Data Collection and Analysis for the Spring Lake – Sink Creek Watershed Report

Nonpoint Source Protection Program CWA §319(h)

Prepared for the Texas Commission on Environmental Quality

and the U.S. Environmental Protection Agency

Region VI

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The Data Collection and Analysis for the Spring Lake – Sink Creek Watershed Report is the fourth in a series of documents that detail the Spring Lake Watershed Characterization Project. This report is the result of collaboration and cooperation between many groups and individuals which have played important roles in the planning, activities, and support for the Spring Lake Project.

The characterization of the Spring Lake Watershed is an ongoing project. The primary authors of this report – Dr. Weston Nowlin and Dr. Benjamin Schwartz - would like to recognize several individuals for their invaluable input, assistance and support. We would like to recognize Philip Ramirez, Gaby Timmins, Benjamin Hutchins, Kerstin Hoesel, and Jesse Becker for their hard work in the field, lab and at the computer. We would also like to thank Mary Van Zant, Hayat Qurunful, Jason Pinchback, Vanessa Lavender, Andy Sansom, Dr. Thom Hardy, and Emily Warren of Texas State University-San Marcos and the River Systems Institute.

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List of Acronyms and Abbreviations

N	Nitrogen
NH_4^+	Ammonium
NPS	Nonpoint Source
P	Phosphorus
SpC	Specific Conductance
TDS	Total Dissolved Solids
TSS	Total Suspended Solids

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Data Collection and Analysis Report

4.1 Introduction

The San Marcos River is an ecologically unique spring-fed ecosystem located along the margin of the Edwards Plateau in central Texas. Spring Lake, located in the City of San Marcos, is the headwaters of the San Marcos River where artesian spring water from the Edwards Aquifer emerges into the lake from approximately 200 openings. Water from these springs support the overwhelming majority of the annual discharge of the Upper San Marcos River (USMR), but the importance of the springs has become evident during recent droughts. During portions of the 1996 drought, San Marcos Springs and nearby Comal Springs combined accounted for 70% or more of flows in the Guadalupe River reaching Victoria and nearly 40% of flows that reached the San Antonio Bay.

Spring Lake is a horseshoe-shaped water body with two main regions: the Spring Arm and the Slough Arm. Most of the hydrological inputs to Spring Lake occur from spring openings in the Spring Arm. Sink Creek, the lake's only significant surface water tributary, discharges into the Slough Arm of the lake. Due to the relatively large spring water influence, Spring Lake and the upper river reaches are characterized by clear water, abundant and productive macrophytes, and a relatively large number of endemic and native species. Spring Lake and the upper sections of the river exhibit nearly constant seasonal flows and water temperatures of ~22^{o}C; this relative environmental constancy has led to a high number of endemic species in the headwaters. However, the potential sensitivity of the headwaters to environmental perturbation, and the limited geographic range of many of the spring-adapted organisms, have led to the designation of a large number of federally- and state-listed taxa in the headwaters of the San Marcos River.

In addition to the high ecological value of the San Marcos River headwaters, the area also has substantial economic and cultural value for central Texas. Spring Lake and the upper river lie within the Texas State University campus and serve as a focal point for the campus and the City of San Marcos. Thousands of people visit the upper San Marcos every year for recreational activities such as swimming, tubing and kayaking, and glass bottom boat rides in the headwaters. While the exact number of recreational users of the San Marcos River and its headwaters is unknown, approximately 125,000 people per year take part in the various programs at the Aquarena Center on Spring Lake, and the City of San Marcos also estimates that two city parks in the upper section of the river receive more than 600 recreational visitors per day on a typical summer day (e.g., not 4th of July weekend). In addition, there have been major archeological finds of prehistoric human artifacts and animal remains in Spring Lake. Further downstream from Spring Lake, the San Marcos River supplies drinking water for a number of communities in the San Marcos – Guadalupe River drainage, including the City of Victoria (60,000 residents). Water quality and quantity is of principle concern to communities below the San Marcos River – Guadalupe River confluence because they are highly dependent upon the San Marcos River contribution to river flows, especially during relatively dry periods.

