APPENDIX D

EXPERT PANEL'S BMP PERFORMANCE ANALYSIS MEMORANDUM
2013/2014 RAINY SEASON

Memorandum

Date: 27 August 2014

To: The Boeing Company (Boeing), Santa Susana Field Laboratory (Santa Susana Site)

From: Geosyntec Consultants and the Santa Susana Site Surface Water Expert Panel

Subject: BMP Performance Analysis
Santa Susana Site
Geosyntec Project: SB0363U

The purpose of this memorandum is to update the annual stormwater quality evaluation being conducted at the Boeing Santa Susana Site (Site) to confirm whether the treatment Best Management Practices (BMPs) in conjunction with upgradient erosion control practices are decreasing pollutant of concern (POC) concentrations. This memorandum incorporates 2013-2014 rainy season data collected at the Site into a dataset that was initiated in December 2009. The National Pollutant Discharge Elimination System (NPDES) POCs addressed in this analysis include total suspended solids (TSS), total lead, total copper, and dioxins (TCDD TEQ, DNQ excluded, BAFs included). In particular, 2013-2014 data were collected to assess effectiveness of culvert modification (CM) installations and the lower lot biofilter, which are all located in the NPDES Outfall 009 watershed. Figures 1-3 and 1-4 in the Annual Report show locations of all stormwater controls and monitoring sites.

Data for the 2013-2014 monitoring season were sparse due to the low precipitation amount and fewer storm events compared to previous years.[1] There was no flow measured at Outfall 008 or any of the Outfall 008 watershed monitoring sites during this monitoring season; therefore, no samples were collected in the NPDES Outfall 008 watershed in the 2013-2014 monitoring season. In addition, no data pairs were collected at Interim Source Removal Action (ISRA) locations during the monitoring season. As a result, ISRA sites and sites in the Outfall 008 watershed are not discussed in this memo.

Paired data from both an influent and effluent sample location at each BMP and collected during the same storm event were evaluated. Split samples were also collected and used for lab comparison purposes; however, only the primary samples were used in the following analysis. The number of paired samples varies by constituent, but for all years combined generally ranges from nine to 15 pairs for each POC for

[1] Average annual rainfall at SSFL from 1960-2006 was 18 inches, compared to 6.07 inches in the 2013-2014 monitoring period. Additionally, only five rain events (more than 0.1 inches of rainfall in a 24-hour period and must be preceded by at least 72 hours of dry weather), two of which produced observable flow, occurred in 2013-2014. This is compared to 13, 10, and nine events in prior reporting years 2010-2011, 2011-2012, and 2012-2013, respectively.

each of the six CM sites discussed here.[2] Performance data for the lower lot biofilter (construction of which was completed in 2013) were collected from two locations within the system (influent and effluent, a mid-point sample was not collected this season due to ponding) during one storm event in the 2013-2014 sampling year. As a result, there are only two sample pairs associated with this location to date, and the 2013-2014 biofilter effluent sample reflects a blend of filtered underdrain flows and overflows that bypassed the filter media. In addition, a new treatment system at the ELV was fully implemented during the current monitoring season, with paired data taken during one event. These data are shown in the line plots and statistical analyses in the following sections, though it should be noted that it is possible that the media bed for this system may still have been flushing fines since this was the first rain event it experienced. The ELV treatment system was also heavily loaded by sediments eroded from the denuded ELV channel prior to implementation of recent erosion control improvements.

With respect to sampling at the CM sites, influent grab samples are collected from flowing surface water upstream of the maximum extent of ponding at each CM as observed before that date.[3] All CMs include a media filter and a slipline HDPE lining through existing galvanized corrugated metal culvert pipes with the exception of B1, which is a media bed with no slipline element. CM effluent grab samples are collected at the culvert outlets on the downstream side of the road, where the culvert pipes discharge to the Northern Drainage, with the exception of CM-9 and B1, where effluent samples were collected from the underdrain outlets beginning in October 2011, rather than the culvert outlet. Flows from the culvert outlets may represent treated runoff (via sedimentation and media filtration) and partially treated runoff (flowing through or over the weir boards). At CM-3, the slipline HDPE pipes were inserted from both the influent and effluent sides and could not be sealed at the point where they meet, and subsurface flows through the road embankment are known to have entered the pipe during rain events from February 2010 through March 2011[4] because water was observed discharging from the HDPE pipe outlet when no water was flowing into the inlet. Therefore, CM-3 performance as designed cannot be reliably assessed due to this bypassing of the media filter.

Monitoring sites CM-1 (influent-east; see additional discussion in Section 1, below), CM-3, CM-8, and CM-11 receive runoff from drainage areas that do not include any known historic industrial activities, although the CM-3 area does include a clean soil borrow area at the top of the watershed. Therefore, influent sample results at these four CM locations (not including CM-1 influent-west) are relatively good quality and considered reflective of "background" stormwater concentrations, making it difficult to achieve additional POC reduction through these CMs. These "background" CM locations were therefore statistically evaluated separately from the other CM locations. Sampling at these background CM locations was discontinued following the 2010-2011 monitoring season.

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[2] As described herein, CM-3 was excluded from this analysis due to dry weather flows observed at the outlet when no flows were observed entering the culvert.

[3] When the extent of ponding increased at the CM-1 and CM-3 culvert basins on December 22, 2010 during a heavy rainfall, the influent sample locations were moved upstream a sufficient distance to remain above the maximum ponded water footprint.

[4] Sampling at this site was discontinued after the 2010-2011 season, so no observations have been made since March 2011.

During the 2013-2014 season, there were two monitored rain events[5], with seven new CM paired samples collected, one sample pair from a single storm for the lower lot biofilter (influent and biofilter outlet), and one sample pair for the ELV treatment BMP. As mentioned earlier, no paired ISRA data were collected this season. The BMPs discussed in this memo and their respective drainage areas are shown in Table 1. While these areas are discussed specifically with respect to performance monitoring data, there are other areas of the SSFL site which are also addressed by BMPs, including CMs, asphalt removal, erosion control, and treatment control BMPs.

Table 1. BMP Sites and Drainage Areas

BMP	Drainage Area (acres)
CM-1	52.8
CM-3	17.2
CM-8	2.5
CM-9	16.4
CM-11	8.3
B1 Media Filter	4.7
ELV treatment BMP	4.5
Lower Lot Biofilter	28.3[1]

[1] A percentage of the 24-inch stormdrain drainage area is diverted to the lower lot biofilter for treatment (this percentage is expected to improve to 30 – 40% after improvements are made at the site). As a result, the percent of runoff volume captured and treated from the smaller (approximately 4 acre) lower lot drainage area is greater than the percent captured and treated from the larger (approximately 24 acre) 24-inch stormdrain drainage area.

1. LINE PLOTS

The log-scale line plots presented in this section illustrate the changes in measured concentrations between influent and effluent sample pairs at each CM and biofilter monitoring site. Paired data were obtained from CM locations B1, CM-1, CM-8, CM-9, and CM-11, the ELV treatment BMP, and the lower parking lot biofilter. Paired data are presented by POC in Figures 1 through 35. Pairs are color-coded based on the sampling year during which they were collected, and different symbology is used for different influent and effluent sample collection locations (symbology is defined in each graph). Additionally, non-detect results are displayed as the detection limit. The statistical analysis of the datasets is presented in Section 2 below.

In addition to evaluating BMP performance, the monitoring data have also been used in the site selection evaluations for consideration for enhancements to selected CMs for improved performance in areas where the effluent remains problematic. This was the case at CM-9 based on previous year results, and upgradient improvements were added in 2013. Other examples of improvements include asphalt removal and filter fabric installation. For these sites, separate graphs are shown for sample results that occurred before and after the improvements were made. At the B1 site, media filter bleed-through was observed during initial sampling dates in the 2011-2012 sampling season. Results collected during this period were

[5] Monitoring occurs when rain events result in observable flow. During the 2013-2014 monitoring period, only two events produced observable flow and therefore these were the only events monitored.

removed from the analysis. As noted above, monitoring data were collected at the new ELV treatment BMP, however, since this was the first rain event that the system experienced, it is possible that the monitoring data reflect fines being flushed out of the system. In addition, during the February/March 2014 storm event, a plug in the storm drain under Helipad Road resulted in high flows from Helipad Road being routed to the ELV sump and treatment system. Additionally, inadequate erosion controls along the earthen ELV channel resulted in sediment filling the sump, and a power outage resulted in the sump pump turning off. The ELV treatment system effluent data are still considered representative, though this may be re-evaluated in following years as more monitoring data are collected for this system.

Several CM locations (CM-1, CM-9, and the B1 media filter) have multiple influent drainage areas:

- CM-1 receives runoff from an eastern tributary that is considered to reflect background concentrations as well as a western tributary comprising paved road and ELV hillside runoff;
- CM-9 receives runoff from the Area I landfill and former Building 1324 parking lot (demolished Summer/Fall 2011), as well as the paved road to the east; and
- B1 receives runoff from the north, comprised of paved road runoff, and the south, comprised of the upper B1 ISRA areas, the sedimentation basin, and paved road runoff.

The selection of the influent location used in the paired analysis was evaluated on a case by case basis, with similar sample dates taking precedence (between influent and effluent); in instances when two influent samples were available for the same effluent-sampling storm event, an impervious area-weighted average (used as an estimate of proportioned flowrate from each influent stream) was used to represent a single influent value. With regards to the CM line plots, the CM effect on influent concentrations above the Permit Limit is the most important since those below the Permit Limit are already of acceptable quality and are generally considered to be at levels unlikely to be further reduced using typical stormwater controls, especially considering the conditions that have been experienced to date in terms of precipitation and watershed erosion. As with most stormwater quality controls, the water quality improvements are largest when the influent concentrations are highest.

These charts are included for general visual assessment purposes only; the statistical tests that follow are used to make evaluations on BMP performance. It should be noted that these samples are all grab samples, and therefore highly variable in terms of water quality results, and may represent collection times that vary throughout the storm event hydrograph. Therefore, relatively large numbers of samples are needed to represent the varying conditions with reasonable statistical confidence and power.

Although not recorded for every event, based on field notes the following five effluent samples were collected during overflow/bypass conditions. These conditions are noted on the plots and indicate decreased performance. No other sampling dates were observed for overflow, so whether or not this occurred for other dates cannot be determined. In addition, observations of weir board overflows were collected starting in the 2011-2012 season. It is unknown which prior samples, if any, were collected during overflow. Future sampling notes will more carefully track this information.

CM-9, effluent underdrain samples:

- A2SW0009S001 on 10/5/2011
- A1SW0009S017 on 3/17/2012

- A1SW0009S004 on 3/25/2012

CM-1, effluent culvert outlet samples:

- A1SW0002S020 on 3/17/2012
- A2SW0002S021 on 3/25/2012

Table 2 summarizes rainfall events in which data were collected for the 2009-2014 seasons (‘non sample collection events’ represent precipitation events where samples were not collected). Not all BMPs had influent and effluent flows during each rain event.

Table 2. Sample collection event rainfall data summary (gray cells indicate dates that did not have data pairs sampled)

Date(s)	Average Intensity (in/hr)	Max Intensity (in/hr)	Event Total (in)	Event Duration (hrs)	Cumulative Rainfall for Sampled Events (in)
10/13/2009 - 10/14/2009	0.05	0.24	2.45	35	2.45
12/7/2009 - 12/13/2009	0.02	0.25	3.43	57	5.88
1/17/2010 – 1/22/2010	0.05	0.52	6.88	123	12.76
2/5/2010 – 2/6/2010	0.04	0.20	1.84	43	14.6
2/9/2010	0.01	0.17	0.20	3	14.8
2/19/2010-2/20/2010	0.01	0.05	0.14	8	14.94
2/24/2010	0.01	0.03	0.12	12	15.06
2/27/2010	0.06	0.34	1.52	17	16.58
3/6/2010	0.02	0.13	0.38	11	16.96
4/4/2010 - 4/5/2010	0.03	0.23	0.86	13	17.82
4/11/2010 - 4/12/2010	0.03	0.22	0.65	11	18.47
Non sample collection event total			0.57		
Total for 2009-2010 monitoring period			**19.04**		
10/5/2010 - 10/6/2010	0.049	0.18	0.93	20	0.93
10/16/2010 - 10/25/2010	0.003	0.22	0.69	216	1.62
11/17/2010 - 11/21/2010	0.011	0.23	0.97	89	2.59
12/5/2010	0.018	0.09	0.41	10	3.0
12/17/2010 – 12/22/2010	0.054	0.37	7.22	131	10.22
12/25/2010 - 12/26/2010	0.03	0.22	0.57	9	10.79
12/29/2010	0.043	0.10	0.43	7	11.22
1/2/2011 - 1/3/2011	0.014	0.12	0.38	17	11.60
2/15/2011 – 2/20/2011	0.019	0.45	2.33	121	13.93
2/25/2011 - 2/26/2011	0.03	0.22	1.50	20	15.43
3/2/2011 - 3/3/2011	0.007	0.03	0.13	8	15.56
3/6/2011 - 3/7/2011	0.006	0.02	0.12	10	15.68
3/18/2011 - 3/27/2011	0.03	--	6.00	197	21.68
5/15/2011 - 5/18/2011	0.009	0.08	0.67	76	22.35
Non sample collection event total			1.03		
Total for 2010-2011 monitoring period			**23.38**		
10/5/2011	0.09	0.18	0.90	9	0.90
11/4/2011 - 11/6/2011	0.041	0.23	0.58	59	1.48
11/11/2011 - 11/12/2011	0.035	0.26	0.76	22	2.24
11/19/2011 - 11/21/2011	0.031	0.29	0.78	35	3.02
12/12/2011 - 12/17/2011	0.006	0.21	0.80	137	3.82
1/21/2012 – 1/23/2012	0.017	0.15	1.06	62	4.88
2/27/2012	--	--	0.00		
3/16/2012 - 3/18/2012	0.052	0.31	1.51	29	6.39
3/25/2012	0.079	0.51	2.12	21	8.51
4/10/2012 – 4/13/2012	0.034	0.36	2.37	64	10.88
4/23/2012 - 4/26/2012	0.003	0.09	0.26	80	11.14
Non sample collection event total			0.27		
Total for 2011-2012 monitoring period			**11.41**		
11/14/2012 – 11/18/2012	0.01	0.36	0.99	99	0.99

Date(s)	Average Intensity (in/hr)	Max Intensity (in/hr)	Event Total (in)	Event Duration (hrs)	Cumulative Rainfall for Sampled Events (in)
11/28/2012 – 12/4/2012	0.011	0.12	1.49	139	2.48
12/12/2012 – 12/18/2012	0.005	0.07	0.68	129	3.16
12/22/2012 – 12/26/2012	0.013	0.18	1.13	87	4.29
1/23/2013 – 1/27/2013	0.02	0.18	1.78	89	6.07
2/8/2013 – 2/9/2013	0.008	0.07	0.12	15	6.19
2/19/2013	0.025	0.09	0.25	10	6.44
3/7/2013 – 3/8/2013	0.041	0.23	0.87	7	7.31
5/5/2013 - 5/6/2013	0.04	0.16	0.48	7	7.79
Non sample collection event total			0.30		
Total for 2012-2013 monitoring period			**8.09**		
11/20/2013 – 11/21/2013	***0.013***	***0.12***	***0.47***	***17***	***0.47***
12/7/2013	***0.070***	***0.09***	***0.28***	***4***	***0.75***
2/6/2014 – 2/7/2014	***0.015***	***0.15***	***0.28***	***16***	***1.03***
2/26/2014 – 3/2/2014	***0.052***	***0.47***	***4.62***	***89***	***5.65***
4/1/2014[1]			***0.22***		***5.87***
Non sample collection event total			***0.20***		
Total for 2013-2014 monitoring period			***6.07***		

[1] Hourly rainfall data was only available through the first quarter of 2014 at the time of drafting of this memorandum. Intensity and duration values could therefore not be calculated for the 4/1/2014 event.

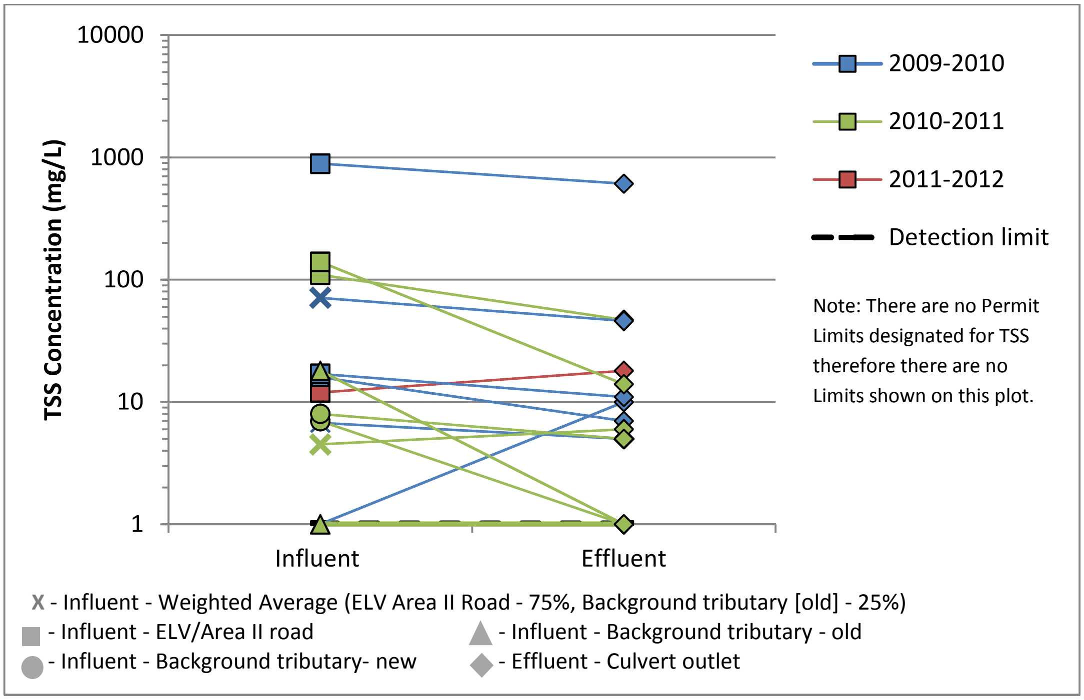


Figure 1. TSS at CM-1, pre filter fabric installation

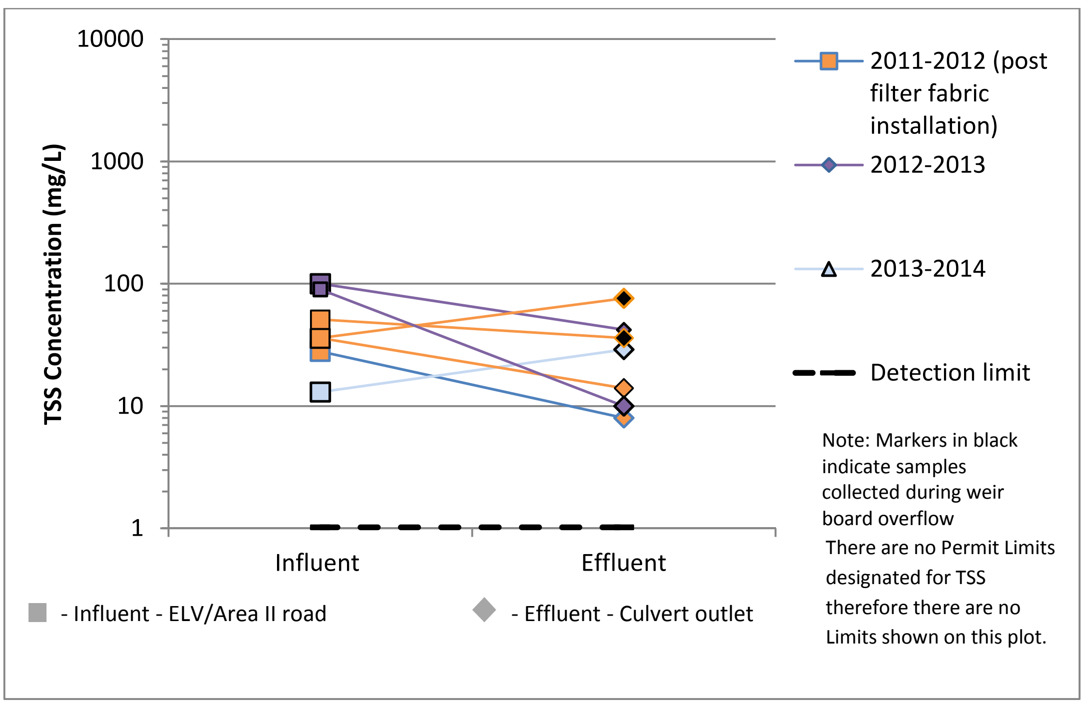


Figure 2. TSS at CM-1, post filter fabric installation

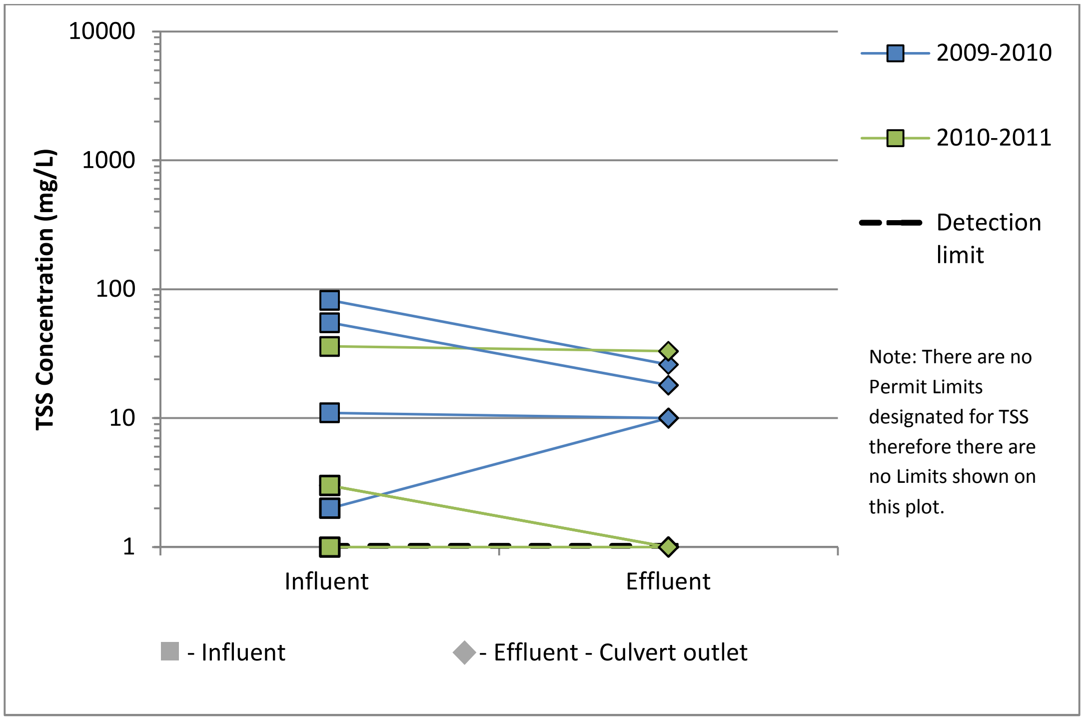


Figure 3. TSS at CM-8

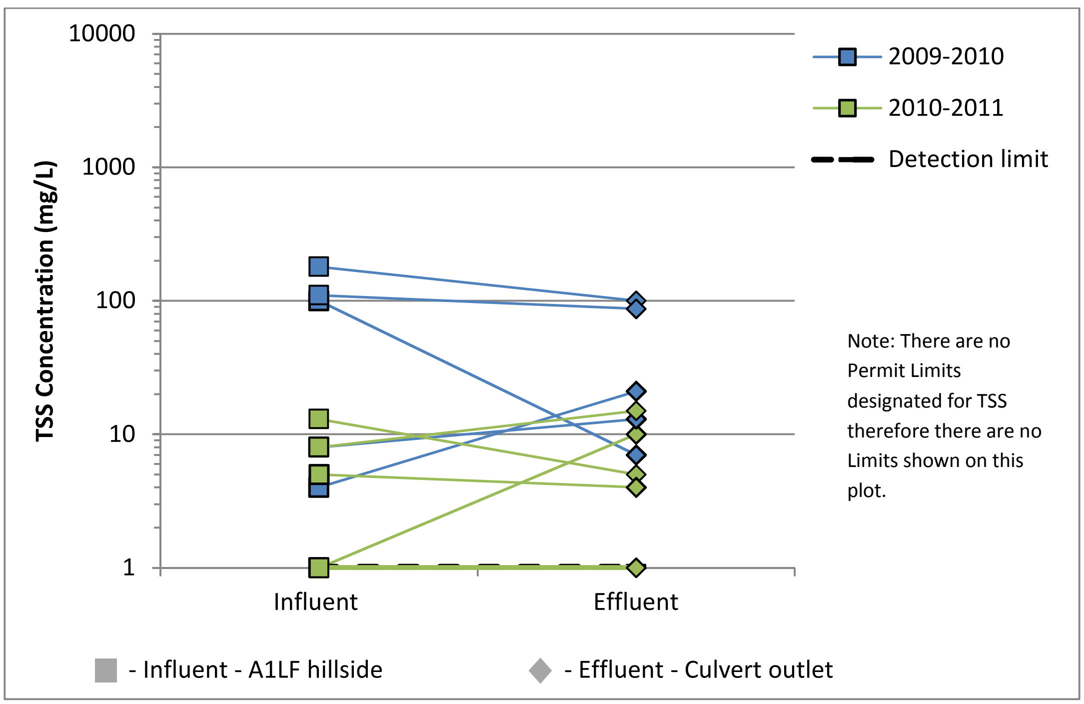


Figure 4. TSS at CM-9, pre improvements[6]

[6] CM-9 Improvements include removal of A1LF asphalt and addition of CM weir board filter fabric.

