CEE 3361
4. Water resources management

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Outline

- Stormwater management
  - Storm sewers – peak flow
  - Storm sewers – pipe design
  - Runoff control
  - Water quality control

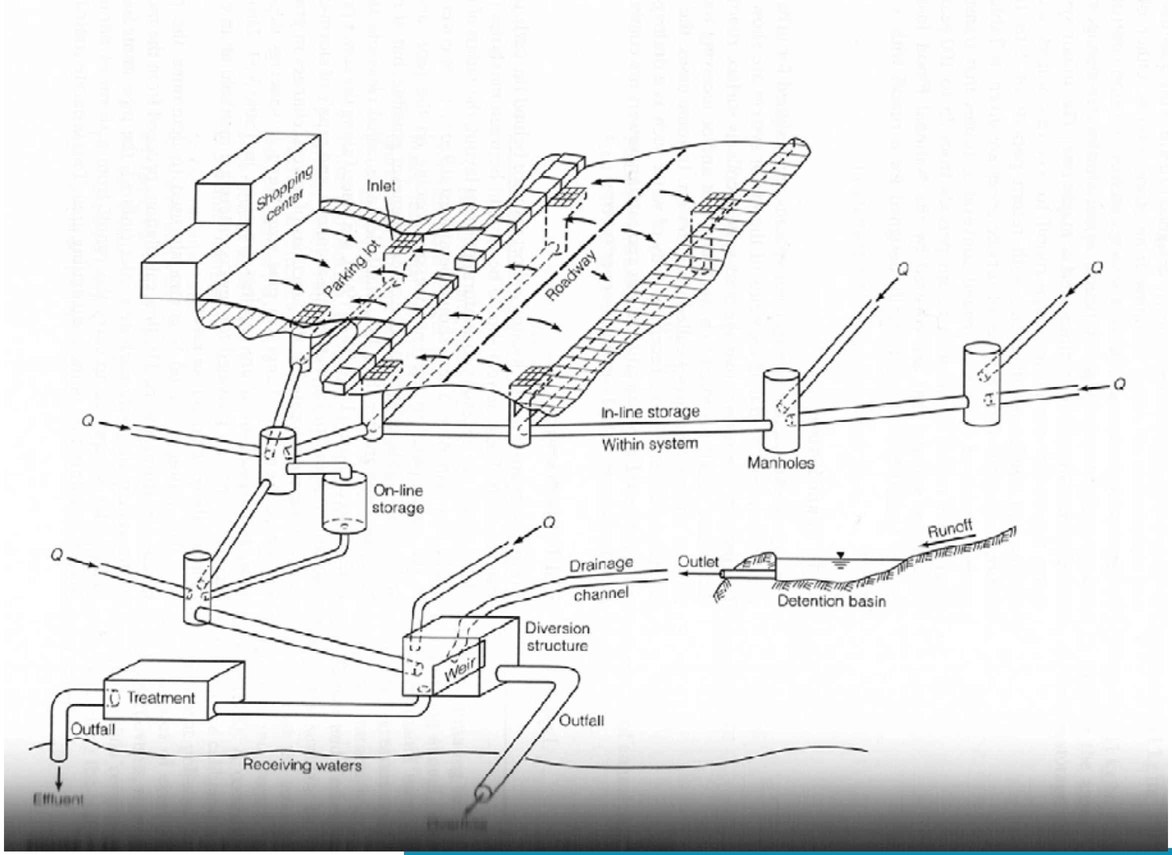
- Chin, D.A. page 479-541

Stormwater management

- Storm water management systems
  - Designed for the control of quantity, quality, timing and distribution of storm runoff
- Two components
  - Minor – route runoff to receiving bodies (2 – 10 years return period)
  - Major – above ground conveyance routes (25 – 100 years return period)

Stormwater management

- Minor systems for urban environments



Stormwater management

- Storm sewers
  - Short distance behind the curb
  - Straight between manholes
  - At least 1 m of cover
  - Manholes/clean out structures/access holes
    - Spacing depends on the pipe sizes (120-200m)
  - Rational method commonly used to determine the peak flows

Stormwater management

- Storm sewers
  - Full flow at the design discharge
  - Limited surcharge above the pipe crown may be permitted
  - Minimum velocity of 60 - 90cm/sec (full) to prevent the deposition of suspended material
  - Maximum velocity of 3 - 4.5 m/sec to prevent scouring
- Flow equation
  - Appropriate: Darcy-Weisbach equation
  - Common practice: Manning equation (valid only for turbulent flow) under the following conditions

$$n\sqrt[6]{RS_0} \geq 9.6 \times 10^{-14}$$

  - n- Manning roughness, R-hydraulic radius of the pipe (m), S_0-slope of the pipe
  - n- Table 5.35 (page 484)

Stormwater management

- Sewer pipes design: calculate the size and slope of the pipes that will carry the design flows at velocities within a specific range and with flow depths that are less than or equal to the diameter of the pipes.
- Manning Q (m^3/sec) D (m)   Darcy-Weisbach f (friction)

$$D = \left(\frac{3.21Qn}{\sqrt{S_0}}\right)^{3/8}$$

$$D = \left(\frac{0.811fQ^2}{gS_0}\right)^{1/5}$$

- Concrete, asbestos-cement, and clay pipes are used for diameters between 10 and 60 cm

