NCHRP Project 25-40 Long Term Performance and Life Cycle Costs of Stormwater Best Management Practices

2014 National Stormwater Practitioners Meeting

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Stormwater BMP Asset Management

- Need for Inspection and Maintenance
- Highlighting NCHRP project 25-40 –Long Term Performance and Life Cycle Costs of Stormwater Best Management Practices report and tools

Enhancing Financial Effectiveness – MnDOT's Wildly Important Goal

- Financial Management
- Project Management
- Asset Management
- Information and Outreach

Asset Management

- Understand Life Cycle Costs (of selected infrastructure categories per "TAMP")
- Develop improved resource consumption tracking methods for MnDOT Maintenance activities, collect resource consumption data.
- Analyze and utilize data to build models which will provide quantifiable information for the maintenance component of asset lifecycle cost analysis.

Challenge

- Many transportation agencies build stormwater BMPs whose long term performance and maintenance costs have not been determined

Good Business Practice

- I & M is a MS4 permit requirement
- DOTs maintain what we build in the R/W
- Proper maintenance lowers risk of BMP failure
- Since we maintain our BMPs – we might as well select ones that perform well and have lower life cycle costs.
- The 25-40 tool can help

NCHRP Project 25-40 Goals

- Develop relationships of maintenance and performance
- Develop long term understanding of changes in performance
- Develop a tool to predict performance and life cycle costs

Acknowledgements

- Scott Taylor, RBF Consulting
- Dr. Michael Barrett, University of Texas
- Marc Leisenring, Geosyntec Consulting
- Neil Weinstein, Low Impact Development Center
- Marie Venner, Venner Consulting

Panel

- Nanda Srinivasan/Chris Hedges, NCHRP Project Manager
- Nick Tiedeken, Minnesota DOT, Chair
- Jon Armstrong, Vermont Agency of Transportation
- Greg Granato, USGS
- Jeffery McKay, NTM Engineering
- Thomas Ryan McReynolds, USFWS
- Nicole Pierce, Oregon DOT
- Lucinda Soto, Texas DOT
- Amy Tootle, Florida DOT
- Patricia Cazenas, FHWA
- Henry Barbaro, Massachusetts DOT

Project Outline

- Background:
  - Literature Review
  - DOT Survey
  - FHWA, EPA, and Legislative Initiatives
  - Maintenance and Inspection
- Assessment:
  - BMP Performance
  - Unit Load Reduction Modeling
  - WLC Models
  - Maintenance and Inspection Protocols
- Tool Development
  - Data Collection Protocols
  - Non-structural BMP Assessment

Limitations

- BMP Datasets are limited (~5 years was longest data set)
- Maintenance information vs. performance is lacking
- Costs are very site-specific, especially in retrofit only scenarios

Tools Developed for

- Vegetated swale
- Filter strip
- Dry detention basin
- Bioretention
- Wet pond
- Sand filter
- Permeable friction course (PFC) overlay

Treatment Paramaters

- Volume
- TSS
- Pathogens
  - Fecal coliform
  - E. coli
- Metals
  - Total copper
  - Total lead
  - Total zinc
- Nutrients
  - Total phosphorus
  - Dissolved phosphorus
  - Nitrate (NO3)
  - Total Kjeldahl nitrogen (TKN)
  - Total nitrogen (TKN + NO3)

Data Sources

- Rain Gages –343 NCDC COOP,40 ASOS
- Highway Runoff Database (HRDB) version 1.0.0a
- National Stormwater Quality Database (NSQD) version 3.1
- International Stormwater BMP Database (3/14/2013 version)

Model Development

- Physically based hydrology and hydraulics
  - Long-term continuous simulation and data analysis
  - Percent volume captured and treated
  - Percent volume lost due to infiltration and ET
- Empirically based water quality
  - Non-parametric statistical methods
  - Determination of significant concentration reductions
  - Influent/effluent regression analysis

Inspection and Maintenance

- Defines inspection requirements, maintenance triggers, and maintenance actions for selected BMPs
- Primary sources: Caltrans, Oregon DOT, Arizona DOT, Maine DOT, New York DOT, DelDOT, NCDOT, and Texas DOT
- Developed three levels of maintenance: Low, medium and high – default is correlated to rainfall (Less than 20 inches, between 20 and 35 inches, 35 inches)

