BENEFITS Low = <30% Medium = 30-65% High = 65-100%			
	Low	Med	High
Suspended Solids			✓
Nitrogen		✓	✓
Phosphorous		✓	✓
Metals			✓
Bacteriological			✓
Hydrocarbons			✓

Description: Infiltration basins are dry ponds constructed to allow infiltration to occur simultaneously with other treatment processes. Infiltration basins are often designed as offline or end-of-pipe BMPs to capture a defined volume of stormwater runoff volume and transform the water into groundwater flow through infiltration. Pollutants are also removed through filtration and adsorption as the water percolates through the underlying soils. A key feature of an infiltration basin is vegetation, which increases the infiltration capacity of the basin. Dense vegetation also impedes soil erosion and scouring of the basin floor. It is generally characterized as an open impoundment dedicated to infiltration, greater than 15 feet wide, with a flat earthen floor.

Typical uses: Residential watersheds

Advantages:
- Can be effective for removing fine sediment, trace metals, nutrients, and bacteria
- Principle benefit is groundwater recharge and preservation of the natural water balance of the development site
- Can be useful for controlling the WQv and often can provide for the channel protection volume (Cpv)
- Reduce flooding
- Reduce thermal impacts to streams

Disadvantages/limitations:
- Not appropriate for treating significant loads of sediment and other pollutants due to potential for clogging of the basin infiltration surface
- Potentially high failure rate due to improper siting, design, and lack of maintenance – especially if pre-treatment is not included in the overall design
- Maintenance of effective upstream pre-treatment, a sediment forebay, and vegetation in the basin infiltration area will prolong infiltration performance and increase the interval between cleaning
- Not recommended in karst areas, industrial parks, high-density or heavy industrial areas, chemical or pesticide storage areas, or fueling stations

Maintenance requirements:
- Remove sediment accumulation from basin and pre-treatment areas
- Mow and remove litter and debris

A. Description

Infiltration basins are dry ponds constructed to allow infiltration to occur simultaneously with other treatment processes. An infiltration basin can be used for both stormwater quality and quantity controls. The storage basin is designed with a large surface area and the design water depth is kept shallow (≤1 foot). The influent point(s) to the basin are configured with energy dissipation and/or a level spreader to efficiently distribute the flow into the basin. Infiltration basins are detention ponds constructed to allow infiltration to occur simultaneously with other treatment processes. Figure C5-S3- 1 provides a typical detail for a conventional infiltration basin. Figure C5-S3- 2 illustrates a combined infiltration/detention basin. The operating characteristics of infiltration basins are essentially the same as for dry detention, with a few significant exceptions:

1. Infiltration basins also remove dissolved solids in the volume of infiltrated water, whereas dry detention basins do not.
2. The settling velocities of the particles are increased by a value equal to the infiltration rate in the basin. The impact would be more important for the clay-sized particles than for silt, sand, and small or large aggregates.
3. Infiltration practices differ from typical dry basins because they have the ability to meet the groundwater recharge requirements (see Chapter 2), and therefore provide an additional element of control or performance.

B. Stormwater management suitability

Infiltration basins are designed primarily for reduction in stormwater runoff volume, but also have high removal capability for fine particulates, metals, and bacteria. Runoff volume control can be achieved for the WQv for smaller storm events, up to the limits of the local infiltration capacity of the local soils. The runoff volume gradually infiltrates through the bottom and sides of the trench and into the subsoil, eventually reaching the water table. By diverting runoff into the soil, an infiltration trench not only treats the water quality volume, but also helps to preserve the natural water balance on a site, recharge groundwater, and preserve base flow.

An infiltration basin can also be designed to capture and infiltrate the entire channel protection volume in either an offline or online configuration. For larger sites, or if only the WQv is diverted to the basin, another structural control must be used to provide Cpv extended detention. Since infiltration basins are similar in form to traditional dry detention basins, additional control for peak discharge reduction (overbank flooding-Q_p) can be provided by adding additional depth for detention storage and including a suitably-sized outlet structure.

C. Pollutant removal capabilities

Infiltration basins are effective in removing both soluble and fine particulate pollutants in urban runoff. Coarse-grained particulates should be removed with preliminary upstream BMPs. While the pollutant removal capability of infiltration basins can be highly variable, the removal is achieved by diverting the run off through the floor of the basin and into the soil. Table C5-S3- 1 provides estimates of removal rates for infiltration basins sized to capture the WQv.

Table C5-S3- 1: Pollutant removal rates for infiltration basins

Pollutant	Removal rate %
Sediment	90%
Total P	60-70%
Total N	55-60%
Metals	85-90%
Bacteria	90%