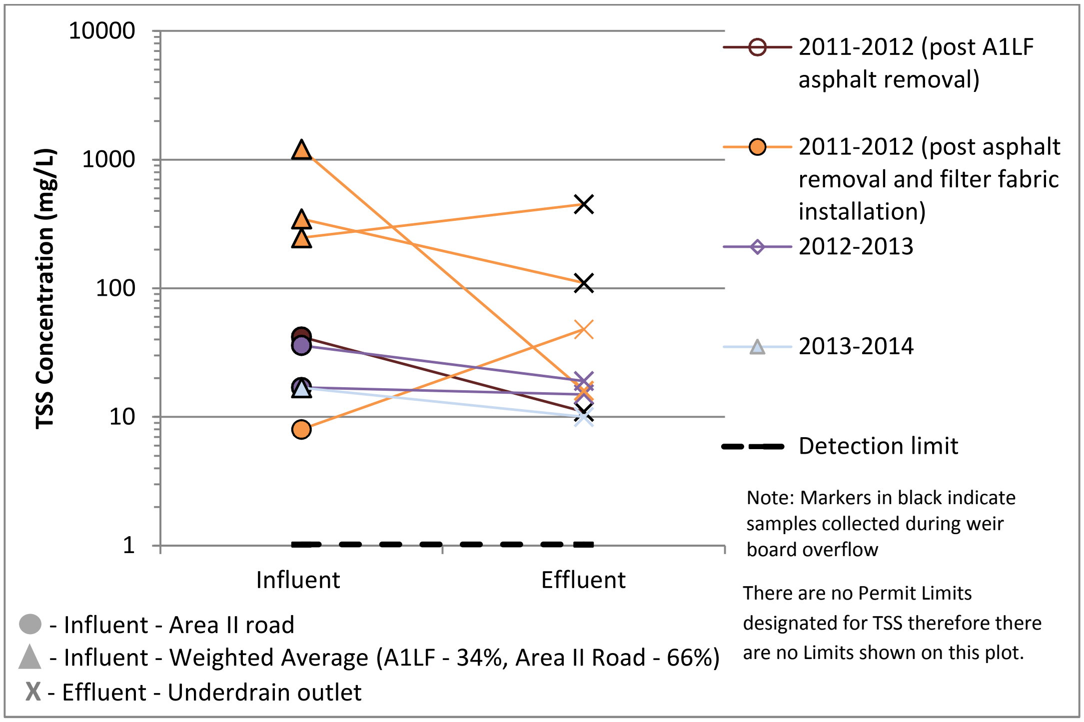


Figure 5. TSS at CM-9, post improvements (removal of A1LF asphalt and addition of CM weir board filter fabric)

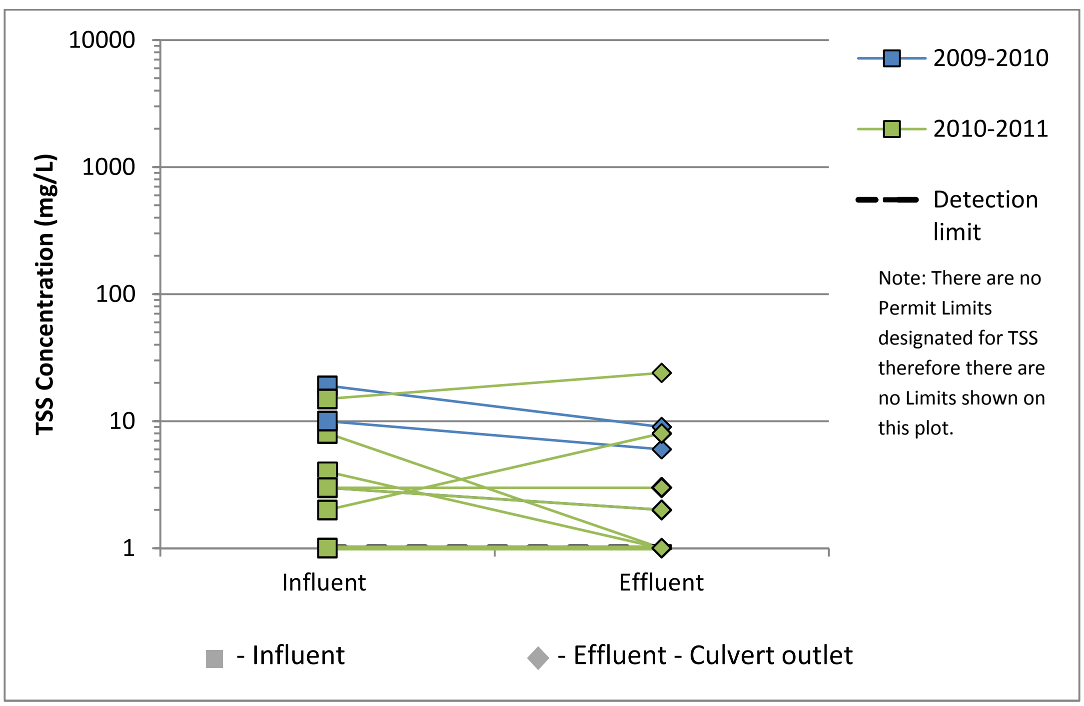


Figure 6. TSS at CM-11

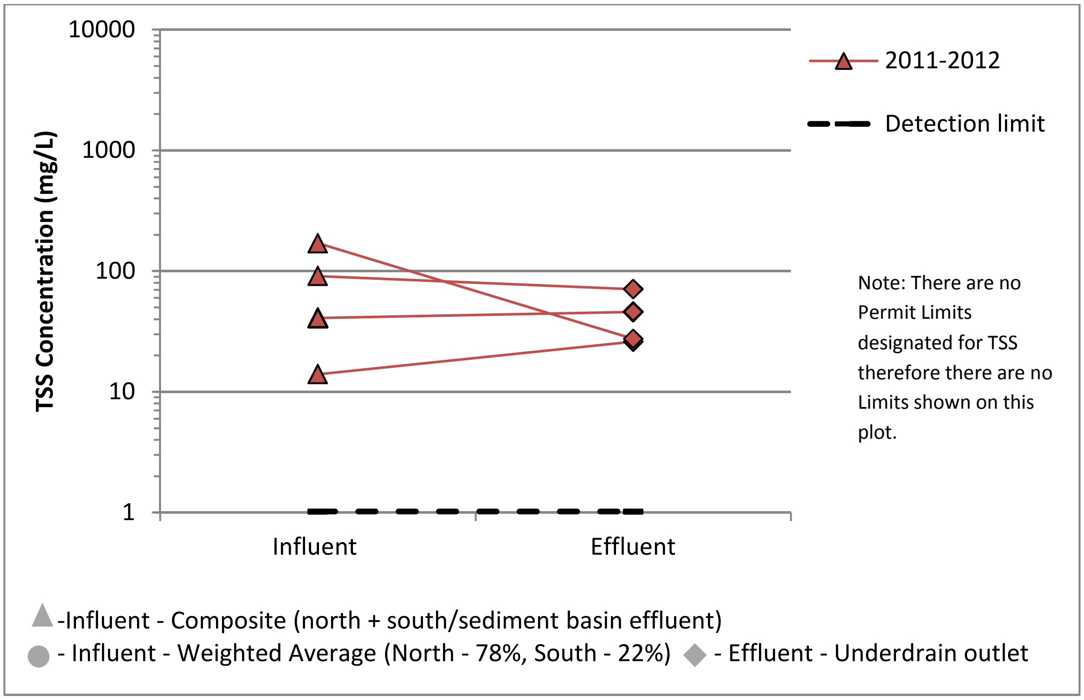


Figure 7. TSS at B1 Media Filter (CM), pre curb cuts

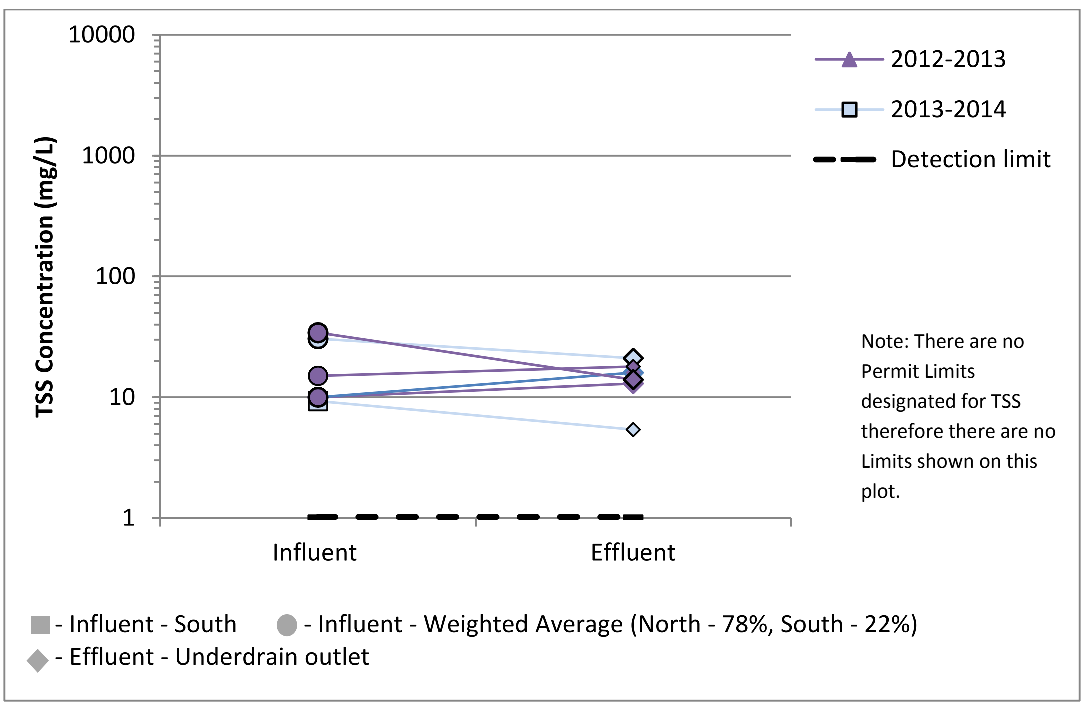


Figure 8. TSS at B1 Media Filter (CM), post curb cuts

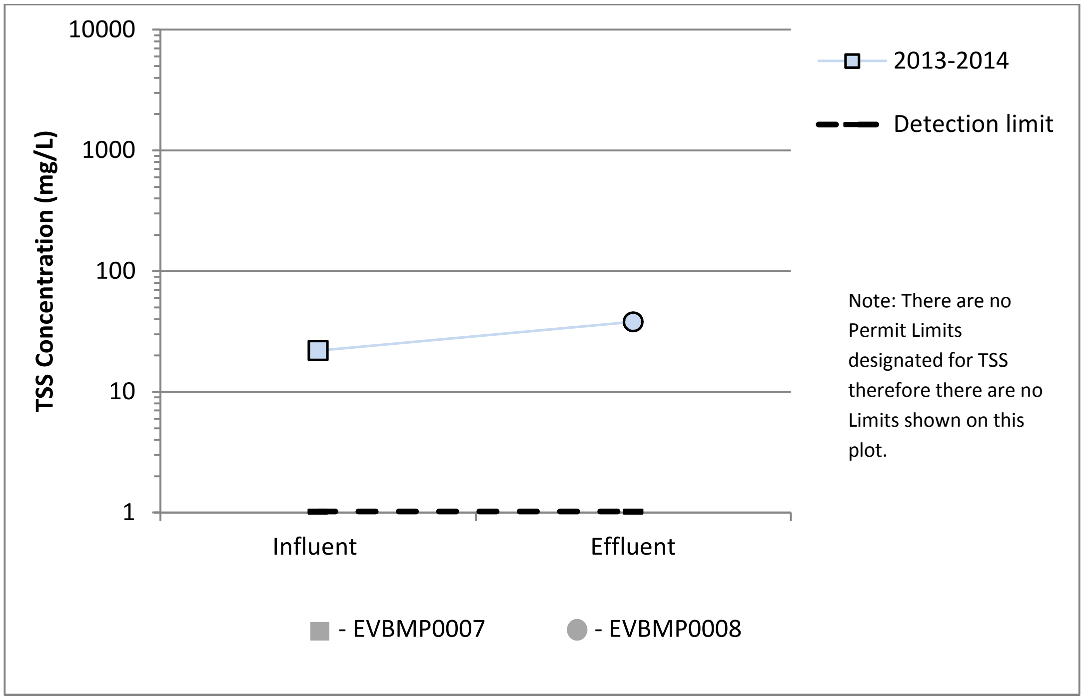


Figure 9. TSS at ELV treatment BMP

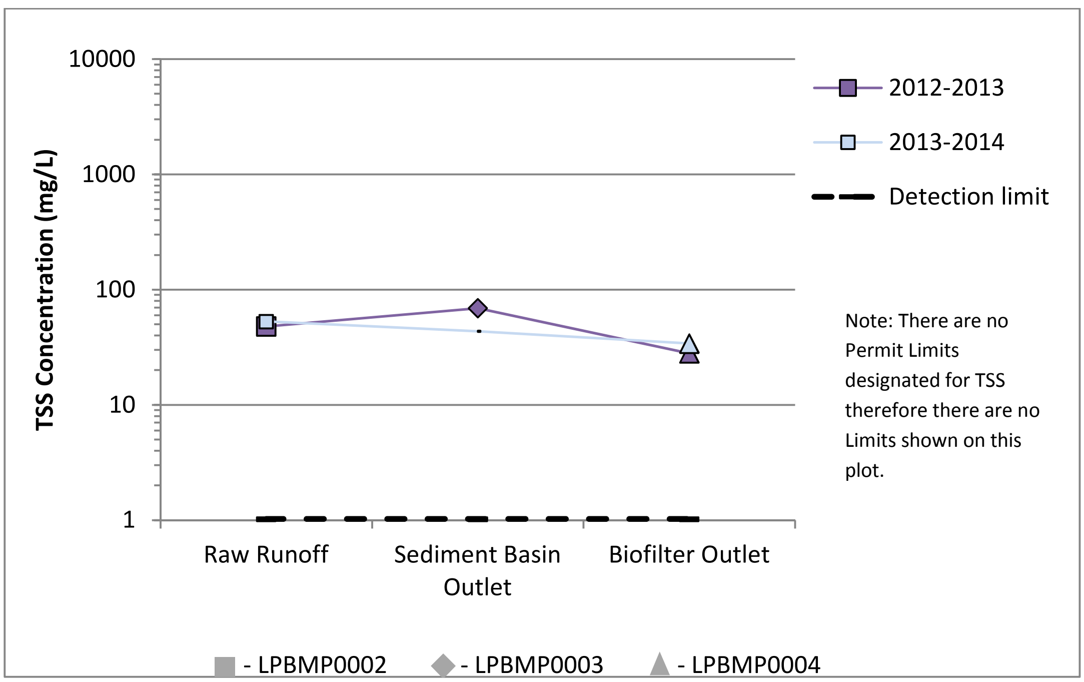
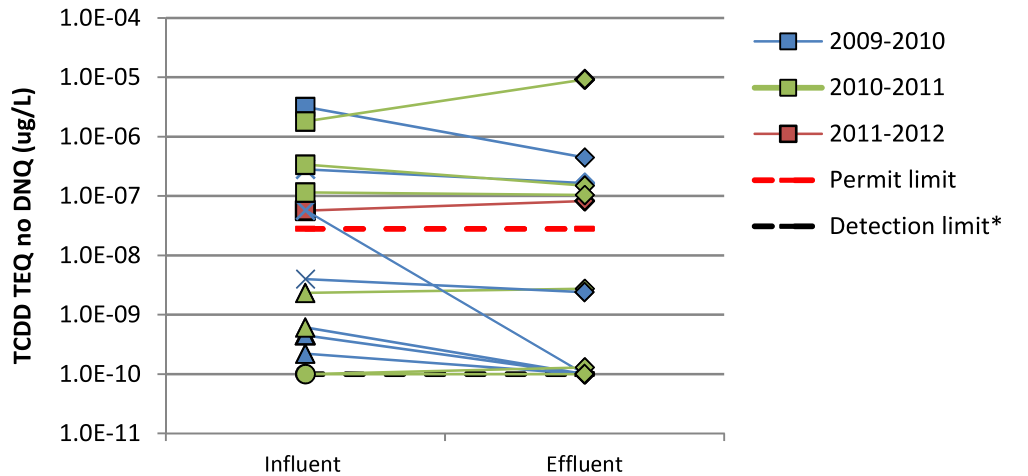


Figure 10. TSS at Lower Lot Biofilter[7]

[7] A sample was not taken at the biofilter inlet (post-sedimentation basin) during this most recent sampling year due to the sample location being submerged and inaccessible. The biofilter outlet sample from the 2013-2014 monitoring season reflects a mix of filtered underdrain flow and unfiltered overflow.

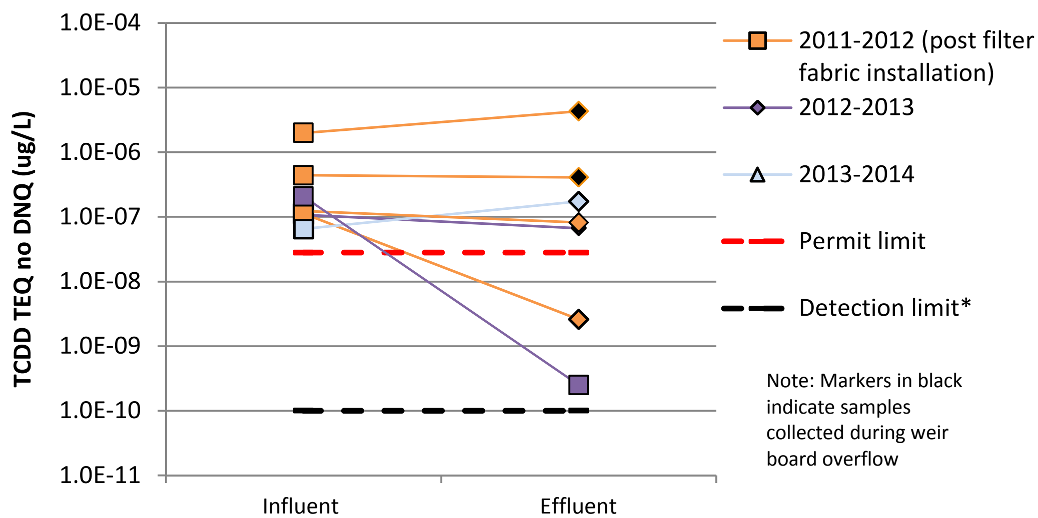


X - Influent - Weighted Average (ELV Area II Road - 75%, Background tributary [old] - 25%)
- Influent - ELV/Area II road
- Influent - Background tributary - old
- Influent - Background tributary- new
- Effluent - Culvert outlet

* 1E-10 ug/L is shown for ND TEQ results as this is in the range of the lowest reported TEQ results with DNQ excluded.

Note: 2,3,7,8-TCDD detected in two effluent samples from 10/6/2010 and 3/17/2012.

Figure 11. Dioxins at CM-1, pre filter fabric installation



- Influent - ELV/Area II road
- Effluent - Culvert outlet

* 1E-10 ug/L is shown for ND TEQ results as this is in the range of the lowest reported TEQ results with DNQ excluded.

Note: 2,3,7,8-TCDD detected in two effluent samples from 10/6/2010 and 3/17/2012.

Figure 12. Dioxins at CM-1, post filter fabric installation

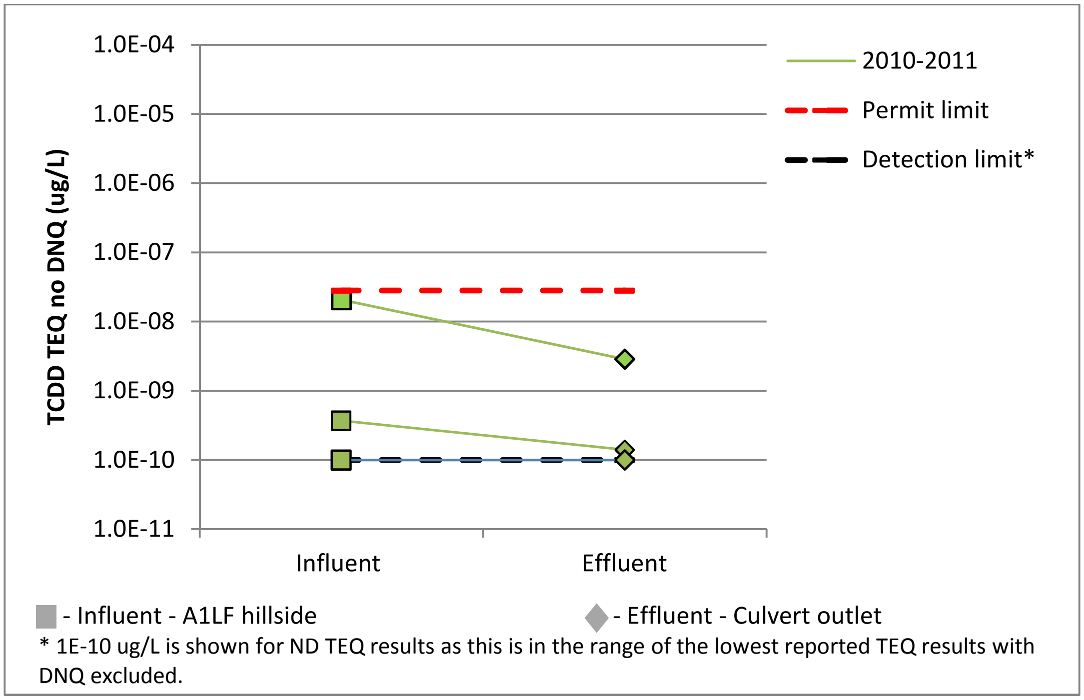


Figure 13. Dioxins at CM-9, pre improvements

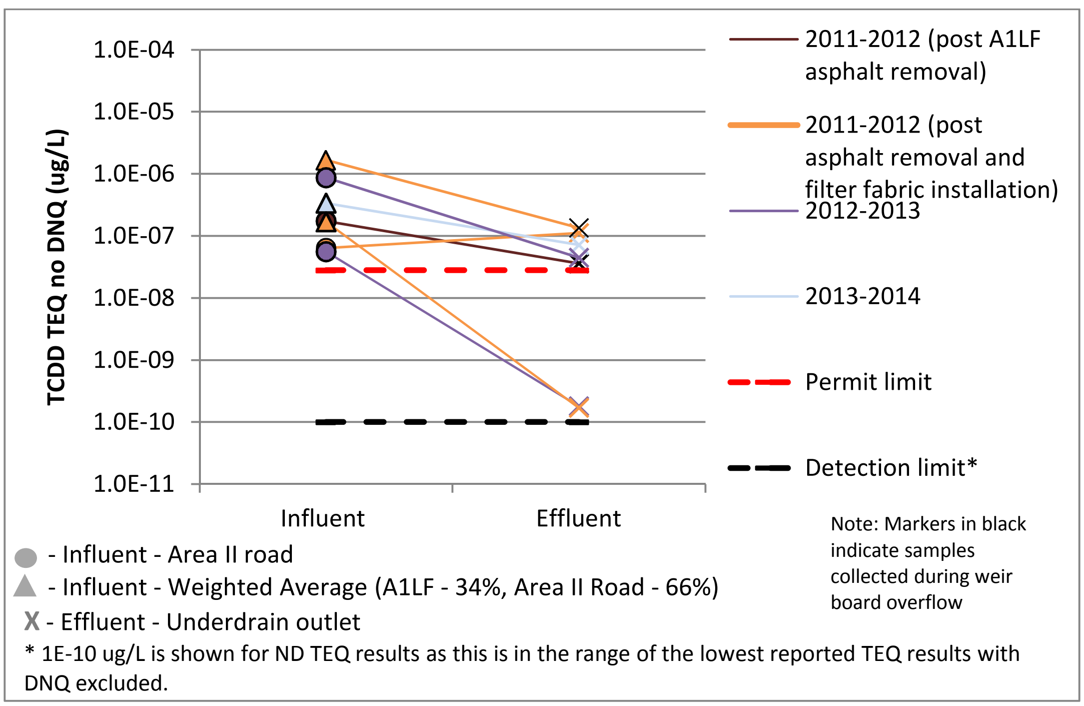


Figure 14. Dioxins at CM-9, post improvements (removal of A1LF asphalt and addition of CM weir board filter fabric)