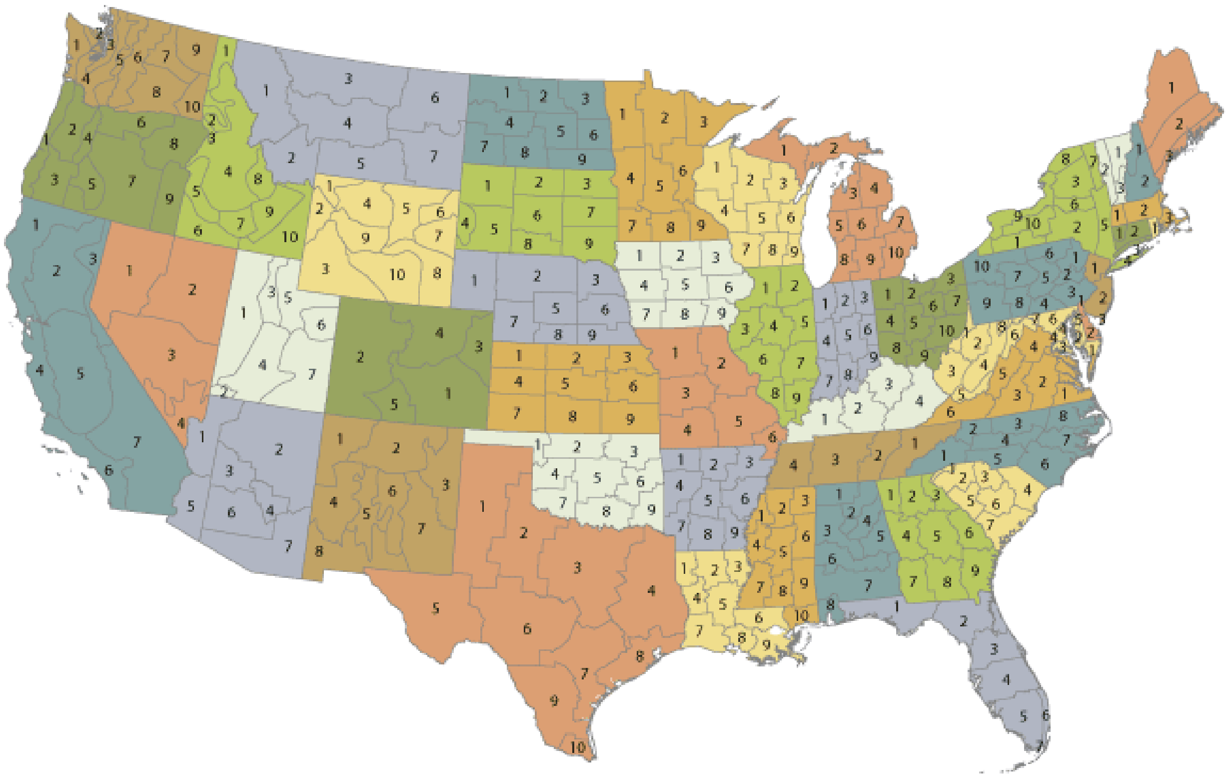
Whole life costs

- Built upon the WERF Whole Life Cost Models
- Line-item basis with defaults from RSMeans and research

Inputs

- Precipitation
- Drainage area
- Impervious area
- Site conditions (soil, slope, runoff coefficient)
- BMP dimensions

- Default/Optional user defined
- Influent
- Capital costs
- O&M costs, frequency



Step 2: Select the State your project is located and the rain gage closest to the project

States within Selected Region	Rain Gages Available in State
Oregon	[2] WILLAMETTE VALLEY - PORTLAND INTL AP

COOP ID	356751
Elevation , feet	19
85th Percentile, 24-Hour Storm Depth, inches	0.63
95th Percentile, 24-Hour Storm Depth, inches	0.98
Average Annual Precipitation Depth, inches	36.7

Step 3: If available, override the existing data and provide project specific rain data

Project Location 85th Percentile, 24-Hour Storm Depth (in)	0.63
Project Location Average Annual Precipitation Depth (in)	36.7

Note: Default precipitation statistics and the project-specific precipitation statistics are for reference and scaling purposes only; they do not imply a BMP size used for performance analysis. The user enters the BMP sizing parameters to be analyzed on the Project Design tab.

