Evaluation of WINSLAMM Model Based on
Revised General Qualitative Stormwater Quality Assessment for
Light Industrial Warehouse Area at
Army Depot
(rev. November 29, 2005)[1]

The report summarizes results on a preliminary assessment of qualitative and quantitative stormwater quality for a light industrial warehouse area at an Army Depot using the WINSLAMM model. Estimates for total annual runoff volume, Rv, total suspended solids (TSS) concentration and yield, as well comparison of percentage of source area contributions based on the small storm hydrology and WINSLAMM models, are addressed. Changes in flows, TSS, and metals (zinc, copper, and lead) contributions for different rains relative to the source areas and rain categories will be discussed. Finally, stormwater controls will be proposed, both for retrofitting in the existing area as well as for hypothetical new construction for a similar area.

BACKGROUND

The area under consideration is a series of brick-sided warehouses used for light industrial purposes (mainly storage) at an Army depot (see aerial photograph - taken from Google Earth website – scale: 1 inch = 1000 ft). Total drainage area under consideration was 0.4 acres.

Traffic through this area is mainly passenger vehicles, with some semi-trailers, tankers, and heavy mobile equipment. One main 2-lane (divided) road runs parallel to the warehouse house and is approximately 1.1 miles. Few administrative buildings are in this area, so the lawn cover is minimal, mainly on the periphery of the warehouse area. The lawn was considered as a small landscaped area consisted of clayey soils. Parking areas are ungraveled and the streets directly adjacent and around the area is a concrete-asphalt material. The road base for the main thoroughfare is asphalt. A single rail line runs to loading docks to each of three warehouses; shipments are made routinely by rail. These railroad tracks are treated as an impervious surface in the assessment. A summary of site development conditions is provided in Appendix 1.

Seven general categories of sources (percentage) of stormwater runoff were identified for this area:

- Flat roofs – directly connected (5%)
- Pitched roofs – directly connected (45%)
- Streets (4%)
- Alleys (15%)
- Unpaved parking areas (5%)
- Paved parking areas (15%)
- Railroad tracks (5%)
- Lawns (5%)[2].

WINSLAMM RESULTS

Estimated total annual runoff volume was 19,840 cubic feet (CF). Estimated total yield are as follows:

- TSS - 2000 lbs
- Total Cu – 0.8582 lbs
- Total Pb – 1.529 lbs.
- Total Zn – 2.602 lbs.

[1] Based on results from the initial *General Qualitative Stormwater Quality Assessment for Light Industrial Warehouse Area at Army Depot* report (dated November 8, 2005).

[2] In the initial November 8 report referenced in Note 1 above, only four general stormwater runoff source categories (percentage) were identified for this area – flat roofs (35%), streets (45%), unpaved parking areas (19%), and lawns (1%). Further review of the site characteristics and recommendations provided in November 22, 2005, meeting with instructor, additional source areas were identified and percentages of sources relative to total area re-distributed/reallocated.

Aerial Photo of Warehouse Area at Army Depot

NOTE:
The area considered in this assessment is enclosed in the dotted red line.

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Minimum, maximum, and average estimates for runoff volume, Rv, and TSS and metals (Cu, Pb, Zn) concentration and yield are summarized in Table 1 below:

Table 1 – WINSLAMM Estimates for Runoff Volumes, Rv, TSS and metals concentrations and yields.

	Min	Max	Avg
Runoff Volume (cf)	0.9294	5297	1804
Rv	0.06	0.91	0.87
TSS conc (mg/l)	0.855	3329	1616
TSS yield (lbs)	4.96E-05	327.7	275.4
Total Cu (ug/l)	1.926	1419	693.2
Cu yield (lbs)	1.12E-07	0.14	0.1185
Total Pb (ug/)	2.475	2469	1235
Pb yield (lbs)	1.44E-07	0.2444	0.2136
Total Zn (ug/l)	31.88	4328	2104
Zn yield (lbs).	1.85-06	0.4262	0.3588

The TSS and metals concentrations and yields were estimated as the 'totals after outfall controls'.

COMPARISON OF WINSLAMM AND SMALL STORM HYDROLOGY MODELS

Table 2 and 3 below compare source area contributions (percentage) of runoff volume based on (1) revised small storm hydrology model calculations[3] and (2) WINSLAMM estimates.

