Water quality problems have accumulated over many decades and may take decades to amend. Confirming that awareness and attitudes are changing and behaviors are being adopted in a watershed is one way that projects can demonstrate progress toward water quality goals. Monitoring social indicators, like monitoring environmental indicators, will give valuable information about how well management strategies are working.

4. MONITORING PLAN

Monitoring and data collection will be undertaken during implementation of the WPP by the COSM, Texas State University, GBRA via the Texas Clean Rivers Program (CRP), TST, and other partners. Flow/discharge and height are captured by gauging stations operated by USGS with support from EAA. Groundwater levels are monitored by EAA and groundwater districts (BSEACD, precincts 1 and 2, HTGDC District 5). Specialized and targeted monitoring including bacterial source tracking, TDS constituent analyses, and biological monitoring are being performed by City, University, EAHCP, and other entities.

Monitoring efforts will be coordinated and used to track water quality conditions with the aim of better understanding nonpoint source pollution contributions to the river over time. Available routine, continuous, and storm event water quality monitoring data will be used to develop a baseline for tracking water quality and WPP progress. Water quality monitoring data will be used to assess efficacy of implemented BMPs and ordinances over time. In addition, EAA and the WPP partners spend considerable effort on monitoring EAHCP progress via water quality and quantity metrics that can be applied to track WPP progress. Potential future monitoring may be used to determine the origins of TDS in source water and river water. Future monitoring may also be used to determine potential effects of stormwater pollution on source water.

The following section provides information related to:
Element I. Water quality monitoring component to evaluate effectiveness of implementation over time

Tracking Load Reductions from Management Measures

WPP Monitoring Plan (Element I) efforts to measure the effectiveness of BMPs and management measures will utilize the Implementation Schedule (Element F), modeled or calculated outcomes of measures (Element B), and identified management objectives (Element C). To evaluate the effectiveness of Plan activities, the monitoring outlined in Table 4.1. Monitoring will be coordinated by Plan partners, recorded, and reported on the WPP website. Data will be compiled and reviewed at least semi-annually by the Stakeholder Committee. Additional sources of data will be reviewed for quality assurance and can also be considered. Data showing increases in pollutants will be further analyzed and used to trigger adaptive management strategies.

Adaptive management guided by water quality analyses will determine future implementation strategies. By tracking water quality trends and responses to both environmental factors and Plan activities, stakeholders will be able to evaluate whether Plan implementation is successful and can determine the need for additional actions or refocusing of existing efforts. This adaptive approach relies on frequent input of watershed information and the comparison of current conditions to the water quality targets and goals.

Figure 4.1 Texas Stream Team monitoring sites along the Upper San Marcos River

Party	Monitoring Activities	Notes
EAHCP (including COSM and Texas State University)	EAHCP monitoring: - Biological monitoring (habitat and population of covered species, macroinvertebrate rapid bioassessment, and water quality grab samples - CRP collected parameters) - Annual even year sediment sampling (toxics) - Real time monitoring data sonde in Spring Lake (collects DO, conductivity, turbidity, temperature, and pH at 15 min intervals) - Annual stormwater sampling (herbicide and pesticide compounds, atrazine in odd years, and a full suite of parameters in even years) - Annual passive diffusion sampling will include adding a PPCP diffusion sampler at the most downstream sampling site - Annual odd year tissue sampling of pelagic, fish apex predator, a covered benthic fish species, and a sediment dwelling filter feeder (parameters to be established) - Annual stormwater sampling (test only for Integrated Pest Management Plan chemicals in odd years, test full suite in even years, 5 samples/ location, priority given to locations at tributary outflows) - Groundwater well sampling conducted through Non-EAHCP programs at EAA	--
COSM	- Weekly collection of E. coli samples in key recreation and habitat areas (Spring Lake, City Park, Rio Vista Park, IH-35 Bridge, upstream and downstream from the waste water plant) - Monitoring of private wells upon request	Samples are processed in National Environmental Laboratory Accreditation Program (NELAP) accredited lab. Bacteria data can be coupled with TST and GBRA data at overlapping sites
COSM	MS4 – storm sewer system and BMP/site (ponds, etc) monitoring and inspection	--
Texas State University - Environmental Health, Safety and Risk Management	MS4 – storm sewer system/stormwater pollution prevention plan and BMP/site (ponds, etc) monitoring and inspection; bi-annual dry weather flow inspections on university outfalls MS4 – water quality monitoring may be included in the next permit (December 2018)	--
BSEACD, EAA	Well level monitoring and other groundwater monitoring, including water quality.	--
USGS	Continuous monitoring of discharge at Spring Lake. Discharge/flow and gauge height on the main stem of the river.	Data is available on website
TPWD	Water quality, habitat, and biological monitoring special projects as needed	--

