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Improvement Test– May. 2018

Sub:	Water Resource Engineering				Sub Code:	10CV846	Branch:	CIVIL
Date:	23/05/18	Duration:	90 min's	Max Marks: 50	Sem/Sec:	VIII		OBE

<u>Attempt any four questions from part A & any one question from part B.</u>

		MARKS	CO	RBT
	PART-A			
1	Explain the important approaches use for storm water management	[10]	CO 1	L2
2	Write short note on (i) **vegetated swales (ii) green roofs**	[10]	CO 1	L2
3	Briefly explain the **important green infrastructure methods**	[10]	CO 2	L2
4	Write short notes on source control techniques for urban drainage system	[10]	CO 2	L2
5	Write down the important design criteria useful for storm water design	[5+5]	CO 2	L2
6	Explain the rational methods use for design a storm water system	[10]	CO 3	L2
	PART-B			
7	Briefly explain the concept use in hydraulic design of culvert.	[10]	CO 3	L2
8	Write down the major effects of urbanization on storm water disaster.	10]	CO 3	L2

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Department of Civil Engineering

SUBJECT: WATER RESOURCE ENGINEERING (10CV846) IAT-3

Solution : Q No. 01

As stormwater controls have begun being integrated into the urban landscape as part of an evolving infrastructure network, the responsibilities for stormwater management have moved beyond the engineers who have historically borne the responsibility to planners and decision-makers who play an equally important role in community and economic development. The coordinated effort of technical and planning staffs and elected officials is critical to the success of a distributed, yet integrated system. Stormwater BMPs are adaptable to both micro- and macro-scale applications to solving water quality problems. They are able to meet stormwater management goals as well as other planning and design needs for urban settings to the benefit of urban dwellers and downstream recipients of stormwater. While often considered solely in a technical context, several planning alternatives can influence stormwater management.

Planning Tools for Water Quality Protection	
Planning Tools	**Function**
Comprehensive master planning	• Provides a coordinated approach with consideration of water quality protection.
Stream and wetland setbacks	• Place limits on development activities within certain distances of streams and wetlands. • Maintain natural flood and erosion control functions. • Protect infrastructure and homes from moving streams. • Use protection zones. ○ Based on public health and safety services. ○ Establishes minimum setback widths. ○ Details permitted and prohibited structures and uses. ○ Allows for non-conforming structures and uses. ○ Includes variance section to maintain buildability and provide flexibility.
Conservation design	• Allows for partial conservation of natural resources while development occurs. • Allows homes to be closer together while remainder of development area is in open space. • Requires understanding of site's soils,

	topography, and natural features.
Distributed stormwater management	• Stormwater controls are site features implemented at the source of impacts. • Potentially reduces stormwater infrastructure costs. • Promotes public participation and public education in pollution prevention and maintenance stormwater management practices. • Satisfies NPDES Phase II stormwater requirements. • Application for retrofit projects.

Creative problem solving of urban runoff with stormwater BMPs can provide a community with a solution that mitigates the identified stormwater problems and adds value to the community in the form of a variety of treatment applications which are attractive and cost less to implement and maintain when considered in a life-cycle cost context. This process allows a municipality to meet its regulatory obligations while enhancing its natural.

Selecting BMP Strategies According to Land Use

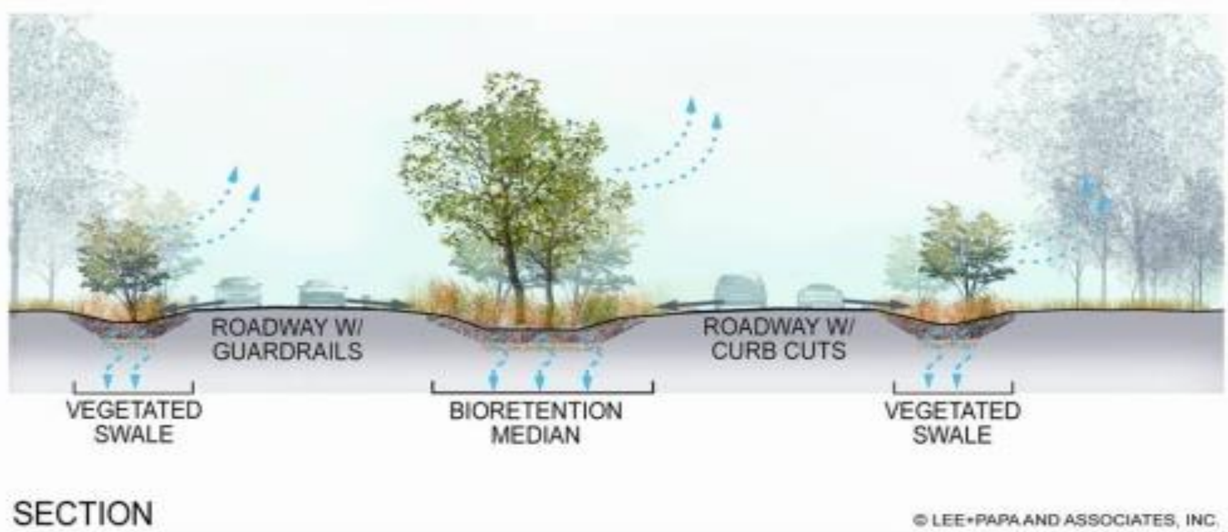
Stormwater BMP suitability for particular land uses will influence the selection of management strategies. Once appropriate controls are identified, implementation alternatives for integrating the controls into site are needed. Four implementation strategies that can be used to encourage BMP implementation are:

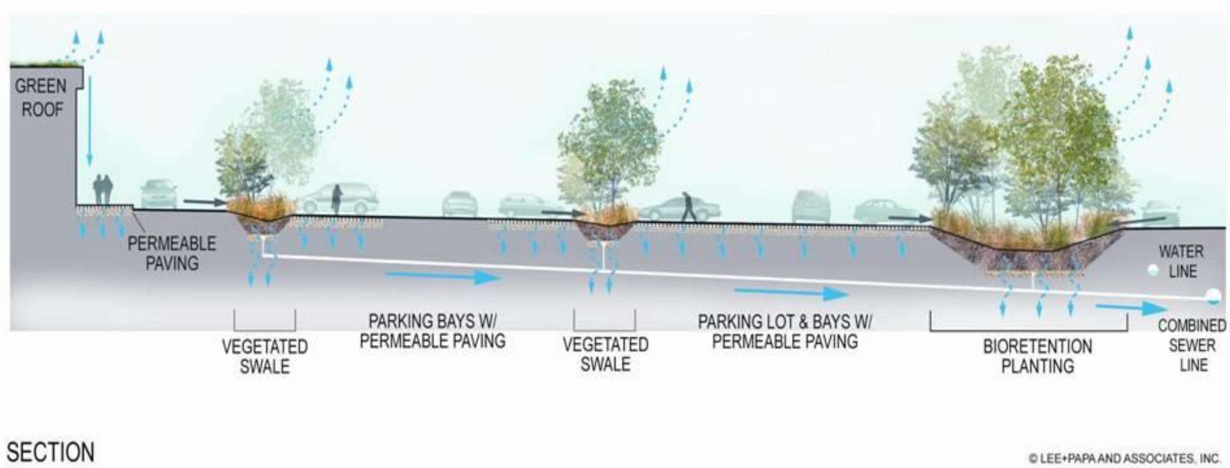
1. pilot installations;
2. watershed-based approaches;
3. building and site redevelopment projects; and
4. large-scale urban revitalization projects.

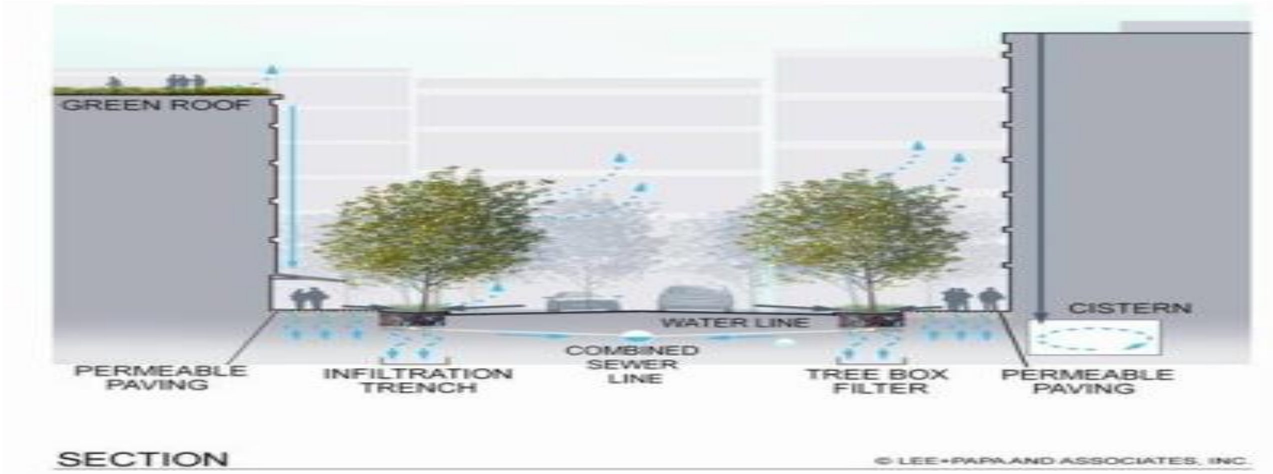
Parks and playfields offer large land areas that can serve dual purposes. The recreational use is unimpeded by the introduction of stormwater controls in this setting. Playing fields can be designed and built to act as infiltration areas for stormwater, forested areas in parks are natural infiltration zones, grassy swales can be used alongside of park roads, hard courts can be constructed of porous pavements or as the top of a large concrete cistern, and rain gardens can be installed as part of a habitat or environmental education initiative in a park. Other practices could be implemented as part of the control strategy for a given park or playfield.

