Louisville MSD Green Infrastructure Update

PROGRESS FOR CONSTRUCTION, SPENDING & PERFORMANCE

August 28, 2013
Overview

- Total Green Valuation
- Exclusions
- Green vs. Gray Comparison
- Comparative Cost Curve
- CSO 130 Example
- 64 & Grinstead Example
- Path Forward
MSD System Description

- 6 Regional Wastewater Treatment Facilities
- 14 Small Wastewater Treatment Plants
- 304 Pump Stations
- 3,200 miles of Sewers
- Louisville Green Production Facility
- Ohio River Flood Protection System
  - 16 Flood Pump Stations
  - 29 miles of Floodwall
What is a CSO?
Urban Side-Street (1905)

- Cholera
- Typhoid
- Yellow Fever
- Dysentery
- Small Pox
High Point Redevelopment - The Challenge

try to make this…

develop like this and …

function like this
Green Program Intent
“Catch & Infiltrate Stormwater Before Hitting Sewer”

- Rain Gardens
- Green Roofs
- Infiltration Trenches
- Pervious Pavers
- Bio-Swales
- Stream Buffers
Green Implementation Strategy

- Right-sizing Gray Infrastructure
  - Green to gray cost effectiveness
  - Maximize drainage capture
  - Saving the tax dollars
- Develop Case Study Template
  - Validation of practices
  - Standardize green modeling parameters
  - Long-term trends & monitoring
  - Practice selection for type and location
- Standardize Design and O&M
- Regulatory compliance
- Maintenance
- Community improvement
- Vacant land utilization
Gray to Green Right Sizing Trend

- Failure
- Gray Storage Practice
- Success
- Incremental Cost Comparison
- Green Project Suites

Cost (Million $) vs. Overflow Reduction (MG)
Green Stormwater Technology Design

Practice Types

• Downspout disconnection
• Permeable pavement strips
• Tree boxes
• Infiltration trenches
• Bioswales
• Rain gardens
• Urban reforestation
• Underground infiltration/storage
Green Stormwater Technology Design

• Define the end goal
  • Evaluate new technologies
  • Evaluate technology performance in various locations/conditions
  • Meet regulatory requirements
  • Use of open parcels vs. demo of vacant properties
  • Site practices there is natural drainage (follow topography)
• Route additional volume to practices
• Select practice types based on:
  • Ancillary community improvement
  • Most economical
Green Stormwater Technology Design

- Site considerations
  - Geotechnical considerations
  - Soil conditions
  - Topography
  - Natural drainage path vs. routing of stormwater flow
  - Drainage capture

- Sizing of practice
  - Infiltration
  - Design of overflow

- Know regulatory constraints
Green Stormwater Technology Design

• Private property
  • Easements
  • Disconnection of downspouts
    • Surface flow vs. underground

• Right of way
  • Routing of drainage from private
  • Federal/state/local considerations

• Land bank/vacant parcels

• Maintenance capabilities
  • Internal
  • external
Integrated Overflow Abatement Plan
Vol. 2 - Final CSO Long Term Control Plan
CSO 130
Green Infrastructure Solution

Legend
- Active CSO
- Existing Manhole
- Existing Catch Basin
- Streams
- Combined Sewer Pipe
- Floodway
- CSO 130 Drainage Boundary
- CSO 130 Practices
- Proposed Green Infrastructure Solutions
  - Pervious Pavers
  - Tree Boxes

General Representation of overflow abatement solutions are currently out for bid and may be altered during the construction process.

1 inch = 166 feet
Scalable when printed on 11” X 17” paper
Some boundaries are uniquely symbolized within the map.
Map Revision
May 18, 2012
Aerial Date: 2007

This document was developed in color. Reproduction in black and white may not represent the data as intended.
### CSO 130 Results

<table>
<thead>
<tr>
<th></th>
<th>Overflow Volume Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CSO 130 Existing Conditions</td>
</tr>
<tr>
<td><strong>Overflow Volume</strong></td>
<td>1.30 MG</td>
</tr>
<tr>
<td><strong>Number of Overflows / Year</strong></td>
<td>16</td>
</tr>
<tr>
<td><strong>20-Year Total Present Worth</strong></td>
<td>$1.72</td>
</tr>
</tbody>
</table>
Articulated Concrete Block – Shaft Verse Trench
Tree Box - Design

Tree Box Inlet
Remove top 1/2 of burials. Turn down top 2/3 of pipe basket if present.