Source: US EPA, 1983; Stahre and Urbonas, 1990; ASCE, 2001

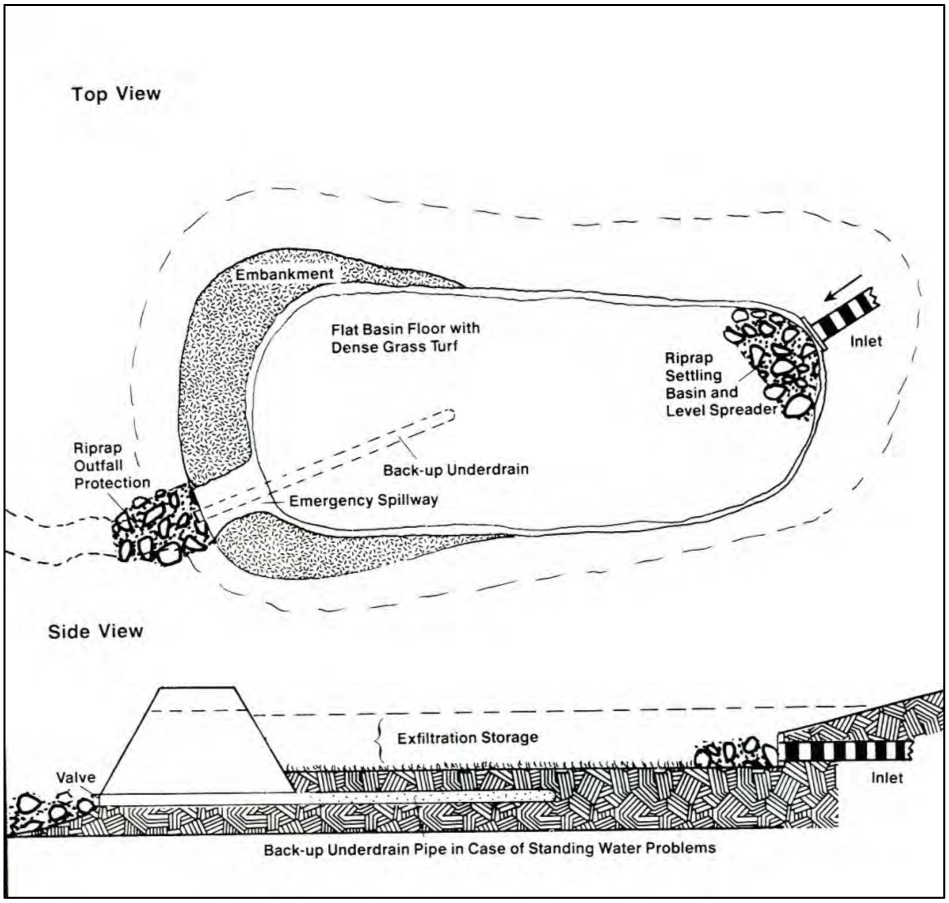

Figure C5-S3- 1: Infiltration basin schematic
Source: Schueler, 1987

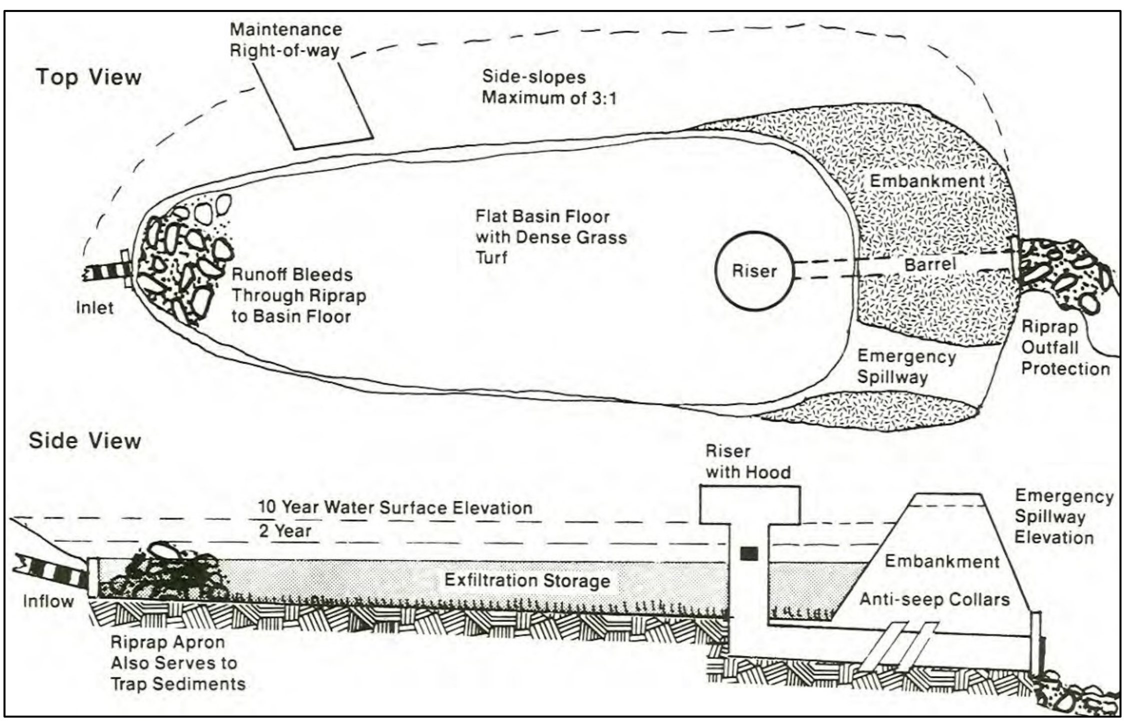

Figure C5-S3- 2: Combined infiltration and detention basin configuration
Source: Schueler, 1987

D. Application and feasibility

The infiltration basin uses an open area or shallow depression for storage. These basins may or may not have a permanent pool. The success of infiltration basins depends on locating the basins above highly-pervious soils and properly constructing the basins to maintain the permeability of the basin floor infiltration area.

1. **Soils.** Soils are the key evaluation factor, and are initially based on an investigation of the NRCS hydrologic soils groups (HSG) at the site (see Chapter 5, section 1). Note that more detailed geotechnical tests are usually required for infiltration feasibility, and during design to confirm permeability and other factors. Infiltration basins must be built in soils with high infiltration rates.

    a. Infiltration basins are not a feasible option on sites with HSG-D soils, or any soil with clay content greater than 30%. Silt loams and sandy clay loams (HSG-C soils) provide marginal infiltration rates, and would not be suitable for infiltration basin application in most circumstances. Soils with a combined silt/clay percentage of over 40% by weight will likely experience frost-heave and should be avoided for infiltration basin application. A site located over fill soils that form an unstable subgrade should also be avoided.

    b. If the soils at the site pass the initial screening discussed above, an additional series of soil cores are collected to a depth of at least 5 feet below the proposed elevation of the basin bottom. Since soil conditions can vary substantially over a short distance, a minimum of 6-8 soil borings may be required across the site to predict future infiltration performance. The soil cores are examined for evidence of impermeable soil layers that can impede infiltration. The presence of impermeable layers may not preclude the use of a basin as long it penetrates the layers completely. Alternately, if impervious layers are present, soils can be removed and replaced with more permeable materials that penetrate to a pervious layer.

    c. At least three in-hole conductivity tests should be performed using USBR 7300-89 or Bouwer-Rice procedures (the latter if groundwater is encountered within the boring); two tests at different locations within the proposed basin, and the third down-gradient by no more than approximately 40-50 feet. The tests should measure permeability in the side slopes and the basin subgrade within a depth of 12-15 feet of the basin floor invert. The minimum acceptable hydraulic conductivity as measured in any of the three required test holes is 0.5 in/hr. If any test hole shows less than the minimum value, the site should be disqualified from further consideration.

    d. The results of a study of disturbed and compacted urban soils (i.e. heavy equipment) compared to undisturbed sites by the NRCS National Soil Mechanics Center show that as soil bulk density increases to 1.65 g/cm^3, infiltration rates of the soil decrease rapidly. When the bulk density increases above 1.65 g/cm^3 infiltration rates decline slowly, approaching zero. The measured infiltration rates for disturbed soils with high bulk densities were significantly lower than expected (OCSCD et al., 2001). For infiltration basin design, soil borings taken throughout the proposed site should indicate soil bulk densities in the basin bottom of $\leq$1.45 g/cm^3, and measured permeability rates of $\geq$0.5 inches/hr.

