87)$$

$$T_t = 60.96 / 3,132$$

$$T_t = 0.02$$

Step 3 – Determine the travel time along the shallow grass channel in hours

$$T_t = L / (3,600 * V)$$

$$T_t = 400 / (3,600 * 2.25)$$

$$T_t = 400 / 8,100$$

$$T_t = 0.05$$

$$T_t = L / (3,600 * V)$$

$$T_t = 121.92 / (3,600 * 0.69)$$

$$T_t = 121.92 / 2,484$$

$$T_t = 0.05$$

Step 4 – Determine the travel time along entire flow in hours

$$T_t = \text{curb flow time} + \text{shallow grass channel flow time}$$

$$T_t = 0.02 + 0.05$$

$$T_t = 0.07$$

$$T_t = \text{curb flow time} + \text{shallow grass channel flow time}$$

$$T_t = 0.02 + 0.05$$

$$T_t = 0.07$$

Step 5 – Convert hours to minutes

$$\text{Minutes} = \text{hours} * 60$$

$$\text{Minutes} = 0.07 * 60$$

$$\text{Minutes} = 4.20$$

$$\text{Minutes} = \text{hours} * 60$$

$$\text{Minutes} = 0.07 * 60$$

$$\text{Minutes} = 4.20$$

Question 23:

Step 1 – Collect the Data

Channel bottom width =	8 feet	<i>2.44 meters</i>
Channel side slopes =	3:1	<i>3:1</i>
Channel flow depth	1 foot	<i>0.31 meters</i>
Channel slope	3.00%	<i>3.00%</i>
Channel n factor	0.03	<i>0.03</i>
Channel length =	1,500 feet	<i>457.20 meters</i>

Step 2 – Calculate the area of the swale at 1 foot (0.31 meter) flow depth

$$\text{Area} = (\text{bottom width} * \text{depth}) + ((0.5 * \text{base} * \text{height}) * 2)$$

$$\text{Area} = (8.00 * 1.00) + ((0.50 * 3.00 * 1.00) * 2)$$

$$\text{Area} = 8.00 + (1.50 * 2)$$

$$\text{Area} = 8.00 + 3.00$$

$$\text{Area} = 11.00 \text{ square feet}$$

$$\text{Area} = (\text{bottom width} * \text{depth}) + ((0.5 * \text{base} * \text{height}) * 2)$$

$$\text{Area} = (2.44 * 0.31) + ((0.50 * 0.91 * 0.31) * 2)$$

$$\text{Area} = 0.756 + (0.141 * 2)$$

$$\text{Area} = 0.756 + 0.282$$

$$\text{Area} = 1.04 \text{ square meters}$$

Step 3 – Calculate the wetted perimeter of the swale at 1 foot (0.31 meters) flow depth

Wetted perimeter = ((square root of (base² + height²)) * 2) + bottom of swale

Wetted perimeter = ((square root of (3.00² + 1.00²)) * 2) + 8.00

Wetted perimeter = ((square root of (9.00 + 1.00)) * 2) + 8.00

Wetted perimeter = ((square root of 10.00) * 2) + 8.00

Wetted perimeter = (3.16 * 2) + 8.00

Wetted perimeter = 6.32 + 8.00

Wetted perimeter = 14.32 feet

*Wetted perimeter = ((square root of (base² + height²)) * 2) + bottom of swale*

*Wetted perimeter = ((square root of (0.91² + 0.31²)) * 2) + 2.44*

*Wetted perimeter = ((square root of (0.828 + 0.096)) * 2) + 2.44*

*Wetted perimeter = ((square root of 0.924) * 2) + 2.44*

*Wetted perimeter = (0.961 * 2) + 2.44*

Wetted perimeter = 1.92 + 2.44

Wetted perimeter = 4.68 meters

Step 4 – Determine the r value

$r = a / P_w$

$r = 11.00 / 14.32$

$r = 0.77$

$r = a / P_w$

$r = 1.04 / 4.68$

$r = 0.22$

Step 5 – Calculate the velocity in feet per second (*meters per second*)

