5.3.13 Naturalized Basins and Retrofitting Existing Detention Basins

Description

A naturalized basin is a flat-bottomed, vegetated, and shallow basin that collects and filters runoff, allowing pollutants to settle out as water infiltrates or is retained in planting soils. A naturalized infiltration basin is designed to retain the SOV or required stormwater volume with no surface discharge. The basin and outlet structure are also designed to provide peak flow rate control. A naturalized detention basin can provide peak rate mitigation while also reducing runoff volume, improving water quality, and providing temperature mitigation. Habitat creation and reduced maintenance (mowing) may be additional benefits.

Retrofitting an existing traditional detention basin into a naturalized basin can be a very cost-effective retrofit method, especially in developed areas where existing basins only provide large storm peak rate mitigation.

A naturalized basin includes:

- A level bottom that allows runoff (in small rainfall events) to disperse across the basin bottom, increasing contact with soils and vegetation.
- Soils and vegetation that retain some portion of the initial runoff, improve water quality, and mitigate temperature impacts.
- A “lengthened” and often meandering flow path through the basin that prevents flows from shortcutting rapidly through the basin.
- A sediment forebay or stabilized discharge location for flows entering the basin to slow velocity, prevent erosion, and allow initial settling and sediment removal in an area that is easily maintained.
- A modified outlet structure designed to retain some volume of initial runoff within the basin, with no surface discharge. The basin may be designed to infiltrate, or for the soils to hold and evapotranspire small amounts of runoff in the same manner as a green roof.

Figures 5.3.13 -1a and b. This detention basin in a residential neighborhood was retrofit to become a naturalized detention basin.

BMP Functions Table

BMP	Applicability	Volume Reduction	Water Quality	Peak Rate Reduction	Recharge	Runoff Temperature Mitigation	Heat Island	Habitat Creation	Maintenance Burden	Cost
Naturalizing Detention Basins	U/S/R	H	H	H	H	H	H	H	L	L

KEY: U = Urban; S = Suburban; R = Rural; H = High; M = Medium; L = Low

Key Design Features

- A level or nearly level (0.5 percent slope) bed bottom across the basin that allows water to disperse over a large planted area. The bottom may be graded to include small, isolated pools of shallow additional depth (2 to 4 inches) if desired.
- A meandering flow path to increase the travel length and time of small storms through the basin. This may include berms or other grading measures.
- A sediment forebay or other measures to trap coarse sediment at entrance locations into the basin.
- Modified soils that absorb and potentially infiltrate runoff.
- A modified outlet structure that retains the SOV portion of runoff.
- Capacity to mitigate peak flow rates, but with limited high water depth (in new basins) to avoid excessive inundation of plantings.
- Limited side slopes with 3:1 maximum recommended in new naturalized basins and 4:1 preferred.
- Naturalized plantings that can tolerate frequent shallow wet conditions and occasional inundation. Plantings, especially deep-rooted vegetation systems that maintain soil porosity, are critical to the success of a naturalized basin.
- Lawn is not acceptable for a naturalized basin. Typical lawn grass has a shallow root system and requires frequent mowing, both of which contribute to limited soil porosity.
- Grasses and vegetation should not be mowed to less than 4 inches in height.
- A design and maintenance plan that allows for mowing and removal of vegetation at the end of the growing season. Access for mowing and sediment removal must be provided.
- Limited depth of basin to ensure sufficient light conditions to support vegetation.
- If appropriate, a maintained edge that provides a transition from manicured landscapes to naturalized landscapes.