2. **Slope.** Infiltration basins are not feasible if the slope of the contributing watershed is greater than 20%. Within the basin itself, a slope of less than 5% is preferable.

3. **Water table.** The bottom of the infiltration facility should be separated by at least 4 feet vertically from the seasonally high water table or bedrock layer, as documented by on-site soil testing.

4. **Drainage area.** The contributing drainage area to an individual infiltration basin practice designed solely for water quality control can range from 5-25 acres. A maximum of 10 acres is recommended for full conventional infiltration basins when all of the site criteria have been met satisfactorily and good pre-treatment is provided. For combination infiltration/detention basins, a drainage area up to 50 acres is typical. The volume to be infiltrated is determined from the WQv and/or Cpv, and the remaining volume for peak discharge control is established above the maximum depth established for infiltration. The storage volume for peak discharge control is discharged through a separate outlet structure. If the drainage area is more than 50% impervious, the space required for

infiltration may be become too large to accommodate on the site.

5. **Head.** Head is the elevation difference needed at a site (from the inflow to the outflow) to allow for gravity operation within the practice. A minimum head of 1 foot, and a maximum of 3 feet is recommended. Additional head may be required if additional storage volume for peak discharge control for Q_p is provided.

6. **Separation distances.** Infiltration basins should be located a minimum of 100 feet horizontally from any water supply well. Infiltration practices should not be placed in locations that cause water problems to downgrade properties. Infiltration facilities should be setback 25 feet down-gradient from structures.

E. Planning and design criteria

1. **Pre-treatment.** A minimum of 25% of the WQv is recommended to be pre-treated prior to entry into the infiltration basin. If the infiltration rate for the underlying soils is greater than 2 in/hr, 50% of the WQv should be pre-treated prior to entry into the infiltration facility. Exit velocities from pre-treatment should be non-erosive (<10 ft/sec) during the 2-year design storm. Infiltration systems can be designed using redundant methods (treatment train approach) to protect the long term integrity of the infiltration rate. The following pre-treatment techniques can be used to provide protection against premature clogging and failure:
   - Grass swale or grass filter strip
   - Sedimentation basin, sediment forebay, stilling basin, sump pit, or other acceptable measures
   - Bottom sand layer

2. **Surface area of basin floor.** The rate and quantity of ex-filtration is enhanced by increasing the surface area of the basin floor, especially as the soil infiltration rate approaches the minimum rate of 0.5 in/hr. Therefore, large and relatively shallow (<3 ft) basins are preferable to basins that are small and deep. Additional surface area for the basin floor can also help compensate for diminished infiltration capacity from long-term surface clogging.

3. **Reducing influent water velocity.** Inlet conveyance channels to the basin are stabilized to prevent incoming runoff velocities from reaching erosive conditions and scouring the basin floor. Providing riprap at the inlet channels and pipe outfalls will provide effective control. The riprap will also serve to spread the incoming flow more uniformly over the surface of the basin floor to provide improved infiltration. The best approach is to avoid a riprap pilot channel, and instead terminate the riprap in the form of a wider structure to serve as a level spreader (Figure C5-S3- 1). A 20-foot filter strip combined with a riprap level spreader will provide effective sheet flow onto the basin floor.

4. **Basin slopes.** The floor of the basin is graded to have a slope close to zero. The goal in infiltration basin design is to achieve a uniform ponding depth across the entire surface of the basin. If the basin is sloped towards the outlet structure riser, or if low spots are created, the runoff volume will concentrate in small portions of the basin and reduce the infiltration effectiveness. The low spots will tend to remain under water a longer period of time, due to the limited soil infiltration capacity. Over a longer period of time, these low spots may eventually become clogged with excess sediment. The basin side slopes should be ≤3:1 to enhance vegetative stabilization. The shallower side slopes facilitate mowing, access, and improved public safety.

5. **Establishing vegetation.** A dense turf of water-tolerant grass is established on the floor and side slopes of the infiltration basin immediately after construction. The turf promotes better pollutant removal because:
   - Root penetration and thatch formation in the turf maintains and may improve the original infiltration capacity of the basin floor
   - The turf grows through the accumulated sediment and pollutant deposited in the basin, preventing re-suspension during larger storm events
   - The turf assimilates soluble nutrients for growth. Plant nutrients can be effectively removed from the system if the clippings are removed during/after mowing operations
   - A dense growth of turf will prevent soil erosion and scouring of the basin floor that could reduce the overall efficiency of the basin. Ground covers such a tall fescues and Bermuda grass are generally used for this purpose.

   A dense and vigorous vegetative cover is established over the contributing pervious drainage areas before runoff is accepted into the facility. Infiltration basin sites should not serve as a sediment control device during the site construction phase. In addition, the erosion and sediment control plan for the site must clearly indicate how sediment will be prevented from entering the infiltration site. Do not construct infiltration practices until all of the contributing drainage area has been completely stabilized.

6. **Basin buffer.** A vegetative screen around the basin to restrict direct view from adjacent properties may improve the aesthetics of the site and public acceptance of the facility. Regular mowing will prevent establishment of woody vegetation growth from the buffer area onto the basin bottom.

7. **Maximum drain time.** The depth of ex-filtration storage within the basin is adjusted to ensure it completely drains within 72 hours after the maximum design ex-filtration event. A drain time of 48 hours can be used for a more conservative design. Complete drainage is needed to maintain aerobic conditions in the unsaturated zone under the basin, to support bacteria that aid in organic pollutant removal. It is also important to completely empty the basin before the next storm. For example, the average time between storms events in Iowa in the warmer season (June to September) is 96 hours.

8. **Sediment forebays.** The long-term performance of an infiltration basin can be enhanced if sediment forebays are constructed near the inlet(s) to trap incoming sediment loads. The forebays also serve to reduce the influent velocity and provide uniform dispersal of flow into the basin area.

9. **Winter operation.** When the soil freezes, infiltration will likely cease. While some nominal infiltration may occur under partially frozen conditions, the basin will not likely treat rain or snowmelt during the winter. In this case, a bypass at the inlet can be provided for the winter season; or an accessory low-level outlet can be provided and opened to allow direct drainage of snowmelt or winter runoff.

10. **Safety.** Fencing around the basin area can be included in the final site plan if public access to the area is not desired. If the area around the basin has a recreational use, a safety shelf around the perimeter of the basin can be included for times when the basin is flooded and the design depth will exceed 3 feet. Steep slopes should be avoided (≤3:1), and signs should warn against deep water or any health risks. An auxiliary spillway is provided to safely bypass or move high flows through the basin and protect against structural failure.

