

**Edwards Aquifer Habitat Conservation Plan
Expanded Water Quality Monitoring Report**

January 2017

EXECUTIVE SUMMARY

The Edwards Aquifer Habitat Conservation Plan (EAHCP) Expanded Water Quality Monitoring Program was developed in accordance with the directives of the EAHCP to identify and assess potential impairments to water quality within the Comal River and headwaters of the San Marcos River systems. The expanded EAHCP sampling requirements are described in the *2016 Edwards Aquifer Authority Water Quality Monitoring Program Work Plan for Comal Springs and San Marcos* (Edwards Aquifer Habitat Conservation Plan [EAHCP] Work Plan) (EAA 2015). The program includes surface water (base flow) sampling, sediment sampling, real-time instrument water quality monitoring, stormwater sampling and passive diffusion sampling. The EAA contracted with SWCA Environmental Consultants (SWCA) to execute the expanded sampling program in 2014, 2015, and 2016, with the exception of RTI water quality monitoring, which is still conducted by the EAA. A groundwater sampling element was also included in the sampling program, which was to be conducted during periods of extremely low spring flow from Comal and San Marcos springs. Spring flow rates remained above minimum flow rates of 30 cubic feet per second (cfs) at Comal Springs and above 50 cfs at San Marcos Springs during 2016 and, therefore, the groundwater sampling element was not conducted.

The Comal Springs complex has five sample locations along the Comal system from the upstream end of Landa Lake (where Blieders Creek empties into the headwaters of Landa Lake) to the south end of the Comal River, upstream of the confluence with the Guadalupe River. In the San Marcos system, samples are collected at seven locations. Sample sites begin at Sink Creek upstream of the headwaters of Spring Lake on the north end of the system and end downstream of Capes Dam on the south end of the system.

Surface water (base flow) and stormwater samples were collected twice annually from each spring complex. Sediment samples were collected once annually from each spring complex. Passive diffusion samplers were deployed in each spring complex for two week periods, six times per year.

There were a limited number of detections above comparative standards, which is indicative of generally high water quality. Bis(2-ethylhexyl) phthalate was detected above the Texas Risk Reduction Program Protective Concentration Level (PCL) in several surface and stormwater samples in 2016 but may be a laboratory or sampling equipment artifact. Total polycyclic aromatic hydrocarbons (PAHs) were detected above the Probable Effect Concentration (PEC) for sediment samples collected in each year of the sampling program at two locations in the San Marcos Springs complex. Lead was detected above the PEC at one sample location (HSM340- City Park and Hopkins Street) in the San Marcos Springs complex in 2014 and 2016.

This page intentionally left blank.

TABLE OF CONTENTS

Executive Summary	i
1.0 Introduction	1
1.1 Surface Water (Base Flow) Samples.....	2
1.2 Sediment Samples	6
1.3 Stormwater Samples.....	6
1.4 Surface Water Passive Sampling.....	7
2.0 Sample Location Detail	7
3.0 Modifications of Activities Due To Drought	16
4.0 Affect on Covered Species	16
5.0 Logistics	16
5.1 Surface Water (Base Flow) Sampling Program	16
5.2 Sediment Sampling Program.....	17
5.3 Stormwater Program	17
5.4 Surface Water Passive Sampling Program.....	17
6.0 Sample Collection Methodology	17
6.1 Surface Water (Base Flow) Sampling Program	17
6.2 Sediment Sampling Program.....	18
6.3 Stormwater Sampling Program	18
6.4 Surface Water Passive Samplers	19
7.0 Sample Results	21
7.1 Comal Springs Sample Results	21
7.1.1 Comal Springs Surface Water / Base Flow Sampling	22
7.1.2 Comal Springs Sediment Sampling	27
7.1.3 Comal Springs Stormwater Sampling.....	36
7.1.4 Comal Springs Surface Water Passive Sampling	44
7.2 San Marcos Springs Sample Results.....	50
7.2.1 San Marcos Springs Surface Water / Base Flow Sampling.....	50
7.2.2 San Marcos Springs Sediment Sampling.....	56
7.2.3 San Marcos Springs Stormwater Sampling	76
7.2.4 San Marcos Springs Surface Water Passive Sampling.....	86
8.0 Summary of Results	95
9.0 Data Quality Objectives	97
10.0 Definitions	98
11.0 Acknowledgements	103
12.0 References	104

LIST OF FIGURES

Figure 1. EAHCP expanded water quality monitoring program, Comal Springs and River.....	4
Figure 2. EAHCP expanded water quality monitoring program, San Marcos Springs and River.....	5
Figure 3. EAHCP Comal Springs detailed map indicating sample locations 110, 210, 310, 410, 120, 320 and 420.....	8
Figure 4. EAHCP Comal Springs detailed map indicating sample locations 130, 330 and 430.	9
Figure 5. EAHCP Comal Springs detailed map indicating sample locations 140, 240, 340, 440, 250, 160, 260, 360 and 460.....	10
Figure 6. EAHCP Comal Springs detailed map indicating sample location 270.	11
Figure 7. EAHCP San Marcos Springs detailed map indicating sample locations 110, 210, 310, 410, 120, 320 and 420.....	12
Figure 8. EAHCP San Marcos Springs detailed map indicating sample locations 130, 230, 330, 430, 231, 140, 240, 340 and 440.	13
Figure 9. EAHCP San Marcos Springs detailed map indicating sample locations 150, 250, 350 and 450.....	14
Figure 10. EAHCP San Marcos Springs detailed indicating map sample locations 160, 260, 360, 460, 170, 270, 370 and 470.....	15
Figure 11. PDS deployment device prior to installation at site HSM440.	21
Figure 12. Bis(2-Ethylhexyl) phthalate (DEHP) in Comal Springs Complex Surface Water Samples Compared to the Protective Concentration Level (PCL).....	24
Figure 13. Benzo(a)anthracene in Comal Springs Complex Sediments Compared to the Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values	30
Figure 14. Benzo(a)pyrene in Comal Springs Complex Sediments Compared to the Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values.....	30
Figure 15. Chrysene Detections in Comal Springs Complex Sediments Compared to the Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values	31
Figure 16. Fluoranthene Detections in Comal Springs Complex Sediments Compared to the Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values	31
Figure 17. Pyrene Detections in Comal Springs Complex Sediments Compared to the Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values	32
Figure 18. Total polycyclic aromatic hydrocarbons (PAH) in Comal Springs Complex Sediments Compared to the Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values	32
Figure 19. Antimony in Comal Springs Complex Sediments Compared to Texas-Specific Background Concentration (TSBC) and Effects Range Low (ERL)	34
Figure 20. Selenium in Comal Springs Complex Sediments Compared to Texas-Specific Background Concentration (TSBC) and Possible Bioaccumulation Toxic Values	34

Figure 21. Stormwater Samples – April 2016 Bacteria Counts in Relation to Stream Discharge and Specific Conductivity – Comal Springs Complex	38
Figure 22. Stormwater Samples – September 2016 Bacteria Counts in Relation to Stream Discharge and Specific Conductivity – Comal Springs Complex	38
Figure 23. Bis(2-ethylhexyl) Phthalate (DEHP) in Comal Springs Complex Stormwater Samples September 2016 Compared to Protective Concentration Level (PCL)	40
Figure 24. Passive Diffusion Sampling – February 2016 Stream Discharge and Specific Conductivity – Comal Springs Complex	45
Figure 25. Passive Diffusion Sampling – April 2016 Stream Discharge and Specific Conductivity – Comal Springs Complex	45
Figure 26. Passive Diffusion Sampling – June 2016 Stream Discharge and Specific Conductivity – Comal Springs Complex	46
Figure 27. Passive Diffusion Sampling – August 2016 Stream Discharge and Specific Conductivity – Comal Springs Complex	46
Figure 28. Passive Diffusion Sampling – October 2016 Stream Discharge and Specific Conductivity – Comal Springs Complex	47
Figure 29. Passive Diffusion Sampling – December 2016 Stream Discharge and Specific Conductivity – Comal Springs Complex	47
Figure 30. Bis(2-ethylhexyl) Phthalate (DEHP) in San Marcos Springs Complex Surface Water Compared to Protective Concentration Level (PCL)	53
Figure 31. San Marcos Springs Sediment Anthracene Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values.....	61
Figure 32. San Marcos Springs Sediment Benzo(a)anthracene Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values	61
Figure 33. San Marcos Springs Sediment Benzo(a)pyrene Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values.....	62
Figure 34. San Marcos Springs Sediment Chrysene Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values	62
Figure 35. San Marcos Springs Sediment Fluoranthene Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values.....	63
Figure 36. San Marcos Springs Sediment Fluorene Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values	63
Figure 37. San Marcos Springs Sediment Phenanthrene Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values.....	64
Figure 38. San Marcos Springs Sediment Pyrene Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values	64
Figure 39. San Marcos Springs Sediment Polycyclic Aromatic Hydrocarbons (PAH) Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values	65
Figure 40. San Marcos Springs Sediment 4,4-DDD Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values	66
Figure 41. San Marcos Springs Sediment 4,4-DDE Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values	67

Figure 42. San Marcos Springs Sediment Aroclor-1260 and Total PCB Detections Compared to Lower Effects Level (LEL), Severe Effects Level (SEL), Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values	68
Figure 43. San Marcos Springs Sediment Antimony Detections Compared to Texas-specific Background Concentration (TSBC) and Effects Range Low (ERL) Values	73
Figure 44. San Marcos Springs Sediment Cadmium Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values	73
Figure 45. San Marcos Springs Sediment Lead Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values	74
Figure 46. San Marcos Springs Sediment Manganese Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values.....	74
Figure 47. San Marcos Springs Sediment Selenium Detections Compared to Texas-specific Soil Background Concentration (TSBC) and Possible Bioaccumulation Level	75
Figure 48. San Marcos Springs Sediment Zinc Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values	75
Figure 49. Stormwater Samples – March 2016 Bacteria Counts in Relation to Stream Discharge and Specific Conductivity – San Marcos Springs Complex.....	78
Figure 50. Stormwater Samples – November 2016 Bacteria Counts in Relation to Stream Discharge and Specific Conductivity – San Marcos Springs Complex.....	78
Figure 51. March 2016 San Marcos Springs Stormwater Bis(2-ethylhexyl) Phthalate (DEHP) Detections Compared to Protective Concentration Level (PCL).....	81
Figure 52. November 2016 San Marcos Springs Stormwater Bis(2-ethylhexyl) Phthalate (DEHP) Detections Compared to Protective Concentration Level (PCL).....	82
Figure 53. Passive Diffusion Sampling – February 2016 Stream Discharge and Specific Conductivity – San Marcos Springs Complex.....	87
Figure 54. Passive Diffusion Sampling – April 2016 Stream Discharge and Specific Conductivity – San Marcos Springs Complex.....	87
Figure 55. Passive Diffusion Sampling – June 2016 Stream Discharge and Specific Conductivity – San Marcos Springs Complex.....	88
Figure 56. Passive Diffusion Sampling – August 2016 Stream Discharge and Specific Conductivity – San Marcos Springs Complex.....	88
Figure 57. Passive Diffusion Sampling – October 2016 Stream Discharge and Specific Conductivity – San Marcos Springs Complex.....	89
Figure 58. Passive Diffusion Sampling – December 2016 Stream Discharge and Specific Conductivity – San Marcos Springs Complex.....	89

LIST OF TABLES

Table 1.	Listing of Analytical Parameters by Sample Type	3
Table 2.	Surface Water Samples – Bacteria Counts - Comal Springs Complex.....	22
Table 3.	Surface Water Samples – Semi-volatile organic compound detections - Comal Springs Complex.....	23
Table 4.	Surface Water Samples – Metal detections - Comal Springs Complex.....	25
Table 5.	Surface Water Samples – Nitrate Detections - Comal Springs Complex	26
Table 6.	Surface Water Samples – Caffeine Detections - Comal Springs Complex.....	27
Table 7.	Sediment Samples – Volatile Organic Compound Detections - Comal Springs Complex.....	28
Table 8.	Sediment Samples – Semi-volatile Organic Compound Detections - Comal Springs Complex.....	29
Table 9.	Sediment Samples – Metal Detections – Comal Springs Complex	35
Table 10.	Stormwater Samples – Bacteria Counts – Comal Springs Complex	37
Table 11.	Stormwater Samples – Semi-volatile Organic Compound Detections – Comal Springs Complex.....	39
Table 12.	Stormwater Samples – Herbicide Detections – Comal Springs Complex	41
Table 13.	Stormwater Samples – Nitrate Detections – Comal Springs Complex.....	42
Table 14.	Stormwater Samples – Caffeine Detections – Comal Springs Complex	43
Table 15.	Passive Diffusion Samples – Comal Springs Complex	48
Table 16.	Surface Water Samples – Bacteria Counts – San Marcos Springs Complex.....	51
Table 17.	Surface Water Samples – Semi-volatile Organic Compound Detections – San Marcos Springs Complex.....	52
Table 18.	Surface Water Samples – Metal Detections – San Marcos Springs Complex.....	54
Table 19.	Surface Water Samples – Nitrate Detections – San Marcos Springs Complex	55
Table 20.	Surface Water Samples – Caffeine Detections – San Marcos Springs Complex.....	56
Table 21.	Sediment Samples – Volatile Organic Compound Detections – San Marcos Springs Complex.....	57
Table 22.	Sediment Samples – Semi-volatile Organic Compound Detections - San Marcos Springs Complex.....	59
Table 23.	Sediment Samples – Pesticide Detections - San Marcos Springs Complex	66
Table 24.	Sediment Samples – Metal Detections - San Marcos Springs Complex.....	71
Table 25.	Stormwater Samples – Bacteria Counts - San Marcos Springs Complex.....	76
Table 26.	Stormwater Samples – Volatile Organic Compound Detections - San Marcos Springs Complex.....	79
Table 27.	Stormwater Samples – Bis(2-Ethylhexyl) Phthalate (DEHP) Detections - San Marcos Springs Complex.....	80
Table 28.	Stormwater Samples – Nitrate Detections - San Marcos Springs Complex	83
Table 29.	Stormwater Samples – Caffeine Detections - San Marcos Springs Complex.....	85
Table 30.	Passive Diffusion – San Marcos Springs Complex – SVOC and VOC Detections.....	90
Table 31.	Passive Diffusion – San Marcos Springs Complex – Organochlorine Pesticide Detections	93
Table 32.	Compounds detected above Protective Concentration Levels (PCL) or Probable Effect Concentrations (PEC).....	95

Table 33. Overview of the Approved Scope of Work 2017	97
---	----

APPENDICES

Appendix A – Edwards Aquifer Habitat Conservation Plan (EAHCP) Work Plan

Appendix B – Spring Hydrographs and Stormwater Quality Graphs

Appendix C – Discussion of Deviations

Appendix D – Edwards Aquifer Authority Groundwater Quality Monitoring Plan

Appendix E – Photographic Log

Appendix F – Record of Stormwater Sampling

Appendix G – Analytical Results

Appendix H – Analytical Data Validation Discussion

Appendix I – Sample Record

1.0 INTRODUCTION

The Edwards Aquifer Authority (EAA) and its predecessor agency, the Edwards Underground Water District (EUWD), in cooperation with the U.S. Geological Survey (USGS) and the Texas Water Development Board (TWDB) have maintained a water quality sampling program since 1968. Analyses of these data have been used by the EAA to assess aquifer water quality. This routine or historical sampling program involves the analyses of a broad spectrum of parameters in wells, springs, and streams across the region. The EAA's existing sampling program was expanded with the adoption of the Edwards Aquifer Habitat Conservation Program (EAHCP) to include collection of additional samples and sample types in the immediate vicinity of Comal and San Marcos Springs. The expanded water quality sampling program was developed in accordance with the directives of the EAHCP to identify and assess potential impairments to water quality within the Comal River and headwaters of the San Marcos River systems. The expanded EAHCP sampling requirements are described in the *2016 Edwards Aquifer Authority Water Quality Monitoring Program Work Plan for Comal Springs and San Marcos* (Edwards Aquifer Habitat Conservation Plan [EAHCP] Work Plan) (EAA 2015), which is included in Appendix A of this document.

Based on the requirements of the EAHCP Work Plan, the expanded sampling program requires the collection of the following sample types:

1. Surface water (base flow) samples
2. Sediment samples
3. Real-time instrument (RTI) water quality monitoring
4. Stormwater sampling
5. Passive Diffusion Samplers (PDS)

The EAA contracted with SWCA Environmental Consultants (SWCA) to execute the expanded sampling program in 2014, 2015, and 2016, with the exception of RTI water quality monitoring, which is still conducted by the EAA. Surface water quality monitoring was enhanced beginning in 2014 by the addition of PDS for trace organic compounds analyses, conducted by SWCA. A groundwater sampling element was also included in the sampling program, which was to be conducted during periods of extremely low spring flow from Comal and San Marcos springs. The groundwater sampling element of the sampling program was only to be conducted if spring flow rates dropped below 30 cubic feet per second (cfs) at Comal Springs or below 50 cfs at San Marcos Springs. Spring flow rates remained above 30 cfs at Comal Springs and above 50 cfs at San Marcos Springs during 2016 and, therefore, the groundwater sampling element was not conducted. Hydrographs of spring flow are presented in Appendix B.

Prior to the implementation of the EAHCP, the historical sampling program had not specifically addressed surface water quality, sediment quality, real-time changes for basic water quality parameters, or stormwater impacts along the Comal River or headwaters of the San Marcos River. Therefore, this expanded sampling program was designed to gather data specific to all of the new parameters. This report presents the surface water, sediment, stormwater and PDS data collected by SWCA in 2016. The data set represents the fourth year of the program and is not sufficient to establish any long-term trends or patterns.

For purposes of this report, the Comal River may also be referred to as Comal Springs or Comal Springs complex, and the San Marcos River headwaters may also be referred to as San Marcos Springs or San

Marcos Springs complex. An overview of surface water, sediment, and stormwater sample locations for Comal and San Marcos springs are shown in Figures 1 and 2. Figures 3–6 provide detailed location data for sample points at the Comal Springs complex. Figures 7–10 provide detailed locations for the sample points at the San Marcos Springs complex.

1.1 Surface Water (Base Flow) Samples

Surface water (base flow) samples are collected twice annually at each spring complex. The Comal Springs complex has five sample locations along the Comal system from the upstream end of Landa Lake (where Blieders Creek empties into the headwaters of Landa Lake) to the south end of the Comal River, upstream of the confluence with the Guadalupe River. In the San Marcos system, surface water samples are collected at seven locations. Sample sites begin at Sink Creek upstream of the headwaters of Spring Lake on the north end of the system and end downstream of Capes Dam on the south end of the system.

Surface water sample locations are designed to provide water quality data for the majority of the surface waters of each spring system and river reach of concern. Sample sites in each system are located upstream and downstream of springflow or other potential surface water inputs (such as Dry Comal Creek or Purgatory Creek). Surface water samples are analyzed for a broad spectrum of parameters as outlined in Table 1. Surface water samples were collected in March and September 2016.

Regulatory standards for surface water quality vary depending upon type of use. For this report, surface water (base flow) results are compared to drinking water quality standards (30 Texas Administrative Code [TAC] Chapter 290, Subchapter F) for detected constituents of concern. These guidelines were selected for use since in general they provide the most stringent quality standards. For detections of interest that do not have an established maximum contaminant level (MCL) under 30 TAC 290, the Texas Risk Reduction Program (TRRP) from 30 TAC 350 was substituted. The TRRP standards used are the Tier I, residential standards and are referred to as protective concentration levels (PCLs). Pharmaceutical and Personal Care Products (PPCP) including caffeine can be chemicals of concern because they can indicate the presence of contamination from anthropogenic sources including wastewater discharge (U.S. Environmental Protection Agency [EPA] 2012). Currently, there are no regulatory standards to compare caffeine detections against, but results are listed in this report to provide an indication of potential anthropogenic impacts. Additionally, bacteriological results were compared with Texas Surface Water Quality Standards for primary recreational waters (30 TAC 307.7). The 30 TAC 307.7 standards are typically applied to waters affected by anthropogenic sources and are used here solely to provide a reference level for bacterial counts. Other guidelines may be more useful or appropriate for particular research; however, for the scope of this report these standards provide an appropriate and applicable guideline with regard to water quality.

Table 1. Listing of Analytical Parameters by Sample Type

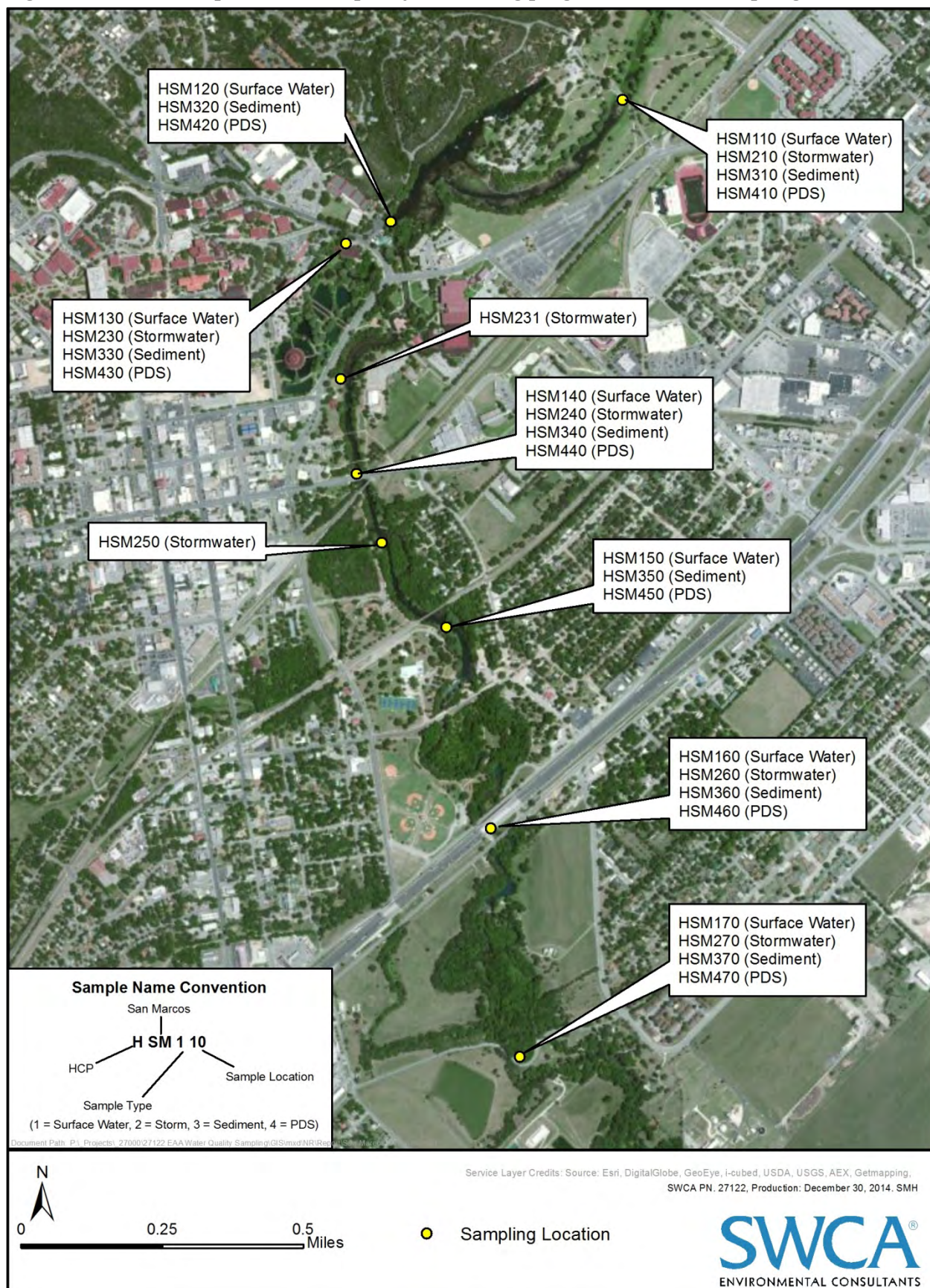
Analytical Parameter	Surface Water (Base Flow) Samples	Stormwater Samples	Sediment Samples	PDS
Volatile Organic Compounds (VOCs)	Yes	Yes	Yes	Yes*
Semi-volatile Organic Compounds (SVOCs)	Yes	Yes	Yes	Yes*
Organochlorine Pesticides	Yes	Yes	Yes	Yes*
Polychlorinated Biphenyls (PCBs)	Yes	Yes	Yes	No
Organophosphorous Pesticides	Yes	Yes	Yes	No
Herbicides	Yes	Yes	Yes	No
Metals (Al, Sb, As, Ba, Be, Cd, Cr [total], Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, Tl, and Zn)	Yes	Yes	Yes	No
General water quality parameters (GWQP), total alkalinity (as CaCO ₃), bicarbonate alkalinity (as CaCO ₃), carbonate alkalinity (as CaCO ₃); Cl, Br, NO ₃ , SO ₄ , F, pH, total dissolved solids (TDS), total suspended solids (TSS), Ca, Mg, Na, K, Si, Sr, CO ₃ ,	Yes	Yes	No TDS or TSS	No
Phosphorus (total)	Yes	Yes	Yes	No
Total Organic Carbon (TOC),	Yes	Yes	Yes	No
Dissolved Organic Carbon (DOC)	Yes	Yes	No	No
Total Kjeldahl Nitrogen (TKN)	Yes	Yes	No	No
Bacteria (E. coli)	Yes	Yes	No	No
Field Parameters (DO, pH, Conductivity, Turbidity, Temperature)	Yes	Yes	No	No
Caffeine	Yes	Yes	No	No

* Passive diffusion samplers (PDS) samplers are analyzed for a modified set of VOCs, SVOCs, and organochlorine pesticides

Figure 1. EAHCP expanded water quality monitoring program, Comal Springs and River.



Figure 2. EAHCP expanded water quality monitoring program, San Marcos Springs and River.



1.2 Sediment Samples

Collection of sediment samples within each spring system was included in the program to help ascertain potential effects on listed species via direct or indirect exposure to sediments. Designated sediment sample locations were coincident with surface water (base flow) sample locations at each spring complex. Specifically, five sediment samples were collected from the Comal Springs area and seven locations were sampled within the San Marcos area. In the first two years of the program, sediment samples were collected from the sediment surface to approximately 18 inches below the surface. The EAHCP Work Plan reduced the sampling depth to three inches below the surface beginning in 2015. Samples were analyzed for the parameters listed in Table 1.

SWCA collected sediment samples as close to each associated surface water sample location as possible. However, for some of the samples, collection points were moved slightly to find adequate sediment or to avoid rocky substrates that prevented collection of adequate sample volume. Appendix C of this report discusses sample locations where any significant deviations from this approach occurred.

Analytical results for sediment samples are compared to the sediment quality guidelines published in *Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems* (MacDonald, Ingersoll, and Berger 2000). These guidelines are based on determination of probable sediment toxicity in freshwater ecosystems and provide a numerical sediment quality guideline for 28 chemicals of concern. The guidance provides two basic standards for comparison: 1) threshold effect concentration (TEC), and 2) probable effect concentration (PEC). Analytical results with a concentration below the TEC are predicted to be non-toxic (on sediment-dwelling organisms), whereas results with a concentration above the PEC are indicated as having a probable toxic effect on sediment-dwelling organisms. Detected compounds with concentrations between the TEC and PEC are considered equally likely to be toxic or non-toxic. Additional guidelines for chemicals of concern that were not included in MacDonald et al. (2000) were taken from *Conducting Ecological Risk Assessments at Remediation Sites in Texas* developed by the Texas Commission on Environmental Quality ([TCEQ] 2014a) and *Guidance for Assessing and Reporting Surface Water Quality in Texas* (TCEQ 2012). While numerous other guidelines for sediment quality exist, these guidelines provide a good reference for the scope of the current investigation. Future researchers may find other guidelines more specific to particular concerns or interests.

1.3 Stormwater Samples

SWCA conducted stormwater sampling at five Comal Springs locations and at seven San Marcos Springs locations. The EAA adopted stormwater sample collection as part of the expanded water quality monitoring effort to assess potential contaminants that may be present in surface water runoff generated by storm events. The stormwater sampling effort was designed to assess what changes in water quality occur within each surface water system during a storm event. SWCA collected storm samples in association with various surface water inputs along each spring complex within the study area. Appendix C of this report discusses details of each stormwater sample location and any deviations from the EAHCP Work Plan. Stormwater samples were analyzed for the same parameters as surface water (base flow) samples as outlined in Table 1.

SWCA collected stormwater samples at three points across the storm hydrograph for each stormwater sampling site. Sample collection was targeted for the rising limb, peak, and receding limb of the storm hydrograph. Timing for sample collection was generally determined using the RTI system's conductivity

and turbidity parameters rather than the flow measurements from the USGS streamflow gauges. The USGS gauges are only updated on an hourly basis, whereas data from the RTIs was available on 15-minute intervals and provided more timely information. Automated sample collection equipment was not utilized for stormwater sample collection due to sample volume, preservation, and analysis limitations. Therefore, sampling was conducted manually. Each spring group was sampled twice for stormwater events during calendar year 2016 per the EAHCP Work Plan.

As previously mentioned, standards for surface water quality vary dependent upon type of use. For this report, stormwater results are compared to drinking water quality standards (30 TAC 290, Subchapter F) for detected chemicals of concern. These guidelines were selected for use since, in general, they provide the most stringent quality standards. For detections of interest that do not have an established MCL under 30 TAC 290, the TRRP PCLs from 30 TAC 350 were substituted. The TRRP standards used are the Tier I, residential standards. Currently, there are no regulatory standards to compare caffeine detections against, but results are listed in this report to provide an indication of anthropogenic contamination. Bacterial counts were compared with Texas Surface Water Quality Standards (30 TAC 307). Other guidelines may be more useful or appropriate for particular research; however, for the scope of this report these standards provide an appropriate and applicable guideline with regard to water quality.

1.4 Surface Water Passive Sampling

SWCA deployed Amplified Geochemical Imaging (AGI) LLC, PDSs in both spring complexes to measure trace organic constituents. Samplers consisted of a sorbent solid phase material that concentrates compounds from the environment. Following collection, the analytes of interest were eluted and analyzed by gas chromatography coupled with a mass spectrometry detector (GC-MS). The increased contact time associated with long-term deployment of the collection material allowed the analytes to be greatly concentrated beyond what is typically found in water samples. Therefore, the PDS provides greater sensitivity to trace level constituents. Analyzed parameters can be found in Table 1.

SWCA deployed PDSs to each of the 12 sample sites for two-week periods in February, April, June, August, October, and December 2016. Sample points coincided with surface water collection points unless prevented by field conditions, and any alterations are discussed in Appendix C.

2.0 SAMPLE LOCATION DETAIL

Details of individual sample locations are provided in the following figures. Figures 3–6 show sample location details for the Comal Springs area. Figures 7–10 provide sample location details for the San Marcos Springs area.

Figure 3. EAHCP Comal Springs detailed map indicating sample locations 110, 210, 310, 410, 120, 320 and 420.



Figure 4. EAHCP Comal Springs detailed map indicating sample locations 130, 330 and 430.

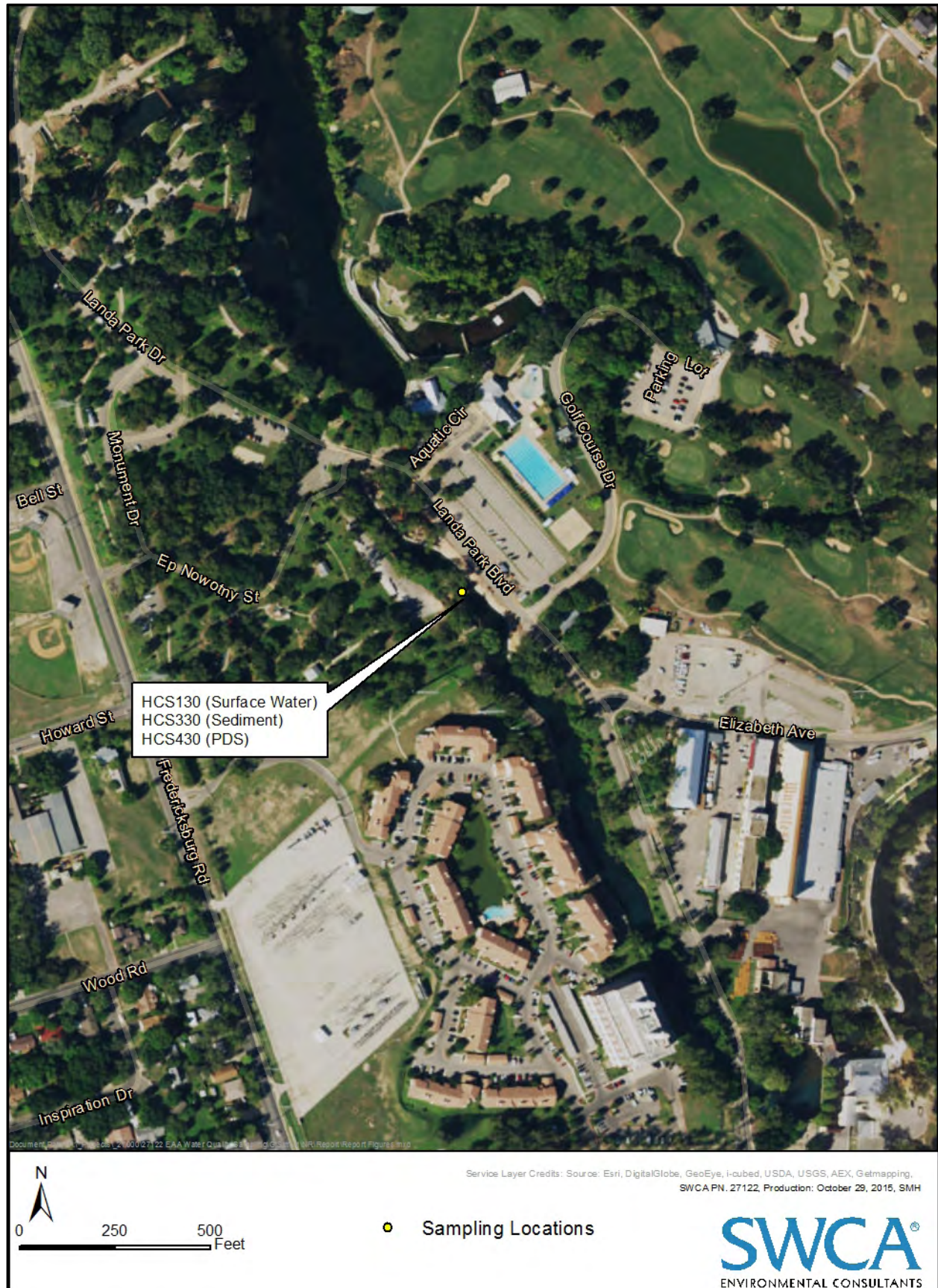


Figure 5. EAHCP Comal Springs detailed map indicating sample locations 140, 240, 340, 440, 250, 160, 260, 360 and 460.



Figure 6. EAHCP Comal Springs detailed map indicating sample location 270.