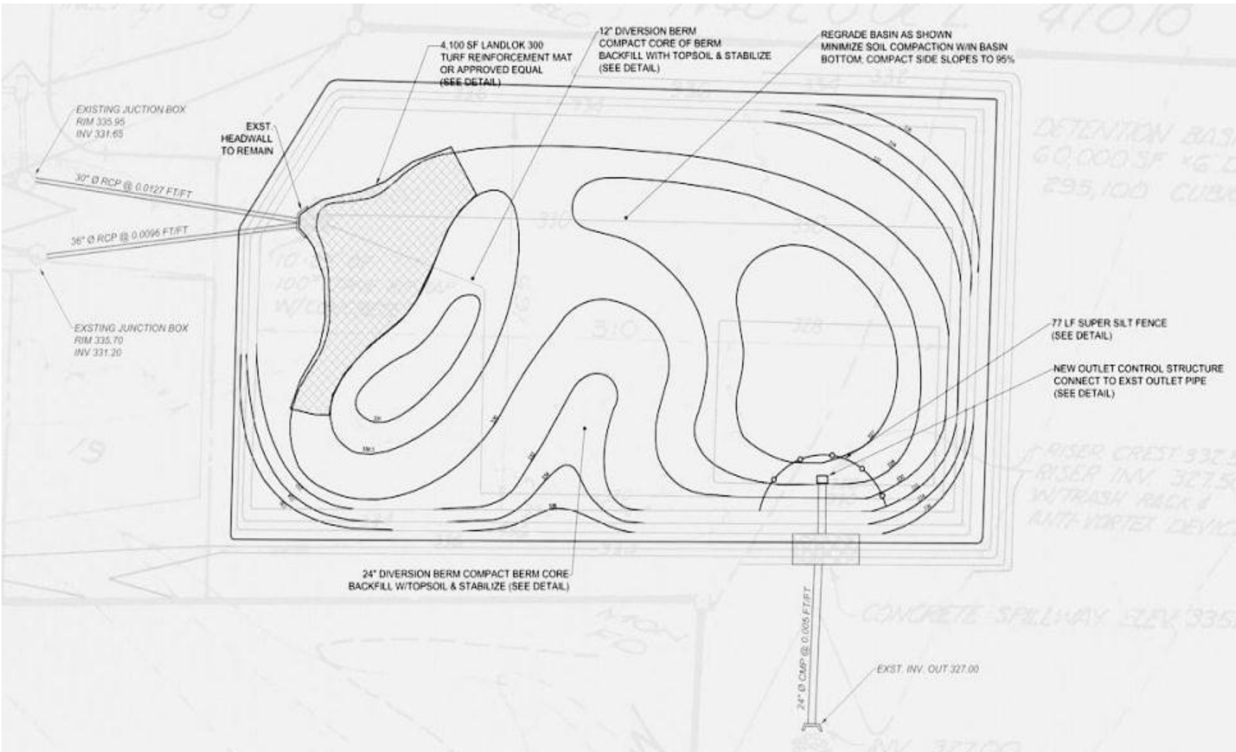

Figure 5.3.13 -2. Example of design components for retrofitting an existing detention basin into a naturalized basin. Key structural components include a more level bottom with berms to divert flow through the basin, a stabilized entrance and berm to disperse erosive flows, and a modified outlet structure to retain small storms.

Applications

- May be implemented in residential, commercial, institutional, and public facilities
- Well suited for linear basins, such as alongside roads and highways
- Excellent option for retrofitting existing dry detention basins (high value)

Advantages

- Provides volume reduction through retention of small storms.
- Provides peak rate attenuation for large and small storms.
- Improves water quality by allowing sediments to settle and nutrient uptake by vegetation.
- May provide habitat for wildlife. Plantings can be designed to increase bird habitat.
- Low maintenance burden after vegetation is established. May reduce mowing and maintenance requirements as compared to a mowed basin.

- Cost-effective, especially as a retrofit option.
- Retention of small rainfall events may reduce erosive stream conditions downstream of existing detention basins.

Disadvantages

- For newly constructed basins, may require a larger footprint to maintain a limited high water depth and still provide peak rate control.
- Requires an alternate maintenance regime.
- Maintenance personnel must be made aware of specific maintenance requirements that are different than conventional mowing.
- Cannot be “forgotten” as maintenance is required for basin performance.
- Vegetation must be harvested to prevent release of captured nutrients.
- Signage may be required to inform the public of intended naturalized conditions. Perceptions that basin is “not maintained” must be addressed with education.

Figure 5.3.13 -3. Concept rendering showing how berms can be used to increase the flow path through a naturalized basin.

