The design and maintenance of affordable urban water quality improvements



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Urban Water Quality Priorities

- Techniques based in science should be used for the design and maintenance of urban water quality improvements
- Focus first on the most important variables, rainfall and the runoff volume
- Infiltration systems should be designed to eliminate the runoff volume for typical rainfall events
- The techniques for the design, construction, and maintenance must be cost efficient

United States Environmental Protection Agency Office of Water (4503T) Washington, DC 20460

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Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act



EPA Section 438 requires federal agencies to reduce stormwater runoff from federal projects to protect water resources The purpose of EPA Section 438 is to replicate the predevelopment hydrology to protect and preserve both the water resources onsite and those downstream.



Figure 1. Pre-Development and Post-Development Hydrology. (USDA).

EPA Section 438 Performance Design Objectives

Option 1 - retaining the 95th percentile rainfall event. If Option 1 is not protective enough to maintain or restore the predevelopment hydrology of the project, use Option 2.

Option 2 - site-specific hydrologic analysis

National Weather Service Tahoe City Rainfall 1968 to 2011



Exceedance Probability

Davis Instrument meteorological

- Tipping bucket
- Heater to melt snow
- Air temperature
- Wind
- \$1,500



Rain Wise Meteorological

• Tipping bucket

• \$100



Runoff Volume Measurement

Volumetric

• \$20





Instrumentation

- \$1,000 level logger
- \$10,000 level and velocity



Example Rainfall verses Runoff Volume Relationships

- Caltrans, Dessert Research Institute, El Dorado County, TMDL sites, and USFS data was used in this presentation
- 27 storms at 9 locations, storm totals ranged from 0.1 to 4 inches.
- Average storm total was 1 inch

			rain	Runoff		
Agency	Location	Date	(inches)	(CF)	CF/inch	
El Dorado County	Montgomery Estates	11/4/2008	1.13	13,299	11,769	
El Dorado County	Montgomery Estates	11/7/2008	0.93	10,716	11,523	
El Dorado County	Montgomery Estates	6/28/2011	0.93	10,555	11,349	
El Dorado County	Montgomery Estates	10/6/2011	0.15	1,842	12,280	
El Dorado County	Montgomery Estates	1/20/2012	4.04	53,688	13,289	
El Dorado County	Rubicon	10/3/2008	0.82	5,604	6,834	
El Dorado County	Rubicon	3/3/2009	2.43	16,928	6,966	
El Dorado County	Rubicon	5/5/2009	1.19	8,437	7,090	
El Dorado County	Rubicon	10/13/2009	4.22	26,650	6,315	
El Dorado County	Rubicon	3/29/2010	1.04	7,128	6,854	
USFS	Snowpark	5/25/2011	0.31	881	2,841	
USFS	Snowpark	6/5/2011	0.48	512	1,067	
USFS	William Kent	10/4/2011	1.35	12,800	9,481	
USFS	William Kent	1/20/2012	3.68	35,950	9,769	
TMDL	Bijou	8/21/2003	0.60	8,726	14,543	
TMDL	Bijou	5/11/2004	0.36	2,755	7,653	
TMDL	Bijou	5/28/2004	0.23	2,043	8,883	
TMDL	Bijou	6/30/2004	0.04	451	11,275	
TMDL	Don Cheapos	3/25/2004	0.52	10290	19,788	
TMDL	Don Cheapos	5/11/2004	0.36	7414	20,594	
TMDL	Don Cheapos	5/28/2004	0.23	2328	10,122	
DRI	Cutthroat Avenue	10/24/2005	1	251	251	
DRI	Cutthroat Avenue	6/27/2006	0.37	116	314	
DRI	Cutthroat Avenue	7/22/2006	0.11	117	1,064	
Caltrans	3-202	8/3/2000	1.16	1,121	966	
Caltrans	3-203	8/3/2000	0.47	1,181	2,513	
Caltrans	3-203	8/30/2000	0.16	987	6,169	

Runoff Volume vs. Rainfall Depth



Rainfall Verses Runoff Conclusions

- The measurement of rainfall and runoff is a repeatable technique to predict runoff volumes
- When several storms exceeding 1 inch were measured, a correlation between rainfall and runoff was apparent
- For storms less than 1 inch, the correlation between rainfall and runoff was less consistent
- The design 24 hour rain storm of 1.6 inches generates between 500 and 30,000 cubic feet of runoff from the example outfalls that were reviewed here

Infiltration BMP Cost data

El Dorado County, USFS, and Washoe County provided construction costs for BMPs between 2001 through 2011

- 4 swales ranged from 260 and 1,800 cubic feet
- 2 rock filled subsurface trenches ranged from 110 to 350 cubic feet
- 13 infiltration basins ranged from 180 to 29,000 cubic feet
- 3 underground chambers ranged from 140 to 2,800 cubic feet

