BMP 6.6.2: Wet Pond/Retention Basin

Wet Ponds/Retention Basins are stormwater basins that include a substantial permanent pool for water quality treatment and additional capacity above the permanent pool for temporary runoff storage.

Key Design Elements

- Adequate drainage area (usually 5 to 10 acres minimum) or proof of sustained baseflow
- Natural high groundwater table
- Maintenance of permanent water surface
- Should have at least 2 to 1 length to width ratio
- Robust and diverse vegetation surrounding wet pond
- Relatively impermeable soils
- Forebay for sediment collection and removal
- Dewatering mechanism

Potential Applications

Residential: Yes
Commercial: Yes
Ultra Urban: Yes
Industrial: Yes
Retrofit: Yes
Highway/Road: Yes

Stormwater Functions

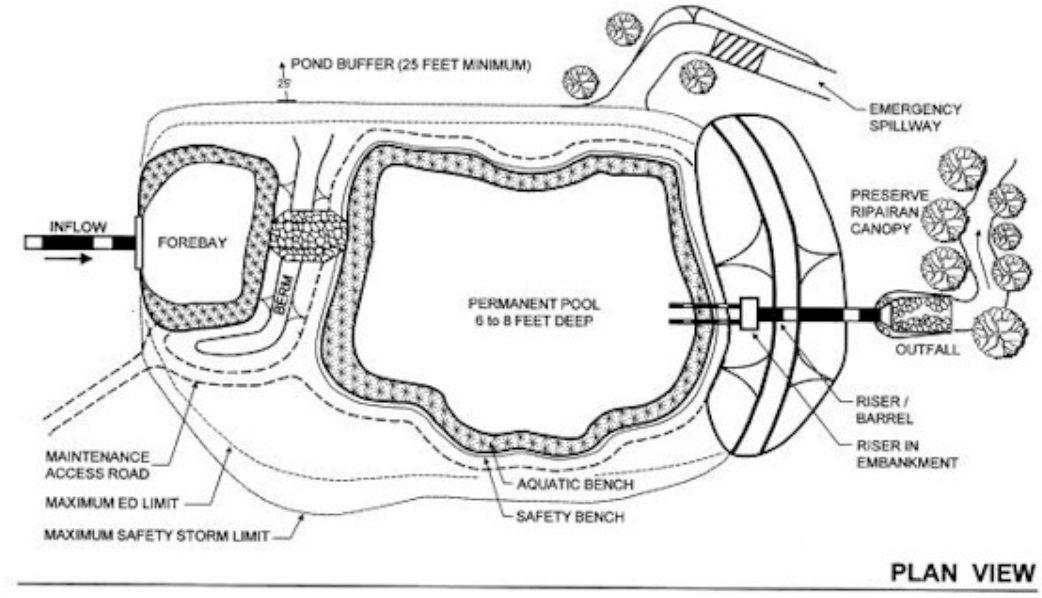
Volume Reduction: Low
Recharge: Low
Peak Rate Control: High
Water Quality: Medium

