7.0 WATER-BASED CONTROL MEASURES

7.1 IDENTIFICATION AND DESCRIPTION OF CONTROL MEASURES

Table 7-1 lists the water-based options being considered for implementation in the initial screening stage. Descriptions of these options follow.

Table 7-1: Water-Based Options

				Goals Addressed							
Number	Category	Option	IWMP*	Dry Weather WQ	Solids/Floatables	Recreation	Tributary Habitat	Tidal Habitat	Water Balance	Wet Weather WQ	Stewardship
W.1	Instream	Dam modification/removal					X				X
W.2	Instream	Daylight orphaned storm sewers	X				X			X	X
W.3	Instream	Stream cleanup and maintenance	X				X				X
W.4	Instream	Channel stabilization and habitat restoration	X				X				X
W.5	Instream	Channel realignment and relocation	X				X				X
W.6	Instream	Plunge pool removal	X	X			X				X
W.7	Instream	Improvement of fish passage	X				X				X
W.8	Instream	Instream aeration		x							
W.9	Instream	Sidestream aeration									
W.10	Riparian	Constructed wetlands along stream corridors	X				X				X
W.11	Riparian	Wetland restoration along tidal rivers						X			X
W.12	Riparian	Enhance stream corridor recreational and cultural resources	X			X					X
W.13	Riparian	Wetland improvement	X				X				X
W.14	Riparian	Invasive species management	X				X				X
W.15	Riparian	Reforestation	X				X				X

*IWMP = Integrated Watershed Management Plan

W.1 Instream: Dam Modification/Removal

Dam removal and modifications are implemented to create and enhance fish habitat. These improvements are especially important to anadromous species, whose life cycles depend on upstream migration to fresh water. Modifications include partial removal, v-notches, and rock ramps. Removal of dams or modifications can increase the range of these species. In Philadelphia, migratory fish species such as American shad (*Alosa sapidissima*), striped bass (*Morone saxatilis*) and river herring (alewife, *Alosa pseudoharengus*, and blueback herring, *A. aestivalis*) migrated through the Schuylkill River drainage until the construction of dams in the early 1800's.

W.2 Instream: Daylight Orphaned Storm Sewers

In a number of locations, separate storm sewers discharge flow directly to a combined sewer. When this situation occurs in a park or other public land and is near an existing stream, an opportunity exists to "daylight" the sewer and have it discharge directly to the stream, thereby allowing for additional capacity in the combined sewer.

W.3 Instream: Stream Cleanup and Maintenance

Keeping streams free of trash is a continuous activity. PWD has established a permanent Waterways Restoration Team. This team periodically removes trash and large debris from each of the tributaries on a rotating schedule. For reaches of stream within the City or along the City boundary, the team focuses on removal of litter and heavy debris, and maintenance of in-stream aquatic habitat improvement projects including fish ladders, fluvial geomorphologic restoration projects, and elimination of outfall plunge pools. PWD also partners with a number of watershed groups and nonprofit organizations to perform volunteer cleanups.

W.4 Instream: Channel Stabilization and Habitat Restoration

Bed conditions in stream channels subjected to urbanized flow often do not support a healthy aquatic ecosystem. High-velocity urbanized flows result in downcutting and widening of the bed over time, and deposition of fine sediments disrupts macroinvertebrate communities that are critical links in the aquatic food chain. Loss of pool and riffle sequences deprives fish of the variety of habitats they need to feed, spawn, and seek shelter from high flows. These channel changes tend to begin downstream and migrate their way upstream over a period of time.

Bed stabilization is recommended for those reaches that are currently degrading through incising or downcutting. Bed stabilization measures include rock/log vanes with grade control, rock/log cross vanes, and using naturally occurring boulders and bedrock. These measures reduce erosion by diverting high flows away from banks and by controlling the grade (slope) of the bed. They also stop downcutting from migrating upstream and restore habitat features that lead to healthy macroinvertebrate and fish communities.

The fine sediment that is deposited in the beds of many urban streams is often the result of bank erosion upstream. In addition to downcutting the stream bed, high-velocity urban flows result in steep, sometimes vertical banks that disconnect the stream from its historical floodplain. Using natural stabilization measures on banks also provide fish habitat and areas of reduced velocity during storms. A properly restored bank prevents further erosion, reconnects the stream to its floodplain (wetlands and riparian forest as appropriate), protects infrastructure located in the bank and provides fish habitat. It also may remove a hazardous and unsightly condition caused by a collapsing bank.