Stormwater management

- Junctions and manholes
  - Must be smooth to avoid high head losses
  - Large angle between the incoming pipes (>60º)
  - Large vertical distance between the pipes (>15cm between the two inverts)
  - Manhole head loss:

$$h_m = K_c \frac{V^2}{2g}$$

  - K_c – a head loss coefficient; V – the average velocity

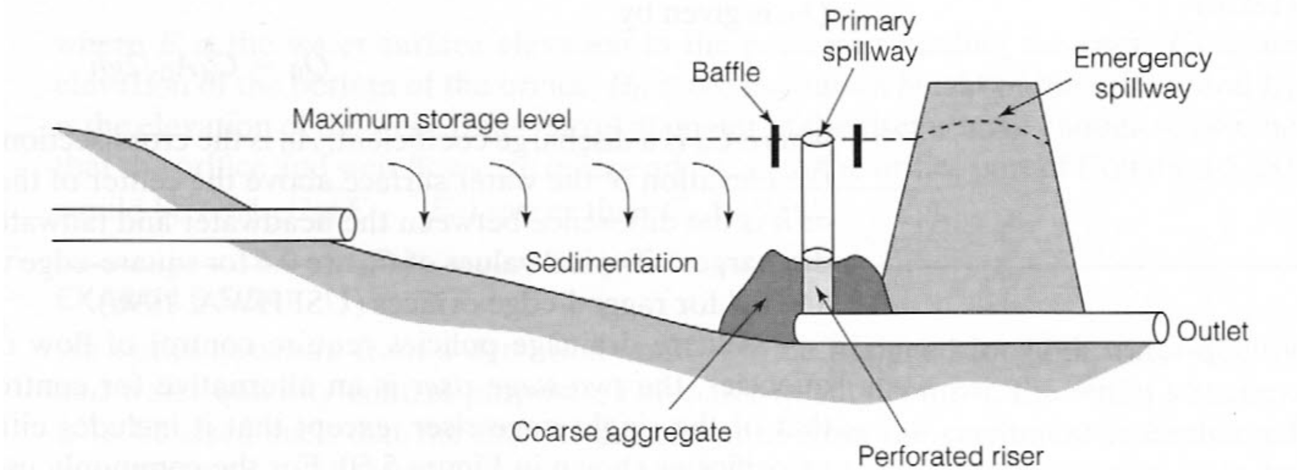
Stormwater management

- Quantity control – flooding and control of post development runoff rates
- Quality control – defined level of treatment: specified detention time in a sedimentation basin or the retention of a specified volume
- Different design requirements
  - Quantity – 10 to 100 years return period
  - Quality – less than 1 year return period
- On site control or regional control
- Minimization of impervious areas!!!!!!!!!!

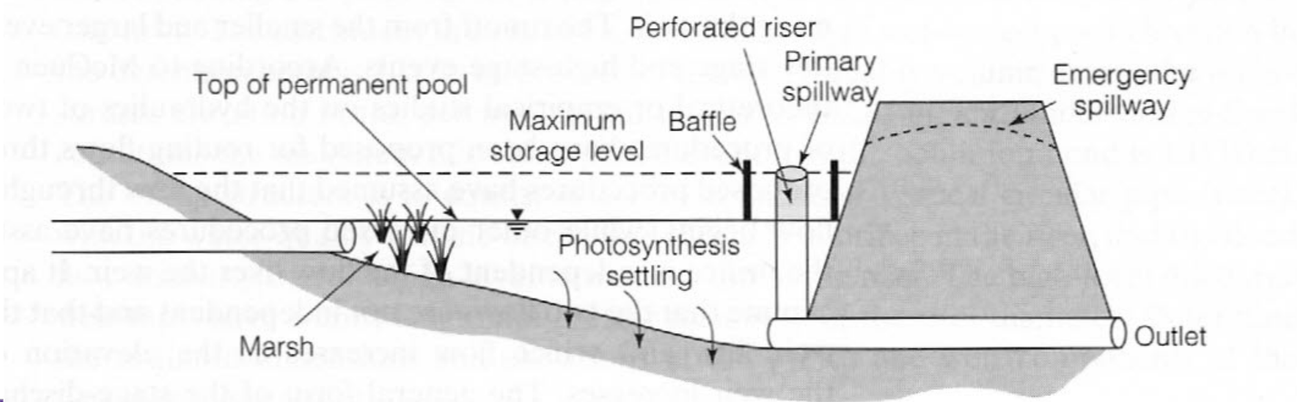
Stormwater management

- Stormwater impoundments
  - Detention basins – storage with uncontrolled outlet
  - Retention basins – storage without outlet
    - Wet basins – permanent water body
    - Dry basins – no water