Table 2-Small Storm Hydrology Model Estimates for Source Area Contributions

Source Area	Area %	Model	% Contribution		
			Min.	Max.	Avg.
Flat roofs	5%	Small Storm Hydrology	0	5	4
Pitched Roofs	45%		35	53	49
Streets	5%		4	5	4
Alleys	15%		11	15	13
Unpaved parking	5%		0	5	4
Paved parking	15%		15	44	20
Railroad tracks	5%		4	5	4
Lawns	5%		0	5	1
TOTAL	100%		---	---	---

Table 3-WINSLAMM Model Estimates for Source Area Contributions

Source Area	Area %	Model	% Contribution		
			Min.	Max.	Avg.
Flat roofs	5%	WINSLAMM	1.5	5.2	5.2
Pitched Roofs	45%		44	56.2	50.5
Streets	5%		4	5	4.8
Alleys	15%		12	15.1	14.4
Unpaved parking	5%		0.9	5.2	4.9
Paved parking	15%		16.3	55.4	16.9
Railroad tracks	5%		0.8	2.2	1.7
Lawns	5%		0.8	2.2	1.7
TOTAL	100%		---	---	---

[3] Per Note 2, revised stormwater contributions for source areas based on the small storm hydrology model are provided in Appendix 2.

The estimates of runoff contribution from the sources calculated by both models appear to agree, which would lead one to conclude that both models predict runoff contributions behavior very similarly. The volume of runoff generated by each source area is summarized in Table 3 below.

Table 3-WINSLAMM Estimates of Runoff Volumes by Source Area

	Rain Total	Flat roofs	Pitched roofs	Paved Parking/ Storage	Unpaved Parking/ Storage	Driveways/ Alleys	Street Area	Small Landscaped Area	Railroad Tracks	Land Use Totals
Min	0.01	0	0	1	0	0	0	0	0	0.9294
Max	4	276	2587	862	273	802	267	114	114	5297
Avg:	1.31	92.55	909.9	305.4	89	259	86.18	30.64	30.64	1804
Total:	15.66	1018	10009	3359	979	2849	948	337	337	19840

PREDICTIONS ON SS, POLLUTANT CONTRIBUTION, AND FLOWS

Estimates for TSS and metal concentrations and yield, as summarized in the Tables 4a and 4b below, appear to be similar to what would be predicted for the three rain categories. The rains between 0.5-1.5 inches accounted for the majority of the pollutant discharges. Rains below and above these ranges account for smaller portions of the pollutant discharges.

Table 4a and 4b – Summary of TSS and metals concentration and yield, by rain event category

	Rain (in.)	MIN	MAX	AVG
TSS (mg/l)	<0.5	0.86	995.20	362.81
	0.5 - 1.5	2006.00	3329.00	2731.50
	>1.5	845.70	2010.00	1380.43
Total Cu (mg/l)	<0.5	1.93	423.30	155.91
	0.5 - 1.5	856.80	1419.00	1165.70
	>1.5	366.00	861.00	593.58
Total Pb (mg/l)	<0.5	2.48	746.20	272.16
	0.5 - 1.5	1501.00	2469.00	2034.50
	>1.5	683.30	1519.00	1066.55
Total Zn (mg/l)	<0.5	31.88	1323.00	505.50
	0.5 - 1.5	2616.00	4328.00	3554.50
	>1.5	1104.00	2614.00	1797.00

	Rain (in.)	MIN	MAX	AVG
TSS (lbs)	<0.5	4.96E-05	15.72	4.40
	0.5 - 1.5	70.52	327.70	199.21
	>1.5	279.50	319.70	296.40
Total Cu (lbs)	<0.5	1.12E-07	6.69E-03	1.88E-03
	0.5 - 1.5	0.03	0.14	0.09
	>1.5	0.12	0.14	0.13
Total Pb (lbs)	<0.5	1.44E-07	1.18E-02	3.30E-03
	0.5 - 1.5	0.05	0.24	0.15
	>1.5	0.22	0.24	0.23
Total Zn (lbs)	<0.5	1.85E-06	2.09E-02	5.90E-03
	0.5 - 1.5	0.09	0.43	0.26
	>1.5	0.36	0.42	0.39

Tables 5a- 5c below summarize the TSS concentration, TSS yield in pounds, and TSS yield by % contribution by source area. These tables indicated that the largest source/contributor to TSS in the runoff is the street – by about 90-98% for all rain categories. However, paved parking areas are also a major TSS contributor during 'large' (greater than 1.5 inch) rain events.