Bank stabilization measures can vary from small plantings to the installation of boulder walls, based on the severity of the erosion and whether it is localized or continues for some distance along a bank. Boulder structures are used in smaller channels that are eroding and over-widening to the point where property is, or is expected, to be lost. More natural bank stabilization methods such as bioengineering, root wads, plantings, logs, and woody structures are appropriate in areas where the bankfull width is limited and significant additional channel changes are not expected (future increases in the rate of erosion, sediment supply, tree fall, channel widening, and channel migration are not expected). These measures enhance aquatic habitat in addition to providing stabilization.

W.5 Instream: Channel Realignment and Relocation

In the most severely degraded reaches, stabilization of the existing bed and banks may not be possible, or migration of the stream channel may threaten valuable infrastructure. In these areas, realignment and relocation of the stream channel may be necessary. This measure increases stability by creating a new channel along a path that is natural for the stream to follow. The design of bed and bank structures is not constrained by existing conditions. In some cases, the existing channel makes an ideal site for a riparian wetland. Channel realignment and relocation is commonly implemented for portions of a channel rather than for an entire length of channel due to construction and maintenance costs, and the amount of disturbance that occurs to existing natural habitat. Stream channel realignment and relocation is best suited to consecutive severely degraded reaches.

W.6 Instream: Plunge Pool Removal

When stormwater and combined sewer outfalls discharge directly to the stream channel, they may create deep, poorly mixed pools. Because these pools are typically near the bank and not in the main flow, they can become poorly mixed during low flow. These pools often have increased odors and reduce the aesthetic quality of the stream. Biological activity in the sediment and water column can reduce dissolved oxygen (DO) to low levels, and this low-DO water can be flushed out and affect downstream areas during wet weather. The depression of DO is a function of both pollutant loads from the outfalls and in stream baseflow, and the physical condition of the channel. When DO is in an acceptable range in the well-mixed portion of the channel but not in nearby plunge pools, elimination of the plunge pools can be expected to eliminate the water quality condition that might affect the aquatic ecosystem.

W.7 Instream: Improvement of Fish Passage

Fish ladders and bypass channels are technologies built to provide passage for fish to swim around dams when dam removal/modifications are not feasible. These devices enhance habitat range for fish and provide spawning opportunities for anadromous fish. PWD has been involved with recent improvements to the Fairmount Dam Fishway on the Schuylkill River originally built in 1979.

W.8 Instream: Instream Aeration

Instream aeration is a technology developed to add oxygen to the water column in areas where slow, stagnant conditions occur in streams. Air can be added directly to stream or river flow using a diffusion system to increase dissolved oxygen levels for the improvement of fish habitat and water quality.

W.9 Instream: Sidestream Aeration

This option consists of adding air directly to a receiving waterway in order to increase dissolved oxygen concentration. Sidestream aeration is when flow is diverted to an offline aeration facility and re-diverted back to the stream or river.

W.10 Riparian: Constructed Wetlands along Stream Corridors

Wetland creation opportunities have been evaluated for many areas in the Cobbs and Tacony-Frankford Creek Watersheds where stream relocation and realignment are proposed. Because stream relocation and realignment typically involve extensive grading and replanting, new runoff patterns and hydrology can be created that are more similar to original riparian conditions, whereby the riparian corridor receives storm runoff sheet flow from the adjacent landscape. In addition, wetland habitats can be created that allow more diverse habitat. Wetlands are rich habitats that rely on saturated soils and vegetation adapted to these conditions. They could be recreated concurrently

with channel realignment, bank restoration, and planting of more diverse native vegetation, including hydrophytic species adapted to saturated soil conditions.

W.11 Riparian: Wetland Restoration Along Tidal Rivers

Historically, freshwater tidal wetlands extended from Trenton, New Jersey to Chester, Pennsylvania, but urbanization has reduced the area by 95%, with only small remnants of freshwater tidal wetlands on the Pennsylvania side of the Delaware River. As part of an effort to identify tidal wetland restoration sites, PWD staff assessed the tidal sections of the Delaware and Schuylkill Rivers in 2006 and 2007. The locations for potential tidal wetland restoration have a gradual slope to littoral shelf and appropriate depth range, appropriate sediment characteristics, and the feasibility for wave/wake attenuation. Approximately 88 acres along the Delaware River and 30 along the Schuylkill River have been identified as potential for wetland creation or enhancement. The goal of this option is to improve the quality of water in the Schuylkill River as well as create habitat for aquatic life, herpifauna and migratory birds.