F. General design

1. Water quality volume (WQv) is determined as described in Chapter 2, section 1 and Chapter 3, section 6.
2. Basin should be sized so the entire water quality volume is infiltrated within 48-72 hours.
3. Vegetation establishment on the basin floor may help reduce the clogging rate.
4. The truncated hydrograph method described later in this section can be used as an alternative analytical procedure if the infiltration basin is used to control peak discharge.
5. If runoff is delivered by a storm drain pipe or along the main conveyance system, the infiltration practice should be designed as an offline practice (see Figure C5-S3- 4).
6. Adequate stormwater outfalls should be provided for the overflow associated with the 10-year design storm event (non-erosive velocities on the downslope).
7. A minimum of 25% of the WQv must be pre-treated prior to entry to an infiltration facility. If the “f” for the underlying soils is greater than 2 in/hr, 50% of the WQv should be pre-treated prior to entry into an infiltration facility. This can be provided by a sedimentation basin, sediment forebay, stilling basin, sump pit, or other acceptable measures. Exit velocities from pre-treatment should be non-erosive during the 2-year design storm.
8. The construction sequence and specifications for each infiltration practice should be followed, as outlined in the SUDAS specifications. The longevity of infiltration practices is strongly influenced by the care taken during construction.
9. Groundwater separation should be at least 4 feet from the basin invert to the measured ground water elevation.
10. Location away from buildings, slopes, and highway pavement (greater than 25 feet) and wells and bridge structures (greater than 100 feet).
11. Sites constructed of fill, having a base flow or a slope greater than 15%, should not be considered.
12. Ensure that adequate head is available to operate flow splitter structures (to allow the basin to be offline) without ponding in the splitter structure or creating backwater upstream of the splitter.
13. A conveyance system should be included in the design of all infiltration basins in order to ensure that excess flow

is discharged at non-erosive velocities. The overland flow path of surface runoff exceeding the capacity of the infiltration system is evaluated to preclude erosive concentrated flow. If computed flow velocities do not exceed the non-erosive threshold, overflow may be accommodated by natural topography or grass swales (see Chapter 9). Adequate stormwater outfalls should be provided for the overflow associated with the 10-year design storm event (non-erosive velocities on the downslope).

14. If runoff is delivered by a storm drain pipe or along the main conveyance system, the infiltration practice should be designed as an offline practice (see Figure C5-S3- 4 for an example of an offline infiltration basin).

G. Physical specifications, geometry, and volume

1. Configuration of a conventional infiltration basin for water quality (WQv) treatment and a combination infiltration/detention basin for quality and quantity control are shown in Figure C5-S3- 1 and Figure C5-S3- 2, respectively.
2. For the design of larger infiltration basins, the routing of small baseflows and larger storm runoff volume can be problematic while still providing effective ex-filtration capacity for the small and moderate size storms. A design variant called a side-by-side infiltration basin (Figure C5-S3- 3) contains a riprap pilot channel along one margin of the basin, and extends all the way to the outlet structure riser. The pilot channel is elevated several feet above the basin floor. Baseflow is confined to the pilot channel (use an impermeable geotextile liner), and travels directly to an under-sized low-flow orifice at the base of the riser, and then discharges from the basin. Storm flow pulses are also directed though the pilot channel. Once the incoming storm flow reaches a given depth, it overflows the liner in the pilot channel and is conveyed down across the basin floor. The invert of the low-flow orifice is set from a dead storage zone down to the basin floor, thus storing the equivalent of the first flush runoff volume, and/or the WQv.
3. The offline design variant (Figure C5-S3- 4) is used to divert and ex-filtrate the first flush runoff volume of larger storms (>1.25 inch) and the WQv design storm (≤1.25 inch) from a storm sewer or open surface channel. These may be useful for development situations where ex-filtration cannot be achieved at a downstream stormwater detention basin due to soil limitations. The design utilizes a combination of an offline sand filter and infiltration basin to treat the WQv or first flush volume. A weir is placed across a natural or man-made channel diverting runoff into an offline sand filter. After passing through the filter, runoff is collected by subdrains leading to a level vegetated infiltration basin. This design is recommended for sites which produce high sediment loads.