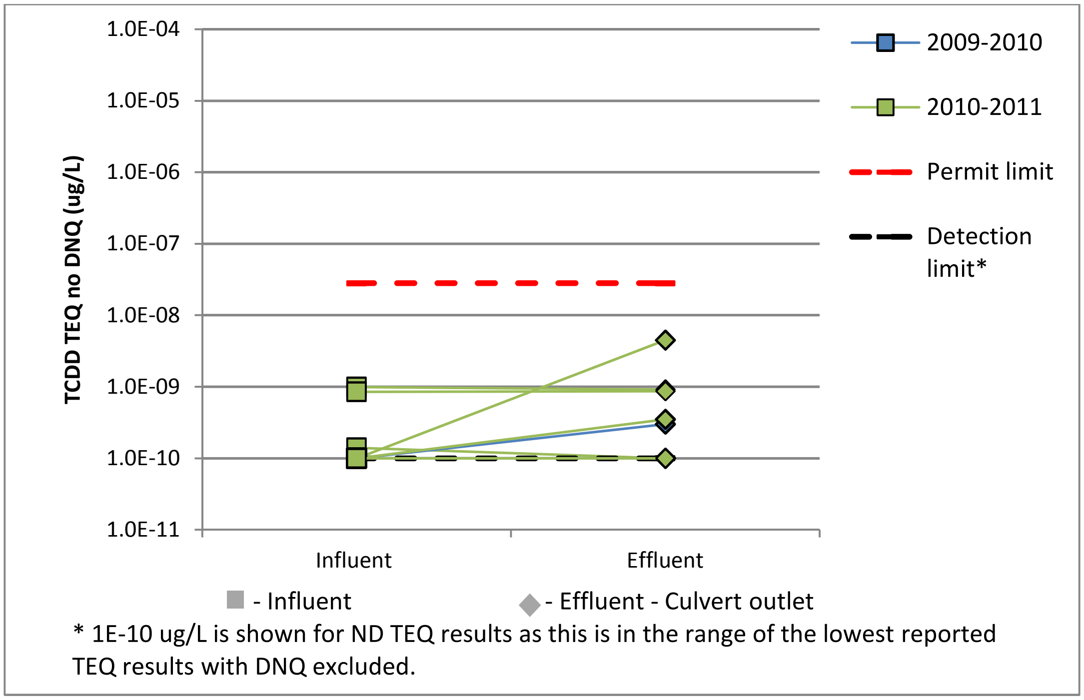


Figure 15. Dioxins at CM-11

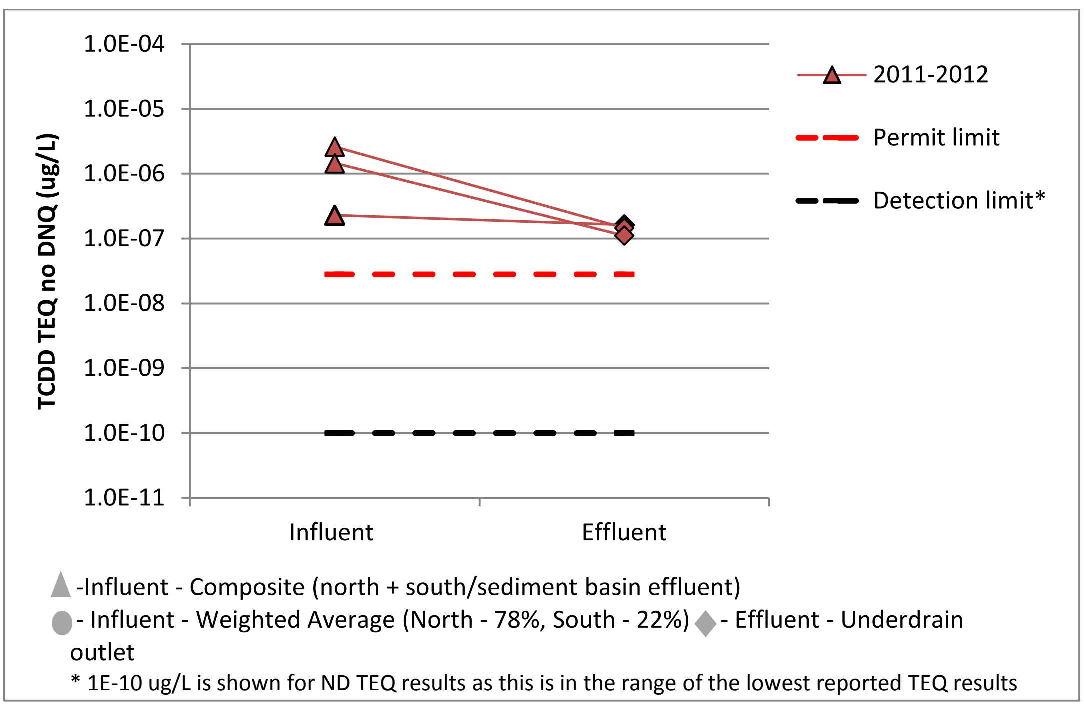


Figure 16. Dioxins at B1 Media Filter (CM), pre curb cuts

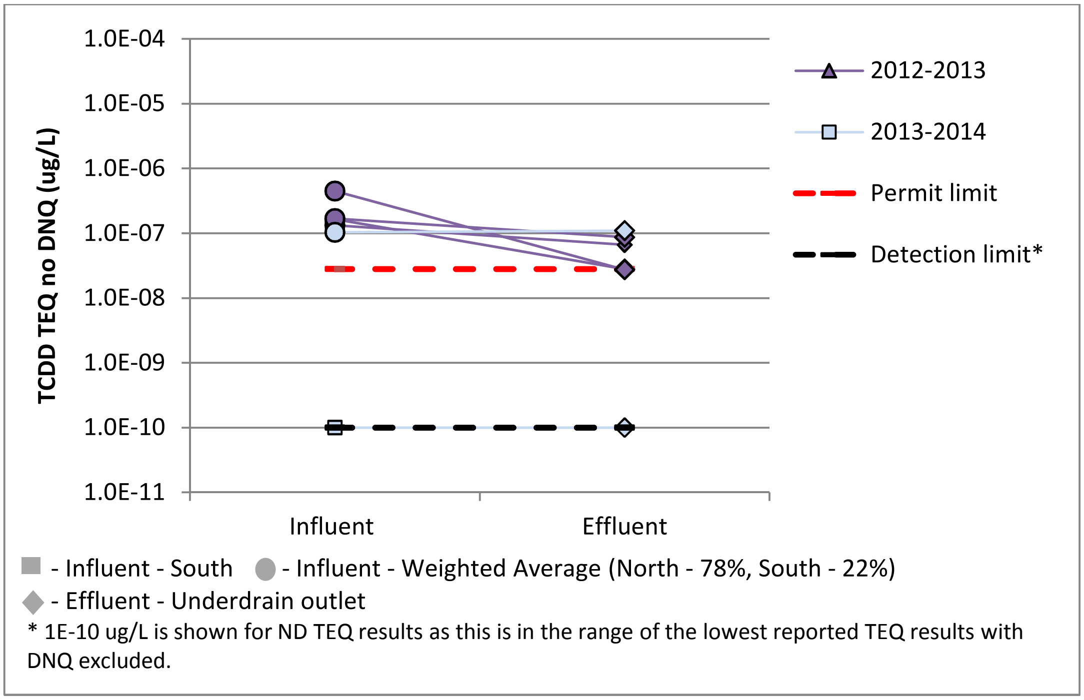


Figure 17. Dioxins at B1 Media Filter (CM), post curb cuts

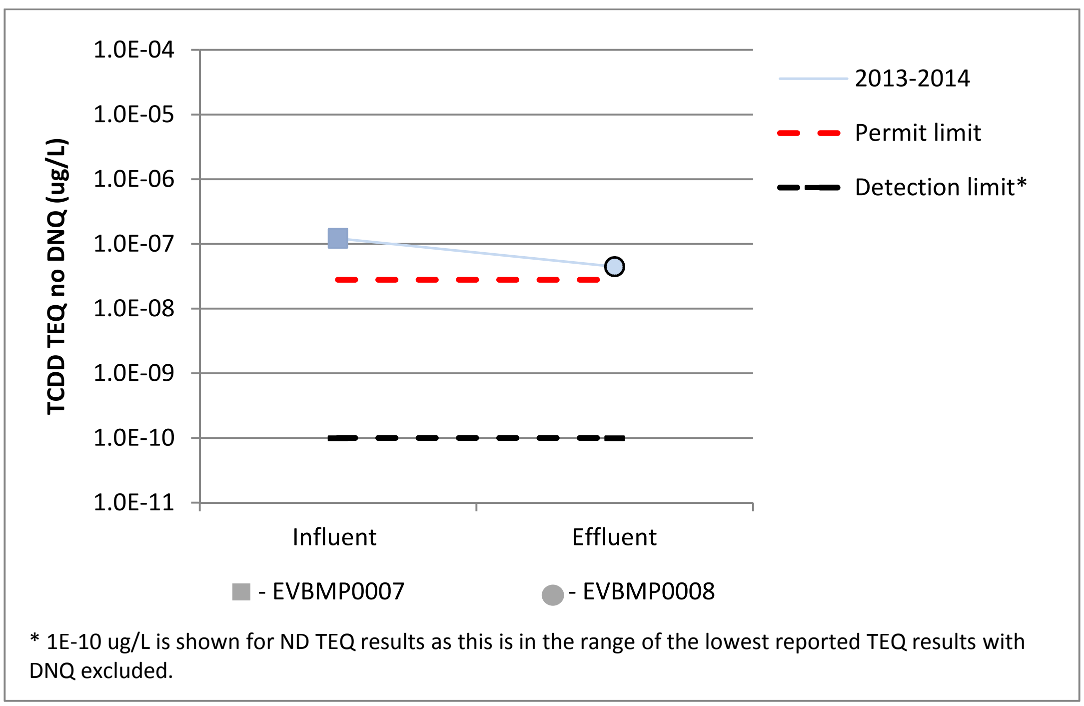


Figure 18. Dioxins at ELV treatment BMP

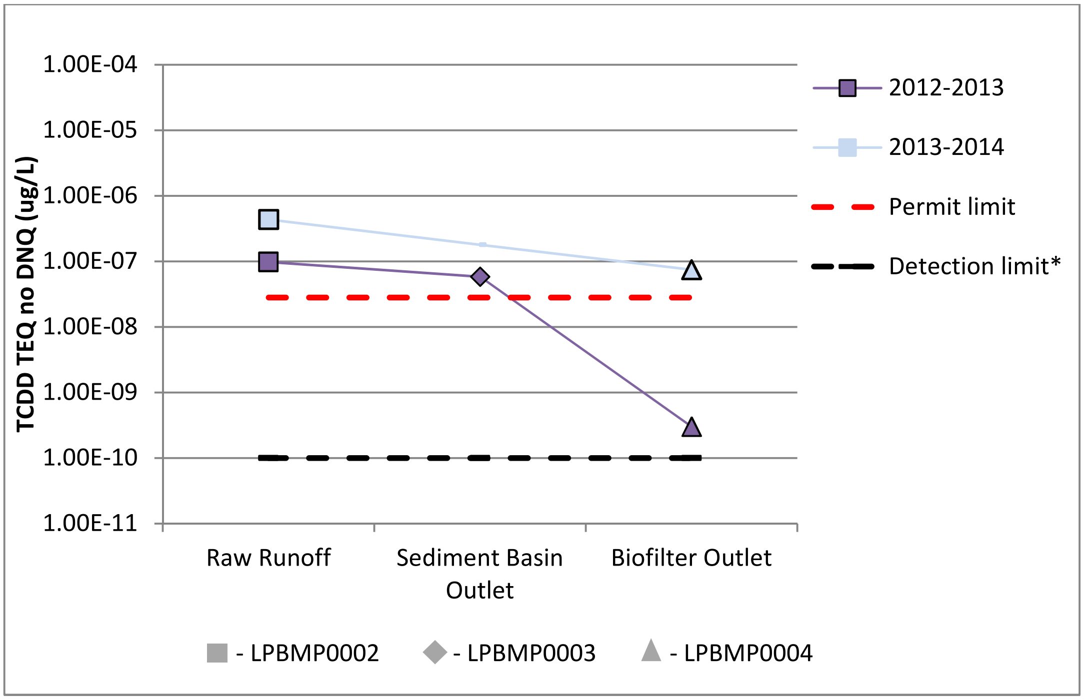


Figure 19. Dioxins at Lower Lot Biofilter[7]

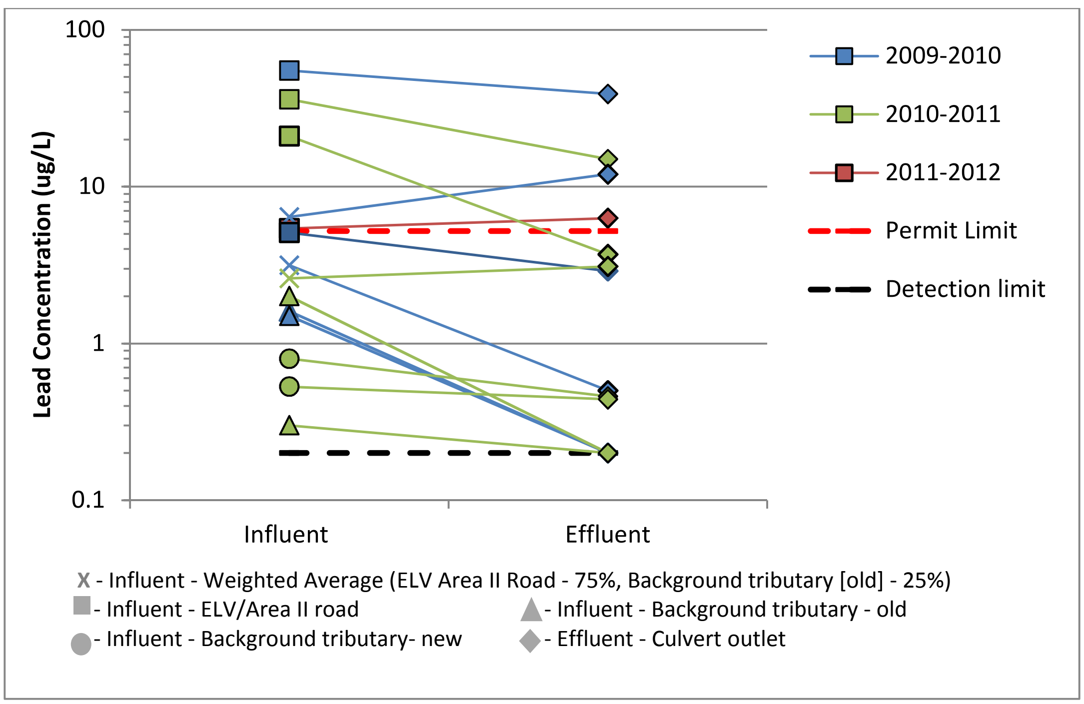


Figure 20. Lead at CM-1, pre filter fabric installation

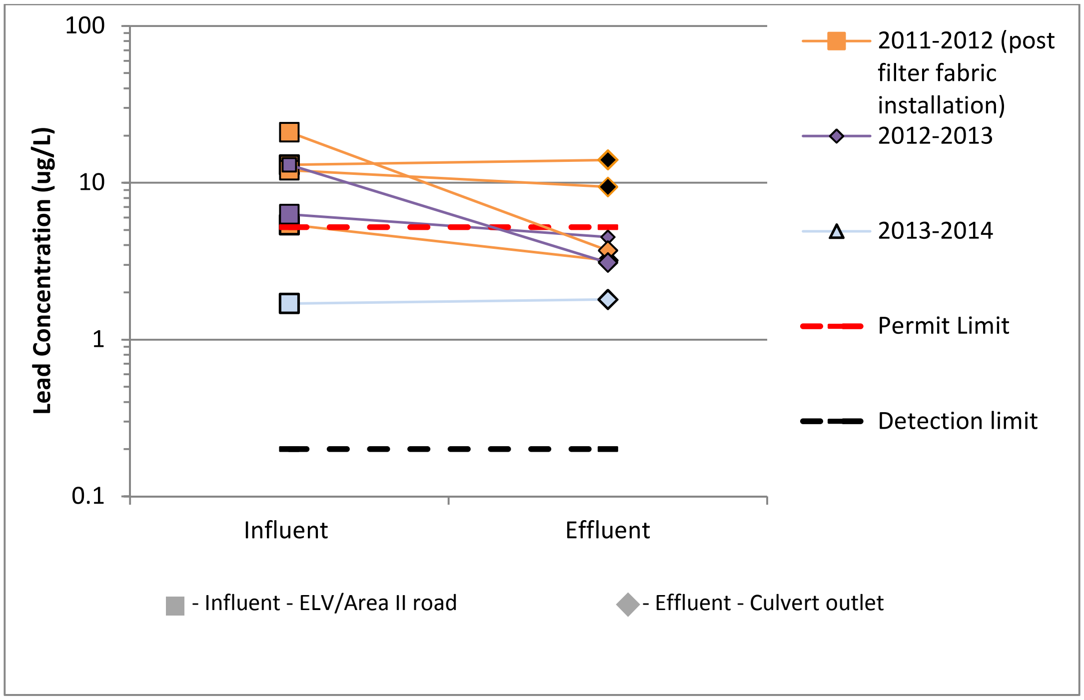


Figure 21. Lead at CM-1, post filter fabric installation

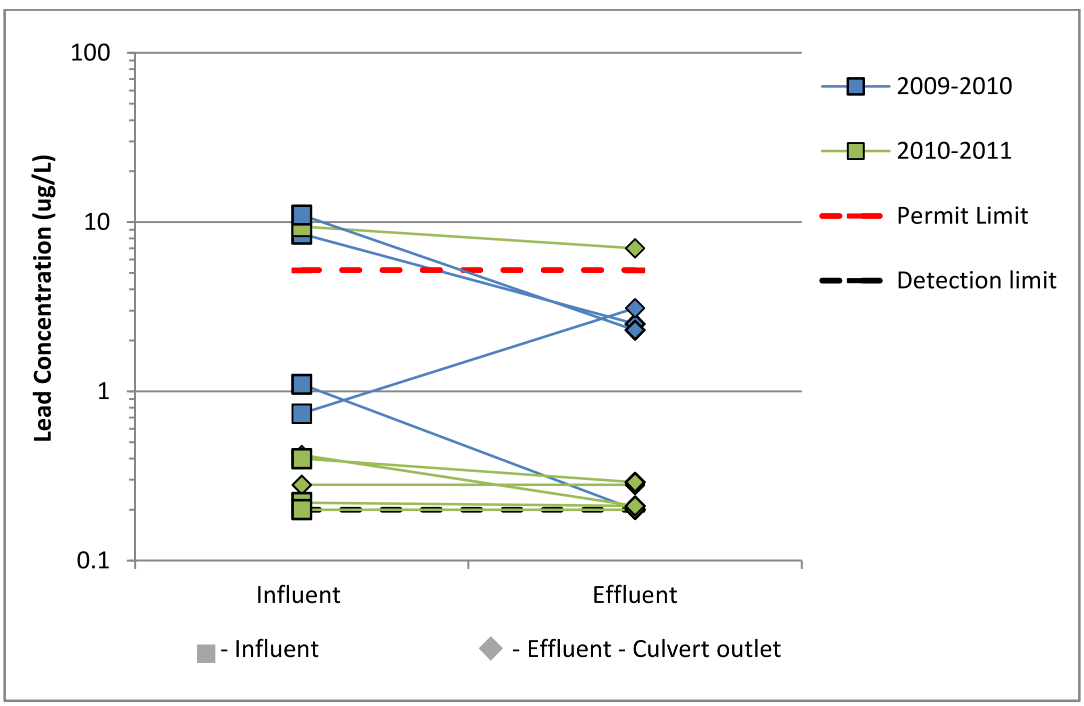


Figure 22. Lead at CM-8

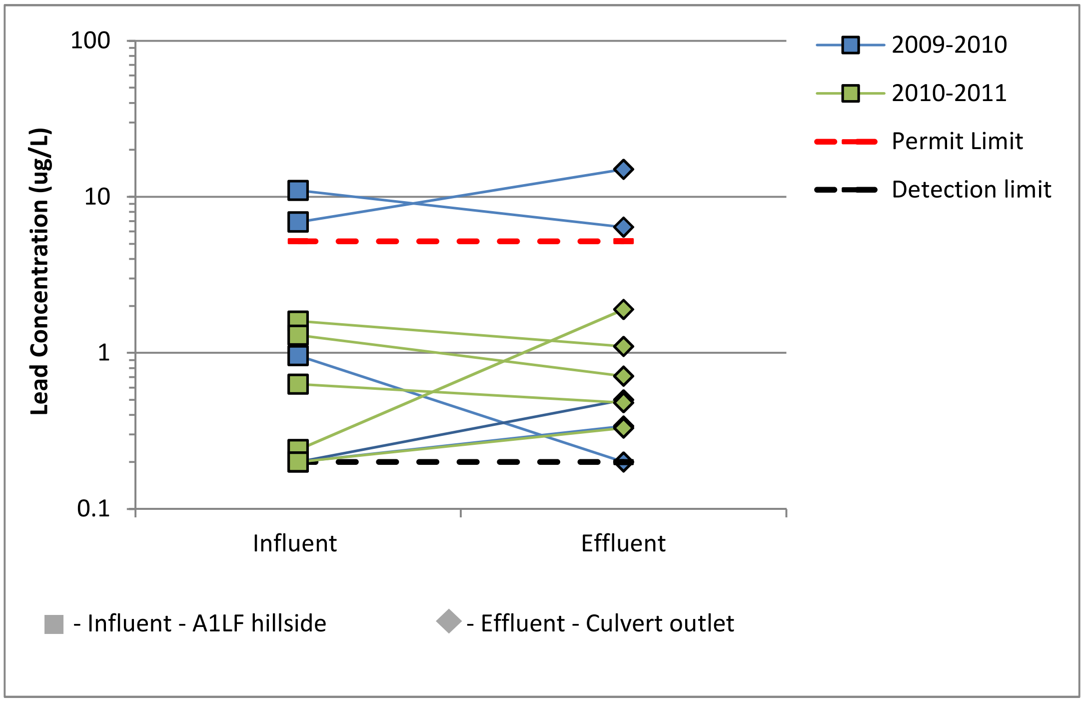


Figure 23. Lead at CM-9, pre improvements

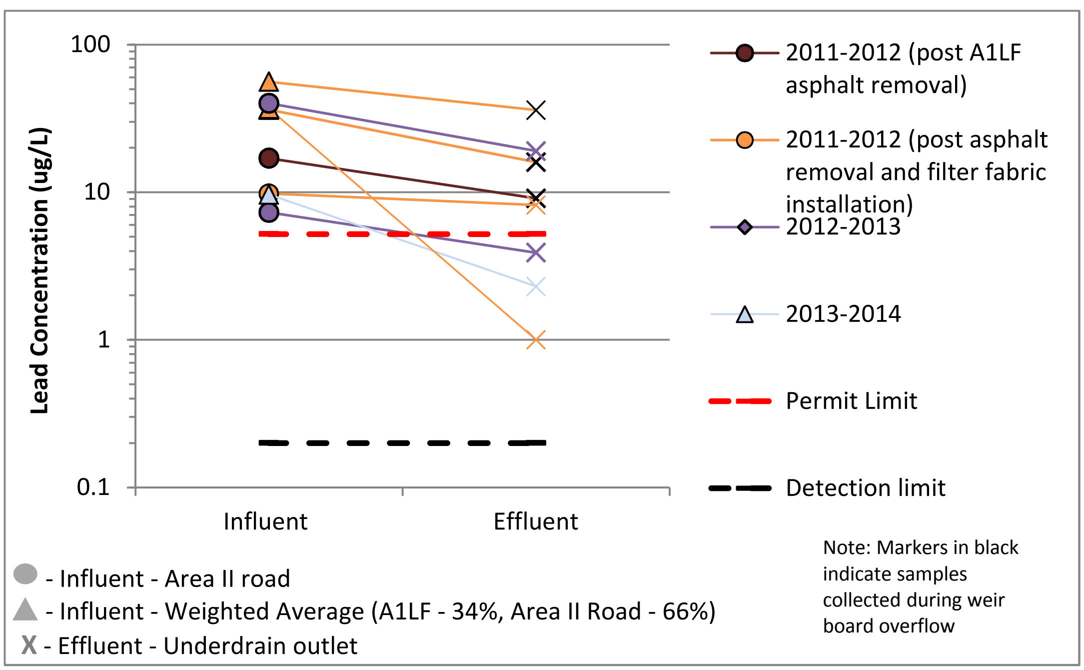


Figure 24. Lead at CM-9, post improvements (removal of A1LF asphalt and addition of CM weir board filter fabric)

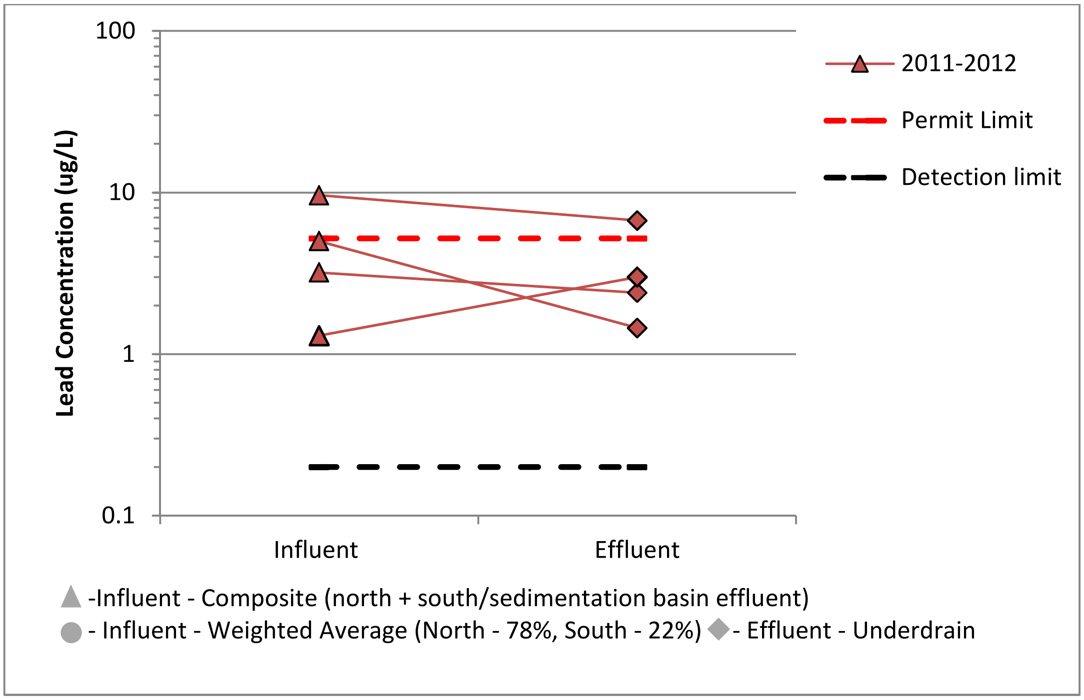


Figure 25. Lead at B1 Media Filter (CM), pre curb cuts

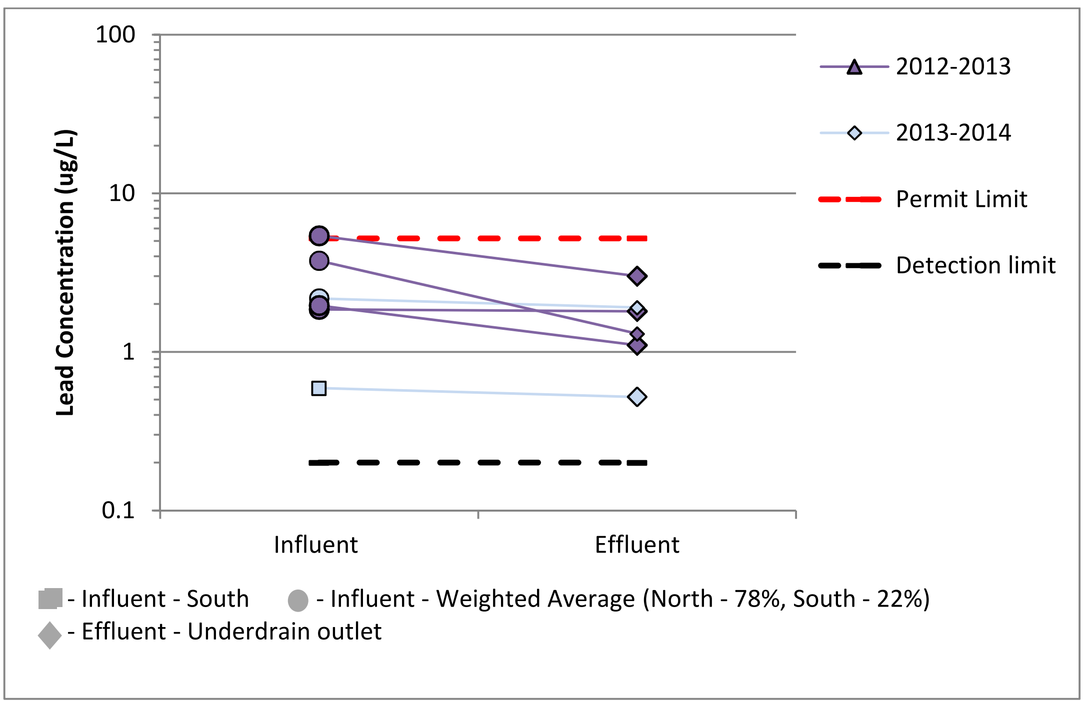


Figure 26. Lead at B1 Media Filter (CM), post curb cuts

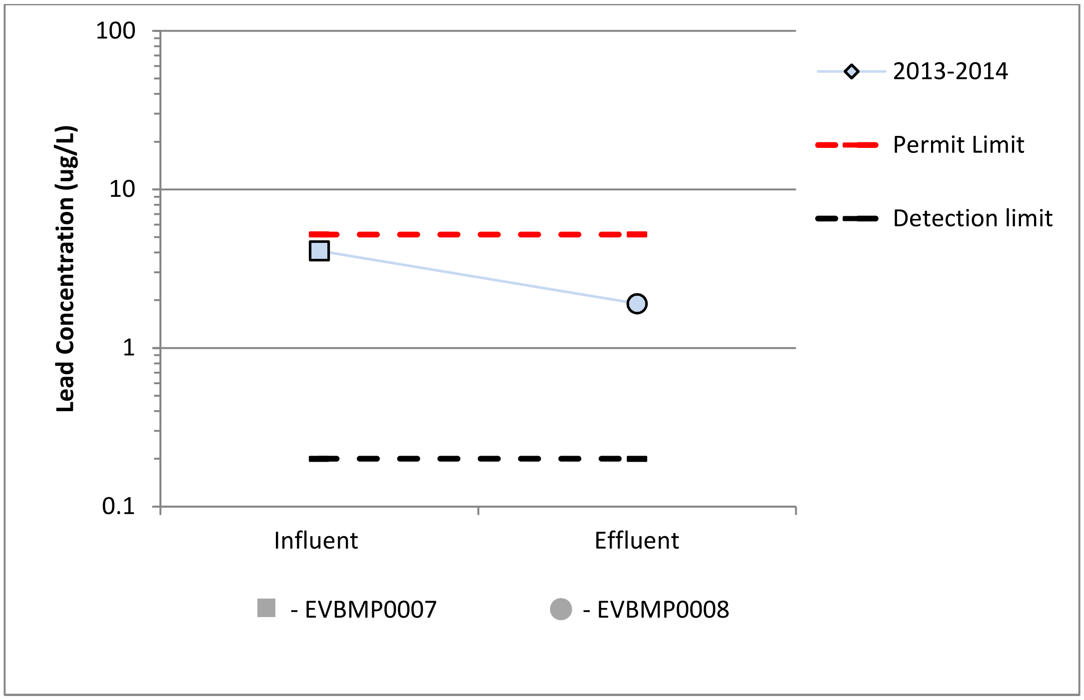


Figure 27. Lead at ELV treatment BMP

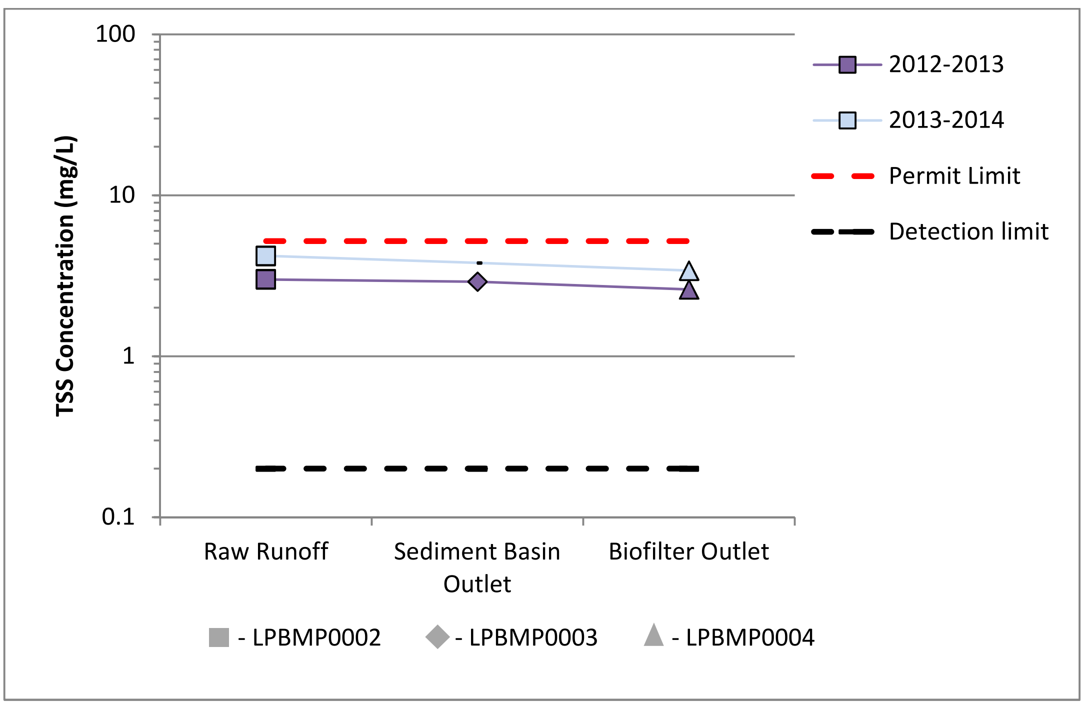


Figure 28. Lead at Lower Lot Biofilter[7]