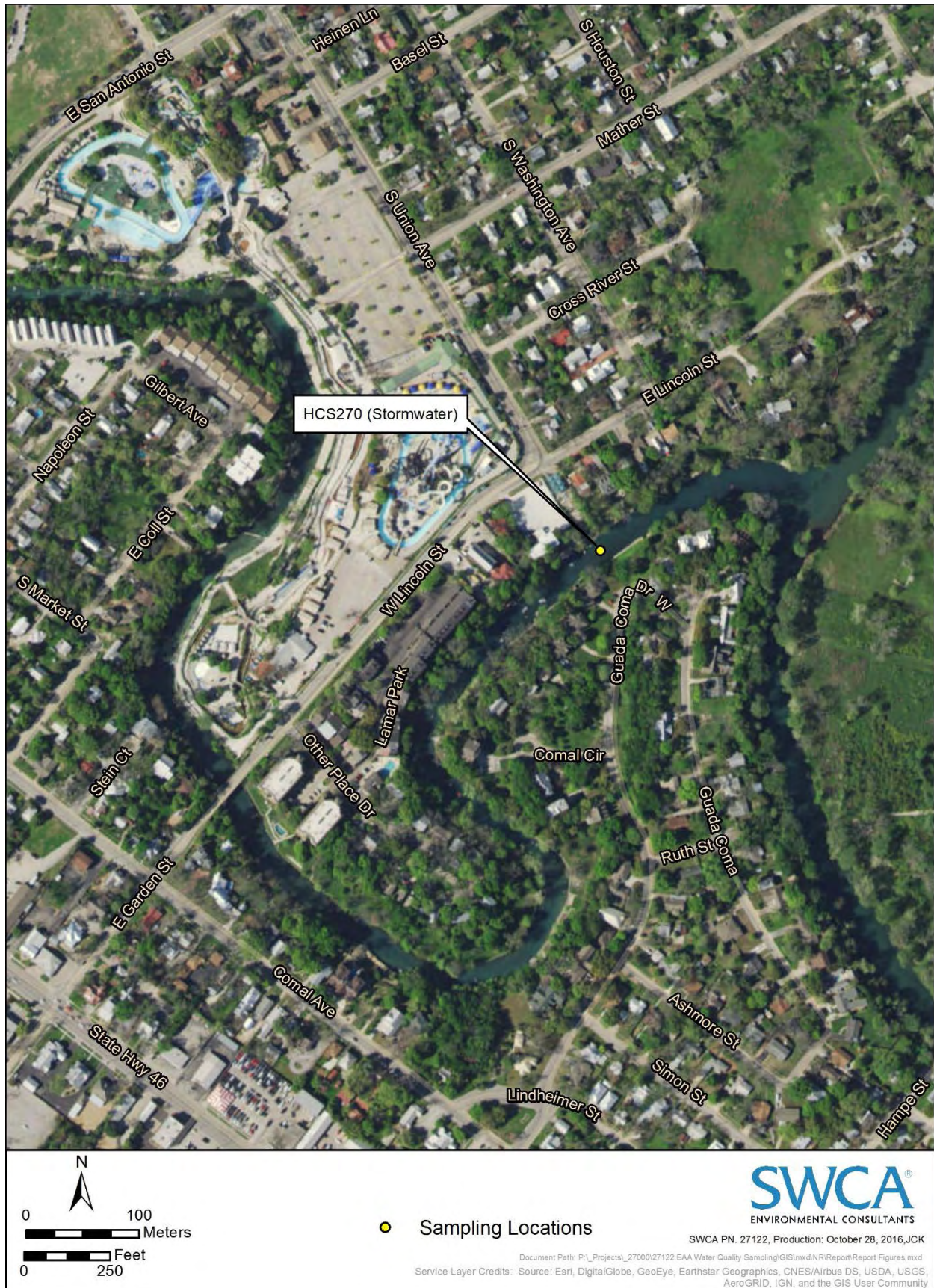


Figure 7. EAHCP San Marcos Springs detailed map indicating sample locations 110, 210, 310, 410, 120, 320 and 420.



Figure 8. EAHCP San Marcos Springs detailed map indicating sample locations 130, 230, 330, 430, 231, 140, 240, 340 and 440.

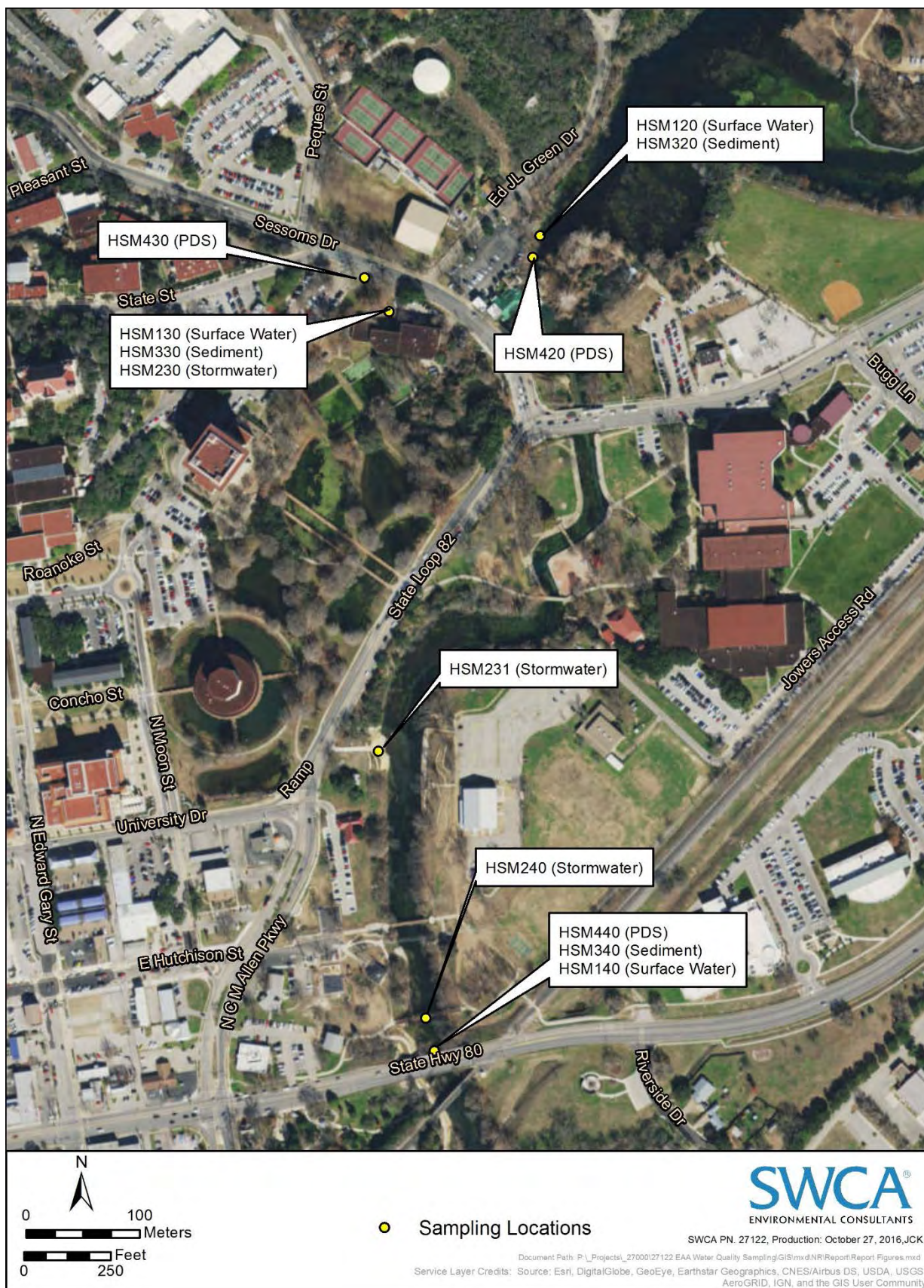


Figure 9. EAHCP San Marcos Springs detailed map indicating sample locations 150, 250, 350 and 450.



Figure 10. EAHCP San Marcos Springs detailed indicating map sample locations 160, 260, 360, 460, 170, 270, 370 and 470.



3.0 MODIFICATIONS OF ACTIVITIES DUE TO DROUGHT

Sampling activities were impacted by the sporadic occurrence of qualifying rainfall events within the project area. Significant rainfall occurred during the first half of 2016. Rainfall for the year was average, however, rainfall was very sparse from July through much of October. Rain events in the second half of 2016 were generally scattered in nature and often too small in magnitude to generate sufficient runoff to sample.

Also, due to abundant rainfall in the spring of 2016, flow rates did not drop below 30 cfs at Comal Springs, or below 50 cfs at San Marcos Springs. No extreme low-flow sampling was initiated at water wells (Sections 6.4.3.3 and 6.4.4.3 of the EAHCP).

4.0 AFFECT ON COVERED SPECIES

The implementation of the EAHCP water quality and sediment sampling program provided baseline data along the Comal River and upper reaches of the San Marcos River system. SWCA collected water quality grab samples twice from each river during base flow conditions and during two storm events. SWCA also collected sediment samples from both systems. PDSs were used to evaluate trace organic compounds six times throughout the year.

The collection and analysis of water quality and sediment samples aids evaluation of the habitat of species by providing base flow, storm flow, and sediment quality data. The data included water quality discharging directly from the springs and water discharging into the Comal and San Marcos Rivers below the springs.

In Section 7, analytical results are compared to various water quality and sediment standards as guidelines to identify any existing problems and create a body of baseline data to ascertain any long-term sediment and water quality trends. These trends can then be compared to trends in biologic survey data that is also being collected as part of the EAHCP.

5.0 LOGISTICS

To accommodate the needs of the EAHCP's expanded water quality monitoring program, a significant amount of resources are required. These resources, including sampling equipment, safety gear, trained staff, and sampling schedules, are all key components to the program. Additionally, the development of sampling strategies and planning of each sampling event are required to insure that resources are used efficiently, and collection is completed within the scheduled time frame. The strategies must account for the unpredictable nature of storm events. Below is a short synopsis of events and tasks undertaken to accomplish the necessary logistics for the EAHCP sampling program.

5.1 Surface Water (Base Flow) Sampling Program

Prior to each sampling event, SWCA staff acquired necessary supplies and equipment including laboratory sample kits, disposable bailers, and 0.45-micron filters.

5.2 Sediment Sampling Program

SWCA acquired sediment sampling equipment in 2014 and 2015, and purchased an additional core sampler extension handle in 2016 to accommodate sampling at site HCS330, because the water depth was greater than in previous years. In May 2016, SWCA staff acquired sample containers from the contract laboratory.

5.3 Stormwater Program

Prior to each sampling event, SWCA acquired laboratory sample kits and prepared them for use in the field. All other sampling and safety supplies were kept stocked and ready for mobilization in the event a storm occurred. SWCA monitored weather forecasts on a regular basis to determine if teams would be mobilized for a potential sampling event. Prior to mobilization, many logistical concerns have to be addressed including, but not limited to, personnel availability, safety, staging area reservation, vehicle availability, sonde rental, and laboratory notifications.

5.4 Surface Water Passive Sampling Program

SWCA acquired PDS from the contract laboratory approximately two weeks prior to each sampling event. SWCA constructed sample deployment devices in 2014, and constructed additional deployment devices in 2016 to replace devices lost or damaged in the field. Prior to each deployment, SWCA decontaminated the devices and placed them inside clean plastic bags.

6.0 SAMPLE COLLECTION METHODOLOGY

6.1 Surface Water (Base Flow) Sampling Program

SWCA collected surface water quality (base flow) grab samples from five sites throughout the Comal Springs complex and seven sites throughout the San Marcos Springs complex, biannually. According to the EAHCP Work Plan, the sample dates were to be six months apart. The preferred method for obtaining a surface water sample is to reach the sampling location from the shoreline or wade to the sample location, obtain field parameters (pH, specific conductivity, dissolved oxygen, and temperature) and then insert the sample bottle directly into the water or use a sample bottle and pole assembly. SWCA collected samples directly within sample bottles as opposed to using a pole assembly. For samples collected while wading, SWCA collected the samples on the upstream side of the sampler. SWCA collected samples in accordance with the criteria set forth in the *EAA Groundwater Quality Monitoring Plan*.

Filtration for methods 6010B (metals), 6020 (metals), 7470A (mercury), 960 (dissolved organic carbon, DOC) and field alkalinity were performed at the sample location by using a 0.45-micron high capacity cartridge filter attached to a single-sample disposable bailer. Preservatives were placed in the bottles (as appropriate) by the contracted laboratory. Samples were placed in coolers with ice immediately upon collection. Samples were later picked up by the contract laboratory. When not in use or after collection, sampling equipment and/or coolers containing samples were secured inside the SWCA vehicles to maintain appropriate sample custody and security.

The *EAA Groundwater Quality Monitoring Plan* required the collection of one field duplicate sample for each spring complex per sampling event. SWCA sampled the field duplicate immediately after the parent water quality sample and in the same manner as the parent water quality sample.

Analyses for field alkalinity were conducted at SWCA's San Antonio office. The method used for field alkalinity is discussed in detail in the *EAA Groundwater Quality Monitoring Plan* (Appendix D). Field alkalinity analysis was performed within 8 hours of sample collection. Any deviations from this hold time are discussed in Appendix C. Representative photographs of field activities are included in Appendix E.

6.2 Sediment Sampling Program

SWCA collected sediment samples once annually from the first three inches of sediment below the streambed surface at each of the 12 sampling locations. Sediment sample collection points generally coincided with the surface water collection points at each of the 12 sample locations in the spring complexes, but varied slightly based on field conditions. Based on the amount of available sediment at each site, the location and area sampled varied. Sample collection location variations are discussed in Appendix C. Sediment sample collection methods were consistent with the guidelines established in the *EAA Groundwater Quality Monitoring Plan*. SWCA collected the majority of samples using stainless steel hand trowels. The trowel was inserted into the sediment three inches, and the sample was scooped into sample containers provided by the contract laboratory. SWCA collected one one-liter jar and one two-ounce jar for volatile organic compound (VOC) analysis at each location. Samples were composed of sediment collected at three locations at each sample point, which was combined and homogenized at the contract laboratory prior to analysis. The water depth at HCS330 made it impossible to collect a sample using hand trowels; instead SWCA collected the sample using a hand core sampler consisting of a two-inch-diameter, 20-inch-long stainless steel barrel with a plastic tube liner. SWCA extruded the samples from the sample tube and into the sample containers.

In compliance with the *EAA Groundwater Quality Monitoring Plan* and consistent with the EAA practices of 2013, SWCA collected two field duplicates and two equipment blanks. One field duplicate sample is required for each spring complex. SWCA collected the field duplicates at the same locations as two of the field samples, using the same methods as the field samples. Two equipment blanks were prepared in the laboratory of SWCA's San Antonio office. To collect one of the blanks, American Society for Testing and Materials (ASTM) Type II Reagent Grade water was poured through a new plastic sampling tube into sample collection containers. SWCA collected the second equipment blank by pouring ASTM Type II Reagent Grade water over a decontaminated trowel into sample collection containers. The samples were containerized in the same manner as a surface water sample using the same types of containers and preservatives. Sample portions for metals analyses requiring field filtration were filtered using a 0.45-micron high capacity cartridge filter and disposable bailer. The equipment blanks were not analyzed for the following analytes: field parameters, turbidity, field alkalinity, and bacteria.

All samples were labeled and put on ice immediately upon collection for later shipment to the contract laboratory. Samples were secured inside locked SWCA vehicles during field operations and appropriate custody was maintained at all times. Representative photographs of field activities are included in Appendix E.

6.3 Stormwater Sampling Program

Stormwater samples are designated by the EAHCP Work Plan (Appendix A) for collection twice annually from each spring complex. SWCA collected stormwater samples when rainfall amounts were adequate to initiate at least a 5% rise at the respective USGS gauging locations for each spring complex. SWCA

collected samples across the storm-affected stream hydrograph at the rise, peak, and recession limb of the associated stream hydrograph. As with the other sample types, SWCA sampled five locations at Comal Springs and seven locations at San Marcos Springs. In general, the turbidity and conductivity data from the RTIs at each site were used as a surrogate for the stream hydrograph due to immediate availability of the data. Stream hydrograph data is only updated hourly on the USGS website. The RTI data is updated every 15 minutes, which provides greater resolution regarding the effect of the storm event on the streams and facilitates quicker sampling response times. Graphs showing water quality parameters during each storm event are included in Appendix B.

Stormwater sample collection was affected by the ongoing dry conditions across the region during the second half of 2016. Often, storms that materialized were insufficient to create adequate runoff for sample collection. In general, when rainfall probabilities exceeded 20% for a given time period, the team was placed on-call for sample collection. The team was mobilized when rainfall probabilities of at least 0.5 inch exceeded 50%. Storm team duty is summarized and documented in Appendix F of this document.

Due to the inherently unsafe conditions associated with stormwater flow, SWCA field staff used disposable single-use bailers when needed in order to safely obtain water samples during stormwater sampling events. Field parameters were collected first by inserting the sonde probe as close to the sample location as possible. In March and November 2016, SWCA sampled location HSM240 using disposable bailers. SWCA staff lowered bailers from the bridge above the sample location and used a rope affixed to the bailer for retrieval. SWCA used new bailers and rope for each sample point. After retrieval, SWCA staff transferred the water to the sample containers. SWCA used only new, disposable equipment for stormwater sampling events.

Stormwater sampling efforts conformed to the protocols outlined in the *EAA Groundwater Quality Monitoring Plan* for sample collection, handling, and decontamination. Filtration for methods 6010B (metals), 6020 (metals), DOC and field alkalinity were performed using a 0.45-micron high capacity cartridge filter and peristaltic pump. Preservatives were placed in the bottles (as needed) by the contract laboratory prior to sample collection. SWCA immediately placed all samples into coolers with ice and later shipped samples to the contract laboratory. When not in use or after collection, sampling equipment and/or coolers containing samples were secured inside locked SWCA vehicles to maintain appropriate sample custody and security.

According to the *EAA Groundwater Quality Monitoring Plan*, SWCA collected two field duplicates for the Comal Springs complex and three for the San Marcos Springs complex per rain event. SWCA sampled field duplicates after collection of the parent sample and in the same manner as the field sample. No equipment blanks were required for stormwater samples as all equipment used was new and disposable.

Analyses for field alkalinity were performed at the field staging area or at SWCA's San Antonio office. The method used for field alkalinity is discussed in detail in the *EAA Groundwater Quality Monitoring Plan*. Representative photographs of field activities are included in Appendix E.

6.4 Surface Water Passive Samplers

SWCA deployed the PDSs at each of the 12 sample locations during the months of February, April, June, August, October, and December 2016. In general, PDS locations corresponded to surface water sampling

points unless prevented by field conditions. Lost PDSs, human tampering, and any variations in deployment locations are discussed in Appendix C.

SWCA staff constructed deployment devices at SWCA's San Antonio office in June 2014. Two-inch thick, 18-inch diameter concrete disks were poured and a stainless steel silverware cup was set approximately one inch deep in the center of the disk. Handles were formed by inserting both ends of an 18-inch length of vinyl-coated stainless steel cable into each side of the disk. Site numbers were marked in the wet concrete to dedicate each device to a sample location. The concrete was allowed to cure, and each device was decontaminated following the *EAA Groundwater Quality Monitoring Plan* guidelines and placed in a clean plastic bag prior to the first deployment. The same decontamination procedures were followed for subsequent sampling events. SWCA constructed additional deployment devices in 2016 to replace devices lost or damaged in the field. The deployment device is pictured in Figure 11.

Upon arrival at the sample location, the PDS was removed from a dedicated vial and affixed inside of a second stainless steel silverware cup with a plastic cable tie. This cup was inverted and placed on top of the cup set in the concrete sampling device enclosing the PDS inside the two cups. The two cups were secured to one another with additional plastic cable ties. The device was then gently lowered into the water. Installation date and time and PDS identification numbers were noted in the field notebook and on the PDS vial. To retrieve the PDS, the devices were simply removed from the water and the cable ties cut. The PDS was then immediately placed back in the dedicated vial and retrieval date and time were notated. Deployment devices were secured at SWCA offices when PDSs were not deployed.

SWCA collected field duplicates as directed by the *EAA Groundwater Quality Monitoring Plan*. To collect field duplicates, a second PDS was installed inside selected deployment devices. Field PDSs were always accompanied by test blank samplers to monitor for VOC contamination. Deployment devices were dedicated to each sample location to avoid cross contamination and were decontaminated following the *EAA Groundwater Quality Monitoring Plan* guidelines prior to each use. Representative photographs of field activities are included in Appendix E.

Figure 11. PDS deployment device prior to installation at site HSM440.



7.0 SAMPLE RESULTS

Results from the sampling efforts related to the EAHCP sampling program are discussed in the paragraphs that follow. Results are discussed by sample type for Comal Springs, followed by a separate discussion by sample type for San Marcos Springs. Sample events are listed in the order of surface water (base flow) samples, sediment samples, stormwater samples, and PDS. Laboratory analyses and field parameters are provided in Appendix G of this document. The laboratory data were reviewed by SWCA staff with the results of that review provided as Appendix H (data validation discussion) of this document. Each sample location (latitude/longitude), name, and other location information are also summarized in Appendix I of this document.

7.1 Comal Springs Sample Results

SWCA sampled the Comal Springs complex for water quality during surface water (base flow) conditions in March and September 2016. In general, few detections were noted. As discussed previously, surface water (base flow) samples are compared to the drinking water standards for water quality in this report.

Sediments at the Comal Springs complex were sampled in June 2016. Sediment results are compared to the standards developed by McDonald et al. (2000) and TCEQ (2012, 2014a). These standards are based on the probability that a detected compound has a toxic effect on sediment-dwelling organisms and are referred to as the TEC and PEC. Detections below the TEC are not considered to be toxic, whereas detections above

the PEC are considered to be toxic to sediment dwelling organisms. Detections above the TEC but less than the PEC are considered equally likely to be toxic or non-toxic.

Stormwater events were sampled at the Comal Springs complex in April and September 2016. Stormwater results did not indicate a significant number of detections of concern.

PDS sampling events were conducted at the Comal Springs complex in February, April, June, August, October and December 2016. Generally speaking, various VOCs and total petroleum hydrocarbons (TPH) were detected at various sample locations, but only tetrachloroethene was consistently detected.

7.1.1 Comal Springs Surface Water / Base Flow Sampling

SWCA sampled the Comal Springs complex on March 2 and September 8, 2016, for surface water (base flow) events.

7.1.1.1 Surface Water / Base Flow - Bacteria

Bacteria results for surface water (base flow) associated with the Comal Springs complex ranged from 11 MPN/100 mL (most probable number of colony-forming units per 100 milliliters of water) to 100 MPN/100 mL for *Escherichia coli* (*E. coli*). Because of the presence of various fauna in surface water collection sites, positive detections are not uncommon. The 2014 Texas Surface Water Quality Standard for *E. coli* in primary recreation waters is a geometric mean of 126 MPN/100 mL with no individual sample exceeding 399 MPN/100 mL (30 TAC 307.7). The geometric mean for surface water samples collected from the Comal Springs complex during 2016 was approximately 38 MPN/100 mL. Surface water (base flow) bacteria counts are summarized in Table 2.

**Table 2. Surface Water Samples – Bacteria Counts
- Comal Springs Complex**

Location	Date	Count (MPN/100 mL)
HCS110	3/2/2016	100
	9/8/2016	96
HCS120	3/2/2016	21
	9/8/2016	25
FDHCS120	3/2/2016	11
	9/8/2016	26
HCS130	3/2/2016	13
	9/8/2016	75
HCS140	3/2/2016	41
	9/8/2016	71
HCS160	3/2/2016	46
	9/8/2016	48

MPN/100 mL – Most probable number per 100 milliliters of water.

7.1.1.2 Surface Water / Base Flow - Volatile Organic Compounds (VOCs)

No VOCs were detected at any of the five sampling sites from the Comal Springs complex during the March or September 2016 sampling events.

7.1.1.3 Surface Water / Base Flow - Semi-volatile Organic Compounds (SVOCs)

Generally, semi-volatile organic compounds (SVOCs) were analyzed because their detection can indicate the presence of chemicals originating from anthropogenic sources and therefore be used to evaluate potential impacts on water quality. Two SVOCs were detected in the Comal Springs complex during the September 2016 sampling events. Bis(2-Ethylhexyl) phthalate (DEHP) and di-n-butyl phthalate were each detected in two samples. The detections were “J” flagged, indicating the detected concentration is less than the laboratory reporting limit, but greater than the method detection limit. DEHP was detected in sample HCS160 at 10.1 J µg/L, exceeding the PCL of 6 µg/L in September 2016. SVOC detections are summarized below in Table 3. DEHP detections are shown further in Figure 12.

Table 3. Surface Water Samples – Semi-volatile organic compound detections - Comal Springs Complex

Location	Date Collected	Bis(2-Ethylhexyl) Phthalate (µg/L)	Di-n-Butyl Phthalate (µg/L)
HCS110	3/2/2016	<5.00	<0.709
	9/8/2016	5.52 J	<0.709
HCS140	3/2/2016	<5.00	<0.709
	9/8/2016	<5.00	2.20 J
HCS160	3/2/2016	<5.00	<0.709
	9/8/2016	10.1 J	2.48 J
MCL		NE	NE
PCL		6	2400

J – Detection is greater than the method detection limit, but less than the reporting limit

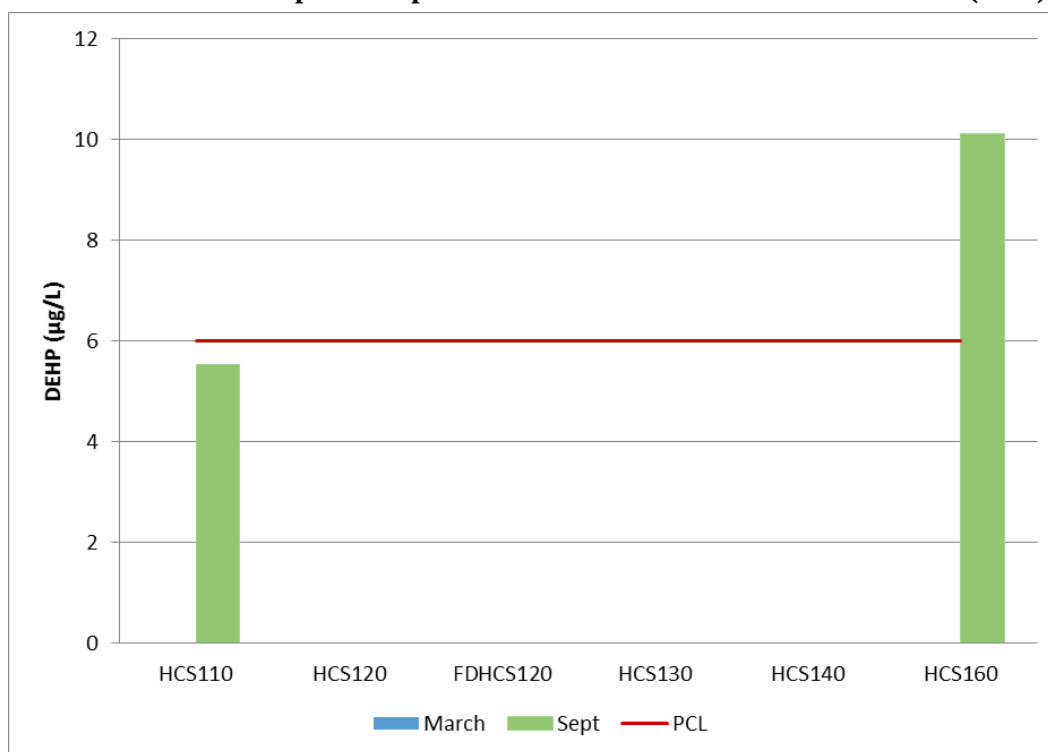
MCL – maximum contaminant level

NE – Not established

PCL – protective concentration levels

µg/L – micrograms per liter

Figure 12. Bis(2-Ethylhexyl) phthalate (DEHP) in Comal Springs Complex Surface Water Samples Compared to the Protective Concentration Level (PCL)



7.1.1.4 Surface Water / Base Flow - Pesticides

Surface water samples were analyzed for pesticides because their detection can indicate the presence of chemicals originating from anthropogenic sources; and therefore, can be used to evaluate potential impacts on water quality. No pesticides were detected in any of the samples collected for the March or September 2016 sampling events at all five sites for the Comal Springs complex. Due to an error at the laboratory, organophosphorus pesticide samples originally collected on September 9, 2016, had to be recollected on October 24, 2016. This deviation is discussed in more detail in Appendix C.

7.1.1.5 Surface Water / Base Flow - Herbicides

Surface water samples were analyzed for herbicides because their detection can indicate the presence of chemicals originating from anthropogenic sources; and therefore, can be used to evaluate potential impacts on water quality. Herbicide analyses indicated no detections for both the March and September 2016 sampling events at all five sites for the Comal Springs complex.

7.1.1.6 Surface Water / Base Flow - Polychlorinated Biphenyls (PCBs)

Surface water samples were analyzed for the various Aroclor compounds that are collectively referred to as Polychlorinated Biphenyls (PCBs). PCB detection can indicate the presence of chemicals originating from anthropogenic sources; and therefore, can be used to evaluate potential impacts on water quality. No PCBs were detected during both the March and September 2016 sampling events at all five sites for the Comal Springs complex.

7.1.1.7 Surface Water / Base flow - Metals

Surface water samples were analyzed for metals that may indicate the presence of chemicals originating from anthropogenic sources. Although metals were detected for the March and September 2016 sampling events at all five sites for the Comal Springs complex, no metals were detected at a concentration in excess of the drinking water standards. The metals arsenic, barium, lead, mercury, and selenium were the detected metals of concern; however, none of their concentrations approached the MCL or PCL. These detections are listed below in Table 4. Note that many of the detections are “J” flagged, indicating the detected concentration is less than the laboratory reporting limit, but greater than the method detection limit. Also note that some metals are naturally occurring in rock, soil, groundwater, and surface water and may not indicate an anthropogenic source.

Table 4. Surface Water Samples – Metal detections - Comal Springs Complex

Location	Date Collected	Arsenic (mg/L)	Barium (mg/L)	Lead (mg/L)	Mercury (mg/L)	Selenium (mg/L)
HCS110	3/2/2016	0.00161 J	0.0464	<0.000733	<0.000130	0.00157 J
	9/8/2016	<0.00109	0.0601	<0.000733	<0.000130	<0.00108
HCS120	3/2/2016	<0.00109	0.0445	<0.000733	<0.000130	<0.00108
	9/8/2016	<0.00109	0.0561	<0.000733	<0.000130	<0.00108
FDHCS120	3/2/2016	<0.00109	0.0445	0.00179 J	<0.000130	<0.00108
	9/8/2016	<0.00109	0.0588	<0.000733	<0.000130	<0.00108
HCS130	3/2/2016	<0.00109	0.0439	<0.000733	<0.000130	0.00153 J
	9/8/2016	<0.00109	0.0547	<0.000733	<0.000130	<0.00108
HCS140	3/2/2016	<0.00109	0.0425	<0.000733	<0.000130	0.00108 J
	9/8/2016	<0.00109	0.0578	<0.000733	<0.000130	<0.00108
HCS160	3/2/2016	<0.00109	0.0435	<0.000733	<0.000130	<0.00108
	9/8/2016	<0.00109	0.0578	<0.000733	0.000302 J	<0.00108
MCL		0.01	2	NE	0.002	0.05
PCL		--	--	0.015	--	--

-- - Not applicable

J – Detection is greater than the method detection limit, but less than the reporting limit

MCL – maximum contaminant level

mg/L – milligrams per liter

NE – Not established

PCL – protective concentration levels

7.1.1.8 Surface Water / Base Flow - Nitrates

Surface water samples were analyzed for nitrate-nitrite as nitrogen. Laboratory analyses indicated a limited range of nitrate-nitrite as nitrogen in surface water samples. Of the 12 surface water samples (ten environmental samples and two field duplicates) collected for the two sample events, concentrations ranged from 1.23 milligrams per liter (mg/L) to 1.92 mg/L. None of the nitrate concentrations detected exceeded

the MCL of 10 mg/L for drinking water. The highest nitrate concentration in surface water at the Comal Springs complex, 1.92 mg/L, was detected at HCS130 on September 8, 2016. Nitrate-nitrogen results are summarized in Table 5.

Table 5. Surface Water Samples – Nitrate Detections - Comal Springs Complex

Location	Date	Concentration (mg/L)
HCS110	3/2/2016	1.23
	9/8/2016	1.53
HCS120	3/2/2016	1.79
	9/8/2016	1.86
FDHCS120	3/2/2016	1.78
	9/8/2016	1.87
HCS130	3/2/2016	1.84
	9/8/2016	1.92
HCS140	3/2/2016	1.76
	9/8/2016	1.83
HCS160	3/2/2016	1.79
	9/8/2016	1.87
MCL		10

MCL – maximum contaminant level

mg/L – milligrams per liter

7.1.1.9 Surface Water / Base Flow – Caffeine

Surface water base flows were analyzed for caffeine, which can indicate an anthropogenic source. Caffeine may enter surface water from leaking sewer or septic systems or it may be present in the aquifer from similar sources in the recharge zone (EPA 2012). Potential ecological effects are currently unknown but could include reduced reproductive success in aquatic species (EPA 2012). Caffeine detections in surface water (base flow) samples from Comal Springs in March 2016 ranged from 2.6 to 15 nanograms per liter (ng/L). Caffeine was only detected at three surface water locations in the Comal Springs system, HCS110, HCS120 and HCS130. There is no regulatory standard or expected value for comparison. Results are shown in Table 6.

Table 6. Surface Water Samples – Caffeine Detections - Comal Springs Complex

Location	Date Collected	Caffeine (ng/L)
HCS110	3/2/2016	5.3
	9/8/2016	<0.31
HCS120	3/2/2016	2.6
	9/8/2016	<0.31
FDHCS120	3/2/2016	3.8
	9/8/2016	15
HCS130	3/2/2016	7.8
	9/8/2016	15
HCS140	3/2/2016	<0.31
	9/8/2016	<0.31
HCS160	3/2/2016	<0.31
	9/8/2016	<0.31

ng/L – nanograms per liter

7.1.2 Comal Springs Sediment Sampling

7.1.2.1 Sediment - Volatile Organic Compounds (VOCs)

Four VOC compounds were detected in sediment samples collected in the Comal Springs system in 2016. All VOC detections are “J” flagged, indicating the detected concentration is less than the laboratory reporting limit, but greater than the method detection limit. None of the VOCs detected have established TEC or PEC values. The detections are summarized below in Table 7.

Table 7. Sediment Samples – Volatile Organic Compound Detections - Comal Springs Complex

Location	Date Collected	Acetone (µg/kg)	2-Butanone (µg/kg)	4-Isopropyltoluene (µg/kg)	Styrene (µg/kg)
HCS310	6/8/2016	64.4 J	<15.5	<3.21	<2.44
HCS320	6/8/2016	43.1 J	7.38 J	<0.671	<0.510
HCS330	6/8/2016	9.15 J	<2.14	<0.445	0.641 J
HCS340	6/8/2016	41.2 J	8.68 J	<0.584	<0.444
HCS360	6/8/2016	199 J	<20.5	<4.26	<3.24
FDHCS360	6/8/2016	224 J	38.7 J	46.3 J	<3.32
TEC		NE	NE	NE	NE
PEC		NE	NE	NE	NE

J – Detection is greater than the method detection limit, but less than the reporting limit

µg/kg – micrograms per kilograms

NE – not established

PEC – probable effect concentration

TEC – threshold effect concentration

7.1.2.2 Sediment - Semi-volatile Organic Compounds (SVOCs)

Several SVOC compounds were detected in the sediment samples collected in the Comal Springs system in 2016. Many of these detections are “J” flagged, indicating the detected concentration is less than the laboratory reporting limit, but greater than the method detection limit. DEHP was detected in all Comal Springs sediment samples in 2016. Sediment samples from HCS320 and HCS340 also contained 3- and 4-methylphenol. The remaining detections were polycyclic aromatic hydrocarbons (PAH) compounds.

The SVOC detections are summarized below in Table 8. PAH compounds exceeding the TEC are shown graphically in Figures 13–17. Total PAH detections are shown in Figure 18, where the total PAH concentrations (sum of all detected concentrations for each sample point) are compared to the TEC and PEC values for total PAH concentration established by MacDonald et al. (2000). Samples HCS360 and FDHCS360 exceed the TEC for total PAH concentrations and five individual PAH compounds.

