Strategies & Technologies to Address Litter within Integrated Urban Water Management
Urban Water System

- In urban areas, rain and storm water enter drainage systems en route to rivers, bays, and oceans.
- Litter can clog drainage systems and impair water and waterways limiting reuse by downstream users.

Photo: Melbourne Water
Urban litter found in drainage systems can come from a variety of sources and take many forms.

<table>
<thead>
<tr>
<th>Domestic litter</th>
<th>Construction materials</th>
<th>Vegetative Litter</th>
<th>Other large litter</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Domestic litter" /></td>
<td><img src="image2" alt="Construction materials" /></td>
<td><img src="image3" alt="Vegetative Litter" /></td>
<td><img src="image4" alt="Other large litter" /></td>
</tr>
</tbody>
</table>
Economic Costs of Urban Litter on Drainage Systems

- Aesthetics (beaches, urban parks, etc.)
  
  Increase in visitations at beach
  - eliminating litter: 211%
  - eliminating parking fees: 51%

- Health hazards (e.g. rats in canals filled with garbage)
- Effects on water quality and ecosystem
- Flooding due to interference with workings of drainage system

- Costs for cleanup
  
  Costs for Long Beach California (2011)
  $2.2 million a year
Oceans are dynamic systems, with currents that coupled with wind and the earth’s rotation, create “gyres.” The gyres form slow rotating whirlpools in which plastic trash from drainage systems ultimately accumulate.

Density of plastic is higher than density of marine debris. There’s growing evidence. Severe challenges with cleanup and global issue.

Concentrations of plastic debris in surface waters of the global ocean. Colored circles indicate mass concentrations (legend on top right). The map shows average concentrations in 442 sites (1,127 surface net tows). Gray areas indicate the accumulation zones predicted by a global surface circulation model. Dark and light gray represent inner and outer accumulation zones, respectively; white areas are predicted as nonaccumulation zones. Data sources are described in SI Appendix, Table S1. Plastic concentrations along the Malaspina circumnavigation and a latitudinal gradient are graphed in SI Appendix, Figs. S4 and S5.
Impacts of Urban Litter on Drainage Systems - A Little Goes a Long Way

- Melbourne Australia
  - <1% of total waste generation
  - 60,000 tons per year
- South Africa
  - 2% of total waste generation
  - 780,000 tons per year

Bottle of a certain height and then estimated from size. Compare litter in all of Australia and all of South Africa - represent a small percentage of the total litter. A little goes a long way small volumes represented in the photos.
Factors Affecting Litter Composition & Quantity

Community characteristics

• Type of development
  ▪ Commercial and industrial areas tend to produce higher litter loads than residential areas

• Density of development
  ▪ Higher densities often generate higher litter loads

• Consumption habits of community
  ▪ Access to consumer products affects generation of litter from products or containers

• Existence of litter intensive activities (ie, special events, tourism and construction activities).

This section provides a basic background of what affects this.
Factors Affecting Litter Composition & Quantity: Relationship to solid waste and cleansing services

<table>
<thead>
<tr>
<th>No services</th>
<th>Inefficient Services</th>
<th>Efficient services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage system functions as disposal facility</td>
<td>Drainage system is a substitute for cleansing and collection</td>
<td>Drainage system is depository for litter.</td>
</tr>
</tbody>
</table>

Volume of litter in drainage system y-axis
X-axis is degree of efficiency in services
Factors Affecting Litter Composition & Quantity
Climate and Catchment Characteristics

• Rainfall pattern
  ▪ Litter will build in catchment until removed by cleanup operations or swept into drains by rain
  ▪ Dry spells give greater opportunity to remove litter, but also result in heavy concentrations of litter sent down stormwater systems with first rains - “first flush”

• Type of vegetation in catchment area: Deciduous trees can interfere with drainage systems by contributing to litter collected in traps
Solving the Problem - Integrated Litter Management Strategy

- Land-use planning
- Urban design
- Planning controls
- Education
- Waste reduction
- Cleansing operations
- Enforcement
- Source controls
- Integrated Litter Management
- Litter traps
- Stormwater treatment
- Cleanup programs
- Downstream controls

(Adapted from Marais and Armitage, 2004)
Planning Controls

• Integrated planning of urban development and water services includes:
  ▪ Protection of water quality and water resources, and
  ▪ Controls that restrict litter-generating activities to areas where they can be effectively controlled and potential impacts can be reduced.

