



NOTICE OF OPEN MEETING

Available at eahcp.org

As jointly determined by the Implementing Committee and the Program Manager (FMA §7.9.3.b), the **San Marcos Water Quality Protection Work Group** has been formed to provide scientific review and input on questions related to the City of San Marcos' implementation of the Edwards Aquifer Habitat Conservation Plan (EAHCP) "Impervious Cover/Water Quality Protection" Measure (HCP §5.7.6). The San Marcos Water Quality Protection Work Group is comprised of members selected from the EAHCP Adaptive Management Science Committee as well as subject matter experts endorsed by the Science Committee for this purpose. A meeting of this Work Group for the EAHCP is scheduled for **Tuesday, July 18, 2017, at 9 a.m. at the San Marcos Activity Center (Room 1), 501 E. Hopkins St., San Marcos, Texas 78666**. Lunch will be provided; the meeting is expected to end by 4 p.m. Work Group members are asked to please RSVP to dlarge@edwardsaquifer.org.

Members of this Work Group include: Charlie Kreitler, Glenn Longley, Jackie Poole, Shaun Condor, Ben Schwartz, and Aarin Teague.

At this meeting, the following business may be considered and recommended for committee action:

1. Call to order.
2. Public comment.
3. Presentation of the San Marcos Water Quality Protection Work Group charge (Attachment 1).
Purpose: To provide the Work Group with information on its charge.
Action: None required.
4. Presentation and possible endorsement of EAHCP staff recommendation of the Sessom Creek watershed as the priority for the City of San Marcos' "Impervious Cover/Water Quality Protection" (HCP §5.7.6) project implementation. (Attachment 2)
Purpose: To obtain input from the Work Group on the proposal to prioritize the Sessom Creek watershed for project implementation and to possibly obtain their endorsement of said proposal.
Action: To obtain Work Group input and to possibly endorse the proposed prioritization of the Sessom Creek watershed.
5. Presentation and possible endorsement of prioritizing the proposed list of water quality protection projects identified for implementation in the chosen watershed. (Attachment 2)
Purpose: To obtain input from the Work Group on the proposed prioritization of water quality protection projects identified for implementation and to possibly obtain their endorsement of said proposal.
Action: To obtain Work Group input and to possibly endorse the proposed prioritization of water quality protection projects.
6. Questions and comments from the public.
7. Adjourn.

Charge of the San Marcos Water Quality Protection Work Group EAHCP Adaptive Management Science Committee

Overview

The Edwards Aquifer Habitat Conservation Plan (EAHCP) calls for the City of San Marcos (COSM) “to establish a program to protect water quality and reduce the impacts of impervious cover” under the “Impervious Cover/Water Quality Protection” (HCP §5.7.6) Measure. The EAHCP also calls for the COSM and Texas State University (TXST) to remove sediment from the river bottom at various locations along the upper San Marcos River through “Sediment Removal below Sewell Park” (HCP 5.3.6) and “Sediment Removal in Spring Lake & Spring Lake Dam to City Park” (HCP 5.4.4) Measures, respectively.

This document lays out the background, creation, charge, and administration of a Work Group created to provide input concerning the selection of a subset of water quality protection projects identified in the *Water Quality Protection Plan for the City of San Marcos and Texas State University* (2015) for implementation, both in fulfillment of the COSM’s “Impervious Cover/Water Quality Protection” commitment, as well as in satisfaction of the objectives of COSM and TXST’s sediment removal commitments cited above.

Background

Since the start of the EAHCP in 2013, the COSM has carried out the “Impervious Cover/Water Quality Protection” (HCP §5.7.6) Measure in developing a water quality protection planning document. In 2015, the *Water Quality Protection Plan for the City of San Marcos and Texas State University* (WQPP) was published. The WQPP lays out a comprehensive array of structural, design, and planning mechanisms associated with water quality protection for implementation across the upper San Marcos River watershed.

As a comprehensive document, the WQPP identifies many more water quality protection projects than can be realized through the funds dedicated to this Measure in EAHCP Table 7.1 alone (§5.7.6), meaning projects will need to be prioritized. In addition, critical attention is also needed to ensure that the prioritized projects will also satisfy COSM and TXST’s sediment removal commitments, which are the subject of a possible Nonroutine Adaptive Management Process (AMP) action to subsume sediment removal under a more proactive upstream water quality protection program, to prevent excessive sediment loads from entering the upper San Marcos River in the first place.

Creation

To provide a focused deliberative body with the appropriate subject matter expertise for scientific review and input on questions related to the COSM’s implementation of the EAHCP “Impervious Cover/Water Quality Protection” Measure, the HCP Program Manager and the Implementing Committee jointly determined to create a Science Committee Work Group (“San Marcos Water Quality Protection Work Group”) comprised of members drawn from the Science Committee (FMA §7.9.3.b), as well as external experts with expertise related to water quality protection projects, for this purpose.

Charge

The Work Group’s charge consists of: (1) considering the EAHCP staff recommendation of the Sessom Creek watershed as the top priority for implementing projects; and (2) reviewing and prioritizing the proposed list of water quality protection projects identified in the WQPP for the chosen watershed.

Administration

It is expected that the Work Group will hold its first meeting in April 2017. The Work Group is anticipated to meet only once. The recommendations of the Work Group will be reported at the next full Science Committee meeting scheduled. The Work Group will be constituted of the following individuals: Glenn Longley, Charlie Kreidler, and Jackie Poole (Science Committee); Shaun Condor (COSM), Aarin Teague (San Antonio River Authority), and Ben Schwartz (TXST). The Work Group will operate by consensus, and will heed the scope designated in the EAHCP for the Measures under consideration.



SAN MARCOS WATER QUALITY PROTECTION WORK GROUP MEETING MINUTES – JULY 18, 2017

Available at eahcp.org

1. Call to order.

Nathan Pence called the meeting to order at 9:09. Mr. Pence provided opening comments and thanked the Work Group members for their participation and contribution to transparency and the public process.

2. Public comment.

There were no public comments.

3. Presentation of the San Marcos Water Quality Protection Work Group charge.

Alicia Reinmund-Martinez provided an overview of the Work Group charge, including an introduction to the EAHCP's adaptive management process. Dr. Chad Furl presented a review of the physical and ecological impacts associated with increased rates of sedimentation that is being experienced in the San Marcos River. Melani Howard provided a presentation of the City of San Marcos and Texas State University's performance data from EAHCP sediment removal efforts to date under measures 5.3.6 and 5.4.4. Dr. Furl and Ms. Reinmund-Martinez provided a summary stating that sediment removal efforts have proven time-intensive, costly, and problematic, and, overall, a reactive strategy to the problem of excessive sediment loading in the San Marcos. John Gleason introduced the Water Quality Protection Plan (WQPP) developed by his firm on behalf of the City of San Marcos in support of the City's EAHCP water quality protection measure. This WQPP provided the original basis for some of the ideas for retrofits that are being considered today by the Work Group, specifically, stream restoration and BMPs in the Sessom Creek watershed.

4. Presentation and possible endorsement of EAHCP staff recommendation of the Sessom Creek watershed as the priority for the City of San Marcos' "Impervious Cover/Water Quality Protection" (HCP §5.7.6) project implementation.

Dr. Furl provided an overview of the criteria used and analyses undertaken to prioritize which of the contributing watersheds to the San Marcos River (Sessom, Willow Springs, Purgatory, and Sink creek watersheds) should be targeted for EAHCP water quality protection implementation, identifying Sessom as exhibiting some of the highest problem indices (e.g., percent impervious cover, highly erodible land, average channel slope, etc.).

Dr. Ben Schwartz provided an overview of the nature of the watersheds in relation to the recharge zone as well as efforts to date to monitor sediment loading to the river. Dr. Schwartz did comment that in the lower Purgatory there is a well that gets inundated during large storm events in which endangered species have been recorded. Dr. Schwartz also commented that springs around lower Sessom discharge into a concrete channel which is not appropriate to be considered habitat; however, the springs do reflect connectivity into the aquifer (to a limited extent) suggesting this reach is not totally without habitat value.

Mr. Gleason introduced information on the existing conditions in the middle Sessom Creek watershed and presented his team members Pat Hartigan (primary white paper author and technical lead on the Sessom Creek analysis) and Lee Sherman (primary author of the retrofit section of the WQPP). Mr. Hartigan discussed exposed wastewater lines in the watershed and other geomorphological evidence observed in the watershed indicating major problems with instability and erosion.

Dr. Furl discussed the Sessom Creek confluence with the river, noting that the confluence flows into the Spring Lake dam reach which provides habitat for Texas wild-rice and is the only area of the river where the TPWD State Scientific Area stretches from bank to bank. Dr. Furl also presented the latest published bio-monitoring mapping for Texas wild-rice showing stands growing in the confluence area.

Mr. Hartigan provided an overview of the other watersheds, noting the Willow Springs, Purgatory, and Sink creek watersheds variously exhibit comparatively less instability and some retardation of flows from Soil Control Service dams.

Dr. Schwartz commented on Sink Creek, noting that the tributaries coming off Hillside Ranch Apartments (1 and 2; accessible off Ramsey Street) are like Sessom, rapidly downcutting and contributing to sediment flows to Spring Lake.

Shaun Condor commented that since the City will already be out working on the wastewater line project it would be good to get both projects (wastewater lines and water quality protection) done at the same time.

Charlie Kreidler commented that, although Sessom Creek watershed may be the priority for this exercise, the other watersheds should also be considered through the EAHCP process to head off the development of hydrologic problems in them that are like Sessom once they become more urbanized. Mr. Gleason commented that City of San Marcos land development regulations would govern this development.

Glenn Longley stated he has no problem prioritizing Sessom Creek watershed; Dr. Schwartz seconded Dr. Longley's endorsement. There was no opposition.

5. Presentation and possible endorsement of prioritizing the proposed list of water quality protection projects identified for implementation in the chosen watershed.