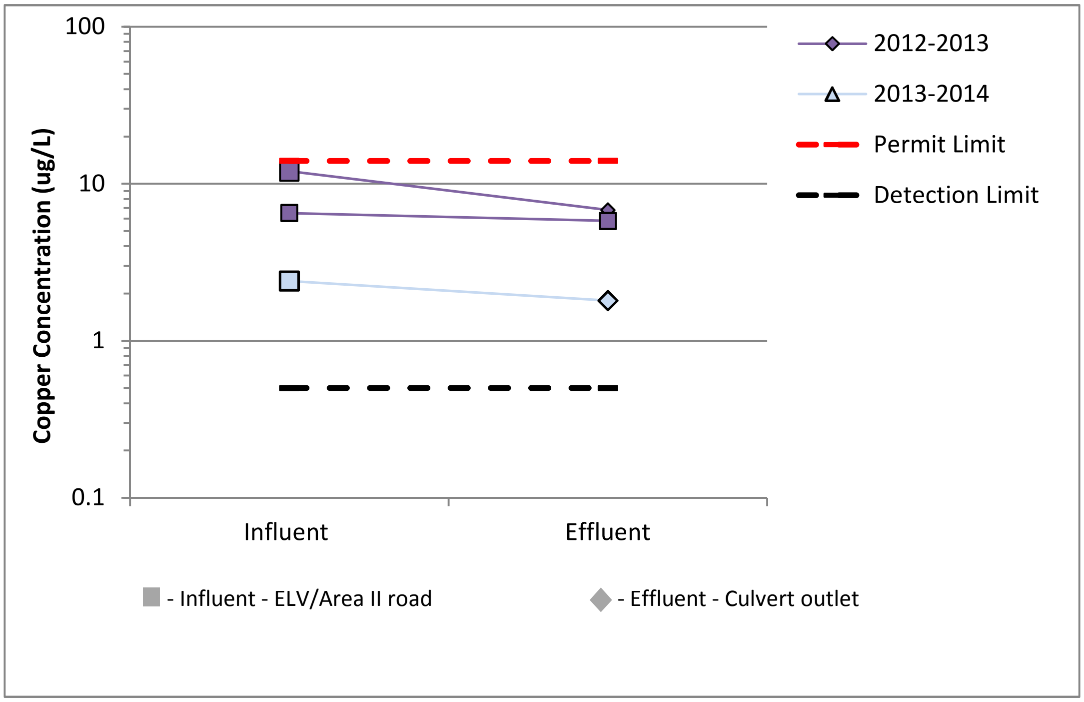


Figure 29. Copper at CM-1, post filter fabric installation

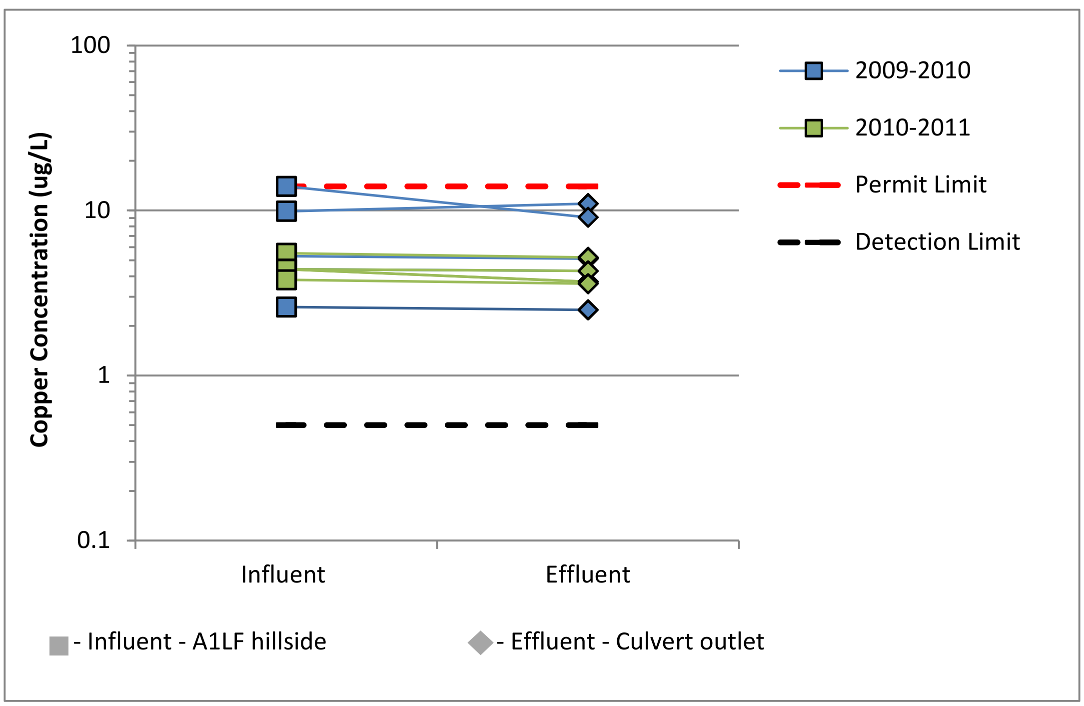


Figure 30. Copper at CM-9, pre improvements

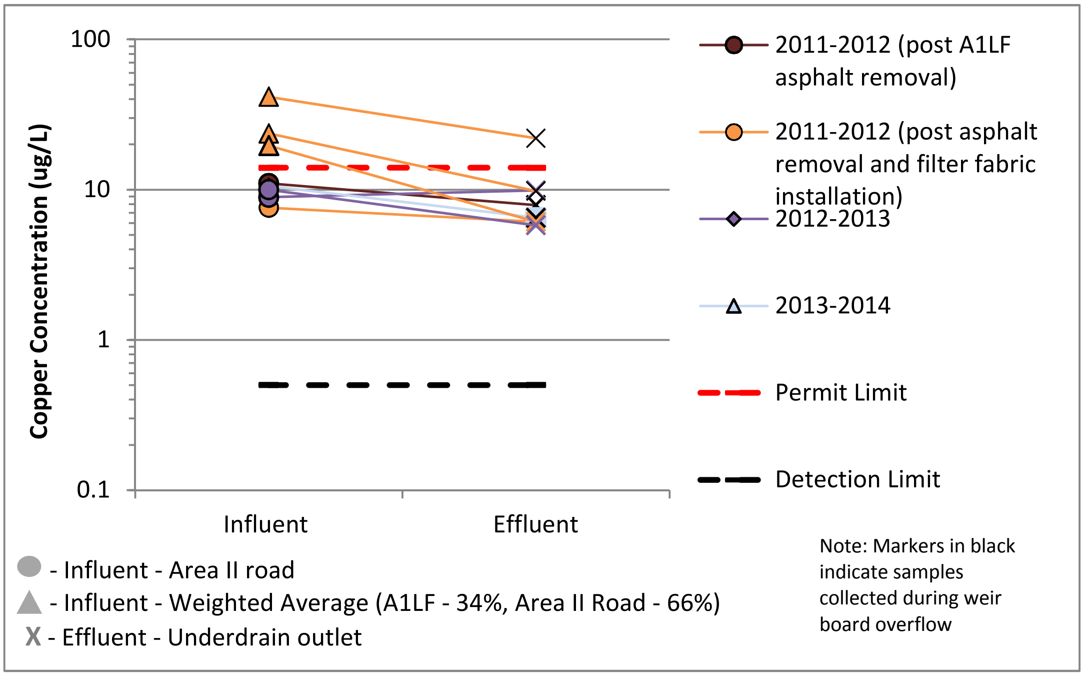


Figure 31. Copper at CM-9, post improvements (removal of A1LF asphalt and addition of CM weir board filter fabric)

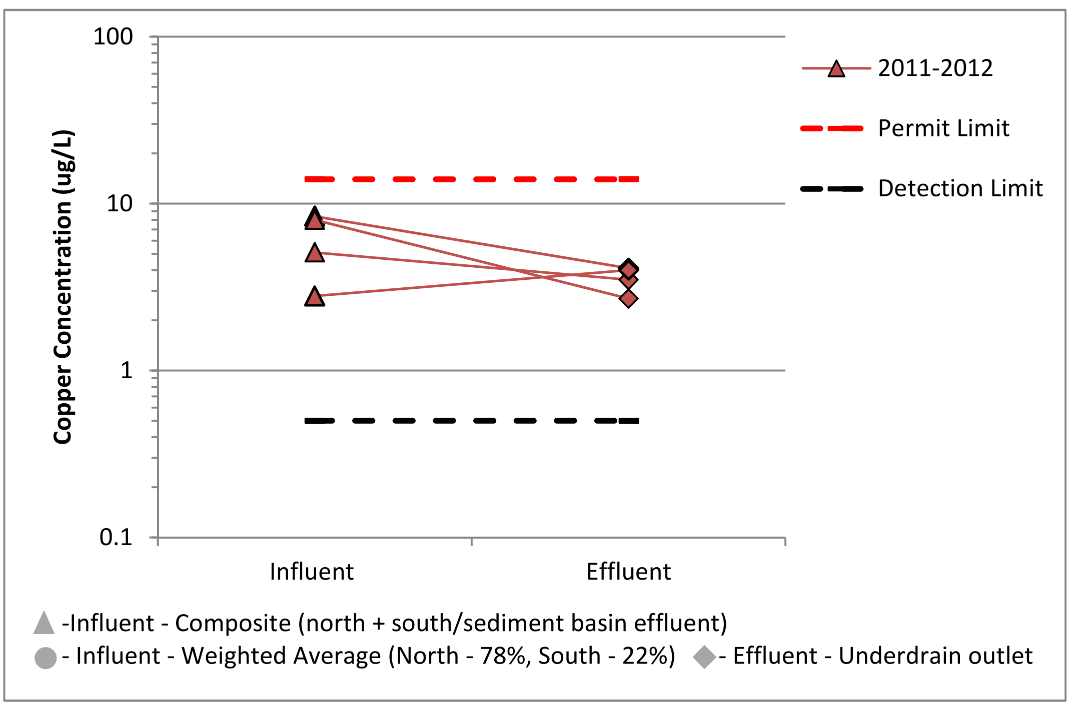


Figure 32. Copper at B1 Media Filter (CM), pre curb cuts

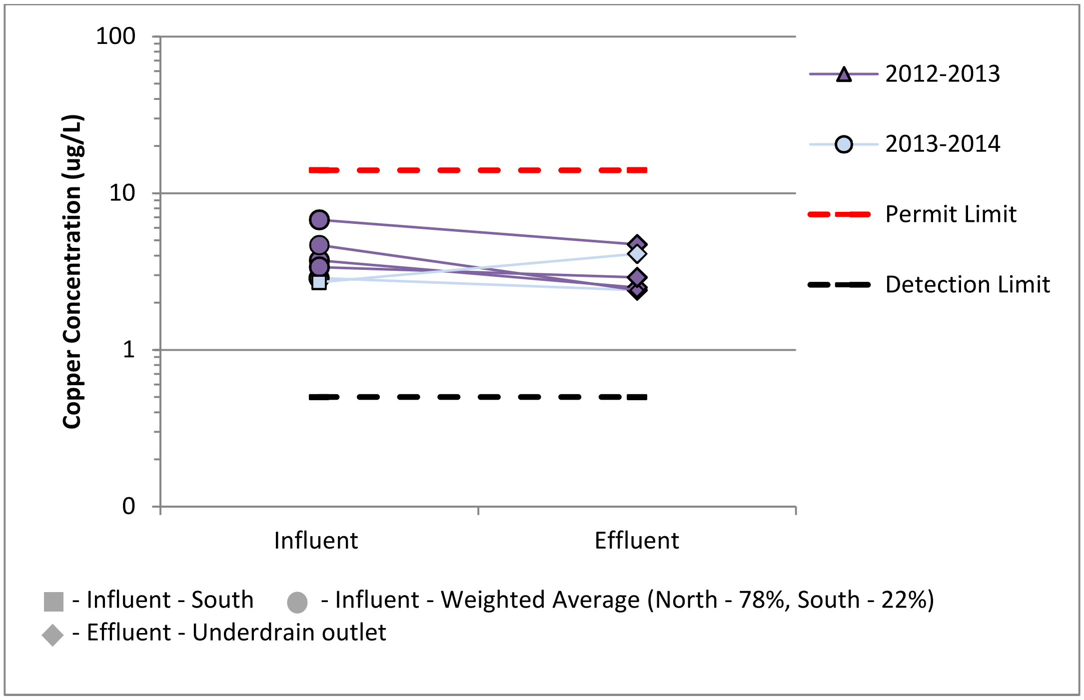


Figure 33. Copper at B1 Media Filter (CM), post curb cuts

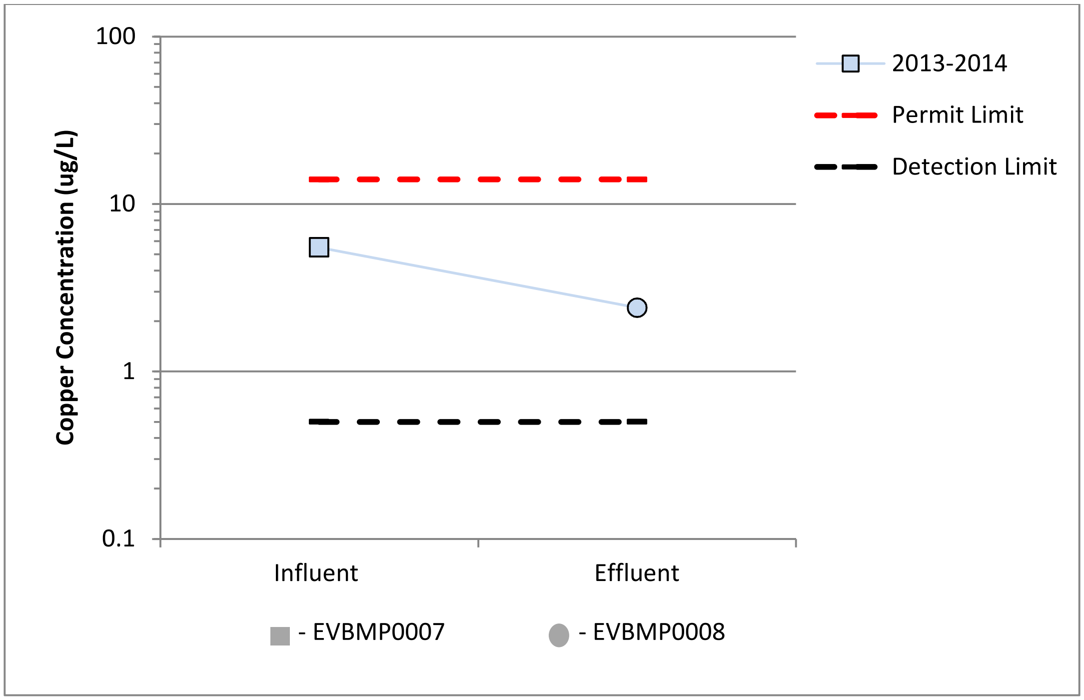


Figure 34. Copper at ELV treatment BMP

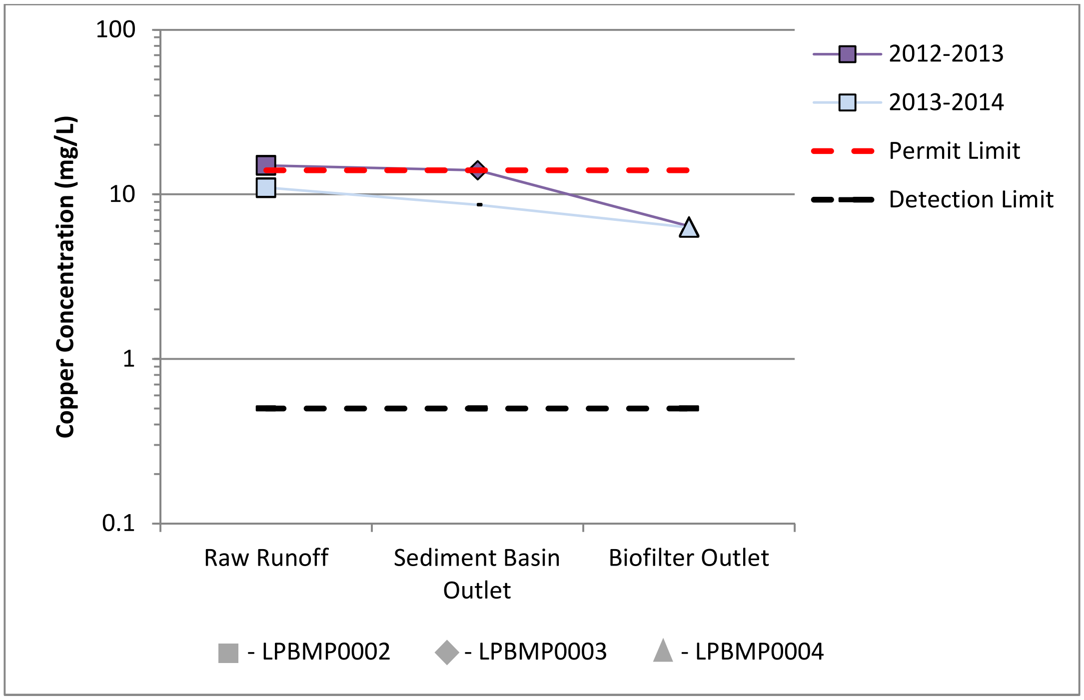


Figure 35. Copper at Lower Lot Biofilter[7]

2. STATISTICAL ANALYSIS

Statistical summaries of the Site cumulative paired data over the 2009-2014 sampling period using the non-parametric 1-tailed sign test are shown for the paired datasets in Tables 3 and 4. This test is used to evaluate statistical differences between paired data points, or in this case, between influent and effluent stormwater samples. For this analysis, data pairs that were taken during observed bypass/overflow events were removed.

Culvert Modification Areas

The six monitored CMs (B1, CM-1, CM-3, CM-8, CM-9, and CM-11) are in the Outfall 009 watershed. At the CM monitoring locations, the total number of collected influent and effluent pairs for all of the CM locations combined ranged from 28 (for copper) to 65 (for TSS). Table 3 and Table 4 summarize the paired data statistics for these locations. CM-8, CM-11, and select CM-1 paired statistics are presented separately since the influent flows to these sites come largely from unimpaired/background sites, and therefore significant reduction of the POC concentrations (which are already generally very low) in those flows by CMs is unlikely. No data were collected from these background sites in the 2013-2014 sampling season. Data from the CM-3 background site were excluded since, as described earlier in this memo, this CM cannot be reliably assessed based on the effluent sample results. At the B1 site, media filter bleed-through was observed during initial sampling dates in the 2011-2012 sampling season. Since this was a malfunction that was subsequently corrected, results from these sample dates were removed from the analysis. The CM-1 effluent sample collected on 2/28/2014 represents a blend of underdrain flow and seepage through the upstream weir boards. Figure 36 at right shows the ponding at the CM-1 weir board during that event.

Figure 36: A photo of the CM-1 weir board taken on 2/28/2014.

In the non-background sites, for TSS, 24 out of 38 (63%) of influent concentrations were greater than their paired effluent concentrations, with an average decrease of 59%. For lead, 28 out of 38 (74%) influent concentrations were greater than their paired effluent concentrations, with an average decrease of 47%. For copper, 24 out of 28 (86%) influent concentrations were greater than effluent concentrations with an average decrease of 27%. For dioxins, 23 out of 31 (74%) influent concentrations were greater than effluent concentrations with an average decrease of 13%; however, it should be noted that this removal average is heavily influenced by one data pair taken during the 2010-2011 season prior to the upgrade at CM-1. If this pair is removed from the analysis, the average removal is 80%. These results show that the comparison of influent concentrations are significantly greater than the effluent concentrations for copper, dioxins, and lead ($p < 0.05$).

Statistically significant decreases from influent to effluent were seen in TSS and lead in background sites (42% and 54%, respectively), as shown in Table 4[8], though again it should be noted that no data were collected from these sites in the most recent sampling year. There was a statistically insignificant increase from influent to effluent for dioxins for the background sites; however, as noted earlier, the influent concentrations at these sites are very low (none of the dioxins samples at these sites, either influent or effluent, were above Permit Limits), so further reductions would be difficult to achieve.

Table 3. CM-1 ("background" samples excluded), CM-9, and B1 Non-background Statistical Analysis

	TSS (mg/L)	Dioxins (µg/L)	Copper (µg/L)	Lead (µg/L)
Total pairs of observations[1]	38	31	28	38
Number of influent samples having larger concentrations than effluent samples	24	23	24	28
Number of effluent samples having larger concentrations than influent samples	13	5	4	10
p by paired nonparametric 1-tailed sign test[2]	0.049	0.0005	0.0001	0.0025
Average (and COV) influent concentrations	96.24 (2.45)	4.28E-07 (1.81)	6.60 (0.61)	9.04 (1.41)
Average (and COV) effluent concentrations	39.18 (2.5)	3.71E-07 (4.45)	4.81 (0.48)	4.82 (1.5)
Average percent change (- sign indicating higher effluent results)	59%	13%	27%	47%

[1] Some pairs consisted of influent concentrations that were equal to effluent concentration; this explains why rows 2 and 3 do not necessarily sum to the total pairs of observations.

[2] One-tail sign test used to evaluate data. Results where influent and effluent concentrations were equal were not used in sign test.

[3] Average change in dioxins is heavily influenced by one pair at CM-1 that was taken during the 2010-2011 season and prior to improvements at that CM. Exclusion of this pair results in an average change of 80% (p = 0.0002). Without this sample, the average influent and effluent concentrations are 3.82E-07 and 7.47E-08 respectively, and the influent and effluent COVs are 1.9 and 1.2 respectively.

[8] Copper data were not collected for background sites.

Table 4. CM-1[1], CM-8 and CM-11 Background Statistical Analysis[2]

	TSS (mg/L)	Dioxins (µg/L)	Copper (µg/L)	Lead (µg/L)
Total pairs of observations[3]	27	17	No data pairs available for copper at background sites	16
Number of influent samples having larger concentrations than effluent samples	17	5		13
Number of effluent samples having larger concentrations than influent samples	4	6		1
p by paired nonparametric 1-tailed sign test[4]	0.004	0.500		0.001
Average (and COV) influent concentrations	11.74 (1.58)	3.88E-10 (1.49)		2.44 (1.49)
Average (and COV) effluent concentrations	6.85 (1.27)	6.34E-10 (1.88)		1.12 (1.64)
Average percent change (- sign indicating higher effluent results)	42%	-64%		54%

[1] Only CM-1 samples that were taken from east/background tributary influent sites are included in this analysis

[2] As noted earlier in this memorandum, the CM-3 performance cannot be reliably assessed based on the effluent sample results. For this reason, the CM-3 paired data were excluded from the statistical analysis presented in this table.

[3] Some pairs consisted of influent concentrations that were equal to effluent concentrations; this explains why rows 2 and 3 do not necessarily sum to the total pairs of observations.

[4] One-tail sign test used to evaluate data. Results where influent and effluent concentrations were equal were not used in sign test.

Lower Lot Biofilter Treatment Train

Construction of the lower lot biofilter, located in the Outfall 009 watershed, was completed in 2013. To date, samples were taken at this location only during the two rain events that occurred after the construction was completed, with samples collected at three locations within the biofilter treatment train (influent, post-sedimentation basin, and post-biofilter) the first year, and two locations (influent and post-biofilter) in the most recent sampling year. The post-biofilter samples collected in 2014 represents a blend of filtered underdrain water and overflow A sample was not taken at the biofilter inlet [post-sedimentation basin] during this most recent sampling year due to the sample location being submerged and inaccessible.

Figure 37: A photo of the submerged biofilter taken on 2/28/14, facing northeast

Table 5, Table 6, and Table 7 summarize the paired sampling data for the biofilter. The pairs in Table 5 (runoff to sedimentation basin outlet) and Table 6 (sedimentation basin to biofilter outlet) were collected during the 2012-2013 monitoring season. The pairs in Table 7 (runoff to biofilter outlet) include one pair from each of the 2012-2013 and 2013-2014 monitoring seasons. For TSS, concentrations were found to increase between the runoff and the sedimentation basin outlet locations during the 2012-2013 sample event (at that time, the sedimentation basin was eroding, which increased TSS levels at the outlet structure). However, TSS decreased from the sedimentation basin outlet to the biofilter outlet during the

2012-2013 sample event, resulting in a net reduction across the system, and decreased from the influent runoff to the biofilter outlet during the 2013-2014 sample event. The average reduction of TSS across the system for both storm events sampled to date is approximately 39%. Copper, lead, and dioxins had net reductions across the system of 51%, 17%, and 86%, respectively. It should be noted that both the influent (runoff) and effluent (biofilter outlet) concentrations of lead were below Permit Limits. Influent (runoff) for copper exceeded Permit Limits with effluent (biofilter outlet) concentrations reduced to below Permit Limits. Influent (runoff) for dioxins exceeded the Permit Limits for both events, and exceeded at the effluent for one event.