CENTER TREE IN BOX
- Replace existing sidewalk removed during excavation with new concrete sidewalk. Use aggregate base compacted to not less than 90% maximum dry density (ASTM D3082) per LPAW STD DWG 701. Meet flush with top of tree box (all sides). Sidewalk finish to match existing sidewalk to remain.

6" Perforated, corrugated HIPS Underdrain, withsock connecting individual tree boxes. Install level, locate underdrain as close to back of curb as possible in order to prevent competition with existing utility poles. Refer to general note D.

No. 3 Aggregate Underdrain blanket apron in non-woven geotextile filter fabric. Install filter fabric per manufacturer's recommendations.

PROVIDE 3/8" EXISTING SUBGRADE AND NEW CONCRETE SIDEWALK MEETS TREE BOX.
- PRECAST CONCRETE TREE BOX WITH 24" WIDE X 8" HEIGHT CURB SIDE INLET AT TOP OF BOX. TOP OF BOX SHALL MEET FLUSH WITH TOP OF EXISTING CONCRETE CURB.
- EXISTING SUBGRADE
- 4" Factory made weepholes per manufacturer's recommendations to per manufacturer's recommendations. See tree box note 4.

INSTALL PLANTING SOIL MEDIA IN 6" LIFTS. WATER THOROUGHLY IN BETWEEN LIFTS.

NO. 57 AGGREGATE CINDER COURSE
- REFER TO DETAIL 17. SHEET 17 FOR SHAFT DETAIL.

TREE BOX / 3' WIDTH PLANTING AREA WITH UNDERDRAIN: LONGITUDINAL SECTION

SCALE: 1/2" = 1'-0"
Tree Box – Design Considerations

- Infiltration rate of soil media is limiting component, not soil at bottom of shaft
- ADA compliance
- Prevent tripping hazards
- Aesthetically pleasing
Underground Infiltration Gallery w/Infiltration Planter – Design Plan View
Underground Infiltration Gallery w/Infiltration Planter – Design Section View

NOTES:
1. Saw cut existing brick pavers in sidewalk and remove existing pavers and soil in the infiltration planter area.

UNDERGROUND INFILTRATION GALLERY WITH INFILTRATION PLANTER N.T.S.
Some practices are better suited to site conditions
Field observation (green unfamiliar to many contractors)
Compaction standard for green may be different
New products may not have all the bugs worked out
No product is maintenance free!!
- Internal vs. external maintenance
  - Contractor maintenance agreements
- Type of equipment needed
- Maintenance procedures
Construction Pervious Pavers

• Different standards for local vs. state roadways

• Coordination with other agencies
  • Other projects such as roadway resurfacing, bike lane painting….may be underway

• Early outreach to project area is critical
  • No matter how “small” the project

• Aesthetics of the practice choice
  • Parking lane
  • Color
  • Continuation of practice
Articulated Concrete Block Installation
Articulated Concrete Block Installation
Articulated Concrete Block Installation
Construction Tree Boxes

- Choosing the correct variety of tree
- Interconnected tree boxes vs. individual boxes
- Proprietary boxes vs. custom design
  - Infiltration considerations
  - Less surface area
- Media type
  - Water quality or water quantity only
- Pretreatment/trash and debris
Construction – Tree Boxes

- Inlet of street flow into the practice
  - Curb considerations
- Enclosing the tree storage area
  - Grated boxes
  - Curbs
  - Railings
  - Mulch or pea gravel
- Agency considerations
Tree Box - Installed
Monitoring In Louisville