Ms. Reinmund-Martinez presented the proposed list of water quality protection projects identified for implementation in the chosen watershed. Dr. Furl provided an overview of the prioritization of the middle reach of the Sessom Creek watershed over either the upper or lower reaches of the watershed.

Mr. Hartigan discussed the proposed stream restoration for "Reach 2" (the middle reach), noting that the project would be based on natural design principles and that fluvial geomorphology and equilibrium theory will be applied to create stable channels.

Dr. Longley asked what specific techniques would be used to stabilize the channel. Dr. Aarin Teague asked what the Rosgen stream classification is; Mr. Sherman explained they are not proposing to use the Rosgen model, but rather a process-based methodology focused on the end goal of establishing a channel in equilibrium.

Dr. Teague asked what the proposed riparian buffer width would be; Mr. Sherman replied they do not know yet. Dr. Schwartz mentioned that there is extensive *Ligustrum* [an invasive exotic species] growth in the watershed just upstream from LBJ, would part of the plan involve removal? Ms. Howard answered that, on a volunteer basis, off the Windmill Tributary, for about 6 months they've been removing Chinese tallow, *Ligustrum*, and Chinaberry, and spreading seed, and thus far, it has been working—so she'd envision continuing these volunteer efforts.

Mr. Hartigan brought up that while stream restoration is a major focus, drainage issues and public safety will also require attention in the scope of the project. Mr. Hartigan reviewed the evaluation criteria used in the assessment of various water quality protection projects under consideration

SAN MARCOS

WATER QUALITY

PROTECTION

WORK GROUP

WORK GROUP PRESENTATION

EAHCP STAFF

JULY 18, 2017



Enhancing Sediment Management in the Upper San Marcos River: Strategy Analysis in Support of the Edwards Aquifer Habitat Conservation Plan

Patrick Hartigan, P.E., Lee Sherman, P.E., John Gleason, RLA

7/10/2017

Executive Summary

- 1. Introduction**
- 2. Rationale**
- 3. Why Sessom Creek?**
- 4. Priorities within the Sessom Creek Watershed**
- 5. Project Types and Metrics**
- 6. Individual Project Descriptions and Performance Comparisons**
- 7. Recommendations**
- 8. References**

Appendices

Appendix A. Photographs Comparing Sessom Creek to Other San Marcos Creeks

Appendix B. Soil Erodibility Ratings for San Marcos Watersheds

Appendix C. Photographs Comparing Reaches within Sessom Creek

Appendix D. Sessom Creek Stormwater Monitoring Data from Texas State University

Appendix E. Theory, Data, and Methodologies for Estimating Loads and Load Reduction Credits for Stream Restoration and Stormwater Management Projects

Appendix F. Methodology for Preparing the Cost Estimate by Task

Note: All photos, tables and figures by John Gleason LLC unless otherwise noted.

Executive Summary

Sediment is impacting critical habitat for endangered and threatened species in the San Marcos River, with Sessom Creek identified as a significant source. The middle reach of Sessom Creek is most impacted due to excessive stream erosion rates, with the adjacent Windmill Tributary also contributing to impacts. Sediment removal has been the traditional practice for addressing the problem, but a sediment mitigation strategy has been proposed for the Sessom Creek watershed, utilizing Natural Channel Design-based stream restoration and stormwater Best Management Practices (BMPs). Detailed hydrologic and geomorphic data is currently unavailable for Sessom Creek, thus regional monitoring and modeling data is proposed for use, in order to estimate sediment loads and load reduction credits for stream restoration projects. Stormwater BMP effectiveness can be quantified using a continuous simulation model developed for the San Marcos Water Quality Protection Plan (JGLLC, 2015, as amended).

Three stream restoration and stormwater BMP alternatives were evaluated for the creek and tributary, with two found to be more cost effective than sediment removal. These alternatives may be refined or revised as more information becomes available during the preliminary engineering and design phases of the project.

1. Introduction

The Edwards Aquifer Habitat Conservation Plan (HCP, EARIP, 2012) identified sedimentation in the San Marcos River as a significant concern. Sedimentation impacts Texas wild-rice, in particular, by smothering or burying rice stands. In response, through the HCP, the City of San Marcos and Texas State University committed to implement mitigation and minimization measures to offset these impacts. Measures 5.3.6, 5.4.4 and 5.4.6 require that sediment be removed from Spring Lake and the San Marcos River downstream to IH-35, including the Sessom Creek sediment bar.

While the HCP specified sediment removal as the recommended measure, removal does not effectively address the sources of excess sediment. For Sessom Creek, the San Marcos Water Quality Protection Plan (WQPP, JGLLC, 2015) recommended a source control approach; that is, reduce erosion and sedimentation in the watershed. This could be a less expensive and more sustainable approach than sediment removal that would also accomplish the aims of sediment removal, and could be substituted as an alternative to sediment removal through a possible HCP Adaptive Management Process (AMP; see EAHCP, 2012) action. Under the AMP, the goal of the sediment removal tasks could be accomplished with source control measures. The primary purpose of this paper is to inform a possible AMP action towards this end.

2. Rationale

A sediment mitigation strategy is proposed as an alternative to sediment removal because mitigation can have fewer impacts, be more sustainable and more cost effective. Sediment removal does not address the actual sources of sediment, such as stream erosion, thus sedimentation impacts will likely be persistent and recurring. In addition, sediment removal practices such as excavating or suctioning will, in themselves, likely cause impacts to critical habitat and protected species. In comparison, mitigating the sediment loading from reaching critical habitat in the first place could avoid or greatly reduce the need for physical disturbance of the habitat through direct removal, a decided advantage.

Sediment mitigation techniques include stream restoration using Natural Channel Design methods, stabilization of eroding stream beds and banks, and stormwater best management practices (BMPs) that reduce erosive flows.

3. Why Sessom Creek?

Sessom Creek was identified as a priority concern for the San Marcos WQPP (JGLLC, 2015) due its proximity to the headwaters of the San Marcos River, presence of endangered species and habitat in the creek and at the confluence with the San Marcos River, high impervious cover, instability of the stream system, excessive erosion, and stormwater retrofit opportunities. This led to the development of a conceptual watershed restoration presentation in 2016 (Figure 1.). The presence of a large and persistent sediment bar at the mouth of Sessom Creek (Figure 2.) has also been identified as a concern, and EAHCP minimization and mitigation measure 5.4.6 directed the City of San Marcos and Texas State University to conduct a study of sediment removal options (EARIP, 2012).

Investigations by the team of John Gleason LLC (JGLLC), as part of the San Marcos WQPP indicate that Sessom Creek may be disproportionately impacting critical habitat, compared to other watersheds that drain into the Upper San Marcos River. It is noteworthy in this regard that the mouth of Sessom Creek flows into a section of the San Marcos designated across the entire river channel as a protected area for Texas wild-rice under the Texas Parks & Wildlife Department State Scientific Area regulation (EARIP, 2012; Sec. 5.6.1). The presence of eroding stream beds and banks, exposed wastewater lines, and damaged or threatened property and infrastructure are more widespread in Sessom Creek (Figure 3) than was observed in Willow Springs, Purgatory and Sink Creeks (photographs, Appendix A). These conditions are indicative of greater stream instability and higher erosion and sediment loading rates in Sessom Creek. Possible explanations for the more degraded condition of Sessom Creek include:

- Impervious cover, a good indicator of stream impacts, is proportionately higher in Sessom Creek than the other watersheds (Figure 4), exacerbated by the more efficient runoff conveyance system.
- Highly erodible soils: Sessom Creek watershed has a much higher percentage of highly erodible soils than the other watersheds (Figure 5), a greater percentage which is located within the stream corridor where stream erosion occurs (Appendix B).
- Channel slope is much higher in Sessom Creek, which can increase the rate and erosive energy of runoff flows. Based on GIS data, the average stream channel slope of Sessom Creek is approximately 3%, but less than 1% for Sink, Purgatory, and Willow Springs Creeks.
- Both Sink and Purgatory Creeks have Soil Conservation Service dams that trap sediments and limit sediment transport.

The Willow Springs Creek watershed is more similar to Sessom Creek, as it has been extensively urbanized, but has a lower impervious cover (24% vs 36%), is less steep, and does not exhibit nearly the degree of instability and erosion. Much of Willow Springs Creek is a concrete channel with mild side slopes (Appendix A). Below the concrete channel, the creek is well connected to its floodplain, allowing for erosive flows to be dissipated. Both Purgatory and Sink Creeks visually exhibit less instability and erosion than Sessom Creek, though a localized problem was found in Purgatory Creek (see photos in Appendix A).

Limited monitoring data provided by the Edwards Aquifer Authority (EAA) also indicates that Sessom Creek runoff typically has total suspended solids (TSS) concentrations at least twice as high as other

monitored San Marcos streams (including Sink Creek, Purgatory Creek, and the Dog Beach outflow culvert at City Park; SWCA, 2014, 2015, 2017). More extensive monitoring data collected by Texas State University (Schwartz data via EAA, 2017, Appendix D) reported peak TSS concentrations over 1700 mg/L, comparable to values seen in other urbanized watersheds in the region.

