Extended Detention Basin TC-22

Design Considerations

- Tributary Area
- Area Required
- Hydraulic Head

Targeted Constituent	Removal
Sediment	Med
Nutrients	Low
Trash	High
Metals	Med
Bacteria	Med
Oil and Grease	Med
Organics	Med
Flow Control	High

Description

Extended detention basins (dry ponds, dry extended detention ponds, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (typically 48 hours) to allow particles, trash and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. They can also be used to provide flood control by including additional flood detention storage.

California Experience

Caltrans constructed and monitored five extended detention basins in southern California with design drain times of 72 hours. Four of the basins were earthen, less costly and had substantially better load reduction because of infiltration than the concrete basin. The Caltrans study reaffirmed the flexibility and performance of this conventional technology. Extended detention basins, while not as effective as systems that provide filtration such as bioretention areas or sand filters, have been shown to be effective at reducing many of the pollutants regulated by the State and Regional Water Boards. Additionally, the Water Boards have determined that extended detention basins can qualify as a ”Full Capture System (FCS)[1]” for trash. Accordingly, in addition to providing general specifications, this fact sheet includes trash-specific information to assist with upgrading either an existing BMP or the design of a planned BMP to meet the FCS definition. See the “**Full Trash Capture Compliance**” section and “***Trash FCS***” subsections in this fact sheet for more information.

---

[1] Full Capture System (FCS): A treatment control, or series of treatment controls, including but not limited to, a multi-benefit project or a low impact development control that traps all particles that are 5 mm or greater, and has a design treatment capacity that is either: a) of not less than the peak flow rate, Q, resulting from a one-year, one-hour, storm in the subdrainage area, or b) appropriately sized to, and designed to carry at least the same flows as, the corresponding storm drain.

Advantages

- Extended detention basins can have a simple, low-cost design, and meet hydromodification management requirements and the full capture system definition for trash control.
- Widespread application can provide significant control of channel erosion and flood management.

Limitations

- The recommended minimum orifice diameter of 0.5” may be too large in drainages less than 5 acres.
- Dry extended detention basins are relatively ineffective at removing soluble pollutants.
- Can detract from property value due to the aesthetics of dry and bare areas.

Performance

The primary purpose of most detention basins is flood control, but they can also garner pollutant removal performance (Table 1). Variations in design can vary this performance, for example vegetated detention basins provide improved pollutant removal when compared to concrete basins. An optional micropool at the basin’s outlet can be incorporated to increase performance of soluble pollutants.

Table 1. Typical pollutant removal and removal processes for constituents

Pollutant	Typical Removal	Median Effluent Concentration[1]	Removal Processes	References
Sediment	Med/High 50-99%	23.3 mg/L	Settling in pretreatment, filtration	Geosyntec Consultants and Wright Water Engineering 2012; Barrett 2008; Harper 1999; Revitt 2004; Scholes 2007
Metals	Medium TCd: 88% TCu: 46-96% TCr: 95% TPb: 92% TZn: 35-95%	TAs: 1.71 µg/L TCd: 0.24 µg/L TCr: 2.55 µg/L TCu: 4.99 µg/L TPb: 3.86 µg/L TNi: 2.73 µg/L TZn: 21.3 µg/L	Removal with sediment, sorption	Geosyntec Consultants and Wright Water Engineering 2012; Barrett 2008; Scholes 2007
Total phosphorus	Low	0.197 mg/L	Settling with sediment, sorption, biological uptake	Barrett 2008; Harper 1999; Geosyntec Consultants and Wright Water Engineering 2012; Walker 1987
Total nitrogen	Low	TN: 1.60 mg/L, TKN: 1.49 mg/L, $NO_{2,3}$-N: 0.27 mg/L	Settling with sediment, sorption, filtration, biological uptake	Barrett 2008; Harper 1999; Geosyntec Consultants and Wright Water Engineering 2012

Pollutant	Typical Removal	Median Effluent Concentration[1]	Removal Processes	References
Bacteria	Medium	E. coli – 429 (MPN/100 mL) Fecal Coliform - 727 (MPN/100 mL)	Sorption, microbial degradation, settling, photolysis	Geosyntec Consultants and Wright Water Engineering 2012; Barrett 2008, Harper 1999; Scholes 2007
Trash	High	N/A	Filtration (Media treatment depth of 1.5 feet) and/or outlet screen	Barrett et al. 2013

[1] Underlined effluent concentrations were (statistically) significantly lower than influent concentrations, as determined by statistical hypothesis testing on the available sampled data.