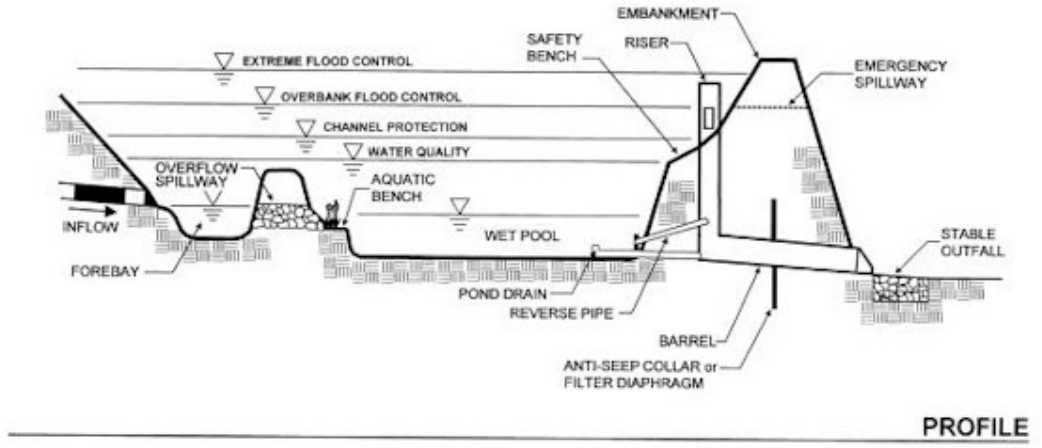
Water Quality Functions

TSS: 70%
TP: 60%
NO3: 30%

Description

Wet Detention Ponds are stormwater basins that include a permanent pool for water quality treatment and additional capacity above the permanent pool for temporary storage. Wet Ponds should include one or more forebays that trap course sediment, prevent short-circuiting, and facilitate maintenance. The pond perimeter should generally be covered by a dense stand of emergent wetland vegetation. While they do not achieve significant groundwater recharge or volume reduction, they can be effective for pollutant removal and peak rate mitigation. Wet Ponds (WPs) can also provide aesthetic and wildlife benefits. WPs require an adequate source of inflow to maintain the permanent water surface. Due to the potential to discharge warm water, wet ponds should be used with caution near temperature sensitive waterbodies. Properly designed and maintained WPs generally do not support significant mosquito populations (O'Meara).



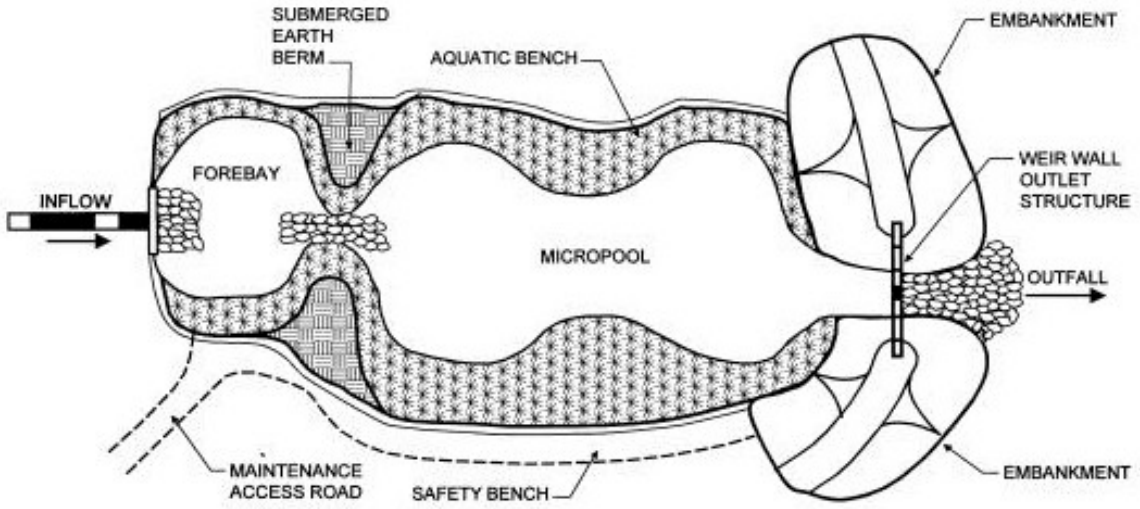


Variations

Wet Ponds can be designed as either an online or offline facilities. They can also be used effectively in series with other sediment reducing BMPs that reduce the sediment load such as vegetated filter strips, swales, and filters. Wet Ponds may be a good option for retrofitting existing dry detention basins. WPs are often organized into three groups:

- Wet Ponds primarily accomplish water quality improvement through displacement of the permanent pool and are generally only effective for small inflow volumes (often they are placed offline to regulate inflow).
- Wet Detention Ponds are similar to Wet Ponds but use extended detention as another mechanism for water quality and peak rate control.
- Pocket Wet Ponds are smaller WPs that serve drainage areas between approximately 5 and 10 acres and are constructed near the water table to help maintain the permanent pool. They often include extended detention as well.

This BMP focuses on Wet Detention Ponds as described above because this tends to be the most common and effective type of Wet Pond. For more information on other types of wet ponds, please consult the "References and Additional Resources" list.