Applications

New Commercial Naturalized Basin

Figure 5.3.13 -4. This naturalized basin captures runoff from a high traffic roadway. The basin is broad and shallow to limit the maximum water depth in extreme events.

Public Basin Retrofit

Figures 5.3.13-5a and b. The existing detention basin in this community park was modified to capture ½-inch rainfall events and to eliminate an erosive flow path condition.

Applicable Protocols and Specifications

The following protocols and specifications (see Appendices A through F) are applicable to naturalized basins and must be addressed:

- Protocol 1 Setbacks from Structures
- Protocol 2 Coordination with Other Utilities

- Protocol 3 Site Evaluation and Infiltration Testing (for swales intended to infiltrate)
- Protocol 4 Infiltration System Design and Construction Guidelines (for swales intended to infiltrate)
- Protocol 5 Planting and Mulching Guidelines
- Appendix F Specifications
  - Stormwater System Specifications
  - Bioretention Soil Specifications
  - Aggregates and Drainage Layers
  - Pipes
  - Control Structures
  - Geotextiles
  - Impervious Liners and Waterproofing

Design Considerations for Naturalized Basins and Retrofitting Existing Detention Basins

The key design components for naturalized basins are provided below. When retrofitting an existing detention basin, it is not always possible to adhere to all design criteria.

1. Location and Capture Area

Locate a new naturalized basin:

- At a lower drainage point on a site to capture portions of the site that have not been addressed by other BMPs.
- To receive discharge from other BMPs, and to meet any remaining SOV and peak rate needs.
- To receive runoff from high sediment areas such as roads and high-use parking lots.
- At locations where a naturalized landscape is appropriate to the land use type and will not create concerns.
- Outside of floodplains and riparian buffers.

Existing detention basins that are good candidates for retrofits (based on location) are basins that:

- Receive direct runoff from roads and parking lots, and can be modified to reduce sediment and temperature impacts from these areas.
- Basins that discharge directly into a stream or waterway. These basins generally were designed to allow the small frequent runoff events to quickly pass through the basin. Capturing and retaining any portion of these frequent events will improve water quality.
- Basins that have a large, relatively flat bottom, or can be regraded to create one.

Slopes

- Naturalized basins require a level and expansive bottom area, and are not well suited to construction on steep (15 percent) and very steep slopes (>25 percent).
- Naturalized basins should not discharge onto steep or very steep slopes, and should not discharge at flow rates that will create erosive conditions. Naturalized basins should be set back a minimum of 100 feet from downstream slopes greater than 10 percent.
- Naturalized basins can receive runoff from drainage areas that are steep or very steep, but entrance velocities into the basin cannot be erosive, and a larger sediment forebay is recommended.

2. Entrance Conditions: Sediment Forebay

Both naturalized basins and existing detention basins that are being retrofitted must include a sediment forebay at each inflow location. A sediment forebay is a settling pool or plunge pool at the inflow location that allows coarse-grained sediment to settle out before runoff is distributed throughout the basin. A sediment forebay can prolong the life of a naturalized basin and allow for easier maintenance by trapping sediment and debris within a confined area. The sediment forebay should be visible and accessible for maintenance.

A sediment forebay is constructed by excavation to create a berm from native material, or by constructing earthen berms, gabions, rock check dams, or rip-rap berms. These structures allow overflow into the larger basin. Key design criteria for a sediment forebay include:

- Capacity to capture between 0.1 inches and 0.25 inches of drainage area runoff volume within the forebay. Areas of high sediment should capture 0.25 inches within the forebay. For retrofit basins, forebay capacity is often a function of what can be achieved within the constraints of an existing basin's drainage area and dimensions but a general rule the forebay volume should be approximately 25% of the total basin volume.
- Wet or dry conditions between storms, or a mixture of both. A sediment forebay may have portion that is dry between storm events to facilitate cleaning and maintenance. A sediment forebay should be designed with a pool near the discharge point that remains wet between storms.
- Designed for non-erosive entrance flows. This may include hardscape measures (rip-rap, cobbles) to disperse flow through the vegetated forebay area, berms to disperse flow, or the use of TRMs.
- Earthen berms must be non-erosive when overtopped in large storm events. Berms can be evaluated as low-head weirs. Earthen berms should be stabilized with erosion control fabrics if necessary.
- Limited in average depth (not greater than 18 inches). Pool areas may be deeper.
- Slightly higher in elevation (1 to 2 feet) than the remaining naturalized basin. This is not always feasible in a retrofit basin.

