Santa Clara Valley
*Urban Runoff*
Pollution Prevention Program

September 2007

# Trash BMP Tool Box

Treatment and Institutional Controls

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# Preface

Over the past five years, the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) has focused on assessing the accumulation and composition of trash in its urban watersheds and identifying existing and appropriate enhancements to management actions for reducing trash impacts on beneficial uses. To better understand the best possible controls and institutional approaches designed to prevent trash from entering local waterways, the Program conducted a review of literature from government, academic and commercial entities. The information was bolstered by discussions with municipal employees that operate and maintain trash control measures and with representatives who sell trash control devices. The results of the literature review are presented in technical information sheets and compiled into a Trash BMP (Best Management Practices) Tool Box.

The Trash BMP Tool Box is intended to assist stormwater managers, municipal officials and other stakeholders in understanding what options are available for controlling and capturing trash within the storm drain conveyance system and the urban landscape. Information about a particular BMP for controlling trash in stormwater and urban runoff, including non-proprietary and proprietary systems, is *not* to be construed as an actual or implied endorsement, warranty or recommendation for use by SCVURPPP or EOA, Inc. Decisions regarding the implementation of site-specific BMPs must be based on local characteristics, conditions and available resources; and made by the appropriate decision-maker within individual jurisdictions. Users of this document assume all liability directly or indirectly arising from use of the information contained herein. This disclaimer is applicable whether information from this document is obtained as a hard copy or downloaded from www.scvurppp.org.

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# Acronyms

| | |
|---|---|
| ac | Acre |
| AHTG | Ad Hoc Task Group |
| BASMAA | Bay Area Stormwater Management Agencies Association |
| BB | Baffle Box |
| BBC | British Broadcasting Corporation |
| BID | Business Improvement District |
| BIEC | Beverage Industry Environment Council |
| BMP | Best Management Practice |
| CAA | Cleanup and Abatement Account |
| Caltrans | California Department of Transportation |
| CASQA | California Association of Stormwater Quality |
| CBI | Catch Basin Insert |
| CCAG | Creek Connections Action Group |
| CEIT | Center for Environmental Industry and Technology |
| CCC | California Coastal Commission |
| CCCWP | Contra Costa Clean Water Program |
| CCDS | California Community Dispute Services |
| CDS | Continuous Deflective Separation |
| cf | Cubic Feet |
| cfs | Cubic Feet per Second |
| CIWMB | California Integrated Waste Management Board |
| cm | Centimeter |
| CRV | California Redemption Value |
| CSO | Combined Sewer Overflows |
| CWA | Clean Water Act |
| CWEA | California Water Environment Association |
| cy | Cubic Yard |
| CWP | Center for Watershed Protection |
| DEC | Department of Environmental Conservation |
| DPW | Department of Public Works |
| ECO | Environmental Control Officer |
| e.g. | For Example |
| EPA | Environmental Protection Agency |
| FCSHWM | Florida Center for Solid and Hazardous Waste Management |
| ft | Feet |
| FY | Fiscal Year |
| GSRD | Gross Solid Removal Device |
| g | Gram |
| ha | Hectare |
| hr | Hour |
| i.e. | That Is |
| in | Inch |
| IS | Inclined Screen |
| ITI | Innovative Technology Inventory |
| KAB | Keep America Beautiful |
| KCB | Keep California Beautiful |

| | |
|---|---|
| kg | Kilogram |
| L | Liter |
| lb | Pound |
| LADPW | Los Angeles Department of Public Works |
| LARWQCB | Los Angeles Regional Water Quality Control Board |
| LACDPW | Los Angeles County Department of Public Works |
| LMI | Lake Merritt Institute |
| LR | Linear Radial |
| MA | Massachusetts |
| MEP | Maximum Extent Practicable |
| m | Meter |
| min | Minute |
| $m^3$ | Cubic Meter |
| MG | Million Gallons |
| mm | Millimeter |
| MS4 | Municipal Separate Storm Sewer System |
| NJCCC | New Jersey Clean Communities Council |
| NPDES | National Pollutant Discharge Elimination System |
| NURP | National Urban Runoff Program |
| O&M | Operation and Maintenance |
| OCSWP | Orange County Storm Water Program |
| PAYT | Pay-As-You-Throw |
| PI/P | Public Information and Participation |
| PSA | Public Service Announcement |
| RTA | Rapid Trash Assessment |
| SCC | Santa Clara County |
| SCVURPPP | Santa Clara Valley Urban Runoff Pollutant Prevention Program |
| SCVWD | Santa Clara Valley Water District |
| sec | Second |
| SEPT | Side Entry Pit Trap |
| SFRWQCB | San Francisco Regional Water Quality Control Board or Water Board |
| SWRCB | State Water Resource Control Board |
| TMDL | Total Maximum Daily Load |
| TNRCC | Texas Natural Resources Conservation Commission |
| TSS | Total Suspended Solids |
| TxDOT | Texas Department of Transportation |
| µm | Micromete |
| UC | University of California |
| US | United States |
| USEPA | United States Environmental Protection Agency |
| VS | V-Screen |
| WSDE | Washington State Department of Ecology |
| WQV | Water Quality Volume |
| yr | Year |

# Glossary

**Baseline:** A defined line or standard by which effectiveness can be measured or compared.

**Best Management Practice (BMP):** Any activity, technology, process, operational method or measure, or engineered system, which when implemented prevents, controls, removes, or reduces pollution. A BMP is also referred to as a control measure.

**Best Management Practice System:** A BMP system includes any BMP and any related bypass or overflow.

**Bypass:** The intentional diversion of waste streams from any portion of a treatment (or pretreatment) facility.

**Conceptual Model:** A model that explicitly describes and graphically represents all existing knowledge on the sources of a pollutant, its fate and transport, and its effects in the ecosystem.

**Control Measure:** Any action that results in the reduction or prevention of stormwater pollution. Control measures include discontinuing the use of a pollutant-containing product, preventing the release of the product or the pollutant into runoff, and treating runoff containing the pollutant prior to its entering or leaving the stormwater drainage system.

**Discharge:** A release or flow of stormwater or other substance from a conveyance system or storage container.

**Effectiveness Assessment:** The process that is used to evaluate if BMPs or programs are resulting in desired outcomes.

**Effectiveness (with regard to treatment BMPs):** A measure of how well a BMP system meets its goals for all storm water flows reaching the BMP site, including flow bypasses.

**Full Capture Device:** A BMP that can trap all particles retained by a 5-mm screen, and has a treatment capacity that exceeds the peak flow rate resulting from a one-year, one-hour storm in the subdrainage area treated by the BMP.

**Gross Solids:** All materials, man made (i.e. trash or litter) and of natural origin, larger than 5 mm. Synonymous with gross pollutants.

**Illegal Dumping:** Act of improperly and illegally disposing of waste items, typically in large volumes, in the environment Illegal dumping primarily occurs to avoid disposal fees or the time, cost, and effort required for proper disposal of items that are not permitted in waste containers (furniture, appliances, hazardous materials, etc) at landfills or recycling facilities.

**Institutional Control:** The attempt to change civic behavior and institutional management or operations through government regulation/mandate, persuasion, and/or economic incentives. While some institutional BMPs involve physical devices (i.e. street sweeping), it is the optimization of the management of that device that forms an institutional BMP.

**Maximum Extent Practicable (MEP):** A standard for water quality that applies to all municipal separate storm sewer systems (MS4) regulated under the NPDES program. Since no precise definition of MEP exists, it allows for maximum flexibility on the part of MS4 operators as they develop and implement their programs. MEP may include management practices, control techniques and systems, design and engineering methods, and other provisions determined to control pollutants, as appropriate.

**Overflow:** To be filled beyond the design capacity of a BMP.

**Performance (with regard to treatment BMPs):** A measure of how well a treatment BMP meets its goals for storm water that flows through, or is processed by it.

**Pollutant:** A substance introduced into the environment that adversely affects or potentially affects the usefulness of a resource.

**Pollutant Load:** The mass of a pollutant discharged into or from a receiving water body.

**Receiving Waters:** Water bodies receiving discharges from municipal stormwater drainage systems.

**Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP):** An association of thirteen cities and towns in Santa Clara Valley, the County of Santa Clara and the Santa Clara Valley Water District that share a common permit to discharge stormwater to South San Francisco Bay.

**Source Control Measures:** Any schedules of activities, structural devices, prohibitions of practices, maintenance procedures, managerial practices or operational practices that aim to prevent stormwater pollution by reducing the potential for contamination at the source of pollution.

**Stormwater:** Runoff from roofs, roads and other surfaces that is generated during rainfall and snow events and flows into a stormwater drainage system.

**Stormwater Drainage System:** Any pipe, ditch or gully, or system of pipes, ditches, or gullies, that is owned or operated by a governmental entity and used for collecting and conveying stormwater.

**TMDL:** The calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources.

**Total Load:** Total amount of a given substance entering a water body during a given time (e.g., tons of trash per year).

**Trash:** Man-made litter in accordance with the California Code Section 68055.1(g). Litter means all improperly discarded waste material, including, but not limited to, convenience food, beverage, and other product packages or containers constructed of steel, aluminum, glass, paper, plastic, and other natural and synthetic materials, thrown or deposited on the lands and water. This definition excludes sediments, and it also excludes oil and grease, and exotic species. Litter can be understood to be any improperly disposed manmade items that cannot pass through a 5 mm mesh screen. Trash is synonymous with litter.

**Trash Disperal:** Inadvertent distribution of trash in the environment due to improper handling and transportation.

**Treatment Control:** Any engineered system designed to remove pollutants by simple gravity settling of particulate pollutants, filtration, biological uptake, media adsorption or any other physical, biological, or chemical process. Sometimes called a treatment measure, treatment control measure, or treatment control BMP. Proprietary treatment controls are manufactured devices that are engineered for specific applications or targeted constituents. Non-proprietary treatment controls are landscape-based measures that are more generic in applications and tend to be effective for a relatively wider range of constituents.

**Urban Runoff:** All flows in a stormwater drainage system and consists stormwater (wet weather flows) and non-storm water illicit discharges (dry weather flows).

**Watershed:** A defined area of land that catches rain and snow and drains or seeps into a marsh, stream, river, lake or groundwater.

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# Section 1. Introduction

Everyday, people in the San Francisco Bay area dispose of consumer items and waste materials including food and beverage containers (e.g., plastic bags and bottles), cigarette butts, food waste, construction and landscaping materials, furniture, electronics, tires and hazardous materials (e.g., paint, batteries). While many of these items are properly disposed of, large amounts of debris enters the environment as “trash”.

Once in water bodies, trash can adversely affect humans, fish and wildlife. Diapers, medical waste (e.g., used hypodermic needles and pipettes), and human or pet waste discarded in water bodies can threaten the health of people who use them for recreation. In addition, broken glass or sharp metal fragments in streams can cause puncture or laceration injuries. Small and large floatables can inhibit the growth of aquatic vegetation, decreasing spawning areas and habitats for fish and other living organisms. Wildlife living in creeks, rivers and riparian areas can be killed by ingesting or becoming entangled in floating trash (Laist and Liffmann, 2000). Trash that settles to the bottom of water bodies can be problematic for benthic communities and contribute to sediment contamination. Floating debris that is not trapped and/or removed will eventually end up on beaches or in the open ocean, repelling visitors from shoreline areas and degrading coastal waters. Marine mammals, turtles, birds, fish and crustaceans have been affected by entanglement in or ingestion of floatable debris (USEPA 2001).

## Potential Impacts to San Francisco Bay Area Creeks

Trash has been found at high levels at some sites within San Francisco Bay area watersheds, creeks and San Francisco Bay. Due to water quality impacts, it has become a concern to citizens, municipalities and water quality regulators. In response, the San Francisco Bay Regional Water Quality Control Board (Water Board) released the staff report entitled *Proposed Revisions to Section 303(d) List of Priorities for Development of Total Maximum Daily Loads for the San Francisco Bay Region* on November 14, 2001. The report preliminarily suggested that urban creeks, lakes and shorelines in the region are being impacted by trash (SFRWQCB 2001).

Within the staff report, municipalities covered under municipal stormwater NPDES permits were advised to assess receiving waters within their jurisdictions before the next 303(d) listing cycle (i.e., 2004) to determine the level of impacts caused by trash. The Water Board suggested that municipalities define trash problems in water bodies (“trash problem areas”); identify the sources of trash through monitoring or existing information; and develop a program of action to address the principle sources of trash.

## SCVURPPP Trash Management and Effectiveness Strategy

In response to the Water Board’s staff report, the Management Committee formed a Trash Ad Hoc Task Group (Trash AHTG) in February 2002. Subsequently, the Trash AHTG developed a multi-year work plan to address trash problem areas in urban creeks and waterways within the Santa Clara Basin. Following the Work Plan, Co-permittees conducted numerous surveys to assess the accumulation and impacts of trash in Santa Clara Valley creeks (i.e., Task 1). In concert, trash evaluations were conducted by Co-permittees to better understand the extent of existing trash management programs in the Santa Clara Valley (Task 2). Summaries of these efforts are provided on the SCVURPPP website (www.scvurppp.org).

In October 2006, SCVURPPP revised the Work Plan to include the Trash Management and Effectiveness Assessment Strategy (Trash Strategy), which includes the following tasks:

1) Assessing urban creeks for trash accumulation and impacts;
2) Evaluating current municipal trash management programs in the Santa Clara Valley;
3) Defining and identifying trash sources and pathways to urban creeks;
4) Identifying the planning level costs and effectiveness of trash best management practices (BMPs);
5) Developing and implementing of pilot implementation projects; and,
6) Measuring effectiveness over time.

To assist stormwater managers, municipal officials and other stakeholders in understanding what options are available for controlling and capturing trash within the storm drain conveyance system and the urban landscape, SCVURPPP created the Trash BMP Tool Box to focus on tasks three and four of the Trash Strategy. A simple conceptual model intended to better define potential trash sources and transport pathways to urban creeks, and the results of an extensive literature review of trash BMP effectiveness, costs and applicability are included.

As part of the Trash Strategy, future efforts will include the implementation of structural treatment controls as part of trash pilot demonstration projects, and the development and implementation of long-term trash management approaches for high-priority watersheds. This Trash BMP Tool Box is intended to assist Co-permittees in the development of these activities.

## Trash Tool Box Organization

The Trash BMP Tool Box is divided into the following four sections:

- **Section 1** - introduces the regulatory and environmental issues surrounding trash;
- **Section 2** - provides a conceptual model that defines potential trash sources and transport pathways to urban creeks. In addition, this section briefly describes what items are identified and collected during Rapid Trash Assessments[1] of San Francisco Bay area creeks;
- **Section 3** - provides an overview of the different categories of trash BMPs (e.g., treatment and institutional BMPs), where BMPs can be implemented within the urban environment, and a framework for understanding how to assess the effectiveness of BMPs; and
- **Section 4** - includes the technical information sheets which describe individual BMPs.

[1] Rapid Trash Assessments (RTA) are conducted to qualitatively assess trash conditions in wadeable creeks. The first RTA Protocol was developed by the San Francisco Bay Regional Quality Control Board (Water Board). In FY 2005-2006, the RTA was refined to better evaluate conditions of trash-impacted sites in urban creeks, as opposed to the Water Board's RTA which addressed both rural and urban creeks. The refined protocol is named the "Urban RTA".

# Section 2. Trash Sources and Pathways to Urban Creeks

At the core, people are the source of all trash in urban creeks and San Francisco Bay. However, similar to other stormwater pollutants, more specific sources and associated transport processes must be identified to allow the implementation of effective management actions. SCVURPPP recently developed a simple conceptual model (Figure 2-1) to better define potential sources of trash found in, and transport processes to urban creeks. Source and pathway categories described are based on urban creek trash assessments conducted in Santa Clara County and local agency staff knowledge of how trash is deposited and transported to local waterways.

Defining source and pathway categories will assist SCVURPPP in:

- Developing consistent terminology for effective communication between Co-permittees, regulatory agencies and other stakeholders;
- Continuing to build conceptual understanding of trash source types present in watersheds and how these sources enter creeks and waterways; and,
- Determining the most optimal and cost effective control points to implement institutional and/or treatment controls.

The following section summarizes SCVURPPP's conceptual understanding of potential trash sources and pathways to urban creeks and provides definitions of key terms used throughout the Trash BMP Tool Box. In addition, information on the types of trash items typically found in creeks is also provided.

## Defining Core Concepts

The following are key terms relevant in understanding trash sources and pathways:

Trash - Man-made litter in accordance with the California Code Section 68055.1(g) (CA State 2007). Litter means all improperly discarded waste material, including, but not limited to, convenience food, beverage, and other product packages or containers constructed of steel, aluminum, glass, paper, plastic, and other natural and synthetic materials, thrown or deposited on the lands and water. This definition excludes sediments, oil and grease and exotic species.

Illegal Dumping – The act of improperly and illegally disposing of waste items, typically in large in volume, in the environment. Illegal dumping occurs in rural or urban settings and primarily happens to avoid disposal fees or the time, cost, and effort required for properly disposing large items (i.e., furniture, appliances) and/or hazardous materials. In addition, large volumes of trash can be illegally dumped or discarded by illegal encampments near or within riparian areas. Direct dumping of grass clippings or other yard wastes are included in this category.

Trash Dispersal - Inadvertent distribution of trash into the environment due to improper containment during handling or transportation.

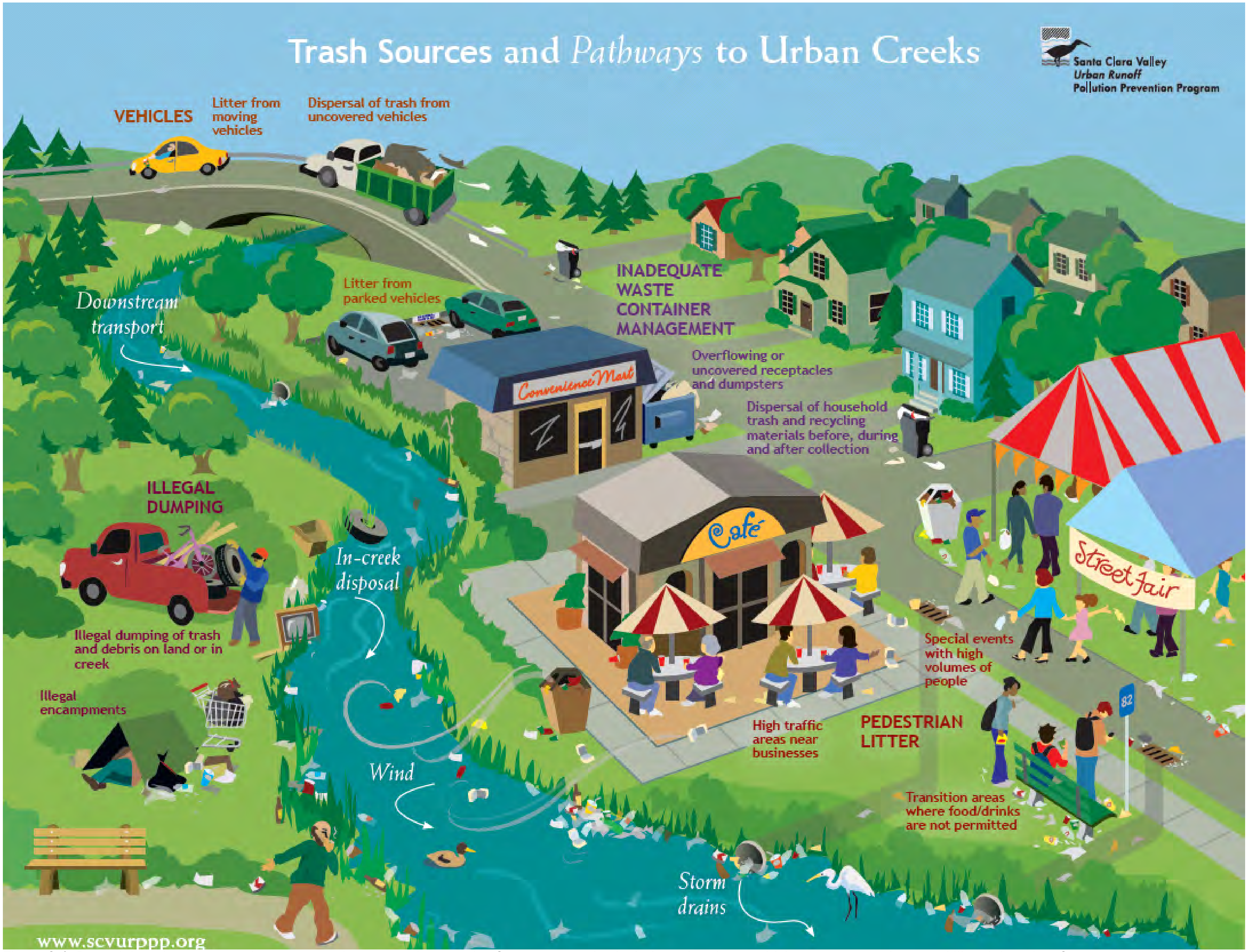


Figure 2-1. Potential trash sources and transport pathways to urban creeks. Source categories include pedestrians, vehicles, waste containers and illegal dumping. Stormwater conveyance systems, wind, direct disposal and downstream transport are transport pathways.

## Trash Sources to Urban Creeks

The conceptual model identifies four distinct source categories for trash to urban creeks:

1. Pedestrians;
2. Vehicles;
3. Inadequate Waste Container Management; and
4. Illegal Dumping.

A definition of each source category and examples of associated sources are provided below. Figure 2-1 illustrates examples of trash sources to urban creeks.

### 1. Pedestrians

Pedestrians who lack the willingness to properly dispose of waste or do not have access to waste containers are likely the greatest source of trash in local water bodies. Land areas where pedestrians litter typically include high foot traffic locations (e.g., shopping plazas, convenience stores, parks), transition points (e.g., bus stops, train stations, entrance to public buildings), and special event venues (e.g., concerts, sporting events and fairs). Pedestrians are generally considered a chronic source of trash to urban creeks.

### 2. Vehicles

Drivers and passengers who litter from vehicles or do not adequately cover their vehicles when transporting trash and debris are also sources. Land areas that may generate trash from vehicles include roads, highways (on/off ramps, shoulders or median strips) and parking lots. Similar to pedestrian litter, vehicles are considered a chronic source of trash.

### 3. Inadequate Waste Container Management

Waste containers (e.g., trash receptacles, recycling bins and dumpsters) may become sources of trash if not managed appropriately. Trash receptacles or dumpsters that are overflowing and/or uncovered can deposit trash on the landscape, allowing transport to storm drains, creeks and other waterways. In addition, improper storage, handling and transport of trash and recycling materials during curbside collection (e.g., residential and commercial areas) can allow trash to be deposited on the land. Inadequate waste container management is a chronic trash source to creeks.

### 4. Illegal Dumping

Illegal dumping can occur on land or directly into a waterway within specific areas throughout a watershed. In most instances, illegal dump sites attract further dumping as the volume of trash increases at a site. This source includes trash illegally dumped or discarded by illegal encampments near or within riparian areas. Illegal dumping typically occurs sporadically and usually consists of large items (e.g., furniture, appliances and tires) compared to other source categories.

## Trash Pathways to Urban Creeks

Trash from source categories can potentially enter urban creeks by four major transport pathways:

A. Stormwater Conveyance Systems;
B. Wind Transport;
C. Direct Disposal into a Creek; and,

D. Downstream Transport.

A description of each transport pathway is included above. Figure 2-1 provides an illustration of transport pathways.

### A. Stormwater Conveyance System

Stormwater conveyance systems can transport trash to waterways from any combination of the four source categories during storm events and dry weather flows. Small and floatable trash items are particularly susceptible to transport through this pathway. Typically, the greater the discharge of runoff and frequency of storm events, the more likely trash will be transported through stormwater conveyance systems to urban creeks.

### B. Wind Transport

Trash can be transported to a waterway by wind, especially when a trash source is located in adjacent land uses with minimal riparian vegetation and obstructions (e.g., fences). Wind can also transport trash over land to the stormwater conveyance system and road crossings over creeks.

### C. Direct Disposal

Trash can enter waterways when directly disposed within the stream channel or on its banks. Illegal dumping and pedestrian litter are the two most prevalent trash source categories applicable to this pathway. Typical trash items associated with illegal dumping into waterways include: construction and landscaping materials, furniture, electronics, tires, and hazardous materials (e.g., paint, batteries). Typical trash items associated with the direct deposition of pedestrian litter into waterways include: beverage containers, food waste and cigarette butts. Easy access to creeks facilitates the direct disposal of trash.

### D. Downstream Transport

Trash that enters the creek from any of the above pathways can be transported and/or deposited to downstream locations. The amount of trash deposited in a creek can vary by site, depending on channel gradient, stream velocity and density of stream/riparian vegetation. Trash items within creeks may be transported to larger downstream waterbodies (e.g., wetlands, bays and estuaries), where additional influences (e.g., tides, currents and wind) affect distribution.

## Trash Characterization

Trash items found in the environment include food and beverage containers (e.g., plastic bags and bottles), cigarette butts, food waste, construction and landscaping materials, furniture, electronics, tires and hazardous materials (e.g., paint, batteries). The relative portion of different trash items can vary depending on surrounding land-use (Armitage and Rooseboom 2000) and the unit of measurement (volume, weight, or count). Typically, by mass or volume, paper and plastic products are the greatest constituents of litter (Allison et al 1997, Lewis 2002). By count, the most numerous items identified and collected during Rapid Trash Assessments in San Francisco Bay Area creeks were made of plastic (e.g., bottles and bags) (Figure 2-2). Materials and items made of paper/cardboard, glass and metal were also frequently found. Plastic bottles, bags and styrofoam pellets were the single most common and abundant types of trash surveyed and removed (SCVURPPP 2007, SFBRWQCB 2007).

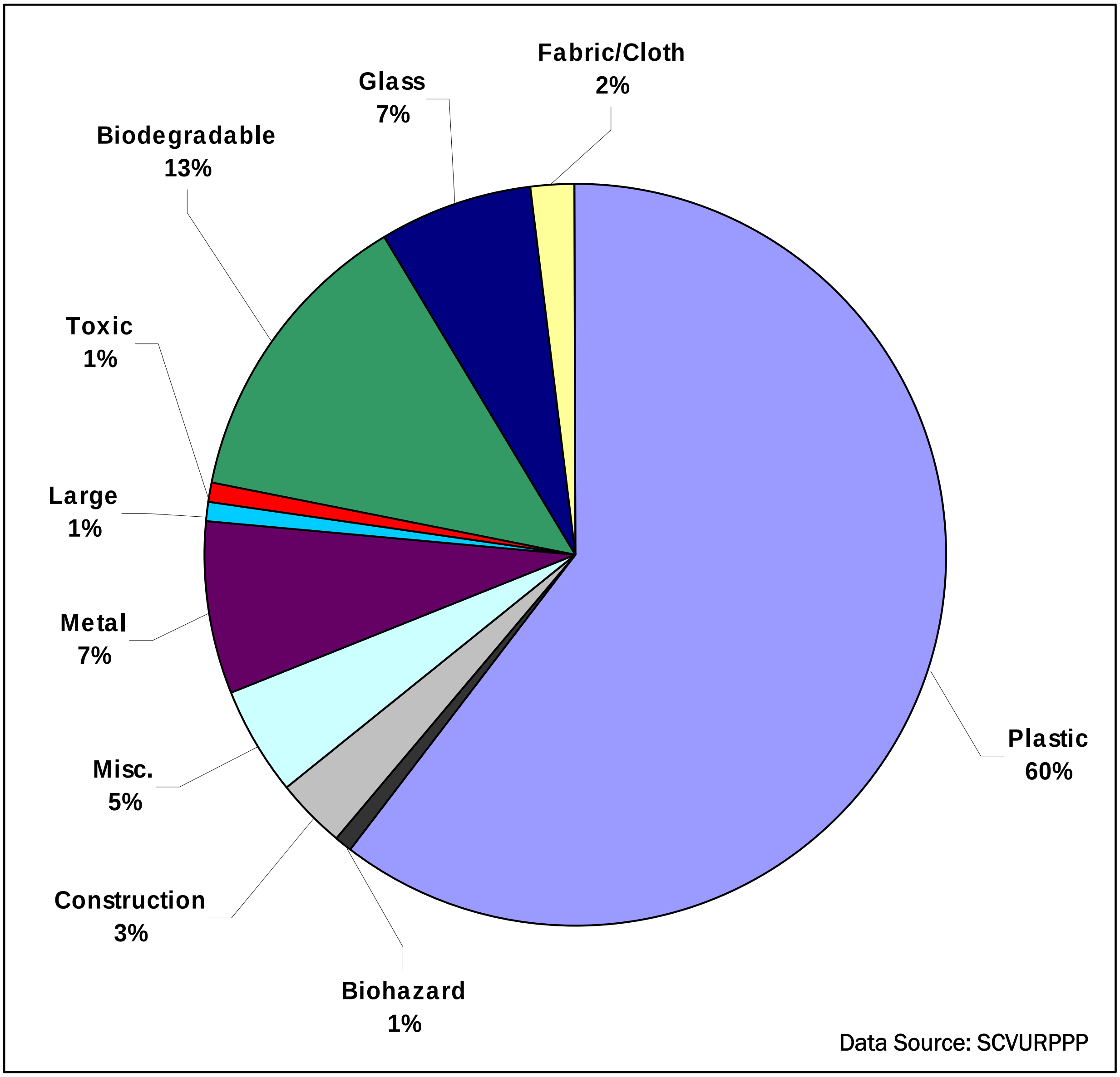


Figure 2-2. Proportion of Trash Pieces, by Category , Observed during Rapid Trash Assessments of San Francisco Bay Creeks (SCVURPPP 2007).

# Section 3. Best Management Practices for Trash Control

There is no single BMP capable of eliminating all trash that accumulates in urban creeks. To achieve a long-term and sustained reduction in the amount of trash entering creeks, stormwater managers will need to develop an integrated, watershed scale strategy that includes the implementation of a combination of institutional BMPs (e.g., source controls and pollution prevention activities) and treatment BMPs (e.g., catch basin inserts). The following section briefly describes the types and applicability of trash BMPs relative to sources and pathways defined in Section 2. In addition, applicable types of effectiveness assessments and cost planning level information are discussed.

## BMP Implementation Points

As described in Section 2, trash enters creeks from a variety of sources and transport pathways. Trash BMPs may be implemented to reduce the source itself (e.g., public education and outreach) or capture trash at a specific point along a transport pathway. The range of implementation points at which BMPs may be implemented include:

- Institutional approaches implemented **on the street**, or within the watershed;
- BMPs placed at the start of the stormwater conveyance system (**start of pipe**);
- BMPs implemented within the system (**in the pipe**);
- BMPs implemented at the **end of the pipe**;
- BMPs that capture/retain trash **in the creek**; and,
- **Dispersed** BMPs (i.e., controls that are not specific to one part of the storm drain system, but are applied throughout a watershed).