$$V = (1.49 * r^{2/3} * s^{1/2}) / n$$
$$V = (1.49 * 0.77^{2/3} * 0.03^{1/2}) / 0.03$$
$$V = (1.49 * 0.839 * 0.173) / 0.03$$
$$V = 0.216 / 0.03$$
$$V = 7.2 \text{ feet per second}$$

$$V = (1.00 * r^{2/3} * s^{1/2}) / n$$
$$V = (1.00 * 0.22^{2/3} * 0.03^{1/2}) / 0.03$$
$$V = (1.00 * 0.363 * 0.173) / 0.03$$
$$V = 0.063 / 0.03$$
$$V = 2.1 \text{ meters per second}$$

Step 6 – Calculate the time of travel in hours

$$T_t = L / (3,600 * V)$$
$$T_t = 1,500 / (3,600 * 7.2)$$
$$T_t = 1,500 / 25,920$$
$$T_t = 0.06 \text{ hours}$$

$$T_t = L / (3,600 * V)$$
$$T_t = 457.20 / (3,600 * 2.1)$$
$$T_t = 457.20 / 7,560$$
$$T_t = 0.06 \text{ hours}$$

Step 7 – Convert hours to minutes

$$\text{Minutes} = \text{hours} * 60$$
$$\text{Minutes} = 0.06 * 60$$
$$\text{Minutes} = 3.60$$

*Minutes = hours * 60*

*Minutes = 0.06 * 60*

Minutes = 3.60

Question 24: The correct answer is a. Series is the most descriptive level of the Soil Taxonomy Pyramid with the largest number of items.

b., c., and d. are incorrect because while they are levels within the Soil Taxonomy Pyramid each has a smaller number of items than the Series. In the Soil Taxonomy Pyramid, Order is the smallest grouping, followed by the following with increasing items contained within each group, Suborder, Great Group, Subgroup, Family, and Series.

Question 25: The correct answer is a.

- b. is the definition of permeability
- c. is the definition of infiltration
- d. is the definition of saturation

Question 26: The correct answer is d. Volcanic environments can be found in all three depositional environments

- a. A continental depositional environment includes sediment that is deposited on land or in fresh water and includes streams, rivers, lakes, swamps, and areas where sediment has been deposited by wind.
- b. A transitional depositional environment includes sediment that is deposited at a location exhibiting influence between both fresh water or air and marine (i.e., saltwater) water and includes deltas, beaches, and valleys created by rising and falling sea levels.
- c. A marine depositional environment includes sediment that is only influenced and deposited by sea water and includes: deep marine (thin sediments formed by slow accumulation of skeletons and clasts dropped into the ocean by wind;

continental slope (deposition dominated by submarine landslides or changes in topography on the ocean floor); and marine shelf (shallow area flowing to deeper zones)

Question 27: The correct answer is c. A Certified Professional should review both current and historic documents, surveys, and conduct a site visit

- a. and b. are incorrect because a Certified Professional should review all available documents and surveys to determine the change of geomorphic landforms over time and how they could affect the current project.
- d. is incorrect

Question 28: The correct answer is a. Velocity in channels should be decreased to reduce the erosion potential within the channel

- b., c., and d. should be considered when developing treatment practices for stormwater and erosion and sediment control.

Question 29: The correct answer is c. There is not an auxiliary storage stage or zone. The auxiliary stage or zone is for temporary overflow conditions, allowing excess water to be retained and flow out of the basin in a safe controlled manner

- a., b., and d. are standard stages or zones within a basin.