- Constructed with a permanent stake or marking indicating depth to where sediment should be removed from forebay during maintenance.

3. Flow Conditions: Flow Path Through Basin

Traditional detention basins do not provide any consideration for management of the small frequent rainfall events, or the initial runoff from larger events. Basins are often designed to intentionally discharge small storms with little or no rate control (to maximize detention capacity during large events). As a result, small rainfalls pass through the basin quickly with limited opportunity for pollutant removal.

Figure 5.3.13-6. The concrete low-flow channel in this existing basin was removed as part of a retrofit. A meandering, vegetated flow path was created in its place.

Naturalized basins are designed to capture the small storm runoff volume, and maximize the ability of runoff to contact vegetation and soils. In addition to a sediment forebay, the basin can be designed to extend the flow path through the basin. This can be done with slight grading and planting berms to force the runoff to disperse widely through the basin bottom area.

Grading to create an extended flow path through a basin is especially useful when retrofitting an existing basin, especially if the basin was designed with inlet and outlet conditions that “shortcut” the flow through the basin.

In retrofitting basins, existing concrete or other low-flow channels should be removed.

4. Naturalized Basin Soil Media

Existing soils can be modified with sand and compost for use in naturalized basins. It is generally impractical to replace existing soils for large basins, but the soils can be modified as necessary. The growing media can be a blend of existing soils, sand, and compost that is 30 to 40 percent compost by weight. The following gradation is recommended:

Sieve Size	Percent Passing
1”	100
No. 4	75 – 100
No. 10	40 – 100
No. 40	15 – 50
No. 100	5 – 25
No. 200	5 – 15

The blend shall have a Coefficient of Uniformity (D60/D10) equal to or greater than 6 to ensure that it is well graded (has a broad range of particle sizes).

The modified soil depth should be between 12 and 18 inches.

5. Dimensions and Area

To support healthy vegetation, naturalized basins must have a limited depth of water during frequent rainfall events, and this water must infiltrate, evaporate, or slow release between rainfall events. During the infrequent large storm events, the water depth and duration cannot cause damage to the existing vegetation. The vegetation and alternating wet and dry conditions are required to maintain soil porosity. The following dimension ranges are recommended:

- Sediment Forebay Depth:
  - 12 to 18 inches, wet pools may be deeper
- SOV Surface Water Depth at Outfall from Basin:
  - 6 to 12 inches (depths of 8 inches or less preferred)
- Maximum High Water Depth During Large Events (for new basins):
  - 3 to 4 feet (2- and 5-year events); 5 feet (10-year and larger events)
- Side Slopes:
  - 3:1 maximum (existing basin side slopes should not be modified)
- Freeboard:
  - 1 foot
- Basin Bottom Slope:
  - Not greater than 0.5 percent
- Length to Width Ratio:
  - 3:1 or greater as measured from inflow to outflow

Retrofit detention basins cannot always be modified to meet the recommended dimensions for new naturalized basins. This should not preclude retrofitting the basin, as volume and water quality improvements will still be achieved.

Naturalized basins are often the most “downstream” BMP applied on a site, providing both SOV and peak rate control. The size and surface area of a newly constructed naturalized basin are a function of the SOV from the drainage area that will discharge to the naturalized basin, less any SOV that has been captured by other BMPs within the drainage area. Dimensions are also determined by the required storage for peak rate mitigation. Because the maximum surface water depths are limited so as not to damage vegetation, and because sufficient bottom area must be provided to meet SOV requirements, a naturalized basin may have a larger area than a traditional deep detention basin. Designers are encouraged to implement upstream BMPs and reduce the size of any new naturalized basins.