Figure 1. Sessom Creek Watershed Conceptual Restoration Presentation cover page

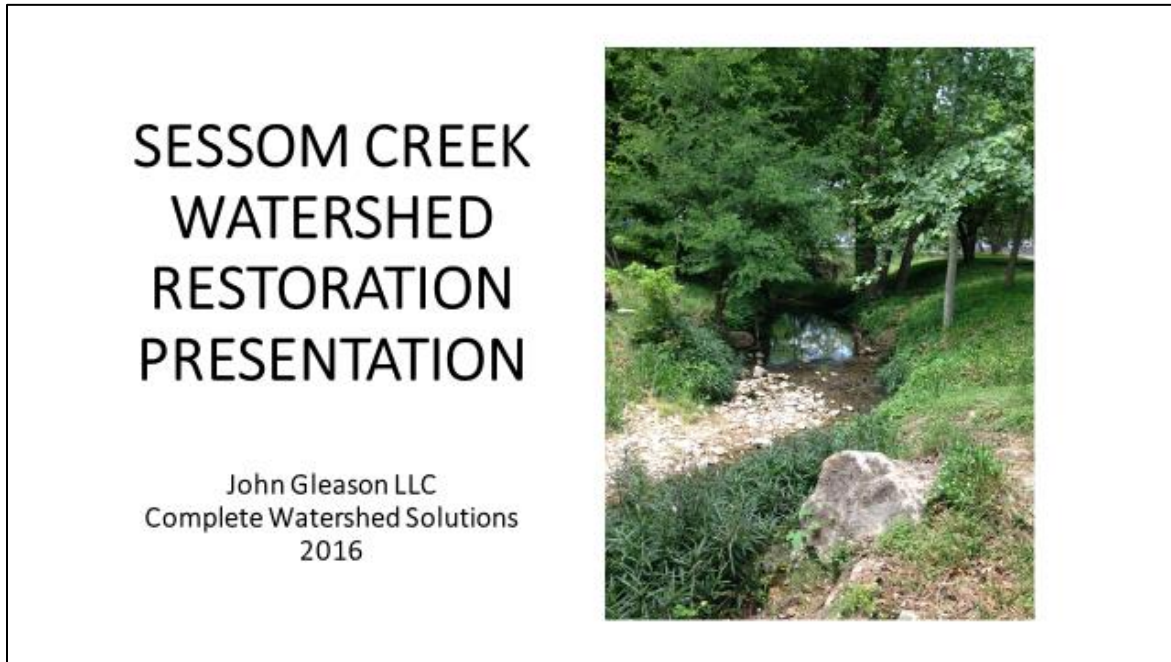


Figure 2. Sediment Bar at mouth of Sessom Creek



Figure 3. Sessom Creek stream erosion



Figure 4. Watershed Impervious Cover for San Marcos Watersheds (JGLLC, 2017, except Purgatory and Sink values from Tolman, et al., 2013)

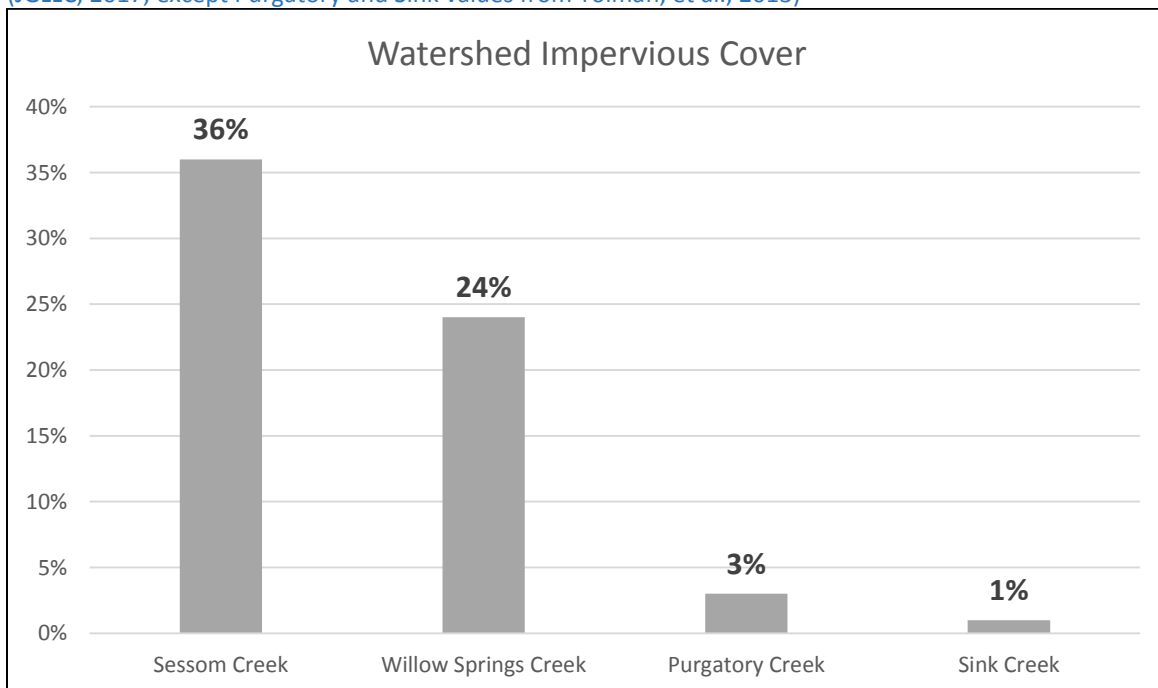
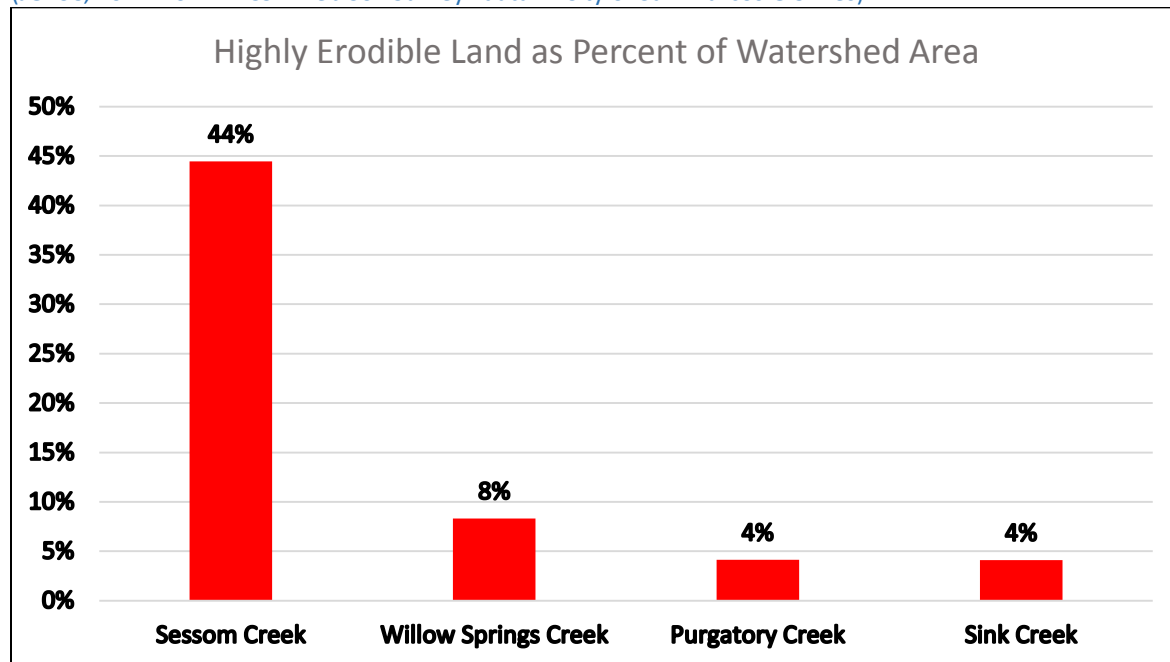


Figure 5. Percentage of Highly Erodible Land in San Marcos Watersheds (JGLCC, 2017 from NRCS "Web Soil Survey" data in City of San Marcos GIS files)