• Rain gages
• Data collection and analysis software
• Individual practice monitoring
  • Selecting parameters to monitor
  • Installation of equipment
    • Within the practice (permanent)
    • Monitoring wells (replaceable)
• System monitoring
  • Selecting parameters to monitor
  • Outfall
  • Various points in the drainage area
Monitoring In Louisville

- Develop monitoring plan & QAPP
  - Validate data (transportability)
  - Details procedures
- Equipment purchase
  - Ancillary supplies (may not be local)
  - Allow extra lead time
- Remote data collection
  - Compatibility of software
- Field analysis
  - Data storage
- Analysis of data
Articulated Concrete Block – Monitoring Equipment

One set of instruments installed in the controls was a collection of Time Domain Reflectometers (TDRs).

All the wiring was run through water-tight conduit to junction boxes along the length of the control.
Articulated Concrete Block – Monitoring Equipment

The instruments in each control are hard wired to the datalogger.
Articulated Concrete Block – Monitoring Results

During the first year of operation, we have monitored about 70 events.
Articulated Concrete Block – Monitoring Results

Intra event exfiltration volumes are significant.

Louisville Control 19H
Level measurements at 1-minute intervals
Rainfall MSD gauge TR05 at 5-minute intervals

\[ \Delta H_{\text{measured}} = 2.14 \text{ m} \]
Articulated Concrete Block – Monitoring Results

The limiting depth value appears to be increasing with age.

<table>
<thead>
<tr>
<th>Ending date</th>
<th>Rain free days</th>
<th>Starting water depth (m)</th>
<th>Final water depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/13/2011</td>
<td>9</td>
<td>Unknown</td>
<td>0.06</td>
</tr>
<tr>
<td>01/11/2012</td>
<td>14</td>
<td>2.23</td>
<td>0.16</td>
</tr>
<tr>
<td>06/17/2012</td>
<td>14</td>
<td>0.76</td>
<td>0.25</td>
</tr>
<tr>
<td>11/26/2012</td>
<td>14</td>
<td>0.87</td>
<td>0.47</td>
</tr>
</tbody>
</table>

Louisville paver strip 19G
Tree Box – Monitoring Equipment

Edge of Road

Mulch: 0.25 ft.

Media: 5.5 ft.

Gravel: 1 ft.

Bracket PVC pipe to concrete with concrete screws & polyethylene hanger straps (above & below media)

= TDR
= Piezometer
= Drain Gauge

Image Not to Scale
The measured water level in the shaft responds quickly to rainfall patterns.
Tree Box – Data

Water ponded on top of stone mulch during more intense rainfall periods.
Maintenance

- No BMP (green or gray) is maintenance free
- Selecting the appropriate type of practice based on maintenance considerations
- Long term maintenance plan
  - Frequency of maintenance
  - Equipment need
  - Routine maintenance
  - As needed maintenance
  - Maintenance based on monitored performance
- Re-evaluation of practice types
- Skilled maintenance providers
Permeable Paver Bricks – Lessons Learned

- Application! Application! Application!
- Excavated/stockpiled material should not be stored where it will wash into practice during construction
- No. 8 aggregate should be flush with the top of the brick - reduces clogging and maintenance
EPA Parking Lot – Permeable Pavers

Most of the fines are trapped in the top 20 mm.
Articulated Concrete Block – Maintenance

Expected flow to concentrate along the curb with much smaller flows from the road crown and direct rainfall entering elsewhere.

Curb Edge

Street Edge

= Assumed Flow Direction

= TDR Location

Not to Scale
Articulated Concrete Block – Maintenance

Expected the concentrated flow to transport and deposit sediment from the drainage area.
Articulated Concrete Block – Maintenance

Visual inspection on February 1, 2012 confirmed where a surface was clogged.
Articulated Concrete Block – Maintenance

The curb edge TDR responses support the predicted clogging progression surface was clogged.