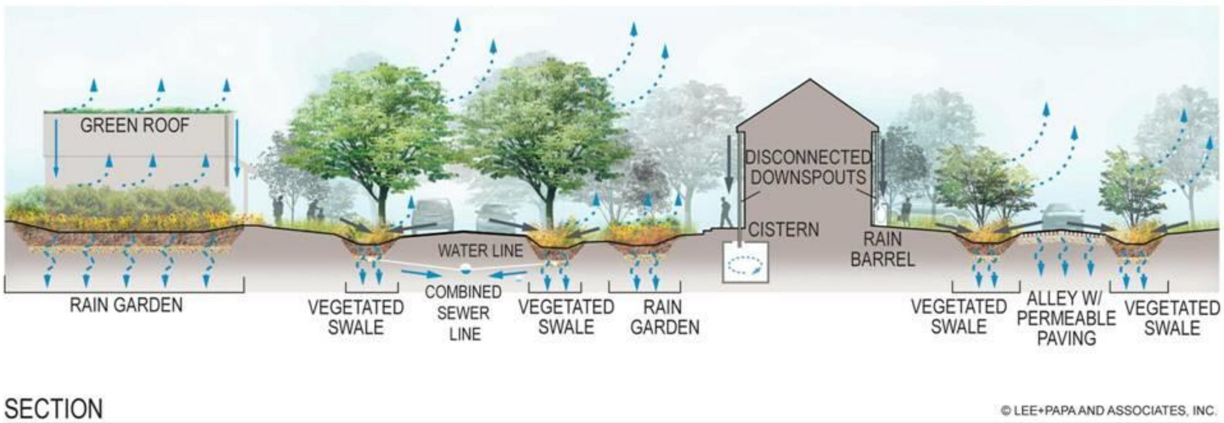
Landscaped areas are often raised up and shed water. These areas can be reconfigured to function as part of a system of BMPs for stormwater control while still serving the original landscaped area functions.

Dense, urban areas will make use of stormwater BMPs that can be most easily integrated within a building footprint or right-of-ways. Mitigating runoff from these highly impervious land uses will focus on managing runoff from roofs, roads, and parking lots. Green roofs, permeable pavements, infiltration planters, and rainwater harvesting are well-suited.









Integrated Storm water management toolbox

The Toolbox introduces the most commonly used approaches and concrete tools for urban storm water management. It is targeted at landscape architects, architects, urban planners and designers, including those interested in or working with the design, planning or management of urban water. The approach used assumes the necessary integration of storm water management into urban planning and development processes at all levels. Stormwater is a resource rather than a problem, and can support positive ecological and social urban dynamics.The tools introduced in the toolbox are organized in the table based on two systems. Firstly, they are classified according to the level of detail and the context in which they are applied. These classes are indicated by four different colours of the toolsheets. Secondly, all the tools and approaches are organized under three-point method.

Green infrastructure and ecosystem services

Low Impact Development (LID)

Water Sensitive Urban Design (WSUD)

Solution Q 2:

1. **Vegetable swales**
2. **Green roofs**

The term “swale” is often used by Permaculture people when designing large earth work constructions but it’s very rarely spoken of in an urban setting, a swale is “a long, shallow depression in the ground designed to collect or redirect water”.

Vegetated Swales Grassed swales are vegetated with native perennial grass, sedge, or rush species along the bottom and sides of the channel. The vegetation in the channel slows runoff, allows sediments to filter out, and can help remove nutrients. Bioswales are vegetated swales that use engineered media (usually a designed soil mix consisting of sand, loam soil and hardwood mulch) beneath the swale to improve water quality, reduce runoff volume, and control peak runoff rates. Although their functions are similar to grassed swales, bioswales have a greater capacity for water retention, nutrient removal, and pollutant removal. Adding gravel or other permeable material below the soil mixture further enhances infiltration.

When installing a swale, use a minimum 2% slope from beginning to end (longitudinal slope) to ensure that water is conveyed away from any structures and to a desired destination. Vegetation in the swale should be established before the first winter storms, so plant

Imagine it as a long, wide cup as opposed to a gutter or drain. While drains are designed to get rid of water – and fast – swales are designed to keep water from draining away too fast. They are meant to slow the water down so it can be redirected throughout a garden to the areas that need it most.

Plants for swales will have to withstand a lot of varying conditions. For instance, in arid places with little annual rainfall but sudden shocking rainstorms that drop huge volumes of water at once, your plants will need to be drought tolerant but require and thrive in sudden but infrequent deluges .The best advice is to stick with native plants as much as possible. They are adapted to your regions changing climate and fluctuating rainfall.

A swale is a shallow trench dug out (dead level) along the land's contour, with a berm on the downhill side. They can be important features in an earth-friendly yard because they help slow, store, and spread stormwater so as not to overwhelm the sewer systems. For the gardener, a swale can be more efficient at storing rainwater than rain barrels (when used appropriately) and requires no engineering or mechanical skills to build.

Write down the following observations.

- **Identify** where water is wasted.
- **Observe** drainage patterns
- **Locate** steep slopes
- **Determine** annual rainfall
- **Calculate** roof water catchment area (if applicable). For example, my roof area is 1,200 square feet.
  - Fruit Tree Guilds
  - Berry-Producing Nitrogen-Fixing Shrubs
  - Perennial Sunflowers
  - Hedgerow

A rain garden is a specialized landscape design that captures stormwater runoff from roofs, driveways, or other impervious surfaces and allows water to SINK back into the ground. It uses plants to remove pollutants and improve infiltration allowing water to soak back into the landscape. In soils with low permeability this system may be used to temporarily store water (not completely infiltrate) and remove pollutants before they enter a waterway.A rain garden design can be as simple as a shallow depression filled with plants that can flourish in both moist and dry conditions. The required size, shape, and depth of the garden depend on how much water you are trying to capture. For large amounts of runoff or areas with insufficient infiltration, there are a full spectrum of engineered features, such as specialized soil mixtures, an aggregate base, and subsurface drains that can be added. These more complex designs are often referred to as bioretention cells.

b. Green Roof:

A green roof system is an extension of the existing roof which involves, at a minimum, high quality water-proofing, root repellent system, drainage system, filter cloth, a lightweight growing medium, and plants. Green roof systems may be modular, with drainage layers, filter cloth, growing media, and plants already prepared in movable, often interlocking grids, or loose laid/built-up whereby each component of the system may be installed separately. Green roof development involves the creation of "contained" green space on top of a human-made structure. This green space could be below, at, or above grade, but in all cases it exists separate from the ground. Green roofs can provide a wide range of public and private benefits and have been successfully installed in countries around the world.