Figure 3-1 illustrates the types of BMPs that may be implemented at the various implementation points. Table 3-1 identifies the applicability of specific BMPs to trash sources and transport pathways. Some BMPs have multiple configurations that allow them to be implemented at several implementation points, while others are restricted to one or two.

## Institutional BMPs

Historically, Bay area cities and counties have managed trash in watersheds and creeks using a variety of institutional (non-treatment) BMPs. For example, street sweeping is conducted throughout the Santa Clara Basin to remove trash from road surfaces and gutters in urbanized areas. Street sweeping is typically conducted anywhere from one to four times a month, depending on the city and land use. Over many years, cities have learned where trash is consistently deposited in streets and have adjusted street sweeping frequencies accordingly.

Creek cleanup events are also periodically scheduled by cities and watershed groups to remove trash from water bodies. Like street sweeping, cleanup events focus on trash already in watersheds and water bodies, as opposed to preventing trash from being improperly disposed of. Since September 1998, SCVURPPP has financially supported at least one of the two major volunteer creek clean-ups in Santa Clara County each year. These major clean-ups, National River Cleanup Day and Coastal Cleanup Day are conducted every May and September, respectively. This effort has helped protect beneficial uses in urban creeks over the years. Since 1998, 412 urban creek, river and shoreline sites have been cleaned and approximately 503,900 pounds of trash and recyclables have been removed (SCVURPPP 2007). Public outreach efforts have been successful with approximately 15,700 volunteers participating in creek clean-ups.

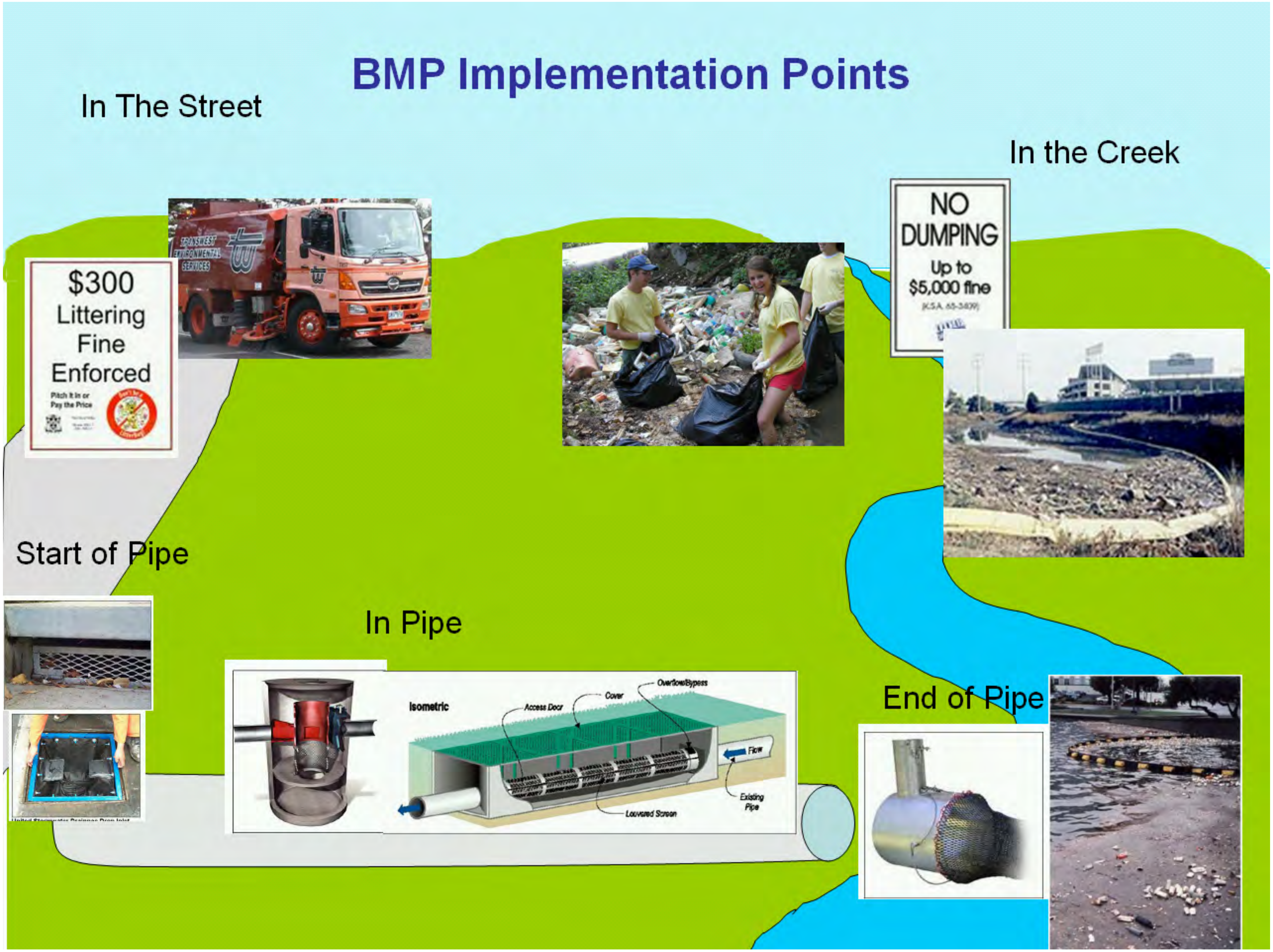


Figure 3-1. Implementation Points for Trash Best Management Practices (BMPs).

Table 3-1. BMP Implementation Points, Applicable Sources and Applicable Pathways.

| BMP Category | Implementation Points | | | | | | Applicable Sources | Applicable Pathways |
|---|---|---|---|---|---|---|---|---|
| | In street | Start of Pipe | In Pipe | End of Pipe | In Creek | Dispersed | | |
| **Treatment BMPs** | | | | | | | | |
| Catch Basin Inserts | | ✓ | | | | | P, V, WC, ID | SC, W |
| Netting Devices | | | ✓ | ✓ | | | P, V, WC, ID | SC, W |
| Hydrodynamic Separators | | | ✓ | ✓ | | | P, V, WC, ID | SC, W |
| Racks & Screens | | ✓ | ✓ | ✓ | | | P, V, WC, ID | SC, W |
| Litter Booms | | | | ✓ | ✓ | | P, V, WC, ID | SC, W, DT |
| **Institutional BMPs** | | | | | | | | |
| Enhanced Street Sweeping | ✓ | | | | | | P, V, WC | W |
| Storm Drain Signage/Marking | ✓ | ✓ | | | | | P, V | SC |
| Education & Outreach | | | | | | ✓ | P, V, WC, ID | SC, W, DD, DT |
| Volunteer Cleanup Efforts | | | | | | ✓ | P, V, WC, ID | SC, W, DD, DT |
| Improved Trash Bin Management | ✓ | | | | | | P, WC, ID | SC, W, DD |
| Enforcement | | | | | | ✓ | P, V, WC, ID | SC, W, DD, DT |
| Fees, Bans, Regulations | | | | | | ✓ | P, V, WC, ID | SC, W, DD, DT |

Sources: P = Pedestrians, V = Vehicles; WC = Inadequate Waste Container Management; and ID = Illegal Dumping. Pathways: SC = Stormwater Conveyance Systems; W = Wind Transport; DD = Direct Disposal; DT = Downstream Transport.

To assist in preventing trash in creeks, public education campaigns have also been historically used to educate citizens about trash impacts on the environment. Who can forget "Woodsy Owl" or the "Crying Native American" as icons of watershed stewardship. The "Don't Trash California" campaign developed by Caltrans is a recent example of efforts attempting to get the attention of citizens. The Bay Area Stormwater Management Agencies Association (BASMAA) has also recently agreed to focus on trash in its next regional advertising campaign.

Other institutional control measures include enhancing public ordinances which focus on assessing fees to businesses that distribute or sell items frequently found in creeks. In addition, several Bay area cities (i.e., Berkeley, Oakland and San Francisco) have legislated bans on the use of non-biodegradable materials (polysterene and non-recycled plastic) in commercial food packaging (City of San Francisco 2007; Zamora 2006). The Cities of San Francisco and Oakland have also banned the distribution of plastic bags in major grocery stores and pharmacies (MacDonald, H. 2007).

## Treatment BMPs

Stormwater treatment BMPs are physical devices that are installed at stormwater catch basins, within the stormwater conveyance system, at an outfall to a creek, or within a water body. Stormwater treatment controls for trash typically block, separate or catch items transported through this pathway. Common types of trash treatment BMPs include catch basin inserts, hydrodynamic separators and outfall netting devices.

Treatment BMPs for trash can be applied at nearly all points within the stormwater conveyance system before or after it discharges to a water body. For example, screens and racks can be used at the start of the stormwater conveyance system (i.e., storm drain) to intercept trash. Catch basin inserts are placed inside an inlet or at the outlet of a catch basin. Hydrodynamic (vortex) separators can be placed in-line to collect trash. Netting devices can be placed at the end of pipes, while litter booms are placed in water bodies to corral trash already present in creeks and rivers.

Many of these types of stormwater treatment BMPs have been recently piloted by Los Angeles County as part of the Total Maximum Daily Load (TMDL) for trash within the Los Angeles River watershed. Based on design and effectiveness considerations, the Los Angeles Regional Water Quality Control Board (LARWQCB) may designate a trash treatment control as "full-capture" (~100% removal). These devices trap all particles retained by a 5-mm screen, and have a demonstrated treatment capacity that exceeds the peak flow rate resulting from a one-year, one-hour storm in the subdrainage area (LARWQCB 2006b). As of August 1, 2007, five full-capture certification requests have been approved by the LARWQCB. They include the following BMPs which have the following configurations:

1. Catch basin inserts developed by the City of Glendale, a combination of brush and aluminum mesh;
2. Vertical and horizontal trash capture screen inserts developed by Advanced Solutions, installed within catch basins;
3. End-of-pipe trash nets developed by Fresh Creek Technologies, Inc;
4. Linear radial gross solids removal device configuration 1 (LR1 I-10) developed by Caltrans; and,
5. Inclined screen gross solids removal device configuration 1 (IS1 SR-170) developed by Caltrans.

## Assessing BMP Effectiveness

Stormwater managers can gauge the effectiveness of BMP implementation at a variety of outcome levels. The California Stormwater Quality Association (CASQA 2007) expresses these levels in terms of four programmatic and two environmental outcomes (Figure 3-2). These outcome levels represent a hierarchy of increasing measurement effort and usefulness. While the ultimate goal for any BMP is to improve the quality of water bodies which receive stormwater, it can be very difficult to show the linkages between BMP implementation and a level 6 outcome (i.e., changes in receiving water quality) due to temporal and spatial variability in water quality parameters. Therefore, the outcome level selected to measure the effectiveness of a single or combination of BMPs is typically dependent on the BMP and the level of change that the BMP (or combination of BMPs) is expected to make in water quality.

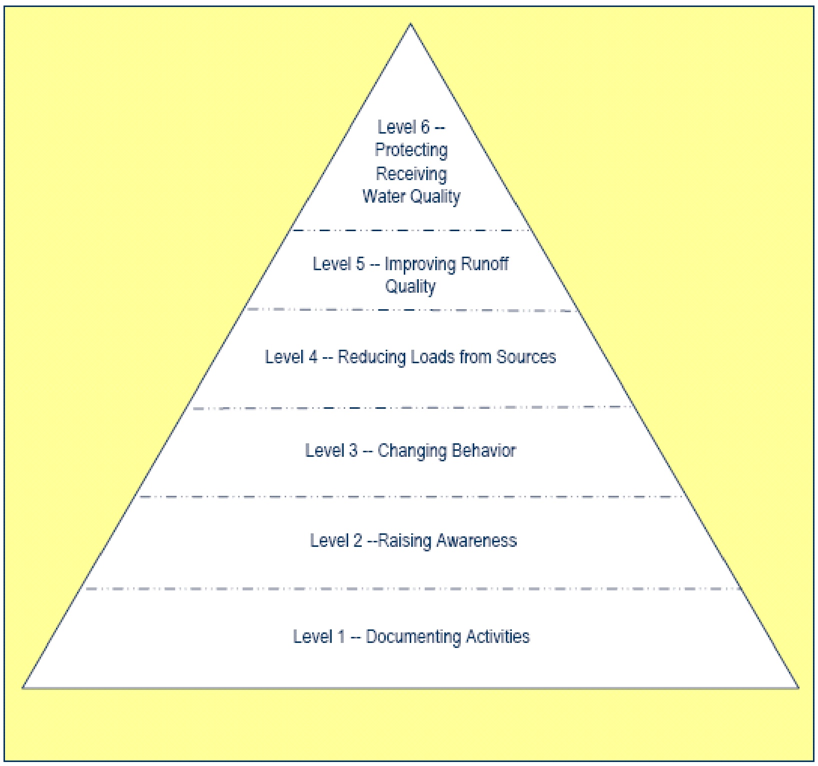


Figure 3-2. Effectiveness Assessment Outcomes for Stormwater Programs (CASQA 2007).

For BMPs designed to reduced or prevent trash from entering water bodies, assessments can be conducted at various outcome levels, depending on the type of BMP implemented. For example, all BMPs can be assessed at outcome level one (documenting activities). Assessments conducted at levels two (raising awareness) and three (changing behavior), are typically used to evaluate the effectiveness of institutional BMPs (e.g., public education and outreach campaigns). Level four outcomes (reducing loads from sources) have been used to estimate loads reduced by institutional controls (i.e., street sweeping and stormwater conveyance system maintenance), while effectiveness of treatment BMPs are typically assessed using level five outcomes (improvements in runoff quality). Due to the large land areas where multiple trash sources and pathways occur, level six outcomes (changes in receiving water quality) are typically used to assess the effectiveness of overall stormwater management strategies and programs overtime, as opposed to individual BMPs. An

Urban Creek Rapid Trash Assessment is an example of a method that can be used to assess effectiveness at a level six outcome.

Table 3-2. BMP Implementation Points, Applicable Sources and Applicable Pathways.

| BMP Category | Most Applicable Effectiveness Assessment Outcome Levels | | | | | |
|---|---|---|---|---|---|---|
| | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 | Level 6 |
| | Documenting Activities | Raising Awareness | Changing Behavior | Reducing Loads from Sources | Improving Runoff Quality | Protecting Receiving Water Quality |
| **Treatment BMPs** | | | | | | |
| Racks & Screens | ✓ | | | | ✓ | |
| Hydrodynamic Separators | ✓ | | | | ✓ | |
| Litter Booms | ✓ | | | | | ✓ |
| Catch Basin Inserts | ✓ | | | | ✓ | |
| Netting Devices | ✓ | | | | ✓ | |
| **Institutional BMPs** | | | | | | |
| Street Sweeping | ✓ | | | ✓ | | |
| Trash Receptacle Management | ✓ | | | ✓ | | |
| Education & Outreach | ✓ | ✓ | ✓ | | | |
| Storm Drain Stenciling/Marking | ✓ | ✓ | ✓ | | | |
| Enforcement | ✓ | ✓ | ✓ | | | |
| Volunteer Cleanup Efforts | ✓ | | | ✓ | | |
| Fees, Bans, Regulations | ✓ | | ✓ | | | |

# Section 4. Technical Information Sheets

To better understand the best possible controls and institutional approaches designed to prevent trash from entering local waterways, SCVURPPP conducted a review of literature from government, academic and commercial entities. The information was bolstered by discussions with municipal employees that operate and maintain trash control measures and with representatives who sell trash control devices. The results of the literature review are presented in twelve technical information sheets provided in this section. The type of information provided within each sheet includes the following:

## Treatment BMPs for Trash

Technical information sheets were developed for the following five categories of structural treatment control devices:

- Catch Basin Inserts;
- Netting Devices;
- Hydrodynamic Separators;
- Racks and Screens; and
- Litter Booms.

Each technical information sheet provides information related to each of the following categories, where available:

- Description/Design;
- Applicability/Siting requirements;
- Demonstrated performance and/or effectiveness;
- Maintenance requirements;
- Predicted or known costs (capital and operation and maintenance); and,
- A brief overview of reported advantages and disadvantages.

## Institutional Controls for Trash

The technical information sheets on institutional controls provide a broad overview of various practices/strategies that have been used to prevent trash from entering, or used to remove trash from water bodies. Sheets were developed for the following seven institutional controls:

- Enhanced Street Sweeping;
- Storm Drain Signage/Marking;
- Education and Outreach;
- Volunteer Cleanup Efforts;
- Improved Trash Bin/Container Management;
- Anti-littering/Dumping Enforcement; and,
- Source Control through Official Bans/Prohibitions and Legislation.

Each technical information sheet provides information related to each of the following categories, where available:

- Description/Design;
- Performance and/or effectiveness;
- Predicted or known costs (capital and operation and maintenance); and,
- A brief overview of reported advantages and disadvantages.

These sheets are intended to assist stormwater managers, municipal officials and other stakeholders in understanding what options are available for controlling and capturing trash within the storm drain conveyance system and the urban landscape. The sheets are ***not*** intended to provide specific recommendations on a particular BMP for controlling trash in urban runoff. Decisions regarding the implementation of site-specific BMPs must be based on local characteristics, conditions and available resources; and made by the appropriate decision-maker within individual jurisdictions.

Santa Clara Valley
*Urban Runoff*
Pollution Prevention Program

# Catch Basin Inserts

Stormtek™ catch basin insert (courtesy of Advanced Solutions).


## Summary

Catch basin inserts are baskets, trays, bags, or screens placed inside the inlet or at the outlet of a catch basin. A wide variety of designs exist, mostly in the form of inlet devices. Maintenance is performed with a vacuum truck and takes approximately 30 to 60 minutes/insert. Capital costs range from ~$200 to ~$6500/unit. Performance and/or effectiveness have not been widely tested in the field. However, a few studies have found that inserts can capture a high proportion of trash and litter if the devices are placed in all catch basins. In practice, inserts are not maintained with sufficient frequency. In addition, flooding has been an issue with some types of inserts. The City of Glendale Trash Excluder and Advanced Solutions StormTek™ catch basin insert have been designated as full capture devices by the Los Angeles Regional Water Quality Control Board (LARWQCB).


## Description

Catch basin inserts (CBIs) are devices that are placed inside a catch basin to prevent sediment, organic material (e.g. leaves and twigs), trash and litter from entering the storm drain pipe within the catch basin. There are two general designs of CBIs, inlet inserts and outlet inserts.

### Inlet Inserts

Inlet inserts consist of a collection basket, tray, or bag that is placed just below the entrance [at the curb or in a drop inlet] of the drain inlet. They are attached to the side walls of the catch basin. Some products consist of more than one tray or mesh grates. This type of insert also has the option to incorporate additional filters or fabric to capture finer sediment or oil. In those that have two trays, the top tray serves as an initial sediment trap with the underlying trays consisting of media

## TC-1 Treatment Control

### Catch Basin Inlet Insert Examples

- Abtech Ultra -Urban Filter
- BioClean
- City of Glendale Trash Excluder
- Clearwater Curb Inlet Insert
- Enviropod™
- Ecosol™
- Fossil Filter™
- Kristar FloGard Plus™ Catch Basin Insert
- SIFT™
- StreamGuard™
- United Stormwater Drainpac Curb or Drop Inlet Filter

### Catch Basin Outlet Insert Examples

- Debris Dam
- Practical Technology Catch Basin Insert
- SNOUT™
- Stormtek™

### Implementation Point

In Street
Start of Pipe ✓
In Pipe
End of Pipe
In Creek
Dispersed

filters (Gordon and Zamist 2006). An access lid above the basket is used for maintenance and inspection. In models using bags, the fabric bag is placed around the perimeter of the grate. Runoff passes through the bag before discharging into the drain outlet pipe. Inlet inserts are installed with space between the insert and the back wall of the catch basin. This provides a flow path for high flows. During high flows or when the basket pores are blocked, water is discharged over the rear of the basket.

Inlet inserts are designed in various shapes and configurations, but only use a fraction of the total volume of the catch basin. They fall into one of four different groups: socks, boxes, trays, and screens (Gordon and Zamist 2006). Some examples include:

- Abtech Ultra -Urban Filter
- BioClean
- City of Glendale Trash Excluder
- Clearwater Curb Inlet Insert
- Enviropod™
- Ecosol™
- Fossil Filter™
- Kristar FloGard Plus™ Catch Basin Insert
- SIFT™
- StreamGuard™
- United Stormwater Drainpac Curb or Drop Inlet Filter

**Figure 1. United Storm Water Drainpac Curb Inlet (courtesy of United Storm Water, Inc.).**

## Outlet Inserts

Outlet inserts consist of either a perforated metal screen placed horizontally or vertically in front of, or above, the storm drain pipe outlet within a catch basin or they can be a plastic or metal hood placed in front of the outlet pipe (USEPA 1999). Outlet inserts are capable of catching smaller and larger debris and maximize the existing catch basin volume (Gordon and Zamist 2006). When stormwater flows into the drain, the inserts will typically retain any objects greater than the mesh size (typically >5mm). Inlet inserts only use a small portion of the total volume of the basin, while the outlet inserts use the whole volume of the basin. The material remains until it is removed by a maintenance crew. As a result, they can hold more trash for a longer period of time. Some examples include:

- Debris Dam
- Practical Technology Catch Basin Insert
- SNOUT™
- StormTek™

**Figure 2. SNOUT™ (courtesy of Best Management Products, Inc.).**

## Applicability/Siting

Catch basin inserts can be designed to be installed in any catch basin located within parking lots, alleys, roadways and sidewalk curbs; and typically service a catchment area of 0.1 to 1 ha (0.247 ac to 2.47 ac) (Allison et al 1998). Inserts designed for curb opening basins are best suited for capturing larger debris (e.g., water bottles and plastics bags), as the opening under the curb may range from four to eight inches (Gordon and Zamist 2006).

## Performance and/or Effectiveness

### Inlet Inserts

In general, few studies have specifically tested the performance and/or effectiveness of inlet inserts for pollutant removal. Even fewer have tested the performance and/or effectiveness with respect to trash capture. However, the studies that have been performed have noted some consistent observations.

One study conducted by the University of Hawaii indicated that Flogard™ inlet inserts capture one to five gallons of trash in five months (DeCarlo et al 2004). Other studies have noted that the inlet inserts can have major problems with flooding and re-suspension of fine particles (White and Pezzaniti 2002, Caltrans 2004, Lee et al 2006).

Figure 3. Enviropod™ (courtesy of Stormwater360).

The University of South Australia's Urban Water Resources Centre conducted an evaluation of the hydraulic functioning of selected inlet inserts, including an Enviropod™. Evaluations were conducted in a full-sized road testing facility with a standard litter sample. Researchers found that flow and grade of the street had an impact on insert performance. For example, during tests, researchers noted that plastic sheeting on both the front and back sides of the basket failed when subjected to high flows (>100L/sec). The grade of the street also had an impact on its ability to capture trash. At a 12% grade, litter was trapped in the overflow outlet (White and Pezzaniti 2002). In an another study conducted by the University of Southern California, the Enviropod™ (and another device, the Bioclean™) caused flooding under flow rates of 632 gallons per minute (Lee et al 2006).

The most thorough analyses of inlet insert performance and/or effectiveness comes from two Australian studies (Lewis 2002 and Allison et al 1998). Lewis (2002) conducted a study to determine the effectiveness of litter trapping devices (Ecosol™ and Net Tech GPI/netting) on the removal of used syringes from stormwater systems in Melbourne, Australia. Forty Ecosol™ drain inlet inserts were installed in two port cities and each catch basin was further modified with a monitoring net. While Lewis (2002) documented the collection of all litter, the study sites were chosen because they are considered syringe hot spots and not necessarily general trash hot spots[1]. To assess effectiveness, the contents of individual units and every monitoring net were weighed and volume estimates were made. Captured material was sorted into categories. Each category was weighed and volumes were estimated. Ecosol™ units were cleaned out four times over five months at intervals of four to six weeks (manufacturer's recommended interval). Total load is the sum of litter and organic matter (vegetation and sediment). .

Figure 4. Ecosol RSF 100 (courtesy of Ecosol).

Lewis (2002) found that the Ecosol™ inserts trapped between 65% - 81% of litter by mass (Figures 5 & 6). The two sites showed considerable differences in their effectiveness. The author attributes this difference to the fact that traps in St. Kilda were comparatively smaller than those in Frankston, but were servicing more gutter length (one pit/95m in St Kilda versus one pit/41 m in Frankston). As a result, traps in St. Kilda received a considerably higher pollutant loading than the inserts in Frankston (six times the loading). On average, the inserts captured 61% of trash and debris by mass and 65% by volume. The findings of Lewis (2002) underscore the fact that insert density can impact effectiveness (Figure 7).

Lewis (2002) found that a number of other factors influenced effectiveness. Catch basins that have inlet inserts need to have a sufficient depth and area to accommodate inserts with adequate storage capacity. Shallow catch basins with long upstream drain length led to flooding. Minor flooding occurred when the region recorded its third consecutive day of rainfall totals that exceeded 25mm (1 inch). The design of the units was also noted to contrib-

[1] Other siting factors include safe access to the drains. The drains also had to be of sufficient size to accommodate the installation of additional monitoring nets.

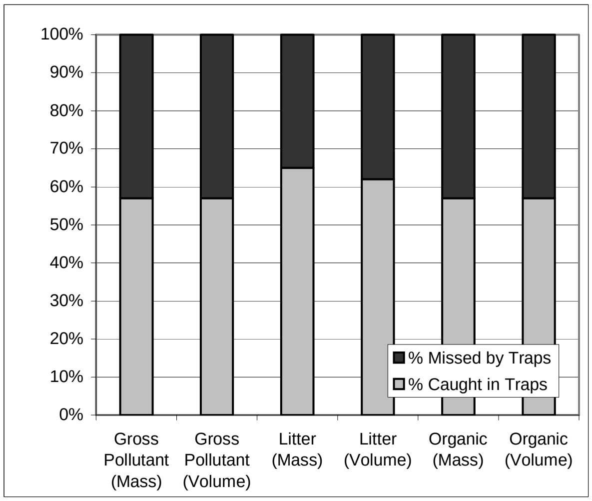


**Figure 5. Effectiveness of Ecosol™ traps installed in the St. Kilda sites (Lewis 2002).**

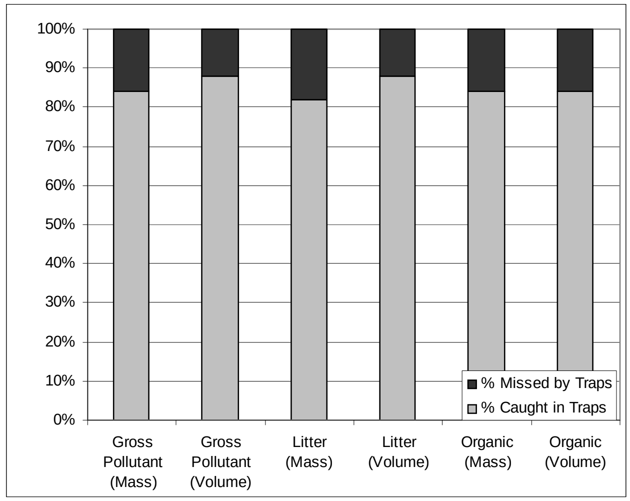


**Figure 6. Effectiveness of Ecosol™ traps installed in Frankston sites (Lewis 2002).**

ute to bypass problems. The Ecosol™ trap relies on the sides of the basin to act as the side walls of the trap. This was identified as a major escape route for gross pollutants entering the traps. At the time of the study, the design included a mesh lip that connected the base of the device to a height of 3 cm up the drain wall. This design element also caused maintenance issues because the mesh netting became loose over time, and would get sucked into the vacuum trucks used to clean the device (and may, over time, tear and further decrease efficiency) (Lewis 2002).

Allison et al (1998) studied the effectiveness of Side Entry Pit Traps (the Australian term for catch basin inserts) installed in an urban watershed in Victoria, Australia. SEPTs were installed in all public entrances in a catchment area that is ~50 hectares (123.5 ac) (35% commercial, 65% residential) with 192 road entrances to the drainage system (Allison et al 1998). The study design also included a Continuous Deflection Separation (CDS™)[2] unit downstream of all SEPTs to help measure the effectiveness of the SEPTs.

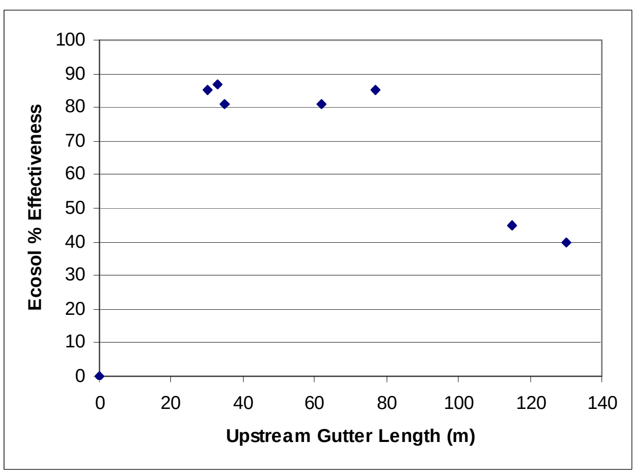


**Figure 7. Trap effectiveness in relation to trap density (Lewis 2002).**

Effectiveness was calculated by comparing the dry mass collected by the SEPTs with the sum of this mass and the mass of material collected in the downstream CDS™ unit over the same period (Table 1). It should be noted that although SEPTs were installed at all public drain inlets, they were not installed at private ones. Therefore, it is not possible to fully attribute all the material captured by the downstream CDS™ to material lost by one or more SEPTs. Observations made at the various SEPTs suggest that bypassing the devices did occur but the proportion of loss is unknown (Allison et al 1998).

Allison et al (1998) concluded that inserts can capture up to 80 – 85% of the total amount of litter loaded to the whole drainage system, but only if inserts are installed in all catch basins. Their study noted that the total amount of trash retained by inserts within a drainage network will vary according to the number of inserts installed and their locations. Allison et al (1998) used data from the Cobourg experiment to demonstrate this point. Figure 4

[2] Continuous Deflection Separators (CDS™) are a proprietary form of hydrodynamic separator. They are capable of capturing close to 100% of material greater than 5mm. In the context of effectiveness tests, they are a useful measure of effectiveness of upstream devices.