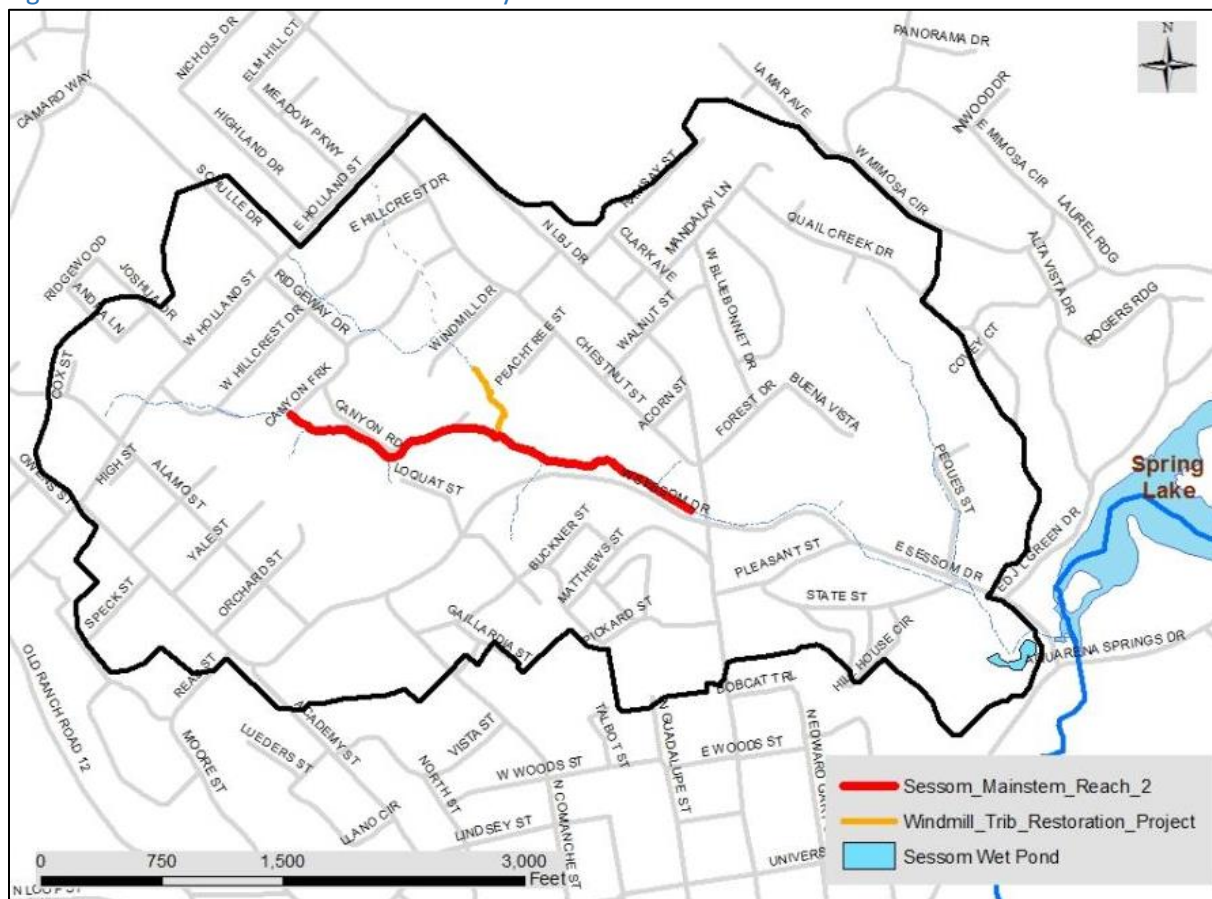


4. Priorities within the Sessom Creek Watershed

The WQPP team conducted qualitative field investigations (as recommended by NRCS, 2007) in 2016-2017, and identified widespread erosion and sedimentation problems in Sessom Creek. The middle reach, from above North LBJ Drive upstream to Canyon Fork Road (Figure 6) is significantly impacted. This is identified as Mainstem Reach 2, aka the middle reach, and was rated a Very High priority by the Sessom Creek Watershed Conceptual Restoration Presentation (Figure 1, JGLCC, 2016). Especially noticeable were eroding stream banks, exposed wastewater lines, damaged drainage system components, unstable head cuts adjacent to the creek, and undermining of Canyon Road, a potentially serious public safety threat (Figure 3 and Appendix C). Upstream of Reach 2 the creek is relatively stable, both concrete-lined and natural channel, with localized erosion problems (Appendix C). Downstream of Reach 2 the creek is mostly a concrete channel which is threatened by erosion in several locations (Appendix C). The concrete channel effectively functions as a flume, transporting upstream sediments quickly downstream towards the San Marcos River.

A major influence to the hydrology and erosion/sedimentation dynamics of the middle reach is the Windmill Tributary, which enters the mainstem from the north (Figure 6). This tributary was rated a High priority by the Sessom Creek Watershed Conceptual Restoration Presentation (JGLCC, 2016). Like Reach 2 of Sessom Creek, the tributary is incised with numerous localized erosion problems (Appendix C). This erosion threatens an exposed wastewater line that is a significant concern (Appendix C). Efforts to reduce excess erosion within the middle reach should also include the Windmill Tributary.

Figure 6. Sessom Creek Watershed Priority Reaches



5. Project Types and Metrics

A. Project Types

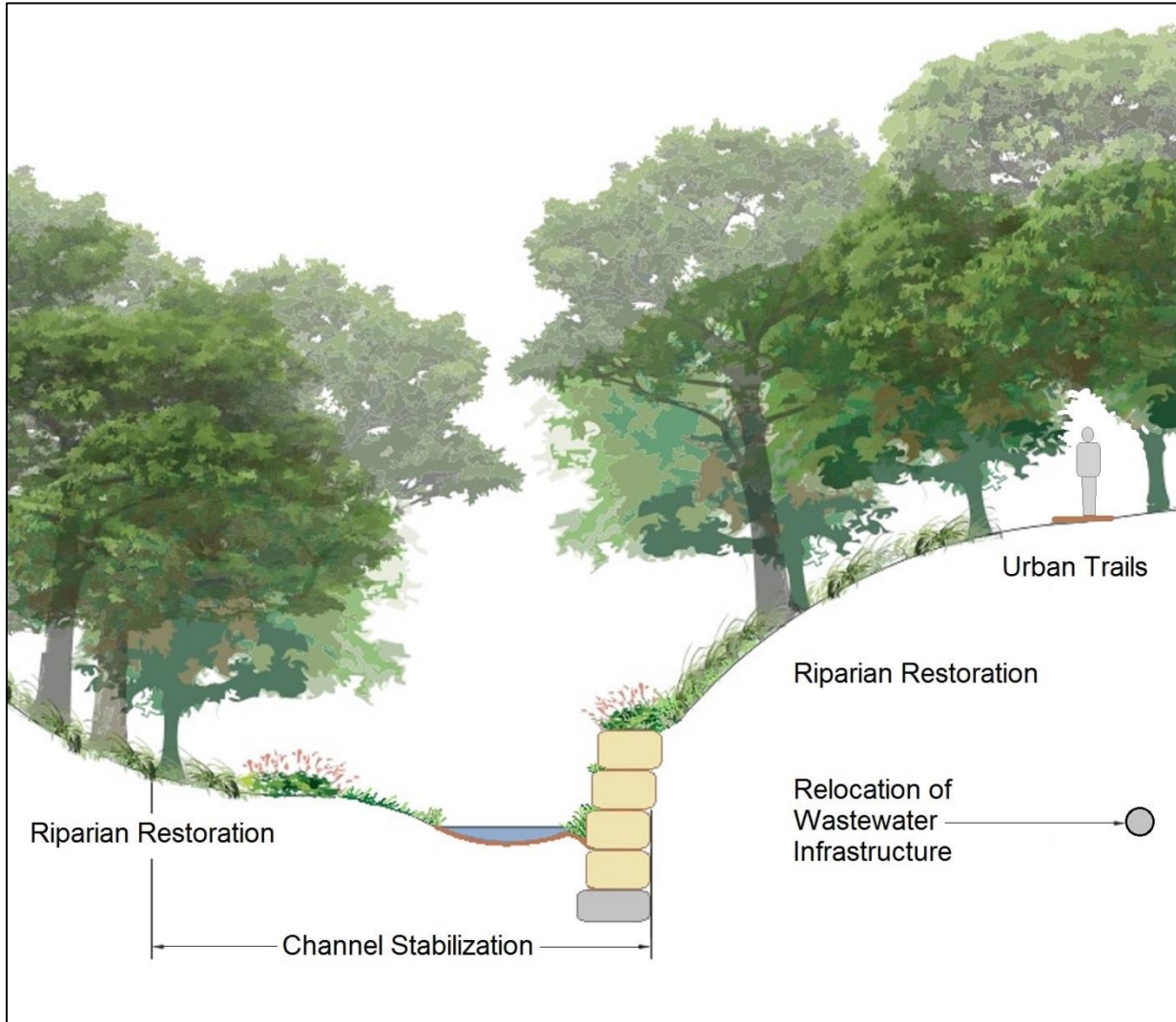
The Sessom Creek Watershed Conceptual Restoration Presentation (JGLLC, 2016) identified over 20 potential projects, including stream and riparian restoration, stormwater retrofits, land conservation, and improved development regulations. For the priority Reach 2 and Windmill Tributary, only the first two are specifically applicable:

1. Stream restoration which will stabilize eroding areas using a Natural Channel Design (NCD) approach (Figure 7). NCD projects are geomorphically-based, are designed to accelerate natural restabilization, using techniques such as grade control (Figure 8), and are more sustainable with fewer downstream impacts than traditional hard channel solutions. The restoration project will incorporate site-specific erosion repairs, stabilization of unstable head cuts adjacent to the creek, and restoration of riparian vegetation.
2. Stormwater BMPs designed to improve runoff hydrology in order to reduce erosive flows in the watershed and remove sediment and pollutants in runoff (Figure 9).

These projects will be compared to the existing sediment removal measures in the HCP. Primary guidance documents for stream restoration include the "Stream Restoration Design National Engineering Handbook" (NRCS, 2007), and "Stream Restoration as a BMP: Crediting Guidance

(WERF, 2016). In addition, the project team has extensive experience with stream restoration and stormwater management projects.

Figure 7. Typical Cross Section of a Stream and Riparian Restoration Project



City of Austin Watershed Protection Dept. and JGLLC

Figure 8. Grade control for stream restoration project on Shoal Creek in Austin, Texas



Figure 9. Extended detention pond to control erosive flows - pond empties within 2 days



(Chesapeake Bay Stormwater Network)

B. Project Metrics

The proposed project metrics are:

1. Sediment loads and Load Reductions
2. Cost
3. Cost Effectiveness

B.1. Sediment Loads and Load Reductions

At this time, limited data and tools are available to predict sediment loads in the Sessom Creek watershed, or the potential effectiveness of stream restoration projects. Additional data will be collected during the preliminary engineering and design phases of the project. The WQPP team is aware of several models which may have some application, such as the Hardy and Raphael Adaptive Hydraulic Model (Hardy and Raphael, 2013), the City of San Marcos's Sessom Creek flood model (Espey, 2007), and the Meadows Center Upper San Marcos Watershed BASINS/HSPF modeling study (Tolman, et al., 2013). Neither of the first two models were available at this time. The Meadows Center model did not assess stream erosion processes, thus is not considered appropriate to use at this time. This is important because stream erosion can account for 90% of the watershed TSS load (TCEQ, 2005). Given the significant data limitations for Sessom Creek, other options were investigated.

The "state of the science" for assigning sediment reduction credit to restoration or stormwater management projects is not well developed. However, in recent years the Federal Clean Water Act Total Maximum Daily Load (TMDL) program has begun allowing pollutant reduction credit for stream restoration projects, with a primary guiding document being the Water Environment and Reuse Foundation (WERF) publication *Final Report Stream Restoration as a BMP: Crediting Guidance* (WERF, 2016). WERF is a research arm of the American Society of Civil Engineers (ASCE), and provides extensive technical guidance to the EPA, state and local governments. The WERF report presented recommendations on quantifying sediment and nutrient reduction credits for a variety of stream restoration projects, specifically:

- Bed and bank stabilization
- Riparian buffers
- In-stream enhancements
- Floodplain reconnection

An important caveat is that WERF acknowledges there is large uncertainty in any sediment loading quantification scheme, and that bank erosion rates can span several orders of magnitude. Likewise, there can be significant uncertainty in the effectiveness of restoration projects, due to regional geomorphic differences, stream response time, and the inherent complexity of stream processes. Where available, uncertainty can be reduced using monitoring data (e.g., actual rates of bank erosion), in conjunction with modeling that accounts for hydrologic and geomorphic variables. Because of these uncertainties, simplifying assumptions are often made for stream restoration projects. For example, in the Chesapeake Bay region, which has been a leader in applying the TMDL process to stream restoration, default assumptions include (1) no more than 50% sediment reduction credit, unless substantiated further and/or (2) assume a sediment reduction rate of between 11 – 310 lb/ft/yr (Chesapeake Bay Expert Panel Report, 2013; Kerr, 2013).