Party	Monitoring Activities	Notes
GBRA CRP Monitoring	Routine (quarterly) monitoring for temperature, conductivity, DO, pH, nitrate/nitrite-nitrogen, TP, TSS, turbidity, SO4 -2 , Cl-1 , chlorophyll-a, total hardness, E. coli, flow, and Texas Surface Water Quality Standards bacteria sampling at one site on the main stem and all parameters except flow on the main stem just below the confluence (lower San Marcos).	Data is quality assured through TCEQ, EPA and available on website NELAP accredited lab
TST and San Marcos River Rangers	Routine (monthly and bimonthly at select sites) monitoring for temperature, DO, specific conductivity, TDS, pH, and total depth. E. coli, nitrate/nitrogen, and orthophosphate/phosphorous at a portion of the sites. At least 15 sites will be utilized in the monitoring plan. Existing monitoring plan will be updated as needed to collect additional data/add sites.	Data collected is quality assured through TCEQ, EPA Data is available on website
City of San Marcos WWTF and Fish Hatchery	Daily monitoring by the WWTF include temperature, conductivity, DO, pH, nitrate/nitrite-nitrogen, TP, TSS, E. coli, and flow A. E. Wood Fish Hatchery discharge data is recorded as a monthly average, along with daily TSS.	Data available at City
Stakeholder committee/ workgroup (City, University, EAA)	Coordination of monitoring activities; compilation and review of results on a regular basis. Identification of trends or issues for further review and triggers for implementation of adaptive management strategies, including additional monitoring activities	All data will be compiled regularly and published on the WPP webpage

For bacteria and nutrients of concern, a 5-year geometric mean will be computed every 6 months. TSS and TDS data will be averaged and compared for individual and quarterly sampling events. Water quality data will be reviewed for each available monitoring site or group of localized sites (against available historical data) and compared to upstream and downstream sites for changes in pollution levels. Assessments will include pre- and post-implementation of management measures, changes in flow and climate conditions and other relevant factors. Water quality will be aggregated for subbasins with identified exceedances or emerging water quality issues (see Appendix C) and analyzed for changes over time and changes in response to management measures.

Modeled and calculated pollution reductions from implementation of structural BMPs will be compared with available water quality data at the subbasin scale. Figure 1.11 shows that the majority of the subbasins with exceedances are in the more urbanized, Southeastern portion of the watershed and the primary constituents of concern are TSS, nitrogen, and bacteria. For example, Sessom Creek watershed (subbasins 10, 11) has been identified as a very high priority for reduction of TSS and erosion. If possible, data will also be compared at the eleven accumulation points used for assessing current and future water quality conditions in the WPP (see the Groundwater Protection Planning document on the SMWI website under Supporting Documents). The stated goal of the stakeholder committee is to reach and maintain Targets A and B shown in Table 1.1, which in most cases are stricter than state standards and screening levels. These pollutant concentration targets were developed based on incremental implementation of the WPP and assume significant accomplishment of pollutant load reductions by the end 2025 and 2035.

Management measures requiring less resources will be implemented early in the process, while implementation of other measures will require more time, coordination, planning, and funding. Reductions in pollutant loads are likely to be gradual and not equivalent across the watershed. Water quality targets will serve as benchmarks of Plan progress and are a tool to facilitate decision-making for prioritizing future implementation activities.