The benefits of green roof technologies are poorly understood and the market remains immature, despite the efforts of industry leaders. In Europe however, these technologies have become very well established. This has been the direct result of government legislation and financial support. Such support recognizes the many tangible and intangible public benefits of green roofs. This support has led to the creation of a vibrant, multi-million dollar market for green roof products.

Green roofs offer many public, private, and design-based benefits.

PUBLIC BENEFITS

AESTHETIC IMPROVEMENTS

- Urban greening has long been promoted as an easy and effective strategy for beautifying the built environment and increasing investment opportunity.

WASTE DIVERSION

- Green roofs can contribute to landfill diversion
  - Prolonging the life of waterproofing membranes, reducing associated waste
  - The use of recycled materials in the growing medium
  - Prolonging the service life of heating, ventilation, and HVAC systems through decreased use

STORMWATER MANAGEMENT

- With green roofs, water is stored by the substrate and then taken up by the plants from where it is returned to the atmosphere through transpiration and evaporation.
- In summer, green roofs can retain 70-90% of the precipitation that falls on them.

- In winter, green roofs can retain between 25-40% of the precipitation that falls on them.
- Green Roofs not only retain rainwater, but also moderate the temperature of the water and act as natural filters for any of the water that happens to run off.
- Green roofs reduce the amount of stormwater runoff and also delay the time at which runoff occurs, resulting in decreased stress on sewer systems at peak flow periods.

MODERATION OF URBAN HEAT ISLAND EFFECT

- Through the daily dew and evaporation cycle, plants on vertical and horizontal surfaces are able to cool cities during hot summer months and reduce the Urban Heat Island (UHI) effect. The light absorbed by vegetation would otherwise be converted into heat energy.
- UHI is also mitigated by the covering some of the hottest surfaces in the urban environment - black rooftops.
- Green roofs can also help reduce the distribution of dust and particulate matter throughout the city, as well as the production of smog. This can play a role in reducing greenhouse gas emissions and adapting urban areas to a future climate with warmer summers.

IMPROVED AIR QUALITY

- The plants on green roofs can capture airborne pollutants, atmospheric deposition, and also filter noxious gases.
- The temperature moderating effects of green roofs can reduce demand on power plants, and potentially decrease the amount of CO_2 and other polluting by-products being released into the air.

NEW AMENITY SPACES

Green roofs help to reach the principles of smart growth and positively affect the urban environment by increasing amenity and green space and reducing community resistance to infill projects. Green roofs can serve and number of functions and uses, including:

- Community gardens (e.g. local food production or co-ops)
- Commercial space (e.g. display areas and restaurant terraces)
- Recreational space (e.g. lawn bowling and children's playgrounds)

PRIVATE BENEFITS

ENERGY EFFICIENCY

- The greater insulation offered by green roofs can reduce the amount of energy needed to moderate the temperature of a building, as roofs, are the sight of the greatest heat loss in the winter, and the hottest temperatures in the summer.

- For example, research published by the National Research Council of Canada found that an extensive green roof reduced the daily energy demand for air conditioning in the summer by over 75% (Liu 2003).

INCREASED ROOFING MEMBRANE DURABILITY

- The presence of a green roof decreases the exposure of waterproofing membranes to large temperature fluctuations, that can cause micro-tearing, and ultraviolet radiation.

FIRE RETARDATION

- Green roofs have much lower burning heat load (the heat generated when a substance burns) than do conventional roofs (Koehler 2004).

REDUCTION OF ELECTROMAGNETIC RADIATION

- Green roofs are capable of reducing electromagnetic radiation penetration by 99.4% (Herman 2003).

NOISE REDUCTION

- Green roofs have excellent noise attenuation, especially for low frequency sounds. An extensive green roof can reduce sound from outside by 40 decibels, while an intensive one can reduce sound by 46-50 decibels (Peck et al. 1999).

MARKETING

- Green roofs can increase a building's marketability. They are an easily identifiable symbol of the green building movement and can act as an incentive to those interested in the multiple benefits offered by green roofs.
- Green roofs, as part of the green building movement, have been identified as facilitating (Wilson 2005)
    - Sales
    - Lease-outs
    - Increased property value due to increased efficiency
    - Easier employee recruiting
    - Lower employee and tenant turnover

DESIGN SPECIFIC BENEFITS

INCREASED BIODIVERSITY

- Green roofs can sustain a variety of plants and invertebrates, and provide a habitat for various bird species. By acting as a stepping stone habitat for migrating species they can link species together that would otherwise be fragmented.
- Increasing biodiversity can positively affect three realms:
  - Ecosystem
    - Diverse ecosystems are better able to maintain high levels of productivity during periods of environmental variation than those with fewer species.
  - Economic
    - Stabilized ecosystems ensure the delivery of ecological goods (e.g. food, constructuion materials, and medicinal plants) and services (e.g. maintain hydrological cycles, cleanse water and air, and store and cycle nutrients)
  - Social
    - Visual and environmental diversity can have positive impacts on community and psychological well-being

IMPROVED HEALTH AND WELL-BEING

- The reduced pollution and increased water quality that green rofos bring can decrease demands for healthcare.
- Green roofs can serve as community hubs, increasing social cohesion, sense of community, and public safety.