To summarize WERF recommendations for quantifying sediment reduction for stream restoration projects, two basic options are potentially applicable to Sessom Creek:

- Option 1: Application of the Bank Assessment for Non-point source Consequences of Sediment (BANCS) model, which has a track record of use and is endorsed by the U.S. EPA. It will require acquisition and training, and has fairly extensive data requirements.
- Option 2: Application of existing monitoring and/or modeling data based on site specific, local or regional data.

Option 2 is recommended as there is insufficient budget and time to develop and apply the BANCS model, and historic regional monitoring and modeling data is available, specifically for Austin streams. It should be noted, however, that modeling will be conducted during the preliminary engineering and/or design phases to assess hydrology, equilibrium slopes, sediment scour and transport, critical shear stress and/or stream power, and other variables necessary for project design. Models under consideration include HEC-HMS, HEC-RAS, EPA SWMM, and SRWall.

The following is the basis for the development of Option 2, i.e., quantifying sediment loads in Sessom Creek using Austin data (further described in Appendix E):

- Urbanization and impervious cover change watershed hydrology by increasing the frequency and magnitude of runoff flows
- Streams respond to urbanization by shifting geomorphically dominant discharges (those that do the most work) from bankfull to sub-bankfull flows, consistent with “equilibrium” or “regime” theory
- Austin streams respond to urbanization consistent with equilibrium theory
- Because of similar geomorphic, climatic, soil, land use, and impervious cover conditions, it can be assumed that Sessom Creek has also responded to urbanization consistent with equilibrium theory, and in a manner similar to Austin streams.
- The shift in dominant discharges increases erosion rates, which can be reflected in monitoring data, i.e. TSS concentrations and loading rates may increase as urbanization increases
- Monitoring and modeling data available for Austin streams thus represent TSS concentrations and loading rates for streams responding to urbanization consistent with equilibrium theory.
- As the Austin streams and Sessom Creek are similar, the Austin data can be reasonably applied to Sessom Creek.
- Despite wide ranges in watershed and stream characteristics, the Austin data is highly correlated to impervious cover, which can thus be used as a predictive variable, especially given the current lack of other data.

For estimating sediment load reduction for stream restoration projects, the Chesapeake Bay procedure is proposed, i.e., assume a 50% reduction. The WERF report did not provide crediting recommendations for stormwater BMPs. However, due to the need to provide an “apples to apples” comparison between stream restoration and stormwater BMPs, the BMP spreadsheet model developed for the San Marcos WQPP (JGLLC, 2015) can be employed. This is a continuous simulation model that can assess the performance of BMPs at reducing pollutant loads and providing hydrologic control of erosive flows. For the existing HCP sediment removal tasks 5.3.6, 5.4.4 and 5.4.6 the actual amount and frequency of sediment removed will be determined from the EAHCP annual reports. The sediment load reduction procedures, using TSS as an indicator of sediment, are further described in Appendix E.

B.2. Cost

B.2.1 Overall Project Funding Commitments by EAHCP and City of San Marcos

For the EAHCP, the total ‘not to exceed’ cost is \$1.5 million. The EAHCP and the City of San Marcos have also identified \$500,000 for the following projects:

- \$300,000 for RPS erosion repair projects 9 and 10 and for surveying cost associated with the Sessom Creek restoration project. Project 9 will repair a scour hole located upstream of North LBJ drive, while Project 10 will repair a localized erosion problem, and modify a severely eroding outfall from a Texas State University detention pond, identified in the WQPP as the “Gulch

Pond.” The actual cost of surveying is not currently known, and an assumption of \$100,000 is currently made, leaving an estimated \$200,000 for the RPS projects (cost estimates will be refined during the preliminary engineering and design phases). The current agreement is that the EAHCP will pay for the two RPS projects.

- \$200,000 for Canyon Road repairs and permanent erosion prevention measures for lowering of water mains under Sessom Creek, all to be paid for by the City of San Marcos. The actual cost for these projects is not currently known but will be determined during the preliminary engineering and design phases. These projects are assumed to have no effect on sediment loads, nor provide any sediment load reductions.

Additional funding may be identified. The current total budget is \$1,800,000, with the EAHCP share being \$1,500,000 and the City of San Marcos share being \$300,000. A planning-level cost estimate for preliminary engineering (PER), design, and construction work is shown in Table 1. The PER will identify, from a high-level, opportunities and constraints within Reach 2 and the Windmill Tributary. Appendix F explains the cost-estimating approach used for Table 1. Table 2 provides a cost summary for years 2017, 2018, and post-2018.

B.2.2 Overall Project Schedule

The stream restoration project is designed to coincide with the COSM plans to remove and replace some of the existing wastewater lines in Sessom Creek. The wastewater project design phase is scheduled to be completed in 2018, with construction to begin in 2019. This means that the restoration project preliminary engineering report should be completed by late October, 2017, so that the design and construction phases match the wastewater project schedule.

B.2.3 Cost Estimates for Individual Projects

The \$1,800,000 cost figure was derived prior to identification of individual project designs, which are described in Section 7. For stream restoration and stormwater BMP projects, an annualized cost (\$/yr) will be estimated to account for on-going operation and maintenance, using the cost estimation procedures developed for the WQPP (JGLLC, 2015).

Consistent with the WERF recommendations (WERF, 2016), the cost for stream restoration projects can be expressed in \$ per foot project length. From WERF:

Practice Category	Estimated unit cost (\$/ft length)
Bed and bank stabilization	\$200
Riparian buffers	\$5 - \$15
In-stream enhancements	\$150
Floodplain reconnection	\$120
Total for All	\$475 - \$485

There is limited information on the cost of restoration projects, especially for urban areas. A study in North Carolina (Templeton, et al., 2008) reported average unit cost of \$242 per linear foot for all projects, \$285 for urban projects, and \$220 for rural ones. These values are somewhat outdated but, adjusted for inflation, would increase the cost of urban projects to over \$300 per linear foot.

Table 1. Cost Estimate by Task						
Task	EAHCP Restoration Projects (1)	EAHCP RPS Projects 9 and 10	COSM Sessom surveying (2)	COSM Canyon Road repair and water main lowering erosion prevention	TOTAL	EAHCP Total Cost
Construction Cost	\$851,573	\$130,734		\$130,734	\$1,113,041	\$982,307
Engineering (25% of construction cost except additional surveying cost)	\$212,893	\$32,684	\$100,000	\$32,684	\$378,260	\$245,577
Project Management Services (2% of construction cost):	\$17,031	\$2,615		\$2,615	\$22,261	\$19,646
Construction Inspection Services (2.6% of construction cost)	\$22,141	\$3,399		\$3,399	\$28,939	\$25,540
Tree mitigation (1% of construction cost)	\$8,516	\$1,307		\$1,307	\$11,130	\$9,823
Utility Relocation (2% of construction cost):	\$17,031	\$2,615		\$2,615	\$22,261	\$19,646
Printing of bid documents	\$500	\$500		\$500	\$1,500	\$1,000
Contingency for Change Orders and Current Level of Uncertainty (20% of construction cost)	\$170,315	\$26,147		\$26,147	\$222,608	\$196,461
TOTAL	\$1,300,000	\$200,000	\$100,000	\$200,000	\$1,800,000	\$1,500,000

(1) Includes Sessom Creek Reach 2 project (2800 linear feet) and Windmill Tributary restoration (525 linear feet max) and/or stormwater BMP

(2) The \$100,000 value is assumed, as actual cost information is not currently available

Table 2. Summary of Tasks with 2017/2018/Post 2018 Breakdown								
Task	Total Proposed Budget				EAHCP Proposed Budget			
	2017	2018	Post 2018	Overall Totals	2017	2018	Post 2018	EAHCP Total
Preliminary Eng. Report (PER)	\$145,000 (1)	\$0	\$0	\$145,000	\$45,000	\$0	\$0	\$45,000
Design & Contract Documents (incl. Construction Phase services)	\$33,500	\$180,282	\$19,478	\$233,260	\$33,500	\$149,886	\$17,190	\$200,577
Construction	\$0	\$0	\$1,113,041	\$1,113,041	0	\$0	\$982,307	\$982,307
Contingency for Change Orders and Current Level of Uncertainty (20% of construction cost)	\$0	\$0	\$308,699	\$308,699	0	\$0	\$272,117	\$272,117
TOTAL	\$178,500	\$180,282	\$1,441,218	\$1,800,000	\$78,500	\$149,886	\$1,271,613	\$1,500,000

(1) Includes \$100,000 for Sessom Creek surveying, funded by City of San Marcos

The WQPP project team also has experience with stream restoration projects, with project costs somewhat similar to the WERF and North Carolina values (unpublished data, Complete Watershed Solutions). The Sessom project may encounter additional costs due to infrastructure and drainage problems that must be addressed, as well as several uncertainties (see "Caveats" in Section 6). It is further recognized that the total cost for recommended projects should not exceed the available EACHP budget of \$1,500,000, which may require flexibility in the project designs to reduce certain design elements. For example, floodplain reconnection may be a minor element of the restoration design, and could possibly be eliminated. Given this information, and the team's experience, \$375 per linear foot is estimated for restoration of Sessom Creek (Reach 2), and \$250 per linear foot for restoration of the smaller Windmill Tributary. These estimates are subject to change as the projects proceed further into the preliminary engineering and design phases.

For stormwater BMPs, capital cost typically range between \$5 - \$50 per cubic foot of storage, with annual O&M costs between \$1500 - \$5000 (unpublished data from Complete Watershed Solutions). Section 6 provides more detail for individual projects.

For the existing HCP sediment removal tasks 5.3.6, 5.4.4 and 5.4.6, the cost for removal will be determined from EACHP annual reports, as presented in Section 6.