Table 5. Lower Lot Biofilter Performance Data – Runoff to Sedimentation Basin Outlet, 5/6/2013

	TSS (mg/L)	Dioxins (µg/L)	Copper (µg/L)	Lead (µg/L)
Total pairs of observations	1	1	1	1
Number of influent samples having larger concentrations than effluent samples	0	1	1	1
Number of effluent samples having larger concentrations than influent samples	1	0	0	0
Influent concentration	48	9.76E-8	15	3.0
Effluent concentration	69	5.83E-8	14	2.9
Percent change (- sign indicating higher effluent results)	-44%	40%	7%	3%

Table 6. Lower Lot Biofilter Performance Data – Sedimentation Basin Outlet to Biofilter Outlet, 3/8/2013 and 5/6/2013

	TSS (mg/L)	Dioxins (µg/L)	Copper (µg/L)	Lead (µg/L)
Total pairs of observations	2	2	2	2
Number of influent samples having larger concentrations than effluent samples	2	2	2	2
Number of effluent samples having larger concentrations than influent samples	0	0	0	0
Influent average	155	2.92E-8	13	5.7
Effluent average	32	3E-10	6.3	3.9
Percent change (- sign indicating higher effluent results)	80%	99%	52%	32%

Table 7. Lower Lot Biofilter Performance Data – Runoff to Biofilter Outlet (showing net reduction), 5/6/2013 and 2/28/2014

	TSS (mg/L)	Dioxins (µg/L)	Copper (µg/L)	Lead (µg/L)
Total pairs of observations	2	2	2	2
Number of influent samples having larger concentrations than effluent samples	2	2	2	2
Number of effluent samples having larger concentrations than influent samples	0	0	0	0
Influent average	51	2.66E-7	13	3.6
Effluent average	31	3.75E-8	6.4	3.0
Percent change (- sign indicating higher effluent results)	39%	86%	51%	17%

ELV treatment BMP

The ELV treatment BMP was installed in November 2013. To date, samples have been collected at this location only during the February/March 2014 storm event. Extenuating circumstances relevant to this site during the February/March 2014 storm event included high flows from Helipad Road to the ELV treatment system (resulting in excess inflows to the sump), inadequate erosion controls along the earthen ELV channel (resulting in excess sediment in the sump [approximately one foot in sump and less than an inch in the sedimentation tanks]), and a power outage (resulting in the sump pump turning off). The ELV treatment system effluent data is still considered representative for the analysis herein, although it is recognized that because this monitoring event was the first at the ELV, media bed loss may have been occurring. Table 8 summarizes the paired data for this location. Copper, lead, and dioxins had net reductions across the system of 56%, 54%, and 64%, respectively. TSS showed a net increase across the system, although the ELV treatment system was heavily loaded by sediments eroded from the denuded ELV channel prior to implementation of recent erosion control improvements.

Since there is only one pair of data for the ELV treatment system, statistical analyses could not be conducted for this dataset.

Table 8. ELV Treatment System Performance Data

	TSS (mg/L)	Dioxins (µg/L)	Copper (µg/L)	Lead (µg/L)
Total pairs of observations	1	1	1	1
Number of influent samples having larger concentrations than effluent samples	0	1	1	1
Number of effluent samples having larger concentrations than influent samples	1	0	0	0
Influent concentration	1.3	1.22E-7	5.5	4.1
Effluent concentration	1.7	4.44E-7	2.4	1.9
Percent change (- sign indicating higher effluent results)	-73%	64%	56%	54%

3. INFLUENT v. EFFLUENT CORRELATION CHARTS

Figures 38 through 41 compare influent to effluent concentrations for the paired data presented above for CM sites (B1, CM-9, and CM-1 non-background sites; CM-1, CM-3, CM-8, and CM-11 background sites are excluded). This analysis will be done for the lower lot biofilter and the ELV treatment system once more data are collected. A least-squares regression was used to fit a line to log-transformed data (log(y) = mlog(x) + b). The slope of the lines, m, is shown in the lower right corner of the graph. In addition to the slope, the p-value is also shown to indicate the significance of the value of the reported slope. In other words, if the p-value is less than 0.05, the significance of the non-zero value of the slope, m, can be said to be 95%. A 1:1 line was also added to each plot. Data above the 1:1 line indicate an effluent increase in concentrations, while data below the 1:1 line indicate an effluent decrease in concentrations (or positive BMP performance in the case of the CMs). Additionally, the location where the 1:1 line intersects the best-fit line represents the irreducible concentration for each constituent (e.g. ~ 13 mg/L for TSS). Pairs where one or both results were not detected were excluded from these graphs.

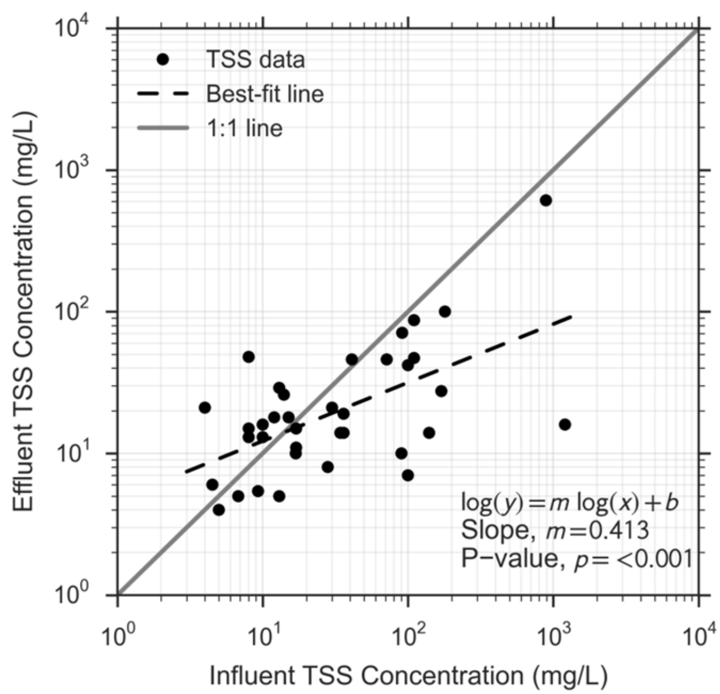


Figure 38: Paired TSS Concentrations at CM Sites

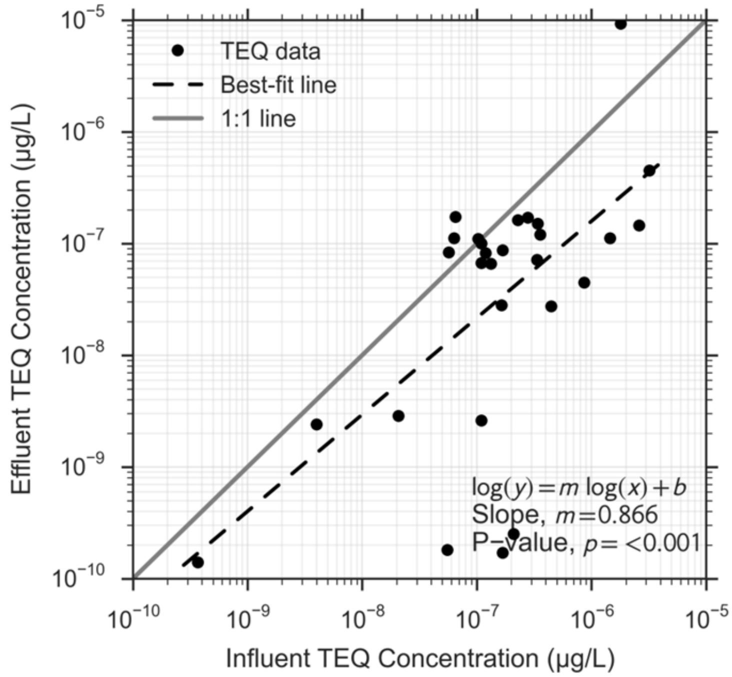


Figure 39: Paired Dioxins Concentrations at CM Sites

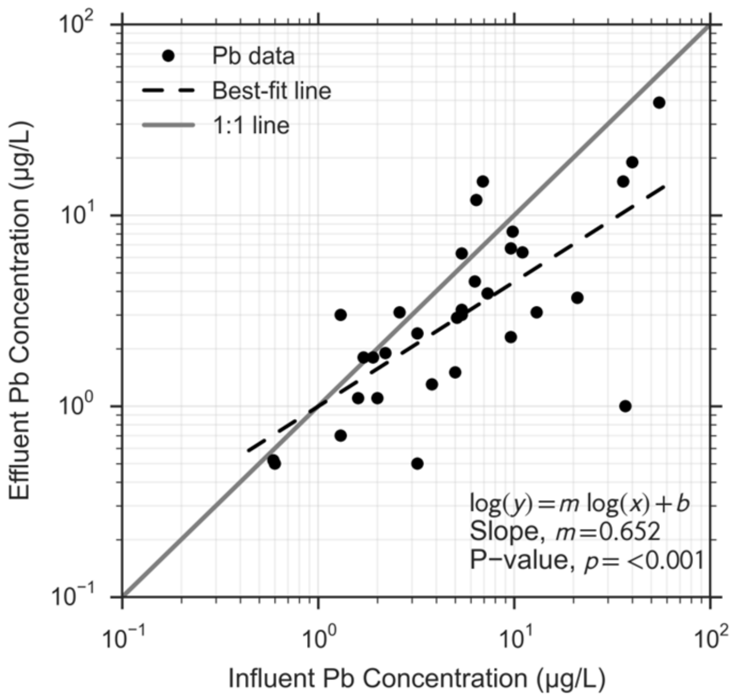


Figure 40: Paired Lead Concentrations at CM Sites

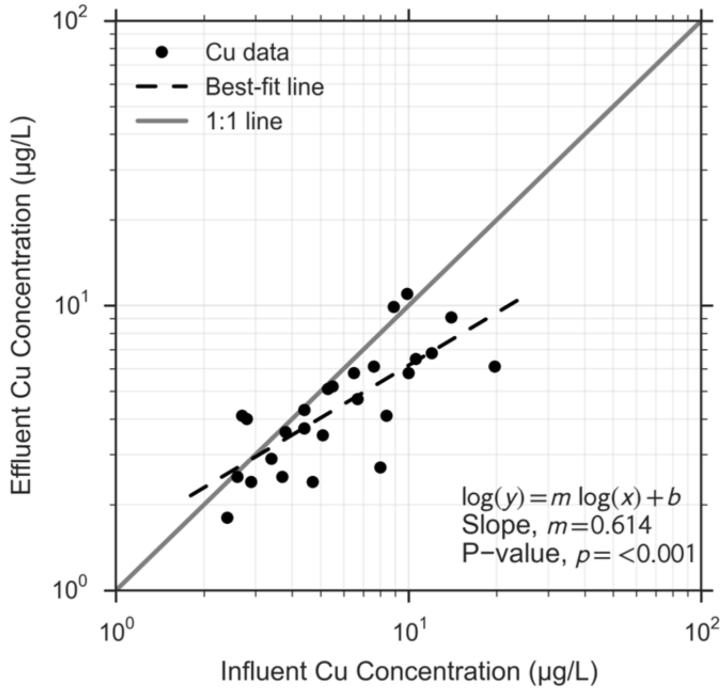


Figure 41: Paired Copper Concentrations at CM Sites

The number of results greater than the Permit Limits for each of the influent and effluent samples at B-1, CM-9, and CM-1 are summarized in Table 9. Influent concentrations were more often higher than the Outfall 009 Permit Limits as compared to effluent concentrations for copper (only one influent sample exceeded), lead (18 influent vs. 9 effluent), and dioxins (25 influent vs. 18 effluent). Looking at the maximum and average ratios of concentration to Permit Limit, a higher ratio is calculated for lead influent than lead effluent, suggesting lead reduction through the CMs. The pattern is reversed for dioxins in that the influent ratios (113 max and 12 average) are lower than the effluent ratios (330 max and 16 average). However, this result is skewed by one result of $9.3x10^{-6}$ ug/L. If that result is removed, then the maximum effluent ratio drops to 16 and the average drops to 3.9, both of which are below the influent ratios, suggesting that in general dioxins are also reduced in the CMs.

Table 9. Influent and Effluent Summary as compared to the Outfall 009 Permit Limits (B1, CM-9, and CM-1 non-background sites)

	Number Samples Greater than Permit Limits		Maximum Exceedance Ratio (Result:Permit Limit)		Average Exceedance Ratio (Result:Permit Limit)	
Parameter	**Influent**	**Effluent**	**Influent**	**Effluent**	**Influent**	**Effluent**
Copper	1	0	1.4	N/A	1.4	N/A
Lead	18	9	11	7.5	3.3	2.7
TCDD TEQ no DNQ	25	18	113	330	19	22.7

4. PROBABILITY PLOTS

Probability plots for CM sites (B1, CM-9, and CM-1 non-background sites), excluding CM-1 background areas, CM-3, CM-8, and CM-11 (due to the substantial flows that they receive from unimpaired/background areas), are shown in Figures 42 through 45. These probability plots are prepared by ranking the available data and calculating their probability of occurrence. There currently are not enough data to prepare probability plots for the lower lot biofilter sites. These probability values (shown on the vertical axis) are plotted against their concurrent concentrations. Where applicable, NPDES Permit Limits for each POC are also shown on the charts for comparison and are presented as vertical lines. While determining the plotting positions, non-detect (ND) data were sorted independently and assigned to the lowest positions, effectively truncating the probability plots at the fraction of non-detected samples. Therefore, only detected results positions are plotted, which leads to the correct probability of occurrence for the observed data, while values less than the detection limit show their unknown specific occurrences. The figures also contain some basic statistics describing the data shown on the graphs. For each influent and effluent dataset, the number of ND results is compared to the total number of results in the dataset and the coefficient of determination (R^2), and the significance values resulting from an Anderson-Darling test for normal and lognormal distributions are shown. The coefficient of determination describes how well the (logarithmic) best-fit line fits the data. The Anderson-Darling results represent the confidence level with which one can say how consistent the data are with the examined distributions. For instance, in the case of influent lead at CM locations, one can be 99% confident that the data are consistent with a lognormal probability distribution, but less than 85% (i.e. not confident) that they are consistent with a normal distribution.

Where influent data (black circles) consistently fall to the right of the effluent points (open circles), consistent water quality improvement is occurring at these areas. The horizontal distance between the datasets (noting it is a log scale) also indicates the magnitude of the concentration change at these BMP types.

The relative difference in the amount of scatter observed in these plots indicates that BMP effectiveness may vary depending on the location and constituent. These plots indicate the influent concentrations above which the CMs are most effective (low concentrations are expected to represent concentrations unlikely to be significantly reduced by the BMP).

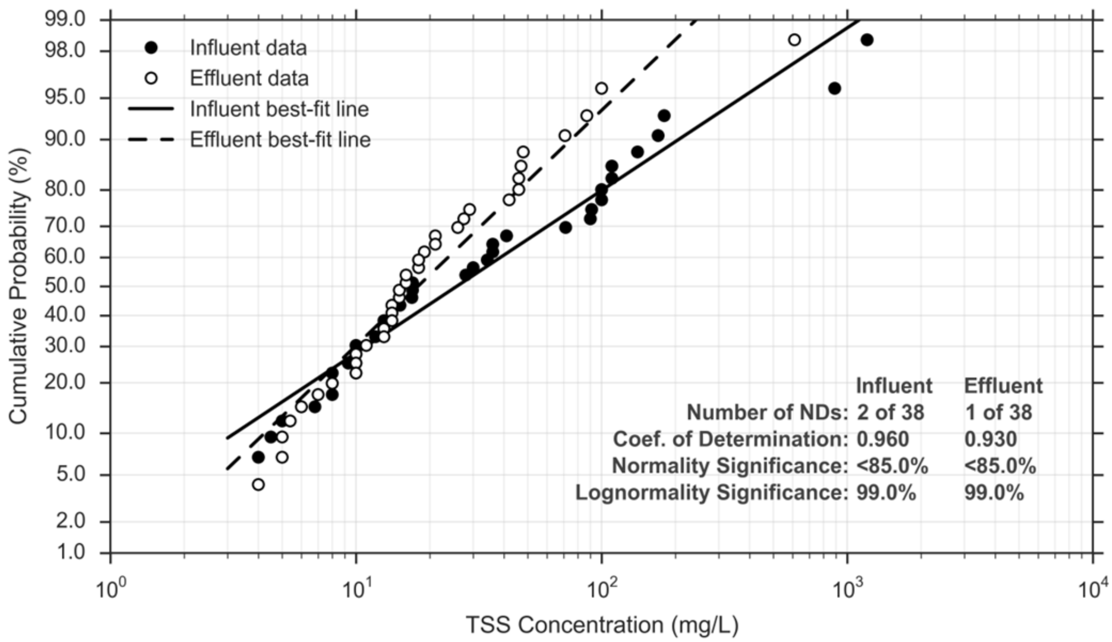


Figure 42: Probability Plot of TSS at CM Locations

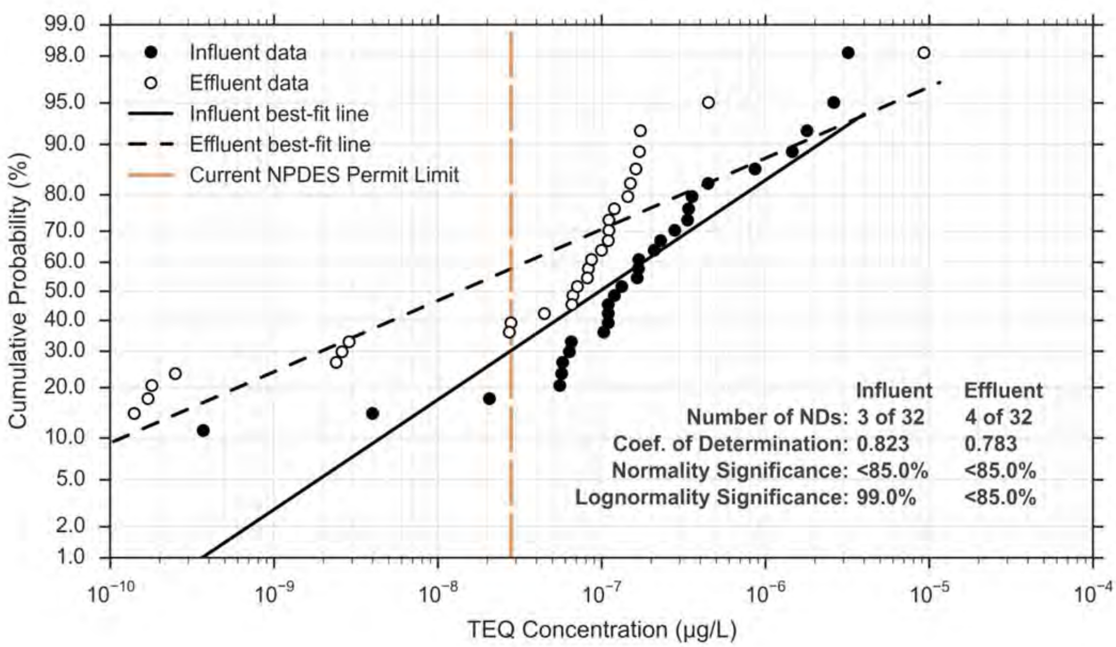


Figure 43: Probability Plot of Dioxins at CM Locations

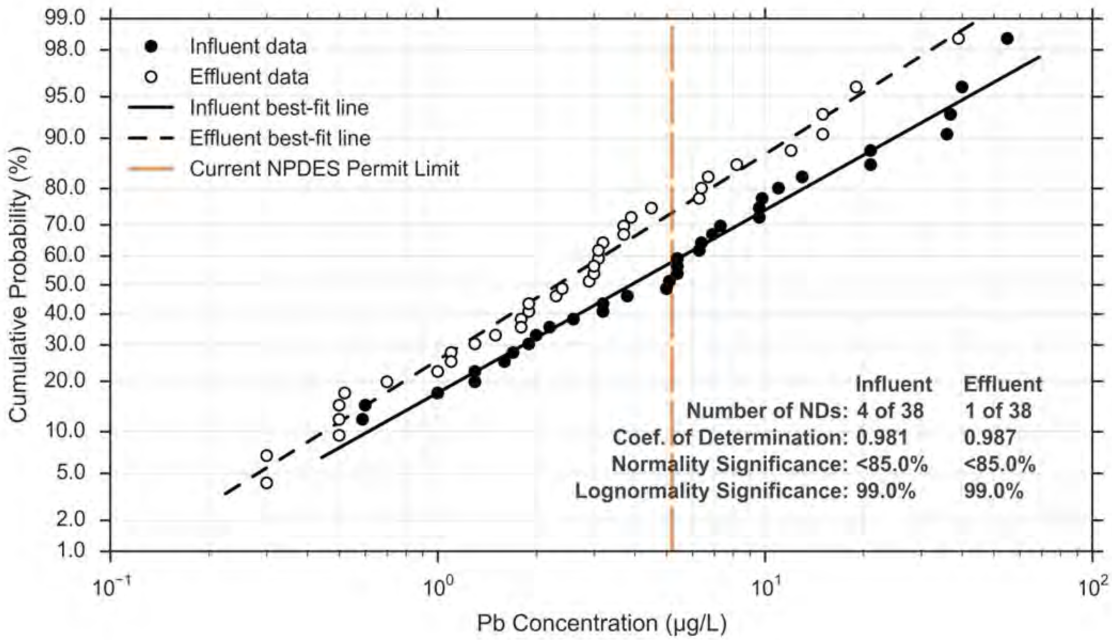


Figure 44: Probability Plot of Lead at CM Locations

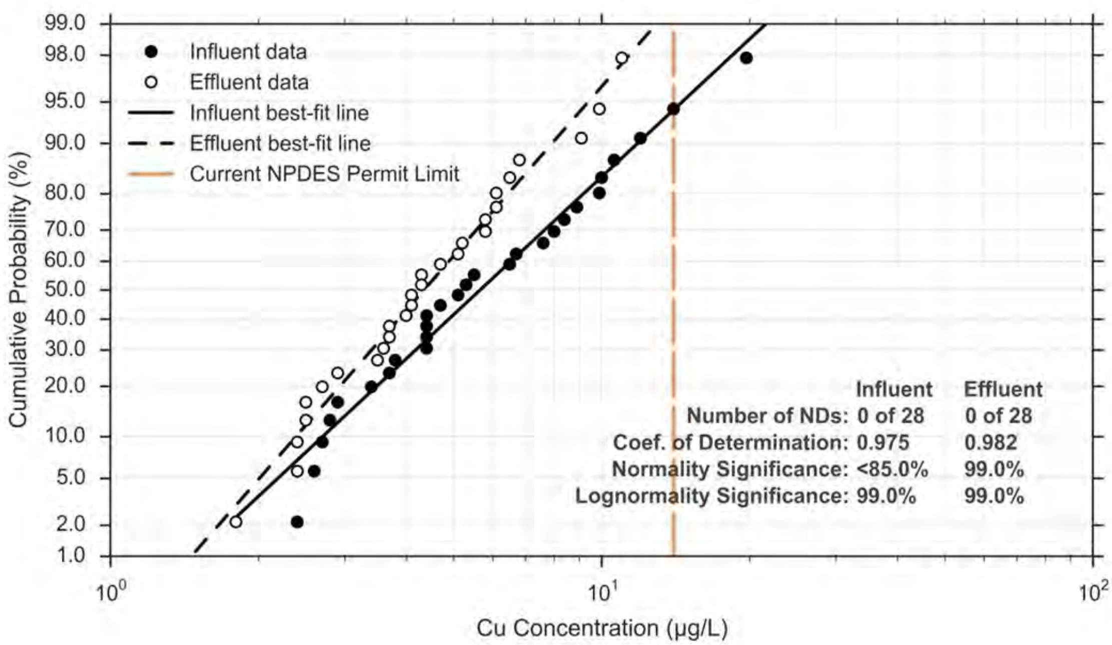


Figure 45: Probability Plot of Copper at CM Locations

5. DISCUSSION AND OBSERVATIONS

The following general observations were made based on an evaluation of the aforementioned data summary charts and tables.

1. The CMs were installed as provisional (pending further evaluation) stormwater controls that could be installed in areas where existing culverts carried the stormwater below the roads. As a result, they handle the wide range of flows during a typical rain year and experience relatively short treatment residence times and frequent overflows of the weirs. However, the monitored performance indicates the benefits of the sedimentation and media treatment unit processes. Cumulative data (as summarized by the statistical analysis tables, correlation charts, and probability plots) indicate that CM and biofilter effluent concentrations were lower than corresponding influent samples for all constituents considered for this analysis, with statistically significant pollutant removal observed for most POCs for these treatment systems, with the exception of TSS at the non-background CM sites, and dioxins at the CM background locations (i.e., some CM-1 pairs, CM-8 and CM-11, where influent concentrations were likely at levels low enough that they were unlikely to be significantly reduced by the specific BMPs installed). Average pollutant reductions in the non-background CMs (i.e., CM-1, CM-9, and B1) ranged from 15-58%. Only the average (non-background) effluent concentration for dioxins was above its Permit Limit.

2. All constituents at non-background (Table 3) CM locations, and TSS and lead at the background sites (Table 4), were found to have effluent concentration reductions (i.e., water quality improvements). Non-background sites (Table 3) had a statistically significant decrease for dioxins, copper, and lead (1-tailed sign test p=0.0005, 0.0001, and 0.0025 respectively). Background sites had a statistically significant decrease for both TSS (1-tailed sign test p=0.004) and lead (1-tailed sign test p=0.001). In non-background sites, 76% of the 33 dioxin sample pairs indicated concentration reductions through the culvert modifications with an average decrease of 15%; however, it should be noted that this removal average is heavily influenced by one data pair taken at the pre-improvement CM-1 during the 2010-2011 season. If this pair is removed from the analysis, the average removal increases to 80%.

   The monitored performance demonstrates the benefits of the sedimentation and media treatment unit processes, as well as erosion control BMPs. The monitoring data have also been used in the subarea ranking evaluations for CM improvement consideration at locations where effluent quality remains problematic. CM-1 performance is expected to improve as a result of NASA implementing the Panel's recommended ELV treatment BMP, which reduces stormwater quantities to CM-1, and improves CM-1 influent (and effluent) quality.

3. Data collected to date at the biofilter showed net TSS, dioxins, copper, and lead reductions of 39%, 86%, 51%, and 17%, respectively, for the two monitoring events available since completion of the biofilter; these reductions likely underestimate the actual reduction through the biofilter since the 2013/14 effluent sample was taken during overflow, so it reflects a blend of treated and untreated flows. Effluent concentrations for dioxins, copper, and lead were below Permit levels (there are no Permit Limits for TSS).

4. Since no runoff occurred at Outfall 008 during this monitoring period, no data were available to evaluate the performance of the new erosion and sediment controls that were installed in 2012 in the Outfall 008 watershed. In addition, no data were collected at ISRA sites during this monitoring period. In general, based on data up until the last season in which ISRA sites were monitored, effluent ISRA concentrations were lower than corresponding influent samples for a number of the constituents, suggesting positive performance of ISRA excavation and stabilization efforts. Exceptions were TSS, lead, and copper, though it should be noted that, in the case of the ISRA locations, comparisons between the influent and effluent concentrations for these constituents were not statistically significant. It should also be noted that for the ISRA areas, having comparable influent and effluent datasets is considered a positive outcome as it suggests that these actions resulted in indistinguishable stormwater quality changes in comparison to unimpacted (influent) runoff quality.

5. Several new monitoring sites were added during the 2013-2014 season, most notably to monitor performance at the new ELV treatment BMP. One sample pair was collected for this site. Data from this pair indicated decreases from influent to effluent for dioxins, lead, and copper.

Overall and in general, these results suggest that stormwater treatment is occurring at the CMs and biofilter for all POCs evaluated.

6. RECOMMENDATIONS

1. Based on evaluation of CM performance, the Panel recommends there be continued inspection and maintenance including the following:

   - Inspection after large storms and at the start of the rainy season, removal of accumulated sediment and debris in ponded footprints above the weir boards (particularly when accumulation depth exceeds 10% of weir board height);
   - Inspection of underdrain flows during storms to ensure water is still flowing effectively through media beds;
   - Replacement of filter fabric when they are damaged or non-functioning;
   - Collection of field notes during sampling to note whether weir board overflow is occurring, etc.

   Furthermore, the Panel will continue to provide specific improvement recommendations for CM areas during current and future monitoring periods, if warranted and likely to be effective.

2. If media clogging or media failure is a concern during field inspections and during sample collection, video inspections would be useful in order to inspect underdrains for signs of clogging, material movement into the pipe, or a cracked pipe. The Panel recommends doing video inspections while the system is dry, and then again after water is introduced upstream of the weir boards in a controlled manner, such as from a water truck. In the "water" inspection, it would be helpful to determine the drainage rate of the ponded water (check to see if ponded more than a day after the rain ended).