Table 8. Sediment Samples – Semi-volatile Organic Compound Detections - Comal Springs Complex

Location	Date Collected	PAH Compounds											Non-PAH Compounds	
		Benzo (a) anthracene	Benzo (a) pyrene	Benzo (b) fluoranthene	Benzo (g,h,i) perylene	Benzo (k) fluoranthene	Chrysene	Fluoranthene	Indeno (1,2,3-cd) pyrene	Phenanthrene	Pyrene	TOTAL PAH	Bis(2-ethylhexyl) phthalate	3 and 4-Methylphenol
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
HCS310	6/8/2016	<0.0782	<0.0633	<0.0558	<0.0558	<0.0484	<0.0558	0.0656 J	<0.0596	<0.0782	<0.0633	0.0656	0.163 J	<0.104
HCS320	6/8/2016	<0.0767	<0.0621	<0.0548	<0.0548	<0.0475	<0.0548	<0.0621	<0.0585	<0.0767	<0.0621	--	0.151 J	0.374 J
HCS330	6/8/2016	<0.026	<0.0211	0.0233 J	<0.0186	<0.0161	<0.0186	0.0443 J	0.0449 J	<0.026	<0.0211	0.1125	0.531	<0.0347
HCS340	6/8/2016	<0.0656	<0.0531	<0.0468	<0.0468	<0.0406	<0.0468	0.0619 J	<0.05	<0.0656	<0.0531	0.0619	0.761	0.572 J
HCS360	6/8/2016	0.14 J	0.184 J	0.376 J	0.0892 J	0.152 J	0.244 J	0.44 J	0.223 J	0.104 J	0.256 J	2.2082	0.381 J	<0.124
FDHCS360	6/8/2016	0.156 J	0.192 J	0.437 J	0.0891 J	0.185 J	0.294 J	0.505 J	0.224 J	0.119 J	0.295 J	2.4961	0.356 J	<0.124
TEC		0.108	0.150	NE	NE	NE	0.166	0.423	NE	0.204	0.195	1.610	NE	NE
PEC		1.050	1.450	NE	NE	NE	1.290	2.230	NE	1.170	1.520	22.800	NE	NE

J – Detection is greater than the method detection limit, but less than the reporting limit

mg/kg – milligrams per kilograms

NE – not established

PAH – polycyclic aromatic hydrocarbons

PEC – probable effect concentration

TEC – threshold effect concentration

-- – not applicable

Figure 13. Benzo(a)anthracene in Comal Springs Complex Sediments Compared to the Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values

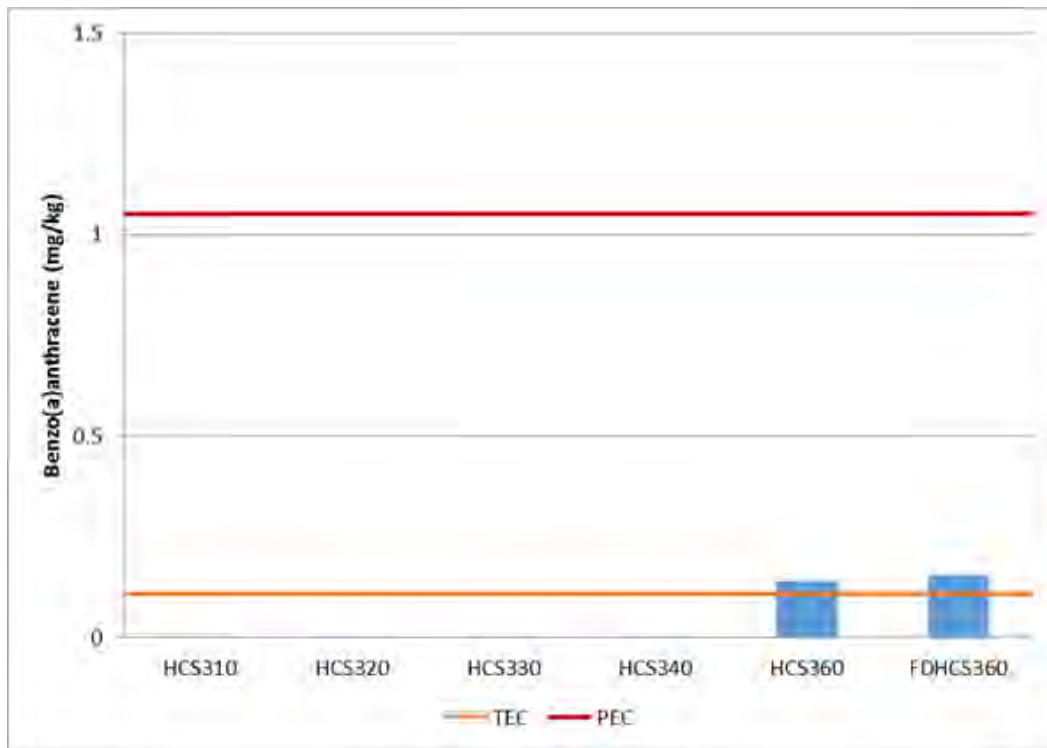


Figure 14. Benzo(a)pyrene in Comal Springs Complex Sediments Compared to the Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values

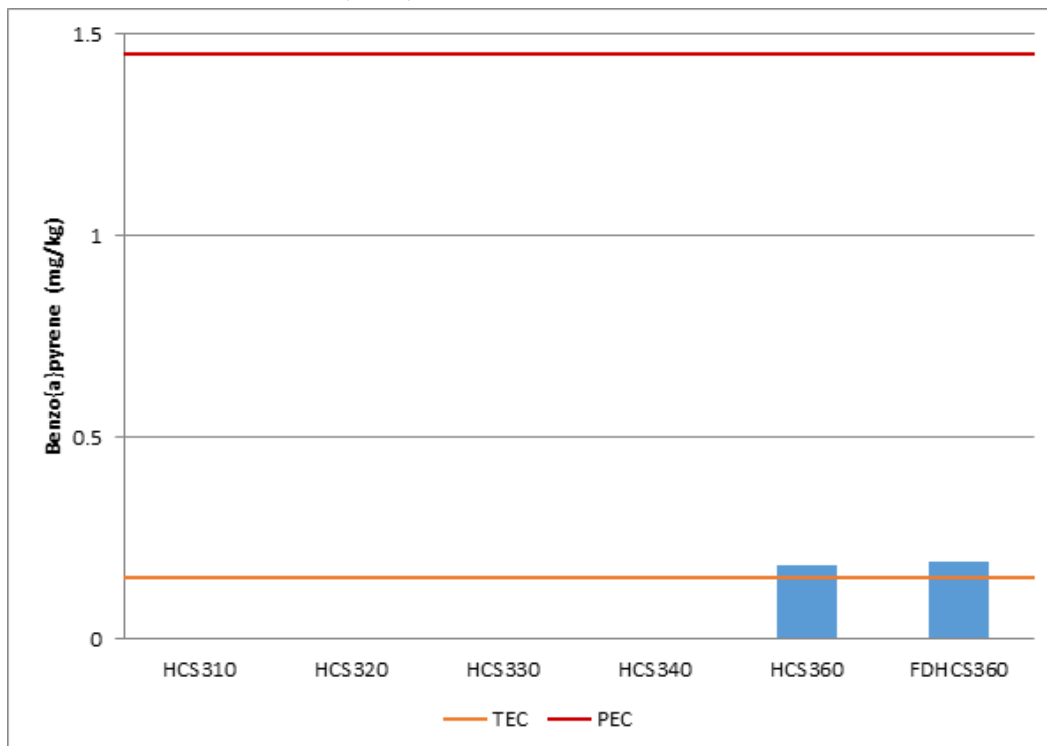


Figure 15. Chrysene Detections in Comal Springs Complex Sediments Compared to the Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values

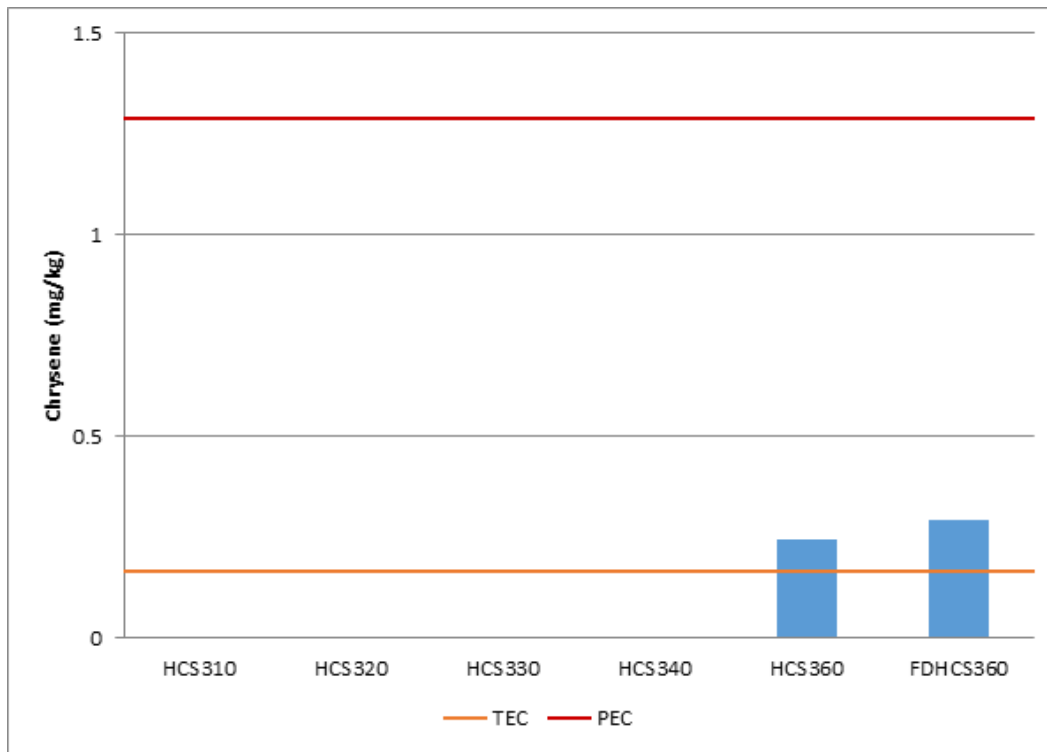


Figure 16. Fluoranthene Detections in Comal Springs Complex Sediments Compared to the Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values

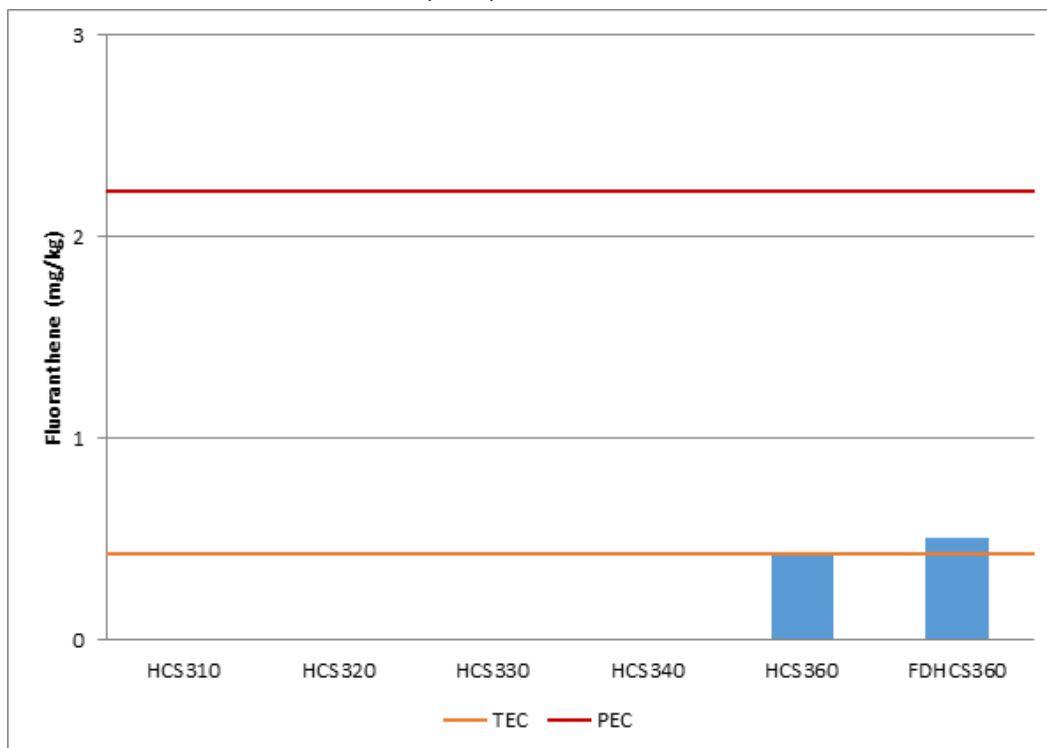


Figure 17. Pyrene Detections in Comal Springs Complex Sediments Compared to the Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values

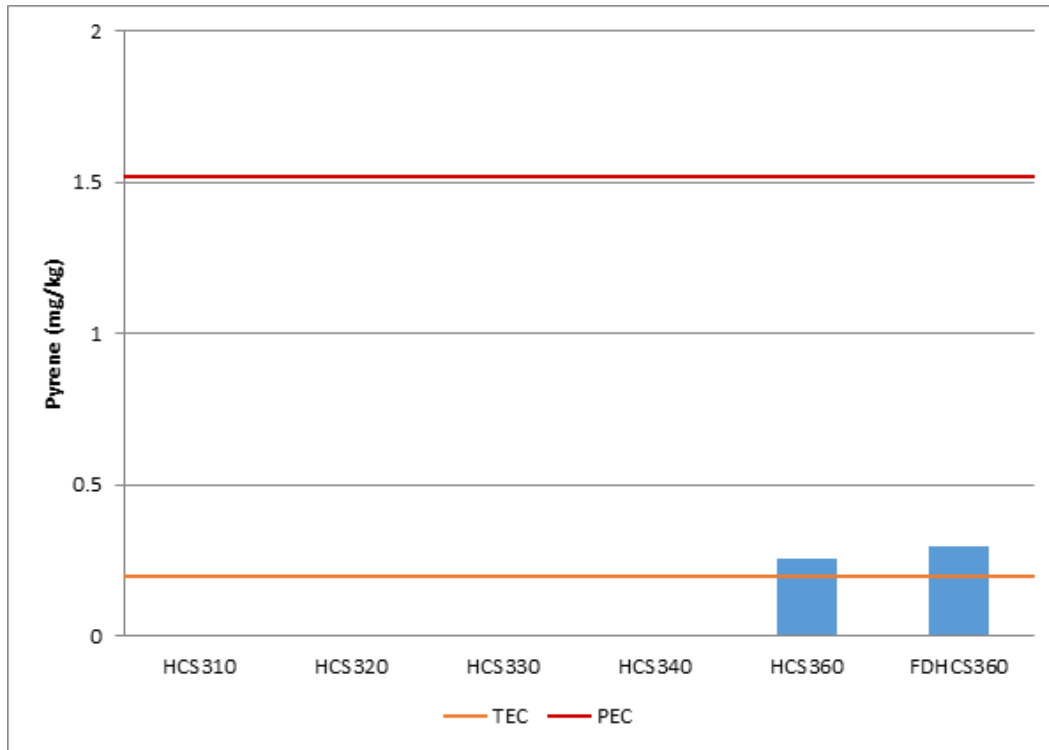
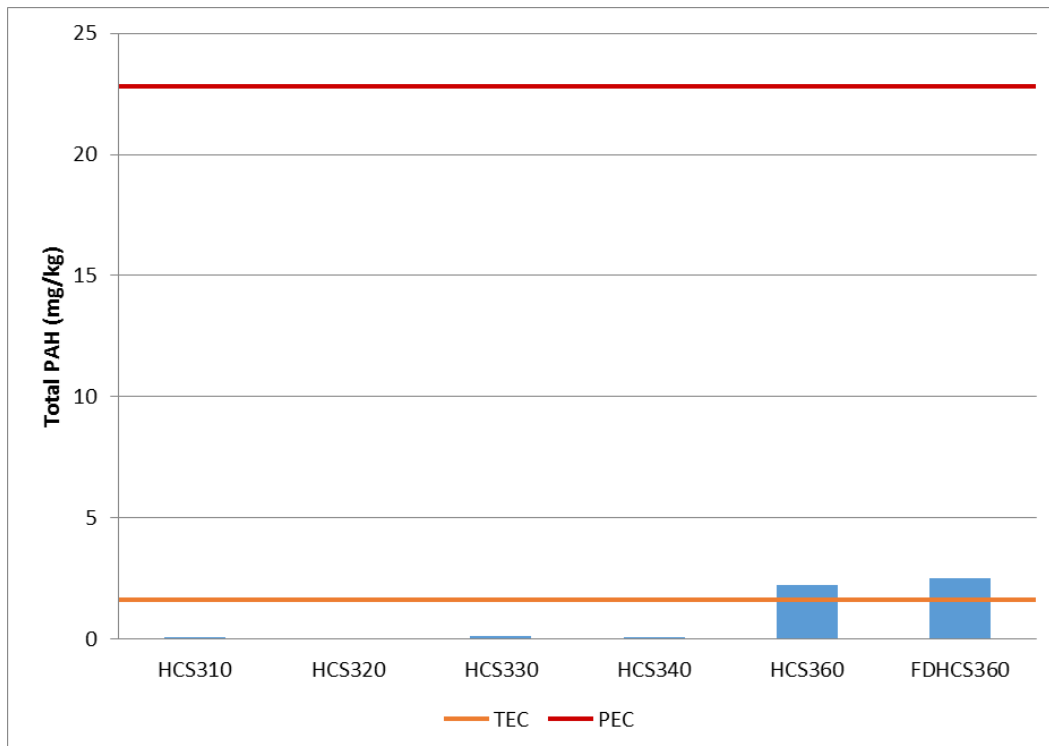


Figure 18. Total polycyclic aromatic hydrocarbons (PAH) in Comal Springs Complex Sediments Compared to the Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values



7.1.2.3 Sediment – Pesticides

Sediment samples were analyzed for both organochlorine and organophosphorus pesticides. No pesticides were detected in any of the sediment samples collected in the Comal Springs complex.

7.1.2.4 Sediment – Herbicides

Sediments were analyzed for herbicide compounds to further assess sediment quality at the Comal Springs complex. Herbicide compounds were detected in two sediment samples collected from the Comal Springs complex. Dalapon was detected at a concentration of 9.72 J µg/kg at HCS320. Another herbicide compound, 2,4-D, was detected in FDHCS360 at a concentration of 5.05 J µg/kg. Both of these detections are “J” flagged, indicating the detected concentration is less than the laboratory reporting limit, but greater than the method detection limit. There are no TEC or PECs established for these compounds.

7.1.2.5 Sediment – Polychlorinated Biphenyls

Sediments were analyzed for PCB compounds to further assess sediment quality at the Comal Springs complex. There was one PCB detection in the sediment samples collected from the Comal Springs complex in 2016. Aroclor 1262 was detected in HCS340 at a concentration of 16.5 J µg/kg. This detection is “J” flagged, indicating the detected concentration is less than the laboratory reporting limit, but greater than the method detection limit. The detection does not exceed the total PCB TEC of 59.8 µg/kg or PEC of 676 µg/kg.

7.1.2.6 Sediment – Metals

Many metals are naturally occurring within soil, rock, and sediment. Sediment sample results for the Comal Springs complex tested positive for several metals, generally at low concentrations. Metals detected above the method detection limit and subsequently evaluated in this report for potential toxic effects using the TEC and/or PEC standards are: arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc. Other metals detected that do not have a TEC or PEC value available were compared to Texas-specific background concentrations (TSBC) (TCEQ 2014b) for soil. These metals are aluminum, antimony, barium, beryllium, iron, manganese, and selenium. None of the metals detected exceeded TEC or PEC values. Only two metals without PECs, antimony and selenium, exceeded the TSBC.

For the evaluation of antimony levels TCEQ recommends an Effects Range Low (ERL) of 2 mg/kg (TCEQ 2014a) and an Effects Range Median (ERM) of 25 mg/kg (TCEQ 2012). Antimony detections were “J” flagged, indicating the detected concentration is less than the laboratory reporting limit, but greater than the method detection limit. Antimony was detected at HCS310 at 2.00 J mg/kg, meeting but not exceed the ERL.

Sediment studies of selenium concentrations have shown that levels below 4 mg/kg are not likely to bioaccumulate in the food chain or have adverse impacts on the reproduction of fish or aquatic birds (Lemly 1995; Moore et al. 1990; Van Derveer and Canton 1996). Selenium detections did not exceed this amount in the sediment samples from the Comal Springs complex in 2016.

Metal detections are listed in Table 9. Antimony and selenium detections are displayed graphically in Figures 19 and 20.

Figure 19. Antimony in Comal Springs Complex Sediments Compared to Texas-Specific Background Concentration (TSBC) and Effects Range Low (ERL)

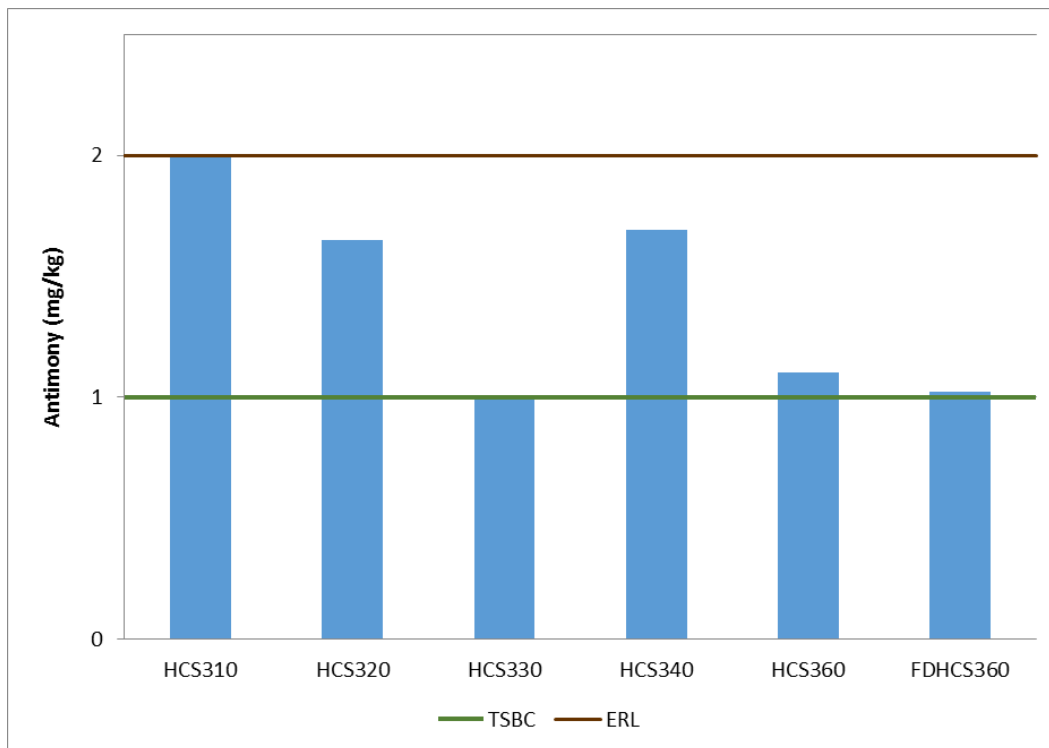


Figure 20. Selenium in Comal Springs Complex Sediments Compared to Texas-Specific Background Concentration (TSBC) and Possible Bioaccumulation Toxic Values

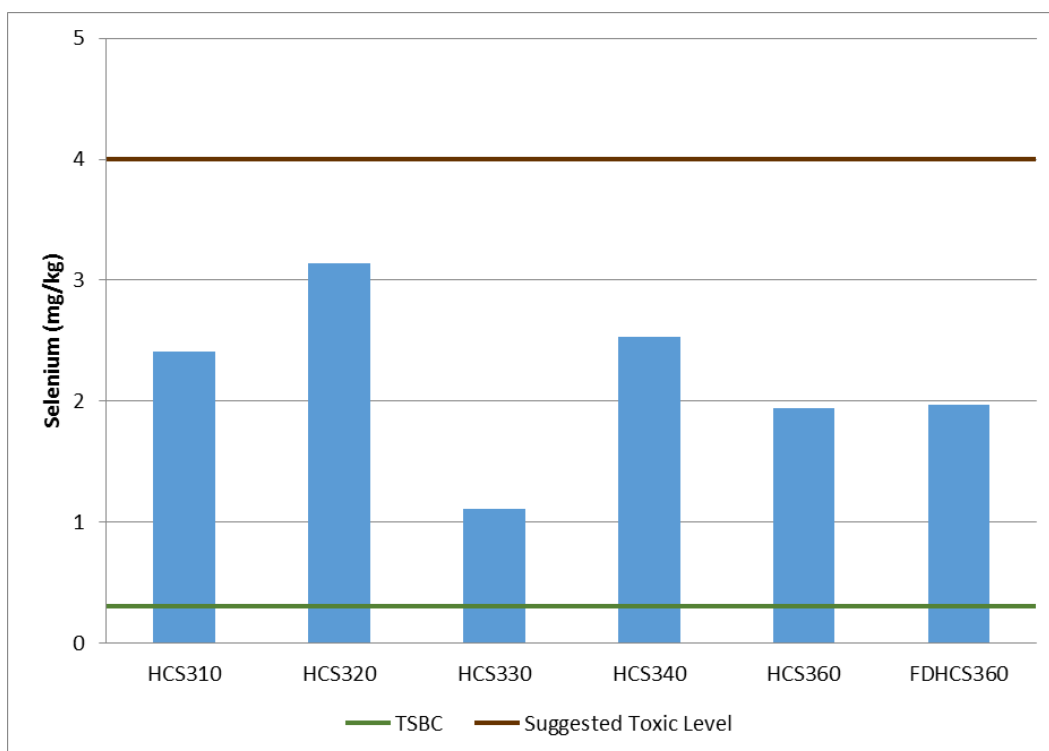


Table 9. Sediment Samples – Metal Detections – Comal Springs Complex

	Date	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Zinc
Location	Collected	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
HCS310	6/8/2016	952	2.00 J	1.25 J	16	0.0750 J	0.258 J	2.77	2.83 J	1640	7.95	41.2	0.0221 J	2.10 J	2.41	20.9
HCS320	6/8/2016	2860	1.65 J	3.75	27.3	0.257 J	0.626 J	7.27	5.36	3980	10.4	42.5	<0.0167	5.88	3.14	43
HCS330	6/8/2016	4120	1.01 J	3.1	51.5	0.391 J	0.597	6.9	3.99	4970	8.2	291	<0.0114	6.22	1.11	14.2
HCS340	6/8/2016	1320	1.69 J	1.22 J	48	0.189 J	0.397 J	3.75	4.74	2490	5.92	62.3	0.0279 J	4.01	2.53	13.6
HCS360	6/8/2016	5540	1.10 J	3.07 J	51.4	0.480 J	0.848 J	10.2	11.4	6120	23.5	126	<0.0203	7.94	1.94	89.1
FDHCS360	6/8/2016	5060	1.02 J	2.85 J	48.8	0.446 J	0.762 J	9.73	10.3	5780	22.3	130	0.0366 J	7.38	1.97	74.1
TEC		NE	NE	9.79	NE	NE	0.99	43.4	31.6	NE	35.8	NE	0.18	22.7	NE	121
PEC		NE	NE	33	NE	NE	4.98	111	149	NE	128	NE	1.06	48.6	NE	459
TSBC		30000	1	5.9	300	1.5	NE	NE	15	15000	15	300	0.04	10	0.3	30

J – Detection is greater than the method detection limit, but less than the reporting limit.

Mg/kg – milligrams per kilograms

NE – not established

PEC – probable effect concentration

TEC – threshold effect concentration

TSBC – Texas-specific background concentrations

7.1.3 Comal Springs Stormwater Sampling

Stormwater samples were collected during two storm events at the Comal Springs complex. SWCA sampled the events according to the guidelines in the EAHCP Work Plan. The events occurred on April 12–13, 2016, and September 26–27, 2016. Total rainfall for the April 2016 event was approximately 1.00 to 1.49 inches (National Oceanic and Atmospheric Administration [NOAA] 2016) causing streamflow measured at USGS Gauge 08169000 to increase from approximately 273 cfs to a peak of 376 cfs (USGS 2016). Total rainfall for the September 2016 event was approximately 3.00 to 3.99 inches in the immediate sampling area but reached up to 6.00 inches in areas to the north and west of the sampling area that are within the catchment area of Comal River tributaries (NOAA 2016). Streamflow measurements from the USGS gauge increased from approximately 359 cfs to a peak of 2100 cfs (USGS 2016). Rain fell in the area in the early morning of September 26, 2016, and by 07:30 rain in the immediate area had stopped and water quality began to recover. SWCA collected a set of peak samples at this time when discharge was approximately 538 cfs. After these peak samples were collected, specific conductivity began to fall again and streamflow began to increase but rain had not been falling in the area. SWCA monitored water quality, streamflow and weather radar and prepared to collect another round of peak samples. At HCS250, SWCA staff observed water levels rising and at approximately 12:30, streamflow gradually ceased and then began to flow upstream. It became apparent that flooding in the Guadalupe River was pushing water up the Comal River. EAA was consulted and it was determined that the peak samples collected at 07:30, near 538 cfs, best represented the peak of the storm since the larger peak at 2100 cfs was influenced by the Guadalupe River. SWCA staff returned on September 27, 2016, to collect the trail samples after the Comal River showed more than 50% recovery from the larger 2100 cfs peak.

7.1.3.1 Stormwater – Bacteria Detections

Stormwater samples collected and analyzed for bacteria analyses generally tested positive for high levels of bacteria. Bacterial analyses were performed for *E. coli*, using a most probable number method. The 2014 Texas Surface Water Quality Standard for *E. coli* in primary recreation waters is a geometric mean of 126 MPN/100 mL with no individual sample exceeding 399 MPN/100 mL (30 TAC 307.7). The geometric mean for stormwater samples collected from the Comal Springs complex during April 2016 was approximately 3,999 MPN/100 mL. Bacteria counts from April 2016 ranged from 1,200 MPN/100 mL to 16,000 MPN/100 mL with all samples exceeding the individual sample limit. The geometric mean for stormwater samples collected from the Comal Springs complex during September 2016 was approximately 6,029 MPN/100 mL. Bacteria counts from September 2016 ranged from 1,100 MPN/100 mL to 240,000 MPN/100 mL, with all samples exceeding the individual sample limit. Individual detections are listed below in Table 10 and shown in relation to stream discharge and specific conductivity in Figures 21 and 22. Due to the timing of storm events and laboratory working hours, it was not possible to deliver all samples to the laboratory within sample holding time of 8 hours (see discussion in Appendix C). These samples were included in the range and geometric mean calculations.

Table 10. Stormwater Samples – Bacteria Counts – Comal Springs Complex

Location	Date	Count (MPN/100 mL)
HCS210 Lead	4/12/2016	4900 H
	9/26/2016	16000 H
HCS210 Peak	4/13/2016	16000 H
	9/26/2016	240000 H
HCS210 Trail	4/13/2016	1700
	9/27/2016	4000
HCS240 Lead	4/12/2016	9200 H
	9/26/2016	13000 H
HCS240 Peak	4/13/2016	7300 H
	9/26/2016	3700 H
HCS240 Trail	4/13/2016	1200
	9/27/2016	1100
HCS250 Lead	4/12/2016	4400 H
	9/26/2016	14000 H
HCS250 Peak	4/13/2016	6900 H
	9/26/2016	13000 H
HCS250 Trail	4/13/2016	2900
	9/27/2016	1300
HCS260 Lead	4/12/2016	5500 H
	9/26/2016	9200 H
HCS260 Peak	4/13/2016	13000 H
	9/26/2016	9800 H
HCS260 Trail	4/13/2016	1300
	9/27/2016	1500
FDHCS260 Trail	4/13/2016	1400
	9/27/2016	1300
HCS270 Lead	4/12/2016	2200 H
	9/26/2016	20000 H
HCS270 Peak	4/13/2016	6000 H
	9/26/2016	11000 H
HCS270 Trail	4/13/2016	3100
	9/27/2016	1900
FDHCS270 Trail	4/13/2016	3400
	9/27/2016	1300

H – Analyzed outside hold time, result included for comparison but not considered valid

MPN/100 mL – Most probable number per 100 milliliters of water

Figure 21. Stormwater Samples – April 2016 Bacteria Counts in Relation to Stream Discharge and Specific Conductivity – Comal Springs Complex

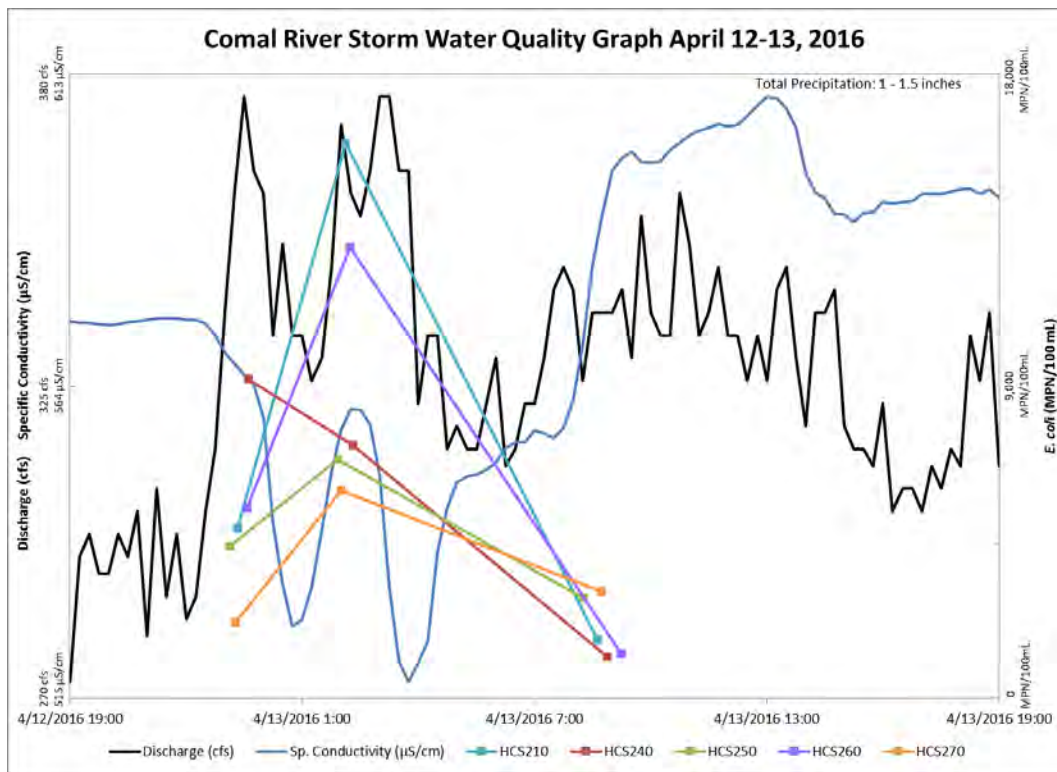
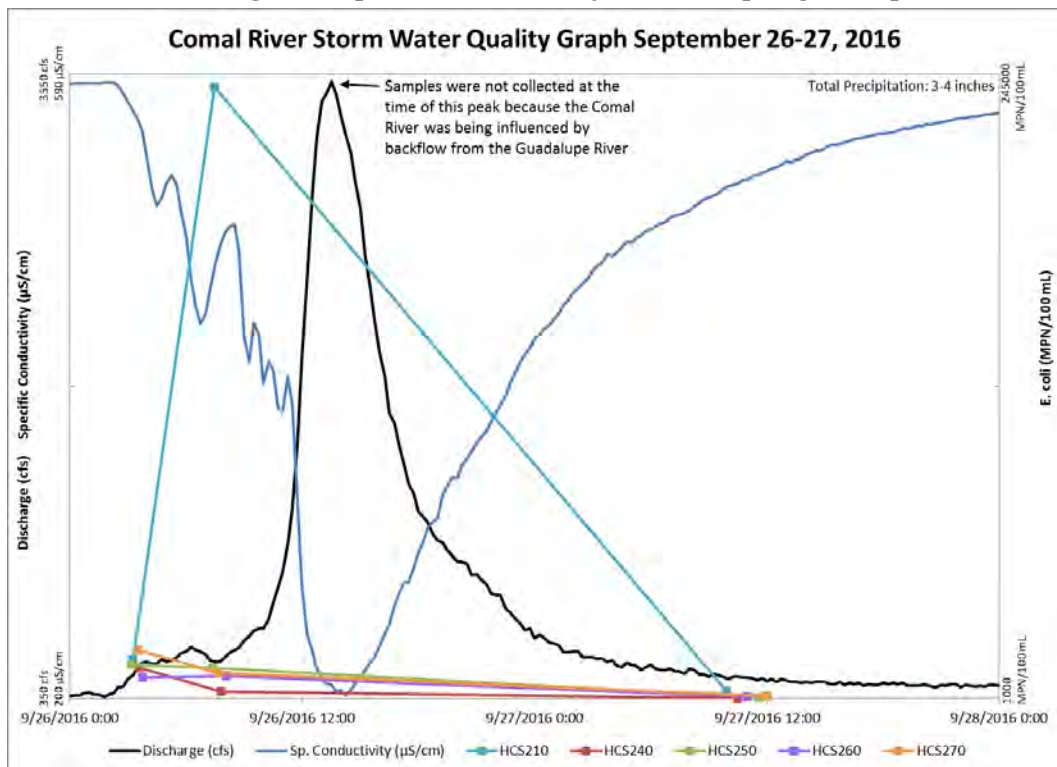


Figure 22. Stormwater Samples – September 2016 Bacteria Counts in Relation to Stream Discharge and Specific Conductivity – Comal Springs Complex



7.1.3.2 Stormwater – Volatile Organic Compounds (VOCs)

There were no VOC detections in stormwater samples during the April or September 2016 storm events. Acetone was detected at a concentration of 7.21 J µg/L in the trip blank associated with the peak samples from September 26, 2016.