Question 30: The correct answer is b. This definition was issued by the U.S. Environmental Protection Agency in 2016

- a. and d. are incorrect because a direct stormwater discharge is considered a Point source
- c. is incorrect because NPS affects ground water as well as surface water

Question 31: The correct answer is a. This document focuses on the job's requirements to improve hiring, training, and performance evaluations and defines what a worker does, how they do it, and why, often ensuring compliance with safety standards and validating certification requirements.

- b. and c. are correct because these documents focus on safety of personnel at the site and during completion of the tasks
- d. is incorrect

Question 32: The correct answer is d. The field data shows what information was gathered in the field. This data should not be modified to match the expected results.

- a., b., and c. are correct because these are items that should be reviewed. In addition to these items the reviewer should compare the electronic field data with the original field data sheets.

Question 33: The correct answer is b. These four items cover the meteorological, physical, and water quality data required for most surface water pollution models

- a. Is incorrect because climate data, while it may be used in some models, is not a typical input
- b. Is incorrect because pollution concentration data, while it may be used in some models, is not a typical input
- c. Is incorrect because previous model data, while it may be used in some models, is not a typical input

Question 34: The correct answer is c. These items typically are not major considerations when considering the pollution source area

- a., b., and d. are major considerations when considering the pollution source area

Question 35: The correct answer is d. Efforts to protect riparian corridors are passive stream restoration. Protection methods can include preventing land use changes, fencing to protect existing vegetation, or reducing duration or intensity of grazing.

a., b., and c. are active methods of stream restoration

Question 36: The correct answer is a. Along with these two methods other methods of hard shoreline stabilization approaches include Riprap and Bulkheads

b., c., and d. are types of Soft Shoreline Stabilization Approaches

Question 37: The correct answer is c. These techniques will help communities plan for climate change impacts

a., b., and d. are specific design techniques, and while they will help communities meet their planning goals, they in themselves are not planning tools.

IMPERIAL UNIT WORKSHEETS

Project	By	Date
Location	Checked	Date

Check one: Present Developed

1. Runoff curve number

Soil name and hydrologic group	Cover description <small>(cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)</small>	CN ^{1/}	Area	Product of CN x area
		Tables 6-2, 6-3 6-4, 6-5	<input type="checkbox"/> acres <input type="checkbox"/> mi ² <input type="checkbox"/> %	

^{1/} Use only one CN source per line

Totals ➡

$$CN \text{ (weighted)} = \frac{\text{total product}}{\text{total area}} = \underline{\hspace{2cm}} = \underline{\hspace{2cm}} ; \text{ Use CN } \blacktriangleright \boxed{\hspace{2cm}}$$

2. Runoff

	Storm #1	Storm #2	Storm #3
Frequency yr			
Rainfall, P (24-hour) in			
Runoff, Q in			
<small>(Use P and CN with Figure 6-7, or equations found on Figure 6-7)</small>			

Project	By	Date
Location	Checked	Date

Check one: Present Developed

Check one: T_C T_t through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet.
 Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_C only)

	Segment ID				
1. Surface description (table 6-6)					
2. Manning's roughness coefficient, n (table 6-6)					
3. Flow length, L (total † 300 ft) ft					
4. Two-year 24-hour rainfall, P ₂ in					
5. Land slope, s ft/ft					
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T _t hr		+		=	

Shallow concentrated flow

	Segment ID				
7. Surface description (paved or unpaved)					
8. Flow length, Lft					
9. Watercourse slope, s ft/ft					
10. Average velocity, V (figure 6-8) ft/s					
11. $T_t = \frac{L}{3600 V}$ Compute T _t hr		+		=	

Channel flow

	Segment ID				
12. Cross sectional flow area, a ft ²					
13. Wetted perimeter, p _w ft					
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r ft					
15. Channel slope, s ft/ft					
16. Manning's roughness coefficient, n					
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute Vft/s					
18. Flow length, L ft					
19. $T_t = \frac{L}{3600 V}$ Compute T _t hr		+		=	
20. Watershed or subarea T _C or T _t (add T _t in steps 6, 11, and 19) Hr					