• Examples include
  ▪ Preserving elements of natural stormwater system such as natural channels, wetlands, and riparian vegetation
  ▪ Locating litter-generating activities in areas where it is easier to contain and control accumulation
  ▪ Requiring pollution control measures as part of development activities
Source Controls – Educational Campaigns

- Educational campaigns increase public awareness of urban litter and improve public response to the problem
- Campaigns inform citizens how streets, drainage systems, rivers, and oceans are interconnected and how daily activities affect stormwater quality
- Their purpose is to inform and motivate households, commerce, industry, local government and law enforcement

https://nuhduttyupjamaica.org/nduj_garbage_3-1-2/
Nuh Duty Up Jamaica is a public education campaign that aims to improve citizens knowledge about the impact of poorly handled waste on public health and the environment, while encouraging personal responsibility for the generation and disposal of waste. Nuh Duty Up Jamaica, launched in February 2015, is one component of the Clean Coasts Project, led by the Jamaica Environment Trust (JET) with the support of the Tourism Enhancement Fund (TEF) and the Wisynco Group.

https://nuhduttyupjamaica.files.wordpress.com/2015/06/nuh-duty-up-jamaica-talking-points.pdf
Source Controls - Waste Reduction

- Commerce and industry are ultimate source of litter:
  - Directly through generation
  - Indirectly through products that are sold
  - Indirectly through packaging
- Waste reduction efforts should focus on wastes that significantly affect a drainage system
  - Bag or foam bans
  - Fees for single use bags.
  - Pollution taxes.
  - Deposits for containers.

Can your butts – from City of Long Beach
http://www.litterfreelb.org/home/butts_pilot_program.htm
Source Controls - Cleansing Operations
Options

• Waste collection coverage and optimization
  ▪ Collection coverage and frequency.
  ▪ Optimization to ensure frequency meets volume
  ▪ Specialized services (events, bulky waste)

• Containerization:
  ▪ Household containers
  ▪ Communal containers

• Better placement and design of public litter bins

(Source: C. Clark)
<table>
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<th>Source Controls - Street Sweeping Options</th>
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<td>• Street cleaning coverage and optimization</td>
</tr>
<tr>
<td>▪ Collection coverage and frequency.</td>
</tr>
<tr>
<td>▪ Specialized services (historic areas, mechanical cleaning)</td>
</tr>
<tr>
<td>• Adjusting service to address litter in drainage:</td>
</tr>
<tr>
<td>▪ Effectiveness requires street sweeping to be more frequent than significant rainfall events (&gt;10mm)</td>
</tr>
<tr>
<td>▪ Seasonal variation may require altering sweeping frequency during the year</td>
</tr>
<tr>
<td>▪ Training of street sweepers (cleaning under vehicles, avoiding sweeping into drains).</td>
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Another type of cleansing operation. Not swept into drains.
Local authorities often have more pressing demands than enforcement of anti-litter legislation.

However, enforcement can create effective incentives for reducing litter.