Table 1. Effectiveness of SEPTs. *Upper limit estimate due to small hole in CDS™ device (Allison et al 1998).

| Cleaning Date | Days between cleaning | Rainfall | Runoff | Total dry mass (CDS+ SEPTs) | % caught SEPTs | % caught SEPT | % caught SEPT |
|---|---|---|---|---|---|---|---|
| | | mm | mm | Dry kg | Human derived | Organics | Total load |
| 29-Aug-96 | 27 | 57 | 18 | 111 | 78 | 59 | 66 |
| 30-Sep-96 | 32 | 60 | 24 | 366 | 83* | 72* | 75* |
| 15-Oct-96 | 15 | 15 | 7 | 206 | 85* | 69* | 71* |
| 15-Nov-96 | 31 | 31 | 17 | 285 | 73 | 59 | 62 |

shows a plot of the cumulative percentage of captured load (y-axis) versus the cumulative percentage of inserts (x-axis). Inserts on the x-axis are ranked (highest to lowest) by how much material was captured. Results indicated that if inserts are installed within 60% of the catch basins in a drainage network, approximately 70% of the total litter load (including bypass) can be captured (Figure 8). Data provided within Figure 8 is from the first experimental clean-out. Data from subsequent clean-outs indicated that the same inserts continued to capture the highest loads. This indicates that the siting of inserts can have an impact on overall effectiveness.

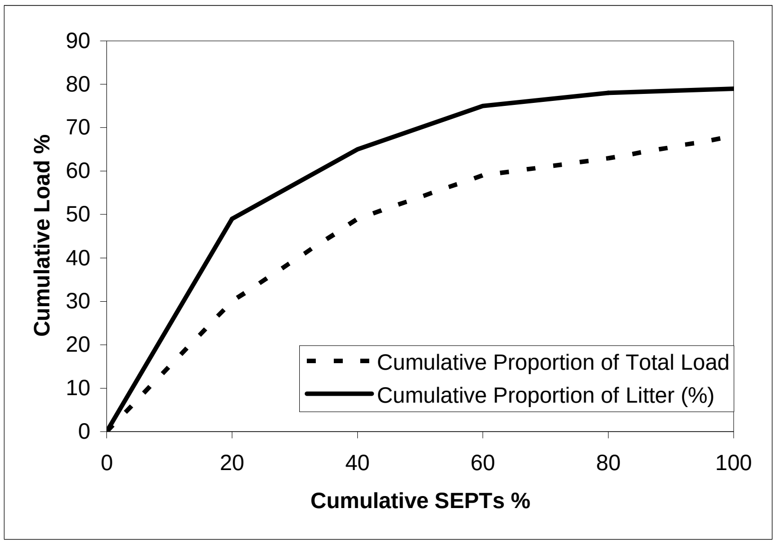


Figure 8. The cumulative percentage of trapped load against the cumulative percentage of traps for the entire experimental storm drain system. Data are estimates from original graph (Allison et al 1998).

## Outlet Inserts

Observations by City of Los Angeles staff of existing catch basin inserts indicated that overflow was a problem in shallow catch basins (max. 35" high). Therefore, staff was particularly interested in finding a device that would circumvent this problem. In 2004-2005, the City of Los Angeles conducted a pilot test of the StormTek™ and Practical Technology outlet inserts. Devices were installed within catch basins in areas considered to generate high levels of trash. Performance was evaluated by comparing what was captured and what bypassed the device. Over the course of one year, the StormTek™ device performed exceptionally well. No bypasses were observed. The lack of bypass was consistent across all retrofitted basins, regardless of size (City of Los Angeles 2005). Catch basins retrofitted with Practical Technology inserts experienced bypass that carried trash and debris out of the insert. The study concluded that Practical Technology inserts performed adequately in larger catch basins, but only as long as the units vertical component was higher than 2 ft. As a result of this study, the City of Los Angeles has chosen the StormTek™ unit for all future installation, particularly to replace existing units in shallow catch basins (max. 35" high). (City of Los Angeles 2005).

As part of a city-wide floatables control study in New York City, the amount of litter released into the combined sewer system was compared for catch basins with and without outlet hoods, under identical flow regimes. The hooded catch basins retained approximately 85% of the litter delivered to the catch basins, while catch basins without hoods captured only 30% of the litter (USEPA 1999).

## Maintenance

Catch basin inserts are usually maintained with a vacuum truck. Depending on the configuration of the insert, maintenance is either through the curb opening or the maintenance grate. A major part of the maintenance cost is the investment in the vacuum truck that can cost between $120,000 and $150,000, and the increased time required to clean the catch basin with an insert. Depending on unit specifications, cleaning is recommended at least semi-annually (Gordon and Zamist 2006).

### Inlet Inserts

Caltrans conducted a BMP Retrofit Pilot Study of CBIs and concluded that maintenance of the inserts depended on the accumulation rate of pollutants and debris, the storage capacity and the requirements for proper operation (Caltrans 2004). The Caltrans study evaluated two types of devices, the FossilFilter™ and the StreamGuard™. The FossilFilter™ inserts experienced flow bypass because sediment and organic debris (leaves, litter, etc.) covered the cartridges. As a result, sediment and debris had to be removed from the top of the cartridges before a storm event and generally once during the event. This requirement could be a major operation and maintenance burden depending on CBI siting (Caltrans 2004). The range of operation and maintenance hours for pilot CBIs was 21 to 56, with an average of 36 field hours per year. Slightly more field hours were spent at the FossilFilter™ CBIs than at StreamGuard™ CBIs. This was primarily due to more frequent cleaning needed by the FossilFilter™ CBI to prevent flow bypass during storm events. The actual number of maintenance hours spent in the field for the FossilFilter™ was on average 36 hr/yr and 20 hr/yr for the StreamGuard™ (Caltrans 2004). Some of StreamGuard™ inserts had to be refitted into the drain inlet because of slippage caused by the weight of the water and material collected within the filter bag. Pre-storm inspections and maintenance of this insert was necessary to minimize slippage during storm events (Caltrans 2004).

As a result of observations made during their BMP Retrofit Study, Caltrans developed annual cost and time estimates for maintaining CBIs. Table 2 presents the expected maintenance costs that would be incurred for a single CBI (Caltrans 2004).

Table 2. Expected average annual maintenance effort for a catch basin insert (Caltrans 2004).

| Activity | Labor Hours | Equipment & Materials $ | Cost, $* |
|---|---|---|---|
| Inspections | 1 | 0 | 44 |
| Maintenance | 18 | 21 | 813 |
| Vector control** | 0 | 0 | 0 |
| Administration | 3 | 0 | 132 |
| Direct cost | - | 115 | 115 |
| **Total** | **22** | **$136** | **$1104** |

* 1999 ($)
** Includes hours spent by consultant and Vector Control District for inspections

### Outlet Inserts

Maintenance of outlet inserts is also performed with a vacuum truck. During the City of Los Angeles' pilot study of the StormTek™ device, maintenance observations indicated that cleaning of the retrofitted basins was relatively easy because trash is held within the basin and not in a separate container. Maintenance crews noted that this type of insert had little impact on their regular maintenance routines. Maintenance crews noted that more care had to be used to clean catch basins retrofitted with the Practical Technology insert because the vacuum hose is placed directly on the horizontal screen and crews feared damaging the screen. In addition, crews found that it was often difficult to push all of the debris towards the hose when pressure washing since the direction of the pressure wash is almost perpendicular to the screen. In this case, substantially more water is used during this cleaning process (City of Los Angeles 2005).

## Costs

### Inlet Inserts

The capital costs of inlet inserts ranges between ~$200 to ~$1650, depending on model and size (DeCarlo et al 2004, Lee et al 2006, LARWQCB 2006a). The low initial costs of inserts make them one of the least expensive structural treatment devices in the short term (LARWQCB 2006b). Construction and installation costs for each inlet insert installed for the Caltrans BMP Retrofit Pilot Study was approximately $1,186 (1999 $) (Table 3). Actual costs include the installation of inlet inserts and associated monitoring activities (Caltrans 2004).

Table 3. Actual construction costs for catch basin inserts (1999 dollars) (Caltrans 2004).

| Device | Actual Cost, $ | Actual Cost w/o Monitoring, $ | Cost[a]/WQV $/cubic meter |
|---|---|---|---|
| Fossil Filter | 32,116 - 51,696 | 1,186 | 7.30 - 46.69 |
| Storm Guard | 32,116 - 51,696 | 1,186 | 9.53 - 66.70 |

[a] Actual cost without monitoring. Costs were normalized for drain inlet inserts by calculating a water quality volume (WQV) treated by the device and the amount of rainfall during the design storm.

Even though inlet inserts have a relatively low capital cost, in the long run, they can still be expensive due to their high maintenance requirements. For example, the County of Los Angeles showed that the total costs of retrofitting the Los Angeles River watershed with inserts over ten years would be $120 million, while the yearly maintenance costs after full implementation would be $60 million (Table 4) (LARWQCB 2006b). The County assumed that ~150,000 catch basins would have to be retrofitted with inserts to cover the 574 square miles of the Los Angeles watershed (LARWQCB 2006b). A summary of estimated costs for using catch basin inserts across the entire watershed is provided in Table 4.

Table 4. Costs of retrofitting the urban portion of the watershed with catch basin inserts. (LARWQCB 2006).

| | Costs (million $) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| # Years into Program | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| O&M costs (yearly, cumulative) | 6 | 12 | 18 | 24 | 30 | 36 | 42 | 48 | 54 | 60 |
| Capital costs (yearly) | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Costs/yr servicing+cap costs) | 18 | 24 | 30 | 36 | 42 | 48 | 54 | 60 | 66 | 72 |

### Outlet Inserts

The capital costs for the Stormtek™ outlet insert are ~$850 and $275 for installation for a total cost of~ $1125 per unit (O. Lugo[4], pers. comm.). SNOUT™ inserts cost between $275/unit for a 12 inch unit and $6500 for a 96 inch unit (Best Management Products, INC 2007).

## Pros

Catch basin inserts have several advantages over other trash control devices. They are relatively small and can easily be retrofitted into existing storm drain systems (curb inlet and flat-grate catch basins). Their installation does not require a large foot print (i.e., additional land). They come in a wide range of sizes and can also be modified to capture other pollutants. Individual maintenance time is low and relatively simple. Outlet inserts take

[4] Octavio Lugo, President Advanced Solutions, manufacturer of StormTek™, June 2007.

advantage of the full volume of the catch basin thus circumventing one of the main criticisms of inlet designs. Inserts generally hold trash in a dry state. They are constructed for easy access and can bypass high flows during peak storm events to prevent flooding. Inserts can be readily serviced by a vacuum truck through a manhole without removal of the insert from the manhole. Two devices (City of Glendale Trash Excluder and Advanced Solutions StormTek™ catch basin insert) have been designated as full capture devices by the LARWQCB.

## Cons

Some CBI models, particularly the inlet types, are susceptible to clogging under high loading. Peak flows could reintroduce trash into the system if not designed properly. Parked vehicles may disrupt removal schedule or impede removal during emergencies. One of the most significant drawbacks of CBIs is their associated maintenance requirements. In the Caltrans BMP Retrofit Study, it was concluded that the absolute number of maintenance hours was not large for each unit, but the timing was critical - cleaning had to be done immediately before and during storm events. However, timely maintenance is unlikely due to other demands on maintenance personnel during storm events (Caltrans 2004).

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Santa Clara Valley
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# Netting

**Fresh Creek Netting TrashTrap™, Signal Hill, CA.**

## Summary

Netting trash traps are systems that rely on the force of flowing water to trap floatables in disposable nylon mesh bags of varying mesh sizes and storage volumes. They can be placed within the storm drain system as in-line units, floating units and end-of-pipe systems. In general, it is expected that end-of-pipe nets will require inspection after every storm greater than 0.25 in. When a net is full, trash is removed and disposed of at a landfill. Nets are removed by a boom truck crane and placed in a container for proper disposal. Effectiveness can range from 86 - 97%. Planning and construction costs for a Fresh Creek Netting TrashTrap™ system range from $75,000 to $300,000. Annual labor and trash disposal costs differ each year since operation and maintenance depends on how many storm events were greater than 0.25 in.

## Description/Design

Netting trash traps are used to capture trash and floatables from the end of combined sewer overflows (CSOs) and stormwater outfalls. These systems rely on the force of flowing water to trap floatables in disposable nylon mesh bags of varying mesh sizes and storage volumes (Guillozet, Trieu, and Galli 2001). Netting trash traps, also known as release nets, are considered to be a relatively economical way to monitor trash loads from municipal drainage systems (LARWQCB 2006). The nets remain on the end of the drains until water levels upstream rise sufficiently to release a catch that holds the net in place. The water level may rise from the bag being either too full to allow sufficient water to pass, or from a disturbance during very high flows. Nylon mesh nets are inspected and trash is usually removed after every storm greater than 0.25 in. In most cases, municipalities elect to reuse nets until they are no longer usable. The life span of a net is approximately six months. When the nets release in certain designs (e.g., NetTech™) , they are attached to the side of the pipe by a steel cable. As they are washed downstream, the nets are tethered off so that trash is not released (LARWQCB 2006).

## TC-2 Treatment Control

### Netting Design Examples

- Netting Trash Trap™ (Fresh Creek Technologies, Inc.)
- NetTech™ (Kristar Enterprises, Inc.)

### Implementation Point

| | |
|---|---|
| In Street | |
| Start of Pipe | |
| In Pipe | ✓ |
| End of Pipe | ✓ |
| In Creek | |
| Dispersed | |

The following should be considered when designing a netting system: the expected peak flow; the maximum flow velocity; and the volume of floatable material per million gallons of water flow (Gordon and Zamist 2006). The mesh netting is sized according to the volume and types of floatables that will be captured. (RBF Consulting 2003).

A Fresh Creek Netting TrashTrap™ net is designed to hold 25 cubic feet of floatables weighing up to 500 pounds (USEPA 1999). In addition, each net is capable of handling flow velocities up to 5 ft/sec, but higher flows can be accommodated with the addition of flow dissipating devices (Fresh Creek 2006). Most systems use two nets. Their design is flexible and can be modified according to site specific conditions. The entire system is designed and manufactured to have a minimum life expectancy of 25 years (Fresh Creek 2006).

Three separate Fresh Creek Netting TrashTrap™ net were installed at the Hamilton Bowl, a flood control detention basin in Signal Hill, CA. Two are maintained by the City of Signal Hill and one by the County of Los Angeles. Each system treats up to 70 cubic feet per second of flow, which is greater than an expected peak flow (defined as 0.6 inches per hour) for a one-year storm event within the Los Angeles River watershed. The system is designed to remove up to 2,000 gallons of trash, solids, and floatables per year. The tributary drainage area is approximately 0.27 square miles (172.8 acres) and is expected to generate approximately 175 gallons of trash per year (Fresh Ideas 2004).

Other models (i.e., NetTech™) can retain 3 to 6 cu ft of gross solids, and have net mesh sizes of 0.5 in and a net length of 6 ft.

Some design examples include:

- Netting TrashTrap™ (Fresh Creek Technologies, Inc.)
- NetTech™ (Kristar Enteprises, Inc.)

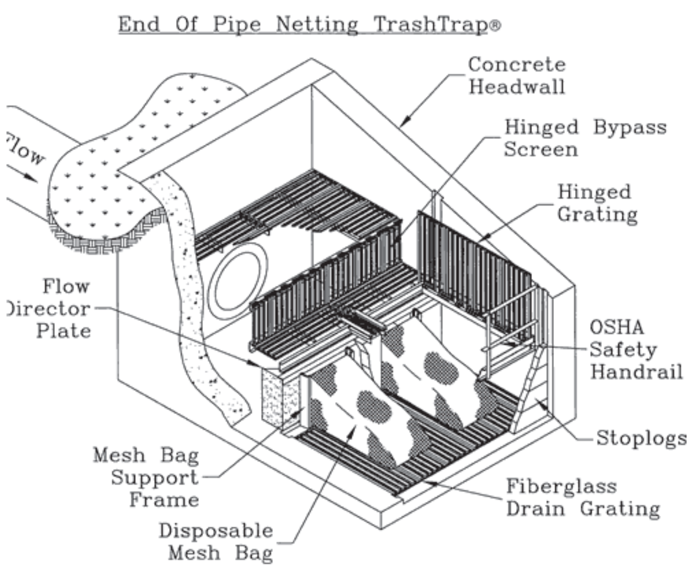


**Figure 1. End Of Pipe Netting TrashTrap® (courtesy of Fresh Creek Technologies, Inc.).**

## Applicability/Siting

Netting systems can be placed within the storm drain system as in-line units, floating units or end-of-pipe systems (Gordon and Zamist 2006). In-line netting is installed in underground concrete vaults containing one or more mesh bags. A metal frame and guide system supports the nets. Floating units are anchored to a pontoon and use floating booms to funnel water flow through a series of large nylon mesh nets. End-of-pipe systems are installed at a storm drain outfall. These units are often installed as a retrofit to an existing outfall structure (USEPA 1999). The system should not be situated in areas that are heavily navigated by boats and areas that have extremely strong currents, severe wave action and high winds (USEPA 1999). Trash nets should also be located in areas with sufficient space to accommodate maintenance equipment.

## Maintenance

Figure 2. Fresh Creek floating unit (courtesy of Fresh Creek Technologies, Inc.).

It is expected that end-of-pipe netting systems will require inspection after every storm event greater than 0.25 in. Cleaning is subject to inspection results. When a net is full, it is removed and disposed of at a landfill (USEPA 2007). Nets with can be removed from the system by several methods. End-of-pipe nets are lifted by a boom truck crane and placed in a carting container for proper disposal. For floating units, nets are floated out through the back of the pontoon structure and picked up by a skimmer or work boat. The crane used for changing the nets should be capable of lifting 1000 pounds and have the reach to access nets from outfalls on a site specific basis (USEPA 1999). A minimum of two people is required to change nets within pontoon units. The change out procedure for one net can usually be completed in 30 minutes (USEPA 2007). However, other studies have shown that two people and a boom truck operator may take one to two hours to change the nets (Guillozet, Trieu, and Galli, 2001).

At the Hamilton Bowl, the County of Los Angeles Department of Public Works is responsible for maintaining its Fresh Creek Netting TrashTrap™ system. During the wet season, the netting system is inspected and/or maintained weekly. During the dry season, the system is inspected and/or maintained monthly. Maintenance involves lifting the net with a boom truck crane. Trash is removed from the net and saved for proper disposal. A vactor truck is used to remove any trash within the storm drain system or netting system. Maintenance requires a minimum crew of two people. The change out procedure for one net can usually be completed in 30 to 45 minutes. In some cases, two workers plus a boom truck operator may take one to two hours to change the nets and conduct maintenance on the system to remove sediment. The life span of a net is approximately six months.

A study conducted on the Anacostia River, Maryland indicated that nets had to be changed twelve times over a nine month period (Guillozet, Trieu, and Galli, 2001). This study estimated that the annual labor hours for operation and maintenance is ~140/yr (Guillozet, Trieu, and Galli, 2001). In Southern California, nets may need to be changed after each storm event, which may be as frequent as ten to twenty times per year depending on site-specific litter and rainfall conditions (RBF Consulting 2003).

## Performance and/or Effectiveness

The most thorough performance and effectiveness data for netting systems is presented in three separate studies: an Australian study using the Net Tech Netting system (Lewis 2002); a USEPA sponsored test for the Fresh Creek Netting TrashTrap™; and a study of the Fresh Creek Netting TrashTrap™ in the Anacostia River, Maryland (Guillozet, Trieu, and Galli, 2001).

### NetTech™ Netting System

Lewis (2002) conducted a study to determine the effectiveness of litter trapping devices on the removal of used syringes from stormwater systems in Melbourne, Australia. As part of this study, one NetTech™ Netting System was installed at the outfall of a main drain in the port city of Frankston (Melbourne). A fine mesh net was installed downstream of the unit to capture any items missed by the NetTech™ Netting System.

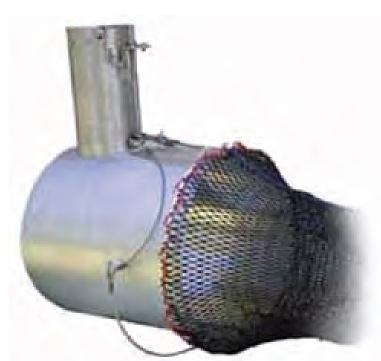

Figure 3. NetTech™ Netting System (courtesy of Kristar Enterprises, Inc.).

The effectiveness of the nets was assessed by comparing how much litter was retained, how much bypassed the net and what was captured by a downstream net. The nets were sampled and cleaned four times over a five-month period (~ every four to six weeks). Captured material was sorted into categories, weighed, and volumes were estimated (the same procedure was followed for the net that was installed downstream). Loads were the sum total of litter and organic matter (vegetation and sediment).

The effectiveness of the net was found to be compromised by being sited in non-ideal conditions, a tidal environment. NetTech™ Netting Systems are not designed for submersion but sometimes become submerged within the tidal environment. Even though submerged, the release net was still very effective at retaining trash and debris. Study results indicated 93%, by volume, of litter was captured by the net. The release net retained 68% of all debris, 65% of organic mass and 84% of litter by mass. Lewis (2002) attributes the lower values for the organic material capture to the following two factors:

- Relatively heavy smaller organic particles became waterlogged, which caused them to break up more rapidly. The higher than expected percentage of fine, dense, organic material was resuspended by tidal action and bypassed the net.
- Fine seaweed became entangled on the outside of the monitoring net. This added to the mass of organic material and falsely reduced the capture efficiency of the NetTech™ Netting System.

## Fresh Creek Netting TrashTrap™-- USEPA- sponsored Pilot Test

The Fresh Creek Netting TrashTrap™ was pilot tested at one location in New York (Fresh Creek) and two locations in New Jersey (Saybrook & Peddie). The goals of the demonstration projects were: to evaluate the technology for eliminating floatables during CSO events; to define conditions under which the technology should perform; and to obtain capital and operation and maintenance (O&M) cost data (USEPA 1999). System effectiveness was evaluated using a secondary boom with an attached curtain to capture any floatables that escaped the nets (USEPA 1999).

Over two years, the Fresh Creek site captured an average 4,250 pounds of trash and debris per net (Table 1). At the two New Jersey sites, the average total weight captured per net was 2,626 pounds and the average weight caught per ten million gallons of discharge was 947 pounds (Table 1). Effectiveness ranged from 90% - 97%.

**Table 1. Summary of effectiveness for Fresh Creek Trash Trap Systems during EPA-sponsored pilot tests (USEPA 1999).**

| | Volume of CSO Discharge ($ft^3$) | Total Weight of Captured Floatables (lbs – all nets) | Floatables Caught/ Discharge (lbs/10 MG) | Effectiveness (%) |
|---|---|---|---|---|
| Fresh Creek<br>2 net system | | | | |
| 0.5 in net | 56,000,000 | 8,500 | 650 | 90 – 95 |
| Saybrook<br>2 net system | | | | |
| 0.25 in nets | 3,302,456 | 1,723 | 697 | 93 |
| 0.5 in nets | 12,452,714 | 4,562 | 637 | 94 |
| Peddie<br>4 net system | | | | |
| 0.25 in | 7,309,504 | 10,184 | 1,862 | 97 |
| 0.5 in | 28,886,223 | 19,273 | 891 | 97 |

## Fresh Creek Netting TrashTrap™-- Anacostia River

During the Anacostia River study, effectiveness was determined by subtracting the amount of floatables captured by an experimental outerboom from the total weight of material captured inside the nets. Researchers monitored ten net

[1] This includes the weight of organic materials (e.g., leaves and branches) but did not include the weight of the nets.

changes between August 8, 2000 and April 30, 2001. As nets were removed, the wet weight of the full nets was measured. The weight of all the floatables within the experimental boom area (collected with a skimmer net) was also measured. Contents of the nets were then sorted into categories and identified.

The wet weight of captured materials was 4,078[1] pounds for nine months. Effectiveness was found to be 86%. The researchers also performed a 'mark-recapture' study, during which they released marked plastic balls of known sizes into the drainage system immediately upstream of the nets. The capture rate of the marked balls was 83% (the 'lost' balls evaded both the Fresh Creek nets and the outer experimental boom) (Guillozet, Trieu, and Galli, 2001). Other observations made during the Anacostia River study found that the netting system became submerged during periods of heavy CSO flow (Guillozet, Trieu, and Galli, 2001).

## Fresh Creek Netting TrashTrap™-- Hamilton Bowl

The Fresh Creek Netting TrashTrap™ system maintained by the County of Los Angeles at the Hamilton Bowl was installed in April 2002. In the first year of operation, the nets were changed out eighteen times. A total of 35,140 pounds of trash and debris was removed (Fresh Ideas 2004). In FY 2005-2006, The County of Los Angeles collected 11,400 pounds of trash. In FY 2006-2007, approximately 7,700 pounds have been collected.

## Costs

Depending on site conditions, the cost of planning and constructing a Fresh Creek Netting TrashTrap™ system may range from $75,000 to $300,000. A typical two-net system with a 50 cubic feet capacity, the capability of handling approximately 500 pounds of damp weight per net and spanning 15 feet of an outfall, is estimated to cost ~$125,000. This includes the cost of fabrication and installation, which can take three to six months. The land-based equipment (trash collection/disposal) associated with the system has an additional estimated capital cost of $25,000 to $75,000 (USEPA 1999). The County of Los Angeles spent approximately $140,000 (i.e., engineering and construction costs) on its Fresh Creek Netting Trash Trap™ Labor costs for maintaining the Fresh Creek Netting Trash Trap™ (i.e., cost of inspecting and removing trash) have been relatively inexpensive. In FY 2005-2006, the County spent $5,300 for operation and maintenance. Labor costs for FY 2006-2007 have been approximately $1,600. Trash disposal costs are not included in labor costs. Annual labor and trash disposal costs differ each year since operation and maintenance depends on how many storm events were greater than 0.25 in. The life span of a net is approximately six months. The cost of replacing one net is ~$125.

The cost for sewage treatment plant staff to operate and maintain a two-net system during the USEPA demonstration project sites in New Jersey was estimated at $1,500 per month per site. The cost for nets and labor, excluding disposal costs, was ~$570/CSO event. Replacement nets at the Saybrook site totaled $200 ($100 per net). Operation and maintenance at the Peddie and Saybrook site occurred under demonstration conditions. In order to obtain site-specific data, more hours then expected were spent on flow monitoring, data collection, miscellaneous adjustments, repositioning equipment, as well as net changes after every CSO event. (USEPA 1999).

The Metropolitan Washington Council of Governments estimated that the regular annual maintenance and associated materials cost for operating a Fresh Creek TrashTrap™ system is $15,143[2] (Guillozet, Trieu, and Galli, 2001).

Replacement nets designed to capture a high velocity discharge cost approximately $100 per net. Disposal costs for captured materials and nets should also be considered when calculating O&M costs. The quantity of captured floatables vary from site to site. Within Southern California, nets may need to be changed out approximately ten times per year (RBF Consulting 2003).

[2] Labor costs were based on a two person crew at $20/ hr and a boom truck operator at a $50/hr. Costs assumed 18 net changes per year and included inspection, removal and disposal costs. It does not include major repair and replacement costs.

The study conducted on the Anacostia River found that the total cost for a two-net Fresh Creek TrashTrap™ system including design, installation and one year of maintenance was ~$300,000 (Guillozet, Trieu, and Galli, 2001).

## Pros

Netting systems use the natural energy of the flow and need no external power. In addition, there is minimal head loss. Systems drain dry at the end of a wet weather event, leaving little or no residual standing water that could otherwise represent a breeding ground for mosquitoes and other insects. Installation and maintenance is simple and relatively fast. There is no need for confined space entry. Effectiveness is high. Designs are scalable and can accommodate a wide range of sites. Fresh Creek Netting TrashTrap™ installed at the Hamilton Bowl have been certified as a full capture device by the LARWQCB. End of pipe and floating designs can be easily retrofitted into existing storm drain systems.

## Cons

Nets hold trash and debris in a visible manner and may not be preferred for some locations for aesthetic reasons. Effectiveness seems to be negatively affected by tidal waters. Maintenance is required frequently, potentially up to eighteen times a year within the California context. Due to spatial constraints, siting may be an issue at outfalls to creeks.

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Santa Clara Valley
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# Hydrodynamic Separators

Continuous Deflective Separation (CDS™) Unit (courtesy of CDS Technologies, Inc.).

## TC-3 Treatment Control

### Hydrodynamic Separator Design Examples

- Bay Saver Separation System
- CDS™ Offline, Inline, Drop Inlet, and Cast In Place Models
- Downstream Defender®
- Ecostorm
- Flo-Gard® Dual Vortex
- Vortsentry™
- Vortechs™

### Implementation Point

| | |
|---|---|
| In Street | |
| Start of Pipe | |
| In Pipe | ✓ |
| End of Pipe | ✓ |
| In Creek | |
| Dispersed | |


## Summary

Hydrodynamic separators divert the incoming flow of stormwater into separation and containment chambers. The circular shape of the chamber allows solids to remain in continuous motion within the separation chamber. The constant motion of solids prevents the blocking of the screen and allows water to pass through the screen and flow downstream. Studies have shown that hydrodynamic separators remove virtually all trash contained within stormwater. Costs vary greatly depending on size of the unit and proprietary model. Capital costs range from $4,000 to $300,000 per unit. Installation costs can be 50% to 100% of the capital costs. Maintenance is done with a vacuum truck and is required approximately two to four times per year. Studies have shown that these devices can be highly effective at trapping trash and litter. High costs are the primary drawbacks.


## Description/Design

Hydrodynamic separators, also known as vortex separators or swirl concentrators, use the tangential forces created by the incoming flow of water to separate trash, debris, oil and other pollutants from stormwater. While there is a range of proprietary designs, all rely on a circular chamber to swirl the stormwater flow and a settling or separation unit to remove pollutants. Water enters the unit on a tangential plane; a circular flow pattern is established by the cylindrical shape of the unit, creating a vortex. The flow at the outer edge of the tank moves at a higher velocity than the flow in the center (RBF Consulting 2003). In general, the vortex flow tends to move denser, heavier material downward to the center, while lighter, floatable materials rise to the surface on the outside (Allison et al 1998). Solids within the separation chamber are kept in continuous motion by the flow of water and do not "block" the screen. Since hydrodynamic separators depend on the energy from flowing water, no outside power source is required. Many designs have a storm bypass weir incorporated to allow excess flows to bypass the system. This is to prevent the unit from flooding or losing its captured material (Caltrans 2004a).

Hydrodynamic separators are available in a range of sizes/treatment capacities depending on the manufacturer (Table 1). Units can be small enough to be retrofitted into existing manholes. Some proprietary models have off line and in-line versions. Size is based on the peak flow of the design treatment event as specified within a local municipal stormwater permit (CASQA 2003). Headloss differs with the product but is generally on the order of one foot or less (CASQA 2003).