3. The Panel recommends continued monitoring at all non-background BMP performance monitoring sites (CM-1, CM-9, ELV treatment system, the lower lot biofilter, and B1) in order to confirm continued stormwater quality improvement as upstream controls are added and re-vegetation continues.

APPENDIX E

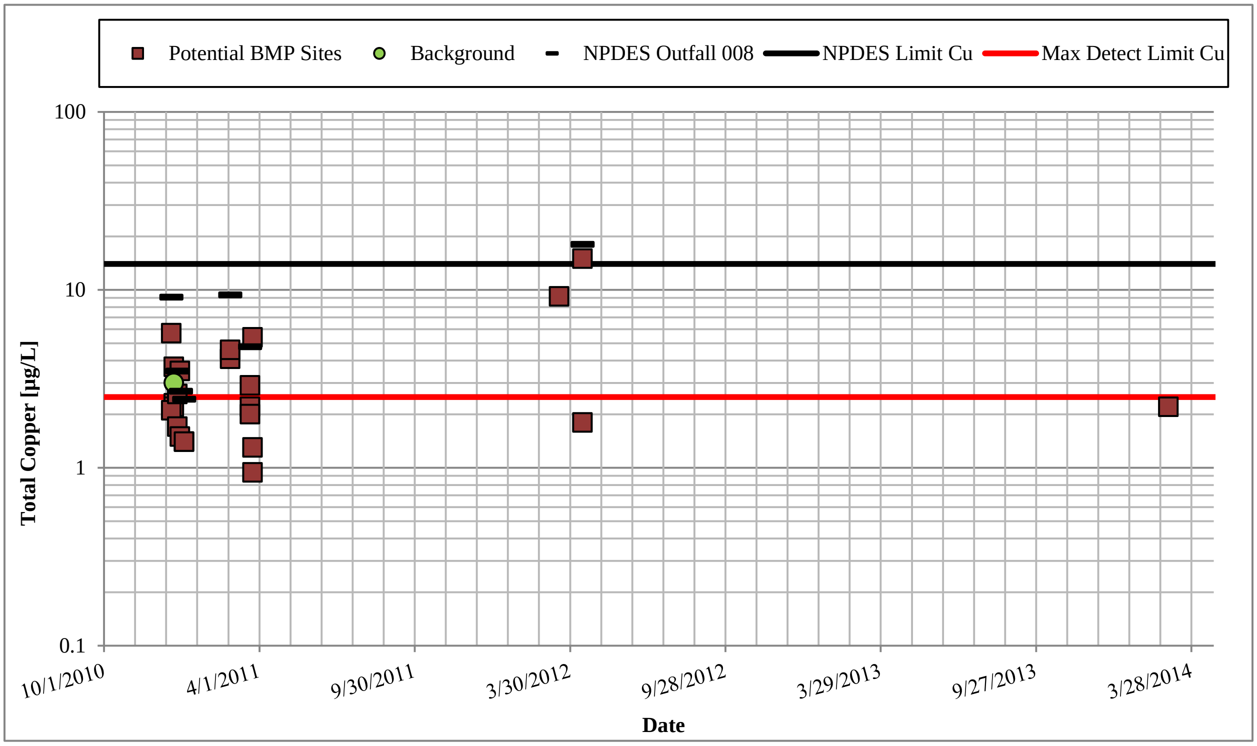
BMP MONITORING CHARTS
2013/2014 RAINY SEASON

APPENDIX E-1

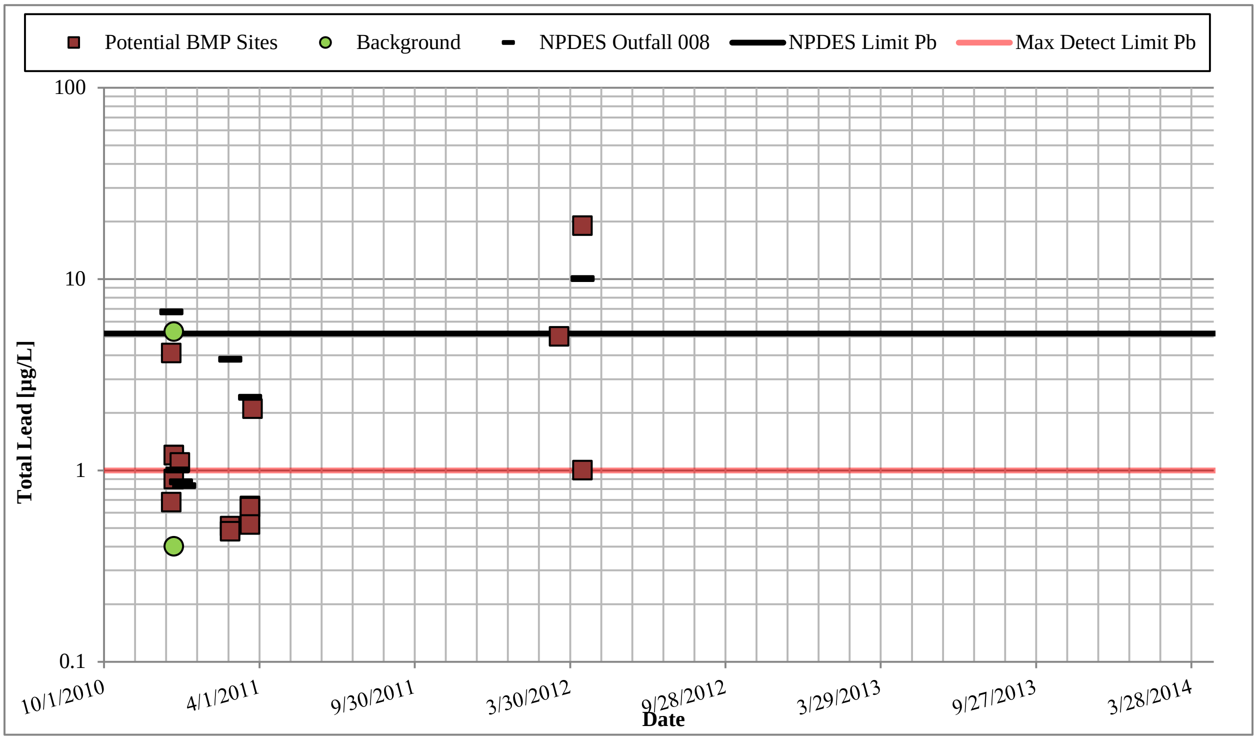
POTENTIAL BMP MONITORING DATA GRAPHS VS. TIME

OUTFALL 008 TIMESERIES CHARTS
POTENTIAL BMP SUBAREA MONITORING PROGRAM

COPPER



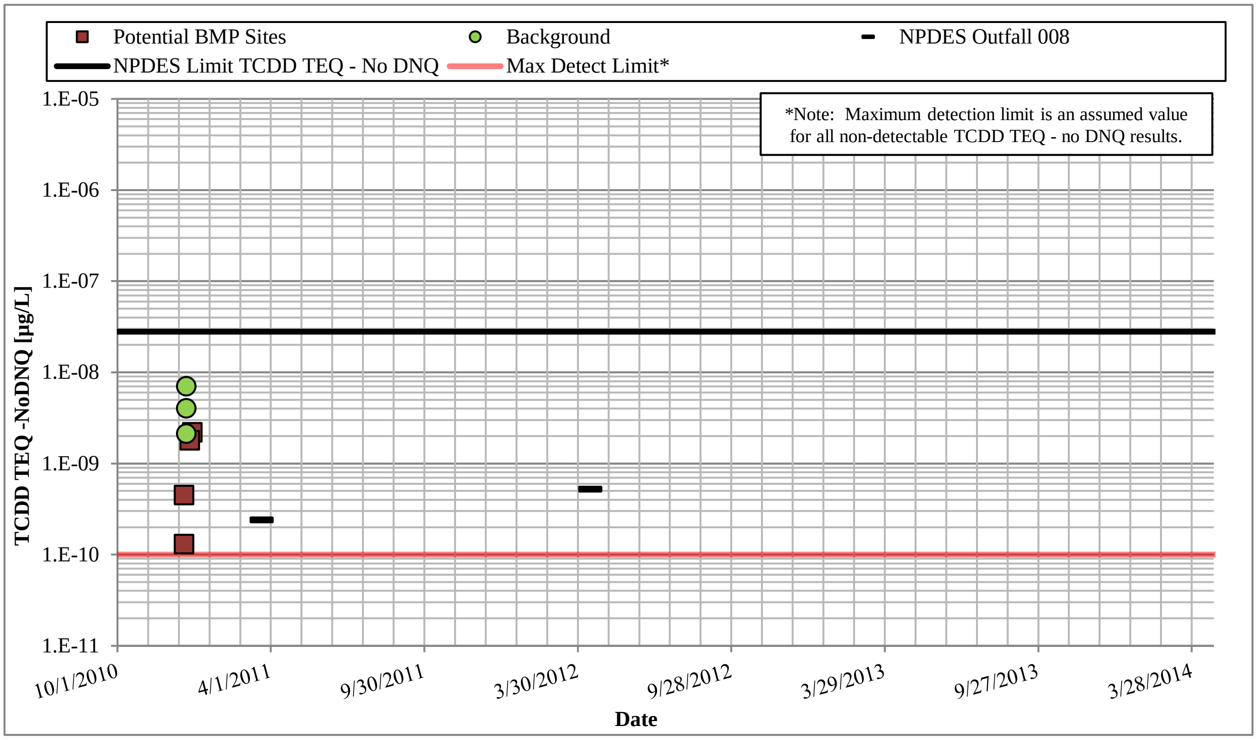
LEAD



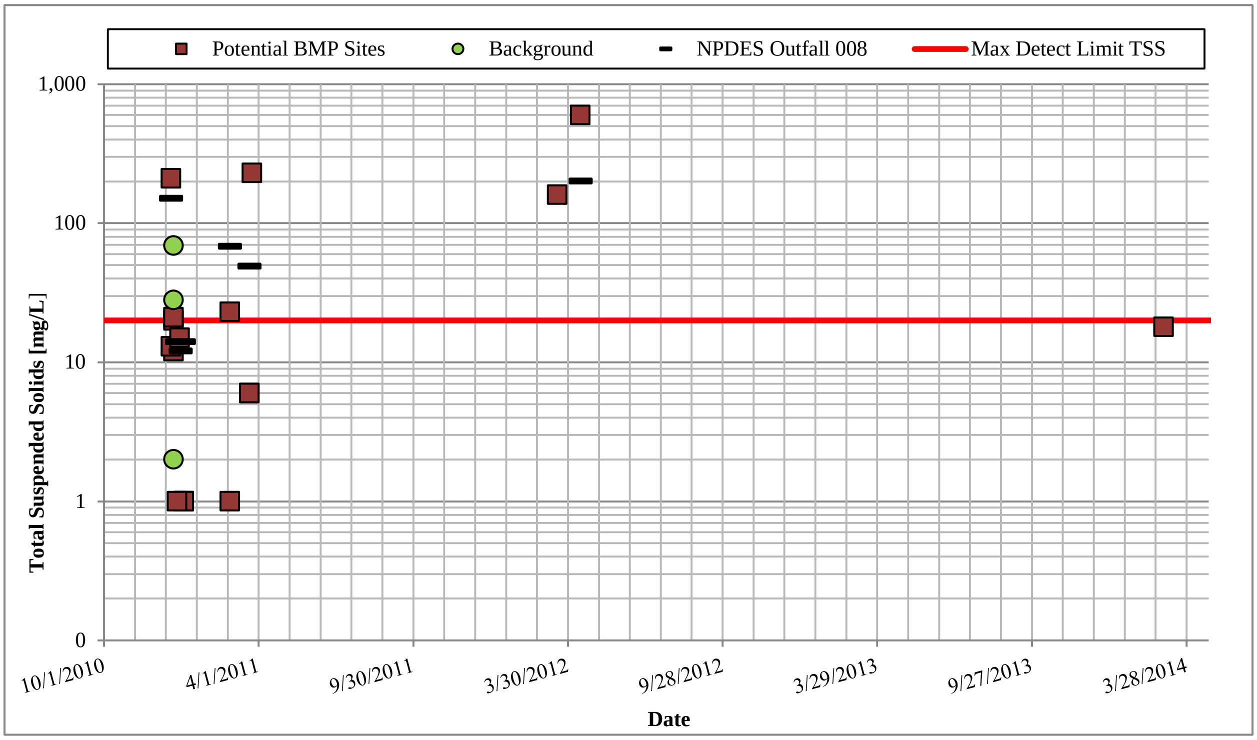
Sample results measured below the detection limit have been excluded. Results shown below the maximum detection limit line correspond to samples with a detection limit less than the maximum detection limit.

OUTFALL 008 TIMESERIES CHARTS
POTENTIAL BMP SUBAREA MONITORING PROGRAM

DIOXINS (TCDD-TEQ – no DNQ)



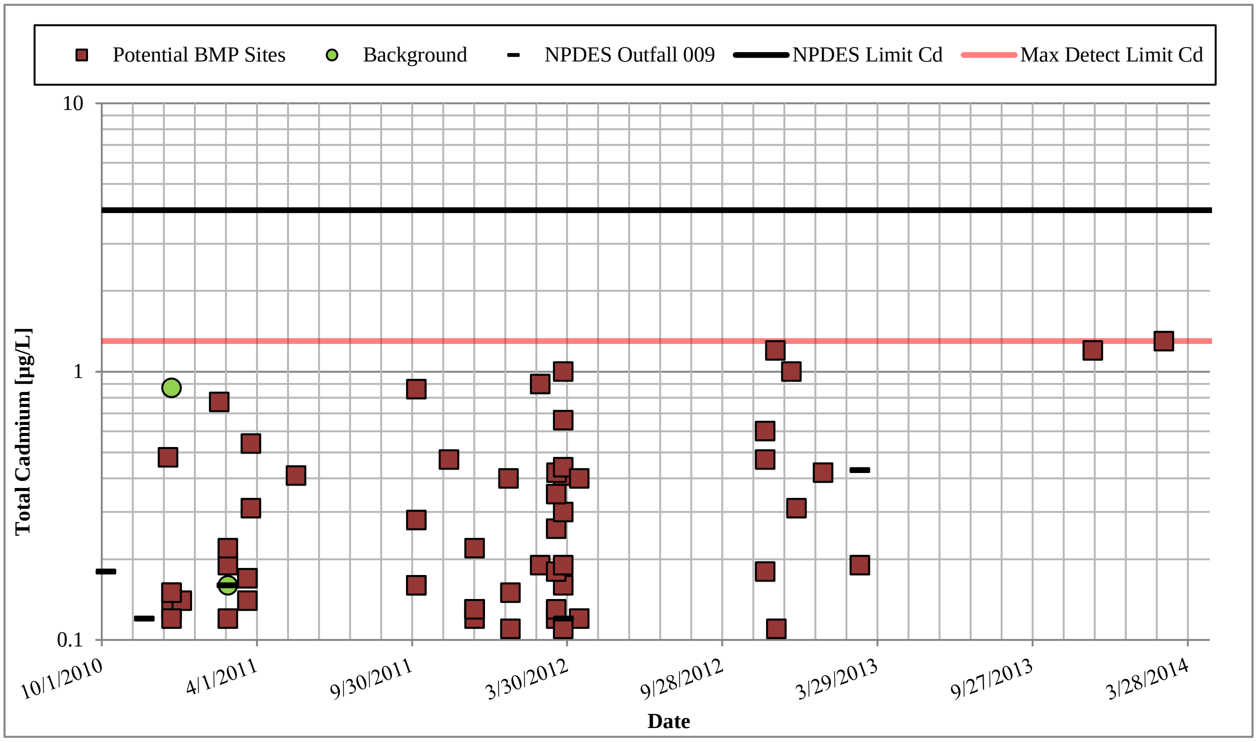
TSS



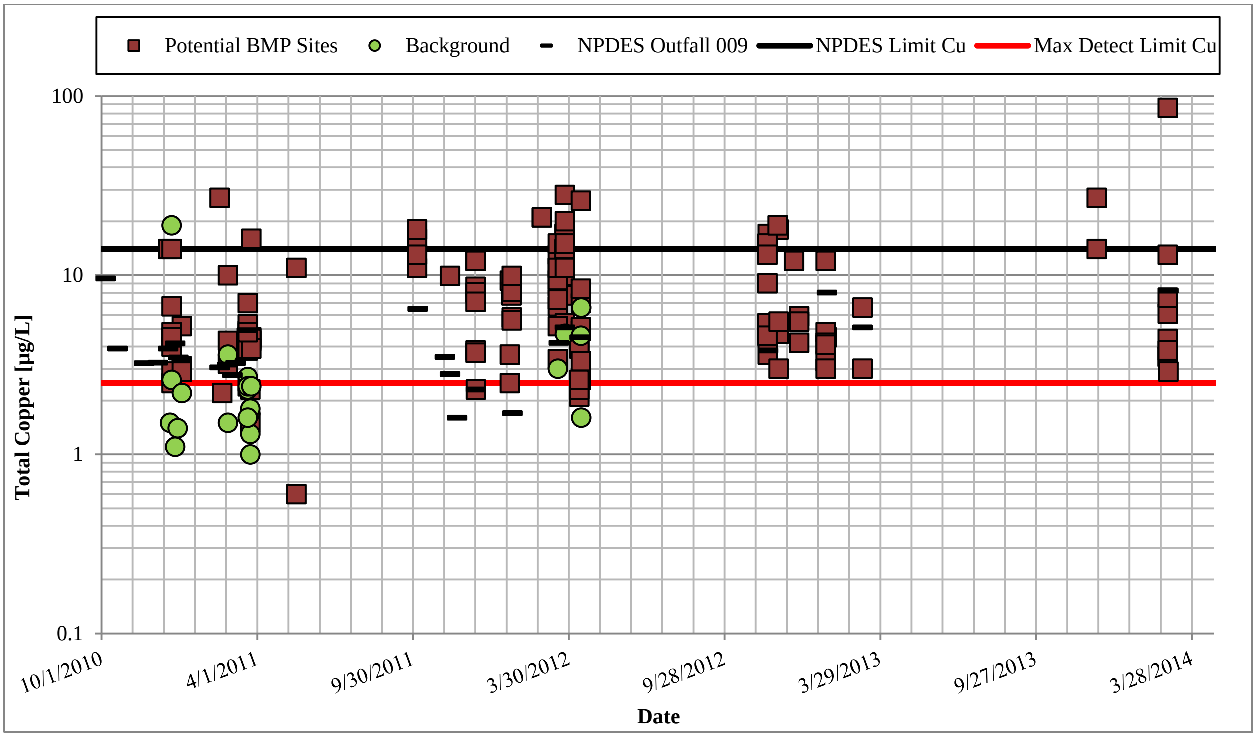
Sample results measured below the detection limit have been excluded. Results shown below the maximum detection limit line correspond to samples with a detection limit less than the maximum detection limit.

OUTFALL 009 TIMESERIES CHARTS
POTENTIAL BMP SUBAREA MONITORING PROGRAM

CADMIUM



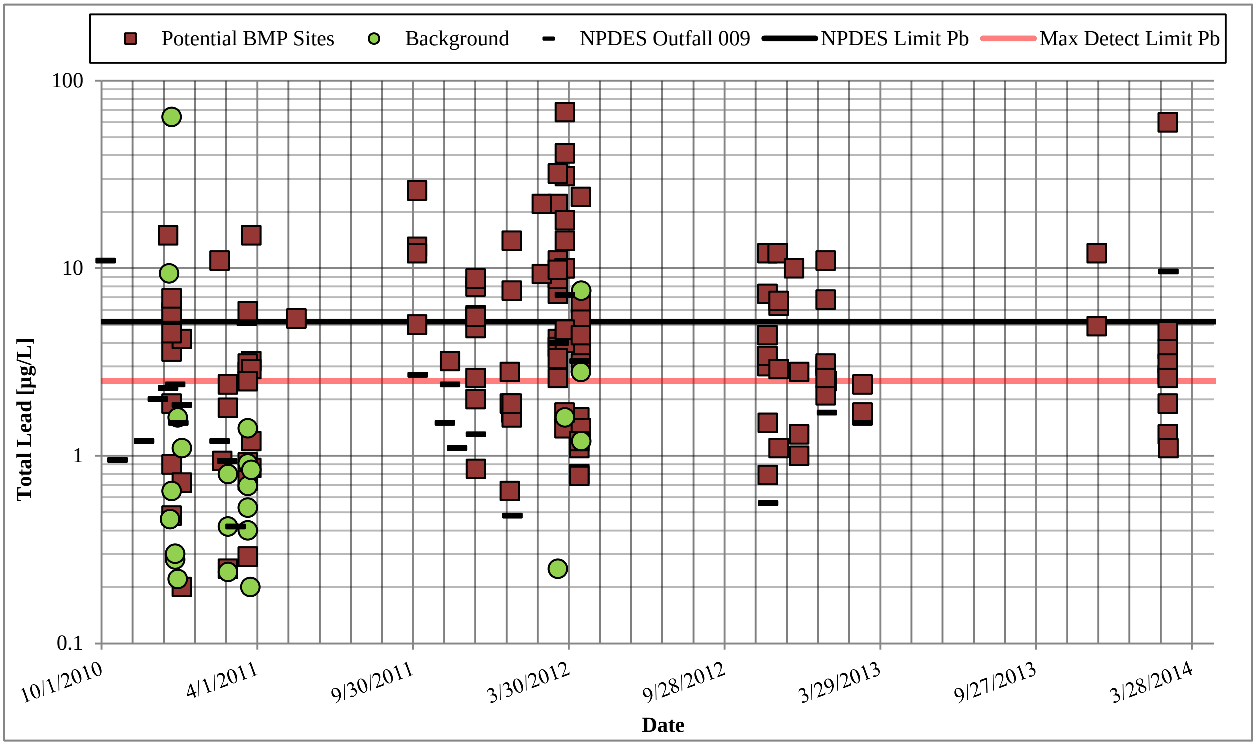
COPPER



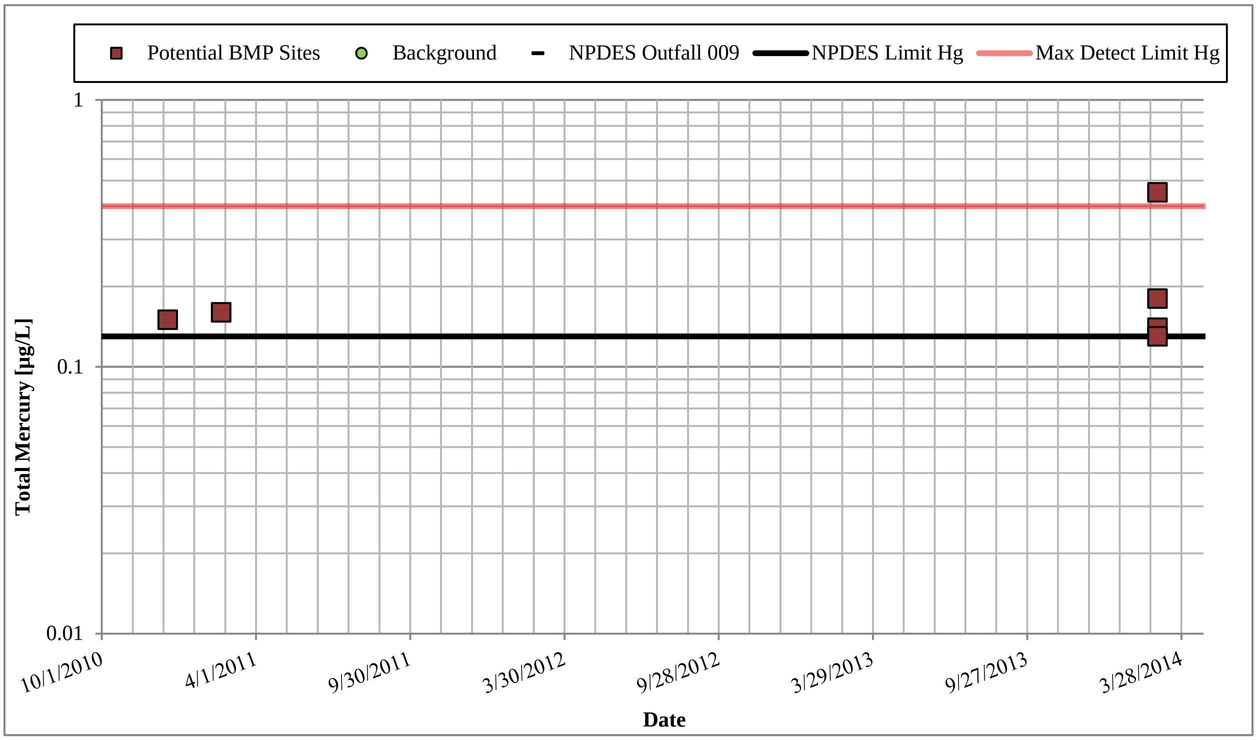
Sample results measured below the detection limit have been excluded. Results shown below the maximum detection limit line correspond to samples with a detection limit less than the maximum detection limit.