Project	By	Date
Location	Checked	Date

Check one: Present Developed

1. Data

Drainage area $A_m =$ _____ mi^2 (acres/640)

Runoff curve number $CN =$ _____ (From worksheet 6-1)

Time of concentration $T_c =$ _____ hr (From worksheet 6-2)

Rainfall distribution = _____ (I, IA, II, III)

Pond and swamp areas spread throughout watershed = _____ percent of A_m (_____ acres or mi^2 covered)

	Storm #1	Storm #2	Storm #3
2. Frequency yr			
3. Rainfall, P (24-hour) in			
4. Initial abstraction, I_a in (Use CN with table 6-8)			
5. Compute I_a/P			
6. Unit peak discharge, q_u csm/in (Use T_c and I_a/P with Figure 6-10 _____)			
7. Runoff, Q in (From worksheet 1)			
8. Pond and swamp adjustment factor, F_p (Use percent pond and swamp area with table 6-9. Factor is 1.0 for zero percent pond and swamp area.)			
9. Peak discharge, q_p ft^3/s (Where $q_p = q_u A_m Q F_p$)			

Project	By	Date
Location	Checked	Date

Check one: Present Developed

Elevation or Stage

Detention basin storage (acre feet)

1. Data:
 Drainage area $A_m =$ _____ mi^2
 Rainfall distribution type (I, IA, II, III) = _____
- | | |
|-----------|-----------|
| 1st Stage | 2nd Stage |
|-----------|-----------|
2. Frequency yr

--	--
3. Peak inflow discharge q_i ft^3/s

--	--

 (from worksheet 6-3, Developed)
4. Peak outflow discharge q_u ft^3/s

--	--

 (from worksheet 6-3, Present)
5. Compute $\frac{q_o}{q_i}$

--	--
6. $\frac{V_s}{V_r}$

--	--

 (Use $\frac{q_o}{q_i}$ with figure 6-11)
7. Runoff, Q in

--	--

 (From worksheet 1)
8. Runoff volume V_r ac ft

--	--

 ($V_r = QA_m 53.33$)
9. Storage volume, V_s ac-ft

--	--

 ($V_s = V_r (\frac{V_s}{V_r})$)
10. Maximum storage E_{max} (from plot)

--	--

^{1/} 2nd stage q_o includes 1st stage q_o .

Pollutant Loading Table Worksheet

$$L = [(P \times P_j \times R_v)/12] \times C \times A \times 2.72$$

$$R_v = 0.05 + 0.009 (I)$$

Existing Condition

Land Use	%I	R _v	Area	Concentration (mg/l)			Pollutant Load (lbs.)		
				BOD	TSS	TP	BOD	TSS	TP
1.									
2.									
3.									
4.									

Future Condition

Land Use	%I	R _v	Area	Concentration (mg/l)			Pollutant Load (lbs.)		
				BOD	TSS	TP	BOD	TSS	TP
1.									
2.									
3.									

STANDARD INTERNATIONAL UNIT WORKSHEETS

Project	By	Date		
Location	Checked	Date		
Check one: <input type="checkbox"/> Present <input type="checkbox"/> Developed				
1. Runoff curve number				
Soil name and hydrologic group	Cover description <small>(cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)</small>	CN ^{1/} Tables 6-2, 6-3 6-4, 6-5	Area <input type="checkbox"/> Hectares <input type="checkbox"/> Km ² <input type="checkbox"/> %	Product of CN x area
^{1/} Use only one CN source per line			Totals ➡	
CN (weighted) = $\frac{\text{total product}}{\text{total area}}$ = _____ = _____ ; Use CN ➡			<input style="width: 80px; height: 20px;" type="text"/>	
2. Runoff				
		Storm #1	Storm #2	Storm #3
Frequency	yr			
Rainfall, P (24-hour)	mm			
Runoff, Q	mm			
(Use P and CN with Figure 6-7, or equations found on Figure 6-7)				