Data before 1st Maintenance
Control 19G
Length: 36.6 m
Articulated Concrete Block – Maintenance

First maintenance on March 20, 2012 used regenerative air vacuum truck.
Articulated Concrete Block – Maintenance

In comparison to initial conditions, TDR responses were low after regenerative air vacuum.

Event #24 was first event after maintenance with regenerative air sweeper.
Articulated Concrete Block – Maintenance

The second maintenance on May 9, 2012 used an air jet to dislodge debris from the spaces between blocks.

Photo: Josh Rivard University of Louisville
Articulated Concrete Block – Maintenance

TDR responses suggested initial infiltration capacity was recovered in most locations using the air jet method.

Indication that infiltration capacity was not restored
Articulated Concrete Block – Maintenance

After first using the air jet (05/09/12) to displace the sediment, a few blocks were removed for inspection.

No inspection was done before using the wand so don’t know if the maintenance forced the solids through the gap or if the solids were there before using the air jet.
Articulated Concrete Block – Maintenance

The third maintenance on October 5, 2012 used pressurized air again.

Photo: Josh Rivard University of Louisville
Articulated Concrete Block – Maintenance

A few blocks were pulled in December 2012, and there was markedly more sediment accumulation under the pavers.

Photos: Amir Ehsaei
Articulated Concrete Block – Maintenance

Costs for maintenance activities undertaken to date, but have concerns about scaling.

<table>
<thead>
<tr>
<th>Method</th>
<th>Cost ($)</th>
<th>Area maintained (ft²)</th>
<th>Unit cost ($/ ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweeping</td>
<td>370</td>
<td>960</td>
<td>0.385</td>
</tr>
<tr>
<td>Air jetting &amp; brush</td>
<td>921</td>
<td>1,400</td>
<td>0.658</td>
</tr>
</tbody>
</table>

Note: We expect some economy of scale to produce lower unit costs when additional controls are built.

Sweeping was only done to control 19G. Fixed mobilization / demobilization costs may skew unit cost estimate.
Recovered sediment particle size analysis shows initial accumulation of fines in the upgradient sections.

Mar. – May 2012 (9 in. rainfall)

Dec. 2011 – May 2012 (19 in. rainfall)
Surface clogging rate is proportional to cumulative rainfall (not time).

“Optimal” maintenance cannot be schedule based (e.g., quarterly).

Clogging rate may be increasing.
Articulated Concrete Block – Lesson Learned

With deep trenches acting as the storage gallery, it appears that more exfiltration occurs through the sidewalls than through the bottom.

Exfiltration rate varies with water depth and strata.
Street slopes (longitudinal and transverse) and curbs (height and condition) are important considerations when placing the controls in a curb and gutter system.

Curb / Sidewalk

Short curbs by design (or resulting from multiple resurfacing without milling) will limit the working flow width of the control.

Steeper slopes concentrate flow and use less surface area.
Articulated Concrete Block – Lesson Learned

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Articulated Concrete Block – Lesson Learned

The important consideration is **working** surface area, not surface area.

It is not obvious what to use as a working width (e.g., mean / median calculated 5-minute average flow width).

The current ICPI guidance is a ratio of control area to drainage area.

S\(_c\) = 2.81%
S\(_o\) = 1.30%
n = 0.013
Louisville Control 19G
Articulated Concrete Block – Lessons Learned

• Differential settlement occurred due to aggregate getting into arch of articulated concrete block

• Some vendors are still new to market and have steep learning curve

Photo: Amir Ehsaei
Articulated Concrete Block – Lessons Learned

- Washed stone is not clean stone
- If all the solids on aggregate migrate to the bottom, the depth would be significant

Est. depth of “fines (silt/clay)” = 23.2 cm (9.1 in.)
Est. depth of sand + “fines” = 33.4 cm (13.2 in.)
Articulated Concrete Block – Shaft Installation

Some of the controls installed have shafts instead of trenches

Photos: Josh Rivard, University of Louisville
Louisville Control 19
B 02 22 2013
Tree Box – Lessons Learned

- Tree box is very heavy and may settle over time
- Challenging to combine level of the box with sloping sidewalk