OUTFALL 009 TIMESERIES CHARTS
POTENTIAL BMP SUBAREA MONITORING PROGRAM

LEAD



MERCURY



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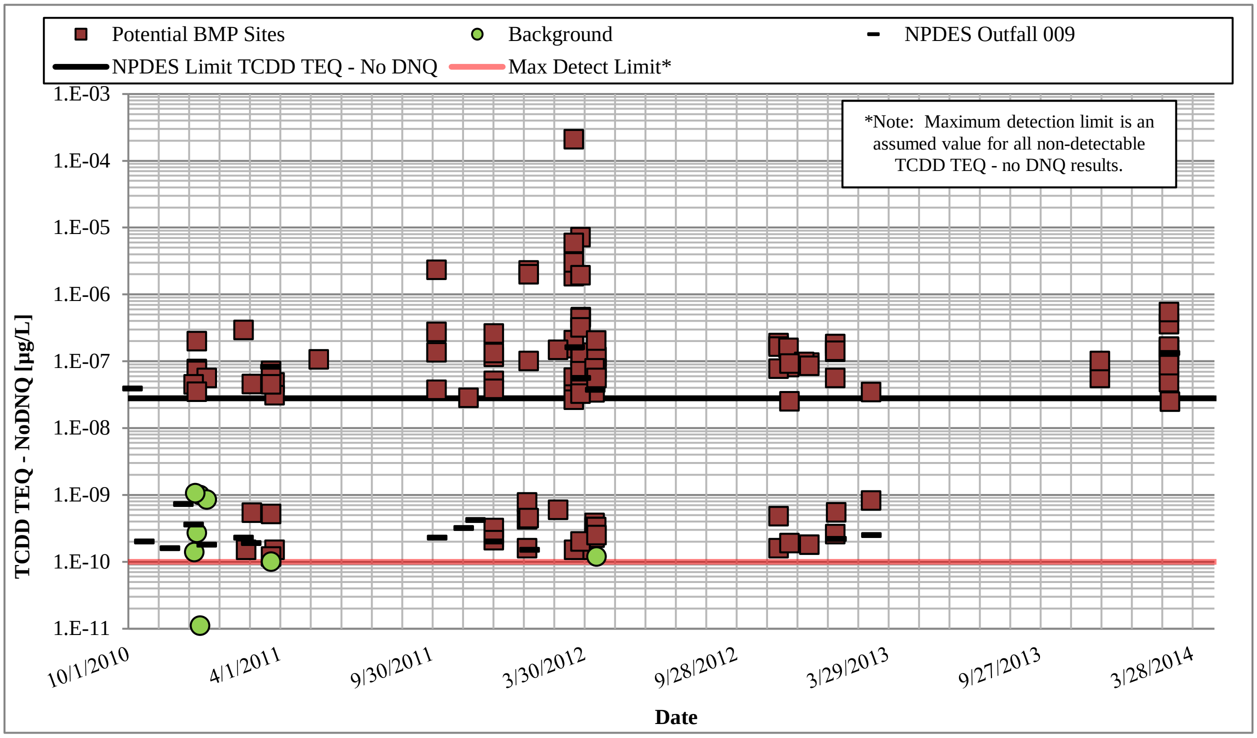
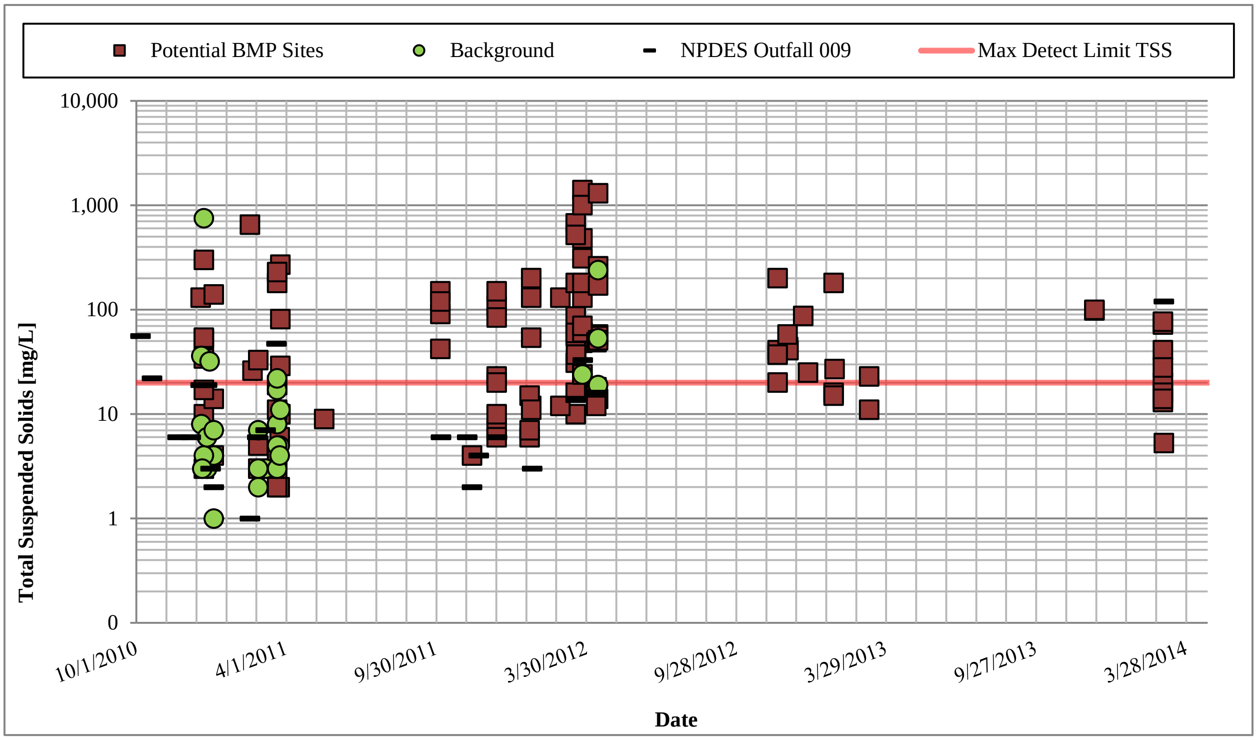
DIOXINS (TCDD-TEQ – no DNQ)



TSS



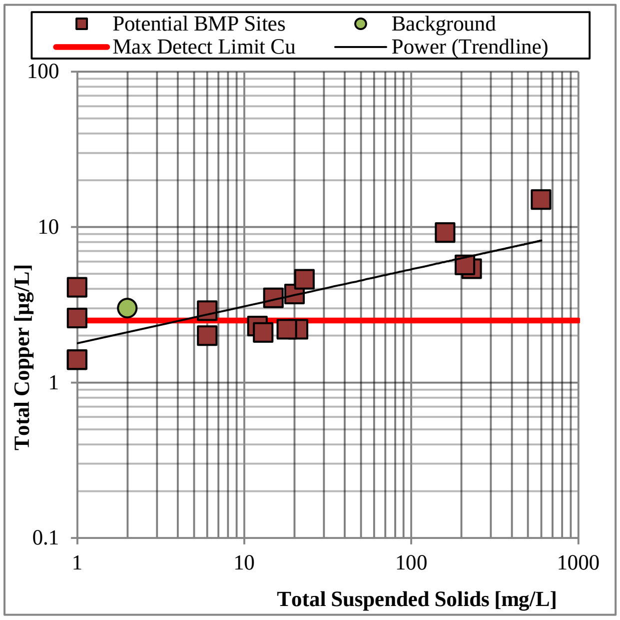
Sample results measured below the detection limit have been excluded. Results shown below the maximum detection limit line correspond to samples with a detection limit less than the maximum detection limit.

APPENDIX E-2

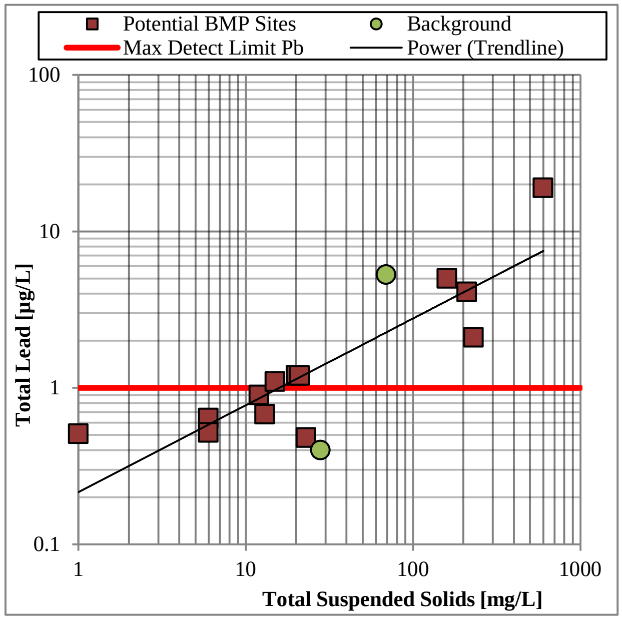
POTENTIAL BMP MONITORING DATA GRAPHS – COC CORRELATIONS

OUTFALL 008 CORRELATION CHARTS
POTENTIAL BMP SUBAREA MONITORING PROGRAM

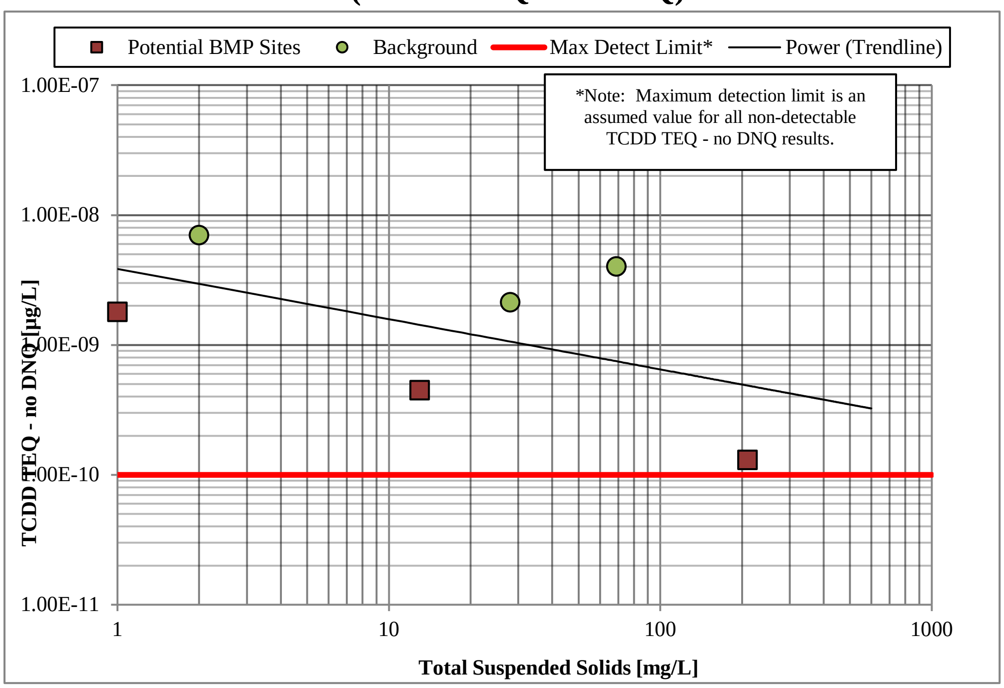
COPPER VS TSS



LEAD VS TSS



DIOXINS (TCDD-TEQ – no DNQ) VS TSS

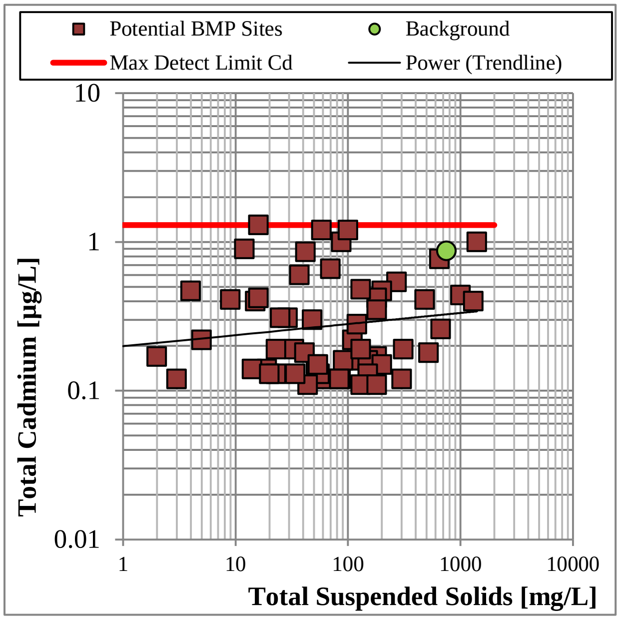


Sample results measured below the detection limit have been excluded. Results shown below the maximum detection limit line correspond to samples with a detection limit less than the maximum detection limit.

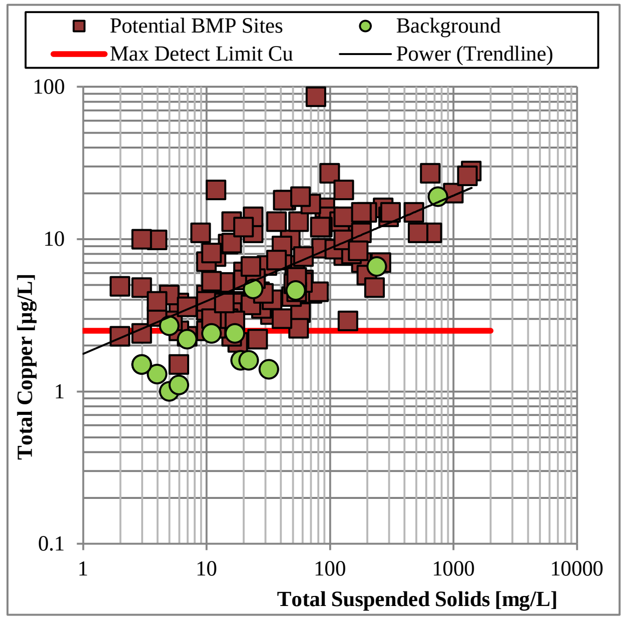
Several Background locations are also shown as CM Upstream locations on the ISRA Performance Monitoring plots.

OUTFALL 009 CORRELATION CHARTS
POTENTIAL BMP SUBAREA MONITORING PROGRAM

CADMIUM VS TSS



COPPER VS TSS



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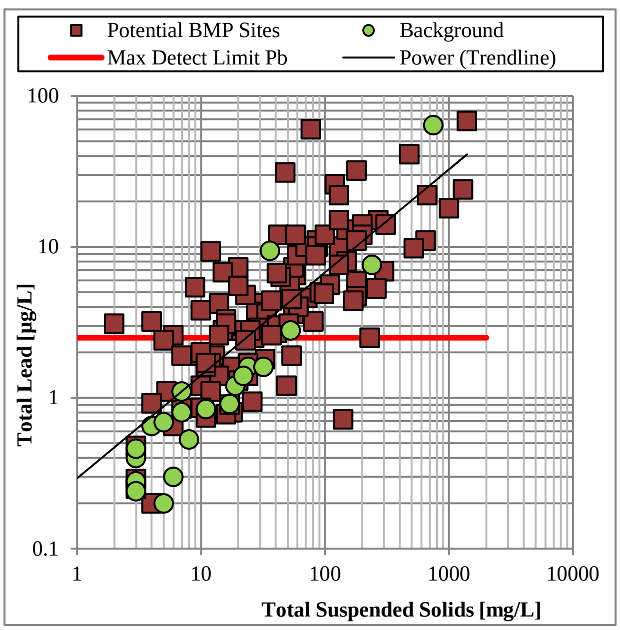
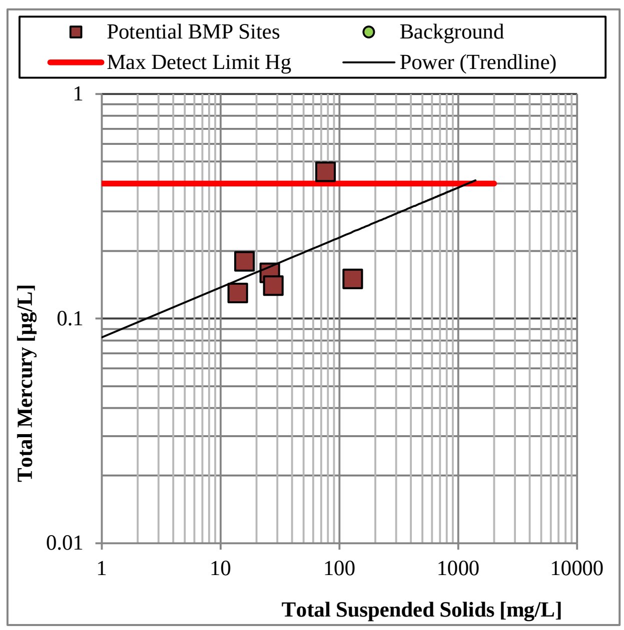


MERCURY VS TSS

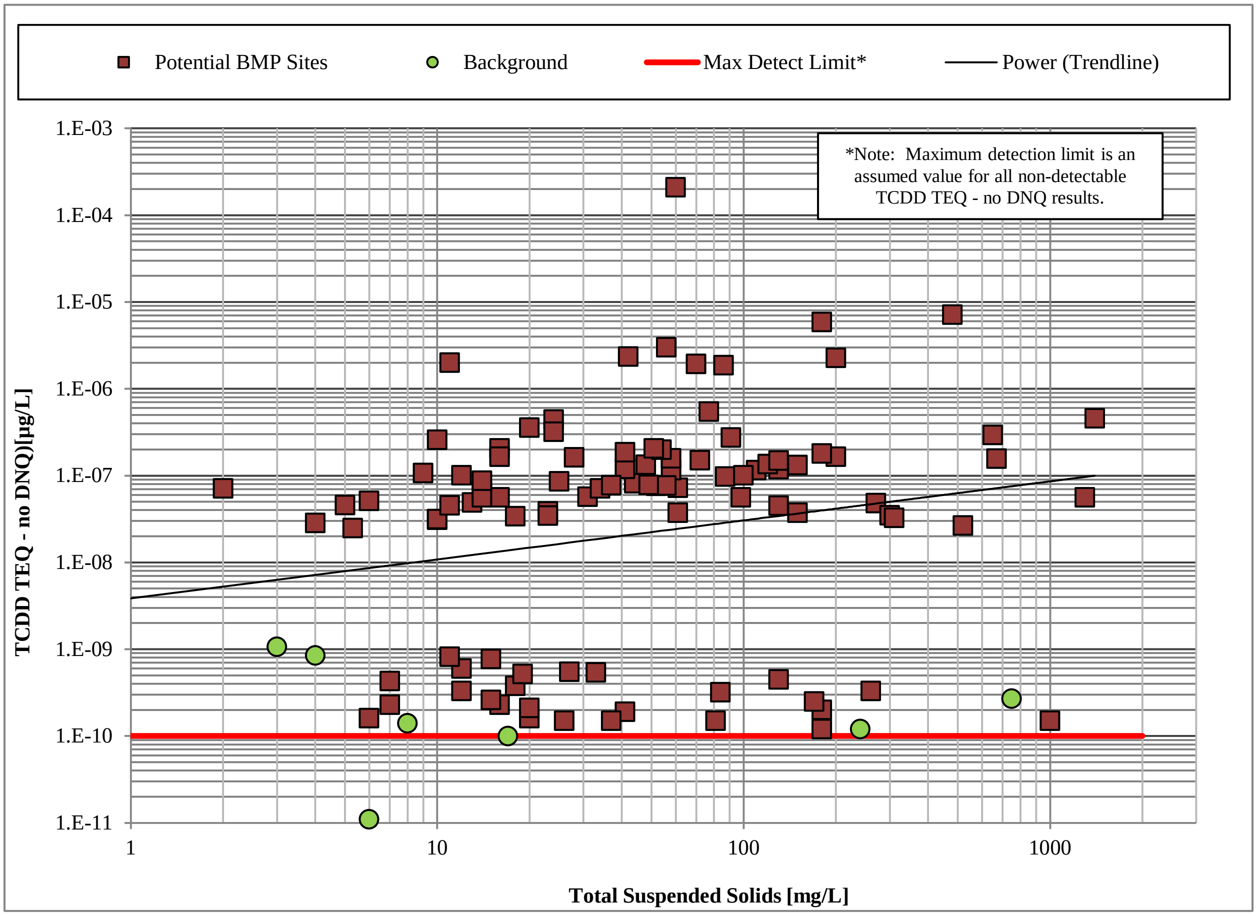


Sample results measured below the detection limit have been excluded. Results shown below the maximum detection limit line correspond to samples with a detection limit less than the maximum detection limit.

Several Background locations are also shown as CM Upstream locations on the ISRA Performance Monitoring plots.

OUTFALL 009 CORRELATION CHARTS
POTENTIAL BMP SUBAREA MONITORING PROGRAM

DIOXINS (TCDD-TEQ – no DNQ) VS TSS



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Several Background locations are also shown as CM Upstream locations on the ISRA Performance Monitoring plots.

APPENDIX F

EXPERT PANEL’S BMP SITE RANKING ANALYSIS MEMORANDUM
2013/2014 RAINY SEASON

SANTA SUSANA SITE WATERSHED 008 AND 009 BMP SUBAREA RANKING ANALYSIS

August 27, 2014

Santa Susana Site Surface Water Expert Panel

Geosyntec Consultants

TABLE OF CONTENTS

ATTACHMENTS

TECHNICAL APPENDIX

LIST OF ACRONYMS

BEF	Bioaccumulation equivalency factors
BMP	Best management practice
Cd	Cadmium
CM	Culvert modification
COC	Constituent of concern
CV	Coefficient of variation
Cu	Copper
CWB	California Water Board
Det	Detected
DNQ	Detected not quantified
ISRA	Interim Source Removal Action
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
mg/L	milligram per liter
ND	Not detected
NPDES	National Pollutant Discharge Elimination System
Pb	Lead
PL	Permit limit
PS	Particulate strength
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigations
RWQCB	Regional Water Quality Control Board
SSS	Santa Susana Site
SW	Stormwater
Tc	Time of concentration
TCDD	Tetrachlorodibenzo-*p*-dioxin
TEQ	Toxic equivalence
TSS	Total suspended solids
USEPA	U.S. Environmental Protection Agency

EXECUTIVE SUMMARY

The Santa Susana Site (SSS) Surface Water Expert Panel (Panel) was tasked by the Los Angeles Regional Water Quality Control Board (RWQCB) with evaluating subareas within the SSS Outfall 008 and 009 watersheds for potential implementation of new Best Management Practices (BMPs). These BMPs may include source controls (such as removal of impacted surface soils), erosion and sediment controls (such as straw wattles and hydromulch), instream measures (such as bank stabilization and grade control structures), and structural treatment controls (such as sediment basins and media filters, and biofilters). The purpose of any new proposed BMPs would be to improve National Pollutant Discharge Elimination System (NPDES) permit compliance at Outfalls 008 and 009 (Order No. R4-2010-0090)[1].

The purpose of this subarea ranking analysis is to rank subareas within Boeing's and NASA's 008 and 009 watersheds for potential implementation of new or enhanced stormwater controls and to evaluate existing measures, based on the most current available data and subarea specific considerations. The Expert Panel's recommended approach to this task is to rank potential BMP subarea monitoring locations based on the results of water quality sample comparisons between (a) stormwater concentrations and permit limits, and (b) subarea stormwater particulate strengths[2] and background stormwater particulate strengths. A statistical methodology was developed to rank the subareas based on these comparison results, while accounting for the number of useable data available at each subarea as well as number of data observations that fall above these thresholds (i.e., reflecting statistical confidence in how frequently each subarea will exceed the comparison thresholds). This methodology relied on "weighting factors" that are calculated for each POC for each subarea. In the end, the pollutant-specific weighting factors were summed to produce a multi-constituent score to allow for relative ranking amongst the potential BMP subareas. This approach was presented at the California Stormwater Quality Association (CASQA) conference in 2011 and published in Stormwater Magazine in 2013.

The data included in this analysis fell into the following categories and periods of record:

1) Interim Source Removal Action (ISRA) and culvert modification (CM) performance monitoring data (2009-2014),

2) NPDES outfall monitoring data (2004-2014), and

3) Potential BMP subarea monitoring data (2010-2014).

[1] Outfall 009 had no NPDES exceedances in three NPDES-sampled events this year; however, total rainfall was only 6.07 inches (33 percent of average annual rainfall [18.4 inches]). February 28, 2014 produced 2.89 inches, which is more than the 1 year, 24 hour storm (2.3 inch depth). This depth was not exceeded on any other day. Outfall 008 did not flow and was not sampled.

[2] Particulate strength is determined by taking the total concentrations of the compound minus its dissolved concentrations and dividing by the total suspended solids. It then provides a measure of the mass of particulate form of the compound per mass of suspended sediment. These values are very useful in identifying erosion and other sources of the particulate-bound pollutants in the runoff.

Where available, data from co-located ISRA subareas were combined with data from BMP subareas in order to provide a more robust dataset at potential BMP locations. The exact periods of record varied by dataset and by sample subarea but were all-inclusive since the beginning of the monitoring program. This ranking evaluation occurs annually during the term of the 008/009 BMP Work Plan (i.e., through 2014); the first was presented by the Expert Panel and Geosyntec in September, 2011, therefore this is the fourth, and last, of four annual BMP data analysis and recommendation reports. Performance monitoring and some BMP monitoring will continue for at least one more season to verify performance for newly implemented controls and to check future conditions at locations with high scores but few data; however, these results will not be incorporated into a future BMP data analysis and recommendation report.

This year, as in previous years, the Expert Panel has overseen and reviewed the BMP ranking analysis, and evaluated the results to make new BMP recommendations. Initial analysis results were presented to the Expert Panel on July 11, 2014, and discussed again on July 18, 2014. The Panel received the draft ranking memo on July 22, 2014 and the revised draft on August 26, 2014. An Expert Panel meeting and site visit was also conducted on August 14, 2014 to finalize the BMP recommendations contained herein.

Subarea Specific Evaluation of Top-Ranked Subareas

Based on these analysis results, the following monitoring locations were identified as the highest ranked subareas, with multi-constituent scores ranging from 0.49 to 0.98 out of a maximum score of 1.0 (see Table ES-1[3]). Scores closer to 1.0 indicate the monitoring locations with poorer historic water quality. Table ES-1 is limited to the top-ranked subareas discussed below; a complete summary table is provided in the main report as Table 9. Besides the multi-constituent scores, the following list is also of significance because it includes:

- Only four of the top twenty monitoring locations (APBMP0001-A, ILBMP0001, LXBMP0006, and B1BMP0003) are either active (i.e., not discontinued or reclassified due to upstream BMP implementation) or are not upstream of an existing BMP (i.e., without downstream stormwater treatment); recommendations for these four sites are provide below;

- Two of the three subareas (ILBMP0002, EVBMP0003, and B1BMP0005, which is the one not highly ranked) where 2,3,7,8-TCDD[4] was detected (but not quantified) in the 2012-2013 wet season (2,3,7,8-TCDD was not detected in any samples collected during the 2013-2014 wet season);

- The top eight highest ranked monitoring locations for dioxins; and

- The top six highest ranked monitoring locations for metals.

[3] Subareas with zero samples have been excluded from table ES-1.
[4] 2,3,7,8-TCDD is a congener that potentially indicates unweathered anthropogenic contamination

In some cases, these results reflect conditions prior to or following implementation of temporary measures or corrective actions and this is described in parentheses following the location designation (in bold). It should be noted that all top 20 monitoring locations described below are located in the 009 drainage area, with none in the 008 drainage area. Water quality at stormwater background locations was generally good with no location ranked above 34.5, though there were several instances of concentrations greater than NPDES permit limits at those locations. No flow or exceedances occurred at Outfall 008 during the current season, indicating that retention occurred within the watershed during the small storms observed. A detailed discussion of each of the top 20 ranked monitoring locations is provided in Section 7 of this report.