Subbasins or accumulation points not meeting or trending toward targeted values, "hot spots" identified via MS4 and EAHCP, and other sources will be reviewed and additional measures will be determined to reduce nonpoint source pollution in those areas.

Coordinating Existing and Future Monitoring Efforts

Continued monitoring of water quality (and in some cases quantity) is an important aspect of the WPP. Project partners will coordinate all ongoing water quality monitoring in the watershed. All acquired data will be compiled in accordance with best practices. Analyses of compiled data will be utilized to evaluate potential and realized reductions in pollutant loads and concentrations over time from ordinance changes and in situ BMPs (LID and GI). Details of known and potential monitoring activities are provided in Table 4.1.

Baseflow Monitoring

The Texas CRP is a partnership between the TCEQ and regional water authorities to coordinate and conduct water quality monitoring, assessment, and stakeholder participation to improve the quality of surface water within each river basin in Texas. GBRA is the partner responsible for administrating the CRP in the Guadalupe River Basin, to which the Upper San Marcos River belongs. The EAHCP also utilizes CRP data for decision making and milestone tracking.

Water quality data collected as part of the CRP includes: water temperature, specific conductivity, DO, and pH. Samples are collected and brought to GBRA's NELAP accredited lab where they are analyzed for TSS, nitrates, ammonia, phosphorus, and E. coli.

There is one main stem monitoring site monitored on a quarterly basis. GBRA also monitors one location just below the confluence of the Upper San Marcos River with the Blanco River. Additional sites may be added as funding allows. Flow and water quality data from this site will provide insight regarding potential nonpoint source of pollution in the lower reach of the Upper San Marcos River.

Stormflow Monitoring

In general, ambient monitoring data are collected under baseflow conditions. However, reliable streamflow data following storm events is required for additional hydrologic characterization and to calculate average pollutant loads as the Plan is implemented. In addition, data on streamflow and water quality will characterize the range and temporal variability of water quantity and quality under the full range of natural conditions. Because water quality parameters are highly influenced by flow rates, it is important to understand the hydrologic response of the watershed to environmental conditions to identify causes and sources of nonpoint source pollution, and identify and implement appropriate BMPs. Any updated modeling efforts are also dependent on accurate flow estimates to ensure the greatest possible accuracy when evaluating potential impacts of future development. The EAA will conduct stormflow monitoring and if it is determined that more frequent monitoring is required, the Stakeholder Committee will work with the City and University to schedule events.

EAHCP Monitoring and Analyses

A variety of data will be collected for the EAHCP, including water quality, groundwater, toxic chemicals, metals, biological habitat, and other types of information. This data provides a robust picture of conditions in the river and the aquifer. Information collected is used to make management decisions related to species protection and can be used to supplement WPP efforts, both with supplemental data and EAA completed analyses.

MS4 Monitoring and Analyses

MS4 efforts include monitoring of BMPs which can provide information about improperly functioning measures that may be contributing pollution, as well as environmental conditions that may contribute to stormwater runoff and pollution.

Citizen Science Data – Texas Stream Team and San Marcos River Rangers

TST is a program at The Meadows Center and is primarily funded by a Section 319(h) grant from the EPA through the TCEQ. The San Marcos River Rangers, with funding from the SMRF collect data for TST and collaborate on projects related to improving or protecting water quality.

Citizen scientists who join TST are trained to collect water quality data in accordance with TST Team's TCEQ approved Quality Assurance Project Plan (QAPP). The parameters collected by TST and River Ranger Citizen Scientists include: water temperature, specific conductivity, pH, DO, water clarity, and field observations. Advanced Citizen Scientists collect nitrates, phosphates, E. coli, turbidity, and stream flow. Sites are sampled bimonthly or monthly. The data is submitted to TST where it undergoes quality assurance review according to TST's QAPP. The verified data is then uploaded to the Data Viewer, an interactive map/database that stores citizen scientists' data for public view and reference.