Examples of cost effective litter enforcement include:

- Cameras to capture litterers in the act
- Volunteer litter patrols can take responsibility for cleaning neighborhoods
- Website for shaming or reporting litterers
- Publication of “pollution hot-lines” where telephone access is available can aid reporting of offenders

http://stpetersnm.com/litter_louts.html
http://www.newtownabbey.gov.uk/contactus/reportlittering.asp

According to the State of Washington Department of Ecology, while many support the use of enforcement, studies show that few jurisdictions are able to enforce littering laws effectively for two reasons:

1. Lack of personnel available for such a low priority issue, and
2. The fact that it is difficult to "catch" offenders in the act.
Downstream Controls

- Physical barriers and removal mechanisms to prevent litter from clogging the drainage system and affecting the environment

- Effective controls as part of an IUWM approach enable use or reuse for various purposes downstream

- For combined sewer systems removal can be achieved at the wastewater treatment plant

- For separated sewer systems, litter must be trapped and removed along the sewer system prior to discharging to waterway

http://www.sweetwaterwetlands.org/about_us

Sweetwater Wetlands Park is a man-made wetland habitat of more than 125 acres. The park has several miles of trails and is teeming with plants and animals. It was designed to trap litter and debris at a sediment basin, and then improve water quality by filtering out pollution and nutrients though the wetlands. The park provides several environmental benefits, such as:

- Restoring the natural water flow to more than 1,300 acres of formerly drained wetlands in Paynes Prairie.
- Protecting and improving water quality in the Alachua Sink and the Floridan aquifer.
- Increasing the amount of conservation lands within Paynes Prairie Preserve State Park.
Downstream Controls - Catchpits

(Source: Blackburn and Roberts)

(Source: Humes)
Downstream Controls - Litter Traps

(Source: J. Seltzer)

(Source: Armitage 2008)

(Source: Dredging systems)
Downstream Controls - Cleanup Measures

- Where planning controls, source controls, and other downstream controls have failed, cleanup efforts can directly remove litter from the environment.

- Such efforts include:
  - Canal or drain cleaning
  - Beach or river cleanups
  - Direct removal from waterways via skimmer boats

Update with Afroz Shah pictures from Mumbai’s Versova Beach – 21 month cleanup effort of 2.5 km of beach with 5.3 million kilograms of trash.

http://www.huffingtonpost.in/2016/09/13/this-mumbai-man-gave-versova-beach-a-makeover-by-cleaning-it-of_a_21470874/
Identifying Your Strategy: What is the goal?

- How is uncontrolled litter impacting the urban environment and broader watershed?

- What negative effects does the community want to prevent?
  - Flooding, aesthetics, environment, health, infrastructure functions
  - Are there upstream contributions?
  - Are there downstream complications?
At times I think (at least in our projects) the solution to the problem has been generically and conveniently identified as "better solid waste management" when in fact there are many solid waste interventions that have a marginal or no impact on garbage in drainage systems and some systems (Buenos Aires for example) that have 100% collection yet have a massive waste problem with their drainage system. On the other side there are places like Haiti that because of the absence of an operating solid waste management system the drainage system is the disposal system and therefore collection is the issue. My feeling is some more thought into this, teasing out the various situations and when it is SWM that matters, vs when litter management matters and when both matter might be useful to the discussion.

Surveys can be done - example of South Africa.
Identifying Your Strategy
Planning for the Sustainability of Your System

A balance of priority measures with short term impact and cost-effective measures with long term impact

Planning Controls

Source Controls

Downstream Controls

Balancing short term impact and cost-effective measures with long term impact
**Other Key Issues**
Identifying and Designing Cost-Effective and Functional Strategies

- **Rainfall patterns**: Many interventions are dependent on storm frequency and strength and will need to be catered to the program

- **Catering awareness campaigns and community involvement**: Ensuring awareness targets a communities concerns about litter and their incentives for involvement

- **Developing functional structural measures**: Careful choice and design of litter traps and other structural mechanisms will help ensure they are both effective and can be easily maintained
  - Detailed hydrologic analysis, costing, and pilot trials are often needed

- **Institutional capacity and mandates**: Effective measures will rely on a variety of agencies including drainage, solid waste, environment with NGOs effectively implementing programs
  - Proper mandate and capacity for each agency is necessary to effectively implement a given measure

Assessing the feasibility of the options in the table it’s important to consider these additional factors.