7.1.3.3 Stormwater – Semi-volatile Organic Compounds (SVOCs)

Generally, SVOCs were analyzed because their detection can indicate the presence of chemicals originating from anthropogenic sources; and therefore, can be used to evaluate potential impacts on water quality. No SVOCs were detected at any of the five sampling sites in the Comal Springs complex during the April 2016 stormwater sampling event. One SVOC, DEHP, was detected in six samples from the September 2016 stormwater sampling event. All of the detections are “J” flagged, indicating the detected concentration is less than the laboratory reporting limit, but greater than the method detection limit. Four DEHP detections exceeded the PCL of 6 µg/L. SVOC detections are listed below in Table 11 and shown graphically in Figure 23.

Table 11. Stormwater Samples – Semi-volatile Organic Compound Detections – Comal Springs Complex

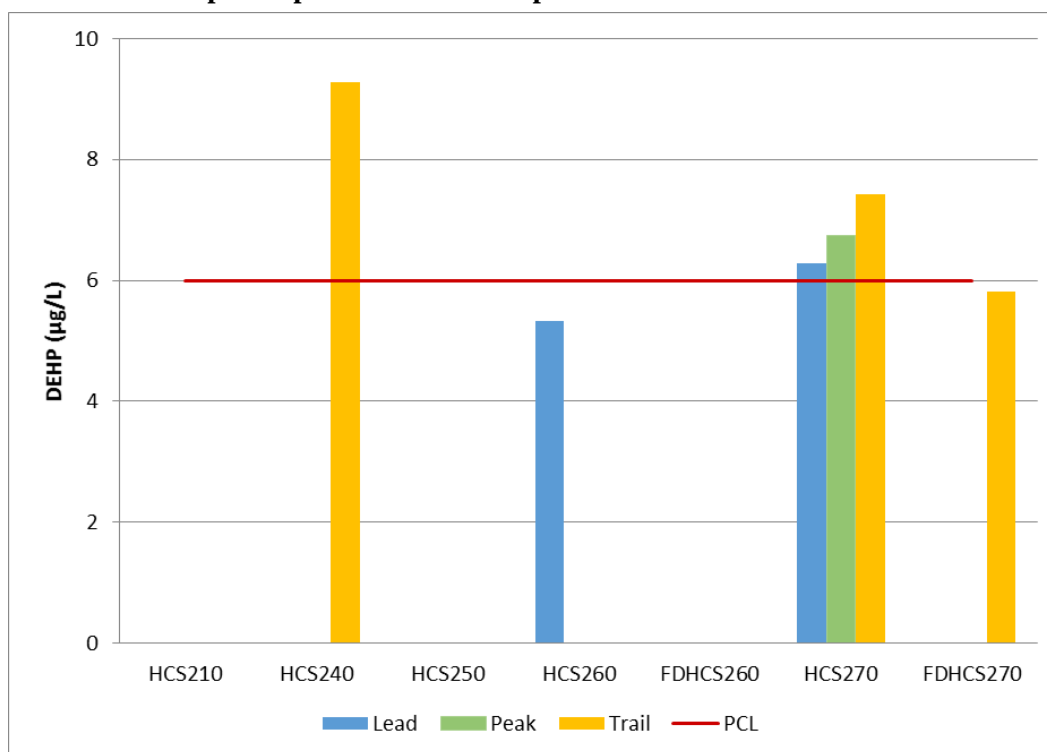
		Bis(2-ethylhexyl) phthalate
Location	Date	(µg/L)
HCS240 Trail	4/13/16	<5.00
	9/27/16	9.28 J
HCS260 Lead	4/12/16	<5.00
	9/26/16	5.33 J
HCS270 Lead	4/12/16	<5.00
	9/26/16	6.28 J
HCS270 Peak	4/13/16	<5.00
	9/26/16	6.74 J
HCS270 Trail	4/13/16	<5.00
	9/27/16	7.43 J
FDHCS270 Trail	4/13/16	<5.00
	9/27/16	5.81 J
PCL		6

J – Detection is greater than the method detection limit, but less than the reporting limit

µg/L – micrograms per liter

PCL – protective concentration level

Figure 23. Bis(2-ethylhexyl) Phthalate (DEHP) in Comal Springs Complex Stormwater Samples September 2016 Compared to Protective Concentration Level (PCL)



7.1.3.4 Stormwater – Herbicides and Pesticides

One organophosphorus pesticide and one herbicide were detected in stormwater samples from the Comal Springs complex in 2016.

The organophosphorus pesticide, disulfoton, was detected in one sample during the September 2016 storm event. The detection occurred at HCS260 Lead at a concentration of 0.373 µg/L. This detection is “J” flagged, indicating the detected concentration is less than the laboratory reporting limit, but greater than the method detection limit. The detection is well below the MCL of 0.98 µg/L.

The herbicide compound, 2,4-D, was detected during the storm event in the Comal Springs complex sampled during both the April and September 2016 events. The compound was detected in a total of five samples. All of the detections are “J” flagged, indicating the detected concentration is less than the laboratory reporting limit, but greater than the method detection limit. None of the detections approach the MCL of 70 µg/L for 2,4-D.

Herbicide detections are summarized below in Table 12.

**Table 12. Stormwater Samples – Herbicide
Detections – Comal Springs Complex**

Location	Date	2,4-D (µg/L)
HCS210 Trail	4/13/16	<0.0354
	9/27/16	0.0368 J
HCS240 Peak	4/13/16	0.0677 J
	9/26/16	<0.0356
HCS250 Peak	4/13/16	0.227 J
	9/26/16	<0.0351
HCS270 Lead	4/12/16	0.255 J
	9/26/16	<0.0350
HCS270 Peak	4/13/16	0.216 J
	9/26/16	<0.0350
MCL		70

J – Detection is greater than the method detection limit, but less than the reporting limit

µg/L – micrograms per liter

MCL – maximum contaminant level

7.1.3.5 Stormwater – Polychlorinated Biphenyls (PCBs)

Stormwater samples were analyzed for the various Aroclor compounds that are generally referred to collectively as PCBs. None of the stormwater samples from the Comal Springs complex indicated positive detections of PCB compounds during the April or September 2016 sampling events.

7.1.3.6 Stormwater – Metals

Stormwater samples were analyzed for metals in accordance with the EAHCP Work Plan. Several positive metal detections were noted in the sample set; however, no samples contained a metal at a concentration in excess of the drinking water MCL and most detections were below laboratory reporting limits.

7.1.3.7 Stormwater – Nitrates

Stormwater samples were analyzed for nitrate-nitrite as nitrogen in accordance with the EAHCP Work Plan. All nitrate results were below the MCL of 10 mg/L. For the April 2016 event, the range of nitrate results was 0.492 J mg/L to 1.77 mg/L, with an average of 1.49 mg/L. During the September 2016 event, nitrate concentrations ranged from 0.404 J mg/L to 1.78 mg/L, with an average of 1.33 mg/L. For comparison the average nitrate in spring water samples at Comal Springs for calendar year 2014 was 1.91 mg/L (EAA 2015). Nitrate results are summarized in Table 13.

**Table 13. Stormwater Samples – Nitrate Detections
– Comal Springs Complex**

Location	Date	Concentration (mg/L)
HCS210 Lead	4/12/2016	0.923
	9/26/2016	0.404 J
HCS210 Peak	4/13/2016	0.492 J
	9/26/2016	0.664
HCS210 Trail	4/13/2016	0.867
	9/27/2016	0.565
HCS240 Lead	4/12/2016	1.77
	9/26/2016	1.04
HCS240 Peak	4/13/2016	1.67
	9/26/2016	1.62
HCS240 Trail	4/13/2016	1.75
	9/27/2016	1.68
HCS250 Lead	4/12/2016	1.63
	9/26/2016	1.21
HCS250 Peak	4/13/2016	1.41
	9/26/2016	1.21
HCS250 Trail	4/13/2016	1.67
	9/27/2016	1.67
HCS260 Lead	4/12/2016	1.76
	9/26/2016	1.78
HCS260 Peak	4/13/2016	1.69
	9/26/2016	1.40
HCS260 Trail	4/13/2016	1.53
	9/27/2016	1.65
FDHCS260 Trail	4/13/2016	1.53
	9/27/2016	1.65
HCS270 Lead	4/12/2016	1.77
	9/26/2016	1.62
HCS270 Peak	4/13/2016	1.60
	9/26/2016	1.21
HCS270 Trail	4/13/2016	1.67
	9/27/2016	1.64
FDHCS270 Trail	4/13/2016	1.66
	9/27/2016	1.63
MCL		10

J – Detection is greater than the method detection limit, but less than the reporting limit

mg/L – milligrams per liter

7.1.3.8 Stormwater – Caffeine

Stormwater was analyzed for caffeine, which can indicate an anthropogenic source. Caffeine may enter surface water from leaking sewer or septic systems or it may be present in the aquifer from similar sources in the recharge zone (EPA 2012). Potential ecological effects are currently unknown but could include reduced reproductive success of aquatic organisms (EPA 2012). Caffeine detections in stormwater samples from Comal Springs in April 2016 ranged from 45 ng/L to 110,000 ng/L. In September 2016, caffeine detections ranged from 13 ng/L to 920 ng/L. There is no regulatory standard or expected value for comparison. These results are shown in Table 14.

Table 14. Stormwater Samples – Caffeine Detections – Comal Springs Complex

Location	Date Collected	Caffeine (ng/L)
HCS210 Lead	4/12/2016	91
	9/26/2016	480
HCS210 Peak	4/13/2016	93000
	9/26/2016	280
HCS210 Trail	4/13/2016	50000
	9/27/2016	170
HCS240 Lead	4/12/2016	45
	9/26/2016	300
HCS240 Peak	4/13/2016	90000
	9/26/2016	67
HCS240 Trail	4/13/2016	9200
	9/27/2016	30
HCS250 Lead	4/12/2016	100000
	9/26/2016	240
HCS250 Peak	4/13/2016	110000
	9/26/2016	450
HCS250 Trail	4/13/2016	9900
	9/27/2016	54
HCS260 Lead	4/12/2016	35000
	9/26/2016	97
HCS260 Peak	4/13/2016	27000
	9/26/2016	150
HCS260 Trail	4/13/2016	38000
	9/27/2016	13
FDHCS260 Trail	4/13/2016	28000
	9/27/2016	36
HCS270 Lead	4/12/2016	47000
	9/26/2016	380

Table 14. Stormwater Samples – Caffeine Detections – Comal Springs Complex

Location	Date Collected	Caffeine (ng/L)
HCS270 Peak	4/13/2016	86000
	9/26/2016	400
HCS270 Trail	4/13/2016	28000
	9/27/2016	920
FDHCS270 Trail	4/13/2016	35000
	9/27/2016	35

ng/L – nanograms per liter

7.1.4 Comal Springs Surface Water Passive Sampling

PDSs were installed in the Comal Springs system in February, April, June, August, October and December 2016. The PDS was not analyzed from site HCS460 in April 2016 due to sediment collection on the deployment device. Any changes to deployment locations or non-recovered samplers are discussed in Appendix C.

Rain events did occur during some PDS deployment periods during 2016. Figures 24–29 show specific conductivity and discharge for each PDS deployment period. In April 2016, samplers were removed from the river after a period of 12 days instead of the 14 days as called for in the EAHCP Work Plan. A large storm was forecasted for the area. When the forecast was brought to the attention of EAA staff, EAA requested the PDS be retrieved prior to the storm event because of concerns that samplers could be lost and that the PDS results would not reflect base flow conditions. This deviation is discussed in greater detail in Appendix C.

There is not a suitable set of regulatory standards to compare PDS results to, but rather the data are a qualitative tool for evaluating the presence of trace concentrations of organic compounds. PDSs were analyzed for a suite of SVOCs, VOCs, and organochlorine pesticides. Few compounds were detected, the most notable are relatively consistent detections of tetrachloroethene. Positive detections are shown in Table 15.

Figure 24. Passive Diffusion Sampling – February 2016 Stream Discharge and Specific Conductivity – Comal Springs Complex

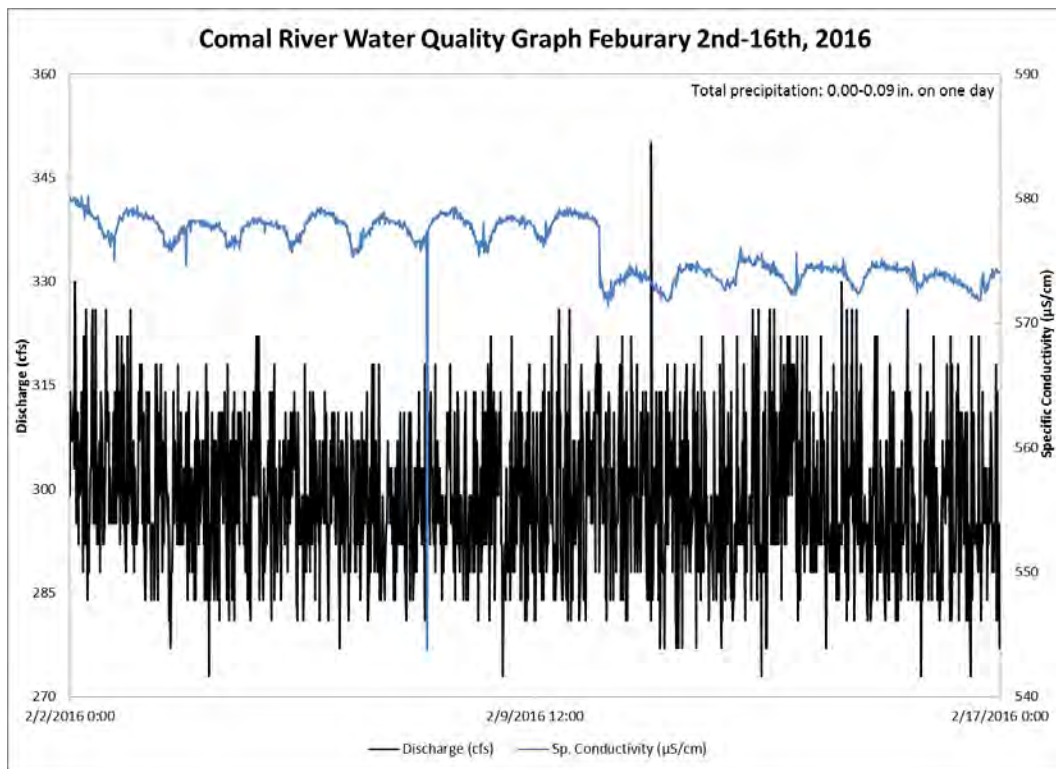


Figure 25. Passive Diffusion Sampling – April 2016 Stream Discharge and Specific Conductivity – Comal Springs Complex

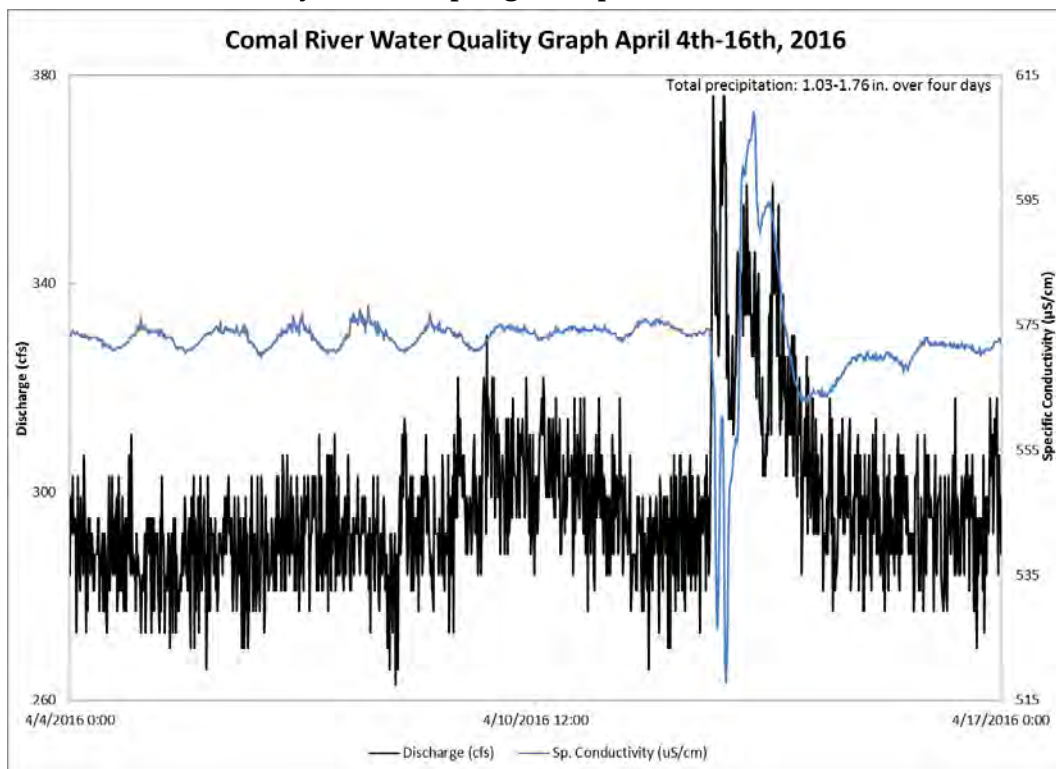


Figure 26. Passive Diffusion Sampling – June 2016 Stream Discharge and Specific Conductivity – Comal Springs Complex

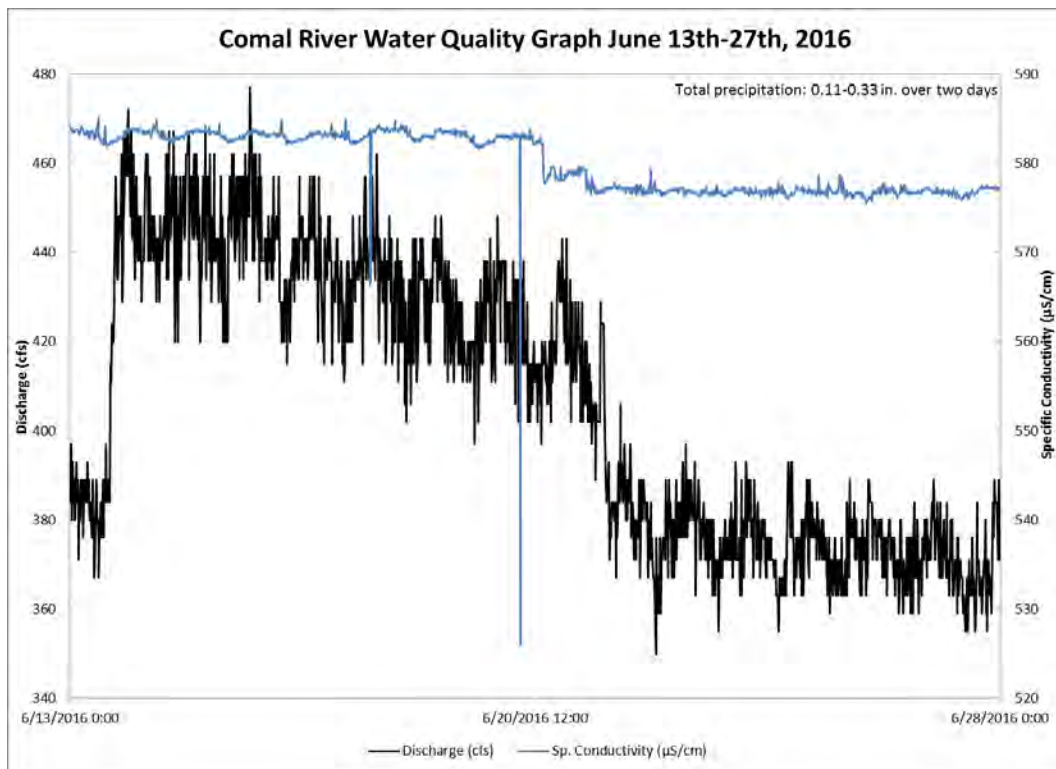


Figure 27. Passive Diffusion Sampling – August 2016 Stream Discharge and Specific Conductivity – Comal Springs Complex

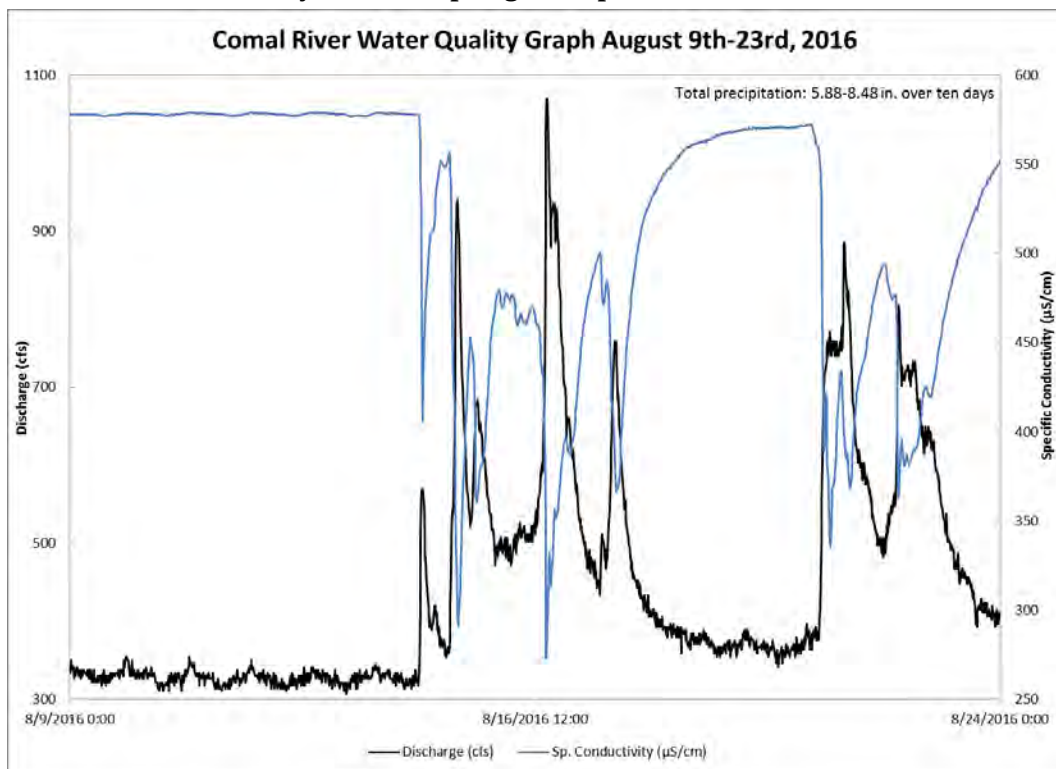


Figure 28. Passive Diffusion Sampling – October 2016 Stream Discharge and Specific Conductivity – Comal Springs Complex

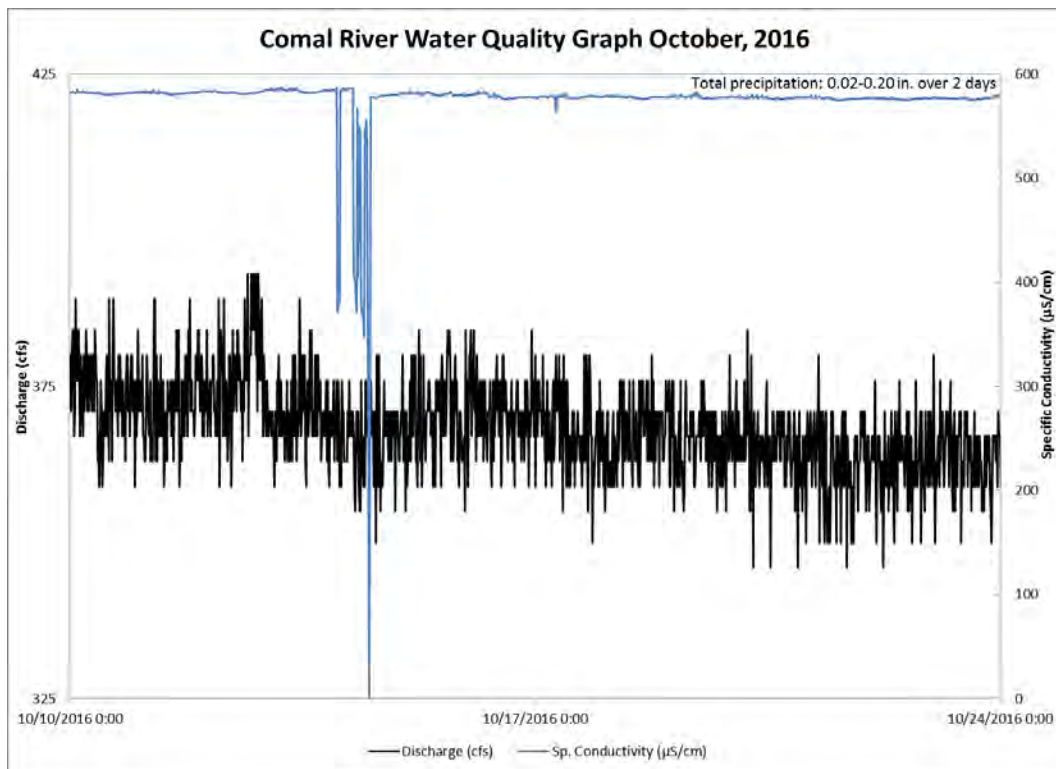


Figure 29. Passive Diffusion Sampling – December 2016 Stream Discharge and Specific Conductivity – Comal Springs Complex

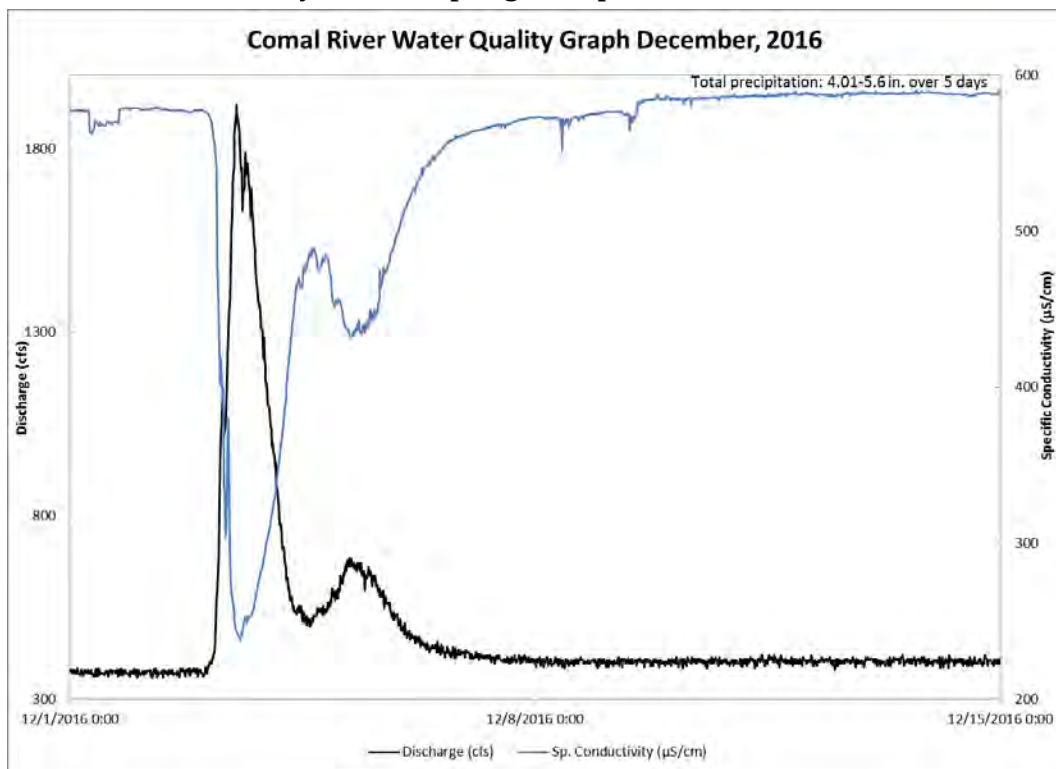


Table 15. Passive Diffusion Samples – Comal Springs Complex

Location	Month 2016	Acenaphthene (µg)	Acenaphthylene (µg)	Anthracene (µg)	BTEX (µg)	Chloroform (µg)	Fluoranthene (µg)	Fluorene (µg)	p/m-Xylene (µg)	Phenanthrene (µg)	Pyrene (µg)	Tetrachloroethene (µg)	TPH (µg)
HCS410	February	<0.05	<0.05	<0.05	<0.02	0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.08	<0.50
	April	<0.05	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.09	<0.50
	June	0.37	0.09	0.11	<0.02	0.02	0.16	0.72	<0.02	0.56	0.14	0.23	6.33
	August	<0.05	<0.05	<0.50	<0.02	<0.02	<0.50	<0.05	<0.02	<0.50	<0.50	0.09	0.51
	October	<0.05	<0.05	<0.05	<0.02	0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.16	<0.50
	December	<0.05	<0.05	<0.05	<0.02	0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.10	<0.50
HCS420	February	<0.05	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.22	<0.50
	April	<0.05	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.16	<0.50
	June	<0.05	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.18	0.72
	August	<0.05	<0.05	<0.50	<0.02	<0.02	<0.50	<0.05	<0.02	<0.50	<0.50	0.19	0.54
	October	<0.05	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.23	<0.50
	December	<0.05	<0.05	<0.50	<0.02	<0.02	<0.50	<0.05	<0.02	<0.50	<0.50	0.32	<0.50
HCS430	February	<0.05	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.40	<0.50
	April	<0.05	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.48	<0.50
	June	0.09	<0.05	<0.05	<0.02	<0.02	<0.05	0.25	<0.02	0.2	<0.05	0.55	1.75
	August	<0.05	<0.05	<0.50	<0.02	<0.02	<0.50	<0.05	<0.02	<0.50	<0.50	0.56	0.55
	October	<0.05	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.58	<0.50
	December	<0.05	<0.05	<0.50	<0.02	<0.02	<0.50	<0.05	<0.02	<0.50	<0.50	0.59	<0.50
HCS440	February	<0.05	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.40	<0.50
	April	<0.05	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.32	<0.50
	June	<0.05	<0.05	<0.05	<0.02	<0.02	<0.05	0.12	<0.02	0.1	<0.05	0.35	1.68
	August	<0.05	<0.05	<0.50	<0.02	<0.02	<0.50	<0.05	<0.02	<0.50	<0.50	0.39	0.75
	October	<0.05	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.32	<0.50
	December	<0.05	<0.05	<0.50	<0.02	<0.02	<0.50	<0.05	<0.02	<0.50	<0.50	0.33	<0.50

Table 15. Passive Diffusion Samples – Comal Springs Complex

Location	Month 2016	Acenaphthene (µg)	Acenaphthylene (µg)	Anthracene (µg)	BTEX (µg)	Chloroform (µg)	Fluoranthene (µg)	Fluorene (µg)	p/m-Xylene (µg)	Phenanthrene (µg)	Pyrene (µg)	Tetrachloroethene (µg)	TPH (µg)
FDHCS440	February	<0.05	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.33	<0.50
	April	<0.05	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.3	<0.50
	June	<0.05	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.02	0.05	<0.05	0.35	1.4
	August	<0.05	<0.05	<0.50	<0.02	<0.02	<0.50	<0.05	<0.02	<0.50	<0.50	0.39	0.77
	October	<0.05	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.34	<0.50
	December	<0.05	<0.05	<0.50	<0.02	<0.02	<0.50	<0.05	<0.02	<0.50	<0.50	0.34	<0.50
HCS460	February	<0.05	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.27	<0.50
	April	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	June	0.25	0.05	0.08	0.04	<0.02	0.08	0.76	0.04	0.46	0.06	0.3	4.99
	August	<0.05	<0.05	<0.50	<0.02	<0.02	<0.50	<0.05	<0.02	<0.50	<0.50	0.19	0.60
	October	<0.05	<0.05	<0.05	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	0.33	<0.50
	December	<0.05	<0.05	<0.50	<0.02	<0.02	<0.50	<0.05	<0.02	<0.50	<0.50	0.27	<0.50

BTEX – benzene, toluene, ethylbenzene, and xylenes

NA – Not analyzed

TPH – total petroleum hydrocarbons

µg – micrograms

7.2 San Marcos Springs Sample Results

The surface waters associated with the San Marcos Springs complex were sampled for surface water (base flow) conditions in March and September 2016. In general, few detections were noted. As discussed previously, surface water samples are compared to the drinking water standards for water quality in this report.

Sediments at the San Marcos Springs complex were sampled in June 2016. Sediment results were compared to the standards developed by McDonald et al. (2000). These standards are based on the probability of a detected compound having a toxic effect on sediment dwelling organisms and are referred to as the TEC and PEC. Detections below the TEC are not considered to be toxic, whereas detections above the PEC are considered to be toxic to sediment-dwelling organisms. Detections above the TEC but less than the PEC are considered to be equally likely to be toxic or non-toxic.

Stormwater events were sampled at the San Marcos Springs complex in March and November 2016. Generally speaking, stormwater results did not indicate a significant number of detections of concern.

PDS sampling events were conducted at the San Marcos Springs complex in February, April, June, August, October, and December 2016. Generally speaking, various VOCs and TPH were detected at various sample locations, but only tetrachloroethene was relatively consistently detected.

7.2.1 San Marcos Springs Surface Water / Base Flow Sampling

The San Marcos Springs complex was sampled on March 3 and September 9, 2016, for surface water (base flow) events.

7.2.1.1 *Surface Water / Base flow – Bacteria*

Bacteria results for surface water (base flow) associated with the San Marcos Springs complex ranged from 5 MPN/100 mL through 91 MPN/100 mL for *E. coli*. Because of the presence of various fauna in surface water collection sites, positive detections are common. The 2014 Texas Surface Water Quality Standard for *E. coli* in primary recreation waters is a geometric mean of 126 MPN/100 mL with no individual sample exceeding 399 MPN/100 mL (30 TAC 307.7). The geometric mean for surface water samples collected from the San Marcos Springs complex during 2016 was approximately 33 MPN/100 mL. No surface water samples collected from the San Marcos Springs in 2016 exceeded the individual sample limit of 399 MPN/100 mL. Surface water (base flow) bacteria counts are summarized in Table 16.

**Table 16. Surface Water Samples – Bacteria Counts
– San Marcos Springs Complex**

Location	Date	Count (MPN/100 mL)
HSM110	3/3/2016	15
	9/9/2016	89
FDHSM110	3/3/2016	13
	9/9/2016	91
HSM120	3/3/2016	64
	9/9/2016	86
HSM130	3/3/2016	5
	9/9/2016	41
HSM140	3/3/2016	49
	9/9/2016	56
HSM150	3/3/2016	28
	9/9/2016	37
HSM160	3/3/2016	17
	9/9/2016	29
HSM170	3/3/2016	17
	9/9/2016	49

MPN/100 mL – most probable number per 100 milliliters

7.2.1.2 Surface Water / Base Flow – Volatile Organic Compounds (VOCs)

No VOCs were detected in the San Marcos Springs surface water samples in March or September 2016.

7.2.1.3 Surface Water / Base Flow – Semi-volatile Organic Compounds (SVOCs)

Surface water samples were analyzed for SVOCs because their detection can indicate the presence of chemicals originating from anthropogenic sources; and therefore, can be used to evaluate potential impacts on water quality. Three SVOCs were detected in surface water samples from the San Marcos Springs complex. Note all detections are “J” flagged, indicating the detected concentration is less than the laboratory reporting limit, but greater than the method detection limit. All detections of DEHP in San Marcos surface water samples from 2016 were above the PCL of 6 µg/L. Di-n-butyl phthalate was detected in the method blank associated with the September 2016 samples at a concentration of 3.858 µg/L, this may have affected detection results. Detections are summarized in Table 17 and DEHP detections are shown in Figure 30.