Table 1. Examples of the range of treatment volume capacities of various hydrodynamic separators.

| Product | Company Name | Unit Flow Capacities (cfs) |
|---|---|---|
| Bay Saver | Bay Saver, Inc. | 2.4 - 11 |
| CDS | CDS Technologies, Inc. | 1.1 - 300 |
| Downstream Defender | Hydro International | 3 - 25 |
| Flo Gard® Dual Vortex | Kristar Enterprises, Inc. | 8 - 71 |

Product Examples:

- Bay Saver Separation System (Bay Saver, Inc.)
- CDS™ Offline, Inline, Drop Inlet, and Cast In Place Models (CDS Technologies, Inc.)
- Downstream Defender® (Hydro International)
- Ecostorm (Royal Enterprises America™)
- Flo-Gard® Dual Vortex (Kristar Enterprises, Inc.)
- Vortsentry™ (Contech Stormwater Solutions)
- Vortechs™ (Contech Stormwater Solutions)

Figure 1. Flo-Gard® Dual Vortex (courtesy of Kristar Enterprises, Inc.).

Figure 2. Vortechs™ (courtesy of Contech Stormwater Solutions).

## Applicability/Siting

Hydrodynamic separators can be used to treat large volumes of stormwater at or near a point of discharge from the storm drain system to a receiving water (USEPA 2006). These devices are placed underground and come in a wide range of sizes. Some are small enough to fit into conventional manholes. This adaptability can make hydrodynamic separators suitable for areas where land availability is limited (USEPA 2006a). Units need to be located in areas where space is available for installation and maintenance (USEPA 2006a). In the appropriate conditions, they can be placed in almost any specific location within a storm drain system. (Gordon and Zamist 2006)

Some typical sites for installation include:

- Airport taxi-way and runways
- Freeways and bridges
- Gas and service stations
- Industrial maintenance facilities
- Parking lots

## Maintenance

Material that collects in the separation chamber can be removed in two ways. The sump can be fitted with a large basket that collects sinking material and can be lifted with crane onto a removal truck. Alternatively, the sump can be cleaned with a powerful vacuum pump (Allison et al 1998). The suction method has the following advantages:

- Minimal road disturbances;
- No manual handling of material;
- Only requires one machine and two people; and
- Removes more of the accumulated material.

CDS Technologies, Inc. recommends that for new installations, the units be checked after every storm event for the first thirty days. Inspections should include measuring accumulation with a calibrated dipstick so that deposition can be tracked. Based on these observations, future inspections can be scheduled based on projections using storm events vs. pollutant buildup (USEPA 2006a). For normal wet weather operation, the unit should be inspected at least every thirty days. The floatables should be removed and the sump cleaned when it becomes above 85% full. At least once a year, the unit should be cleaned and the screen carefully inspected to ensure that the screen is properly fastened and not damaged. Power washing of the screen is recommended prior to inspection. A vacuum truck is recommended for the CDS™ unit cleanout, which can be easily accomplished in less than 30 to 40 minutes for most installations (CDS 2006). Maintenance requires vehicle access for the removal of trash, debris and sediment. Access to the CDS™ unit is typically achieved through two manhole access covers - one allows inspection and cleanout of the separation chamber (screen/cylinder) and sump; and another allows inspection and cleanout of sediment captured and retained behind the screen.

Field studies conducted during the Caltrans BMP retrofit pilot program indicated that staff spent an average of 63 field hours/year maintaining each CDS™ unit (Caltrans 2004a). Trash and debris removal is the most time consuming maintenance activity (Table 2).

Based on the level of maintenance required during the Caltrans BMP retrofit study, Caltrans recommends the following activity and maintenance schedule (Caltrans 2004b):

- Empty CDS™ unit (annually or when needed based on watershed characteristics);
- Remove trash and debris from weir box (monthly) basis;
- Inspect the screen for damage (annually); and
- Inspect the structural integrity of the device (annually).

Local experience with maintaining hydrodynamic separators in San Francisco and Oakland indicate that the units are cleaned out approximately two to four times a year (LMI 2006, USEPA 2006a).

Table 2. Average annual maintenance time, by activity, spent by Caltrans staff on the operation and maintenance of pilot CDS™ units (Caltrans 2004b).

| Maintenance Activity | Average Annual Hours |
|---|---|
| Inspection | 8.9 |
| Graffiti | 1.4 |
| Clearing of Weir Box | 1.3 |
| Trash and Debris Removal | 11.6 |
| Dewatering | 6.5 |
| Erosion/structural repair | 7.0 |
| Vector Control | 6.1 |

## Performance and/or Effectiveness

Two major studies of hydrodynamic separators have demonstrated that at least one major proprietary design (CDS™) met its performance goals for removing trash and litter from stormwater (Allison et al 1998, Caltrans 2004b).

Allison et al (1998) conducted a study of CDS™ performance in a suburb of Melbourne, Australia. The catchment area studied was 50 ha (123.5 acres). To investigate operating performance, measurements of discharge and water levels upstream and downstream of the unit were made and trapped material was removed and analyzed (Allison et al 1998). The unit was cleaned after every storm event and the collected material was sorted and weighed in the laboratory. Trapping performance was determined by measuring how much and how often storm flows bypass the diversion weir and comparing that to how discharges went through the unit. When storm flows did not bypass the diversion weir, the only pathway for material is through the CDS™ screen. However, the screen size (4.7 mm) was smaller than the defined size of trash and litter (5mm) (Allison et al 1998). As a result, fine particles in these flows were not incorporated into performance calculations. Estimating performance in this manner gives no indication of the amount of trash and litter that was transported downstream. However, it did provide an estimate of the discharge proportion that bypassed the unit. The instrumentation indicated that less than 1% of stormwater flowed over the weir during the twelve months of monitoring. In estimating the amount of material passing over the weir, it is assumed that the amount is proportional to the discharge that flows over the weir. Therefore, the authors estimated that CDS performance was ~99% during the twelve months of monitoring (Allison et al 1998).

Table 3 presents a summary of the ten clean-outs conducted over three months (Allison et al 1998). CDS™ units were cleaned out after storm events (defined as when the flow in the pipe reached a maximum depth of more than 150mm, which corresponds to 2 to 3 mm of rainfall on the catchment).

Table 3. Results of cleanouts of experimental CDS™ (Allison et al 1998).

| | Runoff Events | Days between cleanouts | Runoff (mm) | Rain (mm) | Gross Poll. vol ($m^3$) | Tot. Wet Mass (kg) | Trash/ litter Dry (kg) | Organics Dry[1] (kg) | Dry Mass (g/ha) |
|---|---|---|---|---|---|---|---|---|---|
| Avg/clean-out | 1.3 | 8.9 | 5.7 | 18.3 | 0.462 | 118.5 | 9.26 | 26.91 | 723.4 |

A Caltrans study of CDS™ units in Southern California demonstrated effectiveness values of 85% to 92% of trash and debris by weight (Caltrans 2004b). The study placed two CDS™ units near freeway sites (Orcas and Filmore). During the study, the total wet and dry weight and volume of floatables, settleable materials, material contained in the weir box, and bypass material were measured following each clean out. Effectiveness was calculated as the mass retained relative the sum of the mass retained and the mass of material passing, times 100 (Table 4). Approximately 93% of the material retained was vegetative material, while the remainder was trash and litter. The amount of bypass at the

[1] Leaves and twigs.

Orcas site was largely due to one event in January 2001. This event produced more than 100 mm of rain in a 42 hr period. However, the measured peak flow rate was only 0.013 m3/s (0.45 cfs), less than half of the capacity of the unit (Caltrans 2004b). The pilot study report attributes the difference between the two sites to a greater number of trees at the Orcas site, which resulted in more leaf litter. In addition, this site had a smaller mesh size. As a result, its screens clogged more frequently and resulted in more bypass (Caltrans 2004b).

Table 4. Efficacy of the CDS™ units pilot tested by Caltrans 2000-2002 (Caltrans 2004b).

| Site | Gross Pollutant | Captured Gross Solids (kg) | Bypassed Gross Solids (kg) | Total Gross Solids (kg) | Effectiveness (%) |
|---|---|---|---|---|---|
| Orcas | Dry mass | 252 | 45 | 298 | 85 |
| Filmore | Dry mass | 98 | 9 | 107 | 92 |

## Costs

Total costs for buying, installing, and maintaining hydrodynamic separators throughout a watershed can be quite high. The City of Los Angeles estimated that it would cost $30,000,000 to install 40 CDS™ units and maintain them over ten years (Kharaghani 2003).

Capital costs for hydrodynamic separators vary greatly depending on size and product type, but typically range from approximately $4,000[2] for small devices treating two acres (USEPA 2006b) to greater than $332,000 for a unit that treats 300 cfs (Larry Walker Associates 1999) (Table 5).

Table 5. Comparisons of costs associated with outfitting the Los Angeles River watershed with small vs larger capacity hydrodynamic separators. The assumed cost of servicing one unit is $2000/yr (LARWQCB 2006).

| Capacity (cfs) | Acres (avg) | # devices needed on urban portion of watershed | Capital costs ($) | Costs/yr for servicing all devices ($/yr)* |
|---|---|---|---|---|
| 1-2 | 5 | 73,856 | 945,356,800 | 147,712,000 |
| 6-8 | 30 | 12,309 | 553,920,000 | 24,628,000 |
| 19 - 24 | 100 | 3,693 | 332,352,000 | 7,386,000 |

* 1999 ($)

Construction costs will vary depending on the conditions of the installation site, but can often be at least double the capital cost of the device (Larry Walker Associates 1999, Kharaghani 2003, CASQA 2003). For example, during its BMP retrofit study (Caltrans 2004b), Caltrans installed two CDS™ units with a flow capacity of 1.1 cfs (the smallest size manufactured by CDS Technologies, Inc.). The actual construction cost for the two units was $31,684 and $35,681, while the purchase cost of a unit of this size is estimated to be $9,600 (Larry Walker Associates, Inc. 1999). Based on the results of its retrofit study, Caltrans (2004b) expected that the average annual maintenance cost per unit to be $1,037 for equipment and material and $3,717 for labor costs (Table 6).

There is a trade-off between maintenance costs and construction costs for hydrodynamic separators. A larger unit will be considerably more expensive to install, but will be less expensive over time to maintain. The estimated costs for retrofitting the Los Angeles River watershed with large capacity hydrodynamic separators was found to be lower than outfitting the watershed with smaller, but individually cheaper units (Table 5).

[2] Costs are as stated in cited literature and not adjusted to 2007 values

Table 6. Expected annual maintenance costs for a CDS™ unit (Caltrans 2004b).

| Activity | Labor Hours | Equipment & Material ($) | Cost ($)* |
|---|---|---|---|
| Inspection | 1 | - | 44 |
| Maintenance | 40 | 1,037 | 2,797 |
| Vector Control | 12 | - | 744 |
| Administration | 3 | - | 132 |
| **Total** | **56** | **1,037** | **3,717** |

* 1999 ($)

## Pros

Hydrodynamic separators have no moving parts, which eases maintenance and reduces repairs. Smaller units are suitable for sites with limited space and can be easily retrofitted into existing storm drain systems. The wide range of designs allows for siting in diverse conditions. These devices have low head loss requirements, which make siting easier. Studies show that some models are effective. The 'self-cleaning' action created by the flow of water helps prevent clogging of screens. The flow of water is used to create the separation of trash from the water. As a result, no external energy source is needed for separation.

## Cons

Larger units, which have the greater cost benefits over the long term, are limited by the availability of space for siting. Because CDS™ units are designed to retain water in the sump, standing water can remain long enough for mosquito breeding to occur. The costs of buying, installing and maintaining a CDS™ unit can be extremely high. A swirl action will only be achieved if the inlet pipe is carrying full pipe flow.

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Santa Clara Valley
*Urban Runoff*
Pollution Prevention Program

# Screens and Racks

**United Stormwater Screen Cover™ (courtesy of United Stormwater, Inc.).**

## Summary

Screens and racks can be used at the start of the storm drain system (catch basin screens), within stormwater pipes (in-line screening devices) and at outfalls (end-of-pipe screening devices). Catch basin screens are mesh wire or perforated plates that cover the openings of catch basins. They are inexpensive (prices start at $400) and help prevent gross solids[1] from entering the storm drain system. Instead, gross solids accumulate on the street until they are removed by street sweeping activities. In-line screening devices are vaults that contain some configurations of screens that filter gross solids from stormwater and hold it in the surrounding chamber. Caltrans developed and pilot tested a range of these devices. Gross solid removal devices capture between 9% to 100% of all loaded materials. Installation costs vary from ~$50,000 to ~$300,000. Two of these devices have been certified as full capture by the Los Angeles Regional Water Quality Control Board (LARWQCB). End-of-pipe screening devices, which include mesh baskets, bar racks, and horizontal screens, remove solids by direct straining of all objects larger than the screen openings and by filtering smaller particles through the larger objects accumulated on the screen. Capital costs for this type of device are relatively low. The City of Los Angeles installed five end-of-pipe screening devices at a total cost of $40,000.

## Description/Design

Screens and racks are used to prevent large debris and trash from moving through the storm drain system. Various designs exist including catch basin screens, in-line screening devices and end-of-pipe screening devices.

[1] Gross solids are defined as "litter, vegetation and other particles of relatively large size" (Caltrans 2003 Phase 1 Pilot Study). Litter is subsequently defined as "manufactured items made from paper, plastic, cardboard, glass, metal, etc. that can be retained by a 5 mm (0.2 in nominal) mesh screen". This definition is understood to be consistent with the LA River Trash TMDL definition of litter.

## TC-4 Treatment Control

### Catch Basin Screens

- REM Curb Protector™
- United Stormwater Screen Cover™
- Flogard Debris Curb Guard
- Surf-gate
- Opening Screen Cover

### Inline Screening Devices

- Linear Radial Screens
- Inclined Screen
- Baffle Boxes
- V-Screens
- StormScreens™

### End-of-Pipe Screening Devices

- ROMAG™ automatic mechanic screen
- Structural plastic trash racks and debris cages
- Trash Racks

### Implementation Point

| | |
|---|---|
| In Street | |
| Start of Pipe | ✓ |
| In Pipe | ✓ |
| End of Pipe | ✓ |
| In Creek | |
| Dispersed | |

## Catch Basin Screens

Catch basin screens are perforated screens or evenly spaced bars that are designed to fit outside or immediately within the storm drain curb opening. They either manually or hydraulically open when storm flow is detected. Catch basin screens can be fitted with filters to capture oils. Water passes between the screen bars, while debris, trash and litter are prevented from entering the device. These screens are typically used to prevent storm drain pipe blockages (RBF Consulting 2003). Regular street cleaning is necessary to keep debris from clogging the face of the screens and to prevent standing debris from blowing away (Gordon and Zamist 2006). Some examples include:

- REM Curb Protector™ (Revel Environmental Manufacturing)
- United Stormwater Screen Cover™ (United Stormwater, Inc.)
- Flogard Debris Curb Guard (Kristar)
- Surf-gate (American Stormwater)
- Opening Screen Cover (Practical Technology)

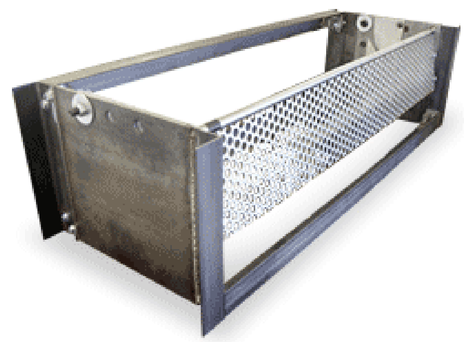

Figure 1. Surf-gate (courtesy of American Stormwater).

## Inline Screening Devices

Storm drain systems can also be modified with vaults configured with screens to hold gross solids for later removal. Examples include a series of inline screening devices developed by Caltrans. These devices, which were named Gross Solids Removal Devices (GSRDs), were developed in response to the trash TMDL instituted in the Los Angeles and Ballona Creek Watersheds. These devices include: Linear Radial Screens, Inclined Screens, Baffle Boxes and V-Screens. Multiple configurations were designed for each device and pilot tested at various sites.

### *Caltrans Devices*

**Linear Radial Screens.** This device uses a modular and linear screen cage constructed of rigid mesh or louvered well casing contained in a vault. Flows enter the device through a screen cage aligned parallel to the direction of flow and exit the device by passing through the cage screen and into the surrounding vault. The screen cage and interior volume are sized to accommodate specified storm discharge volumes from the tributary drainage area. The vault has sufficient volume to reduce flow velocities which allows solids to settle. It is sloped towards the outlet to provide positive drainage. Its linear configuration and low head requirements make it ideal for many typical highway right-of way applications (Endicott et al 2002). Three configurations were developed (Caltrans 2003a).

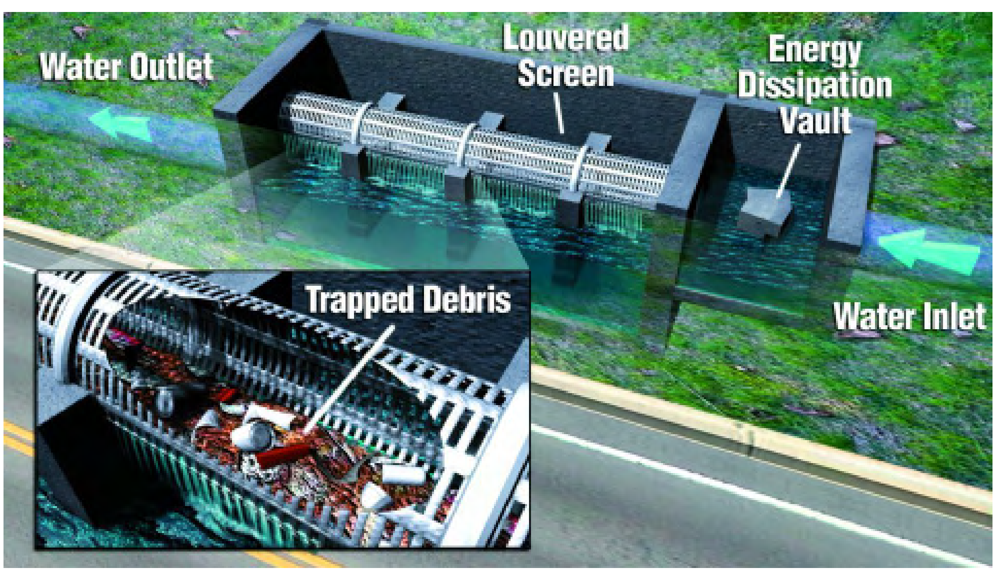


Figure 2. Cut away view of Linear Radial Configuration #1 (LR-1) screen (courtesy of American Society of Civil Engineers Publications).

**Inclined Screen.** This device uses an inclined screen constructed of parallel wires or bars contained in a vault. Gross solids are retained in a storage area of the vault located at the bottom of the inclined screen. Flows enter the device through a trough and weir which distribute inflow across the top of the inclined screen. The trough captures the heavier solids (e.g., gravel and sand). Flows exit the device by passing through the inclined screen. The gross solids storage area is sized to accommodate a once per year removal cycle and sloped towards a grate-covered drain pipe. Caltrans developed four configurations of this device.

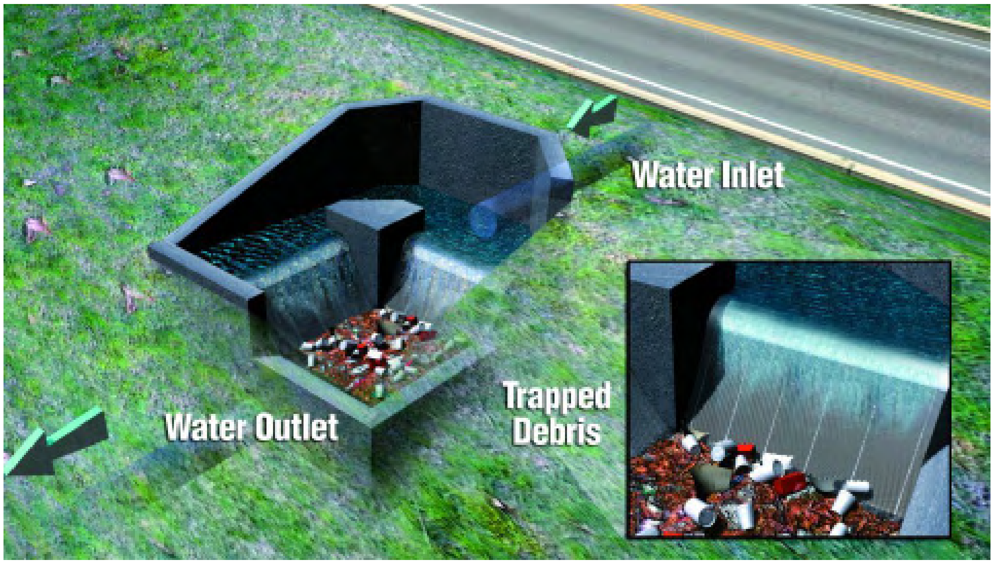


Figure 3. Inclined Screen Configuration #1 (IS-1) (courtesy of American Society of Civil Engineers Publications).

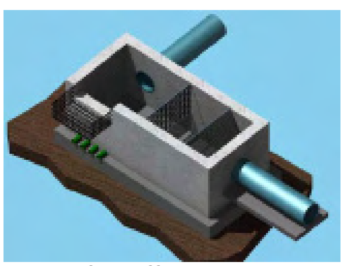

Figure 4. Baffle box (courtesy of Caltrans).

**Baffle Boxes.** This device has two chambers, one that uses an underflow wire to trap floatables and a second chamber that uses a bar rack to screen out any material that passes from the first chamber (Caltrans 2003a). As inflow enters the first chamber, solids are allowed to settle. A hinged chain-link screen allows high flows to pass and keeps the majority of floatables in the first chamber. Baffle boxes also have an overflow weir to convey bypass flow. An overflow basket is attached to capture any solids that flow over the weir (Caltrans 2003a).

**V-Screens.** This device use two sections of a V-shaped wedge wire screen and a 5 mm (0.2 in. nominal) spaced wedge wire sloped screen with the slotting to remove gross solids. Flow passes through the reverse sloping screens and drops to the outlet pipe. Gross solids collect in the solids storage area behind the screen. The solids storage area is sloped to allow for effective drainage. Sufficient screen area and volume are provided to accommodate an estimated once per year maintenance cycle without plugging (Caltrans 2005a). Currently, there are two configurations of V-Screens, which differ between the direction of screen slope (forward or backward) (Caltrans 2005a).

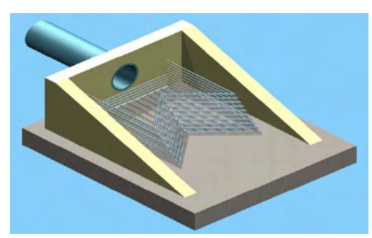

Figure 5. V-screen (courtesy of Caltrans).

*Non-Caltrans Devices*

**StormScreen™.** This device is a passive, high-flow screening system used for removal of trash and debris and some TSS by combining direct screening and settling. The system uses a float-actuated, radial flow cartridge constructed of stainless steel screen. In addition, the StormScreen™ system uses a patented self-cleaning mechanism that prevents binding of the screen surface and also incorporates a high flow bypass. It can be installed into small catch basins or incorporated into large, cast-in-place facilities (Caltrans 2004). The StormScreen™ system maybe used for treating flows inline or end-of-pipe .

### End-of-Pipe Screening Devices

End-of-pipe screening devices, which include wire baskets, bar racks, and perforated screens, are a common and simple method for removing gross solids from stormwater flow. These devices are made of galvanized steel or high density polyethylene and fiberglass and are placed at the end of stormwater pipes or at the entrance to a wet well of a stormwater pump station. Bar racks are often placed at an angle (up to 45º from the vertical) in the water flow. These devices remove gross solids through two basic mechanisms:

- Direct straining of all particles larger than the screen openings; and
- Filtering of smaller particles by straining flow through the mat of solids already deposited on the screen (USEPA 1999a).

There is no industry standard for classifying screens based on width of aperture. However, trash racks tend to have relatively large spaces between bars (~1.5 - 3.0 in) while baskets and screens are designed with a range of spacings to capture smaller particles (0.3 - 1.3 in) (USEPA 1999a). Apertures must be large enough so that partial plugging will not adversely restrict flows reaching the control outlet (Knox County 2007). Spacing of the rack bars or screen aperture should be wide enough to avoid hydraulic interference, but close enough to provide the desired level of clogging protection (Knox County 2007). Some designs (e.g., ROMAG™) incorporate rake mechanisms that automatically clean the deposited material to prevent screen blinding (USEPA 1999a). Some design examples include:

- ROMAG™ automatic mechanical screen (Parkson Corporation)
- Structural plastic trash racks and debris cages (Plastic Solutions)
- Trash Racks (Shurtleff Stormwater Treatment Products)

**Figure 6. Trash Racks (courtesy of Shurtleff Stormwater Treatment).**

## Applicability/Siting

### Catch Basin Screens

Catch basin screens should be located in areas that are prone to storm drain pipe blockages or are known to contribute large amounts of gross solids. Examples include shopping centers and other busy commercial areas (RBF Consulting 2003).

### Inline Screening Devices

Caltrans recommends the use of the Gross Solids Removal Devices (GSRDs) in the following situations:

- Receiving water bodies which are 303(d) listed for gross solids (litter/trash);
- Where recommended by Caltrans Maintenance (if trash persistently affects the storm drain system); and
- Where TMDLs require gross solids removal.

GSRDs are best suited at sites that have sufficient space to safely allow construction and maintenance (Endicott et al 2002). GSRDs require very little head and are well suited for narrow and relatively flat areas (RBF Consulting 2003). They can also be used at the end of storm water pipes.

## End-of-Pipe Screening Devices

Baskets, screens, and racks can be installed on nearly any stormwater outfall, and can also be used at stormwater management impoundment structures.

# Performance and/or Effectiveness

## Catch Basin Screens

The City of Los Angeles has experimented with the installation of catch basin screens. In 2000, city engineers did not observe any clogging at coarse screens installed in the experimental area (City of Los Angeles 2002a).

## Inline Screening Devices

As a response to the trash TMDLs instituted in Southern California, Caltrans undertook a multi-year pilot study to develop and test various devices to capture trash. To be certified (by Caltrans) as meeting the trash TMDL requirements, devices had to meet the following criteria: capture 100% of material greater than 5 mm; no clogging of screens; ability to convey a 25-year peak flow; and drain within 72 hours. In addition, Caltrans required that the device only need one clean-out per year (i.e., has a capacity to hold the total annual load of gross solids) and did not require additional maintenance (Caltrans 2003a).

Effectiveness was calculated as:

$$\text{Effectiveness} = \frac{\text{(Solids Caught in GSRD)}}{\text{(Solids in GSRD + Bypass Solids)}} * 100\%$$

To calculate this percentage, the amount of gross solids (i.e., litter and debris) and the total amount loading to each device was measured annually. The litter fraction was then manually separated from each component. The amount of captured gross solids was defined as the total mass and volume of gross solids removed from within the device during the annual cleaning or, if necessary, incremental cleanings. The total loading was the sum of the captured gross solids and the bypassed gross solids (those gross solids that bypassed by way of overflow or by material passing through the device screen and that were captured in a mesh bag and/or mesh screen box located downstream of the pilot device) (Endicott et al 2002).

Caltrans tested the following four devices: Linear Radial (LR), Inclined Screens (IS), V-Screen (VS), and Baffle Box (BB), each with a range of configurations (3 LR, 4 IS, 2 VS and 2 BB). Two of the Linear Radial devices (LR 1 and 2), both Baffle Boxes, and three of the Inclined Screens (IS 1, 2, and 3) were tested over two years (2000 - 2002). The remaining devices have only one year of data.

Effectiveness for the devices and their various configurations differed widely over the test period (Table 1). Effectiveness values ranged from 8.9% by weight (66.7% by volume) to 100% (by weight or

**Table 1. Observed effectiveness for Caltrans screening devices. Effectiveness was determined over the course of several pilot studies (Caltrans 2003a, Caltrans 2003b, Caltrans 2005a, Caltrans 2005b).**

| Device-Configuration | Effectiveness | |
|---|---|---|
| | % by weight | % by volume |
| IS-1 | 100 | 100 |
| IS-2 | 73 - 100 | 69 - 100 |
| IS-3 | 90 - 96 | 90 - 95 |
| IS-4 | 46 | 66.7 |
| LR-1 | 100 | 100 |
| LR-2 | 87 - 100 | 56 - 100 |
| LR-3 | 8.9 | 43.7 |
| VS-1 | 98 | 88 |
| VS-2 | 93 - 98 | 91 - 95 |
| BB-1 | 93 - 97 | 87 - 90 |
| BB-2 | 100 | 97 - 100 |

volume). These differences cannot be solely attributed to differences in loading. Although some loading values exceeded the design capacity, in general, there was no relationship between loading and effectiveness (Caltrans 2003a,b and Caltrans 2005 a, b). The very low values of LR-3 were due to one design element - LR-3 was the exact same design as LR-1 except for the slope of the vault. LR-1 was designed to have a 2% slope, while LR-3 had a 70% slope. Therefore, the large momentum of the stormwater runoff forced the gross solids out of the device and into the bypass chamber (Caltrans 2005b).

Over the course of testing, many of the devices experienced high bypass proportions, screen clogging, and/or required too much maintenance to meet the approval criteria set by Caltrans. Only three units consistently met the criteria, IS-1, IS-4, and LR-1. IS-4 merited recommendation for approval despite its low initial effectiveness, as all the material in the bypass bag was sediment. Since sediment was smaller than the mesh size of the screen, this configuration was still considered 100% effective for removing trash and debris.

In general, Caltrans found that these devices can be effective to very effective in removing litter from discharges of highway stormwater runoff. Screen clogging and subsequent bypass was found to be the most common cause of failure. Therefore, a device must incorporate a screen of adequate size to prevent clogging and litter bypass during overflow events (Endicott et al 2002). Design loading rates should also consider total trash, including solids, vegetation and litter to help prevent clogging. Trash and debris storage and screen clogging prevention must be individually considered during design (Endicott et al 2002).

Prior to the pilot studies, Caltrans developed a set of goals that had to be met for devices to merit Caltrans requesting full capture certification by the LARWQCB. Three of the device configurations met all the criteria and goals outlined by Caltrans and two devices (LR-1 and IS-1) have now been certified full capture by the LA RWQCB (LARWQCB 2004).

## End-of-Pipe Screening Devices

During December 2001, the City of Los Angeles installed screens at five stormwater outlets within the Los Angeles River watershed (City of Los Angeles 2002a). As part of this study, it was required that the devices would not overflow during intense storms. This was evaluated by visual inspection. The study also measured the total amount of trash and debris held by the various screens. Visual observations made during the first three months of installation indicated that several of the devices had experienced overflow and four of the devices were substantially clogged by trash and debris. Trash and debris was also observed to be escaping underneath the screens at two of the locations. The devices were cleaned during the spring of 2002. A total of 21,355 pounds of trash was removed (Table 2).