B.3. Cost Effectiveness

Cost effectiveness estimates the cost per pound of TSS or sediment removed, and will be the primary metric for comparing projects. Because TSS load reductions are typically expressed in terms of pounds per year (lb/yr), costs will be annualized. The annualized cost accounts for capital cost (preliminary engineering, design, and construction) and ongoing operation and maintenance (O&M). The cost equation developed for the San Marcos WQPP is used for stream restoration and stormwater BMP projects. For the existing HCP sediment removal tasks, cost effectiveness will simply be calculated as sediment removal cost divided by sediment volume.

6. Individual Project Descriptions and Performance Comparisons

A. Individual Project Descriptions

Project 1. Sediment Removal (existing EAHCP measure)

The amounts and costs for sediment removal for the HCP are presented in Table 3, and are compiled from EAHCP annual reports and work plans.

Year	HCP Task and responsible entity	Locations	Sediment Removed			Cost
			Area (m ²)	Volume (m ³)	Est. Load (lb)*	
2013	5.3.6 (COSM) and 5.4.4 (TXST)	Below Sewell Park (Bicentennial Park and City Park) and Spring Lake	106 (86 COSM) (20 TXST)	48 (44 COSM) (4 TXST)	169,509	\$151,800
2014	5.3.6 COSM	Below Sewell Park (Bicentennial Park and City Park)	77	20	70,629	\$180,000
2015	5.3.6 COSM	Below Sewell Park (Bicentennial Park and City Park)	284	85	300,173	\$219,450
2016	5.3.6 COSM	Below Sewell Park (Bicentennial Park and City Park)	92	28	98,880	\$193,042
TOTAL			559	181	639,192	\$744,292

* assuming 100 lb/ft³ dry weight for the sediment

From the table, a total of approximately 639,192 pounds of sediment was removed from 2013-2016, at a total cost of \$744,292, equating to a cost effectiveness of \$1.16 per pound removed. This value will be used for comparing sediment removal vs other projects. Based on four years of data, the annualized cost is \$186,073, with an average sediment removal rate of approximately 159,780 lbs/yr.

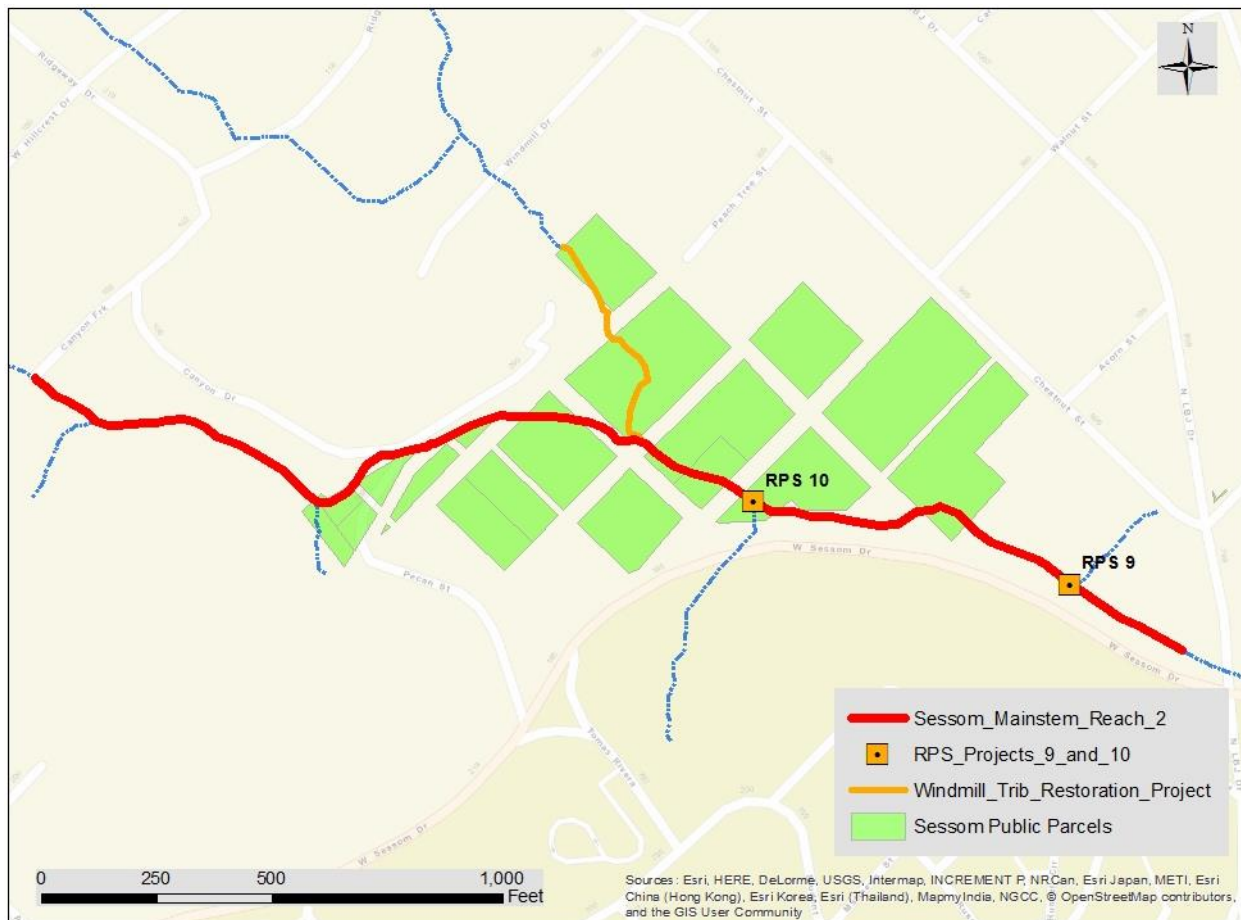
Project 2. Stream Restoration for Sessom Creek Mainstem Reach 2

Stream restoration using Natural Channel Design is proposed for this approximately 2800 feet reach (Figure 10). Restoration techniques will be based on Natural Channel Design principles, and may include grade stabilization, flow diversion, soil bioengineering, bank protection or armoring, stream and/or streambank reconfiguration, stabilization of eroding head cuts next to the creek (e.g. Yale Tributary, LBJ Tributary), riparian revegetation, and stormwater management BMPs. Some existing wastewater lines in the creek will be decommissioned and partially removed by the City's wastewater improvement project, but others may need to be relocated or stabilized as part of the restoration project. The City of San Marcos has indicated that some wastewater lines may be addressed at a later time (personal communication with Melani Howard), but no cost figures are currently available for that action. Close coordination with the City will be necessary, and may require phasing construction of the restoration project to coincide with the wastewater line project.

Within the reach there are two site-specific erosion repair projects, RPS projects 9 and 10, which will be incorporated into the restoration project, with \$200,000 of funding earmarked from the EAHCP. Project 9 will repair a scour hole located upstream of North LBJ drive, while Project 10 will repair a localized erosion problem, and modify a severely eroding outfall from a Texas State University detention pond, identified in the WQPP as the “Gulch Pond.” As RPS projects 9 and 10 will be incorporated into the stream restoration project, no separate sediment reduction credit will be assigned to them. It is anticipated that the stream restoration and the RPS projects will be bid and constructed concurrently, which will more cost-effective with less channel disturbance.

Using the Appendix E procedures, the predicted load reduction of the stream restoration project is 190,383 lb/yr. Based on a unit cost of \$375 per linear foot of restoration, the estimated capital cost is \$1,050,000. The \$200,000 (current estimate) for RPS projects 9 and 10 must be added to this, resulting in a total capital cost of \$1,250,000. Annual Operations and Maintenance (O&M) costs for a successful restoration project should be minimal, and a value of \$1,000 is assumed. The annualized cost for the restoration and RPS projects is estimated as \$74,183 per year, resulting in a cost effectiveness of \$0.39 per pound of TSS removed.

Figure 10. Sessom Creek Mainstem Reach 2 with RPS Projects shown



Project 3A. Stream Restoration of Windmill Tributary

A stream restoration project using Natural Channel Design will be evaluated for approximately 525 feet of stream that is located below the Windmill Apartments (Figure 11). An existing wastewater line in the tributary is threatened by erosion, and will have to be relocated or stabilized as part of a restoration project. The City of San Marcos has indicated that the wastewater line may be addressed at a later time (personal communication with Melani Howard), but no cost figures are currently available for that action. Close coordination with the City will be necessary, and may require phasing construction of the restoration project.

The tributary is incised and eroding, thus use of the Appendix E procedures is deemed appropriate. Using those procedures, the predicted load reduction of the project is 800 lb/yr. Based on a unit cost of \$250 per linear foot of restoration, the estimated capital cost is \$141,250. Annual O&M cost for a successful restoration project should be minimal, and a value of \$1,000 is assumed. The annualized cost is estimated as \$9,270 per year, resulting in a cost effectiveness of \$11.59 per pound of TSS removed. These cost estimates could change depending on the City's decision as to whether the wastewater line in the tributary will be relocated, replaced, or rehabilitated.

Project 3B. Stormwater BMP for the Windmill Tributary with limited stream restoration

There is ROW and publicly-owned land adjacent to the tributary where a stormwater pond system could be located (Figure 11). The pond system could capture sediment from the Windmill watershed while also providing significant control of erosive flows that are impacting Sessom Creek. Due to the steepness of the channel, a series of three extended detention ponds is proposed. Ideally the pond system would be sized to provide the WQPP-recommended "Stream Protection Volume" of 0.32-inch for the 45 acre, 26% impervious cover watershed area, but site constraints may limit the volume to about 0.15-inch, or approximately 25,000 cubic feet. A 48 hour drawdown time is recommended, per the WQPP. As additional survey and other data become available, the size of the pond system could change. Maintenance access to the pond would be from the existing Peach Street access to the Windmill Tributary.