Trash FCS

The Trash Amendments adopted by the State Water Board in April 2015 provide a performance standard for treatment of stormwater for trash in the form of the definition of FCS, which extended detention basins meet (see Section 5.6.1. for FCS details).

Suitability and Design

Dry extended detention basins are among the most widely applicable BMPs and are especially useful in retrofit situations where their low hydraulic head requirements allow them to be sited within the constraints of the existing storm drain system. Fundamental extended detention basin design components and suitability are as follows:

- Drawdown time of 48 hours is required for vector control, but design should also incorporate long flow paths, promote the establishment of low velocities, for improved water quality.
- A facility's drawdown time is regulated by an orifice or weir; with minor design adjustments in outlet design, extended detention basins are applicable in all soils and geology.
- 10-ft setback from foundations, 100-ft from septic fields and water supply wells, and 50-ft from steep slopes.

Extended detention basin design is highly dependent on the constraints of the considered site and costs vary accordingly with design. An optional micropool at the basin's outlet can be incorporated to increase performance of soluble pollutants. Table 2 details a number of core construction components and corresponding design considerations.

Table 2. Cost of design components and associated considerations

Component	Cost	Design Consideration
Excavation	$5.00–$15.00/ft^2	Capture volume determined by local requirements or sized to treat runoff produced by the 85th percentile storm. Length to width ratio of 1.5:1 if feasible. Basin depth of 2 to 5 feet is optimal. Include energy dissipation

Component	Cost	Design Consideration
		in the inlet design to reduce resuspension of sediment. Incorporate maintenance access to the basin design
Vegetation Sod (buffalo) Seeding	 $\$0.67/\text{ft}^2$ $\$0.15–\$0.22/\text{ft}^2$	Turf grasses (not bunch grasses) should be maintained on the surface to prevent erosion and improve treatment. Water and spot fertilize during first year.
Subsurface Option (Figure 3**)** Excavation, Installation, and Backfill Concrete Unit	 $\$9.20/\text{ft}^2$ $\$59.93/\text{ft}^2$	Constructing a subsurface facility includes excavating to depth, installing concrete unit, overdig, and backfill. Concrete unit assumed here: 11' 4". Requires pretreatment BMP to capture trash and debris.
Outlet Structure		No more than 50% of the water quality volume drains within the first 24 hours.

Outlet Design

Design of the outflow structure is crucial in successful operation of the basin. Outlet design can include an outlet riser with orifices sized to discharge the water quality volume, and riser overflow height set to the design storm elevation. A trash rack (i.e. stainless steel screen) should be implemented to prevent clogging at the entrance to the outflow pipes. Screens should have a mesh smaller than 5 mm to meet the full capture requirement for trash. An image with these design components is presented in Figure 1. Alternative outlet design includes a separate riser or broad crested weir for overflow of runoff for the 25 and greater year storms. Figure 2 shows an example of an outlet that provides a variable flow as outlet flow increase with depth.

Figure 1. Example of outlet structure.

Figure 2. Variable flow outlet structure.

Outlet design should also ensure that no more than 50% of the water quality volume drains within the first 24 hours. Discharge through a control orifice is calculated from:

$$Q = CA(2gH-H_o)^{0.5}$$

Where:

Q = discharge (ft^3/s)

C = orifice coefficient

A = area of the orifice (ft^2)

g = gravitational constant (32.2)

H = water surface elevation (ft)

H_o= orifice elevation (ft)

Recommended values for C are 0.66 for thin materials and 0.80 when the material is thicker than the orifice diameter. This equation can be implemented in spreadsheet form with the basin stage/volume relationship to calculate drain time. To do this, use the initial height of the water above the orifice for the water quality volume. Calculate the discharge and assume that it remains constant for approximately 10 minutes. Based on that discharge, estimate the total discharge during that interval and the new elevation based on the stage volume relationship. Continue to iterate until H is approximately equal to H_o. When using multiple orifices the discharge from each is summed.

Subsurface Option

Subsurface extended detention basin are ideal when a surface detention basin is infeasible because of land constraints (Figure 3). Open space parks (e.g., baseball fields, etc.) are an example of where a subsurface extended detention basin is ideal because the park's purpose as a recreational area is not compromised. Additionally, recreational areas typically lack large structures, therefore the issue of overhead weight over the subsurface unit is not a concern.