Table 5a- TSS contribution by source area (mg/l)

	Rain Total	Flat roofs	Pitched roofs	Paved Parking/ Storage	Unpaved Parking/ Storage	Driveways/ Alleys	Street Area	Small Landscaped Area	Railroad Tracks	Land Use Totals
Min	0.01	5	1.27	76.2	600	100	14954	600	600	42.74
Max	4	5	5	273	1903	273	99155	1903	1903	4349
Fl Wt Ave:	0	5	5	101	609.7	100.5	33396	613.8	613.8	1683

Table 5b – Total TSS yield (lbs) by source area

	Rain Total	Flat roofs	Pitched roofs	Paved Parking/ Storage	Unpaved Parking/ Storage	Driveways/ Alleys	Street Area	Small Landscaped Area	Railroad Tracks	Land Use Totals
Min	0.01	3.67E-04	3.29E-05	0.002445	0.2734	0.05673	6.868	0.2445	0.2445	0.002478
Max	4	0.0861	0.807	5.38	10.22	5.003	318.4	4.281	4.281	327.7
Fl Wt Ave:	0	0.05464	0.5114	3.391	6.624	3.166	260.5	2.618	2.618	277
Total:	15.66	0.3175	3.122	21.16	37.27	17.85	1978	12.91	12.91	2083

Table 5c - TSS yield (% contribution by source area)

	Rain Total	Flat roofs	Pitched roofs	Paved Parking/ Storage	Unpaved Parking/ Storage	Driveways/ Alleys	Street Area	Small Landscaped Area	Railroad Tracks	Land Use Totals
Min	0.01	0	0.1	0.5	0.6	0.4	89.2	0.2	0.2	100
Max	4	0	1.3	98.7	3.7	1.8	98.2	1.5	1.5	100
Fl Wt Ave:	1.31	0	0.1	1	1.8	0.9	94.9	0.6	0.6	100

Tables 6a – 6c below summarize the copper concentration, copper yield in pounds, and copper yield by % contribution by source area. Although copper is a much smaller fraction of the pollutants in runoff (both in concentration and yield), these tables indicated that the largest source/contributor to copper in the runoff is the street – by about 87-97% for all rain categories. However, paved parking areas are also a major copper contributor during 'large' (greater than 1.5 inch) rain events.

Table 6a- Total Cu concentration (ug/l) by source area

	Rain Total	Flat roofs	Pitched roofs	Paved Parking/ Storage	Unpaved Parking/ Storage	Driveways/ Alleys	Street Area	Small Landscaped Area	Railroad Tracks	Land Use Totals
Min	0.01	3.219	2.011	63.55	430.5	44.57	6328	33.29	78.27	36.07
Max	4	3.219	3.219	225.3	1031	117.7	41933	98.42	241.1	1883
Fl Wt Ave:	1.31	3.219	3.219	83.9	435	44.76	14126	33.98	80	721.8

Table 6b – Total Cu yield (lbs) by source area

	Rain Total	Flat roofs	Pitched roofs	Paved Parking/ Storage	Unpaved Parking/ Storage	Driveways/ Alleys	Street Area	Small Landscaped Area	Railroad Tracks	Land Use Totals
Min	0.01	2.36E-07	5.21E-08	2.04E-06	1.48E-04	2.45E-05	0.002906	1.27E-05	3.10E-05	2.09E-06
Max	4	5.55E-05	5.20E-04	0.004472	0.007338	0.00223	0.1347	2.38E-04	5.59E-04	0.14
Fl Wt Ave:	1.31	3.52E-05	3.29E-04	0.002819	0.004752	0.001412	0.1103	1.45E-04	3.42E-04	0.1191
Total:	15.66	2.05E-04	0.002011	0.01759	0.0266	0.007955	0.8368	7.15E-04	0.001684	0.8936