Applications

- **Wet Ponds**
- **Wet Detention Ponds**
- **Pocket Wet Pond**
- **Offline Wet Pond**
- **Retrofit for existing detention basins**

Design Considerations

1. HYDROLOGY. Wet Ponds should be able to receive and retain enough flow from rain, runoff, and groundwater to ensure long-term viability. A permanent water surface in the deeper areas of the WP should be maintained during all but the driest periods. A relatively stable permanent water surface elevation will reduce the stress on vegetation in and adjacent to the pond. A WP should have a drainage area of at least 10 acres (5 acres for Pocket Wet Ponds) or some means of sustaining constant inflow. Even with a large drainage area, a constant source of inflow can improve the biological health and effectiveness of a Wet Pond while discouraging mosquito growth. Pennsylvania's precipitation is generally well distributed throughout the year and is therefore suited for WPs.
2. UNDERLYING SOILS. Underlying soils must be identified and tested. Generally hydrologic soil groups "C" and "D" are suitable without modification, "A" and "B" soils may require modification to reduce permeability. Soil permeability must be tested in the proposed Wet Pond location to ensure that excessive infiltration will not cause the WP to dry out.
3. PLANTING SOIL. Organic soils should be used for shallow areas within Wet Ponds. Organic soils can serve as a sink for pollutants and generally have high water holding capacities. They will also facilitate plant growth and propagation and may hinder invasion of undesirable species.
4. SIZE AND VOLUME. The area required for a WP is generally 1 to 3 percent of its drainage area. WPs should be sized to treat the water quality volume and, if necessary, to mitigate the peak rates for larger events.
5. VEGETATION. Vegetation is an integral part of a Wet Pond system. Vegetation in and adjacent to a pond may enhance pollutant removal, reduce algal growth, limit erosion, improve aesthetics, create habitat, and reduce water warming (Mallin et al., 2002; NJ DEP, 2004; University of Wisconsin, 2000). Wet Ponds should have varying depths to encourage vegetation in shallow areas. The emergent vegetation zone (areas not more than 18" deep) generally supports the majority of aquatic vegetation and should include the pond perimeter. Robust, non-invasive, perennial plants that establish quickly are ideal for WPs. The designer should select species that are tolerant of a range of depths, inundation periods, etc. Monoculture planting should be avoided due to the risk from pests and disease. See local sources for recommended plant lists or Appendix B.