Key

User Steps
Headings and Descriptions
User Entered Data
Reference Data; do not edit cells

Outputs

- Volume reduction
- Pollutant treatment
- Effluent
- Amount Bypassed
- Load and Concentration
- Cost per treatment

NCHRP Dry Detention Evaluation Tool

Project Title	Test Run
Project Location	Portland, OR
Company	Geosyntec Consultants

Results Summary Report

Summary of Modeled Scenario

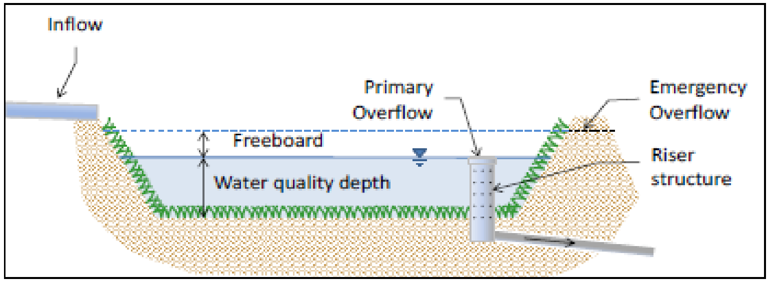
The modeled scenario consists of a tributary area of 5 acres at 60% impervious, draining to a Dry Detention Basin BMP.
Analysis is based on the [2] WILLAMETTE VALLEY - PORTLAND INTL AP gage, in Oregon, with Project Location 85th percentile, 24-hour storm depth of 0.63 inches, and Project Location average annual precipitation depth of 36.7 inches.

Summary of Primary Conceptual Design Parameters

Dry Detention Basin

Storage Volume (cu-ft)	5,000
Underlying Soil Incidental Infiltration Rate (in/hr)	0.2
Impermeable Liner Present?	no
Water Quality Depth (Depth to Primary Overflow) (ft)	3

See "Project Design" tab for detailed inputs



Summary of Whole Lifecycle Cost Results

Summary of Whole Lifecycle Cost Results

Capital Costing Method	Line Item Engineer's Estimate
Assumed Level of Maintenance	M
Estimated Capital Cost, $ (2013)	$54,545
Estimated NPV of Design Life Maintenance Costs, $ (2013)	$29,579
Estimated NPV of Design Life Whole Life Cycle Cost, $ (2013)	$84,124
Estimated Annualized Whole Life Cycle Cost, $/yr (2013)	$3,364.98

Costs are based on design life with routine and major maintenance.

Summary of Volume and Pollutant Load Performance

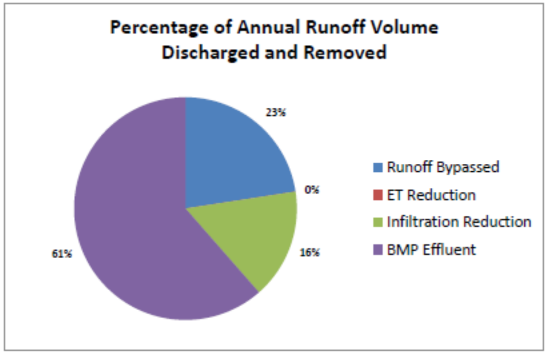
Volume and Pollutant Load Performance	Average Annual Volume, cf/yr	Percent of Baseline Runoff Volume, %	Pathogens (CFU/yr)	
			E. Coli	Fecal Coliform
Baseline Average Annual Runoff Volume	208,298	-	3.554E+15	5.132E+15
Runoff Bypassed	47,000	22.6%	8.020E+14	1.160E+15
BMP Captured	161,298	77.4%	2.752E+15	3.974E+15
Total Volume Reduction	33,300	16.0%	5.682E+14	8.204E+14
ET Reduction	0	0.0%	-	-
Infiltration Reduction	33,300	16.0%	-	-
Treatment Reduction	-	-	1.876E+15	1.554E+15
BMP Effluent	127,998	61.4%	3.080E+14	1.600E+15
Total Discharge	174,998	84.0%	1.110E+15	2.760E+15
BMP Load Reduction	-	-	2.444E+15	2.374E+15
% Annual BMP Load Reduction	-	-	69%	46%