Naturalized basins are likely to receive runoff from a mix of land uses. A naturalized basin should be designed with a bottom surface area that does not exceed a recommended ratio of the impervious and compacted pervious areas draining to it. The amount of rainfall volume must also be considered. The following “rule of thumb” ratios based on design rainfall depth can be used to estimate a naturalized basin bottom surface area:

<u>1-inch Rainfall</u>
1:10 ratio of surface area to impervious drainage area

<u>1.6-inch Rainfall</u>
1:8 ratio of surface area to impervious drainage area

<u>Retrofit Basin:</u> When retrofitting an existing basin, the bed bottom area is limited by existing conditions within the basin. Most detention basins are designed with a slope toward the outfall structure. To increase the bed bottom area of an existing detention basin, and to create capacity for volume capture (without impacting peak rate detention capacity), the basin can be excavated and graded to create a new and level bottom.

Figure 5.3.13-7. In addition to modifying the basin itself, the outflow structure can be modified to retain volume. A simple weir plate at an existing headwall is often a cost-effective outlet modification. This basin was modified to retain a 4-inch water depth below the weir.

The SOV for a retrofit basin is usually determined by the existing drainage area and the extent to which the existing basin can be regraded and/or excavated to capture volume. Many retrofit basins will not be able to achieve the prescribed SOV, but even a partial SOV capture of ½ inch or less can have significant benefits.

6. **Storage and Stay-on-Volume**

The **storage** capacity of a naturalized basin is a function of the volume **below** the lowest overflow structure invert. This includes the surface water storage plus the storage within the modified soils:

Storage Volume (ft^3) = Surface Water Volume + Soil Storage Volume

Surface Water Volume: Available surface water storage beneath the lowest overflow structure invert.

Soil Storage Volume: The available storage in modified soils and planting areas. This is estimated based on the depth and area of modified soils and a void space ratio of 0.20.

For new naturalized basins, designers are strongly encouraged to implement an LID approach and incorporate additional BMPs to achieve the required SOV.

7. **Peak Rate Control**

New naturalized basins must meet the design requirements indicated above while also meeting the City requirements for detention basin performance and construction. Retrofit naturalized detention basins must retain their peak rate control capacity as originally intended and designed. For this reason, increased basin capacity is sometimes achieved by slightly excavating and regrading the basin bottom to provide for increased capacity below the existing maximum detention storage elevation of the basin.

8. **Freeboard**

Naturalized basins that are designed to provide peak rate control must provide the required freeboard in accordance with City requirements. Retrofit basins may be modified to allow a smaller freeboard (not less than 6 inches) if the City determines that conditions allow a smaller freeboard.

9. **Underdrain**

Underdrain systems must be included in the design if the native soil infiltration is less than 0.1 inch per hour or if the system is lined with an impervious liner and intended for slow release only. Underdrains must be located at the intended bottom of the naturalized basin (i.e., below modified soils). See Protocol 3 for the infiltration testing procedure and Protocol 4 for infiltration system guidelines.

Naturalized basins and retrofitted systems may require very low discharge rates to achieve infiltration and/or manage the water quality volume. Constructing a very small orifice will often achieve this, but a small orifice is easily subject to clogging.

One method for achieving a low discharge rate is to install a perforated pipe at the bottom elevation of the basin area. If the pipe is located in the modified soils, it must be set in clean-washed gravel and wrapped in non-woven geotextile to prevent soil movement. A perforated low-flow pipe can be set directly in a stone stormwater bed. The perforated pipe connects to a stormwater structure (such as a catch basin) with a transition coupling for a very small orifice. Various products are available for this purpose.

If infiltration is limited, the naturalized basin may allow for up to 1 inch of surface water storage depth without an underdrain if the top 12 inches of soil have been modified and the ponding area is fully vegetated. This area can be assumed to evapotranspirate or perform as a green roof system.

10. Management of Sediment, Trash, and Debris

In areas of high sediment load, basins should include measures to prevent the movement of material toward the berm and infiltration area.

To prevent erosion during the establishment of vegetation, temporary ECBs should be placed over the basin slopes and infiltration area. If basins are constructed in areas with relatively high runoff velocities where channelization is evident or where soils are currently eroding, it may be appropriate to use permanent TRMs.