**Table 2. Cleanout results of five trash screening devices installed by the City of Los Angeles (City of Los Angeles 2002a).**

| Site | Design | Dimensions (ft) | Volume (cf) | Weight (estimated lbs)[2] |
|---|---|---|---|---|
| 1 | Screen | 3 | 6.8 | 135 |
| 2 | Screen | 8x6 | 35 | 700 |
| 3 | Screen | 14 | 370 | 7,500 |
| 4 | Basket | 2.75x3.75x2.25 | 1 | 20 |
| 5 | Basket | 15.5x7.5x3 | 640 | 13,000 |

The City of Los Angeles concluded that while the screens could hold large amounts of trash and litter, the design of the screens would have to be modified to maximize performance without compromising hydraulics.

In addition, a British study of the effectiveness of the ROMAG™ found that the average solids loading rate before the ROMAG™ screen was 2369 g/min, while the solids concentration after the screen was 3.5 g/min, equaling a 98.5% deflection rate (USEPA 1999a).

[2] The text of the report does not explain how weight of gross solids was estimated and if the weight reflects all gross solids or just trash and litter.

## Maintenance

### Catch Basin Screens

Removal of accumulated trash occurs during regular street sweeping activities. Additional maintenance may be required in areas where flooding is a potential problem (RBF Consulting 2003). Fixed catch basin opening screen covers should be removed or opened prior to the rainy season. Hydraulically retractable designs may require additional maintenance to ensure that they work properly and do not jam (open or closed) (Gordon and Zamist 2006).

### Inline Screening Devices

Caltrans GSRDs were designed to be cleaned on an annual basis and to use maintenance equipment that is commonly available in the Caltrans maintenance fleet (Endicott et al 2002). During the pilot studies, Caltrans maintenance staff spent on average 8 to 24 hrs/person cleaning each device (Table 3). However, it should be noted that the cleaning effort required for the pilot project was much greater than expected for normal cleaning. Monitoring of the devices greatly increased the maintenance effort during the pilot studies. The majority of the devices are designed to use a vacuum truck or boom truck for cleaning (Caltrans 2003a, Caltrans 2005a) with the exception of the IS-3, which is designed to be cleaned with a front-end loader (Caltrans 2003b). The LR-2 configuration also requires the manual removal of mesh bags and shoveling of gross solids collected in the concrete vault (Caltrans 2003a). Inspections (visual observation) of the devices should occur regularly. The inspection schedule should be as follows:

- One inspection thirty days prior to beginning of rainy season (Oct 1- May 1);
- A few inspections during the rainy season. Preferably, after a rain event 25.4 mm (1 in) or greater; and
- One inspection at the end of the rainy season in conjunction with the annual cleaning (Caltrans 2003a).

**Table 3. Total number of times devices were cleaned during Caltrans pilot studies and average hours required to clean the devices.**

| Device (Site) | Total # Cleanings Year 1 | Total # Cleanings Year 2 | Avg Person Hrs/storm season | Avg person hrs/cleaning |
|---|---|---|---|---|
| LR-1 (I-10) | 1 | 1 | 24 | 24 |
| LR-2 (I-210) | 1 | $2^{XY}$ | 36 | 24 |
| LR-2 (I-5) | $2^{X}$ | $2^{Y}$ | 16 | 8 |
| LR-3 (US-101) | 3 | | 12.25 | |
| IS-1 (SR-170) | 1 | 1 | 12 | 12 |
| IS-2 (US-101) | $2^{Y}$ | 1 | 12 | 8 |
| IS-2 (I-210) | $2^{Y}$ | $2^{Y}$ | 24 | 12 |
| IS-3 (I-10) | | | 24 | |
| IS-4 (I-210) | 1 | 1 | 4 | |
| BB (I-405) | $2^{Y}$ | $2^{Y}$ | 12 | 24 |
| BB (I-210) | $2^{Y}$ | 1 | 12 | 18 |
| VS-1 (I-405) | 1 | n/a | 4 | n/a |
| VS-2 (SR 91) | 1 | 1 | 6 | n/a |

$^{X}$Device cleaned because it was >85% full; $^{Y}$Device cleaned due to observed clogging and overflow. Phase 1 GSRDs Pilot Study (Caltrans 2003a). LR = Linear Radial Screen, VS = V-Screen, IS = Inclined Screen, BB = Baffle Box.

### End-of-Pipe Screening Devices

In general, screens and trash racks have moderate maintenance requirements (USEPA 1999b). Self-cleaning units have very low maintenance requirements (USEPA 1999b). Based on their pilot study results, the City of Los Angeles recommends that manual screening devices should be maintained after every rain event that is 0.25 in or greater (City of Los Angeles 2002a).

## Costs

### Catch Basin Screens

Installation costs of entrance grate and screens are low. If cleaning can be incorporated into regular street cleaning, no additional maintenance costs will apply (RBF Consulting 2003). According to the City of Los Angeles, the price for catch basin screens ranged from $400 for a typical, manually removable unit up to $1,500 for the hydraulic-open types (City of Los Angeles 2002b). The City of Los Angeles, Department of Watershed Protection, estimated that it would require ~34,000 inlet catch basin screen covers, which would cost ~$44,200,000 over ten years (Table 4) to meet its trash TMDL requirements (Kharaghani 2003).

Table 4. Estimated costs for implementing catch basin screens within the City of Los Angeles (Kharaghani 2003).

| Capital Costs $ | Total O & M/yr $ | Capital Labor $ | Total/10 yr $ | Total/year $ |
|---|---|---|---|---|
| 34,000,000 | 3,400,000 | 6,800,000 | 44,200,000 | 4,420,000 |

### Inline Screening Devices

The cost of installing various inline screening devices developed for the Caltrans pilot study ranged from $61,560 to $345,000 (Table 5). Installation time ranged from one to two calendar months, depending on the device (Table 6). The additional installation of monitoring equipment/structures increased the final costs, but these would not likely be included for non-pilot installations. The variation in costs was related to differences in conditions at the chosen pilot study sites (Caltrans 2003a).

Table 5. Costs associated with the installation of Caltrans pilot devices. (Caltrans 2003a, Caltrans 2003b, Caltrans 2005a, Caltrans 2005b).

| Device Configuration (Site) | Drainage Area ha (ac) | Total Cost[1] $ | Cost[2] $ | Cost/ha | Cost/ac |
|---|---|---|---|---|---|
| IS-1 (SR-170) | 1 (2.5) | 100,800 | 82 800 | 82 800 | 33 120 |
| IS-2 (US-101) | 1.4 (3.4) | 150,425 | 134 351 | 95 965 | 39 515 |
| IS-2 (I-210) | 0.8 (2.1) | 151,337 | 135 263 | 169 078 | 64 411 |
| IS-3 (I-10) | 1.3 (3.3) | 370,059 | 345,000 | 265,385 | 107,400 |
| IS-4 (I-210) | 1.0 (2.5) | | 113,640 | 113,640 | 45,989 |
| LR-1 (I-10) | 1.5 (3.7) | 66,200 | 48 300 | 32 200 | 13 054 |
| LR-2 (I-210) | 2.5 (6.2) | 172,009 | 155 935 | 62 374 | 25 151 |
| LR-2 (I-5) | 0.4 (0.9) | 110,462 | 94 388 | 235 970 | 104 876 |
| LR-3 (US-101) | 0.8 (2.1) | n/a | n/a | n/a | n/a |
| BB-1 (I-405) | 1.2 (3.0) | 129,422 | 113,348 | 94,457 | 37,783 |
| BB-2 (I-210) | 0.9 (2.3) | 135,629 | 119,555 | 132,839 | 51,980 |
| VS-1 (I-405) | 1.2 (3.0) | | 61,560 | 51,300 | 20,761 |
| VS-2 (SR 91) | 0.8 (2.0) | | 75,881 | 94,851 | 38,386 |

[1]Total costs includes monitoring equipment; [2]Costs do not include monitoring equipment. LR = Linear Radial Screen, VS = V-Screen, IS = Inclined Screen, BB = Baffle Box.

### End-of-Pipe Screening Devices

The cost for end-of-pipe screening devices varies according to the size of the screen, flow rate, construction material (steel vs. plastic) and if it is manual or automatic (USEPA 1999). For example, the capital cost for a ROMAG™ automatic screening device ranged from $55,000 to $185,000 (USEPA 1999). The five manual screens installed by the City of Los Angeles had a total design and installation cost of $40,000 (City of Los Angeles 2002b) and an expected maintenance

Table 6. Number of days to install Caltrans devices. (Caltrans 2003a, Caltrans 2003b, Caltrans 2005a, Caltrans 2005b).

| Device Configuration (Site) | Working Days |
|---|---|
| LR | 21-35 |
| IS | 25-57 |
| VS | 38-45 |
| BB | 33-37 |

LR = Linear Radial Screen, VS = V-Screen, IS = Inclined Screen, BB = Baffle Box.

cost of $20,000/unit/yr (assuming 10 cleanings) (City of Los Angeles 2002b). Construction costs for screen systems include costs for installing a specialized housing unit for the screen within the pipe. This may require costly structural alterations to regulators and outfalls.

## Pros

### Catch Basin Screens

Catch basin screens are relatively easy to install and are easy to retrofit into existing catch basins. They are relatively inexpensive. Their maintenance can easily be incorporated into regular street sweeping schedules and should not add any additional maintenance costs. They can help reduce or prevent storm drain pipe blockages.

### Inline Screening Devices

The Caltrans inline screening devices can be installed in an existing right-of-way (Caltrans 2003a). Based on data gathered by pilot studies, the devices removed nearly all the trash and litter from stormwater runoff with minimal maintenance requirements (i.e., annual cleanouts) (Caltrans 2003a,b, Caltrans 2005a,b). Devices are designed to be cleaned with equipment readily available to maintenance staff. Installations can be shallow and open to air, eliminating need for confined entry. The vaults of the Caltrans devices can be configured with grates or covers, traffic or non-traffic rated, depending upon location within the right-of-way. The devices are relatively moderately priced. Screen openings can be custom sized and end-of-pipe applications have low head loss. Two devices (LR-1 and IS-1) have been certified as full capture by the LARWCQB (LARWQCB 2004). These two units only require one cleaning per year.

### End-of-Pipe Screening Devices

The cost of end-of-pipe screening devices is low compared to other structural control devices. Maintenance is relatively simple and does not involve any confined space for maintenance crews. End-of-pipe screening devices are easy to monitor as gross solids are visible. They can be designed in a wide range of sizes and shapes and accommodate a wide range of applications. Installation is simple and devices can be retrofitted into current stormwater systems. Plastic designs are lightweight, ultraviolet resistant and corrosion resistant.

## Cons

### Catch Basin Screens

Catch basin screens can contribute to flooding problems during high flows. In addition, trash is not held in one location until cleaning, it remains on the street and can be further dispersed by wind. Parked cars can impede street sweeping activities and affect the efficacy of the screen covers. If not designed or installed properly, mechanical versions may prematurely jam (open or closed). Hydraulically retractable designs required more maintenance to ensure that they worked properly and did not jam.

### Inline Screening Devices

Capital and installation costs of inlined screening devices can be relatively high. In addition, they require a relatively high surface area. Traffic control may be required during maintenance and installation. Devices should be designed to eliminate standing water which can provide breeding habitat for vectors. Baffle box designs required significant maintenance to remove accumulated sediment. Caltrans did receive complaints about the aesthetics of the baffle box during the pilot study.

### End-of-Pipe Screening Devices

Clogging can become a problem with screens. If aperture size is increased to relieve clogging, performance will decrease. Finer meshed screens can trap more material but are more susceptible to clogging. As a result, they required more maintenance. The performance of screening units is reduced significantly by the presence of oil and grease. The performance of the various designs has not been thoroughly tested. Self-cleaning devices have more parts that are susceptible to damage or malfunction.

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# Litter Booms

Tuffboom (courtesy of Worthington Products, Inc.).

## Summary

Litter booms are floatation structures with suspended curtains that are used to contain floating trash. Booms are best suited to slow-moving waters. Since more pollutants sink than float, they are only useful for trapping highly buoyant materials and can miss most of the gross solids[1] load. Maintenance is done manually, with a boom truck or with a skimmer vessel. Capital costs can range from $100,000 to $150,000 per site.

## Description/Design

Litter booms are floatation structures with suspended curtains that can be used to contain floating trash (USEPA 1999, Gordon and Zamist 2006). Booms were initially designed as oil slick retention devices (Allison et al 1998) and are still often designed using absorbent materials to collect oil and grease from the water's surface (Gordon and Zamist 2006). The size of a boom depends on the expected volume of floatables released during a storm event. Newer Australian designs use floating polyethylene boom arms with fitted skirts to deflect floating debris through a flap gate into a storage compartment (Allison et al 1997). Litter booms have a five to seven year lifespan before they are deteriorated by ultraviolet light, or are torn by captured debris (RBF Consulting 2003).

Most litter booms are installed with the boom attached to points on the opposite side of the channel with sufficient slack to allow the boom to form a semicircle. Booms are placed downstream of one or more outfalls, preferably in slow moving

[1] Gross solids are defined as "litter, vegetation, and other particles of relatively large size" (Caltrans 2003 Phase 1 Pilot Study). Litter is subsequently defined as "manufactured items made from paper, plastic, cardboard, glass, metal, etc. that can be retained by a 5 mm (0.2 in nominal) mesh screen". This definition is understood to be consistent with the LA River Trash TMDL definition of litter.

# TC-5 Treatment Control

### Litter Boom Manufacturers/ Examples

- Applied Fabric Booms
- Elastec, Inc.
- Kepner Plastics Debris Barrier
- Nautilus Marine Protection, Inc.
- Slickbar Products Co.
- Stormwater Systems Inc. (Bandalong Floating Debris Trap)
- Worthington Products, Inc. (Tuffboom)

### Implementation Point

| | |
|---|---|
| In Street | |
| Start of Pipe | |
| In Pipe | |
| End of Pipe | ✓ |
| In Creek | ✓ |
| Dispersed | |

waters (Allison et al 1997). This results in trash and debris accumulating in the middle of the boom, which is generally located in the middle of the channel, the region of highest water flow velocity. High velocities can drag collected litter under the boom. Orange County found that performance is improved by angling the boom across the channel. This allows trash to accumulate on one side of the channel, away from the high velocity region (Gordon and Zamist 2006).

- Applied Fabric Booms
- Elastec, Inc.
- Kepner Plastics Debris Barrier
- Nautilus Marine Protection, Inc.
- Slickbar Products Corp.
- Stormwater Systems, Inc., Banadalong Floating Debris Trap
- Washington Products, Inc. Tuffboom

**Figure 1. Debris Boom In-Take (courtesy of Slickbar Products Corp.).**

**Figure 2. Bandalong Floating Debris Trap (courtesy of Stormwater Systems, Inc.).**

## Applicability/Siting

Litter booms are best suited for very slow moving waters (Allison et al 1998). Despite early claims of performance (Allison et al 1998), it was later recognized that trash and debris performance is greatly reduced during high flows. This reduction is due to material being forced over and under the boom (Allison et al 1998) or the boom breaking away from the banks. Litter boom performance can be enhanced by angling booms across to the current, and by using mesh skirts. Problems still persist during high flows (Allison et al 1998). As a result, one of the most important factors to consider when siting booms is the receiving water velocity. Booms float and can move with water level fluctuations, but they can be dislodged by high river velocities and winds (USEPA 1999). Special consideration should be given to booms located in highly visible public areas. Booms potentially create unsightly conditions near outfalls and may be inappropriate in areas with waterfront development (USEPA 1999).

## Maintenance

Litter booms are cleaned manually with a vacuum truck or a skimmer vessel (Allison et al 1998, USEPA 1999). Special attention should be given to booms located in highly visible public areas (USEPA 1999). Maintenance of small booms can be achieved by pulling the boom to the bank and accessing the material from land. This method of maintenance has been conducted for some small booms but not for most installations (Allison et al 1998). The recommended cleaning frequency is every two to four weeks (Allison et al 1998). Containment booms must be cleaned after storm events. To help control floatables within Lake Merritt, the City of Oakland has installed litter booms. The Lake Merritt Institute (LMI) is under contract with the City of Oakland to coordinate litter removal. Every week, volunteers remove litter from the entire shoreline. LMI also removes trash from litter booms on a weekly basis or as needed. For some litter booms, LMI has to remove the barrier and scrape off mussels every year or two, or they will sink (Bailey R[2]. *pers. comm*.2007).

## Performance and/or Effectiveness

Results of performance and/or effectiveness studies have been mixed. Booms have been shown to trap large quantities of floatable materials. The County of Los Angeles Department of Public Works pilot tested a litter boom system at the mouth of the Los Angeles River in Long Beach. During the first two years of the pilot testing period, the litter boom system trapped approximately 150 tons urban trash and debris (County of Los Angeles 2003). Approximately 1252 tons of trash has been harvested since the installation of the litter boom system in April 2000 (Teren, E[3]. *pers. comm*. 2007). County of Los Angeles Public Works Department staff estimates that system performance is

[2] Dr Richard Bailey, Executive Director of the Lake Merritt Institute, January 2007
[3] Ed Teren, County of Los Angeles Department of Public Works Flood Maintenance Division, May 2007.

approximately 80%. During FY 2006-2007, approximately 155 tons of trash was harvested from the system. Historical trash collection data indicates a large variation in the volume of trash harvested after each storm event. Approximately 90% of trash harvested from the first storm is vegetation. The remaining 10% is mostly Styrofoam and plastics (Teren, E[3]. *pers. comm*. 2007).

**Figure 3. Los Angeles River litter boom system (courtesy of Los Angeles Department of Public Works).**

In contrast, a Melbourne, Australia study (McKay and Marshall 1993, cited in Allison et al 1998) used tagged litter items, released upstream of litter booms to determine floating boom performance. The results varied from 12% to 50% recapture. These values were considered preliminary because of the low number of items released in the boom catchments. In addition, the items released in the study were highly floatable and do not represent the complete range of items found in urban stormwater. It is expected that the figures quoted by McKay and Marshall (1993) are higher than those expected for the total trash and debris load (i.e., including submerged material) (Allison et al 1998). Other Australian studies have reported capture rates of 24 to 71 kilograms per hectare (2.47 acres) from four booms in Sydney (Gamtron 1992 in Allison et al 1998).

A four-boom containment system was tested by New York City during a two-year pilot study in Jamaica Bay, NY. Floatables were contained by the booms and collected using a skimmer vessel. An assessment of boom effectiveness was made by measuring the quantities of floatable material in the waters and on the shorelines before and after boom installations. Results showed substantial improvements from pre-boom conditions, and indicated that containment booms provide a floatables retention of approximately 75%[4]. During the two-year test period, approximately 40,640 kilograms (44.8 tons) of trash were removed from the containment area (USEPA 1999).

Alameda County installed a sea curtain/litter boom on the Oakland Slough in 1999. The City of Oakland Public Works Department removes debris an average of eighteen times per year. This frequency was higher in the early years of installation. The average amount of debris removed per cleaning is 16 cubic yards. The total debris removed to date is in excess of 3000 cubic yards. The unit has now reached its useful life and needs to be replaced (Bavinger, M[5]. *pers. comm*. 2007).

The angle and manner that a boom is attached to the shore can have an impact on its overall performance (Table 1). A recent study performed at the University of New Mexico (Ho 2005[6]) evaluated the hydraulic performance of various boom designs in an experimental flume. The study used models of the North Pino Arroyo at two different scales. Experimental booms were constructed from various materials and tested in a rectangular flume at a scale of 1:18 under four flow conditions and in a trapezoidal flume at a 1:8 scale. To simulate the boom holding piers, screws were placed into the bottom of the flume. Major design differences include the style of connection to anchor the experimental boom. Test booms were either anchored using a hinge or by drilling a hole through the boom and pinning it. Researchers found that a 30° boom barrier approach angle works better than a 45° model because the smaller angle makes a longer and better performing screening area. In addition, when bending the pier 15° from vertical to the flow direction, the boom is able to move easier (Ho 2005). The researchers also recommended a high buoyancy boom for easy floating but cautioned that turbulent flows make boom movement unstable, reducing debris-keeping capacity. Moreover, it was found that cantilevered booms with piers did not perform well because of the disturbance of the boom movement from both boom cantilevering and piers. The hinge connected boom barrier without piers, which was installed at the sidewall, showed better performance in aspects of debris retention and model simplicity (Ho 2005).

[4] This study did not attempt to evaluate all litter and trash, only the floatable portion.
[5] M. Bavinger, Watershed Program Specialist, Environmental Services Division, City of Oakland, April 2007.
[6] Authors do not give details on how debris trapping was evaluated.

Table 1. Floating boom scaled Arroyo task scenarios (1:8 scale) (Ho 2005).

| Run# | Approach | Pier Bend | Boom Design | Results |
|---|---|---|---|---|
| 1 | 45° | Vertical | PVC | Booms are submerged. All debris is passed. |
| 2 | 45° | 15° | PVC, Barriers | Booms move easier. Side boom barrier works. |
| 3 | 30° | Vertical | PVC, Barriers | Approach angle 30° is better than 45°. |
| 4 | 30° | 15° | PVC, Barriers | Best boom setup. 43% of debris is excluded. |
| 5 | 30° | 15° | PVC, Barriers | Similar results as #4. No intake entry influence. |

Allison et al (1998) found that only 20% of captured litter and less than 10% of the captured vegetation floats[7]. Since booms are only designed to capture floatable trash, a significant portion of trash in stormwater is likely not caught using these devices (Gordon and Zamist 2006). Staff and volunteers at the LMI have noted this particular problem and others with the booms installed in Lake Merritt. According to Dr. Richard Bailey, Executive Director of the Lake Merritt Institute, litter booms:

- Only allow floating trash to be easily removed (a lot of trash becomes waterlogged and sinks where it is hard to remove);
- Can be overtopped by high flows, especially if the barrier is too small for the outfall;
- Allow some material to flow underneath, especially if the barrier is too small for the outfall;
- Leak at the sides where they are attached to the wall. This is especially true because water level rises and falls. If the barrier at the attachment point does not rise and fall with the water, it will be submerged and trash will flow out; and
- Sometimes break and need to be repaired or replaced (Bailey, R. *pers. comm.* 2007)

## Costs

The New York City studies found that the installed cost of a containment boom can range from $100,000 to $150,000 per site (USEPA 1999). Capital costs for the four-boom system pilot-tested in New York City (excluding engineering costs) was $240,000, while O&M costs were $5,000 over eighteen months, not including the cost of removing the captured floatables. The capital costs for skimmer vessels used to collect captured floatables ranged from $300,000 to $700,000, including shore conveyers for transporting the vessel from site to site. Annual operating costs average $75,000 to $125,000 per boat and include vessel maintenance and repair, crew wages, fuel, insurance and disposal fees for the collected material. Disposal costs for removing floatables are heavily dependent on the type of system used for removal, boom accessibility, travel time between locations and fuel use.

According to the Los Angeles County Department of Public Works, the purchase cost of the Los Angeles River litter boom system was $48,000. The amount of money encumbered for the annual operation, maintenance (i.e., collection and disposal) and monitoring of this system is $450,000 (County of Los Angeles 2003). A contractor is responsible for operating and maintaining the litter boom system. The contractor is paid monthly for operation, maintenance and repair; and paid separately for the quantity of trash harvested. The cost of operation and maintenance and the rate for each ton of trash harvested is the following:

[7] This experiment used a CDS™ unit to evaluate how much captured gross solids were buoyant vs. non-buoyant.

Table 2. Operation and maintenance costs and rate paid for each ton of trash harvested from the Los Angeles River litter boom system.

| Season | Time Period | Cost |
|---|---|---|
| Wet Season | (10/15-4/15) | $12,992 |
| Dry Season | (4/15-10/15) | $8,500 |
| | | |
| **Trash Harvested** | **(Per Ton)** | $1,071 |

The capital costs of the sea curtain installed at the Oakland Slough was $36,000 including purchase, installation and access improvements[8] (Bavinger, M[9]. *pers. comm*). The average cost per cleanout is approximately $3,378. Average annual cleanout costs are approximately $61,000. Other factors (e.g., hazardous materials disposal, access road maintenance, sea curtain repair and adjustment, vegetation removal to maintain operation of curtain) add an additional $16,000 annually to operation and maintenance expenses. Since 1999, total costs for installation, debris removal, repair of the sea curtain, hazardous material disposal, access maintenance (new road), crane for removal, etc. is in excess of $650,000 (Bavinger, M[10]. *pers. comm*).

## Pros

Litter booms are relatively easy to install and come in a wide range of sizes and models to accommodate different situations. Litter booms can trap large quantities of floatable materials. Individual maintenance (i.e., collection and disposal) is relative simple and does not require any confined space entry.

## Cons

Litter booms do not necessarily perform well. They are designed to capture only the floatable portion of gross solids loading, which might be a very low fraction of the total loading. Smaller mesh sizes could impede capacity of the storm drain system if not designed properly. Nets which break away could reintroduce trash into the water body if not designed properly. Booms are relatively expensive and can be maintenance intensive.

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[8] Costs for labor and fees to acquire permits, design and inspect project are unknown.
[9] Ibid
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# Enhanced Street Sweeping


Street Sweeping (courtesy of City of San Jose).

## Summary

Enhanced street sweeping involves increasing sweeping frequency, targeting high trash generating areas and modernizing street sweeping equipment. Multiple sweeper designs exist including: (1) mechanical sweepers; (2) vacuum-assisted wet sweepers; (3) regenerative air sweepers; and (4) vacuum-assisted dry sweepers (Table 1). The expected lifespan of a street sweeper is 4 to 7 years. Street sweeping activities do remove significant quantities of trash from roadways, but it is unclear how much trash is prevented from entering receiving waters. Capital costs of purchasing modern equipment can range from $100,000 to $250,000+ ($2005)(Schilling 2005). The potential inability to further restrict parking in urban areas may present a major limitation to increasing street sweeping frequency.

## Description/Design

Street sweeping can minimize pollutant transport to receiving waters. Sediment, debris and trash are the targeted pollutants, but removal of other pollutants may be accomplished. Street sweeping may also prevent pipes and outlet structures within stormwater detention facilities from becoming clogged with debris and trash. Typically, commercial areas are swept more frequently than residential or industrial areas. For example, arterial, commercial and bike routes are swept either twice per month or weekly in the City of San Jose (City of San Jose 2007a), while residential areas are swept once a month on a day immediately following garbage collection (City of San Jose 2007b). Enhanced street sweeping involves increasing street sweeping frequency or focusing efforts in high trash generating neighborhoods.  Although sweeping can be performed on any paved surface (e.g., roadways, parking lots and sidewalks), targeting high trash generating areas (commercial business districts, industrial sites, and intensely developed areas near receiving waters) and adjusting the timing/frequency of sweeping are considered enhanced street sweeping practices. Other common

## IC-1 Institutional Control

### Street Sweeper Designs and Practices

- Mechanical sweeper
- Vacuum-assisted wet sweeper
- Regenerative air sweeper
- Vacuum-assisted dry sweeper
- Tandem sweeping

### Implementation Point

In Street ✓
Start of Pipe
In Pipe
End of Pipe
In Creek
Dispersed

enhanced street sweeping practices may include more frequent sweeping during August to October (City of Los Angeles 2002) or increasing sweeping before and during the rainy season (City of Los Angeles 2002). Within the Bay area, some cities may have to modify their street sweeping schedules to address the heavy leaf-fall season. For example, the City of Palo Alto sweeps streets at least weekly. However, during the fall leaf season (October through January), the City may be off schedule due to an increased work load and holidays. As a result, the City of Palo Alto recognized that weekly sweeping is impractical during these months (City of Palo Alto 2007). Street sweeping is also ideal in urban environments where space for structural stormwater controls is limited.

Currently, multiple sweeper designs exist including: 1) mechanical sweepers; (2) vacuum-assisted wet sweepers; (3) regenerative air sweepers; and (4) vacuum-assisted dry sweepers (Table 1). The expected lifespan of a street sweeper is 4 to 7 years. Vacuum-assisted and regenerative air sweepers are generally better than mechanical sweepers at removing finer sediments, while mechanical sweepers are better at removing larger debris (i.e., trash) (FHWA 2007).

**Table 1. Street sweeper design and practices.**

| Type | Description |
|---|---|
| *Mechanical sweepers* | The most common type of street sweeper. Involves a number of rotating brushes sweeping litter into a collection chamber. A rotating gutter broom removes particles from street gutters and a water spray controls dust. The particles removed are placed in front of a cylindrical broom that rotates to carry the material onto a conveyor belt and into a storage hopper. |
| *Vacuum-assisted sweepers* | This design uses a gutter broom to push particles from the street into the path of a vacuum intake that transports the dirt to the hopper. The transported dirt is usually saturated with water. |
| *Regenerative air sweepers* | Air is blown onto the pavement and a vacuum removes the mobilized particles. They include a dust separation system. Regenerative air sweepers, which are like mechanical vacuum sweepers but use recirculated air to blast the pavement, dislodging litter before it is swept by rotating brushes towards a vacuum for pick-up. This sweeper also uses water sprays for dust suppression. |
| *Vacuum-assisted dry sweepers* | These units combine the elements of a tandem sweeper into a single unit. This system is useful at industrial sites where it is necessary to have complete removal of particulate matter without leakage. A continuous filtration system prevents fine particulates from leaving the unit. |
| *Tandem sweeping* | This practice employs a mechanical sweeper (a broom and conveyer belt system) followed immediately by a vacuum-assisted sweeper. |

## Performance and/or Effectiveness

There is little published data on how much trash and litter is removed by street sweeping, or on how changing sweeping operations affects trash removal (CWP 2007). During the 1980's, USEPA supported a series of studies, the Nationwide Urban Runoff Prevention Program (NURP), to determine whether street sweeping prevented sediment associated contaminants from entering the storm drain system. The general consensus was that street sweeping was not an ideal best management practice (BMP). However, improvements in sweeper technology have caused a recent reevaluation of their performance. Recent estimates are that new vacuum-assisted dry sweepers may achieve a 50-88% overall reduction in the annual sediment loading for a residential street, depending on sweeping frequency (Sutherland and Jelen 1997). It is important to note that the focus of these studies is not on preventing trash from entering waterways, but on fine sediments and their associated pollutants (CWP 2007).

Street sweeping operations do remove substantial quantities of trash from roadways. From FY 2003-2004 through FY 2005-2006, the total volume of material removed by SCVURPPP Co-permittees during street sweeping operations ranged from 57,933 cy to 82,717 cy of material. In addition, the total volume of material removed in Contra Costa County during 2001 until 2006 ranged from 26,407.6 cy to 33,984.2 cy (EOA, Inc., 2007). One percent (by volume) of the material removed was trash (EOA, Inc. 2007). As a result, street sweeping operations in Contra Costa County annually prevented on average 306.5 cy of trash from reaching local waterways.

## Changes to Frequency and/or Timing

There is some evidence that suggests that the frequency of sweeping could increase the amount of litter removed. For example, street sweeping conducted two to three times daily in the commercial business district of Cape Town, South Africa removed as much as 99% of the total litter load (Marais & Armitage, 2003). On the other hand, sweeping selected streets in Springs, South Africa once a day removed approximately 83% (Armitage et al, 1998 in Armitage 2001).