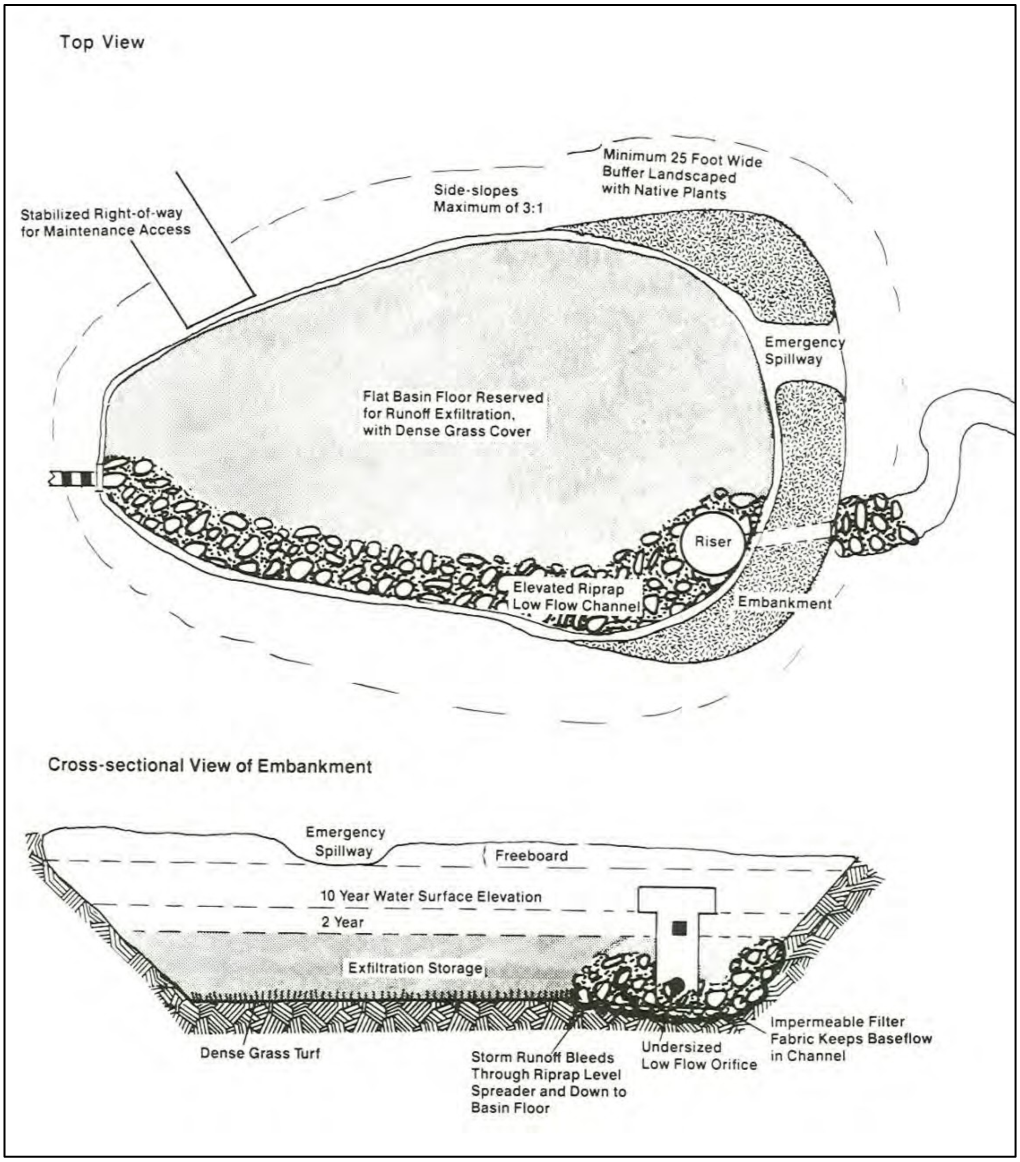

Figure C5-S3- 3: Side-by-side infiltration basin configuration
Source: Schueler, 1987

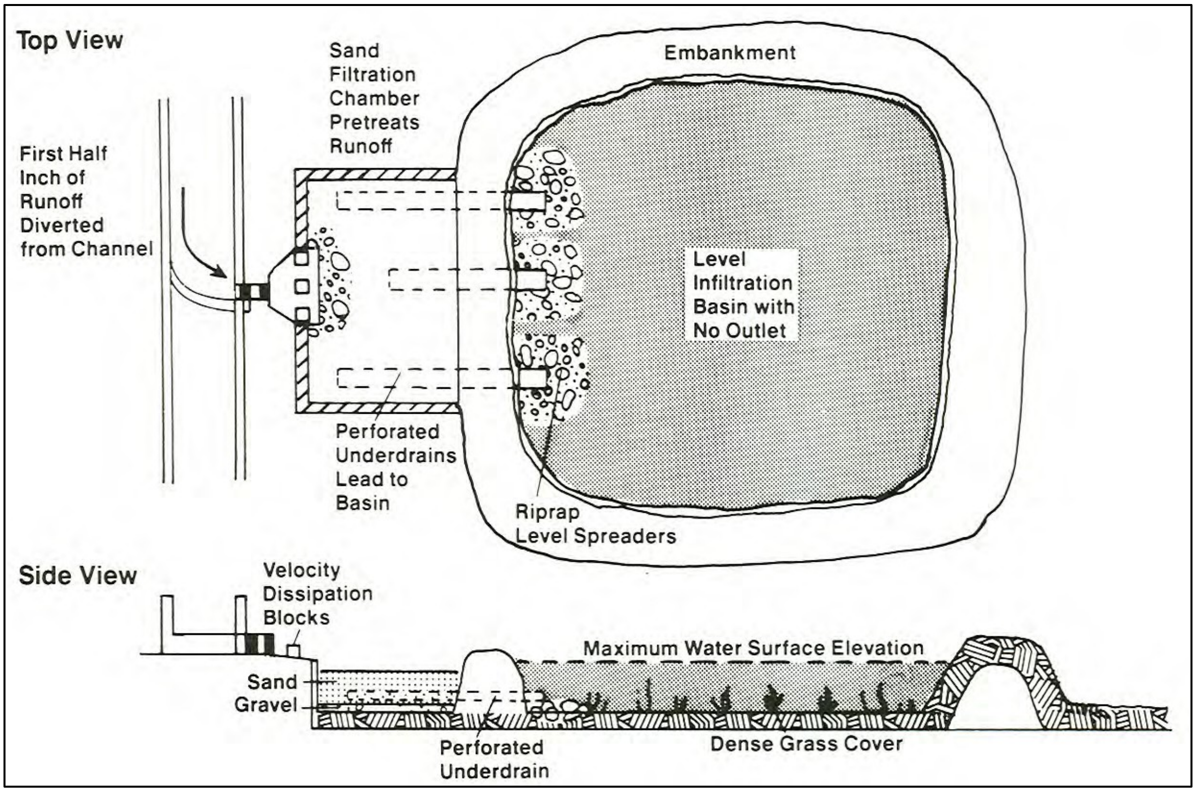

Figure C5-S3- 4: Side-by-side infiltration basin configuration
Source: Schueler, 1987

H. Design of infiltration basins

There are two general types of situations where infiltration basins may be used: First is the determination of the dimensions of an infiltration basin required to provide storage and treatment of the WQv or design peak discharge (Q_p). Second, site conditions may dictate the layout and capacity of the infiltration basin, and in this case, the level of control provided by such a layout might only provide partial treatment of the WQv. In the latter case, control may not be sufficient, and additional control, possibly using other acceptable BMPs, may be required. However, both cases are suitable for use when considering incorporating groundwater recharge into future development. The following procedure can be used for designing infiltration basins to meet the WQv, and the overbank flood protection (Q_p) volume requirements. These methods are based on the methodology described in the Maryland Stormwater Design Manual (2000). The design procedures are based on either intercepting the WQv from the area contributing runoff, or using the truncated hydrograph method for control of the runoff from an area for either the Cpv or Q_p. The design equations may be defined for either case of stormwater quality or quantity control because the volume of water (V_B) stored in the individual infiltration practice may be determined from the methods described earlier.

An alternative sizing criteria is the use of the maximized capture volume method (ASCE/WEF, 1998) described in Chapter 3, section 2.

The design of an infiltration basin is based on the same soil textural properties and maximum allowable depth as the infiltration trench such that a feasible design is possible. However, because the infiltration basin uses an open area or shallow depression for storage, the maximum allowable depth (d_{max}) should meet the following criteria:

Equation C5-S3- 1

$$d_{max} = fT_p$$

Where:
f is the final infiltration rate of the trench area (in/hr)
T_p is the maximum allowable ponding time (hr)

Values of d_{max} for selected types and minimum infiltration rates and drain times of 48 hours and 72 hours are given in Table C5-S3- 2.