	Year	Agency	Project	Туре	Volume (cf)	Construction		\$/cf	Quantity
Swa	Swales								
	2010	USFS	Meyers Work Center Parking Lot		632	\$ 13,753	Bid	\$ 21.76	372
	2009	USFS	Fallen Leaf Campground Parking Lot	Swales	260	\$ 2,561	Bid	\$ 9.85	130
	2010	USFS	Spooner Fire Station	Cobblel Swale Infiltration Trench	1,776	\$ 4,049	Bid	\$ 2.28	222
	2011	Washoe County	Hybrid BMP Swale BMP 2	Swales	270	\$ 6,382	Bid	\$ 23.64	60
Subsurface Rock Filled Trench		ock Filled Trench							
	2010	USFS	Spooner Fire Station	Subsurface Rock Filled Trench	113	\$ 912	Bid	\$ 8.11	100
	2008	USFS	Zephyr Cove Cabins	Subsurface Rock Filled Trench	354	\$ 13,452	Bid	\$ 38.00	354
Basins									
	2011	Washoe County	Hybrid BMP Basin 7	Basin and Curb Inlet	300	\$ 7,790	Bid	\$ 25.97	300
	2011	Washoe County	Hybrid BMP Basin 8	Basin and Curb Inlet	240	\$ 11,420	Bid	\$ 47.58	240
	2011	Washoe County	Hybrid BMP Basin 10	Basin and Curb Inlet	180	\$ 7,954	Bid	\$ 44.19	180
	2011	Washoe County	Hybrid BMP Basin 14	Basin	540	\$ 6,976	Bid	\$ 12.92	540
	2011	USFS	Meyers Work Center Parking Lot	Basin	6,000	\$ 6,500	In House	\$ 1.08	4,000
	2009	USFS	Fallen Leaf Campground Parking Lot	Basin	270	\$ 2,561	Bid	\$ 9.49	270
	2001	El Dorado County	Pioneer Trail III	Cattlemans Basin	28,539	\$ 48,000	Bid	\$ 1.68	
	2001	El Dorado County	Pioneer Trail III	Cold Creek Basin	10,983	\$ 30,000	Bid	\$ 2.73	
	2001	El Dorado County	Pioneer Trail III	Kokanee Basin	28,940	\$ 41,750	Bid	\$ 1.44	
	2004	El Dorado County	Apalachee Phase 1	Nottaway Basin	9,000	\$ 40,000	Bid	\$ 4.44	
	2004	El Dorado County	Apalachee Phase 1	Glen Eagles Basin	1,626	\$ 39,000	Bid	\$ 23.99	
	2004	El Dorado County	Apalachee Phase 1	Boren Basin	1,200	\$ 25,000	Bid	\$ 20.83	
	2004	El Dorado County	Apalachee Phase 1	Boren Basin	1,000	\$ 16,000	Bid	\$ 16.00	
Underground chambers		d chambers							
	2011	Washoe County	Hybrid BMP Underground BMP 1	Stormtech and curb inlet	137	\$ 8,206	Bid	\$ 59.99	29
	2010	El Dorado County	Rubicon 5	24" Perf Pipe	681	\$ 28,373	Bid	\$ 41.64	217
	2010	El Dorado County	Rubicon 5	Stormwater Retention Chamber	2,800	\$ 78,262	Bid	\$ 27.95	

Basins Construction Cost



Swales Construction Cost



Rock Trenches Construction Cost



Underground Construction Cost



Construction Cost



Cost Conclusions

- Infiltration basins were generally the least expensive between \$1 to \$48 per cubic foot
- Swales were also cost efficient from \$2 and \$24 per cubic foot
- Underground chambers were generally more expensive and ranged from \$28 to \$60 per cubic foot
- The larger the BMP, the lower the unit cost per cubic foot of volume

William Kent BMP retrofit

- The LTBMU will be retrofitting water quality BMPs at the William Kent Campground in 2013
- During 2011 and 2012 we measured rainfall and runoff from above and below campground for a 1.4 inch storm and a 3.7 inch storm
- Initial HEC-HMS model was developed with the expectations that most of the runoff volume was originating from above the campground

WILLIAM MENT RIMP RETROFT AND ADWARSTRATIVE SITE REDEVELOPMENT PRELIMINARY ENVTRONMENTIAL ASSESSMENT

FIGURE Z-3

ALTERNATIVE 3-ALTERNATIVE PROPOSED ACTION CONCEPT DESIGN





Typical Infiltration Basin (Nevada Beach Campground)



William Kent Conclusions

- Measurements determined the runoff relationship was 10,000 cubic feet of runoff per inch of rainfall and the runoff from above the project area was insignificant
- Design volume for infiltration is 16,000 cubic foot, design will use 16 small infiltration BMPs throughout site, each sized for 1,000 cubic feet of storage.
- Two BMP concepts were considered, basins will cost approximately \$80,000 and subsurface chambers will cost approximately \$640,000.
- Due to available land and cost and maintenance, basins have been selected as the preferred BMP for this project

Contributors

- Caltrans and Dessert Research Institute rainfall/runoff relationships
- El Dorado County and USFS- rainfall/runoff relationships and BMP Construction Costs
- Washoe County BMP Construction Costs
- Environmental Protection Agency Section 438 Technical Guidance
- National Weather Service precipitation data from Tahoe City

Conclusions

- Measurement of rainfall for storms greater than 1 inch provides repeatable method to predict runoff relationships to size water quality BMPs
- Elimination of runoff from 1.6 inch in 24 hour rain storm will meet EPA Section 438 requirements for the 95% storm
- Cost of infiltration BMPs ranges from \$1 to \$60 per cubic foot of stored runoff volume depending on style and size
- Questions?