Figure 3. Subsurface design of an extended detention basin, during construction.

Full Trash Capture Compliance

This section provides trash-specific information to assist with upgrading either an existing BMP or the design of a planned BMP to meet the FCS definition. In addition to developing and adopting the Trash Amendments, the State Water Board provides implementation information on its Trash Implementation web page: https://www.waterboards.ca.gov/water_issues/programs/stormwater/trash_implementation.html.

The web page includes information on best management practices or Full Capture Systems, including lists of State-certified Multi-Benefit Trash Treatment Systems. So, when selecting BMPs for trash control, fact sheet users should refer to both this BMP fact sheet and the State Water Board's Trash Implementation web page.

Design Modifications to Prevent Trash Migration, Sustain Capacity, and Prevent Reduced Functionality

The extended detention basin must be configured to allow trash to enter the system and for trash to remain in the system until it can be collected and removed. To meet the requirement, inlets must be designed to pass the peak flow produced by the 1 year 1 hour design storm and solids that would be retained by a 5 mm screen or mesh must remain in the system. Preventing trash migration may require modifications to the inlets, and outlets.

Inlets

There are a multitude of inlet configurations that will allow trash to enter and be captured in an extended detention basin. In general, an open inlet is recommended to allow for flow and trash to enter the extended detention basin unrestricted (Figure 4). A forebay or other pretreatment configuration is recommended to consolidate trash collection in the basin.

Figure 4. Example inlet structure.

Trash Containment

Once trash has been captured in an extended detention basin it must be contained so trash does not escape the extended detention basin. Containment may be provided by one or more of these features:

- an external design feature or up-gradient structure designed to bypass flows exceeding the region-specific one-year, one-hour storm event; or
- the BMP having sufficient capacity to trap particles from flows exceeding those generated by the one-year, one-hour storm event; or
- the BMP having sufficient capacity to treat either the design flows or volumes through media filtration or infiltration into native or amended soils; or
- use of a maximum 5 mm mesh screen on all outlets.

Figure 5 shows an example of an outlet with a screen to contain trash. A larger grate on the top of the structure allows larger flows to safely flow out of the system.

Figure 5. Outlet structure with a 5mm screen.

Maintenance

Routine maintenance activity consists primarily of sediment, trash, and debris removal, but also mowing the turf to meet aesthetic and flow routing design of the basin. Vector control can also a significant investment of maintenance hours when poor drainage exists or stilling basins are installed as energy dissipaters.

Table 3. Typical maintenance activities and associated costs and frequency

Frequency	Cost	Activity
Routine Maintenance (required monthly to every 2 years)		Remove excess sediment, trash, and debris across the surface, inlet, and outlet. Check for and stabilize erosion. Mowing overgrown vegetation that interferes with access, or safety.
Routine (small)	$\$0.44/\text{ft}^2$	
Routine (medium)	$\$0.34/\text{ft}^2$	
Routine (large)	$\$0.24/\text{ft}^2$	
End of Life Replacement (service life of 20 years)		Excavate to the depth of soil media. Test soil for excessive soil contamination of common stormwater pollutants (e.g. metals, nutrients). Continue to remove underlying soil if pollutants exceed standard for contaminated soil. Replace with clean soil.
Replacement (small)	$\$8.19\text{ft}^2$	
Replacement (medium)	$\$6.43/\text{ft}^2$	
Replacement (large)	$\$5.99/\text{ft}^2$	
Note: Small System = 500 ft^2; Medium System = 2000 ft^2; Large System = 4000 ft^2 Underlined statement indicates that the activity may be required more frequently than shown in the table to meet the SWRCB's maintenance criteria for Multi-Benefit Treatment Systems to be qualified as Full Capture Systems.		

Trash FCS

Maintenance to Prevent Trash Migration, Sustain Capacity, and Prevent Reduced Functionality

For Multi-Benefit Treatment Systems to be qualified as Full Capture Systems, the State Water Board requires regular maintenance to maintain adequate trash capture capacity and to ensure that trapped trash does not migrate offsite. Additionally, the State Water Board requires the BMP owner to establish a maintenance schedule based on site-specific factors, including the design trash capacity of the Extended Detention Basin Multi-Benefit Trash Treatment System, storm frequency, and estimated or measured trash loading from the drainage area. To meet those criteria, it is likely that the frequency of trash and debris removal will have to be increased above the recommended monthly interval during the wet season to prevent trash from being blown from the extended detention basin or being washed out of the system in the subsequent rain events. Trash can also clog the inlet and the surface of the limiting the flow into the basin and reducing the surface infiltration capacity. Depending on the frequency and size of storms, and upstream pollutant characteristics, trash and debris removal can be as frequent as before and after every wet weather event. The optimum maintenance interval is best determined by observing the BMP in operation for a wet season.