Table 6c- Cu yield (% contribution by source area)

	Rain Total	Flat roofs	Pitched roofs	Paved Parking/ Storage	Unpaved Parking/ Storage	Driveways/ Alleys	Street Area	Small Landscaped Area	Railroad Tracks	Land Use Totals
Min	0.01	0	0.1	1	0.8	0.4	87.3	0.1	0.1	100
Max	4	0	2.5	97.5	6.1	1.8	97	0.2	0.5	100
Fl Wt Ave:	1.31	0	0.2	2	3	0.9	93.6	0.1	0.2	100

Tables 7a – 7c below summarize the lead concentration, lead yield in pounds, and lead yield by % contribution by source area. Lead concentrations are somewhat higher than copper concentrations in the runoff, although the yield of lead (in pounds) is very small compared to the TSS yield. These tables indicated that the largest source/contributor to lead in the runoff is the street – by about 80-96% for all rain categories. However, paved parking areas and pitched roofs are also major lead contributor during 'large' (greater than 1.5 inch) rain events.

Table 7a - Total Pb concentration (ug/l) by source area

	Rain Total	Flat roofs	Pitched roofs	Paved Parking/ Storage	Unpaved Parking/ Storage	Driveways/ Alleys	Street Area	Small Landscaped Area	Railroad Tracks	Land Use Totals
Min	0.01	59.87	15.95	89.79	614	129.9	10805	815.3	815.3	56.83
Max	4	59.87	59.87	317.4	1943	352.8	71578	2584	2584	3231
Fl Wt Ave:	1.31	59.87	59.87	118.5	623.9	130.4	24116	834	834	1285

Table 7b – Total Pb yield (lbs) by source area

	Rain Total	Flat roofs	Pitched roofs	Paved Parking/ Storage	Unpaved Parking/ Storage	Driveways/ Alleys	Street Area	Small Landscaped Area	Railroad Tracks	Land Use Totals
Min	0.01	4.39E-06	4.13E-07	2.88E-06	2.79E-04	7.33E-05	0.00496	3.32E-04	3.32E-04	3.30E-06
Max	4	0.001031	0.009666	0.006314	0.01047	0.006499	0.23	0.005818	0.005818	0.2444
Fl Wt Ave:	1.31	6.55E-04	0.006125	0.003979	0.006781	0.004113	0.1882	0.003559	0.003559	0.2146
Total:	15.66	0.003802	0.0374	0.02483	0.03816	0.02318	1.429	0.01755	0.01755	1.591

Table 7c - Pb yield (% contribution by source area)

	Rain Total	Flat roofs	Pitched roofs	Paved Parking/ Storage	Unpaved Parking/ Storage	Driveways/ Alleys	Street Area	Small Landscaped Area	Railroad Tracks	Land Use Totals
Min	0.01	0.1	0.8	0.8	0.8	0.6	79.8	0.4	0.4	100
Max	4	0.5	12.5	87.5	4.6	2.9	95.9	2.6	2.6	100
Fl Wt Ave:	1.31	0.2	2.4	1.6	2.4	1.5	89.8	1.1	1.1	100

Tables 8a – 8c below summarize the zinc concentration, zinc yield in pounds, and zinc yield by % contribution by source area. Zinc concentrations are somewhat higher than lead concentrations and significantly higher than copper concentrations in the runoff; the yield of zinc (in pounds) is comparable to the lead and copper. These tables indicated that the largest source/contributor to lead in the runoff is the street – by about 90-98% for all rain categories. However, paved parking areas and pitched roofs are also major lead contributor during 'large' (greater than 1.5 inch) rain events.