URBAN AGRICULTURE

- Using green roofs as the site for an urban agriculture project can reduce a community's urban footprint through the creation of a local food system.
- These projects can serve as a source of community empowerment, give increased feelings of self-reliance, and improve levels of nutrition.

EDUCATIONAL OPPORTUNITIES

- Green roofs on educational facilities can provide an easily accessible sight to teach students and visitors about biology, green roof technology, and the benefits of green roofs.

Solution: Q 3 Important green infrastructure methods

Green infrastructure is often confused with the field of **green building**. In the context of building "green," certification programs such as LEED (leadership in environment, energy and design) promoted by the U.S. Green Building Council, or Earth craft, a rating system applied to energy efficient standards for homes are used for individual buildings. LEED has recently expanded to include Neighborhood LEED. However, Earth craft and other building oriented programs do not do a good job of considering the landscape. LEED pays some attention to this, such as recommending siting buildings on the land to achieve least impact, minimizing off-site impacts by capturing and treating storm water, or orienting buildings to maximize heating and cooling efficiency.

Moving from the building envelope to the site itself, approaches such as **Low Impact Development (LID)** are often employed by progressive developers. Low impact development is a *design strategy* with a goal of maintaining or replicating the pre-development hydrologic regime through the use of design techniques to create a functionally equivalent hydrologic site design" (*Low Impact Development DRAFT Technical Bulletin).* LID is used to offset practices of the built environment and operates at the site scale. For example, a raingarden is a wonderful way to slow and filter stormwater and localities and builders are encouraged to employ raingardens in new building sites or, they can be utilized in watershed planning efforts to retrofit developed urban areas with better stormwater management.

Planning that begins within the context of local ecological systems can ensure that development is channeled to the most appropriate areas, such as nearer to existing grey infrastructure. Within larger sites, such as 100 acres or greater, green infrastructure is evaluated within the site and across the landscape so that the site does not become disconnected from other important corridors, such as riparian systems, or large forests or dune systems. Green infrastructure planning provides an opportunity for communities to approach land use planning in a new way.

Green infrastructure can be a cost-effective approach to improve water quality and help communities stretch their infrastructure investments further by providing multiple environmental, economic, and community benefits. On this page, learn more about how other communities have realized cost savings through their green infrastructure programs as well as about tools you can use to inform your own cost-benefit analysis.

GREEN BUILDING

Energy efficiency and renewable energy resources:

Environmental impact:
The built environment has a tremendous impact on the environment. However, your building can interact more positively with the environment, if you pay special attention to preserving the site‟s integrity and natural characteristics, appropriate landscaping and the selection of materials that have lower embodied energy and those that are produced locally.
Resource conservation:
Conserving resources is a cornerstone of green building techniques. There are many ways to conserve resources during the building process. For example, selecting materials that have at least some recycled content can conserve natural resources and virgin materials. Minimizing

construction wastes can ease the impact on landfills and resources. Installing water- and energy-efficient products can conserve resources, while reducing operating costs. Choosing a green (plant-covered) roof can reduce energy use, cool urban heat islands and prevent storm water runoff as well as contributes to wildlife habitat and air quality.

Indoor air quality: Energy-efficient buildings are more airtight and therefore hold greater potential for indoor air quality problems, especially if not properly ventilated.

Community issues: Placing green building projects within easy access of public transportation, medical facilities, shopping areas and recreational facilities decreases the need for automobiles and encourages bicycling and walking. In addition, successful green buildings blend into the community, preserving natural and historical characteristics and will utilise existing infrastructure in order to reduce sprawl. Co-housing represents one approach to creating a community of green buildings.

CO2 emission reduction:

Solution: Q 4

Source control techniques for urban drainage

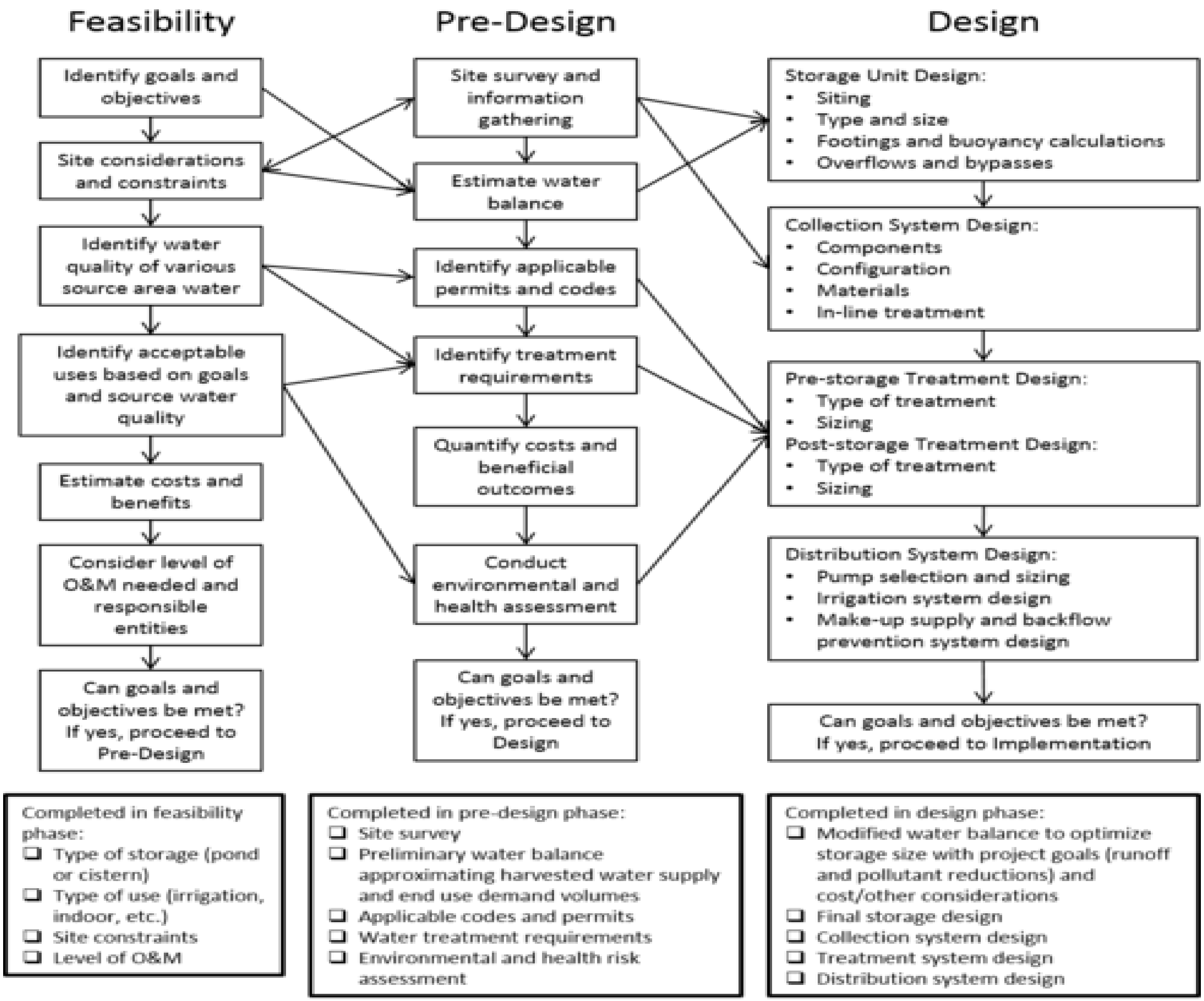
Source control and prevention techniques are designed to counter increased discharge from developed sites, as close to the source as possible and to minimise the volume of water discharged from the site. This offers the benefits of reduced flood risk and improved water quality. It helps to restore underground water resources and maintain flows in surface watercourses during dry weather.

Source Control

- Green roofs
- Infiltration basins
- Infiltration trenches
- Permeable pavements
- Rainwater harvesting
- Soakaways

- **Permeable Conveyance Systems**
  - Filter (or French) drains
  - Swales
- **Passive Treatment**
  - Filter strips
  - Detention basins
  - Retention ponds
  - Wetlands

Solution Q 4



PLANNING FOR DRAINAGE SYSTEMS

There are many components that may make up the drainage system within a development. These components should work together to provide an economical solution for the conveyance of storm water to an outfall location.

public recreation

• horse/bike/hiking trails

• walking paths

• nature preserves

• wildlife habitat areas, etc.

PLANNING FOR STORAGE

PLANNING FOR TRANSPORTATION

PLANNING FOR OPEN SPACE

PLANNING FOR LID

PLANNING FOR DAMS

MAINTENANCE STANDARDS

Hydrology method of analysis

Basin Delineation

Selection of Rational or Hydrograph Method:

For drainage areas less than 200 hundred (200) acres, the basis for computing runoff shall be the rational formula (as defined in Section 5.3) or some other method provided it is acceptable to the Director of TCI. For drainage areas 200 hundred (200) acres or greater, the basis for computing runoff shall be a unit hydrograph method preferably the Soil Conservation Service (SCS) Dimensionless Unit Hydrograph method as contained in the U.S. Army Corps of Engineers Hydrologic Engineering Center HEC-HMS “Hydrologic Modeling Systems".

Selection of Method for Detention Ponds

For detention ponds with drainage areas of twenty (20) acres or less, the basis for computing runoff shall be the modified rational method. When the drainage area of a detention pond is greater than twenty (20) acres the unit hydrograph method shall be used. The unit hydrograph method shall be used when multiple detention ponds within a watershed are being modeled, regardless of drainage area, unless approved by the Director of TCI.

RATIONAL METHOD

The Rational Method is appropriate for estimating peak discharge for small areas up to (200) acres with no significant flood storage. This method provides a peak discharge value but no time-series of flow or flow volume: (Equation 5.3.1) $Q = C I A$ Q = Peak Discharge (cfs) C = Runoff coefficient I = Average rainfall intensity (in./hr.) A = Drainage area (acres)

Runoff coefficients (C) may need to be calculated as a weighted runoff coefficient where multiple values are present in one drainage area. To determine the intensity (I) it is necessary to calculate the Time of Concentration (Tc). This value is used to identify the rainfall intensity.

TIME OF CONCENTRATION

The following methods are recommended for time of concentration calculation: (

Tc = Tt + Tsc + Tch

Tc = Time of Concentration Tt = Sheet flow over plane surface Tsc = Shallow Concentrated Flow Tch = Open Channel Flow.

Overland Flow Flow over plane surfaces: Maximum allowable time is twenty (20) minutes. Minimum is five (5) minutes.

• The overland flow time chart from "Design" by Elwyn E. Seelye may be used to calculate overland flow times. Note that the minimum time has been reduced to five (5) minutes.