Any trash or debris that collects behind berms should be removed regularly.

Woodchip or bark mulch should not be used in a naturalized basin because such material is inclined to float or move during large storm events.

11. Water Quality/Total Suspended Solids

Naturalized basins that can capture and manage the required SOV through capture and infiltration are considered to meet all water quality requirements. Naturalized basins that are underdrained but can capture and treat the required water quality volume as defined in Chapter 7 are also considered to provide water quality treatment. The underdrain must be designed for slow release in accordance with the requirements of Chapter 7.

12. Public Awareness and Signage

Naturalized basins may appear unmaintained to a public that is accustomed to basins that are mowed, especially for a retrofit basin when there is a change in appearance. This should be addressed by:

- Signage that informs the public of the functions and intention of the basin, including the landscape.

- A mowed edge of 4 to 6 feet in width at the edge of the naturalized portion of the landscape to create a transition between "natural" and manicured landscapes. For retrofit basins, the top berm of the basin can serve this purpose.

Construction Considerations

For the best success, naturalized basin areas should not be installed and planted until site construction is complete and site stabilization has occurred. Naturalized and/or existing basin areas completed before site stabilization **must** be protected from receiving sediment-laden runoff. Runoff should be directed around completed basin areas until site stabilization has occurred. Sediment-laden water should not be allowed to enter modified soils.

The excavated capacity of a basin may be used as a temporary sediment trap area during construction. The bottom elevation during use as a sediment trapping and storage measure should be a minimum of 1 foot higher than the final bed bottom elevation. At the time of conversion from a sediment measure to a basin bed, any sediment and the remaining 1 foot of material should be removed for construction of the infiltration bed.

Figure 5.3.13-8. Signage can help the community understand the importance of the naturalized basin and the intent of the "natural" landscape.

Figure 5.3.13-9. A mowed edge can create a transition between a "natural area" and a manicured landscape.

Construction Sequence Example

Step 1 Excavate and Prepare Subgrade

a. The bottom of a naturalized basin shall not be compacted or subject to excessive construction equipment traffic. Protect areas from vehicle traffic during construction with construction fence, silt fence, or compost sock.
b. The naturalized basin should not receive runoff from any disturbed areas in the drainage area until these areas have been stabilized.
c. Where erosion of subgrade has caused accumulation of fine materials and/or surface ponding in the graded bottom, this material shall be removed with light equipment and the underlying soils scarified to a minimum depth of 6 inches with a York rake or equivalent by light tractor.

d. A naturalized basin may be used as a sediment trap during construction, provided that the basin is not excavated to the final bottom elevation until the site is stabilized.

Step 2 Install or Modify Outlet Structure, Berms, and Stabilization Measures at Inflow Locations

a. If possible, close and secure all inlets, pipes, trench drains, and other structures to prevent runoff from entering the naturalized basin before completion and site stabilization.
b. While the basin is closed during construction, maintain drainage overflow pathways to provide for drainage during storm events.
c. Modify existing soils if required. Construct modified flow paths.
d. Modify or install the outlet structure, berms, inlet structures, soil stabilization measures, etc. Complete fine grading.
e. The design engineer should observe the basin conditions following excavation and grading and prior to placement of vegetation to confirm that construction requirements have been met. Documentation of engineering observation must be provided to the City (see Appendix I).

Step 3 Install Vegetation

a. Install vegetation in such a manner as to prevent soil compaction or alteration of grades.

Figure 5.3.13-10. It is important to avoid soil compaction during planting. Retrofit naturalized basins are often good opportunities for volunteer planting efforts if the grading and structural modifications are completed by trained professionals.

Operations and Maintenance

Maintenance is most important during the vegetation establishment period for a naturalized basin, and all basins should include a clear three-year plan for maintenance and removal of invasive vegetation during establishment. After the establishment period:

- Inspect and clean the outlet structure biannually.
- Inspect and remove sediment at all entrance conditions biannually.
- Pruning and weeding may be required.
- Detritus must be removed approximately twice per year. Perennial grasses should be cut down or mowed at the end of the growing season, and all material removed.