Frequent trash maintenance not only plays a role in the functionality of the extended detention basin but also in the aesthetics and public perception of the extended detention basin (and of all BMPs). Part of maintaining positive perception among the public is the visibility of a well-maintained BMP. This positive perception can self-perpetuate further support for integrated stormwater management practices and therefore further investment in regular maintenance.

Schematics

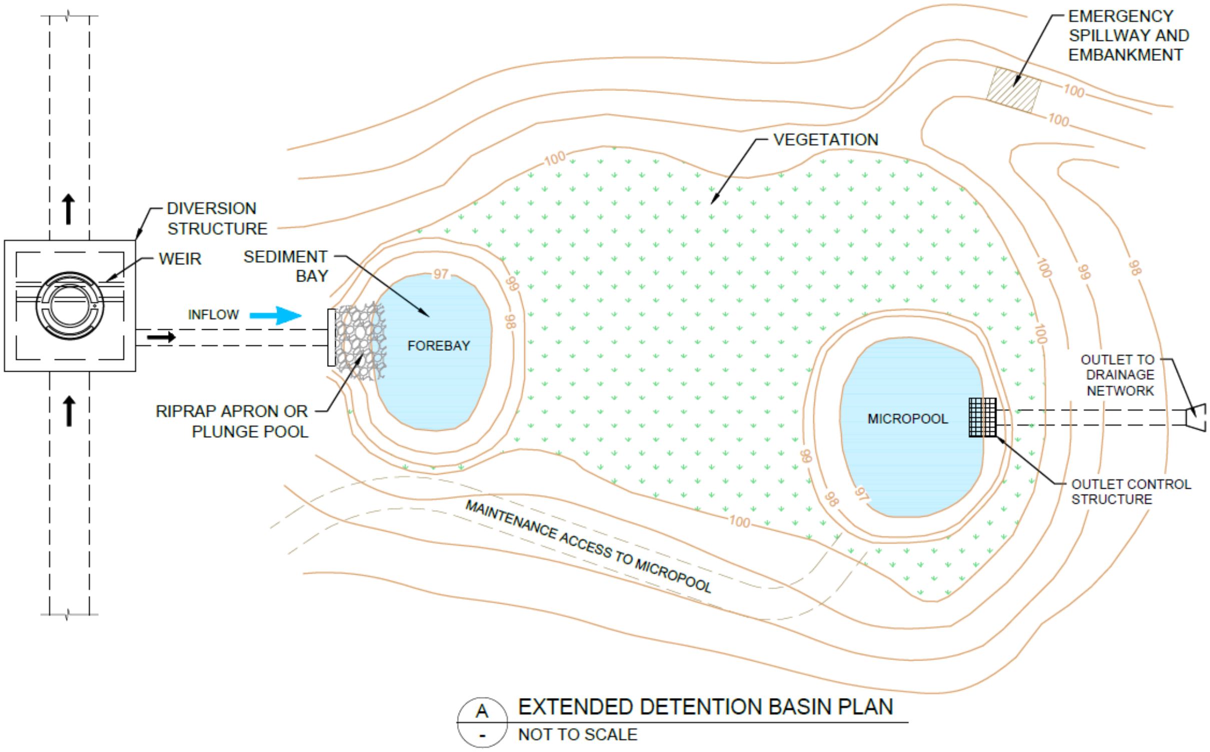

Figure 6. Schematic of an extended detention basin.

References and Sources of Additional Information

Barrett, M.E. 2008. Comparison of BMP performance using the International BMP Database. *Journal of Irrigation and Drainage Engineering* 134(5):556–561.

Brown, W., and T. Schueler. 1997. *The Economics of Stormwater BMPs in the Mid-Atlantic Region*. Prepared for Chesapeake Research Consortium. Edgewater, MD. Center for Watershed Protection. Ellicott City, MD.

Denver Urban Drainage and Flood Control District. 1992. *Urban Storm Drainage Criteria Manual—Volume 3: Best Management Practices*. Denver, CO.