6. CONFIGURATION.
    a. General. Wet Ponds should be designed with a length to width ratio of at least 2:1 wherever possible. If the length to width ratio is lower, the flow pathway through the WP should be maximized. A wedge-shaped pond with the major inflows on the narrow end can prevent short-circuiting and stagnation. WPs should not be constructed within 10 feet of the property line or within 50 feet of a private well or septic system. Slopes in and around Wet Ponds should be 4:1 to 5:1 (horizontal:vertical) or flatter wherever possible (10:1 max. for safety/aquatic benches, see 6.d. below). Wet Ponds should have an average depth of 3 to 6 feet and a maximum depth of 8 feet. This should be shallow enough to minimize thermal stratification and short-circuiting and deep enough to prevent sediment resuspension, reduce algal blooms, and maintain aerobic conditions. Wet ponds should not be constructed within a natural watercourse.
    b. Forebay/Inflows. Wet Ponds should have a forebay at all major inflow points to capture coarse sediment, prevent excessive sediment accumulation in the remainder of the WP, and minimize erosion by inflow. The forebays should contain 10 to 15 percent of the total permanent pool volume and should be 4 to 6 feet deep. They should be physically separated from the rest of the pond by a berm, gabion wall, etc. Flows exiting the forebay should be non-erosive to the newly constructed WP. Vegetation within forebays can increase sedimentation and reduce resuspension/erosion. The forebay bottom can be constructed of hardened materials to facilitate sediment removal. Forebays should be installed with permanent vertical markers that indicate sediment depth. Inflow channels should be fully stabilized. Inflow pipes can discharge to the surface or be partially submerged. Forebays should be offline (out of the path of higher flows) to prevent resuspension of previously collected sediment during large storms.
    c. Outlet. Outlet control devices should draw from open water areas 5 to 7 feet deep to prevent clogging and allow the WP to be drained for maintenance and to provide for additional temperature benefits. Outlet devices are generally multistage structures with pipes, orifices, or weirs for flow control. A reverse slope pipe terminating 2 to 3 feet below the normal water surface, minimizes the discharge of warm surface water and is less susceptible to clogging by floating debris. Orifices, if used, should be at least 2.5 inches in diameter and should be protected from clogging. Outlet devices should be installed in the embankment for accessibility. If possible, outlet devices should enable the normal water surface to be varied. This allows the water level to be adjusted (if necessary) seasonally, as the WP accumulates sediment over time, if desired grades are not achieved, or for mosquito control. A pond drain should also be included which allows the permanent pool to be completely drained for maintenance within 24 hours. The outlet pipe should generally be fitted with an anti-seep collar through the embankment. Online facilities should have an emergency spillway that can safely pass the 100-year storm with 1 foot of freeboard. All outflows should be conveyed downstream in a safe and stable manner.
    d. Safety/Aquatic Benches. All areas that are deeper than 4 feet should have two safety benches, totaling 15 feet in width. One should start at the normal water surface and extend up to the pond side slopes at a maximum slope of 10 percent. The other should extend from the water surface into the pond to a maximum depth of 18 inches, also at slopes no greater than 10 percent.
7. WET POND BUFFER. To enhance habitat value, visual aesthetics, water temperature, and pond health, a 25-foot buffer should be added from the maximum water surface elevation. The buffer should be planted with trees, shrubs, and native ground covers. Except in maintenance access areas, turf grass should not be used. Existing trees within the buffer should be preserved. If soils in the buffer will become compacted during construction, soil restoration should take place to aid buffer vegetation.

8. MAINTENANCE ACCESS. Permanent access must be provided to the forebay, outlet, and embankment areas. It should be at least 9 feet wide, have a maximum slope of 15%, and be stabilized for vehicles.
9. PLAN ELEMENTS. The plans detailing the Wet Ponds should clearly show the WP configuration, inlets and outlets, elevations and grades, safety/aquatic benches, and the location, quantity, and propagation methods of pond/buffer vegetation. Plans should also include site preparation techniques, construction sequence, as well as maintenance schedules and requirements.
10. REGULATION. Wet Ponds that have drainage areas over 100 acres, embankments greater than 15 feet high, or a capacity greater than 50 acre-feet may be regulated as a dam by PADEP (see Title 25, Chapter 105 of the Pennsylvania Code).

Detailed Stormwater Functions

Volume Reduction Calculations

Although not typically considered a volume-reducing BMP, Wet Ponds can achieve some volume reduction through infiltration and evapotranspiration, especially during small storms. According to the International Stormwater BMP Database, wet ponds have an average annual volume reduction of 7 percent (Strecker et al., 2004). Hydrologic calculations that should be performed to verify that the WP will have a viable amount of inflow can also predict the water surface elevation under varying conditions. The volume stored between the predicted water level and the lowest outlet elevation will be removed from the that design storm.

Peak Rate Mitigation Calculations

Peak rate is primarily controlled in Wet Ponds through the transient storage above the normal water surface. See Section 8 for Peak Rate Mitigation methodology.

Water Quality Improvement

Wet Ponds improve runoff quality through settling, filtration, uptake, chemical and biological decomposition, volatilization, and adsorption. WPs are relatively effective at removing many common stormwater pollutants including suspended solids, heavy metals, total phosphorus, total nitrogen, and pathogens. The pollutant removal effectiveness varies by season and may be affected by the age of the WP. It has been suggested that this type of BMP does not provide significant nutrient removal in the long term unless vegetation is harvested because captured nutrients are released back into the water by decaying plant material. Even if this is true, nutrients are usually released gradually and during the non-growing season when downstream susceptibility is generally low (Hammer, 1990). See Section 8 for Water Quality Improvement methodology, which addresses pollutant removal effectiveness of this BMP.