Table 17. Surface Water Samples – Semi-volatile Organic Compound Detections – San Marcos Springs Complex

Location	Date Collected	Bis(2-ethylhexyl) phthalate (µg/L)	Diethyl phthalate (µg/L)	Di-n-butyl phthalate (µg/L)
HSM110	3/3/16	<5.00	<0.666	<0.709
	9/9/16	<5.00	<0.666	2.18 J B
FDHSM110	3/3/16	<5.00	<0.666	<0.709
	9/9/16	<5.00	<0.666	3.66 J B
HSM120	3/3/16	12.5 J	3.16 J	<0.709
	9/9/16	6.04 J	<0.666	<0.709
HSM130	3/3/16	<5.00	<0.666	<0.709
	9/9/16	11.3 J	<0.666	2.30 J B
HSM140	3/3/16	<5.00	<0.666	<0.709
	9/9/16	<5.00	<0.666	<0.709
HSM150	3/3/16	<5.00	<0.666	<0.709
	9/9/16	<5.00	<0.666	<0.709
HSM160	3/3/16	<5.00	<0.666	<0.709
	9/9/16	<5.00	<0.666	<0.709
HSM170	3/3/16	<5.00	<0.666	<0.709
	9/9/16	19.0 J	<0.666	2.11 J B
MCL		NE	NE	NE
PCL		6	20000	2400

B – Analyte was detected in associated method blank

J – Detection is greater than the method detection limit, but less than the reporting limit

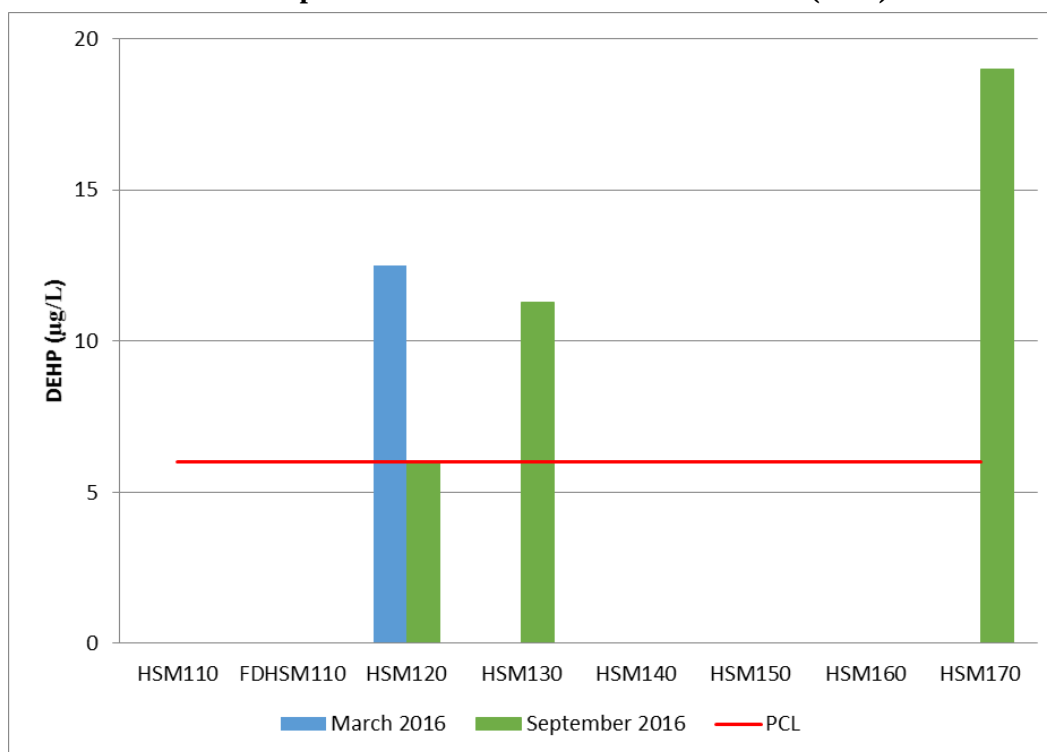
MCL – maximum contaminant level

NE – not established

PCL – protective concentration level

µg/L – micrograms per liter

Figure 30. Bis(2-ethylhexyl) Phthalate (DEHP) in San Marcos Springs Complex Surface Water Compared to Protective Concentration Level (PCL)



7.2.1.4 Surface Water / Base Flow – Pesticides

Surface water samples were analyzed for pesticides because their detection can indicate the presence of chemicals originating from anthropogenic sources; and therefore, can be used to evaluate potential impacts on water quality. No pesticides were detected in any of the San Marcos Springs complex surface water samples during March and September 2016. Due to an error at the laboratory, water samples for organophosphorus pesticides collected on September 9, 2016 were resampled October 24, 2016. This deviation is discussed further in Appendix C of this report.

7.2.1.5 Surface Water / Base flow – Herbicides

Surface water samples were analyzed for herbicides because their detection can indicate the presence of chemicals originating from anthropogenic sources; and therefore, can be used to evaluate potential impacts on water quality. Herbicides were not detected for the March or September 2016 sampling events at any of the seven sites for the San Marcos Springs complex.

7.2.1.6 Surface Water / Base Flow – Polychlorinated Biphenyls (PCBs)

Surface water samples were analyzed for the various Aroclor compounds that are generally referred to collectively as PCBs. PCBs are sampled because their detection can indicate the presence of chemicals originating from anthropogenic sources and therefore help in the evaluation of potential impacts on water quality. PCBs were not detected for the March or September 2016 sampling events at any of the seven sites for the San Marcos Springs complex.

7.2.1.7 Surface Water / Base Flow – Metals

Surface water samples were analyzed for metals because their detection can indicate the presence of chemicals originating from anthropogenic sources; and therefore, can be used to evaluate potential impacts on water quality. Although metals were detected for both the March and September 2016 sampling events at all seven sites for the San Marcos Springs complex, no metals of concern were detected at concentrations in excess of the drinking water standards. Arsenic, barium, chromium, copper, lead, manganese, selenium, and zinc were detected; however, none of their concentrations exceeded a regulatory standard. These detections are listed in Table 18. Note many detections are “J” flagged, indicating the detected concentration is less than the laboratory reporting limit, but greater than the method detection limit.

Table 18. Surface Water Samples – Metal Detections – San Marcos Springs Complex

Location	Date Collected	Arsenic (mg/L)	Barium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Manganese (mg/L)	Selenium (mg/L)	Zinc (mg/L)
HSM110	3/3/16	<0.00109	0.028	<0.0014	<0.002	<0.000733	0.112	<0.00108	<0.00355
	9/9/16	0.00152 J	0.0427	0.0115	0.0334	0.00289 J	0.275	<0.00108	<0.00355
FDHSM110	3/3/16	<0.00109	0.0282	<0.0014	<0.002	<0.000733	0.119	<0.00108	<0.00355
	9/9/16	0.00129 J	0.0417	<0.00140	<0.00200	<0.000733	0.275	<0.00108	<0.00355
HSM120	3/3/16	<0.00109	0.0266	<0.0014	<0.002	<0.000733	<0.0116	<0.00108	<0.00355
	9/9/16	<0.00109	0.0382	<0.00140	<0.00200	<0.000733	<0.0116	0.00165 J	<0.00355
HSM130	3/3/16	<0.00109	0.0317	<0.0014	<0.002	<0.000733	<0.0116	<0.00108	<0.00355
	9/9/16	<0.00109	0.0422	<0.00140	<0.00200	<0.000733	<0.0116	0.00130 J	<0.00355
HSM140	3/3/16	<0.00109	0.0291	<0.0014	<0.002	0.000737 J	<0.0116	<0.00108	<0.00355
	9/9/16	<0.00109	0.0369	<0.00140	<0.00200	<0.000733	<0.0116	0.00184 J	<0.00355
HSM150	3/3/16	<0.00109	0.0375	<0.0014	<0.002	<0.000733	<0.0116	<0.00108	<0.00355
	9/9/16	<0.00109	0.0388	<0.00140	<0.00200	<0.000733	<0.0116	<0.00108	<0.00355
HSM160	3/3/16	<0.00109	0.0351	0.00414 J	0.00677 J	<0.000733	<0.0116	<0.00108	0.00464 J
	9/9/16	<0.00109	0.0385	<0.00140	<0.00200	<0.000733	<0.0116	<0.00108	<0.00355
HSM170	3/3/16	<0.00109	0.0351	<0.0014	<0.002	<0.000733	<0.0116	<0.00108	<0.00355
	9/9/16	<0.00109	0.0377	<0.00140	<0.00200	<0.000733	<0.0116	<0.00108	<0.00355
MCL		0.01	2	0.1	NE	NE	NE	0.05	NE
PCL		--	--	--	1.3	0.015	3.4	--	7.3

-- -- Not applicable

J – Detection is greater than the method detection limit, but less than the reporting limit.

Mg/L – milligrams per liter

MCL – maximum contaminant level

NE – None Established

PCL – protective concentration levels

7.2.1.8 Surface Water / Base Flow – Nitrates

Surface water samples were analyzed for nitrate-nitrite as nitrogen. Laboratory analyses indicated a limited range of nitrate-nitrite as nitrogen in surface water samples. Of the 16 surface water samples (14 environmental samples and two field duplicates) collected for the two sample events, concentrations ranged

from 0.585 mg/L to 1.68 mg/L. None of the nitrate concentrations exceeded the MCL of 10 mg/L for drinking water. The highest nitrate concentration in surface water at the San Marcos Springs complex was 1.68 H mg/L from HSM130 sampled on September 9, 2016. Nitrate-nitrogen results are summarized in Table 19. Due to oversight at the laboratory some nitrate samples were analyzed outside of hold time in September 2016 this is further discussed in Appendix C.

Table 19. Surface Water Samples – Nitrate Detections – San Marcos Springs Complex

Location	Date	Concentration (mg/L)
HSM110	3/3/2016	0.706 H
	9/9/2016	0.585
FDHSM110	3/3/2016	0.706 H
	9/9/2016	0.587
HSM120	3/3/2016	1.24 H
	9/9/2016	1.3
HSM130	3/3/2016	1.67 H
	9/9/2016	1.68
HSM140	3/3/2016	1.25
	9/9/2016	1.21
HSM150	3/3/2016	1.25
	9/9/2016	1.21
HSM160	3/3/2016	1.24
	9/9/2016	1.19
HSM170	3/3/2016	1.23
	9/9/2016	1.18
MCL		10

H – Analyzed outside hold time, result included for comparison but not considered valid

mg/L – milligrams per liter

7.2.1.9 Surface Water / Base Flow – Caffeine

Surface water base flows were analyzed for caffeine, which can indicate the possible presence of human wastewater discharge. Caffeine may enter surface water from leaking sewer or septic systems or it may be present in the aquifer from similar sources in the recharge zone (EPA 2012). Potential ecological effects are currently unknown but could include reduced reproductive success in aquatic species (EPA 2012). Caffeine detections in surface water samples from San Marcos Springs in 2016 ranged from 2.6 ng/L to 53 ng/L. There is no regulatory standard or expected value for comparison. Results are shown in Table 20.

**Table 20. Surface Water Samples – Caffeine
Detections – San Marcos Springs Complex**

Location	Date Collected	Caffeine (ng/L)
HSM110	3/3/2016	23
	9/9/2016	39
FDHSM110	3/3/2016	2.6
	9/9/2016	<0.31
HSM120	3/3/2016	15
	9/9/2016	<0.31
HSM150	3/3/2016	<0.31
	9/9/2016	13
HSM170	3/3/2016	<0.31
	9/9/2016	53

ng/L – nanograms per liter

7.2.2 San Marcos Springs Sediment Sampling

7.2.2.1 Sediment – Volatile Organic Compounds (VOCs)

VOCs were detected in sediment samples collected at all of the seven sample sites in the San Marcos Springs complex in 2016. Note many detections are “J” flagged, indicating the detected concentration is less than the laboratory reporting limit, but greater than the method detection limit. Methylene chloride was detected in the method blank at a concentration of 56.6 J µg/kg, which may affect detection results. None of the detected compounds have established TEC and PECs. The detections are summarized below in Table 21.

Table 21. Sediment Samples – Volatile Organic Compound Detections – San Marcos Springs Complex

Location	Date Collected	Acetone (µg/kg)	2-Butanone (µg/kg)	Methylene chloride (µg/kg)	p-Isopropyltoluene (µg/kg)	Toluene (µg/kg)
HSM310	6/9/16	226 J	40.4 J	<60.2	<4.75	<10.8
HSM320	6/9/16	247 J	33.3 J	<68.5	<5.41	129
HSM330	6/9/16	12.7 J	<1.88	<4.96	<0.392	<0.892
HSM340	6/9/16	62.8 J	<13.4	<35.3	<2.79	<6.35
HSM350	6/9/16	225 J	35.2 J	56.6 J B	15.7 J	<8.04
HSM360	6/9/16	25.8 J	3.89 J	<6.38	<0.504	<1.15
HSM370	6/9/16	13.1 J	<2.36	<6.20	<0.490	<1.12
FDHSM370	6/9/16	10.4 J	<2.50	<6.57	<0.519	<1.18
TEC		NE	NE	NE	NE	NE
PEC		NE	NE	NE	NE	NE

B – Analyte was detected in associated method blank

J – Detection is greater than the method detection limit, but less than the reporting limit.

µg/kg – micrograms per kilogram

NE – Not established

PEC – probable effect concentration

TEC – threshold effect concentration

7.2.2.2 Sediment – Semi-volatile Organic Compounds (SVOCs)

Several SVOC compounds were detected in the sediment samples collected in the San Marcos Springs system in 2016. Many of these detections are “J” flagged, indicating the detected concentration is less than the laboratory reporting limit, but greater than the method detection limit. The discussion of SVOC detections presented below is divided between non-PAH and PAH compounds.

Non-Polycyclic Aromatic Hydrocarbon (PAH) Detections

Three non-PAH SVOC compounds were detected in 2016 sediment samples from the San Marcos Spring complex, butyl benzyl phthalate, diethyl phthalate and 3- and 4-methylphenol. No TECs or PECs have been established for any of the non-PAH SVOCs detected.

Based on analysis of 2013 laboratory data, the EAA concluded that three compounds may have been laboratory artifacts. The compounds were DEHP, di-n-octyl phthalate, and di-n-butyl phthalate. The EAA noted in the *2013 Edwards Aquifer Habitat Conservation Plan Expanded Water Quality Report* (EAA 2013) that as the data set grows, additional conclusions could be drawn. The 2014 laboratory analyses of sediment samples did not detect di-n-octyl phthalate or di-n-butyl phthalate. However, DEHP was detected in three of the sediment samples (HSM320, HSM330, and HSM350) in 2014 leading SWCA to conclude it is possible DEHP is present within the sediment and not just a laboratory artifact. DEHP was detected again in three samples in 2015, HSM330, HSM340 and HSM350. In 2016, DEHP was detected in all San

Marcos sediment samples except HSM310 with concentrations ranging from 0.0671 J mg/kg to 0.668 J mg/kg. All detections in 2016 were less than the laboratory reporting limit, but were greater than the method detection limits. The detection of DEHP over the past three sampling events suggests DEHP is present within the sediment in the San Marcos River in the areas tested.

PAH Detections

The remaining SVOC detections are all PAH compounds and are listed in Table 22. PAH detections are further shown in Figures 31–39, where the total PAH concentrations (sum of all detected concentrations for each sample point) and individual detections are compared to the TEC and PEC values established by MacDonald et al. (2000). Sample locations HSM340 and HSM350 exceed the TEC for total PAH concentrations. HSM320 and HSM330 exceeded the PEC for total PAH concentrations. Individual PAH compound TECs were exceeded in samples HSM320, HSM340 and HSM350. Individual PAH compound PECs were exceeded in samples HSM320 and HSM330.

Table 22. Sediment Samples – Semi-volatile Organic Compound Detections - San Marcos Springs Complex

		PAH Compounds																		Non-PAH Compounds			
Location	Date Collected	Acenaphthene (mg/kg)	Anthracene (mg/kg)	Benzo (a) Anthracene (mg/kg)	Benzo (a) Pyrene (mg/kg)	Benzo (b) Fluoranthene (mg/kg)	Benzo (g,h,i) Perylene (mg/kg)	Benzo (k) Fluoranthene (mg/kg)	Chrysene (mg/kg)	Dibenz (a,h) anthracene (mg/kg)	Dibenzofuran (mg/kg)	Fluoranthene (mg/kg)	Fluorene (mg/kg)	Indeno(1,2,3-c,d) Pyrene (mg/kg)	2-Methylnaphthalene (mg/kg)	Naphthalene (mg/kg)	Phenanthrene (mg/kg)	Pyrene (mg/kg)	Total PAH (mg/kg)	Bis(2-Ethylhexyl) Phthalate (DEHP) (mg/kg)	Butyl benzyl phthalate (mg/kg)	Diethyl phthalate (mg/kg)	3- and 4-Methylphenol (mg/kg)
HSM310	6/9/16	<0.0811	<0.0907	<0.1	<0.0811	<0.0716	<0.0716	<0.062	<0.0716	<0.0668	<0.0907	<0.0811	<0.0907	<0.0764	<0.0716	<0.0764	<0.1	<0.0811	--	<0.124	<0.0668	<0.0764	0.883 J
HSM320	6/9/16	<0.111	0.232 J	1.85	2.09	3.67	1.55	1.3	2.62	0.606 J	<0.124	4.38	<0.124	1.64	<0.0981	<0.105	1.23	2.98	24.148	0.35 J	<0.0915	<0.105	0.289 J
HSM330	6/9/16	0.515 J	1.03	1.93	1.67	2.69	0.634 J	1.1	2.08	0.324 J	0.314 J	5.03	0.613 J	0.825	0.109 J	0.402 J	4.43	3.22	26.916	0.668 J	<0.0621	0.216 J	<0.124
HSM340	6/9/16	<0.0468	0.0841 J	0.295 J	0.307 J	0.547	0.105 J	0.21 J	0.346 J	0.0986 J	<0.0523	0.792	<0.0523	0.207 J	<0.0413	<0.044	0.337 J	0.589	3.9177	0.211 J	0.0554 J	<0.044	<0.0771
HSM350	6/9/16	<0.12	<0.134	0.21 J	0.246 J	0.511 J	0.108 J	0.172 J	0.281 J	<0.0989	<0.134	0.59 J	<0.134	0.324 J	<0.106	<0.113	0.182 J	0.352 J	2.976	0.586 J	<0.0989	<0.113	4.33
HSM360	6/9/16	<0.045	<0.0502	<0.0555	0.0578 J	0.0915 J	<0.0397	0.0601 J	0.0774 J	<0.037	<0.0502	0.13 J	<0.0502	0.114 J	<0.0397	<0.0423	<0.0555	0.073 J	0.6038	0.156 J	<0.037	<0.0423	<0.074
HSM370	6/9/16	<0.0233	<0.026	<0.0287	0.0244 J	0.0498 J	<0.0205	<0.0178	0.0291 J	<0.0191	<0.026	0.0492 J	<0.026	0.0596 J	<0.0205	<0.0219	<0.0287	0.0273 J	0.2394	0.0671 J	<0.0191	<0.0219	<0.0383
FDHSM370	6/9/16	<0.0237	<0.0265	<0.0293	<0.0237	<0.0209	<0.0209	<0.0181	<0.0209	<0.0195	<0.0265	0.0361 J	<0.0265	0.0503 J	<0.0209	<0.0223	<0.0293	<0.0237	0.0864	0.0816 J	<0.0195	<0.0223	<0.039
TEC		NE	0.0572	0.108	0.15	NE	NE	NE	0.166	NE	NE	0.423	0.0774	NE	NE	NE	0.204	0.195	1.610	NE	NE	NE	NE
PEC		NE	0.845	1.05	1.45	NE	NE	NE	1.29	NE	NE	2.23	0.536	NE	NE	NE	1.17	1.52	22.800	NE	NE	NE	NE

J – Detection is greater than the method detection limit, but less than the reporting limit.
Mg/kg – milligrams per kilogram
NE – Not established
PEC – probable effect concentration
TEC – threshold effect concentration
-- – not applicable

This page intentionally left blank.

Figure 31. San Marcos Springs Sediment Anthracene Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values

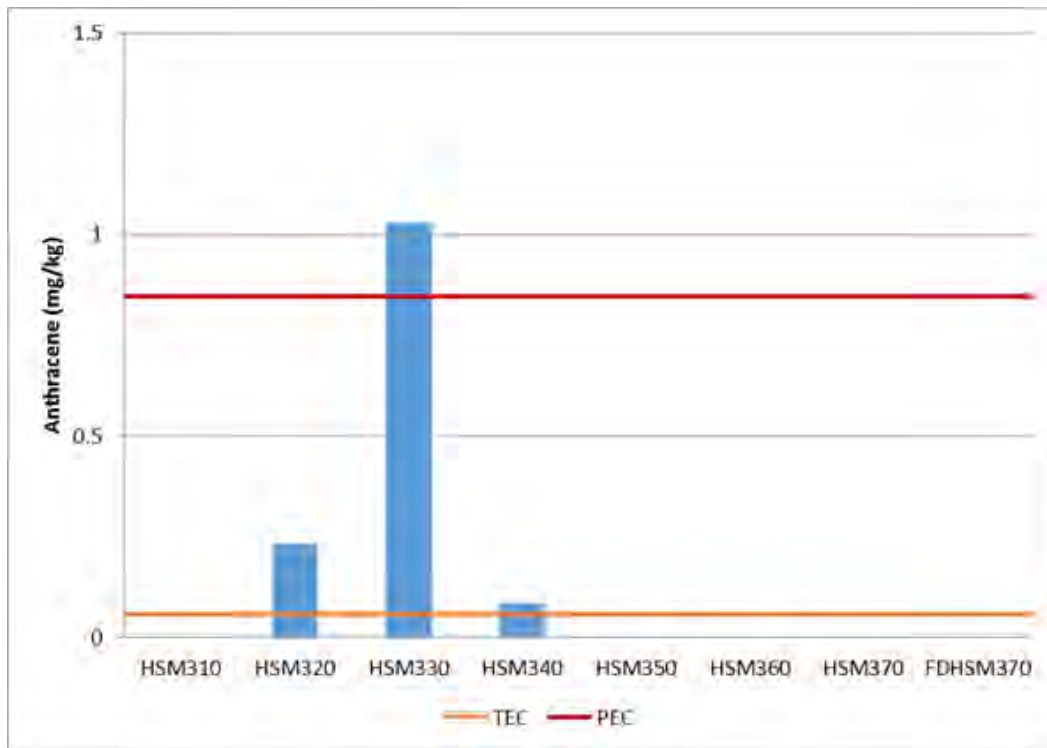


Figure 32. San Marcos Springs Sediment Benzo(a)anthracene Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values

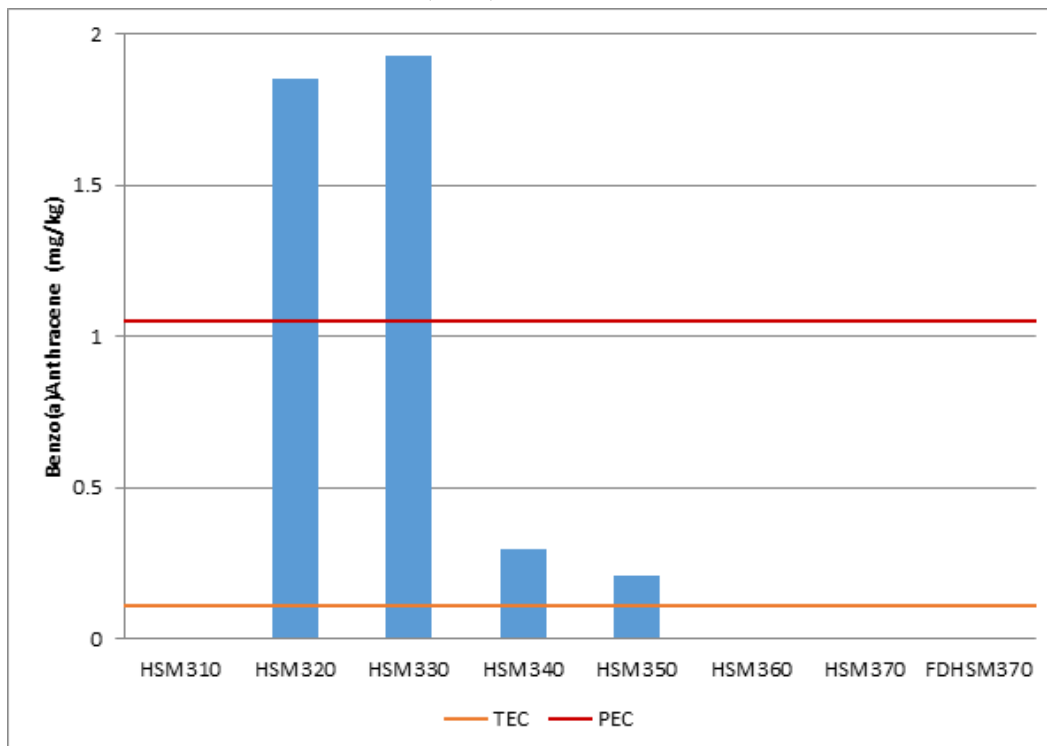


Figure 33. San Marcos Springs Sediment Benzo(a)pyrene Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values

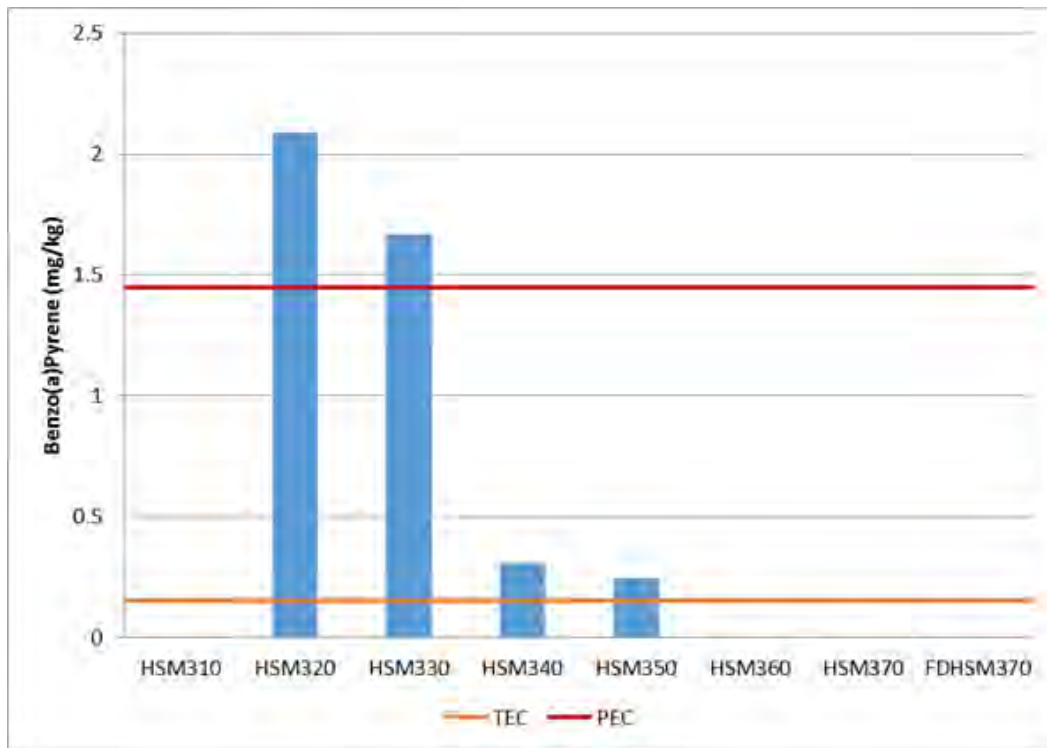


Figure 34. San Marcos Springs Sediment Chrysene Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values

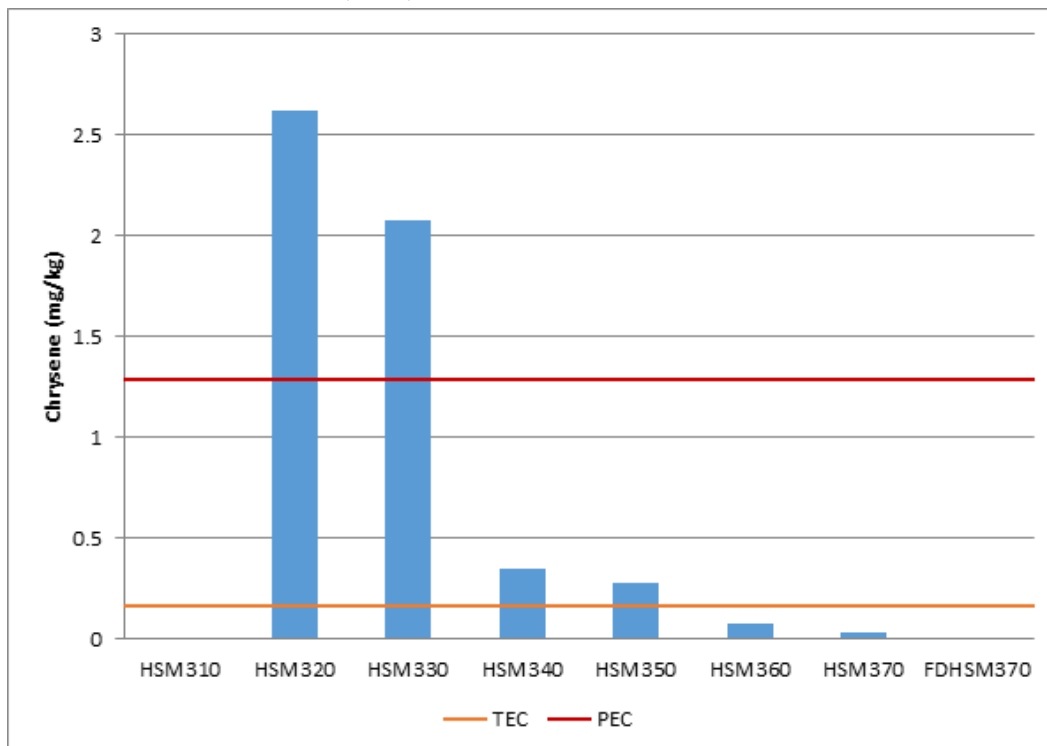


Figure 35. San Marcos Springs Sediment Fluoranthene Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values

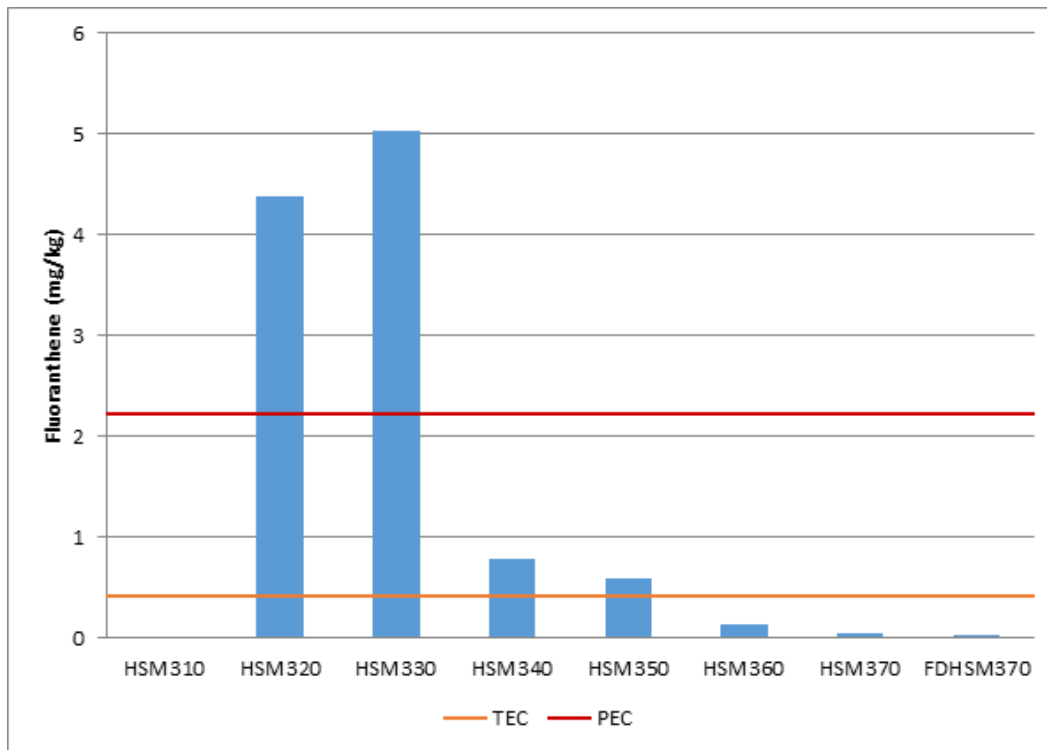


Figure 36. San Marcos Springs Sediment Fluorene Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values

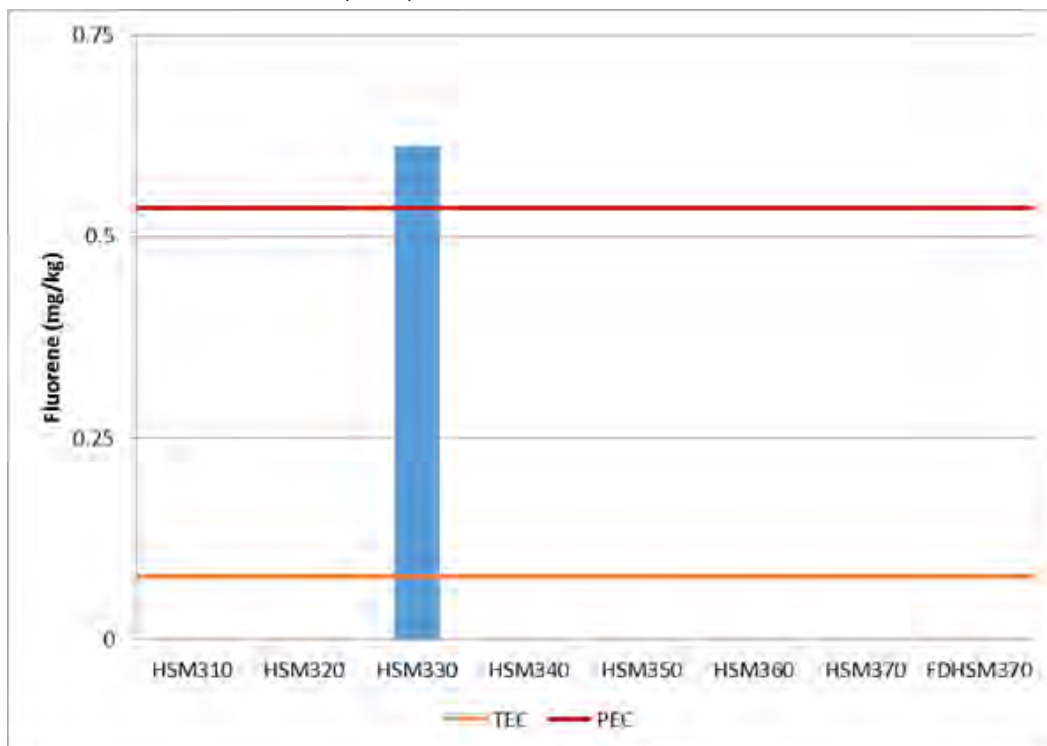


Figure 37. San Marcos Springs Sediment Phenanthrene Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values