Marais & Armitage (2004) developed a computer model of how street sweeping performance changes in response to frequency. Figure 1 shows that the predicted performance of street sweeping is based on the ratio of average days between street sweeping to the average days between significant rainfall events (from about 10 mm upwards). The model output[1] (Figure 1) indicated that once street sweeping drops below the frequency of significant rainfall events (the inter-event dry period), it intercepts less than half of the litter deposited in the streets (Marais & Armitage 2004). This led the authors to conclude that inter-event dry period is a critical factor in assigning street sweeping frequency.

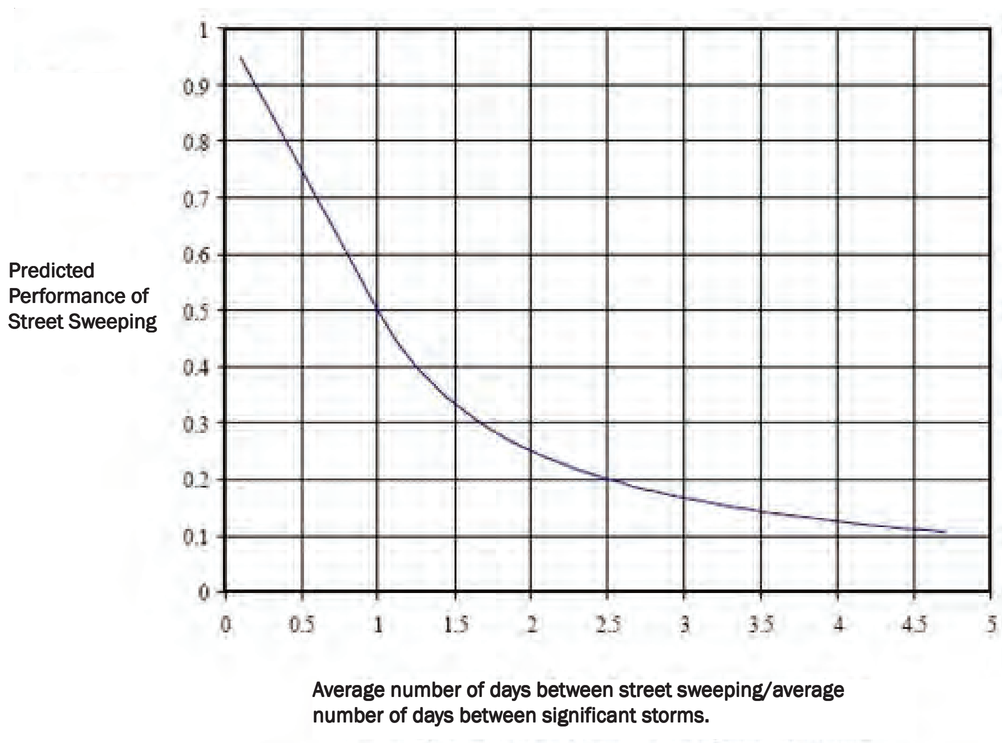


**Figure 1. Modeling results for the maximum expected performance of street sweeping (Armitage 2001).**

[1] This model assumes that street sweeping is able to remove all litter from the road; significant rainfall events are large enough to mobilize all litter remaining on the road; and catch basins have large enough openings to accommodate the largest pieces of litter. In reality, some litter will be inaccessible (e.g., "hidden" under vehicles), few rainfall events are large enough to carry every piece of litter to the catch basins, and the litter frequently accumulates at catch basins without falling into them even though the opening is nominally large enough.

An analysis of street sweeping data from certain cities in Alameda County, CA indicated that increasing street sweeping frequency and/or changing fixed sweeping schedules increases the volume of material removed. For example, the Cities of Hayward, San Leandro and Union City had statically significant increases in the total volume of material removed and the number of miles swept after implementing program changes. However, these changes did not lead to statically significant increases in removal rates (total volume collected vs. total miles swept) (EOA, Inc., 1999).

Some researchers have suggested that it is not simply the frequency that is critical to increasing performance, but also the timing of street cleaning. For example, an Australian study recorded the amount of trash generated within a 918.6 ft strip of a shopping center. Observations started at 5:15 AM, immediately after [daily] street sweeping operations and ended at 6:30 PM. The data indicated that the rate of accumulation of litter was highest between 8:00 AM and 5:00 PM, with litter accumulation effectively ending around 5:00 PM (Walker and Wong 1999). This schedule leaves twelve hours during which trash can be remobilized by rain or wind and potentially enter the storm drain system before the next round of street sweeping (Walker and Wong 1999).

## Effectiveness Study Results

While many studies have examined the effectiveness or performance of street sweepers, the majority have focused on the removal of fine particles, sediment-associated pollutants and nutrients. A few studies have specifically examined the effectiveness of street sweepers with respect to trash or how changing the frequency/timing will impact effectiveness. Nilson et al. (1997) (cited in Walker and Wong 1999)[2] assessed the effectiveness of street sweeping for trash removal in stormwater. For this study, three similar streets were swept at different intervals. Catch baskets were placed in curbside storm drains to collect trash and debris missed by the sweeper. Sweeping frequency for the study streets was the following: every day, once a week and not at all. During the study, pollutants trapped in the baskets were removed and quantified weekly (Walker and Wong 1999). The results of the study show little correlation[3] between the frequency of sweeping and the trash and debris load collected in the catch baskets. The study found that a considerable amount of trash and debris entered the storm drain system during intense rain, wind or both, irrespective of the nature of the street sweeping program (Walker and Wong 1999).

During its Litter Management Pilot Study, Caltrans conducted an assessment of the effectiveness of various BMPs, including street sweeping, for preventing litter from entering the storm drain system (Lippner et al. 2001). For this study, mechanical sweepers were used weekly in treatment areas and monthly (typical Caltrans schedules) in control areas. Sweepers were operated at manufacturer's recommended speed (5 miles per hour). This study used a paired watershed approach, with four study sites, each with three replicate pairs of catchment areas. Each catchment drained to a single pipe outfall, which had a monitoring net at the outfall. The testing was conducted over two rainy seasons (1998 - 1999 and 1999 - 2000). The difference between the treatment and control were expressed as a percent of the control (Table 2).

The effectiveness was expressed as the apparent reduction in litter discharged from treatment outfalls compared to control outfalls. Thus, negative values of apparent reduction indicate that more litter discharged from the treatment outfalls than from the control outfalls (Lippner et al. 2001).

**Table 2. Mean apparent reduction in litter entering the storm drain system due to increased frequency of street sweeping (Lippner et al. 2001).**

| | Avg Collected Dry Weight (kg/ha-yr) | | Avg Collected Volume (liters/ha-yr) | | Avg Count (items/ha-yr) | |
|---|---|---|---|---|---|---|
| | **Year 1** | **Year 2** | **Year 1** | **Year 2** | **Year 1** | **Year 2** |
| Control | 9.4 | 16.8 | 109 | 104.9 | 15272 | 17208 |
| Treatment | 12.1 | 26.7 | 103.5 | 101.4 | 16066 | 21544 |
| Apparent Reduction | -29% | -59% | 5% | 3% | -5% | -25% |

[2] There is no information on the type of sweeper used or how long the study lasted.
[3] The exact statistic is not given in the text.

Results from the study varied depending on which unit of analysis was examined (Table 2). For example, if analyzed using volume, increasing the frequency of street sweeping decreased the amount of litter entering the storm drain system. However, the opposite conclusion is drawn if analyzed solely by weight[4] (Table 2). When all the data were pooled and statistically analyzed regardless of their units[5] , there were no significant differences between control and treatment (Lippner et al. 2001). Therefore, the results from this study do not support the idea that increasing frequency would necessarily divert more litter away from the storm drain system.

## Improving/Modernizing Sweeping Equipment

Earlier studies conducted for NURP indicated that the performance of mechanical sweepers was poor for removing fine particles from roadways (USEPA 1999). The most recent technology is a vacuum-assisted dry sweeper originally developed by Enviro Whirl Technologies, Inc. A computer model developed by Sutherland and Jelen (1997) reported that this sweeper type could remove 70% of particles less than 63µm and up to 96% of pollutants larger than 6370 µm (Table 3). As more chemical pollutants are associated with fine particles, managers would likely have to make a choice between removing more trash sized particles vs. more fine particle associated contaminants.

**Table 3. Predicted street sweeping effectiveness for various particle sizes by technology (Sutherland and Jelen 1997).**

| **Particle Size Range** | **Street Sweeping Technology Effectiveness (%)** | | | | |
|---|---|---|---|---|---|
| µm | NURP era Mechanical | Newer Mechanical | Tandem Sweeping | Regenerative Air | Enviro-Whirl |
| <63 | 44 | 100 | 93 | 32 | 70 |
| 125 | 52 | 100 | 95 | 71 | 77 |
| 250 | 47 | 92 | 93 | 94 | 84 |
| 600 | 50 | 57 | 89 | 100 | 88 |
| 1000 | 55 | 48 | 84 | 100 | 90 |
| 2000 | 60 | 59 | 88 | 100 | 91 |
| 6370 | 78 | 81 | 98 | 94 | 92 |
| >6370 | 79 | 70 | 87 | 92 | 96 |

## Factors Affecting Street Sweeping Performance

The frequency of street sweeping is determined by need, the number of miles to be served, and local budget constraints. Sweeping programs tend to be implemented city-wide, not just in areas serviced by storm drains. Frequent, late fall sweepings are essential in areas with sustained winter rains (USEPA 1999). The performance of any street sweeping activity is in part dependent on the equipment used and the environmental and geographic conditions (e.g. wind and presence of parked vehicles). However, the performance of individual sweeping mechanisms can be a relatively insignificant factor in the overall performance of street sweeping operations unless other factors (e.g., street parking) are addressed (Walker and Wong 1999). According to Walker and Wong (1999), the performance of street sweeping programs depend more on land-use activities, the inter-event dry period, street sweeping frequency and timing, access to source areas and sweeper operation than the actual street sweeping mechanism (Walker and Wong 1999). These factors also influence the deposition, accumulation and removal rates of pollutants on street surfaces. Physical features which include the degree of catchment imperviousness and the hydraulic characteristics of street surfaces can also influence the performance of street sweeping. As a result, these factors require consideration before a thorough assessment of street sweeping for stormwater pollution control can be achieved (Walker and Wong 1999).

[4] A correlated conclusion might be that street sweepers are better at removing large, lighter trash items (e.g., plastic bags) but worse at removing small,heavier trash items (e.g., batteries).
[5] The pooled data from all control sites were compared to the pooled data from all treatment sites using the Wilcoxon Rank Sum Test. At the 5% level, the null hypothesis (i.e., the amount of litter collected by street sweeping twice weekly would be the same as sweeping once monthly) could not be rejected.

In practice, the performance of street sweeping for trash removal is influenced by a number of factors including: access to the street load, operator skill, sweeping speed, sweeping mechanism, time of day sweeping is conducted and weather conditions (Walker and Wong 1999). Ultimately, Walker and Wong (1999) conclude that street sweeping will continue to meet other municipal objectives (street cleanliness and aesthetics). However, there is little evidence that there will be significant improvements in stormwater quality with respect to trash resulting from changing street sweeping practices.

## Costs

The largest cost associated with street sweeping is the capital costs of purchasing the equipment, which can range from $100,000 to $250,000+ ($2005) (Schilling 2005). Total costs associated with sweeping operations can differ depending on the technology used (Table 4). Costs will also depend on sweeping frequency, number of cars on the street, degree of enforcement of parking regulations, volume of litter, and the types of labor and machinery employed. Fall sweeping programs in areas with significant leaf fall will also have additional costs. The standard hopper of a typical sweeper is about 3.5 cubic yards. Sweeping certain streets in neighborhoods with mature trees could quickly fill the hopper. As a result, numerous trips are required to sweep and haul collected materials away (Metropolitan Council 1994). During the fall months, Bay area cities have had to increase labor hours devoted to street sweeping.

**Table 4. Estimated costs associated with two different sweeping technologies (USEPA 1999).**

| | **Sweeper Type** | |
|---|---|---|
| **Features** | **Mechanical** | **Vacuum Assisted** |
| Life (years) | 5 | 8 |
| Purchase price ($2005) | 100,000 | 200,000+ |
| Operation and maintenance costs ($2005/curb mile) | 40 | 20 |
| Annualized Sweeper Costs ($2005/curb mile/year) with a frequency of: | | |
| Weekly | 2,235 | 1,260 |
| Bi-weekly | 1,120 | 630 |
| Monthly | 520 | 290 |
| Four times per year | 170 | 100 |
| Twice per year | 90 | 50 |
| Annual | 45 | 25 |

## Pros

Street sweeping in San Francisco Bay area counties has been shown to prevent large quantities of trash from entering the storm drain system. Many cities perform street sweeping activities as part of their routine municipal activities. Therefore, optimizing some aspects of street sweeping could be done with relative ease which would result in reductions of trash to the storm drain system.

## Cons

Purchasing new street sweeping equipment requires a significant investment of capital and a yearly operation and maintenance budget. Sweepers have a useful life of approximately 4 to 7 years. The potential inability to further restrict parking in urban areas may present another limitation to increasing street sweeping frequency. Additional limitations include training sweeper operators and the lack of solid evidence regarding the level of trash-related pollutant removal. Mechanical sweepers have greater requirements for maintenance than vacuum-assisted and regenerative sweepers since they possess more moving parts that require periodic replacement. Water-based sweepers require water loading, resulting in reduced operational time (Gordon and Zamist 2006). Mechanical sweepers can create large amounts of dust, while regenerative air sweepers can be very noisy. There exists trade-offs between street sweeper types (noise, effectiveness of removal of particles of different sizes). There is little evidence to support the idea that optimizing street sweeping will dramatically reduce trash loading to the storm drain system.

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Santa Clara Valley
*Urban Runoff*
Pollution Prevention Program

# Storm Drain Signage/Marking


Storm Drain Stenciling (courtesy of Agilent Technologies).

## Summary

Storm drain marking consists of labeling storm drains with simple, clear messages (i.e. "Drains to Bay") that aim to increase citizens' awareness regarding the linkages between the storm drain system and receiving waters. Storm drains may be labeled by agency staff or local volunteers. This is an inexpensive method of informing the public that water in storm drains flow untreated into aquatic ecosystems. The use of storm drain signage/marking is a widespread practice. However, there are only a few studies that evaluate the performance of signage/marking in increasing awareness, changing behaviors or reducing the amount of trash from entering the storm drain system.

## Description/Design

The goal of marking storm drains with messages is to remind citizens not to dispose of or wash unwanted materials into the storm drain. Messages are often simple phrases (e.g., "Drains to Bay" or "Only Rain Down the Drain"). Storm drain marking is a ubiquitous practice designed to keep local citizens informed about their storm drain system (Taylor and Wong 2002). Storm drains may be labeled by municipal staff or volunteers.

Municipalities can initiate storm drain marking projects throughout the community, particularly in high trash or other pollutant generating areas. To reduce costs, municipalities should prioritize which drains to mark first. Drains should be carefully selected to reach the maximum number of citizens; and include drains which lead to water bodies where illegal dumping has been identified as a pollution source (USEPA 2007).

**IC-2**
**Institutional Control**

### Sign and Stencil Types

- Painted
- Thermoplastic
- Ceramic
- Metal
- Pre-made plaques

### Implementation Point

In Street ✓
Start of Pipe ✓
In Pipe
End of Pipe
In Creek
Dispersed

In general, there are two ways to mark storm drains. Messages are either painted on to the curb using a plastic or metal stencil; or a pre-cast ceramic, metal, or plastic tile/plaque is glued to the curb. The pre-cast plaques typically last longer than the stenciled messages (TNRCC 2007). The City of Plano, Texas uses ceramic tiles to mark storm drains with the expectation that tiles will last five to ten years (TNRCC 2007). The City of Sunnyvale uses metal plaques to mark storm drains. These plaques are expected to last longer than stenciling - 7 to 10 years for plaques as opposed to 3 to 5 years for messages painted with stencils (McCumby, *pers. comm*. 2007). ACP International, which produces storm drain plaques, offers a ten year warranty (ACP International 2007).

## Performance and/or Effectiveness

Local governments have been successful at labeling many of their storm drains with educational signage. For example, Los Angeles County has over 75,000 County-owned catch basins painted with signage, while the City of Los Angeles applied thermoplastic labels to all 36,000 City-owned basins (Gordon and Zamist 2007). Locally, Bay area cities have also been actively stenciling storm drains. For example, the San Jose Conservation Corps, under contract with the City of San Jose, stenciled approximately 24,000 inlets between 2002 and 2005 (City of San José 2005).

Few studies have been conducted to determine if stormwater marking programs alter people's understanding of the linkages between the storm drain system and aquatic environments, or their behavior. One study conducted by the University of Wisconsin Cooperative Extension Service indicated that stenciling can increase people's awareness of the linkages between storm drains and receiving waters. The University of Wisconsin study surveyed two Wisconsin neighborhoods, one with stenciled storm drains and one without. Researchers observed a significant difference in understanding the relationship between storm drains and water bodies between those who had seen the markers and those who had not. Seventy-one percent who said they had seen the stenciled message understood in subsequent questioning that storm drain pipes lead directly to the nearest water body. Only 40% of those who had not seen the storm drain stencil said they knew storm drains emptied into nearby water bodies (U. Wisconsin. 1999). Other survey findings indicated that labeling storm drains raised awareness in a broader area than just the intended neighborhood. In addition, all survey respondents indicated that stenciled messages were more influential than television, direct mail, conversations with neighbors and/or conversations with agency representatives in raising awareness of general stormwater issues (U.Wisconsin 1999).

Contra Costa County recently conducted a public opinion survey to determine if its citizens understand key water issues. Key findings included:

- Approximately the same percentage of respondents remembered advertisements on stormwater pollution as in 2004. There was significant increase in respondents who recognized the newer message, "Don't pour toxins into the storm drains".
- Almost two-thirds of respondents indicated that they had seen the information on television or in the newspaper. There was a significant increase in responses indicating that they had seen messages on stenciled storm drains.
- A growing percentage (2004: 22%; 2005: 25%) were able to correctly answer that the contents of their storm drains go directly to surrounding water bodies without being treated (CCCWP 2005).

## Costs

Total costs for storm drain signange and marking is quite low. Mylar stencils cost about 45 cents per linear inch and can be used for 25 to 500 stencilings, depending if paint is sprayed or applied with a brush or roller. Permanent signs are more costly. Ceramic tiles cost $5 to $6 each. Earthwater, a Hayfork, California company that produces storm drain stencils, charges $18/pre-designed 20" x 30" Mylar stencil (for orders of 50 or more). Earthwater expects that each stencil should be sufficient to mark approximately 25 storm drains (Earthwater

2007). For custom design stencils, there is a one time fee of $30 or $200 depending on the complexity of the design (Earthwater 2007). Longer lasting metal stencils can cost $100 (TNRCC 2007). Permanent adhesive plaques have higher initial capital costs. For example, ceramic tiles that are glued to curbs can cost $5 - $6 each (TNRCC 2007). The total estimated capital costs for marking 100 storm drains with pre-made plaques is higher than those associated with stencils (Table 1).

Costs associated with pre-made plaques tend to be higher than those associated with the stencil/paint style (Table 1) (WATER 2007). Other costs to consider include hiring staff to manage and maintain programs; and the monitoring of storm drains with plaques or stencils. Local businesses are often asked to donate money to help defray costs. Despite higher initial capital costs, plaques may be less expensive than painted messages in the long term due to their longer lifespan and reduced maintenance requirements

Table 1. Capital costs associated with stormwater signage or marking programs (www.watershedactivities.com).

| Item | Estimated Cost for 100 storm drains. |
|---|---|
| Pre-made plaque/sign | |
| Pre-made markers | $150-$450 (depending on size, quality, and if a custom message is added) |
| Wire brushes (3) | $9.00 |
| Door hangers | $25.00 |
| Glue | $50.00 |
| Hand cleaner (optional) | $5.00 |
| Traffic safety vests (optional) | $10.00 each |
| TOTAL ESTIMATED COST (without optional items): | $234-$534 |
| | |
| Stencil | |
| Stencil | $5.00-$45.00* |
| Paint | $40.00-$60.00** |
| Paint brushes and stirrers | $0.00-$25.00 |
| “WET PAINT” signs | $3.00 |
| Masking tape | $5.00 |
| Drop cloth | $12.00 |
| Paint Remover | $10.00 |
| Wire brushes (3) | $9.00 |
| Door hangers | $25.00 |
| Hand cleaner (optional) | $5.00 |
| Traffic safety vests (optional) | $10.00 each |
| TOTAL ESTIMATED COST (without optional items): | $109-$194 |

*Cost is dependent on whether you are creating your own or purchasing a pre-made stencil.
**Cost is dependent on paint quality and if you are using spray paint and/or applying a background paint.

## Pros

Storm drain marking programs can raise citizens' awareness and understanding of how trash enters storm drains and waterways. There is some evidence that marking may prevent large quantities of trash from being deposited in waterways. Storm drain marking helps address the ultimate source of litter - individuals. They are relatively inexpensive and can also be a net cost benefit to government run litter control programs. Storm drain marking events can be a good initial project for a volunteer group, as long as safety and liability issues are addressed and permitted by the municipality. Pre-cast tiles/plaques can last for many years.

## Cons

It is very difficult to measure the actual effect that storm drain marking programs have on people's behavior. It is imperative to have a thorough understanding of local attitudes and behaviors before designing and determining program performance. Some cities may not want to implement storm drain marking programs with volunteers due to potential liability issues. This usually involves a large marketing/social behavior study. The legibility of plaques and signs must be maintained. If a storm drain marking program is run as a volunteer program, coordinators must be skilled at recruiting and organizing volunteers to provide adequate coverage in larger communities. Municipalities may prefer permanent tiles/plaques over stencils since they are neater and easier to read from a distance. However, permanent signs can be more expensive than painted stencils. Tiles or plaques can be dislodged by pedestrian traffic if disturbed before the glue dries.

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# Education and Outreach


National Education and Outreach Programs (courtesy of Don't mess with Texas (left), Litterbug.org Pennsylvania (top), Don't Trash California (bottom), and Keep America Beautiful, Inc. (right)).

## Summary

Education and outreach programs are designed to teach people about the impacts of littering or illegal dumping; and eventually, change their behavior. Programs usually include a mixture of anti-littering messages which are broadcast on television or radio, posted on billboards, and printed in newspapers or flyers. These programs are usually reinforced with the development of classroom curricula, storm drain signage, volunteer cleanups and toll-free telephone hotlines for reporting illegal dumping. Costs associated with these programs can be moderate to expensive. To effectively target audiences, program managers need to have a strong understanding of the behaviors and attitudes of litterers before developing an outreach program. Programs can change people's attitudes, but implementation needs to be consistent over time to maintain performance.

## Description/Design

Education and outreach programs are designed to raise the awareness and concern of citizens about trash issues within their communities. Their goal is to change individual behaviors and reduce the amount of trash that is improperly disposed. Postings, signs, billboard, and television/radio advertisements discourage citizens from illicitly or negligently disposing of trash. There is usually a toll-free telephone number established so concerned and informed citizens may report trash-related issues. Education and outreach programs are often one component of more extensive public information and participation programs.

Many states and larger urban areas have anti-littering education programs. Improving community aesthetics is often the main goal of trash education and outreach programs, not necessarily reducing stormwater pollution. However, many government entities, including stormwater programs, have implemented

## IC-3 Institutional Control

### Education and Outreach Programs

- Don't Trash California
- Erase the Waste
- Keep America Beautiful
- Don't Mess with Texas
- Don't Be A Litterbug
- Washington State Department of Ecology

### Implementation Point

In Street
Start of Pipe
In Pipe
End of Pipe
In Creek
Dispersed ✓

education programs to prevent trash from entering waterways. Because these programs aim to address the ultimate source of trash (human behavior), they are considered to be a core element of trash control efforts.

> "This is by far the most crucial element of any litter reduction plan. It is a better investment to educate litterers out of their habit than to go around just picking up after them" (FCSHWM 1998).

Some examples within California include:

## "Don't Trash California":

Don't Trash California was a statewide effort implemented by the California Department of Transportation (Caltrans) Storm Water Management Program. Its main goal was to reduce the amount of litter from entering highway storm drain systems. The campaign was based on Caltrans' successful three-year, public education pilot program completed within the Fresno metropolitan area in 2003.

The campaign used a comprehensive, multi-cultural approach which targeted primary offenders of highway littering and the general public. It strived to create communities in California that do not tolerate freeway and highway littering. The campaign, which was conducted in accordance with the National Pollution Discharge Elimination Systems (NPDES) permit requirements, used media advocacy, special events, partnerships, advertising, public service announcements and community outreach to raise the level of awareness of the effects of littering and encouraged the public to stop littering.

As part of its FY2005-2006 anti-littering outreach campaign, Caltrans developed television Public Service Announcements (PSAs) in English and Spanish. Many municipalities within Santa Clara County obtained copies of the PSAs for airing on their public access television stations. The following table includes the number of times the PSAs were aired in Santa Clara County cities.

**Table 1. FY 2005-2006 Public Service Annoucements airings in Santa Clara County.**

| Name of Community[1] | Name of TV Station | Area Served | Number of Airings |
|---|---|---|---|
| Palo Alto, East Palo, Atherton, Menlo Park, Stanford | The Media Center, Channels 27, 28, 30 | Palo Alto, East Palo, Atherton, Menlo Park, Stanford | English – 223<br>Spanish - 86 |
| City of Cupertino | The City Channel | Cupertino | English – 125 |
| City of Santa Clara | City of Santa Clara, Channel 15 | Santa Clara | English – 900 |
| City of San Jose | Civic Center TV | San Jose | English - 25 |

## 'Erase the Waste' Campaign (Los Angeles):

In 2003, the State Water Resource Control Board started the "Erase the Waste" Campaign within the Los Angeles region. The two-year outreach campaign encouraged County of Los Angeles residents to take ownership of their communities; reduce stormwater pollution from the local landscape; and be part of the "pollution solution" by adopting simple, everyday actions. In addition to advertising, the Campaign includes media relations, partnerships (with retailers, corporations and nonprofit organizations), classroom and service learning projects and a "hands-on" community engagement campaign that enlists community stakeholders to bring pollution prevention information and activities into their neighborhoods (SWRCB 2006).

The Erase the Waste Campaign developed the California Storm Water Toolbox to help teach residents, community and civic groups, educators, municipalities and public agencies about the negative aspects of trash and how to prevent it from entering waterways. Strategies implemented to date include:

[1] Includes San Mateo County cities.

- Advertisements, posters, collateral materials and a comprehensive Neighborhood Action Kit in English, Spanish, Chinese, Korean and Vietnamese - a comprehensive "How-to" guide for community-focused pollution prevention;
- A landmark Water Quality Service Learning Model for grades 4-6 that meets the state's curriculum standards;
- The Water Quality Detectives After School Program, an adapted version of the curriculum for middle school and after school settings; and
- The California Storm Water Resource Directory, an on-line inventory of storm water materials developed in partnership with the California Storm Water Quality Association (www.swrcb.ca.gov/erasethewaste/).

Examples of other education and outreach programs/campaigns include:

- Keep American Beautiful, Inc. (www.kab.org) - A non-profit organization whose network of local, statewide and international affiliate programs educates individuals about litter prevention and ways to properly manage waste. In 1970, Keep America Beautiful released the "Crying Indian" PSA, which has been one of the most successful PSAs in history. The City of San Jose is a local Keep America Beautiful affiliate.
- Don't Mess with Texas (www.dontmesswithtexas.org) - An anti-highway litter campaign organized by the Texas Department of Transportation. In addition to creating anti-littering messages, this campaign collaborates with Texas Adopt-a-Highway and Keep Texas Beautiful.
- Don't Be a Litterbug (www.litterbug.org) - Anti-litter campaign developed by the Pennsylvania Resources Council (PRC). This campaign is known for its caricature of a litterbug with a fuzzy body and mischievous look. The caricature has been used by Keep America Beautiful, Inc. and the Pennsylvania Department of Environmental Protection in anti-littering campaigns.
- Keep it Clean! (www.savesfbay.org) - An education campaign developed by Save the Bay. This campaign was developed to educate residents about runoff flowing into San Francisco Bay. The goal of the campaign is to change behaviors which reduce pollutants from reaching the watershed and Bay.

## Performance and/or Effectiveness

It is difficult to measure the impact of education and outreach programs on people's behavior and on trash loadings to waterways. Despite the widely acknowledged necessity of conducting these programs to achieve trash reduction goals, there is little quantitative information regarding how programs measure up to their stated goals. The most common method to evaluate performance is through telephone interviews before and after education campaigns. For example, to determine if its "Don't Mess with Texas" message was reaching Texans, the Texas Department of Transportation has conducted questionnaire-based studies. The 2005 study found that the percentage of people who could recall ads or public service announcements with anti-littering messages was 55%, a decrease from previous years (e.g., recall was 72% in 2003) (TxDOT 2005). The survey also found that in 2005, 71% of respondents could correctly identify the meaning of the "Don't Mess with Texas" slogan (TxDOT 2005). This slogan was most likely to be seen on television (51%) or on a billboard (42%) (TxDOT 2005). When respondents were asked if they would litter after hearing anti-littering messages, 89% said they would be unlikely and 94% said they would properly dispose of their litter. These results indicate that the "Don't Mess with Texas" message is reaching residents of Texas and potentially changing their behavior.

In California, several outreach campaigns have been conducted to educate residents about trash and its impacts on the environment and communities. Caltrans conducted a two year (2001 - 2003) pilot program to test its education and outreach program in Fresno (Caltrans 2003). To track the performance of the program, 830 residents (English and Spanish speakers) were interviewed just prior to the education campaign and interviewed again two years later (Caltrans 2003). The main goal of the evaluation was to understand whether the residents' knowledge and attitudes had been impacted by the education campaign. With English speakers, there was a statistically significant increase in two areas: the number of people who thought litter was bad; and the number of people who recognized that cigarette butts are the most commonly littered item. With Spanish speakers, there was only a statistically significant increase in the number of people who thought litter was a major problem. At the end of two years, there was no statistically significant increase in the number of people who could identify the fines associated with littering. There was also no increase in the number of people who were aware that litter can end up in the storm drain system.

The State Water Resource Control Board's education and outreach program, "Erase the Waste", was successful in reaching a large number of people and showed signs of changing people's behaviors (Mays 2005). According to an August 2004 countywide assessment study on Los Angeles County polluting behaviors, ~one-third of Los Angeles County residents have changed at least one of their polluting behaviors in the past year and ~50 percent of residents have been more active in neighborhood cleanup activities in response to messages they have seen or heard (Mays 2005). The assessment also found that the message was reaching its target audiences - more than 70% of all Los Angeles County adults aged 25 to 54, and men 18 to 24, were reached through the campaign's multimedia advertising. Media coverage surrounding the campaign reached an approximate audience of 3.5 million.