Construction Sequence

1. Separate wet pond area from contributing drainage area:
    a. All channels/pipes conveying flows to the WP should be routed away from the WP area until it is completed and stabilized.
    b. The area immediately adjacent to the WP should be stabilized in accordance with the PADEP's *Erosion and Sediment Pollution Control Program Manual* (2000 or latest edition) prior to construction of the WP.

2. Clearing and Grubbing:
    a. Clear the area to be excavated of all vegetation.
    b. Remove all tree roots, rocks, and boulders.
    c. Fill all stump holes, crevices and similar areas with impermeable materials.

3. Excavate bottom of WP to desired elevation (Rough Grading).

4. Install surrounding embankments and inlet and outlet control structures.

5. Grade and prepare subsoil.

6. Apply and grade planting soil.
    a. Matching design grades is crucial because aquatic plants can be very sensitive to depth.

7. Apply erosion-control measures.

8. Seed, plant and mulch according to Planting Plan

9. Install any anti-grazing measures, if necessary.

10. Follow required maintenance and monitoring guidelines.

Maintenance Issues

Wet Ponds should have a maintenance plan and privately owned facilities should have an easement, deed restriction, or other legal measure to prevent neglect or removal. During the first growing season or until established, vegetation should be inspected every 2 to 3 weeks. WPs should be inspected at least 4 times per year and after major storms (greater than 2 inches in 24 hours) or rapid ice breakup. Inspections should access the vegetation, erosion, flow channelization, bank stability, inlet/outlet conditions, embankment, and sediment/debris accumulation. The pond drain should also be inspected and tested 4 times per year. Problems should be corrected as soon as possible. Wet Pond and buffer vegetation may need support (watering, weeding, mulching, replanting, etc.) during the first 3 years. Undesirable species should be carefully removed and desirable replacements planted if necessary.

Once established, properly designed and installed Wet Ponds should require little maintenance. Vegetation should maintain at least an 85 percent cover of the emergent vegetation zone and buffer area. Annual harvesting of vegetation may increase the nutrient removal of WPs; if performed it should generally be done in the summer so that there is adequate regrowth before winter. Care should be taken to minimize disturbance, especially of bottom sediments, during harvesting. The potential disturbance from harvesting may outweigh its benefits unless the WP receives a particularly high nutrient load or discharges to a nutrient sensitive waterbody. Sediment should be removed from the forebay before it occupies 50 percent of the forebay, typically every 5 to 10 years.

Cost Issues

The construction cost of Wet Ponds can vary greatly depending on the configuration, location, site-specific conditions, etc. Typical construction costs in 2004 dollars range from approximately $25,000 to $50,000 per acre-foot of storage (based on USEPA, 1999). Costs are generally most dependent on the amount of earthwork and the planting. Annual maintenance costs have been reported to be approximately 3 to 5 percent of the capital costs although there is little data available to support this.In addition to the construction and maintenance costs, there is the cost or loss of value for the property involved.

Specifications:

The following specifications are provided for information purposes only. These specifications include information on acceptable materials for typical applications, but are by no means exclusive or limiting. The designer is responsible for developing detailed specifications for individual design projects in accordance with the project conditions.