The Appendix E procedures predict a TSS load of 79,890 lb/yr to the pond system from the Windmill Tributary. Using the WQPP spreadsheet model, the annual average runoff capture efficiency is estimated as 70%, with a TSS load removal efficiency of 58%, equating to a TSS load reduction of about 46,336 lb/yr. The unit cost for extended detention is assumed to be \$6 per cubic foot, which equates to a total capital cost of about \$147,015, with an annual O&M cost of \$5,000 assumed. Using the WQPP Whole Life Cycle procedure, the annualized cost for the pond system would be \$13,607 per year, resulting in a cost effectiveness of \$0.29 per pound of TSS removed.

Because the restoration project 3A does not appear as cost effective, it is proposed to incorporate limited stream restoration (200 feet or less) as a component of the BMP project. This could increase the total capital cost for project 3B to about \$197,015 with an annual cost of about \$16,534, resulting in cost effectiveness of \$0.36 per pound TSS removed.

Figure 11. Windmill Tributary Project Sites



B. Performance Comparisons

Table 3. Performance Comparisons

Metric	Project 1. Existing Sediment Removal Project	Project 2. Stream Restoration of Reach 2 (including RPS 9 and 10)	Project 3A. Stream Restoration of Windmill Tributary	Project 3B. Stormwater BMP for Windmill Tributary w/ limited restoration
Pounds of TSS Removed per year	159,780	190,383	800	46,336
Total Capital Cost (1)	\$744,292	\$1,250,000	\$141,250	\$197,015
Annualized Cost (\$/yr)	\$186,073	\$74,183	\$9,270	\$16,534
Cost per pound TSS removed (2)	\$1.16	\$0.39	\$11.59	\$0.36

(1) Total Capital Costs for Projects 2 and 3 includes preliminary engineering, design, and construction phases

(2) Calculated as Whole Life Cycle Cost divided by Pounds of TSS Removed per year

Caveats

It is important to note that the designs, cost estimates, and performance projections provided in this report are preliminary and subject to change due to limited data availability. For example, neither survey data nor a Preliminary Engineering Report is available, and no engineering designs have been completed for the identified projects. In addition, several issues of concern have been identified that will need to be addressed, and which could impact project design, costs and schedules:

- A. Canyon Road public safety hazard (Appendix C) – Canyon Road adjacent to Sessom Creek, downstream of the Loquat-Canyon intersection, is being undermined by bank erosion and presents a potentially serious public safety threat. The road also presents a constraint to the design of the restoration project. The City of San Marcos has proposed a budget of \$200,000 for repairs, which also includes permanent erosion prevention for an adjacent project that will lower a water main crossing Sessom Creek.
- B. Loquat-Canyon intersection – This intersection and adjacent Sessom Creek have significant drainage problems, both in terms of flooding and erosion. The existing drainage infrastructure is damaged and undersized, and will need to be addressed in some manner by the restoration project. Consultation and close coordination with the City will be required.
- C. A proposal has been made to modify the orientation and design of the Sessom Creek outfall to the San Marcos River as a remedy to the sediment bar problem. The “Sessom Creek Sand Bar Removal” report (Hardy and Raphelt, 2013) was provided as an appendix to the 2016 Edwards Aquifer Habitat Conservation Plan Annual Report. The future disposition of this report’s recommendations is unknown but, in any event, stabilization of the eroding mouth of Sessom Creek is recommended.
- D. A possible alternative to the Windmill Tributary BMP is the “Gulch” pond on the Texas State University campus, because it has a greater impact on Sessom Creek (larger drainage area with higher impervious cover). The pond was identified as a high priority retrofit in the WQPP (JGLLC, 2015). Erosion of the pond outfall will be repaired by RPS project 10, but that repair does not mitigate erosive flows being discharged from Texas State University.

7. Recommendations

Projects 2 and 3B are recommended as they have the highest cost effectiveness. The total capital cost for the two projects is estimated as \$1,447,015, with a total annualized cost of \$90,717, and load removal of 236,719 lb/yr. The resulting overall cost effectiveness is \$0.38 per lb TSS removed vs. \$1.16 per lb for the HCP sediment removal projects.

The \$1,447,015 value reflects the cost to the EAHCP, and is less than the \$1,500,000 budget figure reported in Section 6.B. Recall that the City of San Marcos has separately earmarked \$300,000 for projects located in the same immediate area, but which are not part of the EAHCP budget.

8. References

EAHCP Annual Reports and Work Plans

Blanton and Associates, 2015, Edwards Aquifer Habitat Conservation Plan 2014 Annual Report. Submitted to The U.S. Fish and Wildlife Service in behalf of the Edwards Aquifer Habitat Conservation Plan Permittees.

Blanton and Associates, 2016, Edwards Aquifer Habitat Conservation Plan 2015 Annual Report. Submitted to The U.S. Fish and Wildlife Service in behalf of the Edwards Aquifer Habitat Conservation Plan Permittees.

Blanton and Associates, 2017, Edwards Aquifer Habitat Conservation Plan 2016 Annual Report. Submitted to The U.S. Fish and Wildlife Service in behalf of the Edwards Aquifer Habitat Conservation Plan Permittees.

Edwards Aquifer Authority, 2015, Appendix H 2015 Financial Report for the 2015 Edwards Aquifer Habitat Conservation Plan.

Gulley, Robert, 2012, 2013 Work Plans and Budget for the Implementation of the Habitat Conservation Plan

Gulley, Robert, 2013, 2014 Work Plans and Budget for the Implementation of the Edwards Aquifer Habitat Conservation Plan

Pence, Nathan, 2015, 2016 Work Plans and Budget for the Implementation of the Edwards Aquifer Habitat Conservation Plan

SWCA Environmental Consultants, 2014, Edwards Aquifer Habitat Conservation Plan 2013 Annual Report. Submitted to The U.S. Fish and Wildlife Service in behalf of the Edwards Aquifer Habitat Conservation Plan Permittees.

Other References

Center for Watershed Protection (CWP), 2001, Article 1: The Importance of Imperviousness. *Watershed Protection Techniques* 1(3): 100-111.

Chesapeake Bay Expert Panel Report, 2013, Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects

City of Austin, 1990, Stormwater Pollutant Loading Characteristics of Various Land Uses in the Austin Area.

EAHCP, 2012, *Funding and Management Agreement...to Fund and Manage the Habitat Conservation Plan for the Edwards Aquifer Recovery Implementation Program.*

[http://www.eahcp.org/files/uploads/Funding_and_Management_Agreement_\(Appendix_R\).pdf](http://www.eahcp.org/files/uploads/Funding_and_Management_Agreement_(Appendix_R).pdf)

EAHCP, 2017, Adaptive Management Stakeholder Committee of the Edwards Aquifer Habitat Conservation Plan [http://www.eahcp.org/files/uploads/Final Stakeholder Report, 2017-03-16.pdf](http://www.eahcp.org/files/uploads/Final_Stakeholder_Report_2017-03-16.pdf)

EARIP, Edwards Aquifer Recovery Implementation Plan, 2012, Habitat Conservation Plan.

Espey Consultants, Inc., 2007, San Marcos Flood Protection Plan. Prepared for City of San Marcos.

Griffith, G., Brice, S., Omernik, J., and Rogers, A., 2007, Ecoregions of Texas. Project report to Texas Commission on Environmental Quality.

Hardy, T., and Raphelt, N., 2013, Sessom Creek Sand Bar Removal: HCP Task 5.4.6. Edwards Aquifer Habitat Conservation Plan 2016 Annual Report, Appendix M2.

HDR-Kurkjian Engineering Corporation, 2011, Quantification of the Long-Term Benefits of On-Site Erosion Detention for Developing Austin Watersheds: Stream Protection Curve.

John Gleason LLC (JGLLC), 2015, Water Quality Protection Plan for the City of San Marcos and Texas State University meeting obligations of the Edwards Aquifer Habitat Conservation Plan.

John Gleason LLC (JGLLC), 2016, Sessom Creek Watershed Conceptual Restoration Presentation.

Kerr, B., 2013, Sediment and Nutrient Removal Rates for Stream Restoration Projects

Lane, E.W., 1955, The importance of fluvial geomorphology in hydraulic engineering. Proceedings of the American Society of Civil Engineers 229: 259-384.

MacRae, C.R., 1996, "Experience from Morphological Research in Canadian Streams: Is Control of the Two-Year Frequency Runoff Event the Best Basis for Stream Channel Protection?" Proceedings from symposium Effects of Watershed Development & Management on Aquatic Ecosystems.

NRCS, 2007, Part 654 Stream Restoration Design National Engineering Handbook.

NRCS Web Soil Survey (WSS) analysis conducted 2017 by JGLLC

Osborne, K., 2000, A Water Quality GIS Tool for the City of Austin Incorporating Non Point Sources and Best Management Practices, Master of Science in Engineering and Master of Public Affairs, University of Texas at Austin.

Raymond Chan and Associates, in association with Aquafor Beech, Ltd and Crespo Consulting Services, 1996, Technical Procedures for the Watershed Erosion Assessment C.I.P. No 485-617-2000. Prepared for the City of Austin Drainage Utility Department.

RPS Espey, 2013, Sessom Creek Erosion Remediation Evaluation: Erosion Control Study. Prepared for the City of San Marcos, Texas.

SWCA, 2014, Edwards Aquifer Habitat Conservation Plan USFWS Permit No. TE63663A-0 2013 Annual Report. Prepared for The U.S. Fish and Wildlife Service in behalf of the Edwards Aquifer Habitat Conservation Plan Permittees.

SWCA. December 2014 (edited January 2015). *Edwards Aquifer Habitat Conservation Plan 2014 Expanded Water Quality Monitoring Report*. Prepared for the Edwards Aquifer Authority.

SWCA. December 2015. *Edwards Aquifer Habitat Conservation Plan 2015 Expanded Water Quality Monitoring Report*. Prepared for the Edwards Aquifer Authority.

SWCA. January 2017. *Edwards Aquifer Habitat Conservation Plan 2016 Expanded Water Quality Monitoring Report*. Prepared for the Edwards Aquifer Authority.

TCEQ, 2005, *Complying with the Edwards Aquifer Rules: Technical Guidance on Best Management Practices*.