There are, however, weaknesses with using questionnaires to evaluate program performance. The results of questionnaires may indicate that messages are reaching large numbers of people, but the behavior of people does not always match their responses. For example, an Australian study found that 78% people who had just been observed littering later claimed that littering was a 'very important" or "extremely important" environmental issue (BIEC 1997 in Taylor and Wong 2002). Furthermore, very few outreach programs have quantified how behavioral or attitude changes have led to reductions in trash loadings to waterways. During the Caltrans pilot program in Fresno, an attempt was made to rigorously quantify whether the education program was reducing the amount of litter in the storm drain system. Monitoring nets were placed at outfalls and in catch basins in fourteen highway locations. Contents of the nets were regularly collected, dried and weighed. Data indicated that loadings to these sites actually increased over the study period. However, Caltrans found that factors like increases in traffic confounded the analysis. Furthermore, the statistical analysis showed that four to five years of post-program monitoring would be needed to properly evaluate the program's performance.

In the spring of 2002, Washington State Department of Ecology began a targeted advertising effort to reduce litter. This campaign built upon the results of a previous (1999) Litter Study. As a result of the 1999 study, a new slogan, "Litter and it will hurt", was aimed at the demographic group most likely to litter: males and young adults. The slogan appeared statewide on billboards, freeway signs and litterbags. Thirty-second television and radio spots were aired statewide during professional baseball games (WSDE 2005). One of the goals of the 2004 Study was to gauge the success of its advertising campaign and adapt future efforts, as needed.

The study found that between 1999 and 2004:

- The estimated amount of litter on roadways decreased from 8,322 tons to 6,315 tons; and,
- the estimated amount of litter on interchanges decreased from 617 tons to 443 tons in 2004 (WSDE 2005).

Overall litter generation on interchanges and on county roads exhibited a strong downward trend, but there was no statistically significant[2] decrease in litter generation on all roadways combined, or on roadways individually. Several components of litter showed statistically significant decreases on all roadways combined including:

[2] The observed differences in litter generation across all sites sampled in 1999 and 2004 were compared to the *expected increase* in litter generation from 1999 to 2004. The expected increase was based on Washington State Department of Transportation data showing a relative increase in miles driven in Washington from 1999 to 2004. To apply the tests, it was assumed that littering behavior (or litter generation per mile driven) remained unchanged since 1999. Therefore, there would be an increase in litter accumulation in 2004 due to the increase in miles driven. If the observed difference was less than the expected difference, it was possible that litter generation per mile driven in 2004 was less than in 1999. If the difference between the observed and expected litter generation was large enough (and the variability in observed differences between sites was small enough), the change was labeled as statistically significant.

- All beverage containers combined (43% reduction);
- Glass beverage containers (47% reduction);
- All alcoholic beverage containers combined (30% reduction); and
- Glass alcoholic beverage containers (30% reduction) (WSDE 2005).

Washington State Department of Ecology (WSDE) also established a litter hotline so citizens could report littering incidents they witness (e.g., people throwing litter from vehicles or litter being dispersed from an unsecured load). WSDE operates the litter hotline in cooperation with the Washington State Patrol and the Washington State Department of Licensing. It uses a caller's information to check the license plate number and car description with information in the Department of Licensing vehicle registration system. If the plate and description match, the Washington State Patrol sends the vehicle owner a letter notifying them of the incident and associated fines for littering (WSDE 2007). Every call received by the WSDE is processed. However, not every call results in a letter to the vehicle owner. Letters are not sent when the call was disconnected, the license plate number had no "match", the report was a duplicate or the vehicle was from out-of-state.

Since its inception in 2002, calls to the hotline have increased significantly, averaging 1200 calls a month (Warfield 2006). During one month, the hotline received 59,410 calls. These calls resulted in 45,307 letters being sent to the vehicle owner (Warfield 2006).

In June 2005, WSDE began inserting a postage-paid postcard survey with each hotline letter to track how litterers responded to getting the warning letter. As of April 2006, 683 postcard surveys had been returned (8-10% return rate). Thirty-three percent of respondents admitted to littering while 66% denied the behavior (Warfield 2006). The majority of respondents (68%) believe they are somewhat or very likely to get caught and fined, while only 30% of the general population held such beliefs. A very large majority of respondents (92%) said they would not likely to litter again.

The success of outreach also depends on the communication method used. When developing education and outreach programs, it is important to note that there is variability in how different media influences people. Taylor and Wong (2002) summarized citizens' responses on how the chosen communication method influenced their behavior with regards to watershed improvement education and outreach campaigns (Table 2). In

Table 2. Survey results on the relative performance of communication strategies (Various sources compiled by Taylor and Wong 2002).

| COMMUNICATION METHODS RANKED BY DEGREE OF INFLUENCE | | | | | | | |
|---|---|---|---|---|---|---|---|
| US SURVEYS | MOST INFLUENCE | | | | | LEAST INFLUENCE | |
| Chesapeake Bay, Maryland and Virginia | TV | TV Ad | Newspaper Local Paper | Video | Brochure | Local Cable | Meeting |
| Washington | TV Ad | TV | Newspaper | Radio Ad | Brochure Radio News | Paper Ad | Billboard |
| Oregon | Direct Mail | TV Ad | Newspaper | Radio | TV | Bill Insert | Newsletter Local Paper |
| California | TV Ad | Stencils | Billboard | Local Paper | Brochure | Radio Ad | Bus Sign Direct Mail |
| California | TV | Newspaper | Radio | Magazine | Neighbors | School | Billboard brochure |
| Michigan | TV | Newspaper | Cable TV | Local Paper Newsletter | Video | Meeting | Brochure |
| Wisconsin | TV | Newspaper Newsletter | Brochure | Site Visit | Video | Meeting | - |
| Minnesota | Direct Mail | TV | Neighbors | Extension | Radio | Meeting | Local Cable TV |

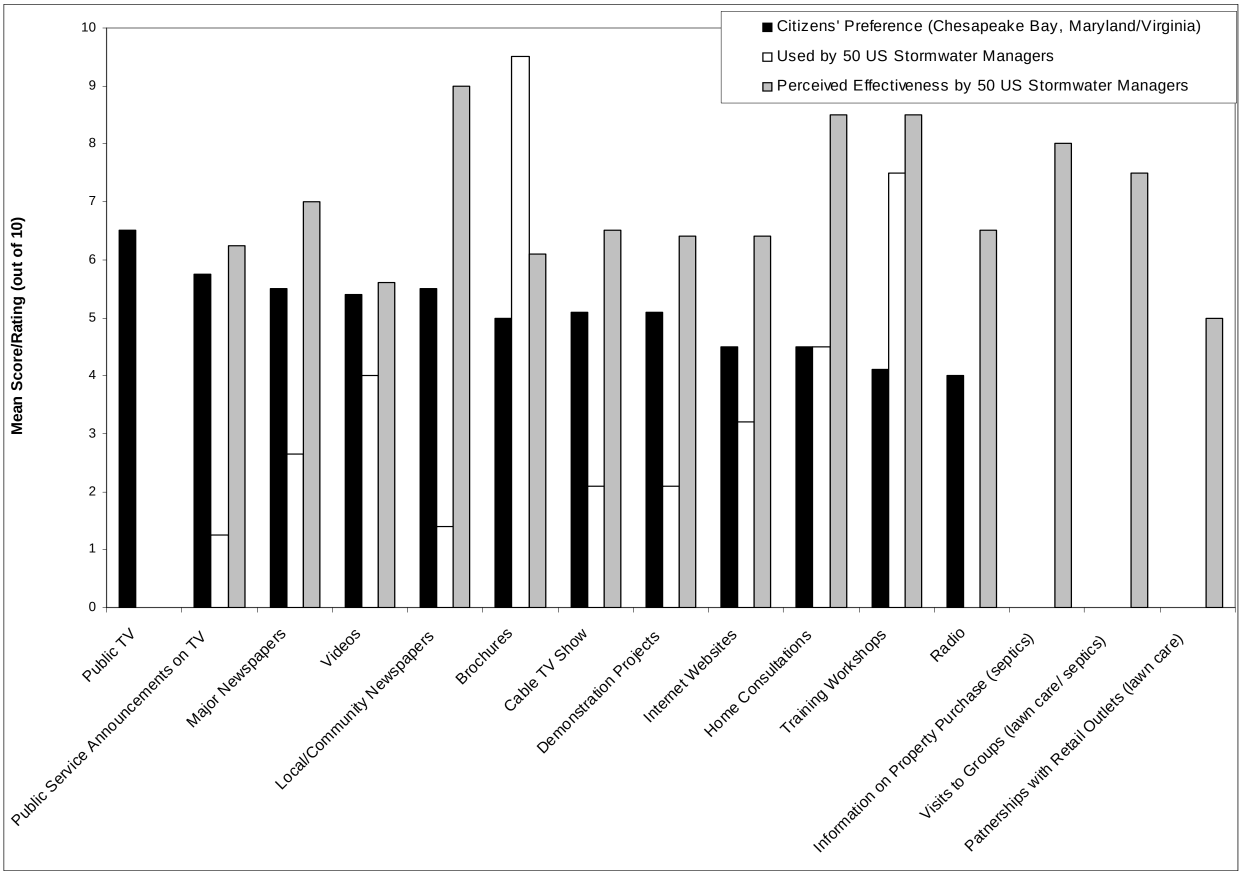


**Figure 1. Communication methods used in US education and outreach campaigns for reducing nutrients in stormwater runoff from urban areas.**

most cases, television was cited as having the most influence. Brochures and training workshops were the most widely used communication methods, but residents gave these methods a moderate to low rating (i.e. a score =5 out of 10) (Figure 1). Interestingly, stormwater managers choose methods of communication that they do not perceive to be the most effective. For example, public service announcements on television, major newspapers and community newsletters have a low degree of use by stormwater managers (i.e., a score < 3 out of 10) but are perceived by stormwater managers to be highly effectiveness (i.e., a score > 6 out of 10) (Taylor and Wong 2002). It is likely that high costs associated with some forms of communication prevent stormwater managers from using the most effective methods.

For outreach and education campaigns to be successful, there must be an understanding of the behaviors of people who do (or do not) litter (Groner 2007). This helps to focus efforts and target problem litterers more effectively (Groner 2007). In addition, education and outreach programs must be maintained. Some programs may take up to 15 years before they show measurable differences in behavior (NJCCC 2005). Any hard won gains made through an outreach program can be lost very quickly when programs are curtailed. For example, when the State of Washington cut funding to its outreach program, littering rates climbed, wiping out a third of the litter rate reduction that had been achieved (WSDE 2005). Since populations grow and change over time, programs need to be maintained, and regularly evaluated and adapted to maintain performance.

## Costs

Education and outreach program costs and funding sources vary depending on the level of organization of the program (small, local volunteer efforts to multi-agency, state supported and staffed programs). Some programs rely on contributions from individuals and corporate support, while others use funds generated through enforcement of regulations, fines or taxes. For example, WSDE's Community Litter Cleanup Program aids counties with the cost of picking up litter, cleaning up illegal dumps and providing anti-littering messages. This program is funded through taxes paid by grocery and drug stores, fast food restaurants, wholesale beverage companies and paper companies. WSDE's budget for 2007 until 2009 is $2,604,000. Monies will be used for litter and illegal dump cleanup and education activities (WSDE 2006). The Department of Ecology's litter hotline costs ~$65,000 a year (costs are based on 2006 call rate and include a contract with a call center, AT&T bills, postage, staff time and a small charge from Department of License to access their system) (Warfield 2006).

California's Erase the Waste Campaign had a budget of $5 million. Approximately fifty percent of the budget was spent on advertising (SWRCB 2004). The Campaign was funded from California's Cleanup and Abatement Account (CAA), which derives funds from court judgments and administrative sanctions levied against corporate, government and industry polluters. By law, all CAA funds must be used for clean water purposes and are not taxpayer dollars (SWRCB 2004). An estimate of the total annual cost per capita of various advertising-based litter reduction programs range from $0.35 to $1.22 (NJCCC 2005).

Examples of other education and outreach budgets include:

- Don't Mess with Texas = Texas Department of Transportation's Litter Education budget originally $2 million, reduced to $1.5 million
- Don't Be a Litterbug (Pennsylvania) = $600,000 annually, collected from a $2 tipping fee at landfills and incinerators.
- Don't Waste Utah = Utah Department of Transportation's Litter Prevention campaign's typical annual budget:
  - Media = $75,000
  - Public Relations = $55,000
  - TV Production = $45,000
  - Collateral Materials = $10,000
  - Contingency = $5,000
  - Total = $190,000

## Pros

There is some evidence that programs can prevent large quantities of trash from being deposited in waterways. They can raise citizens' awareness and understanding of how trash can enter storm drains and waterways. Education and outreach programs address the ultimate source of litter - individuals. They can also be a net cost benefit to government run litter control programs.

## Cons

It is very difficult to measure the actual effect that programs have on people's behavior. Programs need a thorough understanding of the attitudes and behaviors of local audiences. Before a program can be designed and evaluated, a large marketing/social behavior study should be conducted. Programs need to be implemented for long periods before any effects are observed. They also need to be maintained since gains made will quickly be reversed. Performance is maximized when done in conjunction with other trash reduction efforts. Outreach programs are expensive.

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Santa Clara Valley
*Urban Runoff*
Pollution Prevention Program

# Volunteer Cleanup Efforts

Creek Cleanup .

## Summary

Individuals or community groups, which are often supported by corporate and/or government sponsors, conduct routine trash cleanups of creeks, rivers and beaches; and adopt and cleanup specific trash problem areas. Volunteer cleanup efforts have been successful in removing large amounts of trash from waterways and increasing citizen's awareness of trash issues within their communities. These efforts are relatively inexpensive since they rely mostly on volunteer labor and corporate/private sponsorship. Cleanup programs also save taxpayers money because volunteers are doing the work usually conducted by government entities.

## Description/Design

Individuals, community groups and local organizations typically convene for one to two days a year to remove trash from a particular site (e.g., beach, river or creek). Clean up days are often organized to promote environmental awareness and usually coincide with Earth Day (April 22) (Gordon and Zamist 2007). In addition, groups may 'adopt' an area (a creek or a stretch of highway) and commit to keeping it clean over a specified period of time. Some programs are considered cleanup and abatement efforts since they are conducted frequently by local government and nonprofit organizations. Some examples of volunteer clean up efforts include the following:

### The California Coastal Cleanup Day

The California Coastal Commission has been organizing California's Coastal Cleanup Day since 1985. Many municipal agencies participate by organizing local beach and creek cleanups.  This event occurs annually on the third Saturday of September. It is the largest volunteer event within the State of California (Gordon and Zamist 2007).

## IC-4 Institutional Control

### Volunteer Activities

- California Coastal Cleanup Day
- Keep America Beautiful
- National River Cleanup Day
- Adopt-A-Creek
- Adopt-A-Highway

### Implementation Point

In Street
Start of Pipe
In Pipe
End of Pipe
In Creek
Dispersed ✓

## Keep America Beautiful

Keep America Beautiful (KAB) is a nationwide program that organizes communities into local affiliates. KAB has a variety of programs which encourage volunteers to keep their roadways, towns and waterways free of litter. One KAB program, the Great American Cleanup™, organizes community members to pick up litter and conduct other community beautification projects (e.g., planting trees). KAB also offers a range of other educational products including school curricula and educational/program materials. They also organize the Keep America Beautiful National Conference and regional forums.

## Performance and/or Effectiveness

Public Information and Participation (PI/P) programs have successfully attracted citizens to participate in regular clean up efforts. Keep America Beautiful measures performance by tracking the total rate of volunteer participation and the total amount of litter and debris collected. In 2006, 2.2 million volunteers from 15,000 communities nationwide collected 228 million pounds of litter from Great American Cleanup™ activities (Table 1). In addition, sites adopted by the KAB program were 8.5% cleaner than non-KAB sites (NJCCC 2005). When sites were broken down into freeway/rural and urban street categories, the urban KAB sites had a 10.3% lower rate (items/mile), while the freeway/rural KAB sites had 7.4% lower rate (items/mile) (NJCCC 2005).

**Table 1. The results of the 2006 Great American Cleanup, sponsored by Keep America Beautiful and its national sponsors. These figures were derived from reports obtained from participating organizations and describe the extent of their volunteer participation (www.kab.org).**

| Category | Total |
|---|---|
| Events/Volunteers | |
| Volunteers participated: | 2,200,000 |
| Volunteer hours: | 7,530,000 |
| Communities involved/events: | 15,000/30,000 |
| Cleanups | |
| Pounds of litter & debris collected: | 228,000,000 |
| Miles of roads, street & highways cleaned: | 165,000 |
| Miles alongside RR tracks cleaned: | 1,900 |
| Acres of parks & public lands cleaned: | 65,400 |
| Miles of hiking, biking & nature trails cleaned: | 3,900 |
| Playgrounds & community recreation areas cleaned/restored/constructed: | 3,900 |
| Miles of rivers, lakes & shoreline cleaned: | 6,120 |
| Underwater cleanups conducted: | 185 |
| Acres of wetlands cleaned & improved: | 1,100 |
| Illegal dumpsites cleaned: | 10.200 |
| Junk cars removed: | 18,100 |

The California Coastal Commission tracks the rate of participation in its annual Coastal Cleanup Day. In 2005, 52,000 volunteers across California helped remove over 971,000 pounds of debris from 2,028 linear miles of shoreline (both inland and coastal areas) (CCC 2006). Since 1985, California Coastal Cleanup Day has involved approximately 700,000 volunteers. A total of 11,023,594 pounds of debris has been removed (CCC 2007).

In Santa Clara County, the Creek Connections Action Group (CCAG), a consortium of public agencies and non-profit organizations, conduct two volunteer creek cleanups (i.e., National River Cleanup Day and Coastal Cleanup Day) a year. Organizing agencies include the Santa Clara Valley Water District, Santa Clara County Parks and Recreation and the City of San José. The CCAG was formed in the fall of 1995 by several local agency coordinators whose goal was to collaborate their creek cleanup efforts (SCC 2007). Since its inception in 1992, National River Cleanup Day (held the third Saturday in May) has motivated more than 400,000 volunteers to cleanup 4,738 sites covering more than 95,000 miles of waterways through out the United States (SCVWD 2004).

Since September 1998, SCVURPPP has sponsored these two major volunteer creek cleanups. Cleanup efforts have consistently removed large amounts of trash. For example, approximately 15,700 volunteers have removed 503,903 pounds of trash and recyclables from 412 urban sites, thus making a considerable contribution to maintaining the environmental health of local creeks[1] (Table 2).

**Table 2. Summary results of creek clean-up events , September 1998 - May 2007 (SCVURPPP 2007).**

| | FY 98-99 | FY 99-00 | FY 00-01 | FY 01-02 | FY 02-03 | FY 03-04 | FY 04-05 | FY 05-06 | FY 06-07 | Annual Average | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of sites | 35 | 35 | 41 | 37 | 48 | 56 | 61 | 55 | 44 | 46 | 412 |
| No. of volunteers | 1,877 | 1,586 | 1,745 | 1,742 | 2,091 | 1,943 | 1,618 | 1,458 | 1,631 | 1,743 | 15,691 |
| Lbs. of recyclables | | | | 13,750 | 8,071 | 6,537 | 7,890 | 4,110 | 15,394 | 9,292 | 55,752 |
| Lbs. of trash | 84,582 | 43,475 | 58,108 | 59,340 | 44,883 | 36,718 | 39,730 | 29,248 | 52,067 | 49,795 | 448,151 |
| **Total lbs. collected** | 84,582 | 43,475 | 58,108 | 73,090 | 52,954 | 43,255 | 47,620 | 33,358 | 67,461 | 55,989 | 503,903 |

Beginning in FY 2001-2002, some site managers implemented procedures for separating recyclable materials from trash. As a result, the total pounds of material collected are the sum of recyclables and trash. According to the Santa Clara Valley Water District, this procedure is done more frequently at Coastal Cleanup event sites than at National Rivers Cleanup Day sites. Since this procedure is not done at all sites, it is more appropriate to compare the total quantities of materials collected rather than the individual components.

While it is difficult to accurately measure the performance of volunteer cleanup efforts, one indicator of performance is the change in the amount of trash collected (Figure 1). Removal effort represents the total amount of trash collected (in pounds) normalized to the number of clean up sites (which increased over the years) (Figure 1). While there are many factors that might contribute to the observed decrease, it can be assumed that clean up efforts are contributing to the reduction of accumulated trash in creeks.

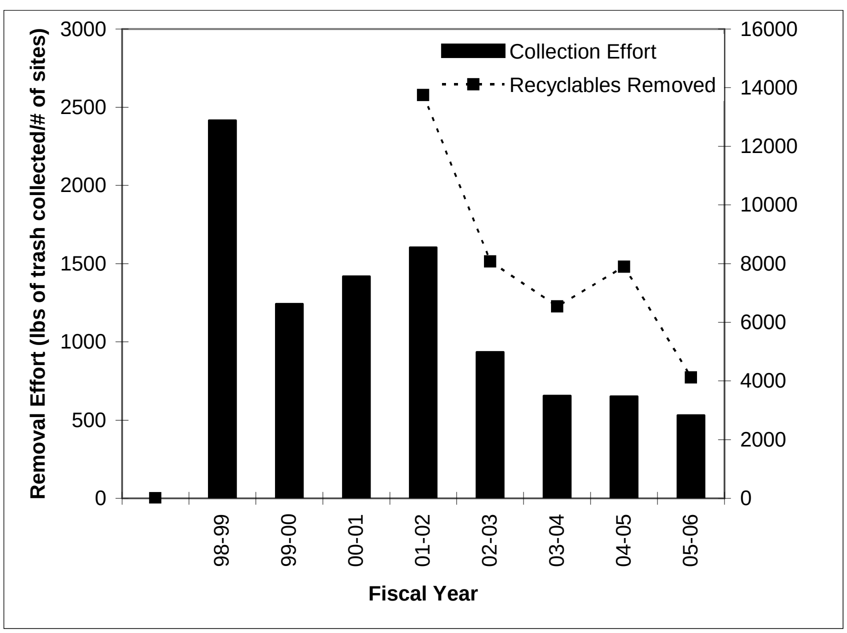


**Figure 1. Changes in the total amount of litter collected during volunteer creek clean up efforts in Santa Clara County, normalized to the number of sites at which collection occurred.**

[1] This data represents the total quantities from the two major creek cleanup events conducted in Santa Clara County. This data does not include quantities of trash that may have been collected by the Santa Clara Valley Water District (SCVWD) or by other volunteer groups during other times of the year.

Other rough measures of performance have shown that adopted sections of highway have less litter than non-adopted sections. For example, the New Jersey Department of Transportation Adopt-a-Highway program has shown that its efforts have reduced the amount of litter on highways. A comparison of adopted sites vs. non-adopted sites indicates that the visible litter rate on adopted sites was ~9.5% lower than on non-adopted sites (NJCCC 2005).

## Costs

Costs for volunteer cleanup efforts are very low. Many events are entirely or mostly organized and implemented by volunteers. Some programs (e.g., Santa Clara Valley Water District) organize an 'Adopt-a-Creek' program. While there is at least one staff person coordinating the program, the work is accomplished by over 100 different local groups or organizations (SCVWD 2002). Other costs associated with cleanup efforts may include garbage bags, dumpsters and disposal fees. Some national programs (i.e., Keep America Beautiful) have fees associated with establishing an affiliate in a town or state. One-time certification fees range from $575 (for populations of 2,000 people) to $11,500 (for populations of 850,000 - 1 million+) (KCB 2007).

The combination of volunteer labor, corporate sponsorship and private donations help lower costs for local government departments. For example, Keep California Beautiful estimates that with corporate sponsors and governmental partners, it has been able to achieve an $11 return in measurable benefits to the state for every dollar invested (KCB 2007).

Other Keep America Beautiful programs report similar cost benefits. For example, Florida's KAB programs estimate that for each dollar invested by state and local governments, a value of $7.09 is provided through volunteer hours, cash contributions and in-kind contributions (FCSHWM 1998).

Florida's KAB affiliate is funded by membership and sponsorship contributions and state grants. In FY 1996-1997, a total of $2.3 million in in-kind contributions and $88,000 in membership contributions was received. Major corporations and associations provided support and in-kind contributions (FCSHWM 1998).

### Adopt-a-Highway Programs

Almost every state within the United States has an Adopt-a-Highway program. Each state calculates value received from volunteer efforts of adopting groups. The following examples provide costs associated with state Adopt-a-Highway programs.

### California

In 1989, Caltrans began coordinating California's Adopt-a-Highway Program. Its annual budget of $6 million funds advertisements, plastic bags, safety goggles, orange vests, gloves, and signs. Each year, Adopt-a-Highway Program efforts save California's taxpayers approximately $14.5 million (Caltrans 2007). Since its inception, the program has saved the state approximately $120 million (FCSHWM 1998).

### Washington

Washington's Adopt-a-Highway program started in 1990. As of November 1997, there were approximately 1,650 groups with an average of 10 people in each group. The program's $2.2 million budget, which is funded by a gasoline tax, pays for program supplies and advertising. In 1996, the Washington State Department of Transportation spent $120,000 disposing litter bags collected by Adopt-a-Highway and Ecology Youth Corps.

In 1997, the Washington State Department of Transportation started a corporate sponsorship program that allows corporations to use private contractors to pickup and dispose collected litter and trash. The cost of this program is from $750 to $10,000 per year depending on the level of activity (FCSHWM 1998).

## Pros

Volunteer cleanup efforts help educate citizens about the state of their local environment and allow citizens to develop a sense of ownership over their waterbodies. Citizens immediately witness the benefits of clean creeks and roadways. Cleanup efforts do help prevent trash from entering and remaining in local waterways. Similar to other public education and participation programs, volunteer cleanups help address the ultimate source of litter - individuals. They are relatively inexpensive to implement and maintain. They can also be a net cost benefit to government-run litter control programs.

## Cons

It is very difficult to measure the impact of volunteer cleanups on people's behavior and on trash accumulation in waterways. Organizers need to make volunteers fully aware of associated physical risks to avoid liability issues. To fully address the issue of trash in aquatic environments, cleanup programs need to operate in conjunction with other trash reduction efforts. If programs are conducted through government programs, there are costs associated with staffing and administration. Programs need to be actively managed to remain successful. It may take several years before trash reductions are realized. Volunteer cleanup efforts do not address trash sources. This approach may be a band-aid rather than a true solution.

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Santa Clara Valley Urban Runoff Pollution Prevention Program

IC-5
Institutional Control

# Improved Trash Bin/Container Management

Improved trash container management, Spokane, WA (courtesy of www.recyclingbin.com (left)), and Pomona, CA (courtesy of Pomona College (right)).

## Summary

Trash bins are public containers used to dispose of waste products. Potential management options which may help reduce the amount of trash accumulating in the environment include increasing the density, size and/or shape of bins and adding lids. Recent studies have shown mixed results. Trash bins are relatively inexpensive and cost ~$67 to $600. Associated operation and maintenance cost can be ~$750/bin/year.

## Description/Design

Trash bins, sited in public places, keep trash contained prior to collection. Having a higher density of trash bins, particularly in high traffic areas (major intersections, bus stops, commercial districts, near convenience stores) helps contain trash since citizens have additional disposal opportunities. In addition, changing bin design (i.e., adding a cover so trash cannot escape) helps reduce the escapement of trash from bins.

Establishing Business Improvement Districts[1] (BIDs) is one way of improving how public trash bins are managed. For example, BIDs in Los Angeles have reduced the amount of illicit trash along selected commercial strips. Most of the thirty formed BIDs in Los Angeles incorporate sidewalk sweeping, litter pickup and maintenance of trash bins. The motivation for establishing BIDs is that commercial strips become more attractive to customers when the amount of visible trash is reduced (City of Los Angeles 2002). Several cities within the Bay area have

[1] BIDs are districts or areas in central cities in which the private sector delivers services for revitalization beyond what the local government can reasonably be expected to provide. The properties and/or businesses within the BIDs pay a special tax or assessment to cover the cost of providing facilities or services. Cities provide some oversight but the BIDs control the purse strings.

## Potential Management Actions

- Adding lids
- Placement in high trash areas
- Placement with recycling bins
- Additional bins
- Improved bin design to encourage proper disposal
- New technologies (e.g., compactors) to reduce bin costs and disposal fees

### Implementation Point

In Street ✓
Start of Pipe
In Pipe
End of Pipe
In Creek
Dispersed

BIDs (e.g., three in San Jose; two in Berkeley and one each in San Francisco, Oakland (LeGates 1999), Palo Alto (PADBA 2007) and Sunnyvale (City of Sunnyvale 2007).

## Performance and/or Effectiveness

Studies on how changes in bin management impact littering behavior and the resulting changes in litter accumulation have shown mixed results. One of the most extensive reviews of littering behavior was conducted by the Beverage Industry Environment Council (BIEC, 1997, cited in Taylor and Wong 2002). The BIEC conducted a literature review (12 studies) on the effects of providing public trash bins on littering behavior. In general, the results showed that simply increasing the number of bins did not necessarily result in less littering. Half of the studies indicated that when bins are provided, local littering is reduced. Five studies found that providing bins had no impact. The final study found that providing bins with unusual designs decreased littering within the immediate environment, but increased it elsewhere.

Figure 1. Jones Beach, NY (courtesy of www.ICARYN.com).

The BIEC also initiated studies that used observational and survey methods to understand littering behavior. The studies found that a lack of bins was not a major factor in littering as most littering occurred on average within five meters of a bin (Taylor and Wong 2002). However, this distance can change depending on the location of the bin (Sustainability Victoria 2007). For example, people at public transport terminals and shops are more likely to put trash in bins when they are within 3.5 meters of bins. In contrast, people at beaches will walk up to 17 meters to properly dispose litter (Sustainability Victoria. 2007). Interestingly, the BIEC study also found approximately half the survey respondents did not consider placing items next to an overflowing bin to be littering. Since there is some evidence that people will litter more when litter is already present, having additional bins that are full may actually create additional littering problems (Taylor and Wong 2002).


Figure 2. Bus stop trash bin, Spokane, WA (courtesy of www.metrospokane.typepad.com).

In 1997-1998, the BIEC further evaluated the effect of providing additional bins on littering during a local research study in Sydney, Australia (BIEC, 1999). The study, which used a combination of litter surveys, bin audits, structured observations and attitude surveys generated mixed results. The study found an associated increase in the percent of items placed in bins and a slight decrease in the percent of items littered (28% to 24%) when recycling facilities/bins were installed in public places. However, the study ultimately found that the performance of any new bin depends on placement and design, and the nature of the site in which the bin is placed (BIEC, 1999).