Table 8a - Total Zn concentration (ug/l) by source area

	Rain Total	Flat roofs	Pitched roofs	Paved Parking/ Storage	Unpaved Parking/ Storage	Driveways/ Alleys	Street Area	Small Landscaped Area	Railroad Tracks	Land Use Totals
Min	0.01	41.79	26.88	75.54	198.1	149.9	19671	960.9	960.9	53.81
Max	4	41.79	41.79	169.4	599.3	313.1	129095	2689	2689	5600
Fl Wt Ave:	1.31	41.79	41.79	87.35	201.1	150.3	43637	979.3	979.3	2191

Table 8b – Total Zn yield (lbs) by source area

	Rain Total	Flat roofs	Pitched roofs	Paved Parking/ Storage	Unpaved Parking/ Storage	Driveways/ Alleys	Street Area	Small Landscaped Area	Railroad Tracks	Land Use Totals
Min	0.01	3.07E-06	6.96E-07	2.43E-06	8.61E-05	6.51E-05	0.008945	3.46E-04	3.46E-04	3.12E-06
Max	4	7.20E-04	0.006748	0.004676	0.003377	0.007501	0.4152	0.006858	0.006858	0.4262
Fl Wt Ave:	1.31	4.57E-04	0.004276	0.002946	0.002188	0.004747	0.3412	0.004194	0.004194	0.3606
Total:	15.66	0.002654	0.02611	0.01831	0.0123	0.02671	2.585	0.02061	0.02061	2.713

Table 8c - Zn yield (% contribution by source area)

	Rain Total	Flat roofs	Pitched roofs	Paved Parking/ Storage	Unpaved Parking/ Storage	Driveways/ Alleys	Street Area	Small Landscaped Area	Railroad Tracks	Land Use Totals
Min	0.01	0.1	0.3	0.4	0.1	0.4	89.9	0.3	0.3	100
Max	4	0.2	22.3	77.7	0.9	2.1	98.3	1.9	1.9	100
Fl Wt Ave:	1.31	0.1	1	0.7	0.5	1	95.3	0.8	0.8	100

RECOMMENDATIONS ON STORMWATER CONTROLS

This section makes some preliminary proposals for stormwater controls for two scenarios: (1) for the existing warehouse area and (2) during construction of for a hypothetical warehouse area of similar configuration.

For the limited space in the existing warehouse area, installation of extensive additional and/or new stormwater controls is not practical. Also, most of the source areas (roofs, parking, etc.) are directly connected, installation of extensive controls will do little to improve stormwater quality (i.e., achieve significant pollutant reduction). Two stormwater practices are feasible for this area: street cleaning and grass drainage swales. The level and effectiveness of street cleaning required to remove pollutants is much more than which is achieved by conventional street cleaning operations. The existing warehouse area is a good candidate for employing street cleaning operations since the main thoroughfare is of moderate texture and no vehicular parking is allowed along the roadway. Grass swales could be incorporated into the current landscaped areas and lawns, as well as reducing some of the asphalt and/or gravel parking areas around the warehouses. The existing topography is relatively flat and long, which would enhance the effectiveness of the swales.

For planned construction of a hypothetical new warehouse area, numerous options (infiltration trenches, rain gardens, catchbasins, etc.) are available to stormwater control and quality for the various source areas. However, many of these options are costly to install and maintain. Conventional control options such as a wet detention pond or ponds, and grass swales placed in strategic locations would be the most cost-effective means of stormwater control and pollutant reduction. Also, porous pavement for parking areas and alleys (which typically is not subject to high traffic flow) should provide adequate treatment for pollutant reduction. These control options would provide sufficient stormwater control and pollutant reduction whether the sources were directly- or partially-connected.

APPENDIX 1 – SITE DEVELOPMENT CONDITIONS FOR ARMY DEPOT WAREHOUSE AREA

The following data is taken from the site survey form incorporated in the November 8, 2005 assessment report:

SITE SURVEY FOR SITE DEVELOPMENT CONDITIONS

Location: Army Depot Site Number; NA
Date: 11/7/05 Time: 4:30 pm
Land-use and industrial activity: Residential – NA
Income – NA
Age of development - < 1960 (~1940s)
Industrial – light (warehouse storage)
Maintenance of buildings: moderate
Heights of buildings - 1 story
Roof drains - 100% underground
Roof types - Flat (composition shingle), and pitched (metal)
Sediment service nearby - NA
Treated wood near streets - telephone poles
Landscaping near road:
- Quantity - some
- Type - lawn
- Maintenance - adequate
- Leafs on streets - none

Topography:
- Street slope – flat (<2%)
- Land slope – flat (<2%)