Hydraulic Principles

Open Channel Flow

Introduction

This chapter describes concepts and equations that apply to the design or analysis of open channels and conduit for culverts and storm drains. Refer to the relevant chapters for specific procedures.

Continuity and Velocity

The continuity equation is the statement of conservation of mass in fluid mechanics. For the special case of steady flow of an incompressible fluid, it assumes the following form:

$$Q = A_1 v_1 = A_2 v_2$$

Equation 6-1.

where:

- Q = discharge (cfs or m^3/s)
- A = flow cross-sectional area (sq. ft. or m^2)
- v = mean cross-sectional velocity (fps or m/s, perpendicular to the flow area).
- The superscripts *1* and *2* refer to successive cross sections along the flow path.

As indicated by the Continuity Equation, the average velocity in a channel cross-section, (v) is the total discharge divided by the cross-sectional area of flow perpendicular to the cross-section. It is only a general indicator and does not reflect the horizontal and vertical variation in velocity.

Velocity varies horizontally and vertically across a section. Velocities near the ground approach zero. Highest velocities typically occur some depth below the water surface near the station where the deepest flow exists. For one-dimensional analysis techniques such as the Slope Conveyance Method and (Standard) Step Backwater Method (see Chapter 7), ignore the vertical distribution, and estimate the horizontal velocity distribution by subdividing the channel cross section and computing average velocities for each subsection. The resulting velocities represent a velocity distribution.

Channel Capacity

Most of the departmental channel analysis procedures use the Manning's Equation for uniform flow (Equation 6-2) as a basis for analysis:

$$v = \frac{z}{n} R^{2/3} S^{1/2}$$

Equation 6-2.

where:

- *v* = Velocity in cfs or m^3/sec
- *z* = 1.486 for English measurement units, and 1.0 for metric
- *n* = Manning's roughness coefficient (a coefficient for quantifying the roughness characteristics of the channel)
- *R* = hydraulic radius (ft. or m) = A / WP
- *WP* = wetted perimeter of flow (the length of the channel boundary in direct contact with the water) (ft. or m)
- *S* = slope of the energy gradeline (ft./ft. or m/m) (For uniform, steady flow, S = channel slope, ft./ft. or m/m).

Combine Manning's Equation with the continuity equation to determine the channel uniform flow capacity as shown in Equation 6-3.

$$Q = \frac{z}{n} A R^{2/3} S^{1/2}$$

Equation 6-3.

where:

- *Q* = discharge (cfs or m^3/s)
- *z* = 1.486 for English measurement units, and 1.0 for metric
- *A* = cross-sectional area of flow (sq. ft. or m^2).

Conveyance

In channel analysis, it is often convenient to group the channel cross-sectional properties in a single term called the channel conveyance (K), shown in Equation 6-4.

$$K = \frac{z}{n} A R^{2/3}$$

Equation 6-4.

Manning's Equation can then be written as:

$$Q = K S^{1/2}$$

Design Considerations: Culvert

Reduced to an annual cost on the basis of the anticipated service life, the long-term costs of a culvert operation include the following:

- initial cost of the culvert
- cost of damage to the roadway
- cost of damage to the culvert and associated appurtenances
- cost of damage to the stream (approach and exit)
- cost of damage to upstream and downstream private or public property.

Site Data

The survey should provide you with sufficient data for locating the culvert and identifying information on all features affected by installation of the culvert, such as elevations and locations of houses, commercial buildings, croplands, roadways, and utilities. See Chapter 3 Process and Procedures and Chapter 4 Hydrology.

Culvert Location

Culvert location involves the horizontal and vertical alignment of the culvert with respect to both the stream and the highway. The culvert location affects hydraulic performance of the culvert, stream and embankment stability, construction and maintenance costs, and safety and integrity of the highway.

- Economics
- Site Data
- Culvert Location
- Waterway Considerations
- Roadway Data
- Allowable Headwater
- Outlet Velocity
- End Treatments
- Traffic Safety
- Culvert Selection
- Culvert Shapes

Multiple Barrel Boxes
Design versus Analysis
Culvert Design Process

The hydraulic operation and performance of a culvert involve a number of factors. You must determine, estimate, or calculate each factor as part of the hydraulic design or analysis.