Table C5-S3- 2: Soil types, infiltration rates and maximum storage depth for infiltration basins

Soil texture type	Minimum infiltration rate	NRCS HSG	Maximum depth of storage dmax (in)	
	f (in/hr)		48 hours	72 hours
Sand	8.27	A	397	595
Loamy sand	2.41	A	116	174
Sandy loam	1.02	B	49	73
Loam	0.52	B	25	37

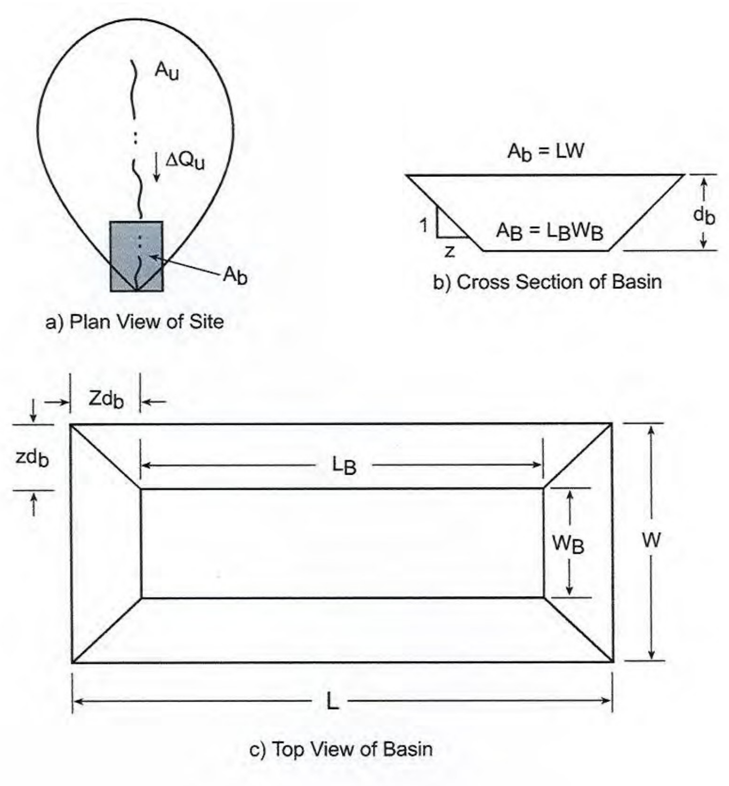

Figure C5-S3- 5: Schematic of basin nomenclature

The following design calculations assume infiltration only through the basin bottom area. Neglecting the likely infiltration through the sides of the basin will provide some additional design factor of safety.

Three design elements must be considered when sizing an infiltration basin:

- Required storage volume
- Maximum basin depth
- Basin volume

An infiltration basin is sized to accept the design volume that enters the basin (V_r), plus the volume of rain that falls on the surface of the basin (PA_B), minus the ex-filtration volume (fTA_B) out of the bottom of the basin. The design volume in most cases will be the WQv determined for the drainage area (A_u). Based on NRCS hydrograph analysis, the effective filling time for most infiltration basins will generally be less than 2 hours. Therefore use T = 2 hours. The volume of water that must be stored in the basin (V_B) is defined as:

Equation C5-S3- 2

$$V_B = V_r + \frac{PA_B}{12} - fTA_B$$

Or

$$V_B = WQv + \frac{PA_B}{12} - fTA_B$$

Where:
P is the design rainfall event (in)
A_B is the basin surface area (ft^2)
WQv (ft^3)

For most design storm events, the volume of water due to rainfall on the surface area of the basin (PA_B) is small when compared to the design volume (V_r or WQv) of the basin, and may be ignored with little loss in accuracy to the final design. Likewise, the term fTA_B represents the volume of water infiltrated through the basin bottom during the time inflow exceeds the outflow (fill time). For a fill time of 2 hours, this volume may be so small in relation to the runoff volume that it can be ignored without introducing significant error.

The volume of rainfall and runoff entering the basin can be defined in terms of basin geometry. The geometry of a basin will generally be in the shape of an excavated trapezoid with a specified side slope (See Figure C5-S3- 5). The average end-area equation (Equation C5-S3- 3) is used to estimate the storage volume of the infiltration basin. The volume of a trapezoidal shaped basin may be approximated by:

Equation C5-S3- 3

$$V = [(A_B + A_b)d_b]/2 = [LW + L_bW_b)d_b]/2$$

Where:
A_b = water surface area at the design depth (ft^2)
A_B = the bottom surface area (ft^2)
d_b = design depth (ft)
L = basin top length
W = basin top width
L_B = L-2Zd_b = bottom length
W_B = W-2Zd_b = bottom width
Z = side slope ratio (W:H)

Calculating Equation C5-S3- 2 and Equation C5-S3- 3 provides the following expression for the required bottom area of the basin (A_B):

Equation C5-S3- 4

$$A_B = \frac{2V_B - A_t d_b}{d_b - 2P + 2fT}$$

If a rectangular shape is used, the bottom length and width of the basin may be defined in terms of the top length and width as:

$$L_B = L - 2Zd_b \qquad W_B = W - 2Zd_b$$

Where:
Z is the specified side slope ratio (i.e., Z: 1)

Substituting the above relationships for L_B and W_B into Equation C5-S3- 4 provides an equation for the basin top length:

Equation C5-S3- 5

$$L = \frac{[V_B + Zd_b(W - 2Zd_b)]}{W(d_b - P)} - Zd_b{}^2$$

The solution of Equation C5-S3- 5 will be based on assuming an initial basin top width or a width set by the constraints of the site. The solution will iterative until the desired L/W ratio is achieved.

I. Procedures for infiltration basin design

1. **Step 1.** Determine the volume of water for storage using the methods for WQv, Cpv, or Q_p, summarized in Chapter 2, section 1 and Chapter 3, section 6.

2. **Step 2.** Compute the maximum allowable basin depth (d_{max}) from the feasibility equation, $d_{max} = fT_p$. Select the basin design depth (d_b) based on the depth that is the required depth above the seasonal groundwater table (4-foot minimum), or a depth less than or equal to d_{max}, whichever results in the smaller depth.

3. **Step 3.** Compute the basin surface area dimensions for the site soil type using C5-S3- 5. A long, narrow basin generally improves infiltration, and may influence the selection of a length-to-width ratio. A side slope steepness must be selected. An initial length or width of the basin is set, and the equation solved for the remaining dimension. If a rectangular shape is used, the basin top length (L_t) and width (W_t) must be greater than $2Zd_b$ for a feasible solution. If L_t and W_t are not greater than $2Zd_b$, the bottom dimensions would be less than or equal to zero. In this case, the basin depth (d_b) is increased for a feasible solution.