Texas State University and the City of San Marcos have taken significant measures to protect the water quality of Spring Lake. The University, a public institution, currently owns the land the lake sits on and acts as a steward to protect the lake's current state. The city has put in place special ordinances to ban swimming and boating in the lake to protect the endangered species habitat in the lake. Additionally, the city partners with the university to monitor water quality in the lake (bacterial testing). The City has acquired and will preserve 251 acres of land from a developer who had planned to build a conference facility immediately upstream of Spring Lake. The stormwater from this property flows directly into Spring Lake and Sink Creek just upstream of the lake. The most current plans for local action include a Watershed Protection Plan that will begin in the next year. This Spring Lake project is a smaller geographic and informational scope than the Watershed Protection Plan. The information gathered and stake holder work completed during this project will be incorporated into the Watershed Protection Plan. At this time, the City of San Marcos and Texas State University are funding a half-time watershed planner position.

To date, there has been a limited attempt to obtain data on nutrient inputs to Spring Lake. Despite the system's high ecological, economic and cultural value, Spring Lake and the USMR have recently experienced increased turbidity and major algal blooms following substantial rainfall events and the associated increases in surface and subsurface flows. While there is an obvious and sometimes persistent deterioration of water quality during and after periods of high surface and ground water inputs to the lake, the relative pollutant load contributions of these sources in the watershed is unknown. Thus, determination of the relative nutrient and sediment inputs to the lake from the various hydrological sources is critical for the management and preservation of the lake. In order to determine the influence of various sources of water on algae and turbidity in the lake, storm event-based data, which are collected at a high-temporal resolution and are quality-assured, are required. In particular, determination of inputs of phosphorus (P) are of greatest concern because productivity of the lake is extremely phosphorus limited due to the low levels of immediately bioavailable phosphorus (<5 µg orthophosphate - P/L) relative to the high levels of bioavailable nitrogen (~1600 µg NO_3^{2-} - N/L) (Groeger et al. 1997).

Among the potential sources of nutrient perturbation to the lake, one of the most likely sources is Sink Creek. Currently, portions of the Sink Creek watershed are experiencing rapid and major land use changes or have been proposed for future development. Sink Creek was historically an ephemeral stream that drained ranching and agricultural areas. However, rapid urban development along the IH-35 Austin-San Antonio corridor has led to a substantial increase in impervious cover and urban lands in the watershed. Most of the land within the Sink Creek watershed is privately owned; however, the City of San Marcos recently purchased approximately 250 acres within the watershed as part of a "greenbelt" and the uppermost headwaters of Sink Creek are located on Freeman Ranch, a property owned by Texas State University. Because Sink Creek discharges into the relatively shallow and biologically productive Slough Arm of Spring Lake, incidents of high precipitation and high surface waters inflows may function as a major contributor to deterioration of lake water quality because of the land use changes within the Sink Creek watershed.

The relative contribution of nutrients from the spring openings during periods of high discharge also remains unclear. During periods of low precipitation and surface flows (e.g., summer and early fall) groundwater dominates hydrological and nutrient inputs to the lake. However, groundwater discharges to the lake also increase with precipitation, but the relative contribution of these groundwater flows to nutrient loading during high flow periods is unknown. In addition, there are numerous spring openings in Spring Lake that vary in flow rate and groundwater sources. Some openings discharge water from largely local sources, while other openings can discharge water from regional sources that are much older. The relative contribution of these various groundwater sources and how they vary seasonally and with local precipitation patterns is also unclear.

Another potential nutrient source to Spring Lake and the USMR is the Texas State University Golf Course. The course lies immediately adjacent to the middle portion of the Slough Arm of Spring Lake, and maintenance practices from the course may lead to nutrient and sediment inputs to the lake. Again, the relative contribution of nutrient runoff from the golf course to algal blooms in the lake remains unknown.

Given the recent substantial water quality issues and the ecological, economic and cultural value of the Spring Lake system, understanding the relative nonpoint source (NPS) contributions of nutrients and suspended materials to Spring Lake via groundwater, the Sink Creek watershed, and the Texas State Golf Course is critical to preserve the biota and water quality of the lake.