Traffic speed (25-40 mph)
Traffic density – light
Parking density – moderate
Width of street – 4 lanes (no parking lanes); alleys mostly 2 lanes
Condition of street – good
Texture of street – intermediate
Pavement material – asphalt (street); concrete (alleys)
Driveways – NA
Gutter material – concrete
- Condition – good
- Street/gutter interface – fair

Litter loading near street – clean
Parking/storage areas – gravel and asphalt (mostly gravel)
- Condition of pavement – good
- Texture of pavement – intermediate

Other paved areas (alleys, playgrounds) - NA

APPENDIX 2 –
REVISED STORMWATER CONDITIONS BY SOURCE AREA[4]

[4]The calculations provided in this Appendix reflect corrections/modifications to values initially submitted on November 8, 2005.

				0.04 in rain		
AREA CATEGORY	LENGTH (mi)	AREA (ac)	AREA %	Rv	Weighted Rv	Contribution
Flat roofs (roofs 1)		0.02	5%	0.00	0.00	0%
Pitched roofs (roofs 2)		0.18	45%	0.25	0.11	35%
Streets	1.1	0.02	5%	0.26	0.013	4%
Alleys		0.06	15%	0.26	0.039	12%
Unpaved parking areas		0.02	5%	0.00	0.00	0%
Paved parking areas		0.06	15%	0.93	0.14	44%
Railroad tracks	1.5	0.02	5%	0.26	0.01	4%
Lawns		0.02	5%	0.00	0.00	0%
TOTAL		0.4	100%	N/A	0.317	100%

				0.12 in. rain		
AREA CATEGORY	LENGTH (mi)	AREA (ac)	AREA %	Rv	Weighted Rv	Contribution
Flat roofs		0.02	5%	0.30	0.015	2%
Pitched roofs		0.18	45%	0.75	0.3375	53%
Streets	1.1	0.02	5%	0.49	0.025	4%
Alleys		0.06	15%	0.49	0.074	12%
Unpaved parking areas		0.02	5%	0.30	0.015	2%
Paved parking areas		0.06	15%	0.96	0.144	23%
Railroad tracks	1.5	0.02	5%	0.49	0.0245	4%
Lawns		0.02	5%	0.00	0.000	0
TOTAL		0.4	100%	N/A	0.634	100%

				0.20 in. rain		
AREA CATEGORY	LENGTH (mi)	AREA (ac)	AREA %	Rv	Weighted Rv	Contribution
Flat roofs		0.02	5%	0.54	0.027	4%
Pitched roofs		0.18	45%	0.85	0.3825	53%
Streets	1.1	0.02	5%	0.55	0.0275	4%
Alleys		0.06	15%	0.55	0.0825	11%
Unpaved parking areas		0.02	5%	0.54	0.027	4%
Paved parked areas		0.06	15%	0.97	0.1455	20%
Railroad tracks	1.5	0.02	5%	0.55	0.0275	4%
Lawns		0.02	5%	0.05	0.0025	0.3%
TOTAL		0.4	100%	N/A	0.722	100%

				0.39 in. rain		
AREA CATEGORY	LENGTH (mi)	AREA (ac)	AREA %	Rv	Weighted Rv	Contribution
Flat roofs		0.02	5%	0.72	0.036	5%
Pitched roofs		0.18	45%	0.93	0.4185	53%
Streets	1.1	0.02	5%	0.60	0.03	4%
Alleys		0.06	15%	0.60	0.09	11%
Unpaved parking areas		0.02	5%	0.72	0.036	5%
Paved parking areas		0.06	15%	0.97	0.1455	18%
Railroad tracks	1.5	0.02	5%	0.6	0.03	4%
Lawns		0.02	5%	0.08	0.004	0.5%
TOTAL		0.4	100%	N/A	0.79	100%

				0.59 in. rain		
AREA CATEGORY	LENGTH (mi)	AREA (ac)	AREA %	Rv	Weighted Rv	Contribution
Flat roofs		0.02	5%	0.79	0.0395	5%
Pitched roofs		0.18	45%	0.95	0.4275	52%
Streets	1.1	0.02	5%	0.64	0.032	4%
Alleys		0.06	15%	0.64	0.096	12%
Unpaved parking areas		0.02	5%	0.79	0.0395	5%
Paved parking areas		0.06	15%	0.97	0.1455	18%
Railroad tracks	1.5	0.02	5%	0.64	0.032	4%
Lawns		0.02	5%	0.1	0.005	0.6%
TOTAL		0.4	100%	N/A	0.817	100%