In contrast to the Australian studies, the City of Los Angeles found that there was a net benefit to the storm drain system when the number of trash bins was increased. The City conducted a pilot study to assess the performance of placing additional trash bins on streets. The difference in trash accumulation in catch basin inserts before and after the placement of additional bins (one per block) was monitored. Trash bins were emptied weekly. Results indicated that additional trash bins can be highly beneficial if located in strategic areas. The additional trash bins performed best when placed in areas of mixed commercial and residential land use (City of Los Angeles 2004 cited in Gordon and Zamist 2007).

The following strategies have been proposed to improve the performance of trash bin management:

- Keep observable litter to a minimum (e.g. through frequent collections);
- Involve the community in litter management initiatives (Taylor and Wong 2002);
- Place litter and recycling bins in locations that are convenient and accessible to the public (i.e., located close) and to the litter source (e.g., fast food outlets, ATMs and exits from large public venues);
- Conduct site assessments to identify bins that are the most heavily used, particularly near stormwater management systems and water bodies. These bins should be subject to increased levels of inspection (and if necessary, maintenance);
- Design bins that are easily identifiable and catch the public's attention;
- Be consistent to avoid confusion (e.g., make the colors and shape of litter and recycling bins consistent);
- When designing bins, the bin opening should be small enough to discourage illegal dumping, yet acceptable for normal litter items;
- Decisions made regarding bin size should seek to minimize the required emptying frequency while discouraging illegal dumping;
- Assess the need for specialty bins in specific locations (e.g., for cigarette butts, sharps, etc.); and
- Placement of politely worded signage close to where littering occurs (DEC 2005).

## Costs

The use of trash bins is a relatively inexpensive method to control litter dispersal in the environment, even though prices vary depending on design and size. Prices can be as a high as $600 per bin (Trash Can Depot 2007). In the City of Los Angeles, the cost per bin was $67. Associated operation and maintenance cost were $750/bin/year (City of Los Angeles 2002).


**Figure 3. Seahorse Power Big Belly® (courtesy of Seahourse Power Company).**

New technologies have been developed to reduce the cost of adding trash bins. The Seahorse Power Company has developed a solar-powered trash compactor designed specifically for municipal and public use. The BigBelly Cordless Compaction© system can hold 300 to 350 pounds of trash and runs on a 12-Volt battery, which is kept charged by a solar panel. The battery reserve lasts for a couple weeks without any sunlight. The units require minimal sunlight, even in winter, with short days and colder temperatures (Seahorse Power 2007). Recommended maintenance includes routine lubrication of the chains, and replacement and recycling of the battery every four years. Since the system is enclosed, odors are contained inside the system (Seahorse Power 2007). The design of the system, which is similar to a mailbox, reduces trash overflow, prevents dumping of illegal items and keeps out animals (e.g., birds, raccoons and bears). Currently, a dumpster sized bin is being designed. (Seahorse Power 2007). Due to compaction, recyclable items (e.g., cans and bottles) will not be casually recycled. In addition, liquids may escape the system during compaction resulting in a potential pollution source (Lowrie, L[2]. *pers.comm*. 2007). While the BigBelly© system costs more than a regular trash can (a unit costs between $3,600 and $3,900; Redorbit 2007), it reduces collection requirements by four times or more, which can save money for municipal operations (Seahorse Power 2007). BigBelly© systems have been installed in several cities across North America, including Vail, CO, Boston, MA, New York, NY, Ventura, CA and Santa Cruz, CA.

[2] Leah Lowrie, City of San Jose, July 2007.

## Pros

Adding additional trash bins and/or changing the frequency and design of trash bins used can prevent trash from getting into the storm drain system. Trash bins are easy to maintain and monitor. Adding new bins might have minimal impact on current municipal operations.

## Cons

To significantly reduce littering rates, trash bins have to be part of the overall trash management strategy. Trash bins may need frequent maintenance. Quantifying the impact on reducing trash loading to storm drain systems is difficult and poorly understood. Trash bins only address trash generated by pedestrians. Trash bin maintenance responsibility (e.g., City vs. local transit authority) may impact effective trash bin management.

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Santa Clara Valley
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# Anti-Littering/Dumping Enforcement


**Illegal dumping and enforcement (courtesy of Regional Environmental Council of Central Massachusetts (left), City of Oakland Public Works (middle), and BBC News (right).**

## Summary

Successful anti-littering/dumping enforcement programs include laws or ordinances that make littering or dumping of trash illegal. Laws are enforced by various agency staff members who issue citations in response to citizen complaints or other enforcement programs (surveillance cameras). Fines typically range from $50 to $1000. It is difficult to enforce small littering events without witness or solid proof linking the offender with the litter. Therefore, enforcement tends to focus on larger scale illegal dumping activities.

## Description/Design

Anti-littering/dumping enforcement consists of establishing laws or ordinances that make littering and dumping illegal. Local enforcement agencies are authorized to issues citations for littering and dumping. Enforcement efforts include mechanisms (e.g., toll-free telephone numbers) for citizens to register complaints concerning littering or dumping. Other enforcement mechanisms include the use of surveillance cameras and signage installed at illegal dumping hot spots. Enforcement is usually conducted by multiple agencies including police, sheriff and public works departments. For example, the City of Oakland currently enforces illegal dumping and blight laws on public property. Each year, the City of Oakland Public Works Agency collects over 45,000 cubic yards of illegally dumped appliances, furniture, tires and household trash (City of Oakland 2006). The City of San Francisco recently increased its fine structure to strengthen its program. In some California jurisdictions, the minimum fine for littering is $500 and the maximum penalty for highway littering is $1000 (City of San Francisco 2007a). In the City of San Francisco, citation officers may issue littering citations ranging from $80 to $1,000.

## IC-6 Institutional Control

### Existing Program Examples

- City of Oakland
- City of San Francisco
- Washington State Department of Ecology

### Implementation Point

In Street
Start of Pipe
In Pipe
End of Pipe
In Creek
Dispersed ✓

In 2005, the City of San Francisco announced it would train 400 City employees from 43 different classifications and give them the authority to issue litter citations. The new citation officers focus their administrative citations on individuals who actually litter, levying fines intended to lead to behavior change (City of San Francisco 2005).

Random acts of littering or dumping are very difficult to enforce unless they are witnessed. Thus, public outreach and education is typically a key component of any successful enforcement program. For example, the San Francisco Department of Public Works (DPW) instituted a program to curb illegal dumping at 25 chronic dumping sites DPW staff extensively monitored these sites and removed illegally dumped material (over 2,500 person-hours were spent monitoring sites and 1,900 person-hours were spent removing trash). These activities resulted in 488 investigations, which involved educational contacts, warnings and citations. Over 900 letters, which provided instructions on how to resolve the investigation, were sent to property owners. The Department received over 250 responses from property owners interested in resolving outstanding issues.

## Performance and/or Effectiveness

Although enforcement is widely cited as a measure used to help combat litter and illegal dumping, there is little information on its performance as a control measure. While it is possible to determine the number of citations issued, there is very little information indicating if citations change behavior or result in less trash accumulating in waterways.

Toll-free litter hotlines are a key tool in the enforcement of litter laws. In 2002, Washington State Department of Ecology started a litter hotline. Calls to the hotline steadily increased from 6060 in 2000 to 13,877 in 2006 . Citizens who witness an act of littering can report the license plate number to the Department. The Washington State Patrol sends the vehicle owner a notification stating that they were observed littering. An associated fine schedule is attached to the letter. In 2005, the Washington State Department of Ecology included a survey questionnaire in the letters. A large majority of survey respondents (92%) admitted to be cognizant of littering fines. An equal proportion of respondents stated that they would unlikely litter again after being caught (Warfield 2006).

Depending on implementation/strictness, litter enforcement programs may result in large numbers of citations. For example, the City of Oakland cited 1,784 people for littering or illegal dumping between January 2002 and July 2006. By November 2006, the number of citations issued increased to 2,250 (Lewis, R. 2007). However, the issuing of citations does not necessarily lead to penalties. One in five citations issued by the City of Oakland was dismissed. The combination of dismissals, reduced fines and offenders who either cannot pay or cannot be located has resulted in only $250,000 from a possible $2.1 million in fines being collected from the 1,784 citations.

In order to improve its enforcement program, the City of San Francisco DPW has increased the publicity of its litter hotline (415-28-CLEAN). This hotline receives approximately 4,500 complaints per month (City of San Francisco 2007b). The San Francisco DPW also increased the number of Environmental Control Officers (ECOs) who issue littering fines from 14 to 22, which results in two enforcement officers for each supervisory district. The City of San Francisco also recognized that the processing of littering and illegal dumping citations was slow since they were heard as misdemeanor citations in the regular court system. Since the severity of this infraction is low compared to other cases, it receives low priority in the justice system. In 2000, the City set up the California Community Dispute Services (CCDS) to adjucate the infractions issued by the ECOs and others for litter and illegal dumping. From the onset of this program in January 2000 through February 28, 2001, a total of 2985 citations were referred to the CCDS. Violators elected to appear in 1748 cases at the CCDS or at one of the Community Courts (City of San Francisco 2007b).

## Costs

Costs associated with litter enforcement are primarily associated with staffing, establishing and maintaining hotlines, and creating outreach materials. Municipalities should not expect that money collected from fines will recoup the costs of implementing the enforcement programs. For example, counties in Florida incurred $1,476,960 in costs but only received $128,309 in collected fines (Table 1) (FCSHWM 2002).

**Table 1. Cost benefits associated with enforcement of local litter ordinances (Florida CSHWM 2002).**

| | Citations Issued | County Costs ($) | County Revenue from Fines/Penalties ($) |
|---|---|---|---|
| Collier | 50 | 10,000 | 1,380 |
| Dade | 40 | 906,900 | 115,429 |
| Hamilton | 8 | 2,000 | 0 |
| Madison | 10 | 0 | 500 |
| Manatee | N/a | 3,060 | n/a |
| Orange | 60 | 0 | 0 |
| Palm Beach | N/a | 120,000 | n/a |
| Santa Rosa | 93 | 85,000 | n/a |
| St. John's | 4 | n/a | n/a |
| St.Lucie | 1,020 | 350,000 | 11,000 |
| **Totals** | **1649** | **1,476,960** | **128,309** |

Every day, San Francisco DPW staff is dispatched to resolve and clean sites identified by resident's complaints; and patrol 37 illegal dumping locations. City staff spends ~30 to 60 minutes per site collecting evidence from illegally dumped piles in an attempt to identify offenders. In 2003, the City proposed to target 25 of the 37 chronic illegal dump sites for clean up and enforcement with the intent to completely eliminating illegal dumping (City of San Francisco 2003). In the FY 2003-2004, DPW had an enforcement budget of $1.1 million. It is estimated that costs associated with targeting chronic illegal dumping sites was $1,355,230 (Table 2) (City of San Francisco 2003).

**Table 2. Costs associated with the City of San Francisco's enforcement program to target chronic illegal dumping areas.**

| Item | Total Cost |
|---|---|
| Cleanup Labor Costs | $789,250 |
| Stakeout and Signage Mitigation Costs | $135,160 |
| Inspection Labor Costs | $109,820 |
| Remote Camera Enforcement Pilot Program | $321,000 |
| Total | $1,355,230 |

## Pros

When used in conjunction with citizen reporting hotlines, enforcement programs offer citizens a mechanism to help control litter and illegal dumping. In addition, enforcement can help change public attitudes. If there is sufficient budget, enforcement programs are relatively simple to implement. Strict enforcement can help abate chronic dump sites that degrade neighborhoods.

## Cons

Small amounts of litter are very difficult to enforce unless witnessed and reported. As a result, enforcement is often focused on large-scale illegal dumping. Generally, there is insufficient enforcement for the level of littering within a city (e.g., the City of Oakland has only six litter control officers). Money recouped from fines does not match the costs of enforcement.

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# Source Control through Official Bans/Prohibitions and Legislation


Source control organizations and initiatives (courtesy of stopwaste.org , Alameda County, CA (top left), King County Solid Waste Division, Seattle, WA (top right), Zero Waste, CA (bottom left), and District of Columbia Department of Publlic Works (bottom right)).

## Summary

Source controls involve a range of initiatives aimed at reducing waste generation and disposal. Initiatives involve local governments setting formal waste diversion goals (with associated programs for increasing the amount of municipal, residential and commercial recycling) or by officially banning products (e.g., plastic bags or polystyrene food containers) in commercial establishments. Waste diversion programs have been quite successful at decreasing the total amount of waste disposed. The programs are often very cost-effective and can offer a net economic benefit, mostly through job creation. However, it is currently not clear what effect these programs have on the accumulation of trash in waterways.

## Description/Design

Government agencies can institute legislative bans or prohibitions which discourage practices or activities that contribute to the creation of litter or illegal dumping. In addition, agencies can also institute programs or legislation which provides incentives to citizens or businesses to reduce their waste production. Source control programs work by either passing legislation with specific goals to reduce or divert waste to landfills through recycling (and composting) programs or by prohibiting items that are commonly disposed and not easily biodegradable.

## IC-7 Institutional Control

### Source Control Initiatives

- AB2020 California Beverage Container Recycling and Litter Reduction Act
- Oakland Waste Reduction Resolution
- Oakland Zero Waste Resolution
- Oakland Excess Litter Fee Program Ordinance 12727
- Oakland Green Food Service Ware
- Pay-as-you-throw (PAYT) Waste Disposal

### Implementation Point

In Street
Start of Pipe
In Pipe
End of Pipe
In Creek
Dispersed ✓

## California Initiatives

Statewide:

**AB2020 California Beverage Container Recycling and Litter Reduction Act (Act).** Initiated in 1987, the California Beverage Container Recycling and Litter Reduction Act is designed to promote the returns of bottles and cans through the payment of a redemption value. In January 2007, the cash refund consumers receive when returning California Redemption Value (CRV) bottles and cans to recycling centers increased (DOC 2007). Legislation raised the refund received from California recycling centers to a nickel for containers less than 24 ounces and a dime for containers 24 ounces and larger. For the first six months of 2007, the amount of CRV consumers pay at the store will remain four cents on smaller containers and eight cents on larger ones.

The Act has helped move beverage-container recycling into the mainstream. It also sets processing fees, which are paid to recyclers to cover their recycling costs. To facilitate the program, a network of 5,400 recycling centers was established. By law, unredeemed funds are directed towards supporting the Community Conservation Corps and grants and payments to private and public organizations for recycling-related projects. In addition, funds help container manufacturers reduce costs and save jobs, and have helped communities finance curbside recycling programs (DOR 2007).

Bay Area Local/Municipal:

Recycled Content Procurement and Source Education Policy Waste Reduction and Recycling Act (Measure D, 1989) In November 1990, voters in Alameda County approved Measure D. This established the Alameda County Source Reduction and Recycling Board. Measure D describes countywide goals for the reduction and diversion of non-hazardous solid waste from landfills; creates a framework for comprehensive source reduction and recycling programs; imposes a surcharge (which increased to $6.59 per ton effective January 1, 2002) on waste landfilled in the unincorporated county to fund these programs; and establishes an Alameda County Source Reduction and Recycling Board (Recycling Board) to oversee the distribution of funds and implementation of countywide programs. As a result of Measure D, the Recycling Board must establish recycling programs which meet and/or exceed recycling policy goals set forth in the initiative and those mandated by State law (Brown, Vence & Associates 2002).

**Clean Safe Creeks and Natural Flood Protection Program (Measure B).** The Santa Clara Valley Water District (SCVWD) has increased trash awareness, abatement and outreach through the implementation of Measure B (a special parcel tax which includes the Clean, Safe Creeks and Natural Flood Protection) and its “Adopt-a Creek” program. Measure B provides resources that allow the SCVWD to conduct four major cleanup events a year (or 60 over 15 years) within three different watersheds and maintain response times of less than five days to remove litter and graffiti. Since the implementation of Measure B, the SCVWD has removed approximately 31,193 cubic yards (11,697 tons) of trash and debris. The “Adopt-a-Creek” program encourages community groups to care for a designated section of creek. Groups pick up trash at least two times a year at creek locations not included in the major creek cleanups (SCVWD 2007).

**StopWaste.Org.** StopWaste.Org consists of the Alameda County Waste Management Authority and the Alameda County Source Reduction and Recycling Board. These organizations operate as one public agency to implement programs that achieve waste reduction and diversion goals.

**Oakland Waste Reduction Resolution (No. #77500 C.M.S., 2002).** In alliance with the Alameda countywide waste reduction goal of 75%, the City of Oakland established a 75 % waste reduction goal (by 2010) for wastes going to landfills.

**Oakland Zero Waste Resolution (No. #79774 C.M.S., 2006).** The City of Oakland adopted a zero waste goal by 2020. This resolution directs the Public Works Agency, in concert with the Mayor's Office, to develop a zero waste strategic plan to achieve the City's goal.

## Bans on Particular Products

Green Food Service Ware (No. #12747 C.M.S., 2006

In accordance with Green Food Service Ware (No. #12747 C.M.S., 2006), the City of Oakland prohibits the use of polystyrene foam disposable food service ware and requires, when cost neutral, the use of biodegradable or compostable disposable food service ware by food vendors and city facilities.

City of San Francisco

The City of San Francisco has passed a similar ban. Effective June 1, 2007, San Francisco food vendors may no longer use polystyrene foam (i.e., Styrofoam™). Vendors will be required to use compostable or recyclable, disposable food service ware or to-go containers unless there are no suitable alternatives (i.e., products which are within 15% of the cost of non-compostable or non-recyclable alternatives). In addition, the San Francisco Board of Supervisors recently passed legislation that outlaws plastic bags at large grocery stores and large chain pharmacies (Goodyear 2007).

## Altering Fees Associated with Waste Disposal

Pay-as-you-throw (PAYT) Waste Disposal

In traditional waste collection systems, residential owners are charged by taxation or through a flat fee system for collecting household waste. In PAYT systems, the amount residential owners pay is proportional to how much waste they generate. Therefore, PAYT systems create an economic incentive for households to reduce their trash and recover as much as possible. Two basic PAYT systems exist: (1) the bag and tag system in which residents pay for each bag or tagged can set out at the curb; and (2) residents who subscribe to trash service levels with containers of varying capacities pay higher fees for larger or more containers. Under the bag system, two sizes are usually available: a 15-gallon bag or a 30-gallon bag (USEPA 1999).

Oakland Excess Litter Fee Program Ordinance 12727

On February 21, 2006, the City of Oakland adopted Ordinance 12727, enacting an Excess Litter Fee on fast food businesses, convenience markets, gasoline station markets and liquor stores. This ordinance is intended to maintain litter-free streets, sidewalks and public spaces by assessing a fee on businesses known to generate high amounts of disposable materials. The fee will be used to support the collection and disposal of trash and to help keep trash and litter from entering the City's storm drain system.

To file, businesses must submit their gross receipts. Eligible businesses that pay into a BID have their fees reduced by 50%. The annual excess litter fee is based on the gross receipts (Table 1) (City of Oakland 2007).

**Table 1. Value of excess litter fees for businesses.**

| | Annual Gross Receipts | Litter Fee |
|---|---|---|
| Large Business | ≥$1,000,000 | $3,815 |
| Medium Business | $500,000 - 999,999 | $910 |
| Small Business | $5,000 - $499,999 | $230 |

## Performance and/or Effectiveness

Through the implementation of cost-effective recycling programs, several municipalities across the United States have been successful at diverting the amount of waste products sent to landfills (USEPA 1999). USEPA recently profiled eighteen communities that achieved high diversion rates and found that they achieved waste reduction levels of 40 - 65% (USEPA 1999). One of the communities profiled was the City of San Jose. In 1993, San Jose implemented its Recycle Plus Program. Prior to the program, residents disposed of unlimited amounts of trash (for a flat monthly fee) and recycled only five material categories. The new program increased the number of recyclable material categories; offered multi-family dwellings with recycling and yard debris collection services; and paid recycling contractors per household and per ton recycled. The net result of the program showed that from 1992 to 1996, the single-family household participation increased from 66% to 83%; and the single-family waste reduction level increased from 33% to 55%. In FY 1997-1998, the City of San Jose diverted 45% of its residential waste and 42% of its commercial waste to recycling or composting. Overall diversion was 43% (34% was recycled and 9% was composted) (USEPA 1999).

Other recycling initiatives within the Bay Area have shown equal levels of success at diverting waste from its landfills. For example, through its Zero Waste campaign, the City of Oakland has increased its diversion rate from 10% in 1990 to almost 60% in 2005 (Figure 1). In Santa Clara County, total waste generated has decreased (Figure 2) and the County has achieved a 45% diversion rate (CIWB 2007).

Other examples of highly successful programs for diverting waste from landfills include AB2020, California's Beverage Container Bill (Figure 3). Since the Bill was implemented in 1987, the recycling rate for beverage containers has more than doubled (California Resource Recovery Association 2007). When beverage containers are not returned to retail outlet recycling centers, but placed in a curbside recycling bins, the deposit value is kept by the curbside recycling program. Curbside programs receive $23 million in retained redemption values and $9 million in processing fees, administrative fees and grants each year (California Resource Recovery Association 2007). Seven million California grocery-store based convenience recycling centers recycle the containers of seven million Californians. In fact, consumers are choosing to recycle 23% of all beverage containers at grocery-store convenience recycling centers (by comparison, curbside recycling programs collect only 7% of beverage containers).

A UC Berkeley study (Berck and Goldman 2003) found that the best way to increase participation in the beverage container redemption program was to increase the redemption value[1]. In January 2007, redemption values were increased.

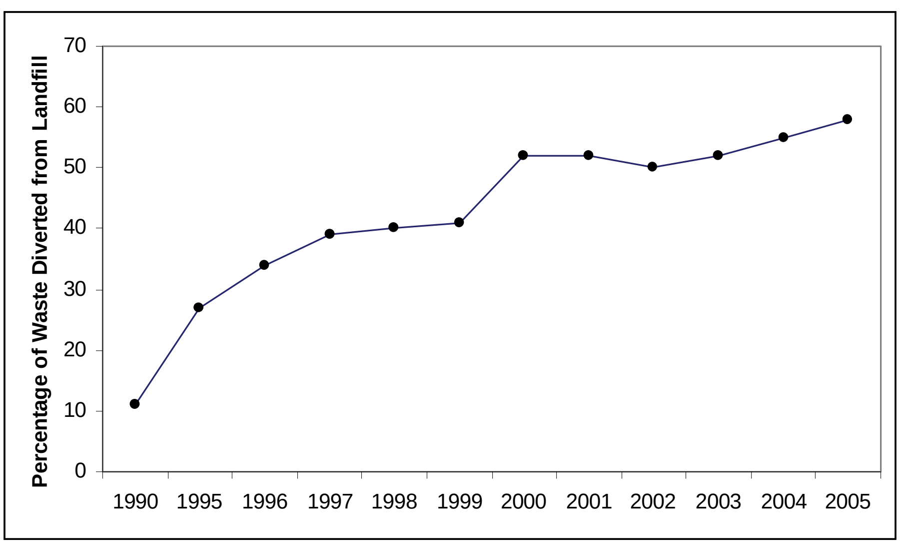


**Figure 1. Waste diverted from landfills in Oakland (Swenerton 2007).**

[1] California had the lowest redemption value in the country.

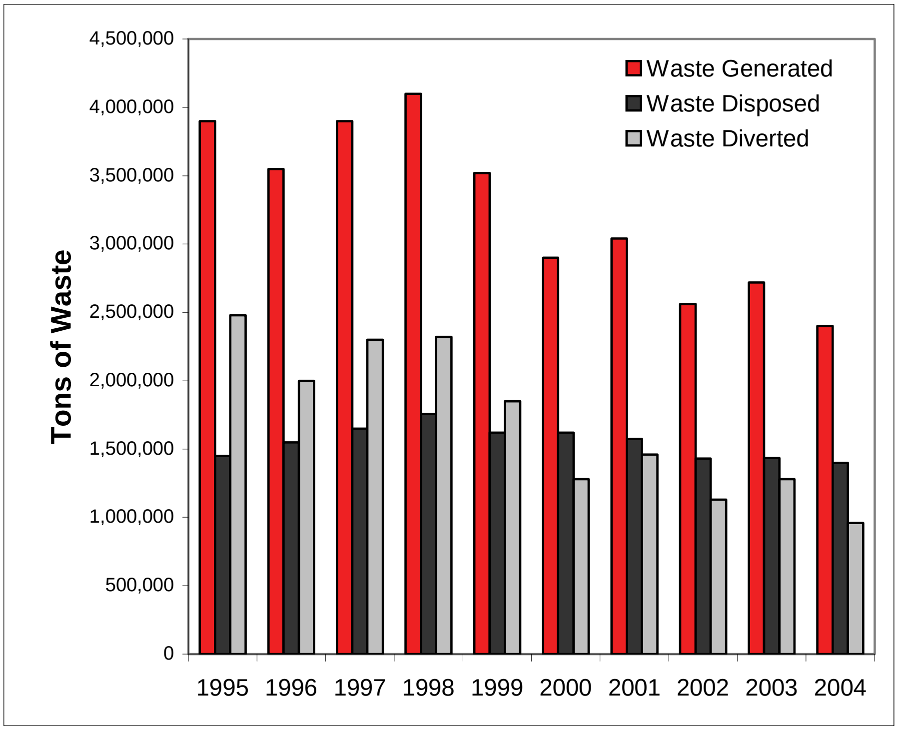


Figure 2. Santa Clara County disposal and diversion levels in tons (CIWMB 2007).

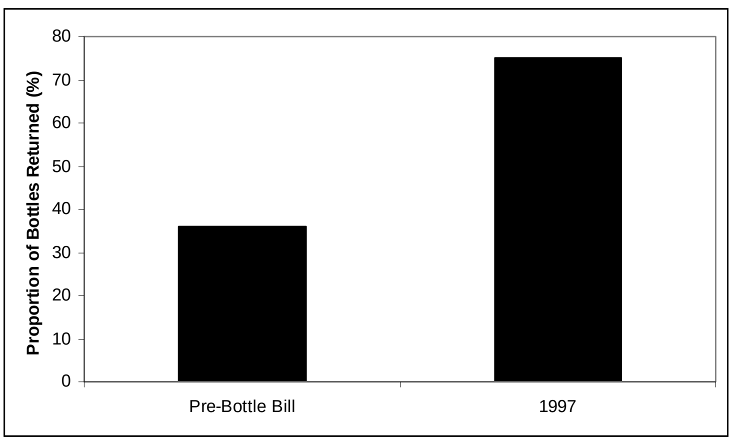


Figure 3. Statewide increase in recycling rates due to California's beverage container bill (California Resource Recovery Association 2007).

Maintaining a convenient recycling program is necessary to achieving high participation and high waste reduction. For example, in Worcester, Massachusetts residential recovery increased from 41% to 52% when collection switched from biweekly to weekly (USEPA 1999). Other ways to increase the perceived ease of programs is to allow residents to 'commingle' their recyclables. Research indicates that higher rates of recycling participation (90% vs. 77%) and additional recyclables are recovered (32.1 gallons vs. 5.5 gallons per household per week) are achieved when commingling is permitted (Oskamp et al 1996). Other factors which increase performance include supporting markets for recycled materials (USEPA 1999). This includes identifying and securing agreements with materials brokers and end users. Recycling collection programs can only be as successful as the recycling marketing program. Consequently, market analysis must be included in the planning stages and be maintained throughout the program (USEPA 1999). For programs to be ultimately successful, recycling or waste diversion must be considered an integral part of a municipalities' overall waste management plan.

## Costs

The cost associated with implementing a waste management program within the City of San Francisco (the Fantastic Three program) requires purchasing a new fleet of dual compactor vehicles and thousands of containers (Table 2). The company contracted to collect waste, Sunset Scavengers, can provide the expanded program at a cost similar to the original system. Recycling and composting service is included in residential trash rates at no extra cost. Residents can save money by switching to a smaller trash container (for example, 20 gallons).

**Table 2. Sunset Scavenger's equipment costs (for City of San Francisco residential program) ( CIWMB 2007).**

| Equipment Item/Service | Unit Cost |
|---|---|
| Dual compactor vehicle | $192,000 |
| Organics collection vehicle | $142,000 |
| 32-gallon container | $35 |
| 64-gallon container | $41 |
| 2-gallon kitchen pail | $3.50 to $4 |
| Container delivery with outreach materials ($/cart) | $2 to $3 |

Other methods of decreasing total costs associated with waste disposal include the implementation of PAYT trash programs. In 1991, the City of Dover, New Hampshire instituted a PAYT system and curbside recycling program. Since implementation, Dover's net residential solid waste management costs dropped from $1.1 million in 1990 to $798,000, while adding more than 1,000 customers. Per household costs have decreased from $122 in 1990 to $73 in 1996 (USEPA 1999). Similarly, program costs incurred by the City of San Jose dropped as the amount of materials diverted increased (Table 3).

**Table 3. Total amount of material diverted in San Jose and costs associated with program.**

| PROGRAM SUMMARY | FY93 | FY97 |
|---|---|---|
| Tons Per Year MSW | NA | 1,315,436 |
| Tons Per Year RSW | 283,000 | 433,576 |
| Tons Per Year ICW | NA | 881,860 |
| Percent MSW Diverted | NA | 43% |
| Percent RSW Diverted | 33% | 45% |
| Percent ICW Diverted | NA | 42% |
| Average lbs./HH/day[2] | 8.61 | 8.82 |
| Net Program Costs/HH[2] | $206.85 | $187.03 |
| Disposal Services | $142.78 | $81.95 |
| Diversion Services | $64.07 | $105.09 |

MSW = municipal solid waste RSW = residential solid waste
ICW = institutional and commercial waste
NA = not available
Notes: 1992 dollars adjusted to 1996 dollars using the GDP deflator.

In addition to reducing waste management costs, it is estimated that recycling can also contribute to local economies through job creation and other benefits. According to the California Integrated Waste Management Board, meeting the state's 50 percent recycling goal will add $2 billion to California's economy and create over 45,000 new jobs over the next seven years. In 1992, the City of San Jose projected that developing the industrial capacity to absorb its recovered materials would support 40 facilities and 775 manufacturing jobs. The City estimated $109 million in value added, $9.4 million in avoided landfill costs and $88.4 million in production cost savings (CAW 2007).

[2] Figures reflect residential sector only. FY93 tonnage data represents 180,000 single-family dwellings only; multi-family dwellings were included in commercial service at the time. In FY97, 269,340 single-family dwellings and multi-family dwellings were served.

## Pros

Reducing waste generation is a critical component of reducing the amount of trash which may accumulate in waterways. Government initiatives have been successful at increasing the amount of waste diverted from landfills. These initiatives also function to raise citizens' awareness of the environmental consequences associated with their consumption and empowers individuals to take control of their contribution to the problem. Government programs have a net positive impact on local economies.

## Cons

While recycling programs have been successful at reducing the amount of waste in landfills, it is less clear if they have reduced waste generation or if they have had any impact on the amount of trash accumulating in waterways. Some initiatives (e.g., San Francisco's plastic bag policy or Oakland's Excess Litter Fee) have been met with opposition from local businesses.

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