TST can increase stakeholder involvement by training local stakeholders to collect water quality data. The data can then be presented to stakeholders and the public for a better understanding of current water quality conditions. This data also can help supplement other water quality data that is collected in the watershed. In addition to its traditional water quality monitoring programs, TST offers aquatic macroinvertebrate assemblage and riparian system monitoring. TST staff and citizen scientists will collect samples in conjunction with water quality sampling and quality assure data.

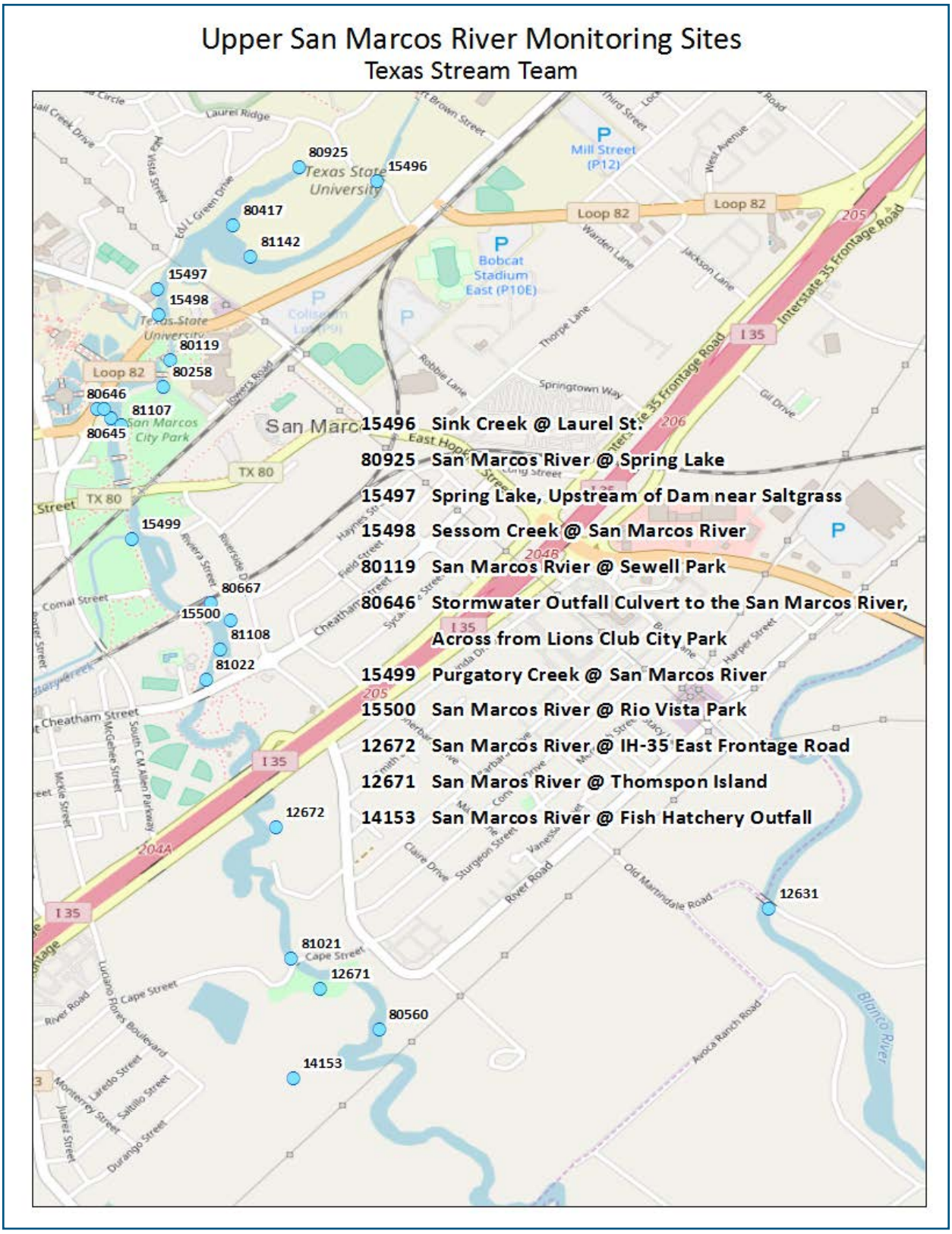

Figure 4.1 Texas Stream Team monitoring sites along the Upper San Marcos River

Well Level Data

Well level and well pressure data collected by the groundwater districts and EAA provides valuable insight to linkages between source water and surface water. This data may help stakeholders better understand and manage recharge features that allow pollutants carried by stormwater that enter the aquifer (later resurfacing as surface water at the headwaters). Some of these features also may contribute significant levels of recharge and should be managed to protect flows. Comparing this data with water quality data may help identify future BMPs to protect flows and water quality. Well and pumping data coupled with water quality data can also strengthen the case for community water conservation efforts.

Supplemental Surface Water Monitoring

Other monitoring activities in the watershed provide useful information and allow for more in depth understanding of surface water quality data, especially at the subbasin or site-specific level. Additional water quality and quantity monitoring efforts are likely to arise throughout the long-term implementation of the Plan and may be of considerable value. Examples include:

Increased Surface Water Quality Monitoring
If it is determined that progress is not being made toward achieving water quality targets or if more data is deemed necessary, additional sites within the watershed may be identified for monitoring (routine, storm, or other) by partners.

Further, stakeholders may determine that there is value in testing for constituents other than those with identified targets. Other pollutants of concern could include emerging contaminants, Pharmaceutical and Personal Care Products (PPCPs), oil, and grease. USGS and select private companies can run analysis for a wide variety of contaminants. GBRA can process samples for oil and grease. Presence of oil and grease is measured as mg/L and is typically only done when there is a sewage/septic spill. Total hydrocarbon tests could also be performed, which would test for oil and grease as well as other pollutants like gasoline. Currently, the oil and grease levels in the watershed are too low to justify testing and sampling expenditures, but as development in the watershed continues, the Stakeholder Committee may choose to implement oil and grease testing.