Table ES-1. Subareas Ranked by Multi-Constituent Score

Rank	Potential BMP Subarea (Co-locations)	Watershed	Description	Approximate Upgradient Drainage Area (ac)	Multi-Constituent Score	Rank from Maximum Metals Weighting	Rank from Maximum Dioxins Weighting	Total Number of Events Sampled	Site Status
1	**ILBMP0002**[a]	Outfall 009	Road runoff to CM-9	2.5	0.98	1	5	10	Being addressed – no further action needed
2	**EVBMP0003** (A2SW0001)[a]	Outfall 009	CM-1 upstream west	2.3	0.89	3	1	19	Being addressed; no further action needed
3	**EVBMP0002**	Outfall 009	Helipad (pre-sandbag berms) - OLD	4.1	0.66	17.5	8	6	Being addressed; no further action needed
5	**EVBMP0005**[a]	Outfall 009	2012-2013 ELV drainage ditch (pre-ELV-1C ISRA) - OLD	11	0.63	21	7	2	Being addressed; no further action needed
5	**A1SW0009-A**	Outfall 009	CM-9 downstream-underdrain outlet (post-A1LF asphalt removal, pre-filter fabric over weir boards) - OLD	16.4	0.63	4.5	24.5	1	Being addressed; no further action needed
5	**APBMP0001-A**	Outfall 009	Area II road runoff, post-ELV stormwater improvements	0.2	0.63	4.5	24.5	1	Revisit after more data become available
7	**EVBMP0004**[a]	Outfall 009	2012-2013 Lower Helipad Road	1.8	0.62	2	35.5	3	Being addressed; no further action needed
8.5	**LPBMP0002**[a]	Outfall 009	Lower parking lot influent to cistern	4.2	0.60	11.5	12.5	2	Being addressed; no further action required
8.5	**APBMP0001**	Outfall 009	Ashpile culvert/inlet road runoff, pre-ELV improvements-OLD	32.9	0.60	6	24.5	2	Refer to APBMP0001-A
10	**ILBMP0001**[b]	Outfall 009	Lower lot 24" stormdrain outlet	23	0.58	23	6	18	Targeted for current control
11	**B1BMP0004 (B1SW0015, B1BMP0004-5)**[a]	Outfall 009	B1 media filter inlet north	3.7	0.51	35	2	12	Being addressed; no further action required
15.5	**LPBMP0001-A**[a]	Outfall 009	Lower lot sheetflow (post-gravel bag berms)	5.1	0.50	37.5	4	6	Being addressed; no further action required
15.5	**B1SW0002**[a]	Outfall 009	Woolsey Canyon Road runoff	1.3	0.50	11.5	24.5	2	Being addressed; no further action required
15.5	B1BMP0001 (B1SW0010)[a]	Outfall 009	B1 media filter inlet (post-media filter installation)	4.5	0.50	11.5	24.5	3	Being addressed; no further action required
15.5	LXBMP0006 (LXSW0010)[a]	Outfall 009	LOX east, runoff along dirt road	0.43	0.50	11.5	24.5	1	Being addressed; no further action required

Rank	Potential BMP Subarea (Co-locations)	Watershed	Description	Approximate Upgradient Drainage Area (ac)	Multi-Constituent Score	Rank from Maximum Metals Weighting	Rank from Maximum Dioxins Weighting	Total Number of Events Sampled	Site Status
15.5	EVBMP0006[a]	Outfall 009	2012-2013 Area II Road near ELV ditch	11	0.50	11.5	24.5	1	Being addressed; no further action required
15.5	LPBMP0003[a]	Outfall 009	Lower parking lot sediment basin outlet	4.2	0.50	11.5	24.5	1	Targeted for current control
15.5	B1SW0014-A (B1BMP0006)	Outfall 009	B1 media filter effluent (pre-media filter reconstruction) - OLD	4.7	0.50	11.5	24.5	1	Being addressed; no further action required
15.5	LPBMP0001[a]	Outfall 009	Lower lot sheetflow (pre-gravel bag berms) - OLD	5.1	0.50	11.5	24.5	2	Being addressed; no further action required
20	**B1BMP0003** **(B1BMP0002)**	Outfall 009	B1 parking lot / road runoff to culvert inlet	5.2	0.49	51	3	18	Being addressed; no further action required

Notes

- ([a]) These potential BMP subarea monitoring locations are upstream of existing stormwater quality treatment controls.
- ([b]) These potential BMP subarea monitoring locations have new planned (i.e., designed and ready for construction) stormwater quality treatment controls.
- The rounding of weights may account for similar weights being ranked differently.
- Approximate drainage areas based on the cumulative drainage area of the SWMM catchment in which the monitoring location is located (Geosyntec, 2011). At locations where the monitoring point is upstream of the catchment outfall a "<" sign is used.
- **Bolded** locations indicate that both the NPDES permit limit and 95th percentile background particulate strength threshold were exceeded for any one POC.
- Gray text indicates historic subarea monitoring locations that are discontinued.
- "OLD" in the location description means that the location is now sampled under a new suffix (-A, -B, etc.) due to a change in the upstream watershed, typically BMP implementation.

Table ES-2 summarizes the key locations that have both an influent and effluent paired location, which includes some of the locations ranked in the top 20 from the multi-constituent ranking analysis. This comparison demonstrates that treatment through the BMPs resulted in improved water quality. For example, two influent streams within the B1 area (ranked 11 and 23) are both ranked higher than the B1 effluent, which is ranked 43. A similar occurrence is observed for the influent/effluent ranks for CM-1, CM-9, and the lower parking lot sedimentation basin and biofilter (based on just two samples). B1 parking lot and road runoff have been included to more fully describe improvements in the vegetated area downstream of the B1 media filter B1 area. Although the ELV treatment BMP rankings were based on just one sample, separate samples collected in past monitoring years that represent influent quality have typically been ranked highly (e.g., EVBMP0005). Therefore, EVBMP0007 and EVBMP0008 have both been included in Table ES-2 to illustrate a water quality improvement between the recent BMP influent and effluent.

Table ES-2. Ranking Comparison of Influent and Effluent Pairs

BMP Area	Influent			Effluent			Rank Change
	Monitoring Location	Description	Influent Rank	Monitoring Location	Description	Effluent Rank	
CM-9	**ILBMP0002**	Road runoff to CM-9	1	A1SW0009-C	CM-9 downstream-underdrain outlet (post- perforated pipe and upper basin installed)	34.5	-33.5
CM-1	**EVBMP0003 (A2SW0001)**	CM-1 upstream west	2	A2SW0002-A (A2BMP0007)	CM-1 effluent (post-filter fabric over weir boards)	42	-40
B1 Media Filter	**B1BMP0004 (B1SW0015, B1BMP0004-5)**	B1 media filter inlet north	11	B1SW0014-C (B1BMP0006)	B1 media filter effluent (post-media filter reconstruction, post-curb cuts)	43	-32
	B1BMP0005 (B1SW0013, B1SW0011, B1BMP0004-5)	B1 media filter inlet south	23				-20
Lower Lot Sediment Basin	**LPBMP0002**	Lower parking lot influent to cistern	8.5	**LPBMP0003**	Lower parking lot sediment basin outlet	15.5	-7
				LPBMP0004	Lower parking lot biofilter outlet	40.5	-32
Vegetated Area Downstream of B1 Media Filter	**B1BMP0003 (B1BMP0002)**	B1 parking lot / road runoff to culvert inlet	20	B1BMP0007	B1, vegetated channel	48	-28
	B1SW0014-C (B1BMP0006)	B1 media filter effluent (post-media filter reconstruction, post-curb cuts)	43				-5
ELV treatment BMP*	EVBMP0007	Influent to ELV treatment BMP	25	EVBMP0008	Effluent from ELV treatment BMP	34.5	-10.5

NOTES

- **Bolded** locations indicate that the monitoring location is ranked within the top 20 of the multi-constituent table (Table ES-1).
- Gray text indicates historic subarea monitoring locations that are discontinued.
- (*) Based on a single influent/effluent sampling event.

BMP Recommendations and Status Updates on 2013 Recommendations

The following area summaries provide a status update on the Expert Panel's 2013 BMP recommendations, as well as new additional recommendations for 2014. Additional details on these BMP concepts and implementation schedule will be provided in the BMP Work Plan Addendum, which will be submitted to the RWQCB in September 2014.

1. **ELV Area:** The ELV treatment BMP was installed in November of 2013 and just one sample has been collected from each of the system influent and effluent. Last year, the Expert Panel had no additional recommendations beyond completion and startup of this facility. During a field meeting on August 14, 2014 amongst NASA and the Panel, recommendations were made regarding modifications to the ELV channel to further improve performance, including: adding sandbags along the edge of the ELV channel rip rap, extending the matting over the side of the ELV channel especially where rodent holes were observed, and adding pass-through bags parallel to the ELV channel to hold matting down but allow runoff to enter the channel. This year the Expert Panel recommends continued inspection and maintenance of the ELV treatment BMP, and that stormwater samples be collected at the mid-point, between the sedimentation basin and the media filter.

   Earlier this year, based on a site visit in March 2014, the Expert Panel recommended continued inspection and maintenance of the stormwater system, in addition to robust erosion control improvements along the ELV channel. The complete list of Panel recommendations from March 2014 is as follows:

   - Improve erosion control along the earth-bottom portions of ELV channel (e.g., add rock check dams, remove soils placed on top of exposed rock, etc.). This will also reduce long-term maintenance costs for the media filter.
   - Modify influent screen in the sump if significant clogging is observed.
   - If overflows are observed, incorporate automated pump controls to trigger shutoff when settling or filtration tanks are full, and then to restart when low water level set point is reached.
   - Evaluate capacity of filter tank overflow pipe (3" diameter PVC pipe) to prevent tank overtopping (note: this would be the backup to the pump auto-shutoff).
   - Conduct additional media rinsing until low turbidity goal is met (e.g., <25 NTU or several stable readings in a row).
   - Monitoring:

- Perform turbidity sampling of settling tank effluent
    - Modify settling tank influent sample port to draw water from side of pipe rather than top (top sampler reflects decanted water)
- Clarify tank draining procedures (e.g., pump vs. gravity drain) and rules (e.g., number of post-storm days that ponding is allowed) to address vector control concerns.

NASA representatives met with Panel members at the Santa Susana Site in March and August of 2014. NASA has considered the Panel's March recommendations for BMP improvements at the ELV area, and has implemented improved erosion controls along the ELV channel (the first bulleted recommendation above), including removal of loose soils, placement of filter fabric on the soil surface, and placement of rip rap in the drainage channel. NASA will continue to consider the additional recommendations as opportunities arise during future operations and maintenance.

2. **ISRA:** The Expert Panel's 2013 recommendations were to continue ISRA performance monitoring at all locations, because the unusually dry 2012-2013 rainy season resulted in relatively few new data. The Panel also recommended adding ISRA performance monitoring locations at recently completed ISRA areas (e.g., LOX). The Panel has no new recommendations this year, and acknowledges that the ISRA performance monitoring will be phased out after final sampling during the 2014/15 season.

3. **CM-9 (Boeing):** In March of 2013, improvements were made at the CM-9 area including: erosion control blanket and straw wattles were installed along the slopes adjacent to the Area II Road; a low flow diversion inlet structure and diversion pipe with perforations; and a rock berm was installed for ponding runoff as pretreatment prior to CM-9. The inlet and diversion pipe were installed to spread road runoff along the vegetated slope south of the CM-9 media filter. In September of 2013, sediment removal was performed at CM-9. Additionally, maintenance was performed at the perforated pipeline conveying runoff from the Area II Road culvert inlet to upstream of the rip rap berm. The pipe was found to be partially clogged with leaf litter and twigs, so this material was removed and a mesh screen was placed over the culvert inlet pipe to prevent future blockages. In 2013, downstream monitoring at CM-9 was reassigned to the BMP monitoring program, under which other treatment BMPs are currently being monitored (e.g., CM-1 and B1 Media Filter). The Panel also recommended ongoing maintenance of previously installed BMPs. In addition, the Panel recommended: replacement of the filter fabric on the CM-9 weir boards when the fabric became clogged or damaged; monitoring of sediment accumulation at the inlet of the CM and at the new pretreatment rock berm; observation of the duration of water ponding upstream of the weir boards as ponding for greater than 72 hours may suggest that media or underdrain maintenance is needed; and continued performance monitoring, inspection, and maintenance in accordance with the ISRA SWPPP for the CM-9 downstream underdrain outlet (A1SW0009-A). All of these recommendations were implemented in the 2013-2014 wet season. This year the Expert Panel recommends continued implementation of these inspection and maintenance recommendations.

4. **CM-1 (NASA):** Last year the Expert Panel recommended CM-1 filter fabric inspection (to replace when the fabric became clogged or damaged), monitoring of sediment accumulation in front of weir boards (removal when accumulation nears top of first weir board), and monitoring of water ponding after storms (ponding for greater than 72 hours should be noted as it may suggest that media or underdrain maintenance is needed). These actions were completed as recommended, in accordance with the ISRA SWPPP. In September of 2013, sediment removal was performed at CM-1. This year the Expert Panel recommends continued inspection and maintenance of CM-1 in addition to potentially increasing the CM-1 capacity.

5. **Helipad (NASA):** In August of 2013 the construction of a concrete curb north of ISRA area ELV-1C, parallel to the edge of the Helipad paved area, replaced an existing row of sandbags that had been installed in the previous rainy season. At the same time, drainage from the west was modified by the installation of a lowered concrete slab, increasing flows to the Helipad from the previous monitoring season. The sandbag berms were kept in operation during the 2013-2014 season. The Panel also recommended continued operation of this temporary pumping system or equivalent runoff capture and treatment as a temporary interim control strategy until NASA was able to remove asphalt from the Helipad area during planned demolition; this recommendation still stands as the asphalt has not yet been removed. This year the Expert Panel also recommends that ponded water be pumped out of the sump area and the storm drain inlet "plug" under Helipad Road be removed when either 1) Outfall 009 is flowing or 2) the sump is overflowing onto Helipad road. The Panel also recommends continued inspection and maintenance of the helipad sandbag berms and any future BMPs.

6. **LOX Area (NASA):** Last year the Expert Panel recommended robust erosion and sediment controls during and following the ISRA soil removal to control runoff along the dirt road. The LOX ISRA excavations were completed during August of 2013. Post-ISRA erosion controls included re-contouring without backfill, installation of fiber rolls, hay bales, and/or silt fencing, and application of hydroseed mulch. Additional actions completed included placement of jute matting on the slope south of the dirt road, installation of fiber rolls along the dirt road and slope to the south, fresh gravel applied along the road, repairs to the grade control structure on the northern drainage channel at the base of LOX, and hydroseed applied to the slope. This year the Expert Panel recommends continued inspection and maintenance of the LOX BMPs.

7. **Lower Lot:** Last year the Expert Panel recommended ongoing inspection of the low-flow diversion, comprehensive erosion controls post-Building 1436 demolition, upper parking lot asphalt removal where possible, and treatment of runoff from the paved storage area near Building 1436. Building 1436 demolition is complete and construction of the detention BMP will commence after permitting is completed, likely in fall of 2014. Hydraulic monitoring of the low flow diversion, cistern, trench drain, and the 24-inch storm drain outlet was conducted between February and April 2014 to assess the quantity of flow along these drainage systems – a calibrated model has calculated that, with the proposed changes, the lower lot biofilter will treat 30-40% of the long term runoff volume from the 24-inch storm drain. The Panel also

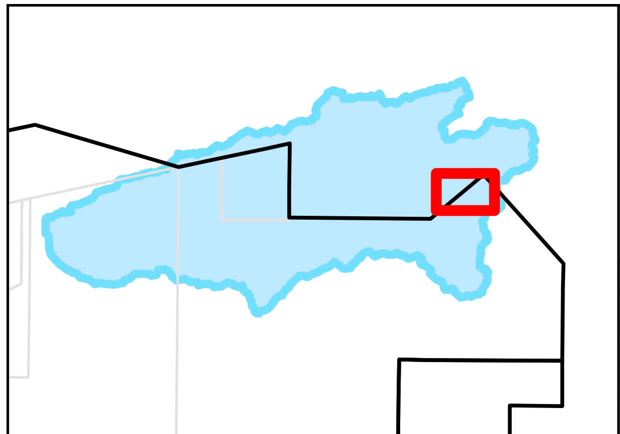
recommended maintenance of the float switch in the sedimentation basin outlet structure, stabilization of the banks that are eroding in the sedimentation basin, and modification of the concrete "pan" distribution channel in the biofilter so water is not ponded for prolonged periods. Since then, the banks of the sedimentation basin have been stabilized and holes were drilled at the inlet of the biofilter distribution channel to avoid prolonged periods of ponding. This year, the Expert Panel recommends review of the cistern pump programming to prevent future overflows of the biofilter. Additionally, given that a sample at the sediment basin outlet (LPBMP0003) could not be collected this season due to inaccessible conditions, the Panel recommends that the monitoring program be modified such that the sample at LPBMP0003 be collected from the sediment basin outlet structure using a sample pole. This should be more accessible during ponding events. The Panel also recommends that field observations be recorded when biofilter effluent samples are collected during periods of overflow, and that effluent samples be collected from the underdrain outlet within the biofilter outlet structure. Lastly, the Panel recommends continued inspection, maintenance, and monitoring of the lower lot biofilter system.

8. **B1 Media Filter:** Last year the Expert Panel recommended continued maintenance of the filter media bed, hillside erosion controls, pretreatment check dams, and curb cuts (B1BMP0004). Inspections were performed of this area as part of the ISRA SWPPP. In addition, prior to each forecasted rain event, sandbags were placed at the curb cuts to help divert storm water runoff towards the cuts (these were removed when it was not raining to prevent them from being run over and worn down). Accumulated vegetation and debris was also cleared away from within the pretreatment check dams. This year the Expert Panel recommends continued inspection and maintenance of the B1 media filter and adjacent BMPs.

9. **BMP Monitoring Program:** Based on the data collected for the BMP monitoring program to date, the only recommended change to the monitoring program for the 2014-2015 rainy season is to discontinue "planned" BMP monitoring locations where BMP installations were complete and replace with up- and downstream BMP performance monitoring locations (e.g., Bldg. 436 swales). This was initiated last season with the BMP monitoring locations EVBMP0007 (influent) and EVBMP0008 (effluent). Additionally, it is recommended that monitoring at planned BMP locations continue if the locations were ranked in the top 20 in 2013-32014, or if insufficient data exist.

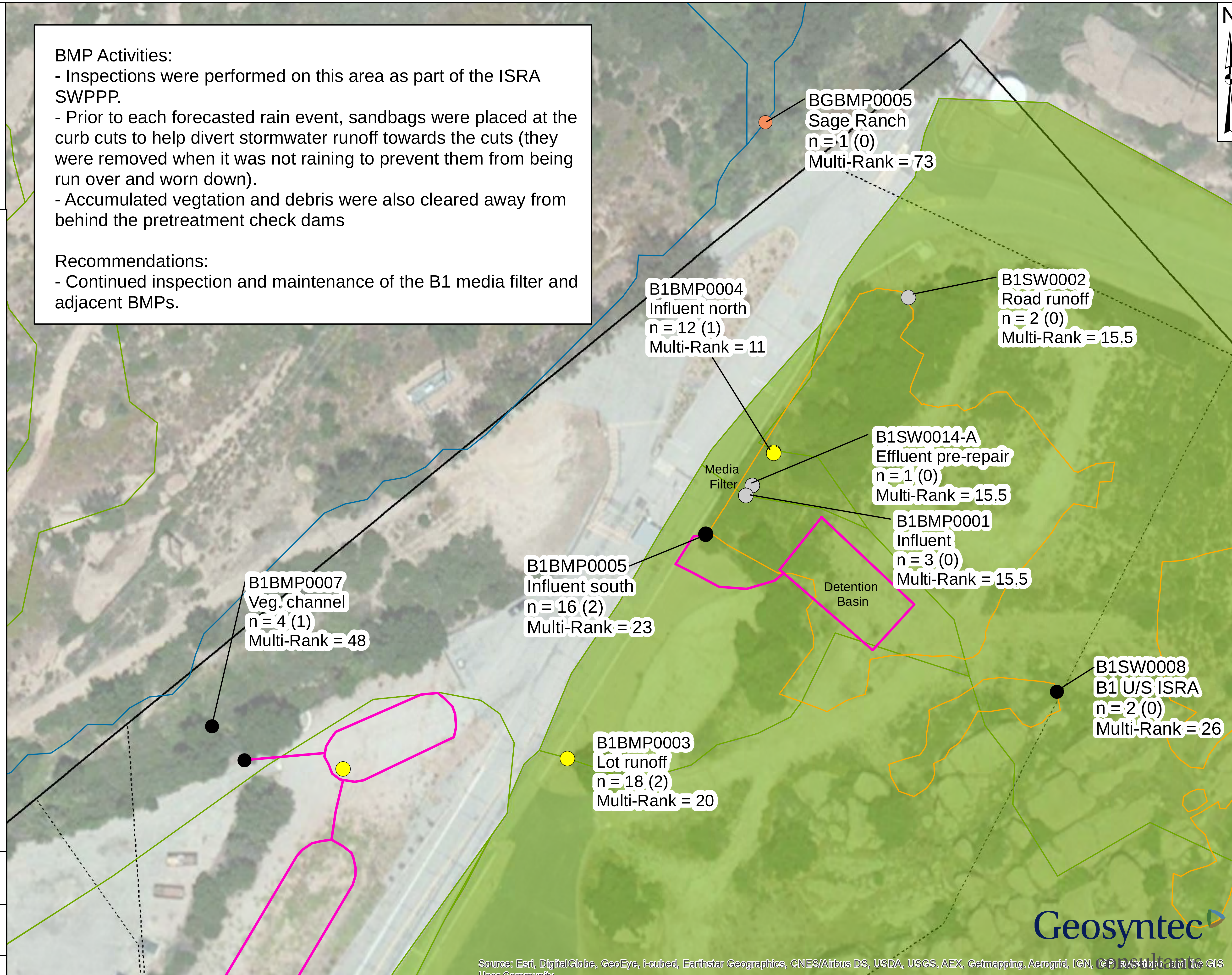
Although this analysis primarily focuses on the selection of potential stormwater treatment control locations, the Expert Panel continues to strongly recommend the rigorous application of erosion and sediment control practices and stream channel stabilization measures throughout the 008 and 009 watersheds, including and especially at areas where substantial soil removal may be planned at steep areas and/or in proximity to drainage courses. The Expert Panel also continues to recommend the stabilization of unpaved roads and the implementation of source controls (including source removal, such as through the ISRA and demolition programs). Culverts should also continue to be inspected for evidence of piping (or seepage along the outside of the culvert), not only for water quality purposes, but also for safety concerns near the roadways. Finally, it is important that routine maintenance be undertaken at all CM locations and where sedimentation basins have been constructed (e.g., above B1).

The Expert Panel believes that new and planned activities, taken together, will improve NPDES compliance at Outfalls 008 and 009 at discharges under and up to the Panel's proposed design storm flows.



BMP Activities:
- Inspections were performed on this area as part of the ISRA SWPPP.
- Prior to each forecasted rain event, sandbags were placed at the curb cuts to help divert stormwater runoff towards the cuts (they were removed when it was not raining to prevent them from being run over and worn down).
- Accumulated vegtation and debris were also cleared away from behind the pretreatment check dams

Recommendations:
- Continued inspection and maintenance of the B1 media filter and adjacent BMPs.



Legend

- Top 20 Ranked Discontinued Stormwater Monitoring Location
- Top 20 Ranked Active Stormwater Monitoring Location
- Other Location
- Background Location
- BMPs
- Drainage Area (Approx.)
- ISRA
- Property Boundary
- RFI Site Boundary
- Drainage

Location Labels:
ID
Description
n = total samples (2013-2014 samples)
Multi-Consituent Rank = x

0 35 70 140 Feet

Figure ES-1: B1 Area

Santa Susana Site
Ventura County, CA

August 2014

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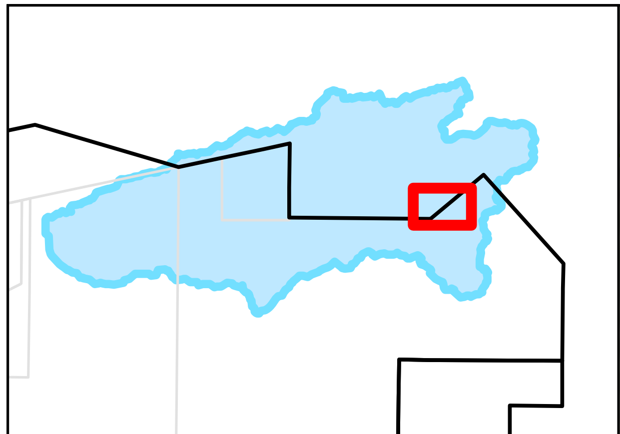

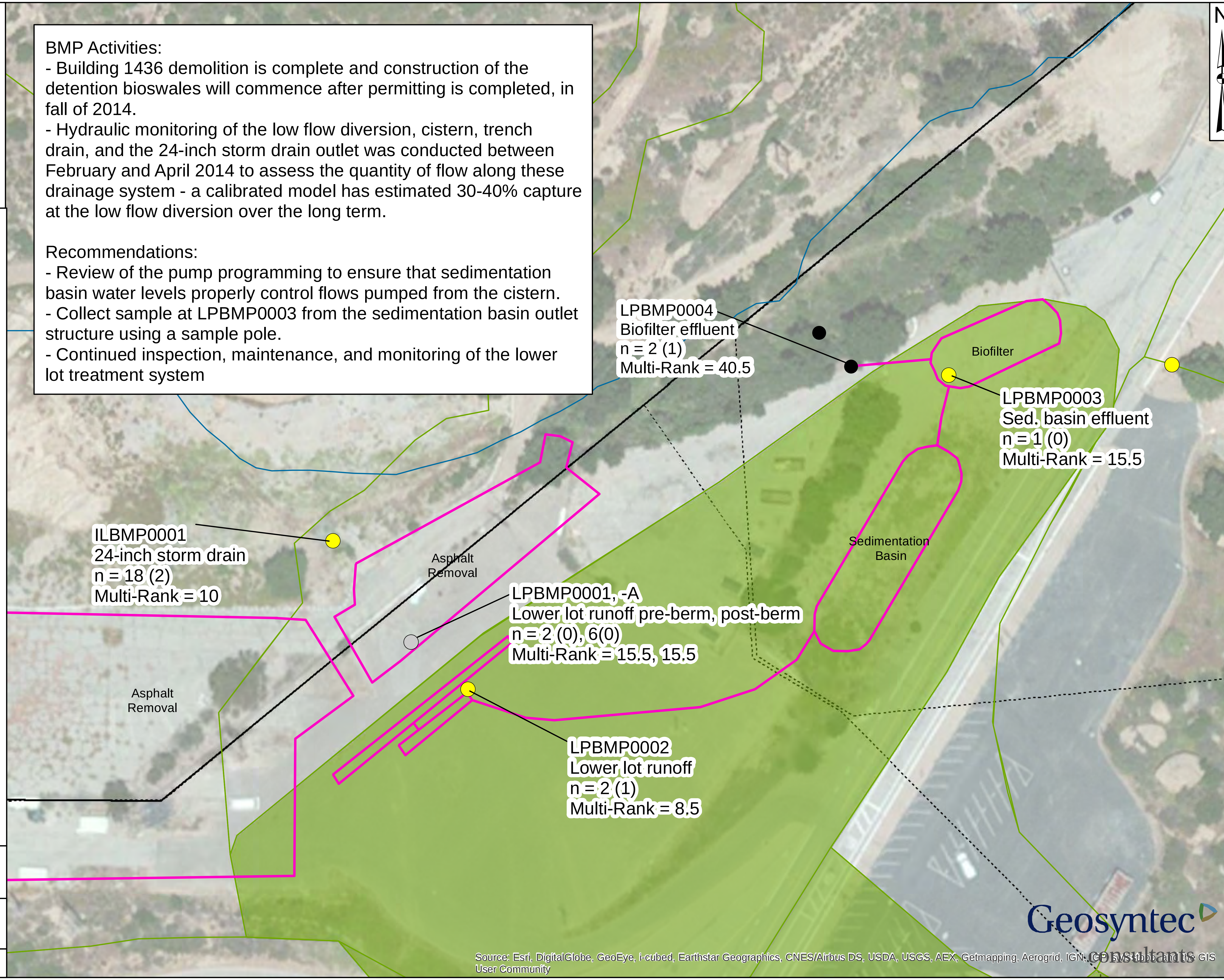

BMP Activities:
- Building 1436 demolition is complete and construction of the detention bioswales will commence after permitting is completed, in fall of 2014.
- Hydraulic monitoring of the low flow diversion, cistern, trench drain, and the 24-inch storm drain outlet was conducted between February and April 2014 to assess the quantity of flow along these drainage system - a calibrated model has estimated 30-40% capture at the low flow diversion over the long term.

Recommendations:
- Review of the pump programming to ensure that sedimentation basin water levels properly control flows pumped from the cistern.
- Collect sample at LPBMP0003 from the sedimentation basin outlet structure using a sample pole.
- Continued inspection, maintenance, and monitoring of the lower lot treatment system

Legend

- Top 20 Ranked Discontinued Stormwater Monitoring Location
- Top 20 Ranked Active Stormwater Monitoring Location
- Other Location
- BMPs
- Drainage Area (Approx.)
- ISRA Areas
- Property Boundary
- RFI Site Boundary
- Drainage

Location Labels:
ID
Description
n = total samples (2013-2014 samples)
Multi-Consituent Rank = x

0 35 70 140
Feet

Figure ES-2: Lower Lot

Santa Susana Site
Ventura County, CA

August 2014

Date: 8/27/2014, Path: P:\GIS\Projects\Boeing\SSFL\Projects\Projects-OldArcMap\2014 Priority Sites-LowerLot_final.mxd, User: MMOtto