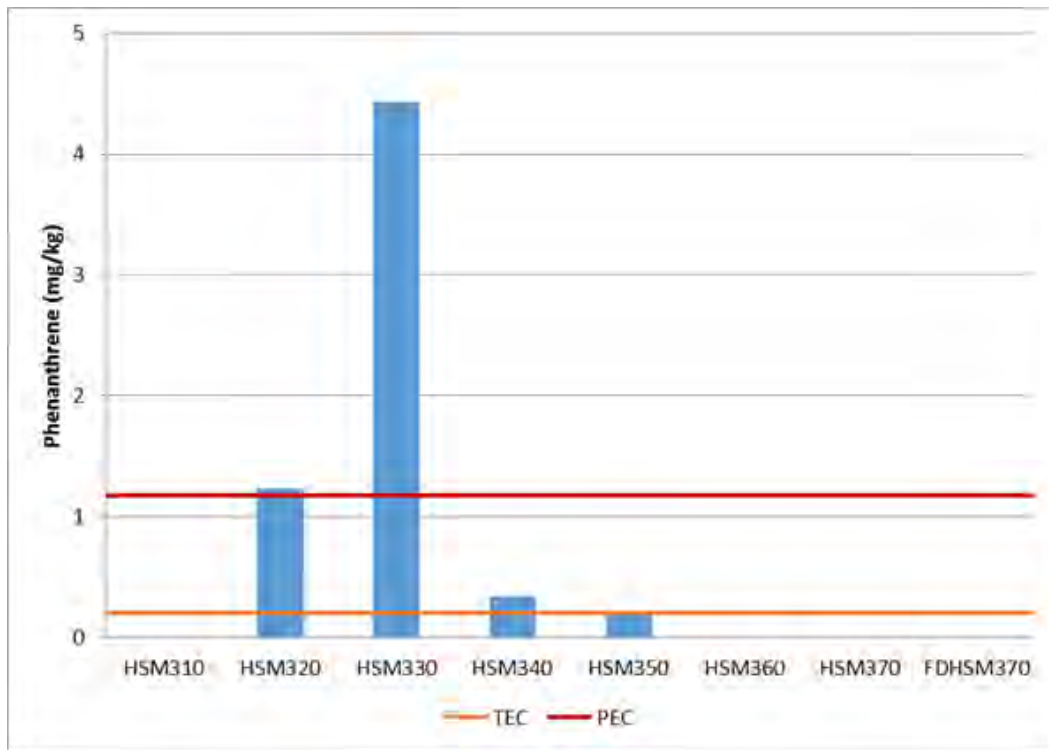


Figure 38. San Marcos Springs Sediment Pyrene Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values

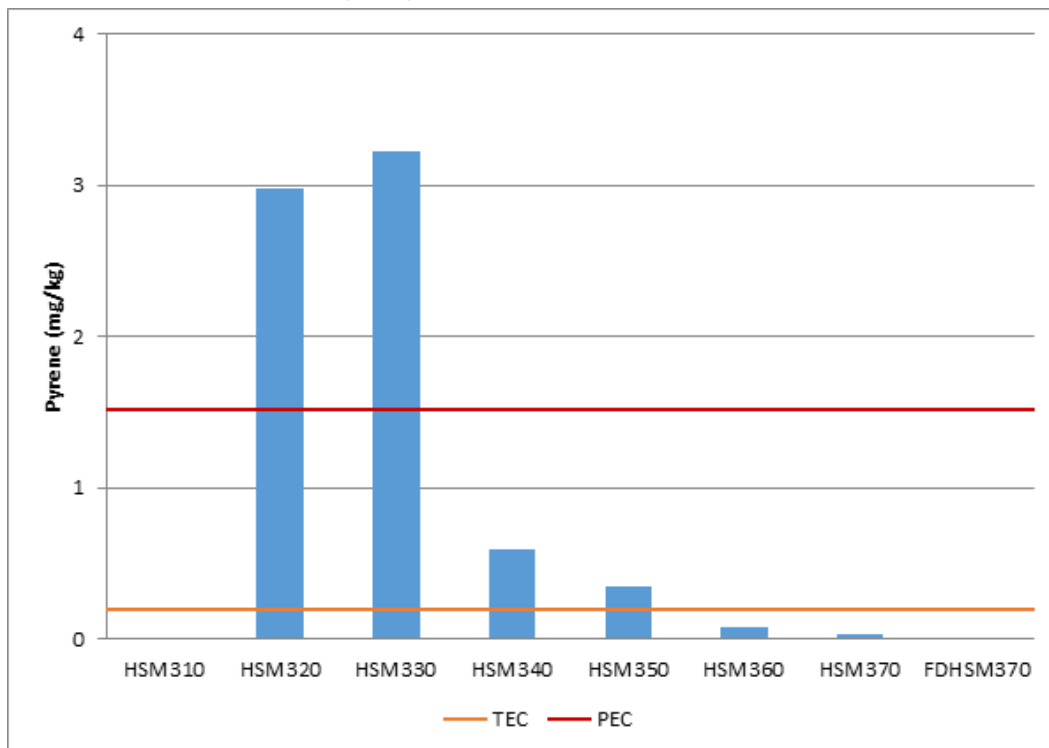
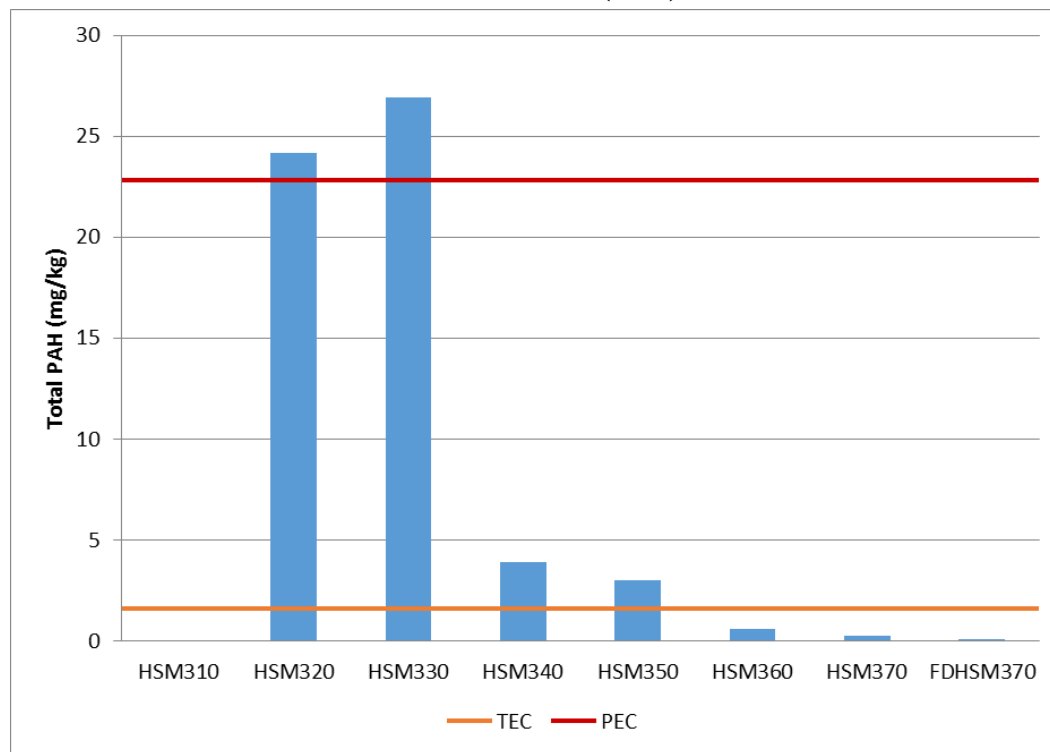


Figure 39. San Marcos Springs Sediment Polycyclic Aromatic Hydrocarbons (PAH) Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values



7.2.2.3 Sediment - Pesticides

Sediment samples were analyzed for both organochlorine and organophosphorus pesticides. Organochlorine pesticides were detected in the San Marcos Springs sediment samples in 2016 at HSM320, HSM340, and HSM350. The TEC for 4,4-DDD was exceeded in samples HSM320 and HSM340. The TEC for 4,4-DDE was exceeded at HSM350. The PEC for 4,4-DDE was also exceeded at HSM320 and HSM340. Alpha-chlordane and gamma-chlordane were also detected but do not have established TEC or PECs. Concentrations are listed in Table 23. TEC and PEC exceedances are shown graphically in Figures 40 and 41.

Table 23. Sediment Samples – Pesticide Detections - San Marcos Springs Complex

Location	Date Collected	4,4-DDD (µg/kg)	4,4-DDE (µg/kg)	Alpha-chlordane (µg/kg)	Gamma-chlordane (µg/kg)
HSM320	6/9/16	16	103	<5.50	<4.33
HSM340	6/9/16	13.3	31.5	7.54	19.2
HSM350	6/9/16	<3.03	9.72	<2.98	<2.34
TEC		4.88	3.16	NE	NE
PEC		28	31.3	NE	NE

NE – not established

PEC – probable effect concentration

TEC – threshold effect concentration

µg/kg – micrograms per kilogram

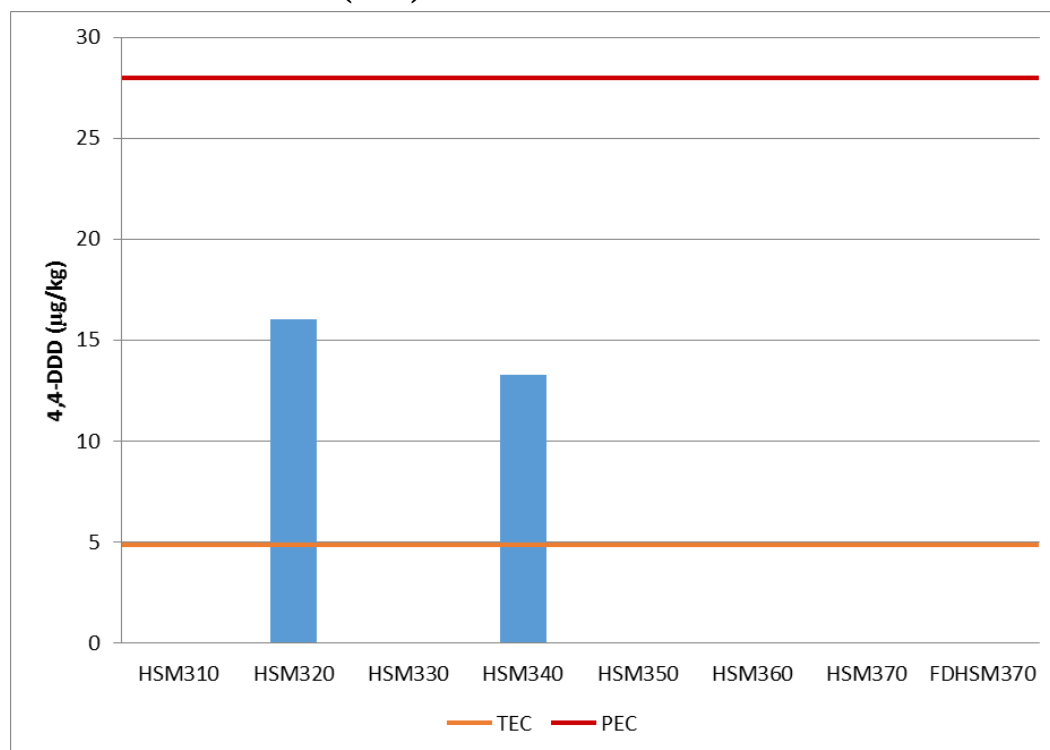
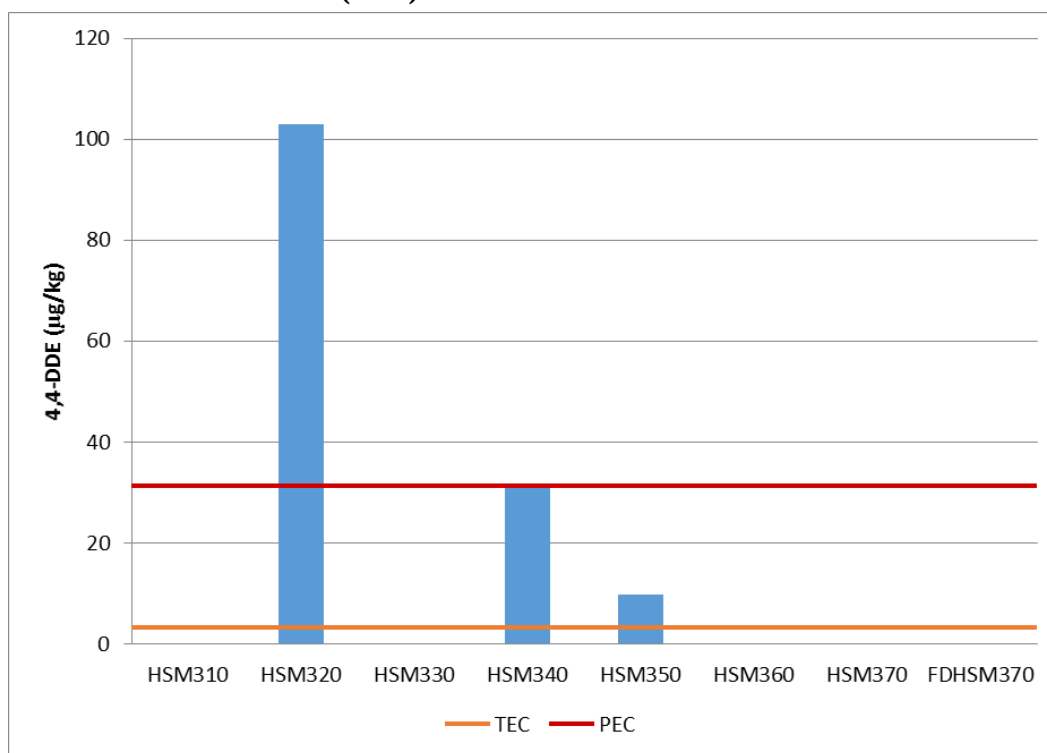
Figure 40. San Marcos Springs Sediment 4,4-DDD Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values

Figure 41. San Marcos Springs Sediment 4,4-DDE Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values



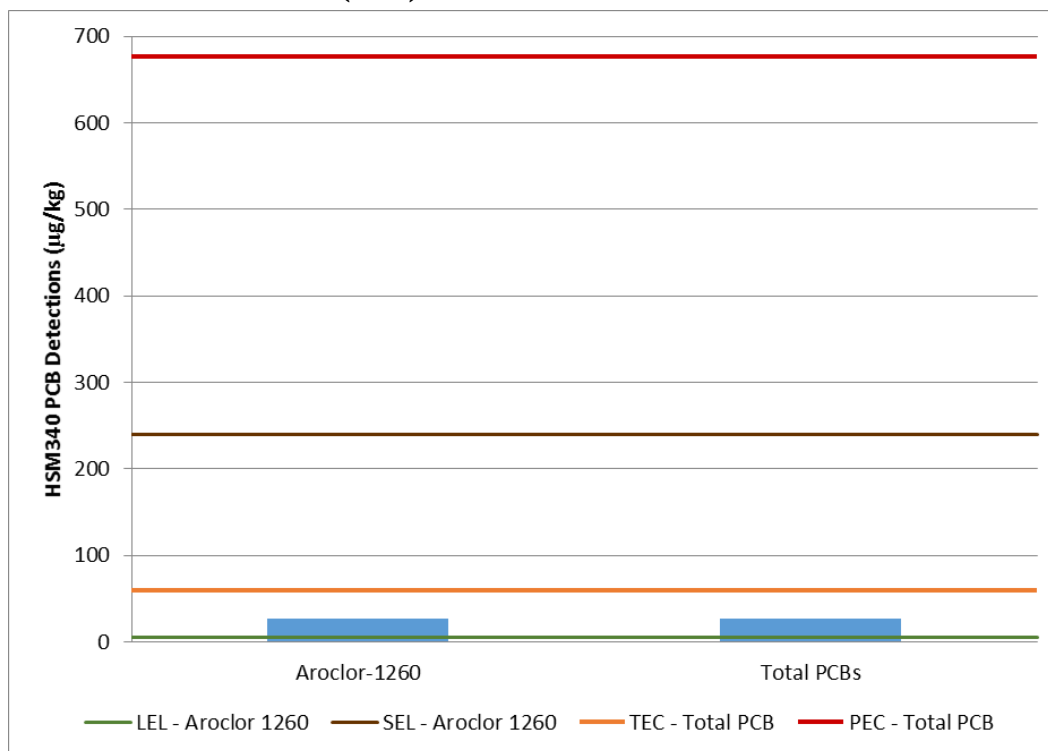
7.2.2.4 Sediment - Herbicides

Sediments were analyzed for herbicide compounds to further assess sediment quality at the San Marcos Springs complex. No herbicides were detected in any of the sediment samples from the seven sites in the San Marcos Springs complex.

7.2.2.5 Sediment - Polychlorinated Biphenyls

Sediments were analyzed for PCB compounds to further assess sediment quality at the San Marcos Springs complex. Aroclor-1260 was detected at a concentration of 26.3 J µg/kg in the sediment sample collected from HSM340. This detection was “J” flagged, indicating the detected concentration is less than the laboratory reporting limit, but greater than the method detection limit. MacDonald et al. (2000) established a TEC and PEC for Total PCB compounds but not individual PCBs. The detection was not above the TEC of 59.8 µg/kg or the PEC of 676 µg/kg for Total PCBs. However, TCEQ lists a Lower Effects Level (LEL) and Severe Effects Level (SEL) for select individual PCBs (TCEQ 2012, TCEQ 2014). The detection exceeded the LEL of 5 µg/kg for Aroclor-1260. The detection did not exceed the SEL of 240 µg/kg for Aroclor-1260. The detection is shown in comparison to the LEL and SEL values for Aroclor-1260 and the TEC and PEC values for Total PCBs in Figure 42.

Figure 42. San Marcos Springs Sediment Aroclor-1260 and Total PCB Detections Compared to Lower Effects Level (LEL), Severe Effects Level (SEL), Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) values



7.2.2.6 Sediment - Metals

Many metals are naturally occurring within soil, rock, and sediment. Sediment sample results for metals at the San Marcos Springs complex tested positive for several metals, generally at low concentrations. Metals detected above the method detection limit and subsequently evaluated in this report for potential toxic effects using the TEC and PEC standards are: arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, and zinc. Other metals detected that do not have a TEC or PEC value available are aluminum, antimony, barium, beryllium, iron and selenium which were compared to TSBC (TCEQ 2014b). Several samples exceeded one or more of these limits in 2016. The TEC for cadmium was exceeded in samples HSM310 and HSM350. Lead detections exceeded the TEC in samples HSM350 and HSM360. Lead concentrations also exceeded the PEC at HSM340. The manganese detection exceeded the TEC at HSM310. The Zinc concentration exceeded the TEC in sample HSM360.

All selenium detections were above the TSBC level of 0.3 mg/kg. Sediment studies of selenium concentrations have shown that levels below 4 mg/kg are not likely to bioaccumulate in the food chain or have adverse impacts on the reproduction of fish or aquatic birds (Lemly 1995; Moore et al. 1990; Van Derveer and Canton 1996). Selenium detections did not exceed 4 mg/kg in 2016 San Marcos sediment samples.

For the evaluation of antimony levels, TCEQ recommends an ERL of 2 mg/kg (TCEQ 2014) and an ERM of 25 mg/kg (TCEQ 2012). Antimony detections were “J” flagged, indicating the detected concentration is

less than the laboratory reporting limit, but greater than the method detection limit. Antimony detections at HSM330, HSM350, HSM370 and FDHSM370 exceeded the TSBC but did not exceed the ERL.

Metal detections are listed in Table 24. Metals with detections above an established TEC, TSBC or PEC value are displayed graphically in Figures 43–48, for antimony, cadmium, lead, manganese, selenium and zinc, respectively.

This page intentionally left blank.

Table 24. Sediment Samples – Metal Detections - San Marcos Springs Complex

Location	Date Collected	Aluminum (mg/kg)	Antimony (mg/kg)	Arsenic (mg/kg)	Barium (mg/kg)	Beryllium (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Lead (mg/kg)	Manganese (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Selenium (mg/kg)	Zinc (mg/kg)
HSM310	6/9/16	5560	<0.562	7.44	60.4	0.586 J	1.2	13.7	7.24	11400	11.5	710	0.0261 J	10.6	1.44 J	30.4
HSM320	6/9/16	2420	<0.694	3.78 J	24.6	0.251 J	0.650 J	5.96	10.7	6440	17.2	68	0.0386 J	5.03 J	2.78	48.8
HSM330	6/9/16	1210	1.72 J	7.01	21.2	0.172 J	0.819	6.77	5.65	8050	10.2	338	0.0161 J	7.51	1.54	32.1
HSM340	6/9/16	4340	0.861 J	3.47	41.3	0.437 J	0.788	35.8	9.28	5540	260	156	0.0715 J	7.14	1.15	52.7
HSM350	6/9/16	3020	1.35 J	4.14	38.3	0.312 J	1.11	10.5	10.1	5880	43.4	294	0.0799 J	8.87	1.93	46.3
HSM360	6/9/16	5050	0.820 J	5.76	38.1	0.474 J	0.955	16.9	8.8	7260	116	352	0.0201 J	8.9	1.09 J	447
HSM370	6/9/16	3930	1.05 J	3.16	36.9	0.512 J	0.777	7.97	5.03	5970	14.5	302	0.0234 J	7.27	0.952 J	28.7
FDHSM370	6/9/16	3380	1.28 J	2.4	37.1	0.347 J	0.784	9.16	4.47	4710	17.3	339	<0.0140	5.47	1.13	25.9
TEC		NE	NE	9.79	NE	NE	0.99	43.4	31.6	NE	35.8	460	0.18	22.7	NE	121
PEC		NE	NE	33	NE	NE	4.98	111	149	NE	128	1100	1.06	48.6	NE	459
TSBC		30000	1	5.9	300	1.5	NE	NE	15	15000	15	300	0.04	10	0.3	30

J – Detection is greater than the method detection limit, but less than the reporting limit.
Mg/kg – milligrams per kilogram
NE – Not established
PEC – probable effect concentration
TEC – threshold effect concentration
TSBC – Texas-specific soil background concentration

This page intentionally left blank.

Figure 43. San Marcos Springs Sediment Antimony Detections Compared to Texas-specific Background Concentration (TSBC) and Effects Range Low (ERL) Values

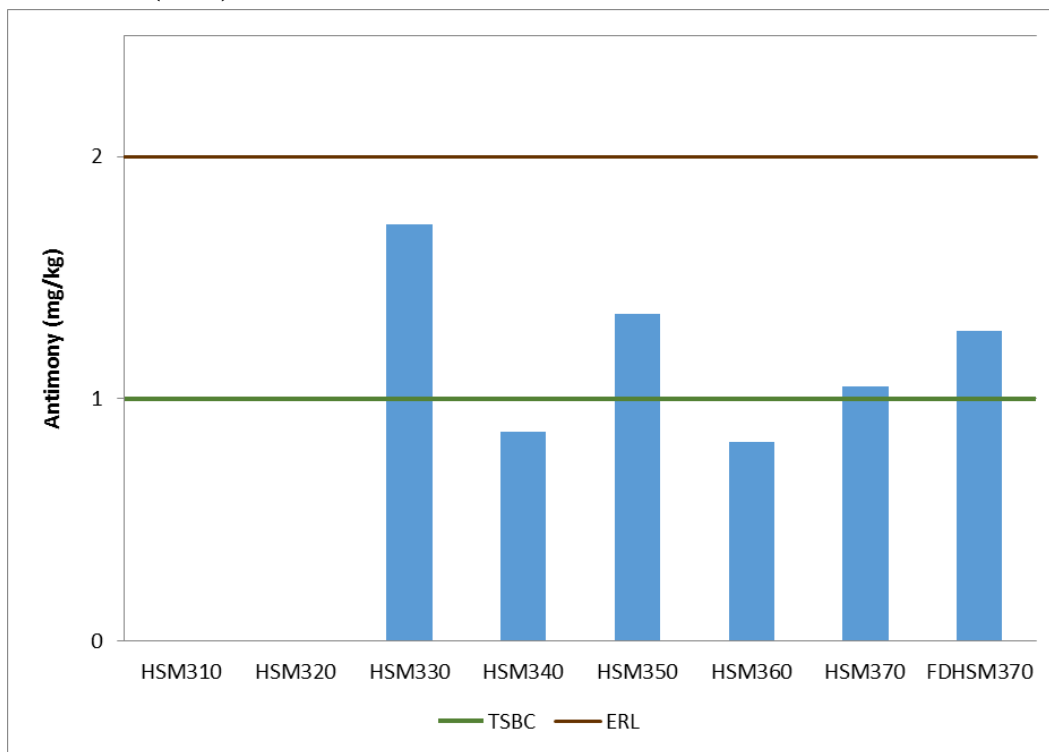


Figure 44. San Marcos Springs Sediment Cadmium Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values

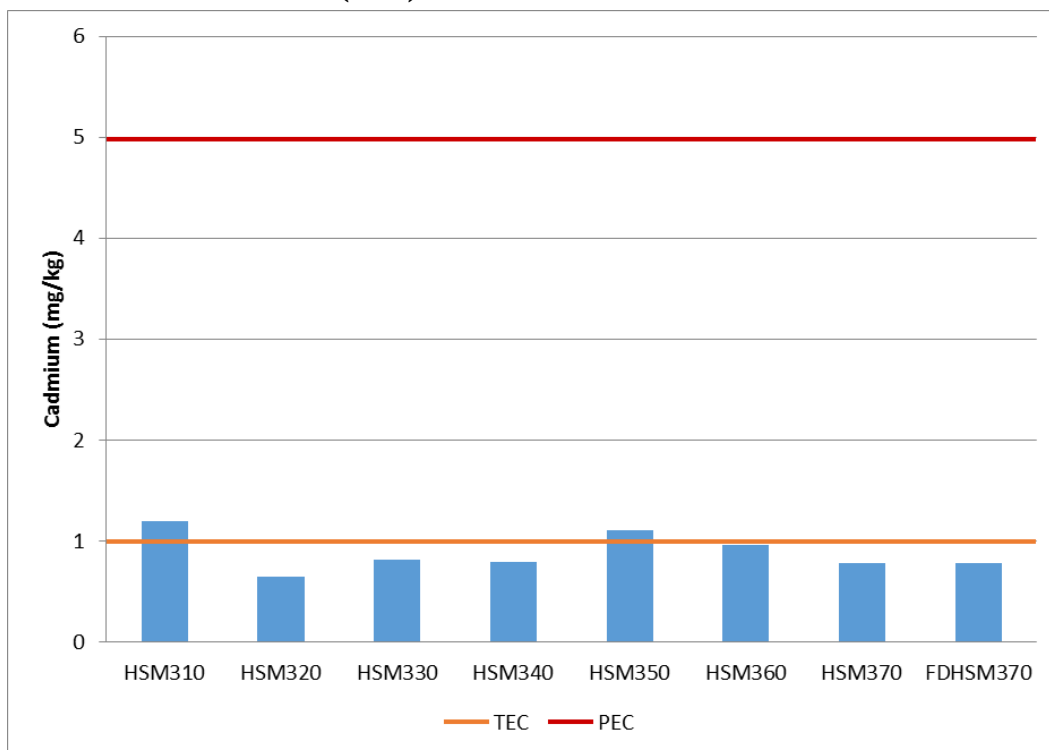


Figure 45. San Marcos Springs Sediment Lead Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values

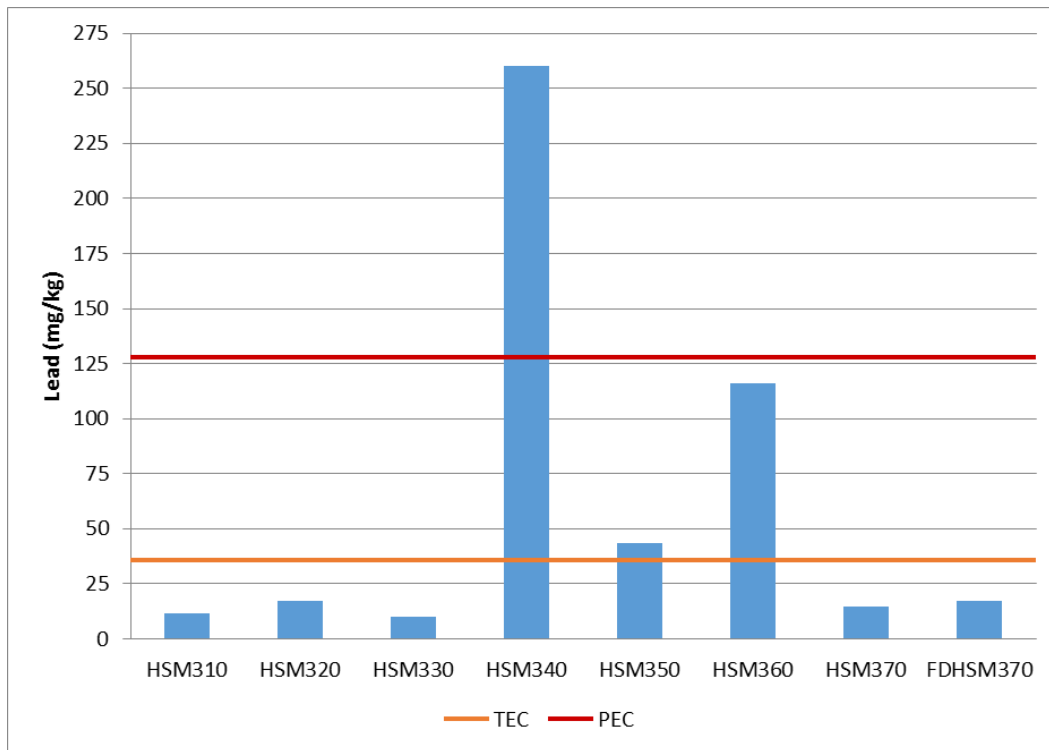


Figure 46. San Marcos Springs Sediment Manganese Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values

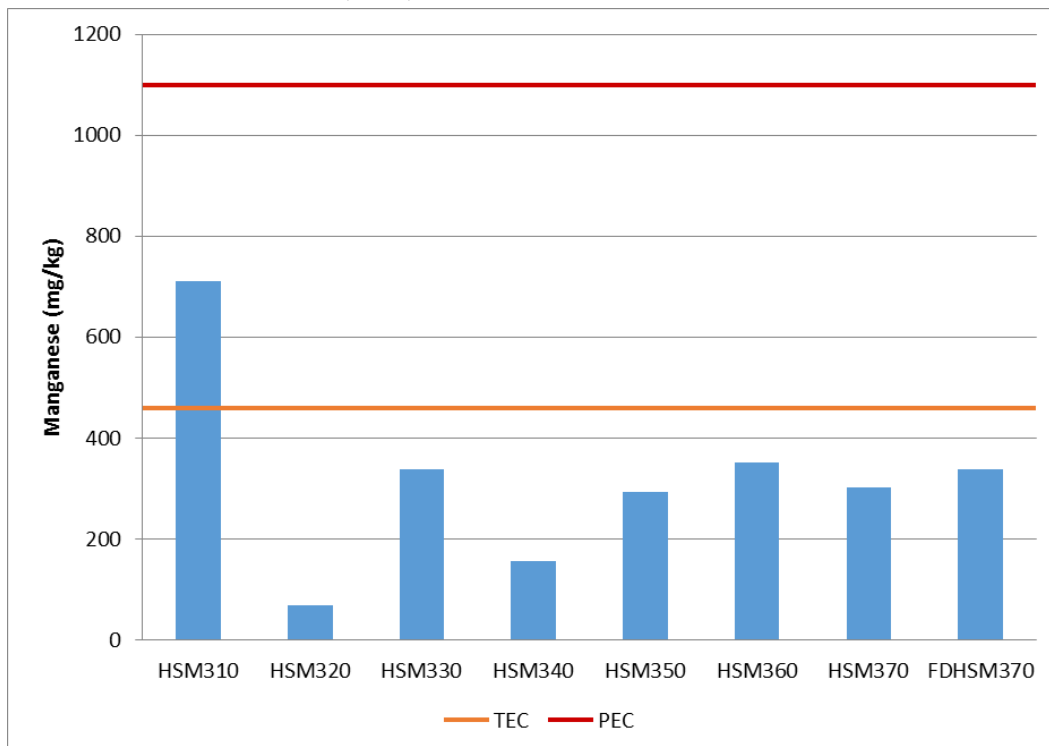


Figure 47. San Marcos Springs Sediment Selenium Detections Compared to Texas-specific Soil Background Concentration (TSBC) and Possible Bioaccumulation Level

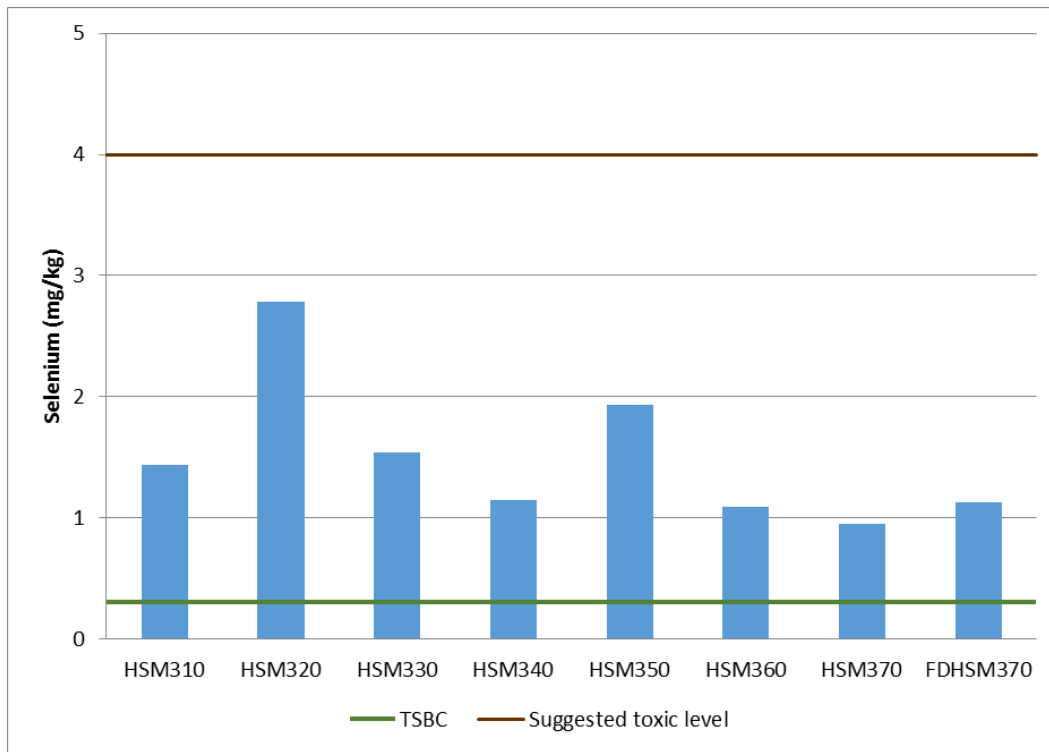
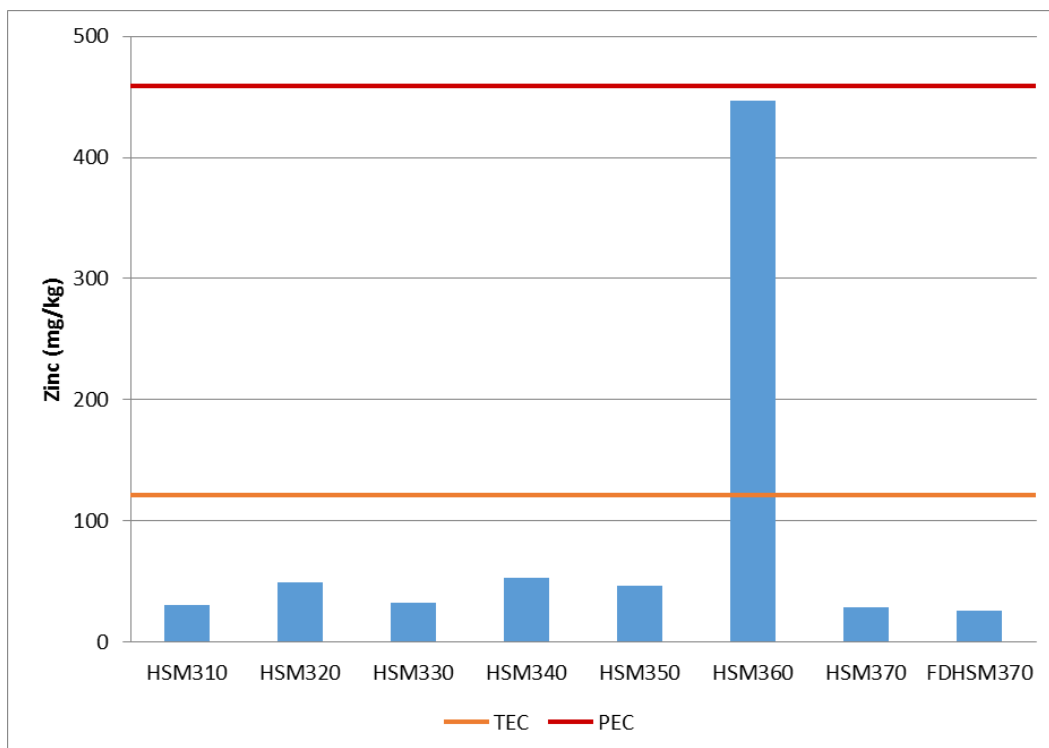


Figure 48. San Marcos Springs Sediment Zinc Detections Compared to Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) Values



7.2.3 San Marcos Springs Stormwater Sampling

Stormwater samples were to be collected during two storm events at the San Marcos Springs complex in 2016. Each event was to be sampled according to the guidelines in the EAHCP Work Plan. The first sampling event occurred on March 9, 2016. Total rainfall for the first event was approximately 0.75 to 0.99 inches (NOAA 2016). The streamflow measured at USGS Gauge 08170500 increased from 245 cfs to 246 cfs during the event (USGS 2016), it is unclear if the gauge was operating correctly during the event, as a larger increase is generally observed during storm events. A more than 20% change in specific conductivity and other water quality parameters did occur during the event and SWCA staff observed a rise in water levels at sampling locations. Therefore, the storm event is considered valid for sampling based on the guidelines in the *EAA Groundwater Quality Monitoring Plan*. The second event occurred on November 3, 2016. Total rainfall for the November 2016 event was approximately 0.50 to 0.75 inches (NOAA 2016). The storm caused streamflow to increase from 255 cfs to 306 cfs (USGS 2016).