Stormwater management



- Dry

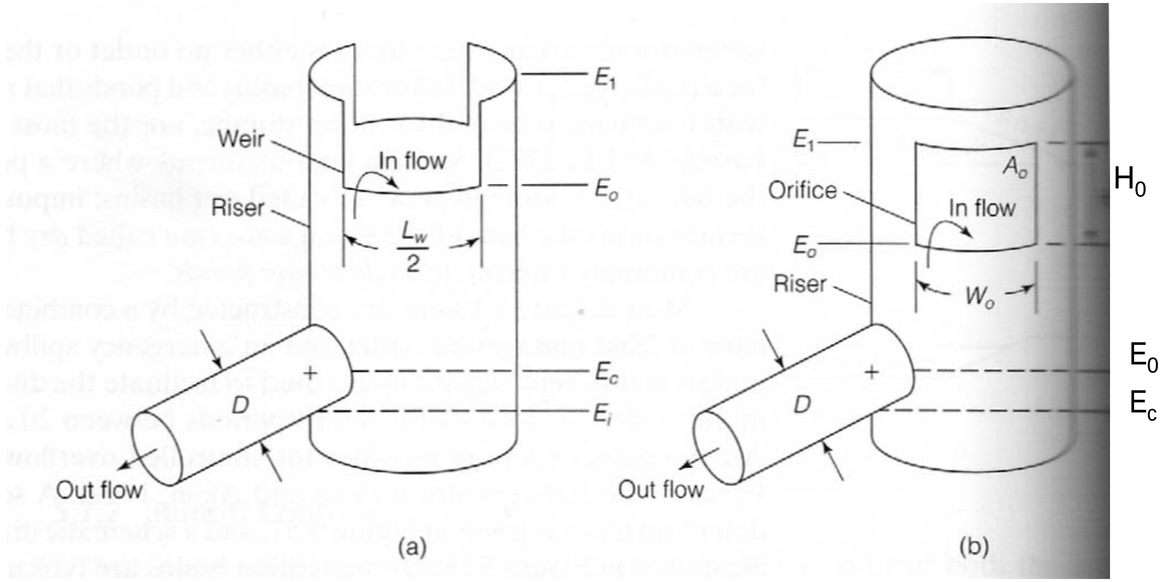


- Wet

Stormwater management

- Most common outlets
  - Orifice type
  - Weir type
- Outlets
  - Single stage riser
  - Two stage riser

Stormwater management



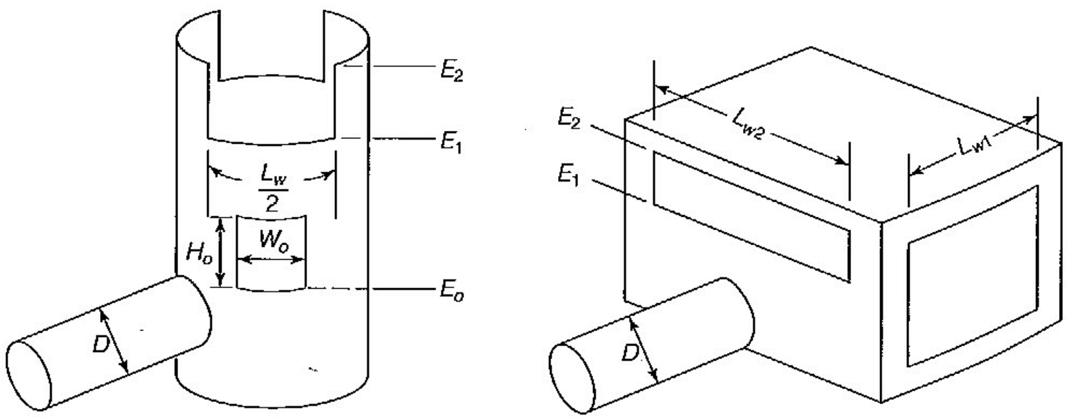
$$Q_w = C_w L_w h^{3/2}$$

$$Q_0 = C_d A_0 \sqrt{2g}\, h$$

C_w – weir coefficient (typical 1.83)
h – elevation of the water above the crest [m]

C_d – discharge coefficient (0.6 for square edge)
h – elevation of the water above the center of the orifice [m]

Stormwater management



(a) Weir/orifice control

(b) Weir/weir control

$$Q = \begin{cases} 0, & E \le E_0 \\ C_w L_w (E - E_0)^{1.5}, & E_0 \le E \le E_0 + H_0 \\ C_d A_0 \sqrt{2g(E - E_0}, & E_0 + H_0 \le E \le E_1 \\ C_w L_w (E - E_0)^{1.5} + C_d A_0 \sqrt{2g(E - E_1}, & E_1 < E \end{cases}$$

E – water surface elevation in the pond

Stormwater management

- Flood control – discussed earlier
- Water quality control – non structural and structural
  - Structural
    - defined level of treatment (detention time in a sedimentation basin)
    - the retention of specified volume of initial runoff called the water quality volume

Stormwater management

- Detention and retention
  (a) detain the design runoff long enough to provide targeted level of treatment (about 18hr settles 60% of total suspended solids and 45% of total BOD)
  (b) evacuate the design runoff soon enough to provide available storage for the next runoff event (average time between storms 73-108 hr)
- Reservoir routing problem
- Layouts (page 524, 526, 528)