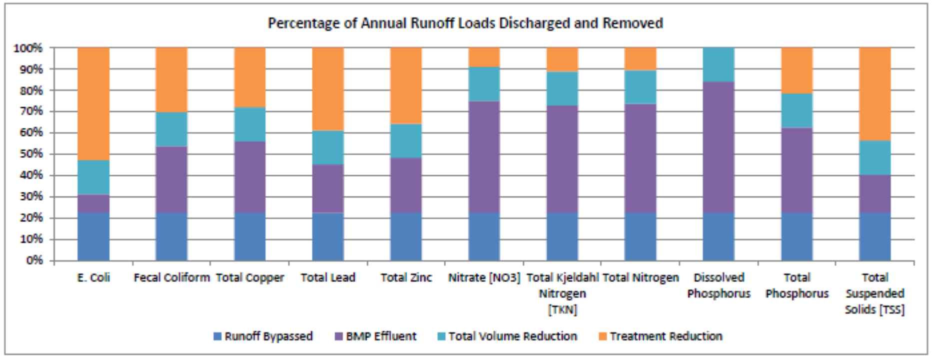
Annualized Cost Per Unit of Performance	Hydrologic Performance ($$/cu-ft removed)		Pathogens ($$/10^12 CFU removed)	
	Volume Reduction	Volume Capture	E. Coli	Fecal Coliform
Whole Lifecycle Cost per Unit, annualized (2013 dollars)	$0.10	$0.02	$1.38	$1.42

Summary of Volume and Pollutant Load Performance

Volume and Pollutant Load Performance	Average Annual Volume, cf/yr	Percent of Baseline Runoff Volume, %	Average Annual Pollutant Loads										
			Pathogens (CFU/yr)		Metals (lb/yr)			Nutrients (lb/yr)					Sediment (lb/yr)
			E. Coli	Fecal Coliform	Total Copper	Total Lead	Total Zinc	Nitrate [NO3]	Total Kjeldahl Nitrogen [TKN]	Total Nitrogen	Dissolved Phosphorus	Total Phosphorus	Total Suspended Solids [TSS]
Baseline Average Annual Runoff Volume	208,298	-	3.554E+15	5.132E+15	0.543	0.573	2.470	13.78	30.17	43.95	3.25	5.75	1806.0
Runoff Bypassed	47,000	22.6%	8.020E+14	1.160E+15	0.123	0.129	0.558	3.11	6.81	9.92	0.73	1.30	408.0
BMP Captured	161,298	77.4%	2.752E+15	3.974E+15	0.421	0.444	1.913	10.67	23.36	34.03	2.52	4.45	1398.5
Total Volume Reduction	33,300	16.0%	5.682E+14	8.204E+14	0.087	0.092	0.395	2.20	4.82	7.03	0.52	0.92	288.7
ET Reduction	0	0.0%	-	-	-	-	-	-	-	-	-	-	-
Infiltration Reduction	33,300	16.0%	-	-	-	-	-	-	-	-	-	-	-
Treatment Reduction	-	-	1.876E+15	1.554E+15	0.152	0.222	0.883	1.23	3.34	4.61	0.00	1.23	787.8
BMP Effluent	127,998	61.4%	3.080E+14	1.600E+15	0.182	0.130	0.635	7.24	15.20	22.40	2.00	2.30	322.0
Total Discharge	174,998	84.0%	1.110E+15	2.760E+15	0.304	0.260	1.190	10.30	22.00	32.30	2.73	3.60	730.0
BMP Load Reduction	-	-	2.444E+15	2.374E+15	0.239	0.314	1.278	3.43	8.16	11.63	0.52	2.15	1076.5
% Annual BMP Load Reduction	-	-	69%	46%	44%	55%	52%	25%	27%	26%	16%	37%	60%