W.12 Riparian: Enhance Stream Corridor Recreational and Cultural Resources

Once dry weather water quality and aesthetics have been improved, the recreational value of stream and river corridors will be enhanced, and better accessibility becomes important. Measures include establishing and improving trails and greenways and protecting historic sites.

W.13 Riparian: Wetland Improvement

Existing wetlands may have a direct hydrologic relationship with the stream yet show degraded conditions at present. A wetland's hydrologic relationship with the waterway may be partially compromised or the wetland may exhibit somewhat degraded conditions because of the impacts of stormwater inflow to the wetland.

W.14 Riparian: Invasive Species Management

plan to control invasive plant species is necessary when restoring or enhancing wetlands and riparian forests. Invasive species provide little value to native animals that depend on native species for habitat and food. Japanese knotweed (Polygonum cuspidatum) is the one prevalent invasive species that was observed during the field reconnaissance. In many areas, knotweed, due to its aggressive nature, has already outcompeted native vegetation. Maintaining a healthy riparian plant community will retain biodiversity and support a healthy stream ecosystem.

W.15 Riparian: Reforestation

PWD's riparian corridor restoration and enhancement plans cover the width of the stream corridor from developed edge to developed edge, including both lowland and upland forest. Reforestation that occurs adjacent to the channel will provide wetland habitat and other associated benefits. Although priority reforestation areas consist of floodplains, steep slopes, and wetlands, smaller areas such as public rights-of-way, parks, schools, and neighborhoods also provide reforestation opportunities. Benefits of reforestation are numerous: cooler temperatures, rainfall interception, reduced runoff, reduced sediment load, reduced discharge velocities, increased groundwater recharge, increased species diversity and habitat, and improved air quality and aesthetics.

7.2 SCREENING CRITERIA

The following criteria are proposed for initial screening of options:

1. Options that are required by NPDES permit or other regulation are recommended for inclusion in all management alternatives

2. Options recommended for implementation in one of PWD's Integrated Watershed Management Plans are recommended for inclusion in all management alternatives

3. Other options must meet at least one stated goal of the LTCPU to be considered for inclusion in management alternatives. Options also must be technically feasible to implement and maintain

7.3 SCREENING RESULTS

The options listed above were considered as part of PWD's commitment to a balanced "land-water-infrastructure" approach for achieving watershed management and CSO control goals. Many of the water-based options focus on improving aquatic habitats including water quality. These water-based options are an important part of achieving the ultimate goal of regaining the resources in and around streams that have been lost due to urbanization, both within the City of Philadelphia and in the surrounding counties, while achieving full regulatory compliance in a cost-effective manner.

Table 7-2 contains the recommendations for each water-based option's inclusion in the alternatives analysis. All water-based options are included in the alternatives except for instream (W.8) and sidestream aeration (W.9). These were not included because they are only beneficial in areas where stagnated, pondlike conditions cause severe dissolved oxygen deficiencies.

Table 7-2: Recommendations for Water-Based Options

Number	Category	Option	Include in All Alternatives	Consider Including in Alternatives	Do Not Include in Alternatives
W.1	Instream	Dam Modification/Removal	X		
W.2	Instream	Daylight Orphaned Storm Sewers	X		
W.3	Instream	Stream Cleanup and Maintenance	X		
W.4	Instream	Channel Stabilization and Habitat Restoration	X		
W.5	Instream	Channel Realignment and Relocation	X		
W.6	Instream	Plunge Pool Removal	X		
W.7	Instream	Improvement of Fish Passage	X		
W.8	Instream	Instream Aeration			X
W.9	Instream	Sidestream Aeration			X
W.10	Riparian	Constructed Wetlands along Stream Corridors	X		
W.11	Riparian	Wetland Restoration Along Tidal Rivers	X		
W.12	Riparian	Enhance Stream Corridor Recreational and Cultural Resources	X		
W.13	Riparian	Wetland Improvement	X		
W.14	Riparian	Invasive Species Management	X		
W.15	Riparian	Reforestation	X		