7.2.3.1 Stormwater - Bacteria Detections

Stormwater samples collected and analyzed for bacteria analyses generally tested positive for high levels of bacteria. The 2014 Texas Surface Water Quality Standard for *E. coli* in primary recreation waters is a geometric mean of 126 MPN/100 mL with no individual sample exceeding 399 MPN/100 mL (30 TAC 307.7). The geometric mean for stormwater samples collected from the San Marcos Springs complex in March 2016 was approximately 5,065 MPN/100 mL. Bacteria counts ranged from 75 MPN/100 mL to 61,000 MPN/100 mL with several samples exceeding the individual sample limit during the March 2016 event. November 2016 *E. coli* counts ranged from 72 to >24,000 MPN/100 mL with a geometric mean of approximately 2543 MPN/100 mL. Individual detections are listed below in Table 25 and shown in relation to stream discharge and specific conductivity in Figures 49 and 50. Due to the timing of storm events and laboratory working hours, it was not possible to deliver all samples to the laboratory within sample holding times (see discussion in Appendix C). Samples exceeding hold times were included in the range and geometric mean calculations.

**Table 25. Stormwater Samples – Bacteria Counts
- San Marcos Springs Complex**

Location	Date	Concentration (MPN/100 mL)
HSM210 Lead	3/9/2016	75 H
	11/3/2016	72 H
HSM210 Peak	3/9/2016	960
	11/3/2016	93 H
HSM210 Trail	3/9/2016	2000
	11/3/2016	240 H
FDHSM210 Trail	3/9/2016	2400
	11/3/2016	280 H
HSM230 Lead	3/9/2016	61000 H
	11/3/2016	>24000 H
HSM230 Peak	3/9/2016	49000
	11/3/2016	16000 H

**Table 25. Stormwater Samples – Bacteria Counts
- San Marcos Springs Complex**

Location	Date	Concentration (MPN/100 mL)
HSM230 Trail	3/9/2016	14000
	11/3/2016	4900 H
FDHSM230 Trail	3/9/2016	26000
	11/3/2016	6500 H
HSM231 Lead	3/9/2016	7300 H
	11/3/2016	>24000 H
HSM231 Peak	3/9/2016	7700
	11/3/2016	2000 H
HSM231 Trail	3/9/2016	880
	11/3/2016	390 H
FDHSM231 Trail	3/9/2016	1400
	11/3/2016	610 H
HSM240 Lead	3/9/2016	6100 H
	11/3/2016	4400 H
HSM240 Peak	3/9/2016	5800
	11/3/2016	980 H
HSM240 Trail	3/9/2016	1700
	11/3/2016	360 H
HSM250 Lead	3/9/2016	6900 H
	11/3/2016	10000 H
HSM250 Peak	3/9/2016	20000
	11/3/2016	17000 H
HSM250 Trail	3/9/2016	2400
	11/3/2016	4100 H
HSM260 Lead	3/9/2016	990 H
	11/3/2016	1700 H
HSM260 Peak	3/9/2016	17000
	11/3/2016	6900 H
HSM260 Trail	3/9/2016	4600
	11/3/2016	3300 H
HSM270 Lead	3/9/2016	25000 H
	11/3/2016	7700 H
HSM270 Peak	3/9/2016	14000
	11/3/2016	>24000 H
HSM270 Trail	3/9/2016	5800
	11/3/2016	11000 H

H – Analyzed outside hold time, result included for comparison but not considered valid

MPN/100 mL – Most probable number per 100 milliliters of water

Figure 49. Stormwater Samples – March 2016 Bacteria Counts in Relation to Stream Discharge and Specific Conductivity – San Marcos Springs Complex

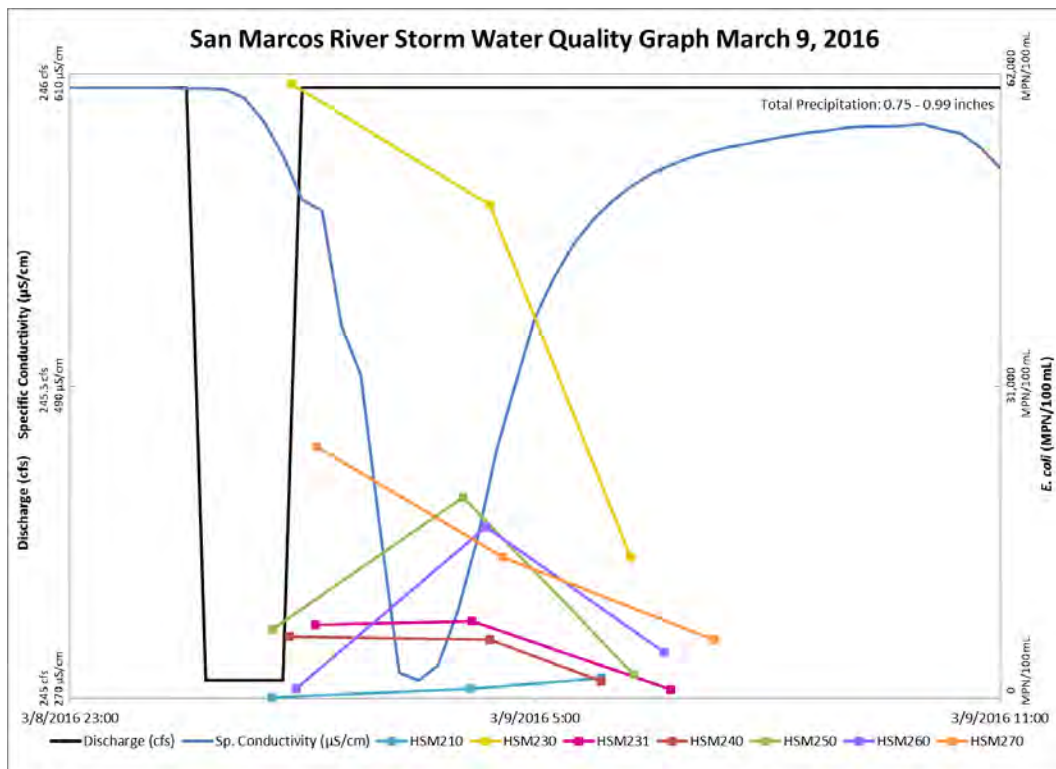
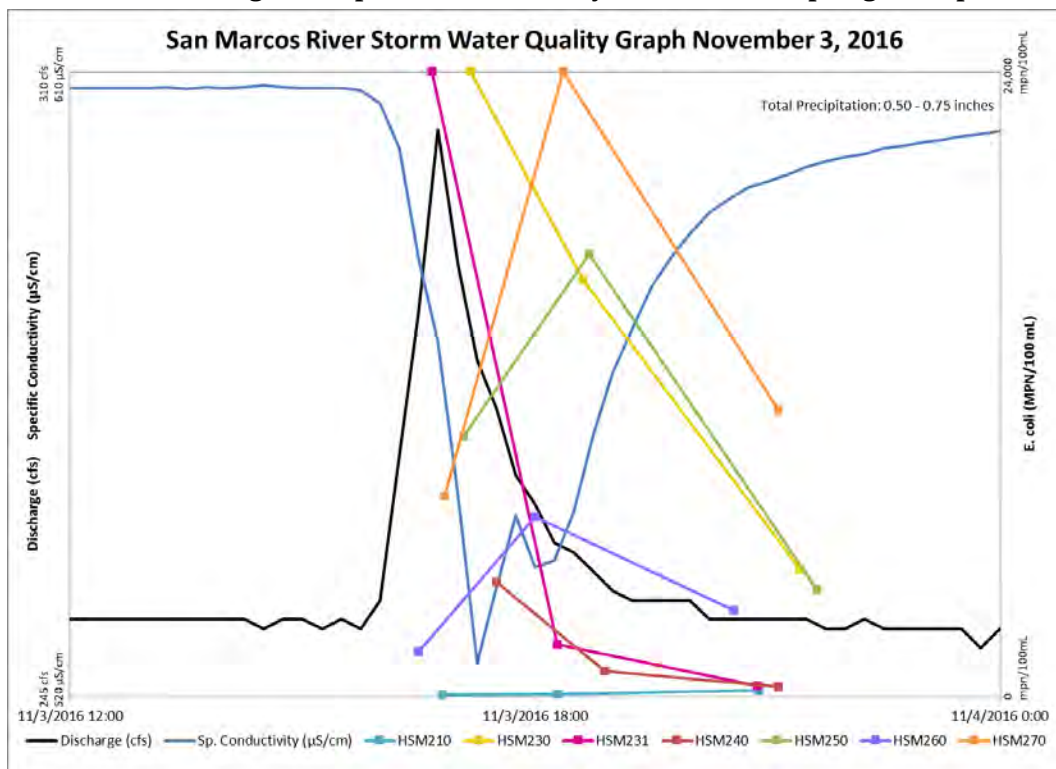


Figure 50. Stormwater Samples – November 2016 Bacteria Counts in Relation to Stream Discharge and Specific Conductivity – San Marcos Springs Complex



7.2.3.2 Stormwater - Volatile Organic Compounds (VOCs)

One VOC compound, acetone, was detected in several stormwater samples from the March 2016 Sampling event and one sample from the November 2016 event. All of these detections were less than the established PCL, and one exceeded the laboratory reporting limit. The detections are summarized in Table 26.

Table 26. Stormwater Samples – Volatile Organic Compound Detections - San Marcos Springs Complex

Location	Date	Acetone (ug/L)
HSM210 Lead	3/9/2016	<5.00
	11/3/2016	<5.00
HSM210 Peak	3/9/2016	<5.00
	11/3/2016	<5.00
HSM210 Trail	3/9/2016	<5.00
	11/3/2016	<5.00
FDHSM210 Trail	3/9/2016	6.27 J
	11/3/2016	<5.00
HSM230 Lead	3/9/2016	5.45 J
	11/3/2016	<5.00
HSM230 Peak	3/9/2016	<5.00
	11/3/2016	<5.00
HSM230 Trail	3/9/2016	7.75 J
	11/3/2016	<5.00
FDHSM230 Trail	3/9/2016	<5.00
	11/3/2016	<5.00
HSM231 Lead	3/9/2016	8.09 J
	11/3/2016	<5.00
HSM231 Peak	3/9/2016	<5.00
	11/3/2016	<5.00
HSM231 Trail	3/9/2016	<5.00
	11/3/2016	7.41 J
FDHSM231 Trail	3/9/2016	5.61 J
	11/3/2016	<5.00
HSM240 Lead	3/9/2016	<5.00
	11/3/2016	<5.00
HSM240 Peak	3/9/2016	<5.00
	11/3/2016	<5.00
HSM240 Trail	3/9/2016	<5.00
	11/3/2016	<5.00
HSM250 Lead	3/9/2016	12.4
	11/3/2016	<5.00
HSM250 Peak	3/9/2016	<5.00
	11/3/2016	<5.00

Table 26. Stormwater Samples – Volatile Organic Compound Detections - San Marcos Springs Complex

Location	Date	Acetone (ug/L)
HSM250 Trail	3/9/2016	<5.00
	11/3/2016	<5.00
HSM260 Lead	3/9/2016	<5.00
	11/3/2016	<5.00
HSM260 Peak	3/9/2016	6.49 J
	11/3/2016	<5.00
HSM260 Trail	3/9/2016	<5.00
	11/3/2016	<5.00
HSM270 Lead	3/9/2016	<5.00
	11/3/2016	<5.00
HSM270 Peak	3/9/2016	<5.00
	11/3/2016	<5.00
HSM270 Trail	3/9/2016	6.41 J
	11/3/2016	<5.00
MCL		NE
PCL		22,000

J – Detection is greater than the method detection limit, but less than the reporting limit

µg/L – micrograms per liter

NE – Not established

MCL – maximum contaminant level

PCL – protective concentration level

7.2.3.3 Stormwater - Semi-volatile Organic Compounds (SVOCs)

Stormwater samples were collected and analyzed for SVOCs. One SVOC, DEHP, was detected in HSM240 Lead in March 2016 at a concentration of 9.88 J µg/L. DEHP was also detected in several samples from the November 2016 storm event. These detections were less than the laboratory reporting limit but greater than the established PCL of 6 µg/L. These detections are summarized in Table 27 and shown graphically in Figures 51 and 52.

Table 27. Stormwater Samples – Bis(2-Ethylhexyl) Phthalate (DEHP) Detections - San Marcos Springs Complex

Location	Date	Concentration (µg/L)
HSM240 Lead	3/9/2016	9.88 J
	11/3/2016	<5.00
HSM250 Lead	3/9/2016	<5.00
	11/3/2016	11.0 J
HSM260 Peak	3/9/2016	<5.00
	11/3/2016	14.5 J

Table 27. Stormwater Samples – Bis(2-Ethylhexyl) Phthalate (DEHP) Detections - San Marcos Springs Complex

Location	Date	Concentration (µg/L)
HSM260 Trail	3/9/2016	<5.21
	11/3/2016	8.46 J
HSM270 Peak	3/9/2016	<5.00
	11/3/2016	7.00 J
HSM270 Trail	3/9/2016	<5.00
	11/3/2016	17.4 J
PCL		6

mg/L – milligrams per liter

NA – Not analyzed

Figure 51. March 2016 San Marcos Springs Stormwater Bis(2-ethylhexyl) Phthalate (DEHP) Detections Compared to Protective Concentration Level (PCL)

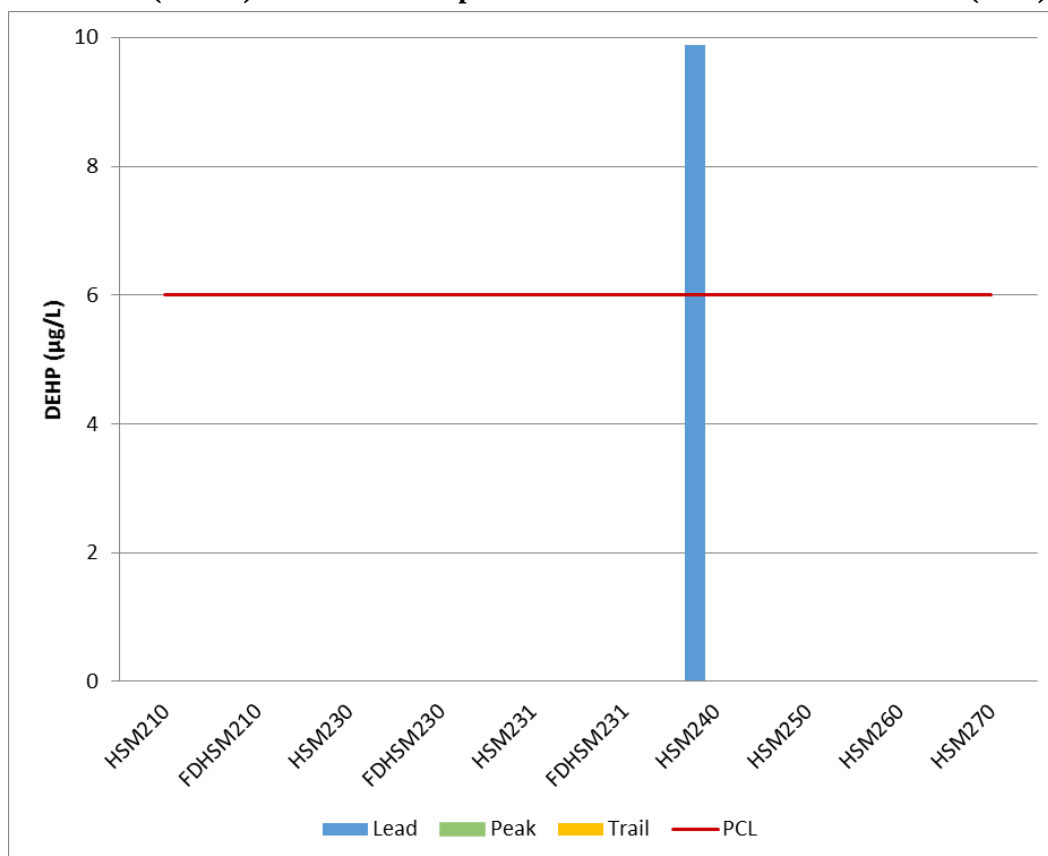
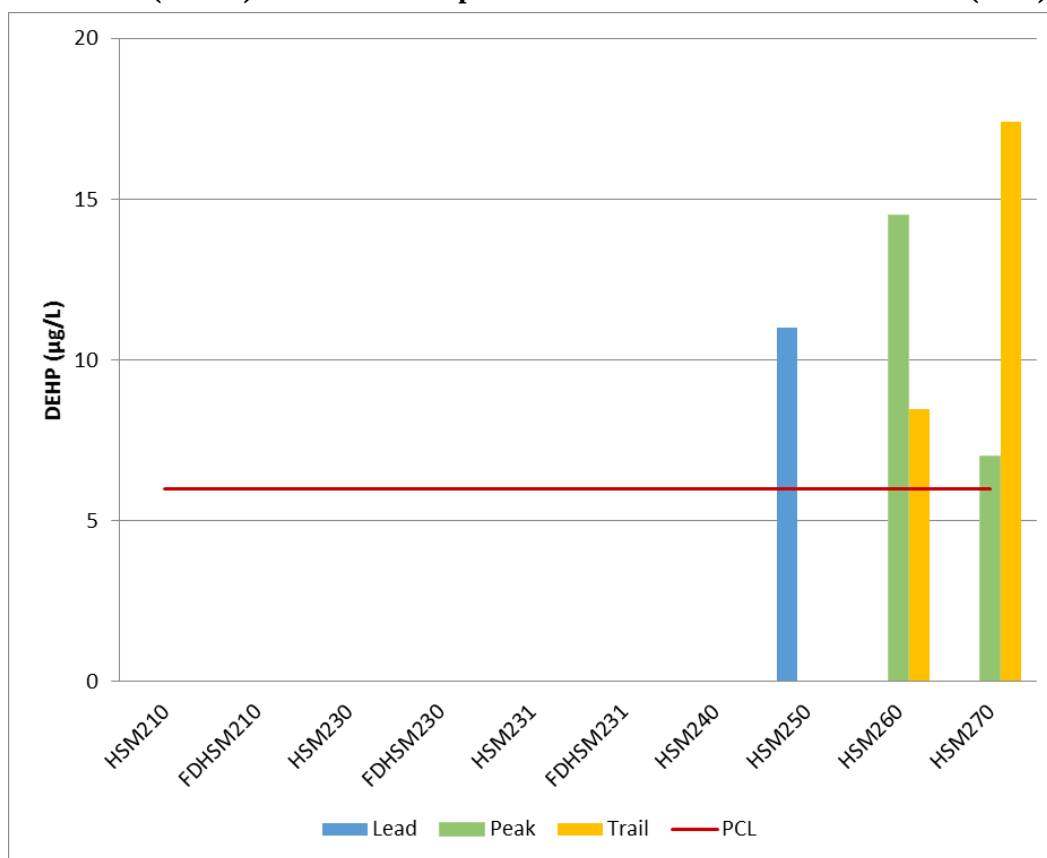


Figure 52. November 2016 San Marcos Springs Stormwater Bis(2-ethylhexyl) Phthalate (DEHP) Detections Compared to Protective Concentration Level (PCL)



7.2.3.4 Stormwater - Herbicides and Pesticides

Stormwater samples were collected and analyzed for organochlorine pesticides, organophosphorous pesticides, and herbicides. There were no detections of herbicides or pesticides during the March or November 2016 stormwater event.

7.2.3.5 Stormwater - Polychlorinated Biphenyls

Stormwater samples were analyzed for the various Aroclor compounds that are generally referred to collectively as PCBs. None of the stormwater samples from the San Marcos Springs complex indicated positive detections of PCB compounds during the March or November 2016 sampling event.

7.2.3.6 Stormwater - Metals

Stormwater samples were analyzed for metals in accordance with the EAHCP Work Plan. Several positive metal detections were noted in the sample set; however, no samples contained a metal at a concentration in excess of the drinking water MCL, and many detections were below laboratory reporting limits during the March or November 2016 sampling event.

7.2.3.7 Stormwater - Nitrates

Stormwater samples were analyzed for nitrate-nitrite as nitrogen in accordance with the EAHCP Work Plan. All samples contained nitrate results below the MCL of 10 mg/L. During the March 2016 event, the

range of nitrate results was 0.687 mg/L to 1.27 mg/L, with an average concentration of approximately 1.07 mg/L. In November 2016, nitrate results ranged from 0.469 mg/L to 1.42 mg/L, with an average concentration of approximately 0.999 mg/L. For comparison, the average nitrate in spring water samples at San Marcos Springs for calendar year 2014 was 1.42 mg/L (EAA 2015). Nitrate detections are summarized in Table 28.

Table 28. Stormwater Samples – Nitrate Detections - San Marcos Springs Complex

Location	Date	Concentration (mg/L)
HSM210 Lead	3/9/2016	0.728
	11/3/2016	0.469 J
HSM210 Peak	3/9/2016	0.723
	11/3/2016	0.505
HSM210 Trail	3/9/2016	0.743
	11/3/2016	0.546
FDHSM210 Trail	3/9/2016	0.687
	11/3/2016	0.544
HSM230 Lead	3/9/2016	0.922
	11/3/2016	0.668
HSM230 Peak	3/9/2016	1.1
	11/3/2016	1.34
HSM230 Trail	3/9/2016	1.21
	11/3/2016	1.42
FDHSM230 Trail	3/9/2016	1.2
	11/3/2016	1.42
HSM231 Lead	3/9/2016	1.24
	11/3/2016	0.868
HSM231 Peak	3/9/2016	1.2
	11/3/2016	1.13
HSM231 Trail	3/9/2016	1.26
	11/3/2016	1.15
FDHSM231 Trail	3/9/2016	1.27
	11/3/2016	1.15
HSM240 Lead	3/9/2016	1.2
	11/3/2016	1.07
HSM240 Peak	3/9/2016	1.23
	11/3/2016	1.14
HSM240 Trail	3/9/2016	1.26
	11/3/2016	1.15
HSM250 Lead	3/9/2016	1.18
	11/3/2016	0.895
HSM250 Peak	3/9/2016	1.03
	11/3/2016	1.01

**Table 28. Stormwater Samples – Nitrate
Detections - San Marcos Springs Complex**

Location	Date	Concentration (mg/L)
HSM250 Trail	3/9/2016	1.23
	11/3/2016	1.13
HSM260 Lead	3/9/2016	1.25
	11/3/2016	1.10
HSM260 Peak	3/9/2016	0.875
	11/3/2016	1.04
HSM260 Trail	3/9/2016	1.15
	11/3/2016	1.12
HSM270 Lead	3/9/2016	1.13
	11/3/2016	1.04
HSM270 Peak	3/9/2016	0.889
	11/3/2016	1.01
HSM270 Trail	3/9/2016	1.06
	11/3/2016	1.05
MCL		10

mg/L – milligrams per liter

NA – Not analyzed

7.2.3.8 Stormwater – Caffeine

Stormwater was analyzed for caffeine, which can indicate an anthropogenic source. Caffeine may enter surface water from leaking sewer or septic systems or it may be present in the aquifer from similar sources in the recharge zone (EPA 2012). Potential ecological effects are currently unknown but could include reduced reproductive success in aquatic species (EPA 2012). Caffeine detections in stormwater samples from San Marcos Springs in March 2016 ranged from 7.7 ng/L to 5,100 ng/L and was detected in all samples except HCS210 Lead. Caffeine detections from November 2016 ranged from 45 ng/L to 3700 ng/L. There is no regulatory standard or expected value for comparison. Results are shown in Table 29. The caffeine sample container for HSM230 Peak from March 2016 was broken in shipment to the laboratory, so this sample was not analyzed.

**Table 29. Stormwater Samples – Caffeine
Detections - San Marcos Springs Complex**

Location	Date Collected	Caffeine (ng/L)
HCS210 Lead	3/9/2016	<0.31
	11/3/2016	3700
HCS210 Peak	3/9/2016	7.7
	11/3/2016	<0.31
HCS210 Trail	3/9/2016	53
	11/3/2016	<0.31
FDHSM210 Trail	3/9/2016	69
	11/3/2016	<0.31
HSM230 Lead	3/9/2016	5100
	11/3/2016	<0.31
HSM230 Peak	3/9/2016	NA
	11/3/2016	1100
HSM230 Trail	3/9/2016	2300
	11/3/2016	600
FDHSM230 Trail	3/9/2016	2400
	11/3/2016	600
HSM231 Lead	3/9/2016	220
	11/3/2016	2200
HSM231 Peak	3/9/2016	150
	11/3/2016	150
HSM231 Trail	3/9/2016	30
	11/3/2016	<0.31
FDHSM231 Trail	3/9/2016	36
	11/3/2016	<0.31
HCS240 Lead	3/9/2016	470
	11/3/2016	720
HCS240 Peak	3/9/2016	130
	11/3/2016	45
HCS240 Trail	3/9/2016	52
	11/3/2016	<0.31
HCS250 Lead	3/9/2016	920
	11/3/2016	1900
HCS250 Peak	3/9/2016	540
	11/3/2016	1400
HCS250 Trail	3/9/2016	78
	11/3/2016	230
HCS260 Lead	3/9/2016	140
	11/3/2016	69

**Table 29. Stormwater Samples – Caffeine
Detections - San Marcos Springs Complex**

		Caffeine
	Date	
HCS260 Peak	3/9/2016	830
	11/3/2016	1200
HCS260 Trail	3/9/2016	170
	11/3/2016	400
HCS270 Lead	3/9/2016	550
	11/3/2016	1500
HCS270 Peak	3/9/2016	740
	11/3/2016	1200
HCS270 Trail	3/9/2016	250
	11/3/2016	660

NA – Not analyzed
ng/L – nanograms per liter

7.2.4 San Marcos Springs Surface Water Passive Sampling

PDSs were installed in the San Marcos Springs system in February, April, June, August, October, and December 2016. HSM430 and FDHSM430 were not analyzed in April 2016 because the deployment device was flipped upside down and sediment accumulated around the deployment device and came in contact with these PDSs. During the June 2016 PDS deployment period, the deployment device from HSM440 was lost, the sampler was found by the City of San Marcos and returned but was not analyzed. The sampler for HSM470 in October 2016 showed signs of human tampering and was not analyzed. Sediment accumulated inside the deployment device and contacted the samplers for HSM430 and FDHSM430 during the December 2016 deployment, the samplers were not analyzed. Any lost or damaged samplers and changes to deployment locations are discussed in Appendix C.

Rain events did occur during some PDS deployment periods during 2016. Figures 53–58 show specific conductivity and stream discharge rates for each PDS deployment period. In April 2016, samplers were removed from the river after a period of 12 days instead of the 14 days as called for in the EAHCP Work Plan. A large storm was forecasted for the area. When the forecast was brought to the attention of EAA staff, EAA requested the PDS be retrieved prior to the storm event because of concerns that samplers could be lost and that the PDS results would not reflect base flow conditions. This deviation is discussed in greater detail in Appendix C.

There are no regulatory standards for comparison to PDS results. PDSs were analyzed for VOCs, SVOCs, and organochlorine pesticides. Few compounds were detected, only tetrachloroethene and TPH were consistently detected. Positive detections are shown in Tables 30 and 31.

Figure 53. Passive Diffusion Sampling – February 2016 Stream Discharge and Specific Conductivity – San Marcos Springs Complex

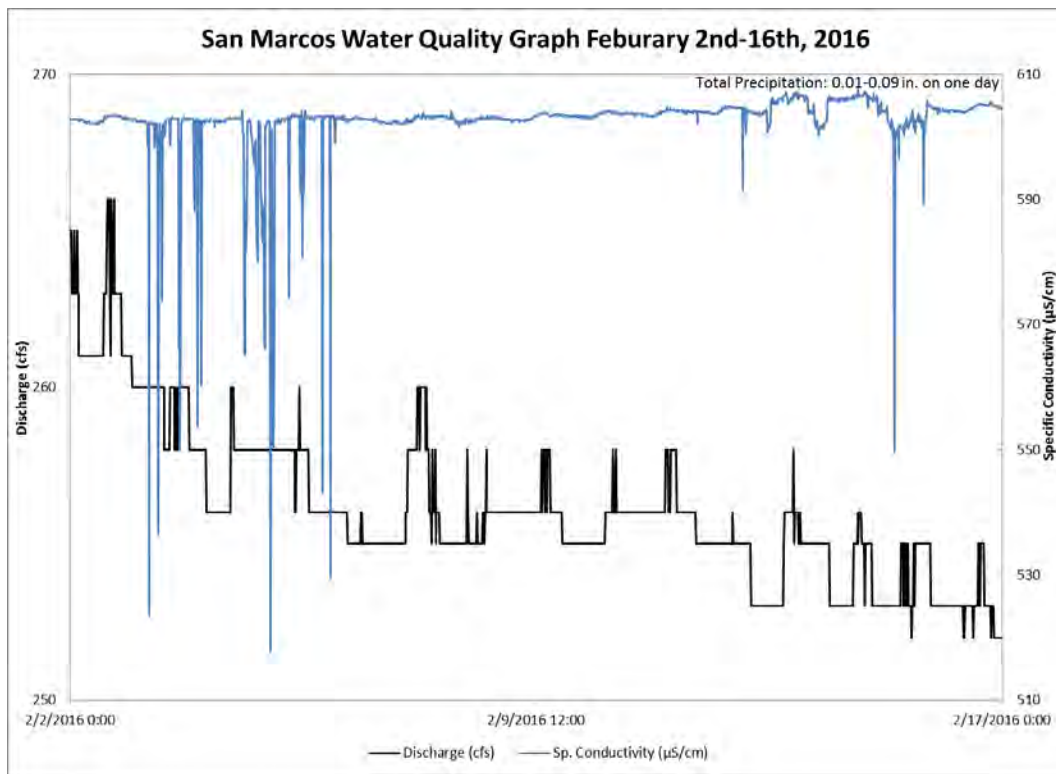


Figure 54. Passive Diffusion Sampling – April 2016 Stream Discharge and Specific Conductivity – San Marcos Springs Complex

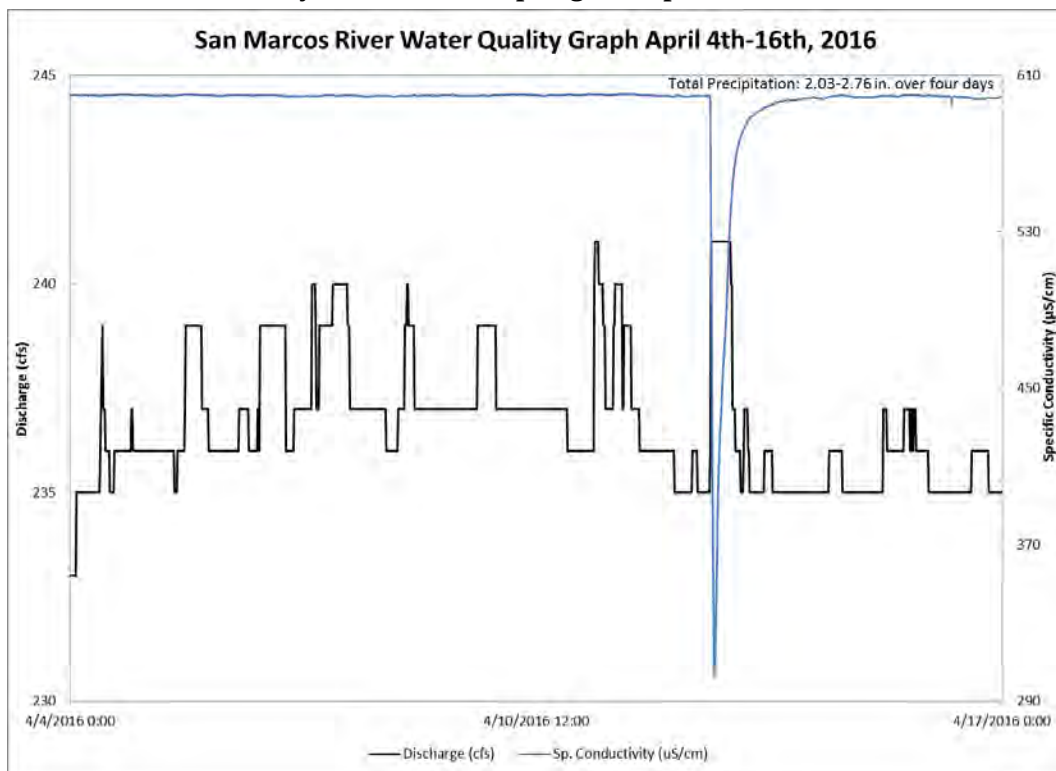


Figure 55. Passive Diffusion Sampling – June 2016 Stream Discharge and Specific Conductivity – San Marcos Springs Complex

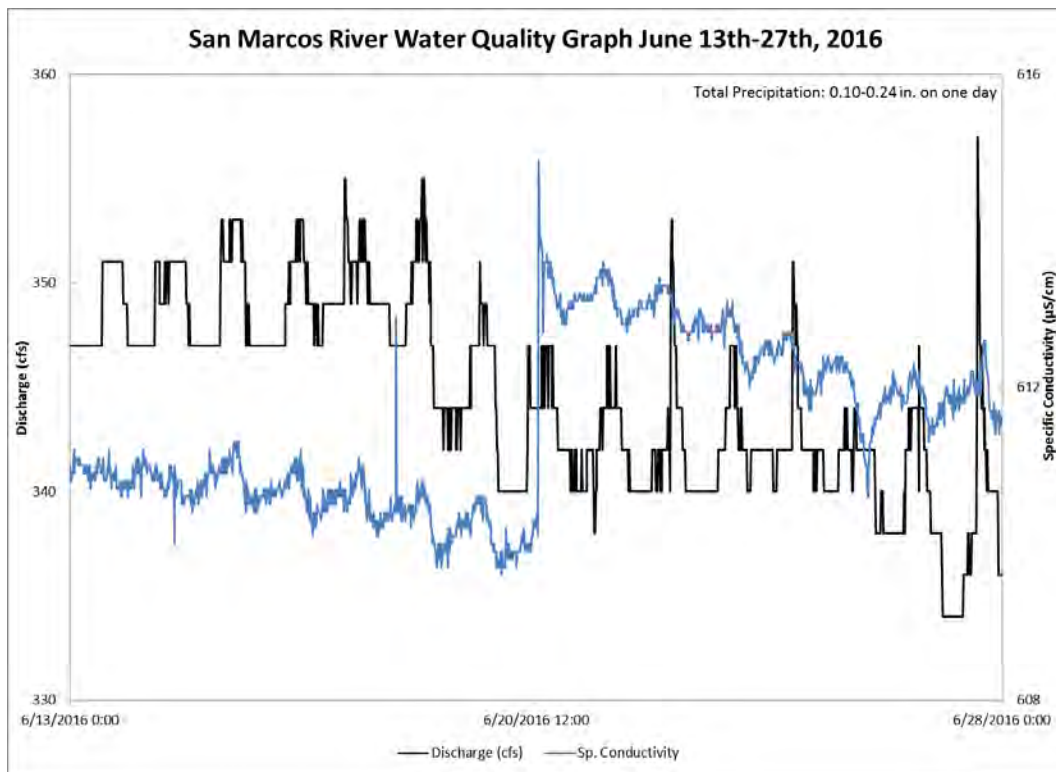


Figure 56. Passive Diffusion Sampling – August 2016 Stream Discharge and Specific Conductivity – San Marcos Springs Complex