Annualized Cost Per Unit of Performance	Hydrologic Performance ($$/cu-ft removed)		Pathogens ($$/10^12 CFU removed)		Metals ($$/lb removed)			Nutrients ($$/lb removed)					Sediment ($$/lb removed)
	Volume Reduction	Volume Capture	E. Coli	Fecal Coliform	Total Copper	Total Lead	Total Zinc	Nitrate [NO3]	Total Kjeldahl Nitrogen [TKN]	Total Nitrogen	Dissolved Phosphorus	Total Phosphorus	Total Suspended Solids [TSS]
Whole Lifecycle Cost per Unit, annualized (2013 dollars)	$0.10	$0.02	$1.38	$1.42	$14,106	$10,721	$2,634	$981	$412	$289	$6,503	$1,564	$3.13


Percentage of Annual Runoff Volume Discharged and Removed
23%
0%
16%
61%
Runoff Bypassed
ET Reduction
Infiltration Reduction
BMP Effluent


Percentage of Annual Runoff Loads Discharged and Removed
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
E. Coli
Fecal Coliform
Total Copper
Total Lead
Total Zinc
Nitrate [NO3]
Total Kjeldahl Nitrogen [TKN]
Total Nitrogen
Dissolved Phosphorus
Total Phosphorus
Total Suspended Solids [TSS]
Runoff Bypassed
BMP Effluent
Total Volume Reduction
Treatment Reduction

Summary of Average Water Quality Concentrations

Average Influent and Effluent Quality Summary Table	Pathogens (CFU/100ml)	
	E. Coli	Fecal Coliform
Influent Concentration	6025	8700
Treated Effluent Concentration	849	4426
Whole Effluent Concentration*	2239	5574

* Accounting for treated effluent quality, bypass effluent quality, capture efficiency and volume reduction

Summary of Average Water Quality Concentrations

Average Influent and Effluent Quality Summary Table	Average Annual Concentration										
	Pathogens (CFU/100ml)		Metals (µg/L)			Nutrients (mg/L)					Sediment (mg/L)
	E. Coli	Fecal Coliform	Total Copper	Total Lead	Total Zinc	Nitrate [NO3]	Total Kjeldahl Nitrogen [TKN]	Total Nitrogen	Dissolved Phosphorus	Total Phosphorus	Total Suspended Solids [TSS]
Influent Concentration	6025	8700	41.76	44.08	189.93	1.06	2.32	3.38	0.25	0.44	138.84
Treated Effluent Concentration	849	4426	22.76	16.30	79.48	0.91	1.90	2.80	0.25	0.29	40.36
Whole Effluent Concentration*	2239	5574	27.86	23.77	109.15	0.95	2.01	2.96	0.25	0.33	66.82

* Accounting for treated effluent quality, bypass effluent quality, capture efficiency and volume reduction

Nonstructural BMPs

- The non-structural BMPs that are qualitatively assessed within the report are:
  - Storm drain cleaning
  - Sweeping
  - Irrigation runoff reduction practices
  - Smart landscaping
  - Trash management programs (including education/outreach)
  - Elimination of groundwater infiltration (to storm drains)
  - Slope and channel stabilization
  - Winter maintenance activities (traction aides)

Qualitative Assessment

- Performance
- WLC cost Factors
- Pollutant load reduction
- Sustainability Rating
  - Pollutant avoidance/removal effectiveness
  - Cost/mile
  - Social/Institutional Impacts

Uses

- Comparison between BMPs
- Evaluating BMPs at a watershed scale
- Optimizing cost effective performance
- Estimating resource needs
  - I & M schedules
  - Staffing
  - Equipment
  - Funding
- Enhance performance of non-structural BMPS

Needs

- Emphasis on Volume Control BMPs
  - NCHRP 25-41 and 25-42 tools
- Innovative adaptations and enhancements
- New and additional BMPs
- Tracking of actual performance and cost

Summary

- Fiscal responsibility and asset management are fundamental DOT goals
- I & M important to achieve these
- 25-40 tools can help predict long term performance and costs
- 25-40 tools can help optimize water quality compliance strategies
- Tools needed for additional BMPs

25-40 Webinar Coming in October

- October 9 ???
- 2-3:30 ET ??