4. **The truncated hydrograph method for stormwater quantity management.** For local overbank flooding control (Q_p), the peak discharge for the post-developed hydrograph for a selected return period(s) should not exceed the peak discharge from the pre-developed hydrograph after development for stream channel erosion control and/or flood control purposes. In previous stormwater quantity management infiltration design methods, the difference between the pre-development and post-development runoff volumes was stored in the proposed infiltration structure. In most cases, this volume of runoff occurs prior to the actual hydrograph peak (see Figure C5-S3- 5), and therefore actual peak discharge control is not provided. Therefore, when considering an infiltration basin for peak discharge or stormwater quantity control, the truncated hydrograph method is used to determine the necessary infiltration storage volumes.

   The pre-development and post-development peak discharges are computed using NRCS WinTR-55 or WinTR-20 methodology. The time (T_2) at which the allowable discharge occurs on the receding limb of the post-development hydrograph, as shown in Figure C5-S3- 5, is determined from the NRCS methods. The volume of runoff under the post-development hydrograph and to the left of the allowable discharge at T_2 is the design storage volume (V).

   The computed infiltration storage volume, V, may be adjusted to account for the volume of water which ex-filtrates from the infiltration structure during the period of time required to fill the structure. The ex-filtration volume (V_e) is the product of the minimum soil infiltration rate (ft/hr), the filling time (hr), and the surface area of the infiltration practice. The filling time (T_f) of the infiltration practice may be determined directly from the post-development hydrograph, as shown in Figure C5-S3- 5. T_f is the difference between T_2, where the allowable discharge occurs on the recession limb, and the time, T_1, where the discharge value on the rising of the hydrograph is equal to the minimum infiltration discharge. The times T_1 and T_2 can be determined from the TR-20 output file after the WinTR-55 program scenario is run. The minimum discharge is equal to the minimum soil infiltration rate (expressed as ft/sec) times the surface area (ft^2) of the infiltration practice.

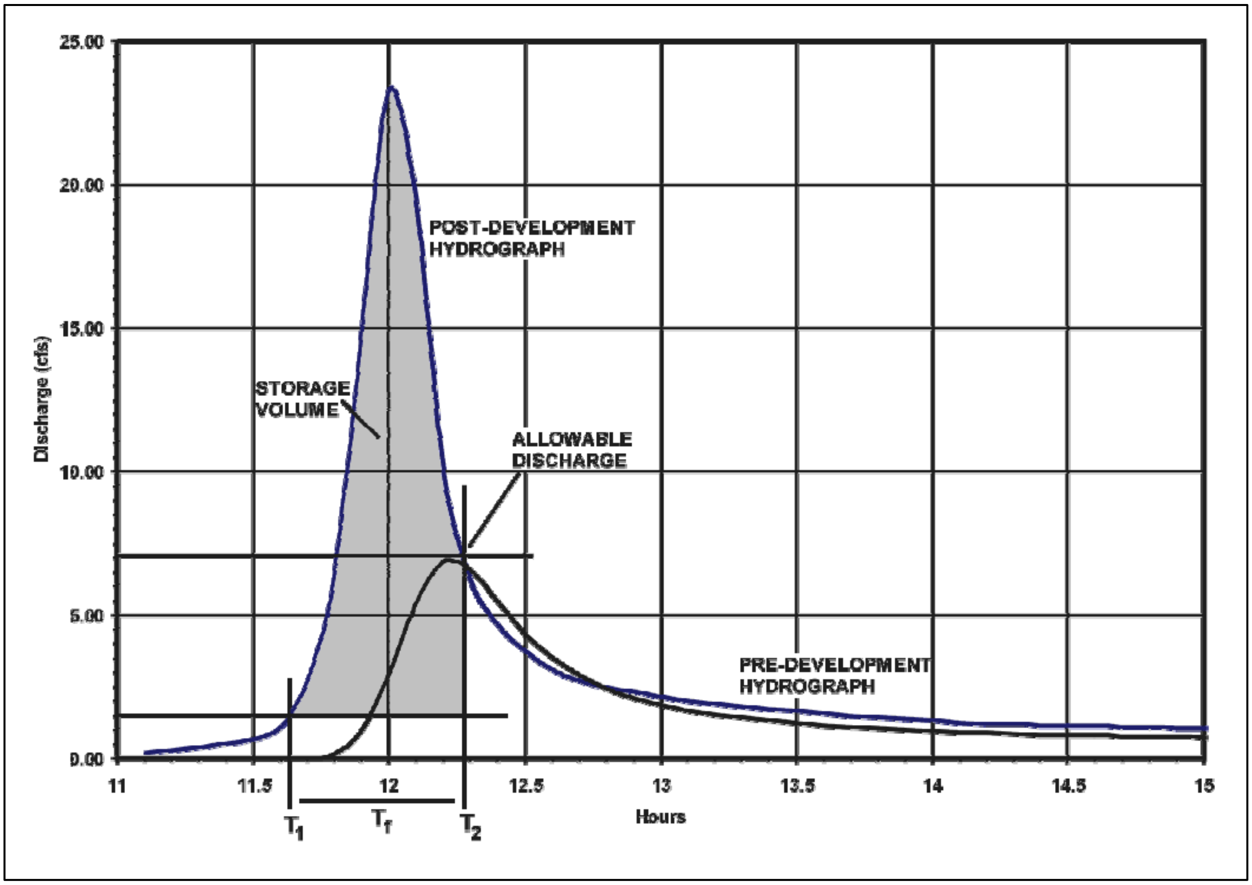

Figure C5-S3- 6: Truncated hydrograph method

J. Maintenance

Infiltration basins are relatively high-maintenance BMPs. Infiltration basins fail for one or more of the following reasons:

- Premature clogging with sediment
- A design infiltration rate greater than the actual infiltration rate
- The basin site was used for construction site erosion control (sediment trap or basin)
- Soil was compacted during construction
- The upland soils or the basin sides were not stabilized with vegetation, and excessive sediment was delivered to the basin

Consideration should be given to placing the basin into operation only after 90% of the upland development site has been built out and stabilized with vegetation. The other option is to strictly enforce construction site erosion controls during the development build-out process. If the basin was designed as an offline structure, bypass the structure as excessive sediment loads are being transported from the drainage areas during development.

The stormwater management plan includes maintenance, inspection, access, and enforcement of the operating requirements for the structure. The key elements of the plan are as follows:

1. An operation and maintenance plan should be prepared prior to placing the basin into operation.

2. Following construction, inspect the basin monthly, as well as after every major storm to ensure the basin is draining within the maximum drain time limit.