Groundwater Quantity and Quality Monitoring
Most of the water quality data collected for the watershed is focused on surface water quality. Groundwater quantity and quality monitoring is needed to better understand what pollution is contributed via aquifer recharge to surface water flows in Spring Lake and the River, as well as important sources of recharge required to maintain flows. In addition, TDS constituent analysis of groundwater will determine the portion of TDS directly related to physical aquifer conditions and which cannot be managed with BMPs.

More information about stormwater contributions to aquifer pollution (that later emerge in surface water) will allow WPP partners and stakeholders to determine the most appropriate BMPs and which karst features are priorities for protection measures. Current monitoring includes well level and pressure monitoring by groundwater districts and EAA and continued operation of the USGS stream gauges 08170500 (main stem) and 08170000 (at the headwaters/springs). EAA performs additional groundwater monitoring that may be used to provide additional information regarding aquifer levels and water quality of source water.

Monitoring of BMPs

BMPs implemented early in the implementation may be monitored for effectiveness of mitigating pollution entering the River and its tributaries. If it is determined that a BMP may not be operating effectively, the Stakeholder Committee will work with project partners to determine what changes are needed. BMPs that are working effectively will be presented to the community and encouraged for implementation where appropriate across the watershed.

Monitoring of Existing and Implemented BMPs

Existing and newly installed BMPs on City, University, Hays County, and private property (and implementation of nonstructural measures) may require monitoring to determine effectiveness. Available data may be coupled with available pollution reduction calculation tools to estimate efficacy, as well as to determine the required size and scope for management measures.

Bacterial Source Tracking

Monitoring for bacteria only shows the concentration present at a sample site, and provides no information as to the source of the pollutant. Bacterial source tracking (BST) identifies sources of fecal matter allowing targeted management strategies. Identification and assessment of sources is a key component for effective abatement programs. Additionally, BST can provide information about potential water quality impacts from the permitted discharges in the watershed. A project for BST may be implemented if water quality targets are not being achieved.