4.1.2 Executive Summary

The San Marcos River is an ecologically unique spring-fed ecosystem located along the margin of the Edwards Plateau in central Texas. Spring Lake, located in the City of San Marcos, is the headwaters of the San Marcos River where artesian spring water from the Edwards Aquifer emerges into the lake from approximately 200 openings. Water from these springs support the overwhelming majority of the annual discharge of the USMR, but the importance of the springs has become evident during recent droughts. To date, there has been a limited attempt to obtain data on nutrient inputs to Spring Lake. Despite the system's high ecological, economic, and cultural value, Spring Lake and the USMR have recently experienced increased turbidity and major algal blooms following substantial rainfall events and the associated increases in surface and subsurface flows. While there is an obvious and sometimes persistent deterioration of water quality during and after periods of high surface and ground water inputs to the lake, the relative pollutant load contributions of these sources in the watershed is unknown. Thus, determination of the relative NPS nutrient and sediment inputs to the lake from the various hydrological sources is critical for the management and preservation of the lake.

The purpose of this report is to provide information on spatial and temporal variability in water quality in the Upper San Marcos River under both baseflow and stormflow conditions, and to compare water quality under these conditions to existing surface water quality standards. This comparison allows identification of times and locations at which water quality standards for

particular parameters may or may not be exceeded, and provides guidance for future efforts to focus on mitigating any sources of NPS which may be contributing to water quality impairment.

4.2 General Watershed Information

Spring Lake is the headwaters of the San Marcos River where artesian spring water emerges into the lake from >200 spring openings; this spring system is the second most hydrologically productive in the state. Water from these springs originates from the Edwards Aquifer. The Edwards Aquifer is a large, complex limestone karst aquifer spanning a substantial portion of the central Texas region. A more detailed discussion of the flow paths of Edwards Aquifer waters to Spring Lake are provided in a previous report associated with this project (see the Spring Lake Watershed Initial Characterization Report).

Although Spring Lake receives most of its annual hydrological inputs from groundwater sources, Sink Creek discharges into the Slough Arm of the lake. Flows from Sink Creek originate more than 15 stream miles upstream to the northwest near the city of Wimberley. Much of the time, Sink Creek is dry and experiences little to no flow. However, during strong rain events or in relatively wet years (e.g., El Niño years), Sink Creek flows and appears to discharge substantial loads of sediments and nutrients into Spring Lake and the upper river. As the name implies, water in the creek also "sinks" and presumably provides some recharge to local groundwater sources. However, the extent of this groundwater recharge from the creek is not known. There are also several flood retention structures (dams) upstream from Spring Lake on Sink Creek, with the largest of these structures located on Freeman Ranch. Presumably, these flood retention structures also provide some opportunity for surface waters to recharge the aquifer.

As a result of the strong spring water influence on Spring Lake and the upper San Marcos, the upper river typically exhibits high water quality with low turbidity, low suspended sediment loads, and low phosphorus (P) concentrations. Spring Lake and the USMR have recently experienced increased turbidity and declines in water quality after rainfall events, presumably from inputs by Sink Creek. However, the relative pollutant load contributions of these ground- and surface water sources to Spring Lake and the USMR currently remain unknown.

This Data Collection and Analysis Report describes the data collected to characterize spatial and temporal properties of water quality in the Spring Lake watershed. Several approaches were used to accomplish this, and can be separated into three types of data collection and monitoring efforts: 1) Continuous monitoring of basic field parameters; 2) Routine sampling for water quality; and 3) Targeted sampling for water quality. A description of methods used and the results will be presented separately for each effort, and followed by a discussion and conclusion that integrates the findings of all three efforts.

4.3 Sampling Sites

Locations in Spring Lake and the Sink Creek watershed where manual or automated water samples, and automated water quality data are collected, are referred to as Sampling Sites (Table 4.1). Together, these sites are part of the Continuous Monitoring, Routine Sampling, and Targeted Sampling programs, which were designed to assess existing baseline water quality as well as changes in water quality due to storm events and seasonal-scale effects. Figures 4.3.1 and 4.3.2 illustrate the geographic locations of these sites.