3. Inspect annually or semi-annually for settling, cracking, erosion, leakage, tree growth on the embankments, condition of the inlet and outlet channels, sediment accumulation in the basin bottom, and the condition of the grass turf.

4. If the basin has a sediment forebay, determine the degree of sediment accumulation and schedule a clean-out if necessary.

5. The basin should be mowed at least twice a year to prevent woody growth, stimulate grass growth, and enhance nutrient removal.

6. Do not mow when the ground is wet to avoid compaction of the bottom soils.

7. Remove trash and debris at least twice a year, or more often as necessary.

8. If the soils were marginal for infiltration and the basin is prone to extended ponding, periodic tilling of the basin bottom and re-seeding might be necessary. Till and re-vegetate in the early fall.

9. Over time, an infiltration basin will accumulate sediment, and the overall infiltration rate will diminish. Deep tilling, regrading, and replanting will help to restore the original infiltration performance. When the basin is thoroughly dry, remove the top cracked layer of sediment, and till and re-seed the remaining soil. Basins can be designed with a 6-12 inch layer of sand on the bottom or a filter fabric to facilitate removal.

10. If the sediment is accumulating faster than the growth of the turfgrass, the pre-treatment system needs to be re-evaluated. Maintenance of the pre-treatment system (sediment forebay, filter strip, grass) must occur on a regular basis to prevent heavy sediment build-up in the basin. The operating life of the pre-treatment system or inlet/bypass structure will likely be shorter than the infiltration basin, and will require occasional structural repair or equipment replacement.

K. Design example

Infiltration Basin

An infiltration basin is proposed for a development site northwest of Sioux City, IA. The site soil conditions have been investigated and found to be appropriate for an infiltration basin. The preliminary NRCS soil survey indicated HSG-B soils, which was confirmed with a series of soil borings to verify soil texture gradation, depth to groundwater, and soil bulk densities. The pre- development condition is undeveloped, and current land use is pasture and some wooded area. The total drainage area is 6 acres. The development is a residential subdivision with ½-acre parcels. The estimated impervious area after development will be 28%.

- Soils – 80% loam and 20% sandy loam (HSG-B)
- Nominal infiltration rate from soil survey analysis – 0.8 in/hr
- Depth to seasonal high groundwater – 12 feet
- Soil cores indicate a uniform loam/sandy loam to a depth of 15 feet
- Average of four in-situ soil permeability tests with a double ring infiltrometer indicating an average final infiltration rate of 0.96 in/hr. Initial infiltration rates averaged 2.3 in/hr.

Determine the bottom dimensions of an infiltration basin given the following design criteria:

- Design for drain time 72 hours
- Maximum ponding depth will be 24 inches for the WQv
- Design storm for WQv is 1.25 inches
- Additional storage volume will be provided in the infiltration/detention basin for Cpv (Calculations not included in this design example)
- The pre-development T_c was determined to be 0.42 hour
- The post-development T_c is estimated to be 0.2 hour at full build-out
- The goal for the L/W ratio for the basin is a minimum of 3:1

1. **Determine WQv:**

$$R_v = 0.05 + 0.009(28\%) = 0.302$$
$$WQv = R_v \times P = (0.302)(1.25 inches) = 0.38 inches$$
$$WQv = \left(\frac{0.38 inches}{12}\right) \times (43{,}560 ft^2/acre)(6 acre) = 8{,}276 ft^3$$

2. Determine Rev - percent volume method:

$$Rev = \frac{SR_vA}{12}$$

Where:
R_v = 0.302
A = site area in acres
S = soil-specific recharge factor (from HSG) = 0.34 (Table C2-S1- 4, for HSG-B soils)

$$Rev = \frac{(0.34)(0.302)(6ac)}{12} = 0.051ac - ft = 2{,}236ft^3\ (considered\ part\ of\ the\ WQv)$$

For this site, the goal is to infiltrate the entire WQv so the Rev requirement will be met.

3. Compute the maximum allowable depth, d_{max} (Equation C5-S3- 1):

$$d_{max} = fT_p$$

d_{max} = 0.96 inches/hr x 72-hr = 69.12 inches = 5.76-ft

4. Determine the required storage volume for the basin, V_B (Equation C5-S3- 4). Assume a trapezoidal basin with 3:1 side slopes. For this design, the design depth, d_b = 2 ft (24 inches), the desired basin L/W ratio is 3:1, and the desired basin top width (W) is 40 feet.

5. Desired design depth of 2 feet is less than d_{max}, or 5.7 feet.

6. Calculate storage volume required – Equation C5-S3- 2:

$$V_B = WQv + \frac{PA_B}{12} - fTA_B$$
$$= 8{,}276ft^3 + \frac{(1.25in)WL}{12} - \frac{(0.96in/hr(2hr)}{12WL}$$
$$= 8{,}276ft^3 + \frac{(1.25in)(40ft)(L\ ft)}{12} - \frac{(0.96in/hr(2hr)}{12(40ft)(L\ ft)}$$
$$= 8{,}276ft^3 + 4.17(L)ft^3 - 6.4(L)ft^3 = 8{,}276ft^3 - (2.23ft^2)(L\ ft)$$

7. Determine the length dimension for the basin using a W = 40 ft, Z = 3, and D_b = 2 feet:

$$V_B = \left[\frac{L_W + L_BW_B}{2}\right]d_b$$

From Step 6 above:

$$V_B = 8{,}276ft^3 - (2.23ft^2)(L\ ft) = [(L\ ft)(40ft) + (40ft - 12ft)(L\ ft - 12ft)]/2 \times 2ft$$

$$8{,}276ft^3 - (2.23ft^2)(L\ ft) = [(40ft)(Lft) + (28ft)(L\ ft) - 336ft^2]/2\ \times 2ft$$

$$8{,}276ft^3 - (2.23ft^2)(L\ ft) = (68ft^2)(L\ ft) - 336ft^3$$

$$(70.23ft^2)(L\ ft) = 8{,}612ft^3$$

L = 122.6 ft ≈ **123 ft** (L/W = 3.07)

8. Total surface area of basin, A_b = 123 ft x 40 ft = 4,920 ft^2

9. **$A_B = L_B \times W_B$ = 111 ft x 28 ft = 3,108 ft^2**

10. **Check drain time for f = 0.96 in/hr and ponding depth of 24 in:**

    $T_p = d_b/f$ = 24 inches/0.96 in/hr = 25 hrs