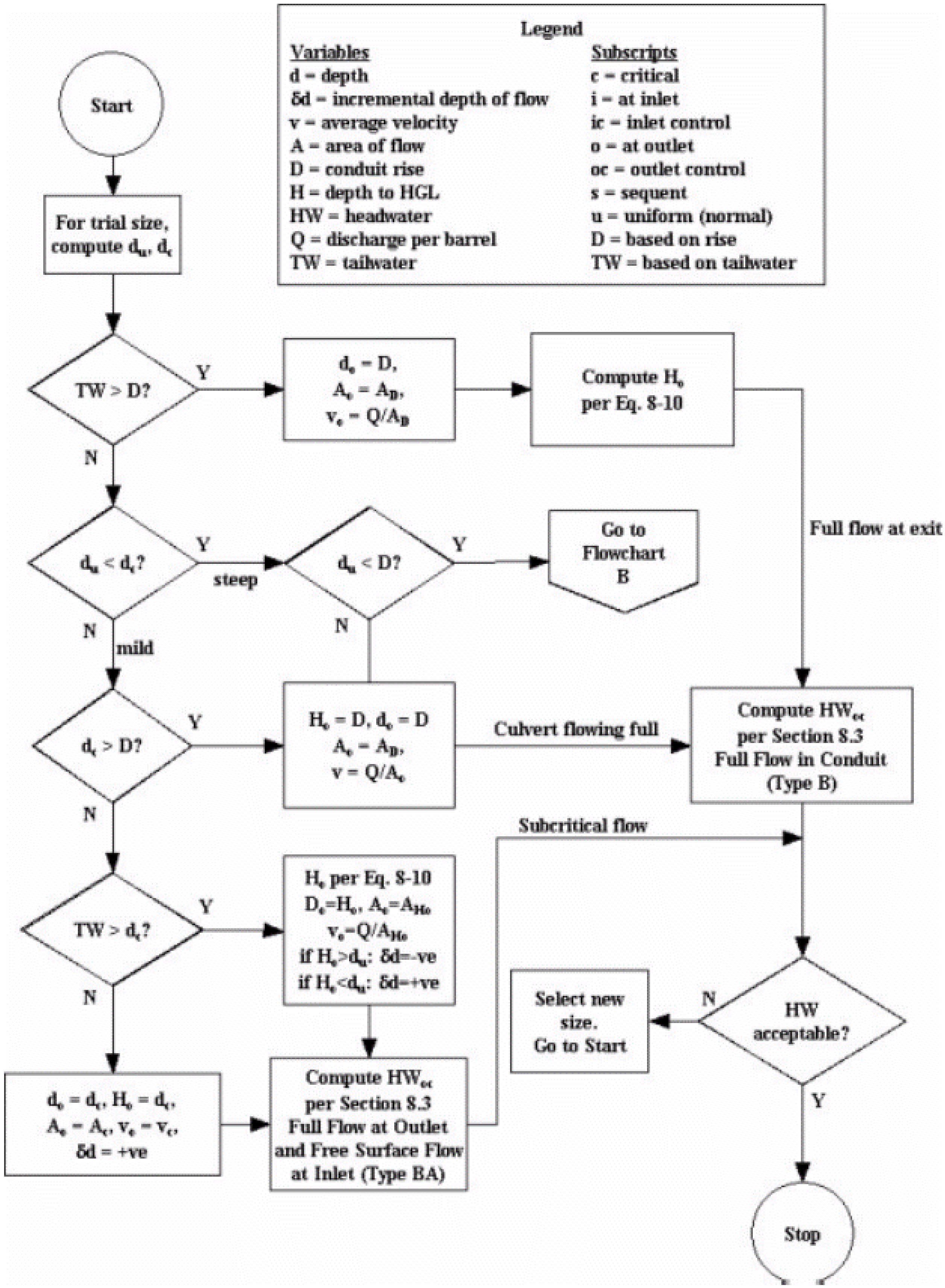
The following procedures assume steady flow but can involve extensive calculations that lend themselves to computer application.

The design engineer should be familiar with all the equations in the previous Section before using these procedures. Following the design method without an understanding of culvert hydraulics can result in an

Design Guidelines and Procedure for Culverts

Assemble Site Data

• Site survey and locality map. • Embankment cross-section. • Roadway profile. • Photographs, aerial photographs. • Details from field visit (sediment, debris and scour at existing structure). • Design data for nearby structures. • Studies by other authorities near the site, including small dams, canals, weirs, floodplains, storm drains. • Recorded and observed flood data.


Legend
Variables
d = depth
δd = incremental depth of flow
v = average velocity
A = area of flow
D = conduit rise
H = depth to HGL
HW = headwater
Q = discharge per barrel
TW = tailwater
Subscripts
c = critical
i = at inlet
ic = inlet control
o = at outlet
oc = outlet control
s = sequent
u = uniform (normal)
D = based on rise
TW = based on tailwater
Start
For trial size, compute d_u, d_c
TW > D?
Y
N
d_o = D, A_o = A_D, v_o = Q/A_D
Compute H_o per Eq. 8-10
Full flow at exit
d_u < d_c?
steep
mild
d_u < D?
Go to Flowchart B
d_c > D?
H_o = D, d_o = D, A_o = A_D, v = Q/A_o
Culvert flowing full
Compute HW_{oc} per Section 8.3 Full Flow in Conduit (Type B)
Subcritical flow
TW > d_c?
H_o per Eq. 8-10, D_o=H_o, A_o=A_{Ho}, v_o=Q/A_{Ho}, if H_o>d_u: δd=-ve, if H_o<d_u: δd=+ve
d_o = d_c, H_o = d_c, A_o = A_c, v_o = v_c, δd = +ve
Compute HW_{oc} per Section 8.3 Full Flow at Outlet and Free Surface Flow at Inlet (Type BA)
HW acceptable?
Select new size. Go to Start
Stop

Solution Q. 8

Major Effect of urbanization on storm water disaster

HYDROLOGIC EFFECTS OF URBAN DEVELOPMENT

HYDRAULIC EFFECTS FROM CHANGES TO STREAM CHANNELS AND FLOODPLAINS

EFFECTS OF URBAN DEVELOPMENT ON FLOOD DISCHARGE AND FREQUENCY

Some water-quality issues that relate to urban development.

- Population Growth
- Erosion and Sedimentation
- Urban Runoff
- Nitrogen
- Phosphorus
- Sewage Overflows
- Waterborne Pathogens
- Pesticides

Environmental Impacts:

Air pollution and Water pollution

Natural habitat destruction

Food security problem heavy load on environment

Economical and social impacts

Inequalities and urban growth

Fertility rate and infrastructure