Project	By	Date
Location	Checked	Date

Check one: Present Developed

Check one: T_C T_t through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet.
 Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_C only)

	Segment ID				
1. Surface description (table 6-6)					
2. Manning's roughness coefficient, n (table 6-6)					
3. Flow length, L (total L ≤ 90)					
4. Two-year 24-hour rainfall, P ₂					
5. Land slope, s					
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T _t		+		=	

Shallow concentrated flow

	Segment ID				
7. Surface description (paved or unpaved)					
8. Flow length, L					
9. Watercourse slope, s					
10. Average velocity, V (figure 6-8)					
11. $T_t = \frac{L}{3600 V}$ Compute T _t		+		=	

Channel flow

	Segment ID				
12. Cross sectional flow area, a					
13. Wetted perimeter, p _w					
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r					
15. Channel slope, s					
16. Manning's roughness coefficient, n					
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V					
18. Flow length, L					
19. $T_t = \frac{L}{3600 V}$ Compute T _t		+		=	
20. Watershed or subarea T _C or T _t (add T _t in steps 6, 11, and 19)					Hr

Project	By	Date
Location	Checked	Date

Check one: Present Developed

1. Data

Drainage area $A_m =$ _____ Km²

Runoff curve number CN = _____ (From worksheet 6-1)

Time of concentration $T_c =$ _____ hr (From worksheet 6-2)

Rainfall distribution = _____ (I, IA, II, III)

Pond and swamp areas spread throughout watershed = _____ percent of A_m (_____ Hectares or Km² covered)

	Storm #1	Storm #2	Storm #3
2. Frequency yr			
3. Rainfall, P (24-hour) mm			
4. Initial abstraction, I_a mm (Use CN with table 6-8)			
5. Compute I_a/P			
6. Unit peak discharge, q_u m ³ per Km ² per mm (Use T_c and I_a/P with Figure 6-10 _____)			
7. Runoff, Q mm (From worksheet 1)			
8. Pond and swamp adjustment factor, F_p (Use percent pond and swamp area with table 6-9. Factor is 1.0 for zero percent pond and swamp area.)			
9. Peak discharge, q_p m ³ / _s (Where $q_p = q_u A_m Q F_p$)			

Project	By	Date
Location	Checked	Date

Check one: Present Developed

Elevation or stage

Detention basin storage (acre feet)

1. Data:
 Drainage area $A_m =$ _____ Km^2
 Rainfall distribution type (I, IA, II, III) = _____

1st Stage	2nd Stage
--------------	--------------

2. Frequency yr
3. Peak inflow discharge q_i m^3/s

(from worksheet 6-3, Developed)
4. Peak outflow discharge q_u m^3/s

(from worksheet 6-3, Present)
5. Compute $\frac{q_o}{q_i}$
6. $\frac{V_s}{V_r}$

(Use $\frac{q_o}{q_i}$ with figure 6-11)
7. Runoff, Q mm

(From worksheet 1)
8. Runoff volume V_r m^3

($V_r = QA_m 53.33$)
9. Storage volume, V_s m^3

($V_s = V_r (\frac{V_s}{V_r})$)
10. Maximum storage E_{max} (from plot)

^{1/} 2nd stage q_o includes 1st stage q_o .

$$L = [(P \times P_j \times R_v)/1000] \times C \times A \times 10.09$$

$$R_v = 0.05 + 0.009 (I)$$

Pollutant Loading Table Worksheet

Existing Condition

Land Use	%I	R _v	Area	Concentration (mg/l)			Pollutant Load (kilograms)		
				BOD	TSS	TP	BOD	TSS	TP
1.									
2.									
3.									
4.									

Future Condition

Land Use	%I	R _v	Area	Concentration (mg/l)			Pollutant Load (kilograms)		
				BOD	TSS	TP	BOD	TSS	TP
1.									
2.									
3.									