1. **Excavation**
    a. The area to be used for the WP should be excavated to the required depth below the desired bottom elevation to accommodate any required impermeable liner, organic matter, and/or planting soil.
    b. The compaction of the subgrade and/or the installation of any impermeable liners will follow immediately.
2. **Subsoil Preparation**
    a. Subsoil shall be free from hard clods, stiff clay, hardpan, ashes, slag, construction debris, petroleum hydrocarbons, or other undesirable material. Subsoil must not be delivered in a frozen or muddy state.
    b. Scarify the subsoil to a depth of 8 to 10 inches with a disk, rototiller, or similar equipment.
    c. Roll the subsoil under optimum moisture conditions to a dense layer with four to six passes of a sheepsfoot roller or equivalent. The compacted layer shall be at least 8 inches thick.
3. **Planting Soil (Topsoil)**
    a. Use a minimum of 12 inches of topsoil in the emergent vegetation zone (less than 18" deep) of the pond. If natural topsoil from the site is to be used it must have at least 8 percent organic carbon content (by weight) in the A-horizon for sandy soils and 12% for other soil types.
    b. If planting soil is being imported it should be made up of equivalent proportions of organic and mineral materials.
    c. Lime should not be added to planting soil unless absolutely necessary as it may encourage the propagation of invasive species.
    d. The final elevations and hydrology of the vegetative zones should be evaluated prior to planting to determine if grading or planting changes are required.
4. **Vegetation**
    a. Plant Lists for WPs can be found locally. No substitutions of specified plants will be accepted without prior approval of the designer. Planting locations shall be based on the Planting Plan and directed in the field by a qualified wetland ecologist.
    b. All Wet Pond plant stock shall exhibit live buds or shoots. All plant stock shall be turgid, firm, and resilient. Internodes of rhizomes may be flexible and not necessarily rigid. Soft or mushy stock shall be rejected. The stock shall be free of deleterious insect infestation, disease and defects such as knots, sun-scald, injuries, abrasions, or disfigurement that could adversely affect the survival or performance of the plants.
    c. All stock shall be free from invasive or nuisance plants or seeds.
    d. During all phases of the work, including transport and onsite handling, the plant materials shall be carefully handled and packed to prevent injuries and desiccation. During transit and onsite handling, the plant material shall be kept from freezing and shall be kept covered, moist, cool, out of the weather, and out of the wind and sun. Plants shall be watered to maintain moist soil and/or plant conditions until accepted.
    e. Plants not meeting these specifications or damaged during handling, loading, and unloading will be rejected.
    f. Detailed planting specifications can be found locally, and in Appendix B.
5. **Outlet Control Structure**
    a. Outlet control structures shall be constructed of non-corrodible material.
    b. Outlets shall be resistant to clogging by debris, sediment, floatables, plant material, or ice.
    c. Materials shall comply with applicable specifications (PennDOT or AASHTO, latest edition)

References

Auckland Regional Council. *Stormwater Management Devices: Design Guidelines Manual*. Auckland, New Zealand: 2003.

Caraco, D. and Claytor, R. *Stormwater BMP Design Supplement for Cold Climates*. 1997.

Center for Watershed Protection and Maryland Department of the Environment. *2000 Maryland Stormwater Design Manual*. Baltimore, MD: 2000.

Center for Watershed Protection for NYS Department of Environmental Conservation. *New York State Stormwater Management Design Manual*. October 2001.

CH2MHILL. *Pennsylvania Handbook of Best Management Practices for Developing Areas*. 1998.

Cummings and Booth, circa 2003. "Stormwater Pollutant Removal by Two Wet Ponds in Bellevue, Washington." Department of Civil and Environmental Engineering, University of Washington, Seattle, WA, 23 pp.

"Effectiveness of Best Management Practices (BMPs) for Stormwater Treatment." City of Greensboro (NC), Water Resources Department, circa 2000. Available as of October 2004 at http://www.greensboro-nc.gov/stormwater/Quality/bmpeffectiveness.htm.

Federal Highway Administration, *Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring*. "Fact Sheet – Detention Basins."

Hammer, D.A. (editor). *Constructed Wetlands for Wastewater Treatment, Municipal, Industrial and Agricultural*. Ann Arbor, MI: Lewis Publishers, 1990.

Mallin, M.; Ensign, S.; Wheeler, T.; and Mayes; D. "Pollutant Removal Efficacy of Three Wet Detention Ponds." *Journal of Environmental Quality* 31: 654-660 (2002).

New Jersey Department of Environmental Protection. *New Jersey Stormwater Best Management Practices Manual*. 2004.

O'Meara, G.F. "Mosquito Associated with Stormwater Detention/Retention Areas." University of Florida, Institute of Food and Agricultural Sciences.

Strecker, E.W.; Quigley, M.M.; Urbonas, B.; and Jones, J. "Analyses of the Expanded EPA/ASCE International BMP Database and Potential Implications for BMP Design." Proceedings of the World Water and Environmental Resources Congress 2004, Salt Lake City, Utah.

United States Environmental Protection Agency (USEPA). *Storm Water Technology Fact Sheet: Wet Detention Ponds* (EPA 832-F-99-048) 1999.