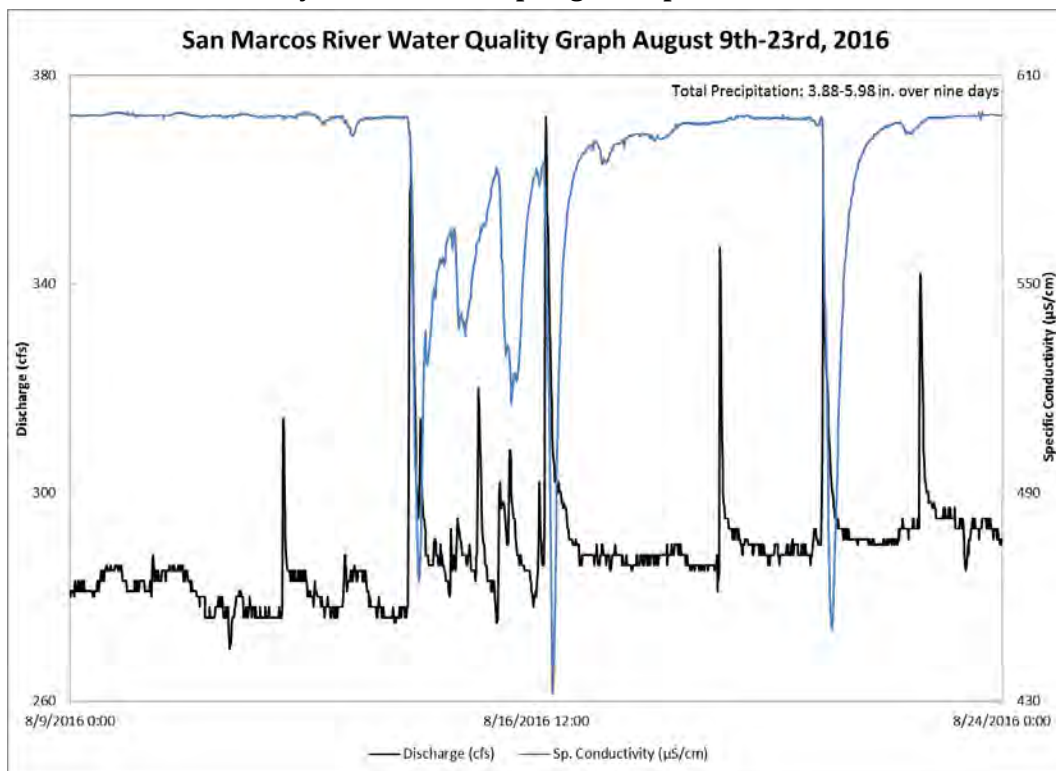


Figure 57. Passive Diffusion Sampling – October 2016 Stream Discharge and Specific Conductivity – San Marcos Springs Complex

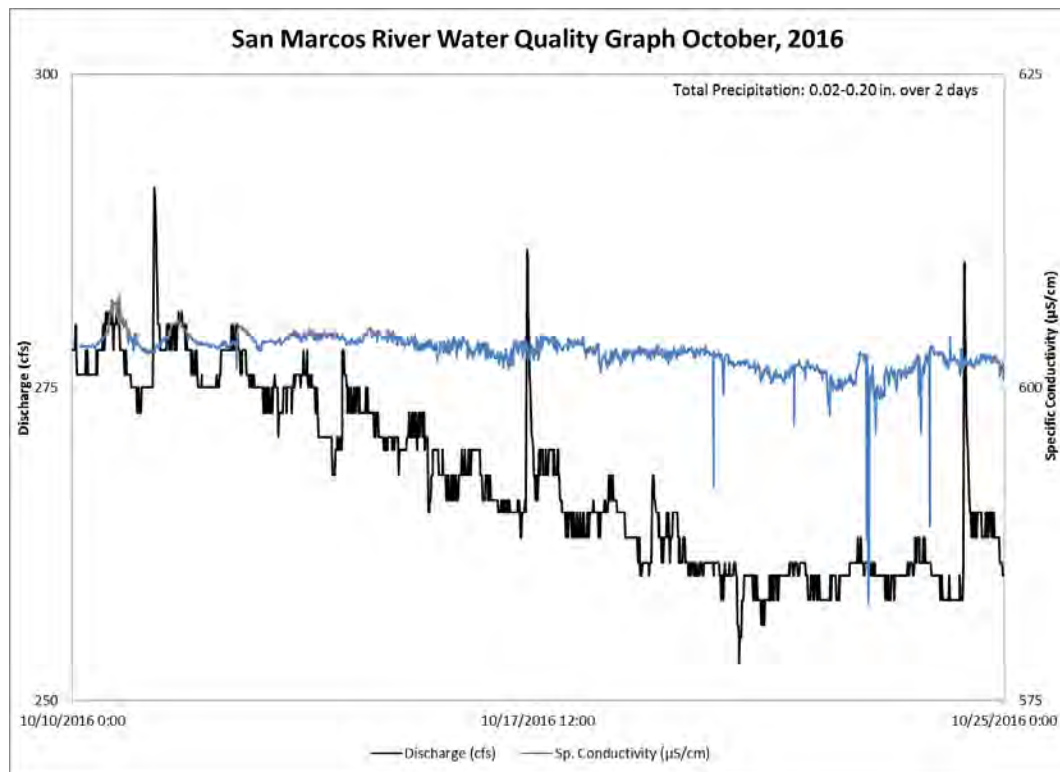


Figure 58. Passive Diffusion Sampling – December 2016 Stream Discharge and Specific Conductivity – San Marcos Springs Complex

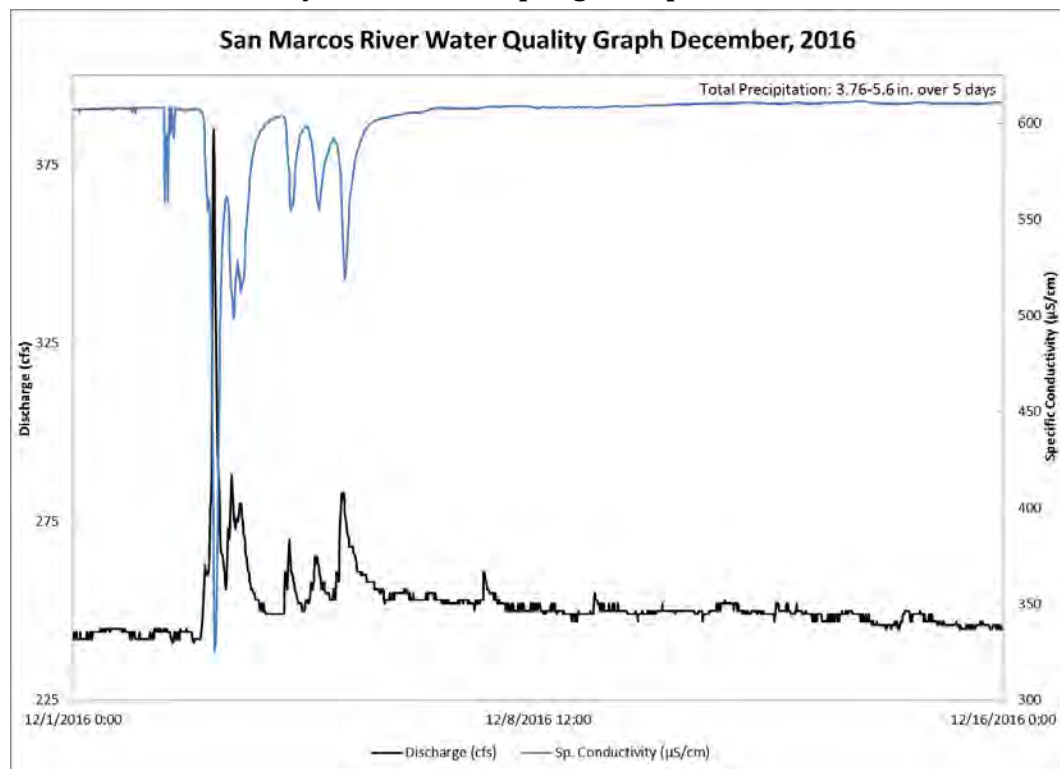


Table 30. Passive Diffusion – San Marcos Springs Complex – SVOC and VOC Detections

Location	Month 2016	1,2,4-trimethylbenzene (µg)	Acenaphthene (µg)	Acenaphthylene (µg)	Anthracene (µg)	Benzene (µg)	BTEX (µg)	c-1,2-Dichloroethene (µg)	Chloroform (µg)	Fluoranthene (µg)	Fluorene (µg)	p/m-Xylene (µg)	Pentadecane (µg)	Phenanthrene (µg)	Pyrene (µg)	Tetrachloroethene (µg)	Toluene (µg)	TPH (µg)
HSM410	February	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<0.50
	April	<0.02	<0.05	<0.05	<0.05	0.28	0.37	0.14	<0.02	<0.05	<0.05	0.02	<0.05	<0.05	<0.05	<0.02	0.07	2.75
	June	<0.02	4.26	0.72	1.42	<0.02	<0.02	<0.02	<0.02	1.9	9.44	<0.02	0.22	6.85	1.62	<0.02	<0.02	103.02
	August	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	<0.02	<0.02	0.60
	October	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	<0.02	<0.02	<0.50
	December	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	<0.02	<0.02	<0.50
HSM420	February	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	<0.05	0.09	<0.02	<0.50
	April	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	<0.05	0.05	<0.02	<0.50
	June	<0.02	0.46	0.08	0.14	<0.02	<0.02	<0.02	<0.02	0.11	1.29	<0.02	<0.05	0.74	0.09	0.14	<0.02	6.63
	August	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	0.09	<0.02	0.53
	October	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	0.17	<0.02	<0.50
	December	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	0.22	<0.02	<0.50
HSM430	February	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	<0.05	0.55	<0.02	<0.50
	April	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	June	<0.02	0.75	0.15	0.28	<0.02	<0.02	<0.02	0.03	0.3	1.7	<0.02	<0.05	1.37	0.28	1.87	<0.02	16.56
	August	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	0.80	<0.02	0.56
	October	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	1.03	<0.02	0.93
	December	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 30. Passive Diffusion – San Marcos Springs Complex – SVOC and VOC Detections

Location	Month 2016	1,2,4-trimethylbenzene (µg)	Acenaphthene (µg)	Acenaphthylene (µg)	Anthracene (µg)	Benzene (µg)	BTEX (µg)	c-1,2-Dichloroethene (µg)	Chloroform (µg)	Fluoranthene (µg)	Fluorene (µg)	p/m-Xylene (µg)	Pentadecane (µg)	Phenanthrene (µg)	Pyrene (µg)	Tetrachloroethene (µg)	Toluene (µg)	TPH (µg)
FDHSM430*	February	<0.02	<0.05	<0.05	<0.05	<0.02	0.02	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	<0.05	0.54	0.02	<0.50
	April	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	June	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<0.02	0.03	<0.05	0.07	<0.02	<0.05	0.06	<0.05	1.82	<0.02	0.84
	August	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	0.87	<0.02	0.72
	October	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	0.96	<0.02	1.18
	December	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HSM440	February	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	<0.05	0.09	<0.02	<0.50
	April	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	<0.05	0.1	<0.02	<0.50
	June	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	August	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	0.11	<0.02	0.55
	October	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	0.11	<0.02	<0.50
	December	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	0.08	<0.02	<0.50
FDHSM440*	April	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	<0.05	0.09	<0.02	<0.50
	December	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	<0.05	0.07	<0.02	<0.50
HSM450	February	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	<0.05	0.05	<0.02	<0.50
	April	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	<0.05	0.04	<0.02	<0.50
	June	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	August	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	0.05	<0.02	<0.50
	October	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	0.06	<0.02	<0.50
	December	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	0.07	<0.02	<0.50

Table 30. Passive Diffusion – San Marcos Springs Complex – SVOC and VOC Detections

Location	Month 2016	1,2,4-trimethylbenzene (µg)	Acenaphthene (µg)	Acenaphthylene (µg)	Anthracene (µg)	Benzene (µg)	BTEX (µg)	c-1,2-Dichloroethene (µg)	Chloroform (µg)	Fluoranthene (µg)	Fluorene (µg)	p/m-Xylene (µg)	Pentadecane (µg)	Phenanthrene (µg)	Pyrene (µg)	Tetrachloroethene (µg)	Toluene (µg)	TPH (µg)
HSM460	February	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	<0.05	0.07	<0.02	<0.50
	April	<0.02	<0.05	<0.05	<0.05	<0.02	0.02	<0.02	<0.02	<0.05	<0.05	0.02	<0.05	<0.05	<0.05	0.05	<0.02	<0.50
	June	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.05	0.08	<0.02	<0.05	0.08	<0.05	0.13	<0.02	1.04
	August	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	0.06	<0.02	<0.50
	October	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	0.08	<0.02	<0.50
	December	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	0.09	<0.02	<0.50
HSM470	February	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	<0.05	0.05	<0.02	<0.50
	April	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	<0.05	0.04	<0.02	<0.50
	June	<0.02	<0.05	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.05	<0.05	<0.02	<0.05	<0.05	<0.05	0.15	<0.02	1.4
	August	<0.02	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	0.07	<0.02	0.70
	October	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	December	0.03	<0.05	<0.05	<0.50	<0.02	<0.02	<0.02	<0.02	<0.50	<0.05	<0.02	<0.05	<0.50	<0.50	0.11	<0.02	<0.50

* The field duplicate sample location was HSM430 for each sample event except for the April and December 2016 events.

Table 31. Passive Diffusion – San Marcos Springs Complex – Organochlorine Pesticide Detections

Location	Month 2016	4,4-DDD (µg)	4,4-DDE (µg)	4,4-DDT (µg)	Dieldrin (µg)	Endosulfan Sulfate (µg)	Endrin Ketone (µg)	Methoxychlor (µg)
HSM410	February	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	April	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	June	0.37	0.4	0.26	0.3	0.3	0.55	0.23
	August	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	October	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	December	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
HSM420	February	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	April	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	June	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	August	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	October	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	December	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
HSM430	February	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	April	NA	NA	NA	NA	NA	NA	NA
	June	0.09	0.07	<0.05	0.08	<0.05	0.21	0.1
	August	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	October	NA	NA	NA	NA	NA	NA	NA
	December	NA	NA	NA	NA	NA	NA	NA
FDHSM430*	February	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	April	NA	NA	NA	NA	NA	NA	NA
	June	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	August	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	October	NA	NA	NA	NA	NA	NA	NA
	December	NA	NA	NA	NA	NA	NA	NA
HSM440	February	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	April	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	June	NA	NA	NA	NA	NA	NA	NA
	August	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	October	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	December	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
FDHSM440*	April	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	December	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Table 31. Passive Diffusion – San Marcos Springs Complex – Organochlorine Pesticide Detections

Location	Month 2016	4,4-DDD (µg)	4,4-DDE (µg)	4,4-DDT (µg)	Dieldrin (µg)	Endosulfan Sulfate (µg)	Endrin Ketone (µg)	Methoxychlor (µg)
HSM450	February	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	April	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	June	NA	NA	NA	NA	NA	NA	NA
	August	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	October	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	December	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
HSM460	February	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	April	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	June	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	August	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	October	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	December	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
HSM470	February	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	April	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	June	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	August	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	October	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	December	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50

* The field duplicate sample location was HSM430 for each sample event except for the April and December 2016 events.

8.0 SUMMARY OF RESULTS

SWCA staff collected surface water (base flow), stormwater, sediment, and passive diffusion samples from Comal and San Marcos springs complexes. The sampling events met the requirements of the EAHCP and provided background data for these two systems. The limited number of detections above comparative standards is indicative of generally high water quality. However, the total PAH, non-PAH SVOCs, and lead results that exceeded comparative standards were of concern. Specific compounds detected above a PCL (for water) or PEC (for sediment), are listed below in Table 32.

Table 32. Compounds detected above Protective Concentration Levels (PCL) or Probable Effect Concentrations (PEC).

Sample Location	Sample Type	Date	Compound	Concentration	PCL or PEC
HCS160	Surface Water (Base Flow)	September 2016	DEHP	10.1 J µg/L	6 µg/L
HCS240 Trail	Stormwater	September 2016	DEHP	9.28 J µg/L	6 µg/L
HCS270 Lead	Stormwater	September 2016	DEHP	6.28 J µg/L	6 µg/L
HCS270 Peak	Stormwater	September 2016	DEHP	6.74 J µg/L	6 µg/L
HCS270 Trail	Stormwater	September 2016	DEHP	7.43 J µg/L	6 µg/L
HSM120	Surface Water (Base Flow)	March 2016	DEHP	12.5 J µg/L	6 µg/L
HSM120	Surface Water (Base Flow)	September 2016	DEHP	6.04 J µg/L	6 µg/L
HSM130	Surface Water (Base Flow)	September 2016	DEHP	11.3 J µg/L	6 µg/L
HSM170	Surface Water (Base Flow)	September 2016	DEHP	19 J µg/L	6 µg/L
HSM320	Sediment	June 2016	Total PAH	24.148 mg/kg	22.8 mg/kg
HSM320	Sediment	June 2016	4,4-DDE	103 µg/kg	31.3 µg/kg
HSM330	Sediment	June 2016	Total PAH	26.916 mg/kg	22.8 mg/kg
HSM340	Sediment	June 2016	4,4-DDE	31.5 µg/kg	31.3 µg/kg
HSM340	Sediment	June 2016	Lead	260 mg/kg	128 mg/kg
HSM240 Lead	Stormwater	March 2016	DEHP	9.88 J µg/L	6 µg/L
HSM250 Lead	Stormwater	November 2016	DEHP	11.0 J µg/L	6 µg/L
HSM260 Peak	Stormwater	November 2016	DEHP	14.5 J µg/L	6 µg/L
HSM260 Trail	Stormwater	November 2016	DEHP	8.46 J µg/L	6 µg/L
HSM270 Peak	Stormwater	November 2016	DEHP	7.00 J µg/L	6 µg/L
HSM270 Trail	Stormwater	November 2016	DEHP	17.4 J µg/L	6 µg/L

DEHP – bis(2-ethylehexyl) phthalate

J – Detection is greater than the method detection limit but is less than the reporting limit.

mg/kg – milligrams per kilogram

PAH – Polycyclic aromatic hydrocarbon

µg/kg – micrograms per kilogram

µg/L – micrograms per liter

PAHs in Sediment

PAHs are a group of SVOCs common in urban runoff (Mahler et al. 2005) that can have adverse effects on aquatic life including plants, invertebrates, and fish. The effects of exposure vary but can include organ damage, reproductive harm, or immune system weakening (Mahler et al. 2005). Coal-tar parking lot sealants have been identified as a significant source of PAHs in urban waterways and were banned from use in areas surrounding the recharge zone of the Edwards Aquifer within Comal and Hays Counties by the EAA in 2012. In each sample year thus far, levels of total PAH in sediment samples have exceeded TECs and PECs at two sites in the San Marcos Springs complex.

DEHP

DEHP was detected in the majority of sediment samples from the Comal and San Marcos springs complexes in 2013. However, DEHP results were noted in the laboratory blank samples for October 2013 surface water (base flow) sampling event and were considered likely post collection contaminants or false positive detections. In general, DEHP is quite problematic in that it is common in plastics and other materials. Therefore, the EAA considered DEHP as a likely laboratory or sampling equipment artifact. DEHP was not detected in water quality samples from both spring complexes in 2014 and 2015. In 2016, DEHP was detected in multiple surface water (base flow) and stormwater samples collected from both spring complexes. Nonetheless, DEHP detections were “J” flagged indicating that the detection was greater than the method detection limit, but less than the reporting limit.

Lead in Sediment

Lead has been detected at concentrations of 56.0 mg/kg, 235 mg/kg, 63.5 mg/kg, and 260 mg/kg in years 2013, 2014, 2015, and 2016, respectively at sample location HSM340. The TEC and PEC for lead are 35.8 and 128 mg/kg, respectively.

Proposed Activities for 2017

In 2015, the EAHCP received the *National Academy of Sciences (NAS) Report 1* (2015), containing recommendations for EAHCP’s Monitoring, Modeling and Applied Research programs, including the Expanded Water Quality Monitoring Program. From *Report 1*, a list of water quality monitoring recommendations was presented to the NAS Recommendation Review Work Group (NAS Work Group). Based on the NAS Work Group assessment, at its February 18, 2016, meeting, the Implementing Committee convened the 2016 EAHCP Expanded Water Quality Monitoring Program Work Group (WQWG) to carry out a holistic review of the Expanded Water Quality Monitoring Program, taking into account the recommendations of NAS, the NAS Work Group, the input of the Science Committee, the Permittees, and the subject matter experts. The purpose of the WQWG was to produce a final report for review by the Implementing Committee, developed through a consensus-based decision-making process. The WQWG held meetings from March to May 2016. An overview of the approved Scope of Work 2017 can be seen in Table 33 below.

Table 33. Overview of the Approved Scope of Work 2017

Sample Type	Frequency
Sediment	Biennially in even years
Real-time monitoring	Add one monitoring station per system
Stormwater	• Reduced to one sampling event per year • Test only for integrated pest management plan chemicals in odd years • Test full suite in even years as currently done • Add two samples to the rising limb of the hydrograph for a total of five samples per location when possible ○ Priority given to locations at tributary outflows
Passive Diffusion Samplers	• Currently done • Add PPCP membrane only at the bottom of the channel in both systems
Tissue sampling	One sample in odd years from both systems

9.0 DATA QUALITY OBJECTIVES

SWCA evaluated each sampling event to determine if procedures should be modified to improve data collection to ensure data quality objectives are met. Appendix C provides a discussion of problems encountered, deviations to the Work Plan, and resolutions to these circumstances. The only ongoing challenge recognized is the inability to consistently deliver *E. coli* samples to a laboratory within hold times during stormwater sampling events. This inability is inherent to stormwater sampling events due to the occurrence of storms during non-working hours. SWCA uses special runners to deliver samples to the laboratory as early as possible to minimize hold time exceedances.

Based on procedures implemented to correct or improve data collection methods and the relatively low significance of the deviations, the circumstances described in Appendix C do not compromise the integrity of the study or this report.

10.0 DEFINITIONS

Alkalinity	The capacity of water to neutralize acids, a property imparted by the water's content of carbonate, bicarbonate, hydroxide, and on occasion borate, silicate, and phosphate. It is expressed in milligrams per liter of equivalent calcium carbonate (mg/l CaCO ₃).
Aquifer	Underground geological formation or group of formations containing water; source of groundwater for wells and springs.
ASTM	Abbreviation for American Society for Testing and Materials. A nonprofit organization that develops and publishes approximately 12,000 technical standards, covering the procedures for testing and classification of materials of every sort.
Bacteria	Microscopic living organisms that can aid in pollution control by metabolizing organic matter in sewage, oil spills, or other pollutants. However, certain bacteria in soil, water, or air can also cause human, animal, and plant health problems.
Basin	Any area draining to a point of interest.
Baseline data	Initial data generated by consistent monitoring of the same sites over time.
Caffeine	A stimulant drug found naturally in coffee, tea, and chocolate, and also within soft drinks and other foods. If detected, it might indicate an anthropogenic source of water impacts.
Channel	A long, narrow excavation or surface feature that conveys surface water and is open to the air.
Deionized water	Water with all ions removed.
Detection limit	The lowest concentration of a given pollutant that an analytical method or equipment can detect and still report as greater than zero. Generally, as readings approach the detection limit, they become less and less reliable quantitatively.
Dissolved solids	The total amount of dissolved material, organic, and inorganic, contained in water or wastewater. Measurements are expressed as ppm or mg/L.
DO	Abbreviation for dissolved oxygen. Oxygen molecules that are dissolved in water and available for living organisms to use for respiration. Usually expressed in milligrams per liter or percent of saturation. The concentration of DO is an important environmental parameter contributing to water quality.
DOC	Abbreviation for dissolved organic carbon, a broad classification of organic molecules of varied origin and composition within aquatic systems. Organic

carbon compounds are a result of decomposition processes from dead organic matter, such as plants.

DQO	Abbreviation for data quality objectives, a process used to develop performance and acceptance criteria or data quality objectives that clarify study objectives, define the appropriate type of data, and specify tolerable levels of data needed to support decisions.
Drainage	The collection, conveyance, containment, and/or discharge of surface and stormwater runoff.
EARIPHCP	Abbreviation for Edwards Aquifer Recovery Implementation Program Habitat Conservation Plan.
Endpoint	That state in titration at which an effect, such as a color change, occurs, indicating that a desired point in the titration has been reached.
Equipment blank	Sample used to assess the effectiveness of the decontamination process on sampling equipment. The equipment blank is prepared by pouring reagent-grade water over/through sampling equipment and analyzing for parameters of concern (to match the sampling routine applicable to the site).
Field duplicate	Second sample collected simultaneously from the same source as the parent sample, but which is submitted and analyzed as a separate sample. This sample should generally be identified such that the laboratory is unaware that it is a field duplicate.
Filtration	The process of separating solids from a liquid by means of a porous substance (filter) through which only the liquid can pass.
Groundwater	Water found beneath Earth's surface that fills pores between materials, such as sand, soil, or gravel.
Habitat	The specific area of environment in which a particular type of plant or animal lives and grows.
HCP	Abbreviation for Habitat Conservation Plan. A planning document that is required by the United States Fish and Wildlife Service as part of their enforcement of the Endangered Species Act.
LCS/LCSD	Abbreviation for Laboratory control samples and laboratory control sample duplicate. LCS/LCSD are evaluated to assess overall method performance and are the primary indicators of laboratory performance. In general, laboratory control samples are similar in composition as the environmental samples, contain known concentrations of all the analytes of interest, and undergo the same preparatory and determinative procedures as the environmental samples. An LCS/LCSD may be analyzed to provide information on the precision of the analytical method.

MS/MSD	Abbreviation for matrix spike/matrix spike duplicate. MS/MSD results are examined to evaluate the impact of matrix effects on overall analytical performance and potential usability of the data. A matrix spike is a representative environmental sample that is spiked with target analytes of interest prior to being taken through the entire analytical process in order to evaluate analytical bias for an actual matrix. A matrix duplicate is a collected (e.g., a VOC soil sample) or a homogenized sample that is processed through the entire analytical procedure in order to evaluate overall precision for an actual matrix.
MDL	Abbreviation for method detection limit, minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero, as determined from analysis of a sample containing the analyte in a given matrix.
MPN	Abbreviation for most probable number. An analytical method used to detect the presence of coliforms in a water sample and estimate their numbers.
PCBs	Abbreviation for polychlorinated biphenyls. Group of more than 200 chlorinated toxic hydrocarbon compounds that can be biomagnified.
PCL	Abbreviation for protective concentration levels, which is established to protect human health.
Peak	Maximum instantaneous flow at a specific location resulting from a given storm condition.
pH	A measure of the alkalinity or acidity of a substance. Also defined as the negative logarithm of the hydrogen ion concentration ($-\log_{10}[\text{H}^+]$) where H^+ is the hydrogen ion concentration in moles per liter. The pH of a substance is neutral at 7.0, acidic below 7.0, and alkaline above 7.0.
PQL	Abbreviation for practical quantitation limit, which is the smallest concentration of the analyte that can be reported with a specific degree of confidence.
Precipitation	The discharge of water, in liquid or solid state, out of the atmosphere, generally upon a land or water surface. Precipitation includes rainfall, snow, hail, and sleet.
Precision	The ability of a measurement to be consistently reproduced.
QA/QC	Abbreviation for quality assurance/quality control. The total integrated program for assuring reliability of monitoring and measurement data.
Recession	End of runoff event, which is defined as the point in time when the recession limb of the hydrograph is $< 2\%$ of the peak or is within 10% of the prestorm base flow, whichever is greater.

RPD	Abbreviation for relative percent difference. The RPD provide a measure of precision.
Representative	Said of samples collected that are similar to those of groundwater in its in situ condition.
RL	Abbreviation for reporting limit, the smallest concentration of an analyte reported by the laboratory to a customer. The RL is never less than the PQL and is generally twice the MDL.
Runoff	Precipitation, snowmelt, or irrigation water that runs off the land into surface water. Runoff can carry pollutants from the air and land into the receiving waters.
Sediment	Fragmental material that originates from weathering of rocks and is transported by, suspended in, or deposited by water or air.
Shelby Sampler	A thin-walled tube with a cutting edge at the toe. A sampler head attaches the tube to the drill rod and pressure vents. Generally used in cohesive soils. Soil or sediment sampled from this sampler is considered undisturbed.
Spring	Water coming naturally out of the ground.
Stormwater	Stormwater is the water that runs off surfaces such as rooftops, paved streets, highways, and parking lots. It can also come from hard, grassy surfaces such as lawns, play fields, graveled roads, and parking lots.
Surface water	Water that forms and remains above ground, such as lakes, ponds, rivers, streams, bays, and oceans.
SVOC	Abbreviation for semi-volatile organic compounds, which is a group of chemicals composed primarily of carbon and hydrogen that have a relatively low tendency to evaporate (volatilize) into the air from water or soil. Some of the compounds that make up asphalt are examples of SVOCs.
TDS	Abbreviation for total dissolved solids, or the total amount of all inorganic and organic substances, including minerals, salts, metal, cations, or anions that are dispersed within a volume of water.
Temporal	Over a period of time.
TKN	Abbreviation for total Kjeldahl nitrogen, which is the total concentration of organic and ammonia nitrogen in wastewater.
TOC	Abbreviation for total organic carbon, which is the gross amount of organic matter found in natural water. Suspended-particulate, colloidal, and dissolved organic matter are part of the TOC measurement. Settable solids consisting of inorganic

	sediments and some organic particulate are not transferred from the sample by the lab analyst and are not part of the TOC measurement.
TSBC	Texas-specific Background Concentrations as established by the Texas Commission on Environmental Quality.
Turbidimeter	An instrument for measuring turbidity in which a standard suspension is used for reference.
Turbidity	A measure of how clear the water is; how much the suspended material in water results in the scattering and absorption of light rays. An analytical quantity is usually reported in turbidity units and determined by measurements of light diffraction. Material that can increase turbidity (reduce clarity of water) are suspended clay, silt, sand, algae, plankton, microbes, and other substances.
Trip blank	Sample known to be free of contamination (for target analytes) that is prepared in the laboratory and treated as an environmental sample after receipt by the sampler. Trip blank samples are applicable to VOC analysis only.
TSS	Abbreviation for total suspended solids, which are the nonfilterable residue retained on a glass-fiber disk filter mesh measuring 1.2 micrometers after filtration of a sample of water or wastewater.
USGS	Abbreviation for United States Geological Services. USGS is a federal research organization that provides impartial information on health of ecosystems and environment, natural hazards that may threaten us, natural resources, impacts of climate and land use change, and core science systems which provide timely, relevant, and useable information.
VOC	Abbreviation for volatile organic compounds, which are often used as solvents in industrial processes and are either known or suspected carcinogens or mutagens. The five most toxic are vinyl chloride, tetrachloroethene, trichloroethene, 1,2-dichloroethane, and carbon tetrachloride.
Whirl-Pak®	Sterilized, clear polyethylene bag used to collect water samples for analysis.
WQAL	Abbreviation for a list of parameters defined as the following: pH, conductivity, temperature, dissolved oxygen, turbidity, and alkalinity in the field. Other parameters submitted for laboratory analysis include cations, anions, nutrients, metals, VOCs, SVOCs, herbicides and pesticides, bacteria, TOC, PCBs, and phosphorous.

11.0 ACKNOWLEDGEMENTS

SWCA would like to thank the San Marcos Nature Center staff, especially Melani Howard, for helping with coordination efforts and providing a work area during storm sampling activities. SWCA would also like to acknowledge the City of New Braunfels staff for coordination efforts with the local police and park staff and for coordinating sample locations and access.

The work of the SWCA stormwater sampling team is also much appreciated. Team members are listed below.

Jenna Cantwell
Jennifer Moreland
Philip Pearce
Matt Nordgren
Chris Collins
Katie Sloan
Marli Claytor
Guy Rubio
Jeffery Fox
Cody Boazman
Benjamin Morton
Chris Matthews
Kathleen Jenkins
Heather McFeeters
Katie Snipes
Tina Nielson
Stefan Schuster

This report was prepared by: Jennifer Moreland, Lauri Logan, and Philip Pearce.

12.0 REFERENCES

- Edwards Aquifer Authority. 2013. Edwards Aquifer Habitat Conservation Plan Expanded Water Quality Report 2013, 33 p.
- . 2015. 2016 Edwards Aquifer Authority Water Quality Monitoring Program Work Plan for Comal Springs and San Marcos (EAHCP Work Plan), 23 p.
- . 2015. *Hydrologic Data Report for 2014*, Edwards Aquifer Authority Report
- Environet. 2016. RTI Water Quality Data. Available online at: <https://ienvironet.com>. Accessed October 2016.
- Lemly, A.D. 1995. A protocol for aquatic hazard assessment of selenium. *Ecotoxicology and Environmental Safety*, 8 p.
- MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Archives of Environmental Contamination and Toxicology*, 31 p.
- Mahler, B.J., P.C. Van Metre, T.J. Bashara, J.T. Wilson, and D.A. Johns. 2005. Parking lot sealcoat: an unrecognized source of urban polycyclic aromatic hydrocarbons. *Environmental Science & Technology*, 39(15), 5560-5566.
- Moore S.B., J. Winckel, S.J. Detwiler, S.A. Klasing, P.A. Gaul, N.R. Kanim, B.E. Kesser, A.B. DeBevec, K. Beardsley, and L.K. Puckett. 1990. *Fish and Wildlife Resources and Agricultural Drainage in the San Joaquin Valley, California: San Joaquin Valley Drainage Program, Sacramento, California*.
- National Oceanic and Atmospheric Administration (NOAA). 2016. Precipitation Data. Available online at: http://www.srh.noaa.gov/ridge2/RFC_Precip/. Accessed October 2016.
- Office of the Secretary of State. 2014. MCL information and tables. Available online at: [http://info.sos.state.tx.us/pls/pub/readtac\\$ext.ViewTAC?tac_view=5&ti=30&pt=1&ch=290&sch=F&rl=Y](http://info.sos.state.tx.us/pls/pub/readtac$ext.ViewTAC?tac_view=5&ti=30&pt=1&ch=290&sch=F&rl=Y). Accessed October 2014.
- . 2014. Texas specific soil background metals concentrations. Available online at: <http://info.sos.state.tx.us/fids/200700768-1.html>. Accessed October 2014.
- Texas Commission on Environmental Quality (TCEQ). 2012. Table 3.5 Screening levels for sediment. In *2012 Guidance for Assessing and Reporting Surface Water Quality in Texas*, p. 3-16 – 3-19.
- . 2014a. Table 3.3 Ecological benchmarks for sediment and Table A.2. Second effects levels for sediment. In *Conducting Ecological Risk Assessments at Remediation Sites in Texas*, p. 66-70, 227-231.
- . 2014b. Texas risk reduction program rules and protective concentration levels (PCL) tables. Available online at: http://www.tceq.state.tx.us/assets/public/remediation/trrp/trrptbls1_5_042308.xls. Accessed October 2014.
- U.S. Environmental Protection Agency (EPA). 2012. Pharmaceutical and personal care products. Available online at: <http://www.epa.gov/ppcp/>. Accessed October 2014.

- U.S. Geological Survey (USGS). 2016. Water resources streamflow data. Available online at: <http://www.usgs.gov/water/>. Accessed October 2016.
- Van Derveer, W.D., and S.P. Canton. 1996. Selenium sediment toxicity thresholds and derivation of water quality criteria for freshwater biota of western streams. *Environmental Toxicology and Chemistry*, 8 p.