Dorman, T., M. Frey, J. Wright, B. Wardynski, J. Smith, B. Tucker, J. Riverson, A. Teague, and K. Bishop. 2013. San Antonio River Basin Low Impact Development Technical Design Guidance Manual, v1. San Antonio River Authority. San Antonio, TX.

Emmerling-Dinovo, C. 1995. Stormwater Detention Basins and Residential Locational Decisions. *Water Resources Bulletin 31(3)*: 515–521.

Galli, J. 1990. *Thermal Impacts Associated with Urbanization and Stormwater Management Best Management Practices*. Metropolitan Washington Council of Governments. Prepared for Maryland Department of the Environment, Baltimore, MD.

Geosyntec Consultants and Wright Water Engineering. 2012. *International Storm Water BMP Database Pollutant Category Summary Statistical Addendum: TSS, Bacteria, Nutrients, and Metals*. 2012. International Storm Water BMP Database. http://www.bmpdatabase.org/.

GKY, 1989, *Outlet Hydraulics of Extended Detention Facilities* for the Northern Virginia Planning District Commission.

Harper, H. J. Herr, D. Baker. 1999. Performance evaluation of dry detention stormwater management systems. In Proceedings of the Sixth Biennial Stormwater Research & Watershed Management Conference. Tampa, FL. September 14-17, 1999.

MacRae, C. 1996. Experience from Morphological Research on Canadian Streams: Is Control of the Two-Year Frequency Runoff Event the Best Basis for Stream Channel Protection? In *Effects of Watershed Development and Management on Aquatic Ecosystems*. American Society of Civil Engineers. Edited by L. Roesner. Snowbird, UT. pp. 144–162.

Maryland Dept of the Environment, 2000, Maryland Stormwater Design Manual: Volumes 1 & 2, prepared by MDE and Center for Watershed Protection. http://www.mde.state.md.us/environment/wma/stormwatermanual/index.html

Metzger, M. E., D. F. Messer, C. L. Beitia, C. M. Myers, and V. L. Kramer. 2002. The Dark Side Of Stormwater Runoff Management: Disease Vectors Associated With Structural BMPs. Stormwater 3(2): 24-39.

Revitt, D.M. 2004. Water pollution impacts of transport. Editors: Hester,R.E., Harrison, R.M. Transport and the Environment. Issues in Environmental Science and Technology 20: 81-109, Royal Society of Chemistry, Cambridge, UK, (ISBN: 0854042954).

Santana, F., J. Wood, R. Parsons, and S. Chamberlain. 1994. Control of Mosquito Breeding in Permitted Stormwater Systems. Prepared for Southwest Florida Water Management District, Brooksville, FL.

Scholes, L. M. Revitt, J. Ellis. 2007. A systematic approach for the comparative assessment of stormwater pollutant removal potentials. Journal of Environmental Management, 88(2008): 467–478.

Schueler, T. 1997. Influence of Ground Water on Performance of Stormwater Ponds in Florida. *Watershed Protection Techniques* 2(4):525–528.

Tetra Tech (Tetra Tech, Inc.). 2015. Enhancements to the City of San Diego Green Infrastructure Design Standards City of San Diego Storm Water Division by Tetra Tech, Inc., San Diego, CA.

Tetra Tech (Tetra Tech, Inc.). 2014. Low Impact Development Handbook Stormwater Management Strategies County of San Diego Department of Public Works by Tetra Tech, Inc., San Diego, CA.

Walker, W. 1987. Phosphorus removal by urban runoff detention basins. Lake and Reservoir Management 3:314-326.

Watershed Management Institute (WMI). 1997. *Operation, Maintenance, and Management of Stormwater Management Systems*. Prepared for U.S. Environmental Protection Agency, Office of Water. Washington, DC.

Young, G.K., et al., 1996, *Evaluation and Management of Highway Runoff Water Quality*, Publication No. FHWA-PD-96-032, U.S. Department of Transportation, Federal Highway Administration, Office of Environment and Planning.

Information Resources

Center for Watershed Protection (CWP), Environmental Quality Resources, and Loiederman Associates. 1997. *Maryland Stormwater Design Manual*. Draft. Prepared for Maryland Department of the Environment, Baltimore, MD.

Center for Watershed Protection (CWP). 1997. *Stormwater BMP Design Supplement for Cold Climates*. Prepared for U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds. Washington, DC.

U.S. Environmental Protection Agency (USEPA). 1993. *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*. EPA-840-B-92-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.