				0.79 in. rain		
AREA CATEGORY	LENGTH (mi)	AREA (ac)	AREA %	Rv	Weighted Rv	Contribution
Flat roofs		0.02	5%	0.83	0.0415	5%
Pitched roofs		0.18	45%	0.96	0.432	52%
Streets	1.1	0.02	5%	0.67	0.0335	4%
Alleys		0.06	15%	0.67	0.1005	12%
Unpaved parking areas		0.02	5%	0.83	0.0415	5%
Paved parking areas		0.06	15%	0.97	0.1455	17%
Railroad tracks	1.5	0.02	5%	0.67	0.0335	4%
Lawns		0.02	5%	0.11	0.0055	0.7%
TOTAL		0.4	100%	N/A	0.8335	100%

				1.2 in. rain		
AREA CATEGORY	LENGTH (mi)	AREA (ac)	AREA %	Rv	Weighted Rv	Contribution
Flat roofs		0.02	5%	0.86	0.043	5%
Pitched roofs		0.18	45%	0.98	0.441	51%
Streets	1.1	0.02	5%	0.73	0.0365	4%
Alleys		0.06	15%	0.73	0.1095	13%
Unpaved parking areas		0.02	5%	0.86	0.043	5%
Paved parking areas		0.06	15%	0.98	0.147	17%
Railroad tracks	1.5	0.02	5%	0.76	0.038	4%
Lawns		0.02	5%	0.12	0.006	0.7%
TOTAL		0.4	100%	N/A	0.864	100%

				2.0 in. rain		
AREA CATEGORY	LENGTH (mi)	AREA (ac)	AREA %	Rv	Weighted Rv	Contribution
Flat roofs		0.02	5%	0.9	0.045	5%
Pitched roofs		0.18	45%	0.99	0.4455	49%
Streets	1.1	0.02	5%	0.84	0.042	5%
Alleys		0.06	15%	0.84	0.126	14%
Unpaved parking areas		0.02	5%	0.9	0.045	5%
Paved parking areas		0.06	15%	0.99	0.1485	16%
Railroad tracks	1.5	0.02	5%	0.84	0.042	5%
Lawns		0.02	5%	0.17	0.0085	0.9%
TOTAL		0.4	100%	N/A	0.9025	100%

				3.2 in. rain		
AREA CATEGORY	LENGTH (mi)	AREA (ac)	AREA %	Rv	Weighted Rv	Contribution
Flat roofs		0.02	5%	0.94	0.047	5%
Pitched roofs		0.18	45%	0.99	0.4455	48%
Streets	1.1	0.02	5%	0.9	0.045	5%
Alleys		0.06	15%	0.9	0.135	15%
Unpaved parking areas		0.02	5%	0.94	0.047	5%
Paved parking areas		0.06	15%	0.99	0.1485	16%
Railroad tracks	1.5	0.02	5%	0.9	0.045	5%
Lawns		0.02	5%	0.24	0.012	1.3%
TOTAL		0.4	100%	N/A	0.925	100%

				4.2 in. rain		
AREA CATEGORY	LENGTH (mi)	AREA (ac)	AREA %	Rv	Weighted Rv	Contribution
Flat roofs		0.02	5%	0.96	0.048	5%
Pitched roofs		0.18	45%	0.99	0.4455	47%
Streets	1.1	0.02	5%	0.93	0.0465	5%
Alleys		0.06	15%	0.93	0.1395	15%
Unpaved parking areas		0.02	5%	0.96	0.048	5%
Paved parking areas		0.06	15%	0.99	0.1485	16%
Railroad tracks	1.5	0.02	5%	0.93	0.0465	5%
Lawns		0.02	5%	0.35	0.0175	2%
TOTAL		0.4	100%	N/A	0.94	100%

Rain (in.)	Runoff (in.)
0.04	0.013
0.12	0.08
0.2	0.14
0.39	0.31
0.59	0.48
0.79	0.66
1.2	1.04
2.0	1.81
3.2	2.96
4.9	4.61