Templeton, S., Duman, C., and Sessions, W., 2008, *Estimation and Analysis of Expenses of Design-Bid-Build Projects for Stream Mitigation in North Carolina: Research Report RR 08-01*, Clemson University Department of Applied Economy and Statistics.

Tolman, K., Clary, C., and Hardy, T., 2013, *Assessing Water Quality Changes under Existing and Future Build-Out Scenarios in the Upper San Marcos Watershed*. Prepared for the City of San Marcos by the Meadows Center for Water and the Environment.

USDA, 1978, *Predicting Rainfall Erosion Losses: A Guide to Conservation Planning*, Agricultural Handbook Number 537.

USEPA, 1986, *Methodology for Analysis of Detention Basins for Control of Urban Runoff Quality*, EPA 440/5-87-001.

USEPA, 2011, *Recovery Potential Metrics Summary Form: Tools for Comparing Impaired Water Bodies Restorability*

USEPA, 2017 download from Causal Analysis/Diagnosis Decision Information System (CADDIS) website

USGS, 2003, *Effects of Urban Development on Floods*, Fact Sheet FS-076-03.

WERF, 2016, *Stream Restoration as a BMP: Crediting Guidance*.

APPENDIX A. PHOTOGRAPHS COMPARING SESSOM CREEK TO OTHER SAN MARCOS CREEKS

Figure A1. Sessom Creek stream erosion



Figure A2. Willow Springs Creek near Senior Activity Center



Figure A3. Willow Springs Creek above McKie Street, below concrete channel



Figure A4. Willow Springs Creek below McKie Street and concrete channel; some incision of channel but good floodplain connection and riparian zone



Figure A5. Purgatory Creek above Mitchell Street; stable stream system



Figure A6. Purgatory Creek below Comal Street; bank erosion and sediment bar, possible due to flow hydraulics of bridge culverts



Figure A7. Purgatory Creek above Comal Street near confluence with San Marcos River



Figure A8. Sink Creek below Lime Kiln Road



APPENDIX B. SOIL ERODIBILITY RATINGS FOR SAN MARCOS WATERSHEDS

Figure B1. Percentage of Highly Erodible Land in San Marcos Watersheds
(JGLCC, 2017 from NRCS "Web Soil Survey" data in City of San Marcos GIS files)

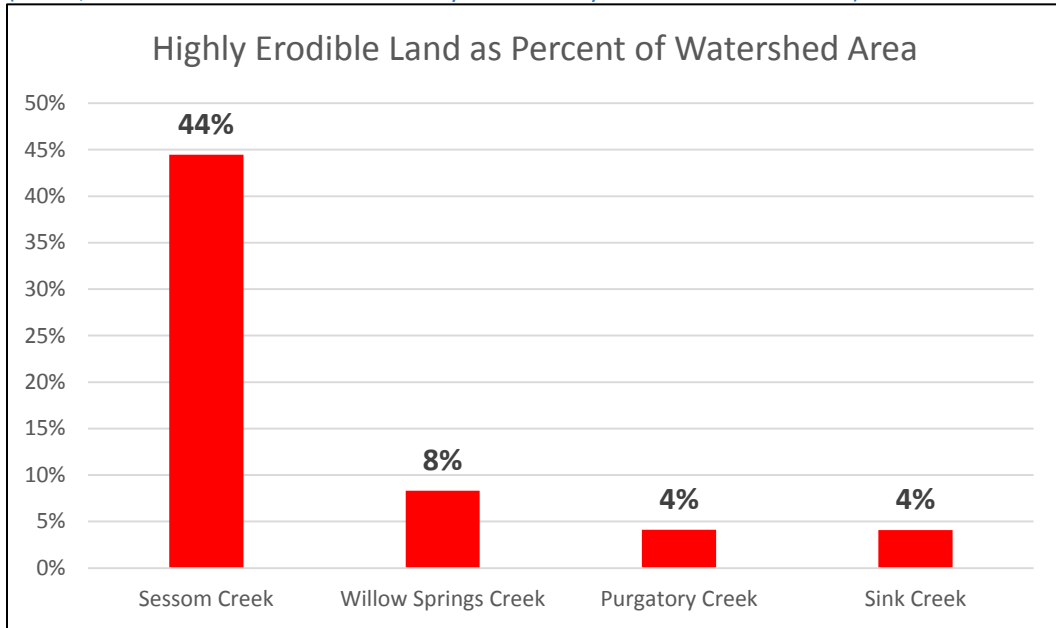


Figure B2. Sessom Creek Watershed Soil Erodibility Ratings

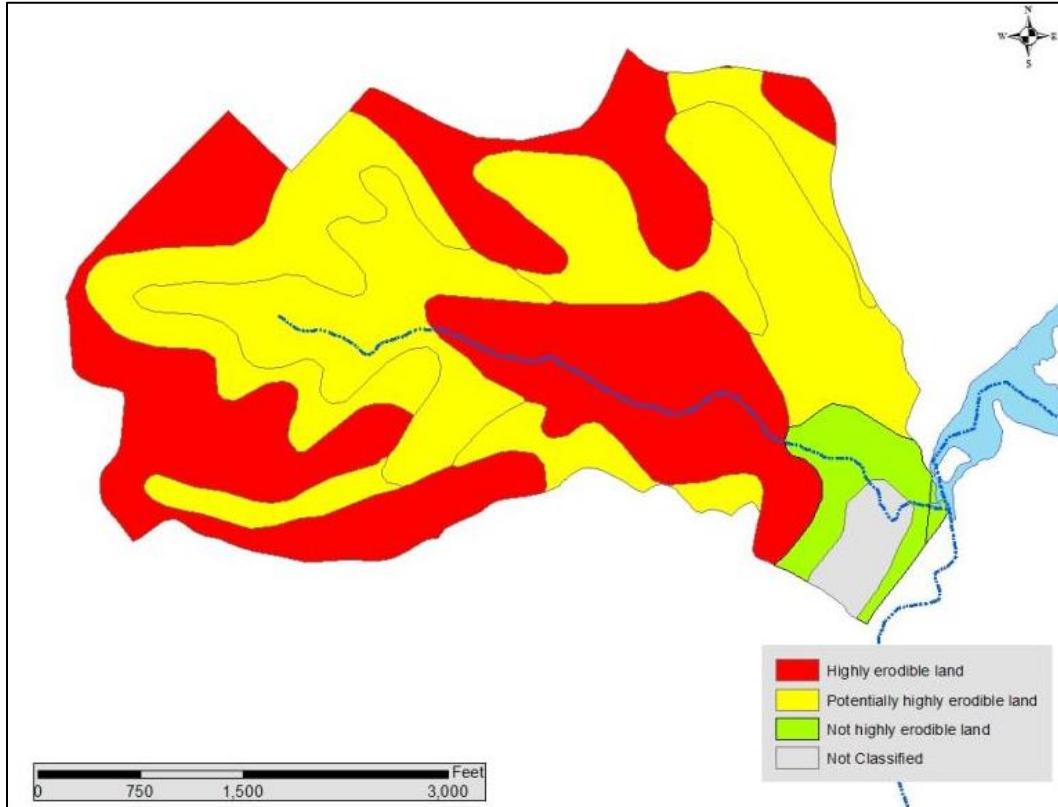


Figure B3. Willow Springs Creek Watershed Soil Erodibility Ratings

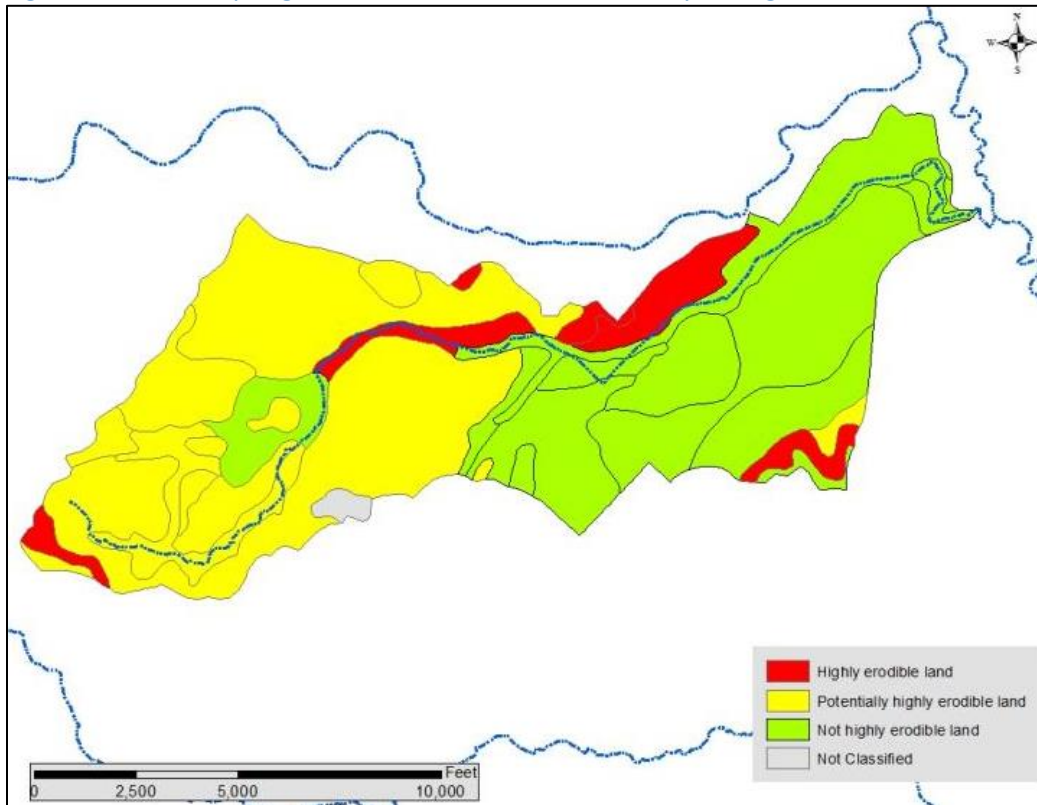
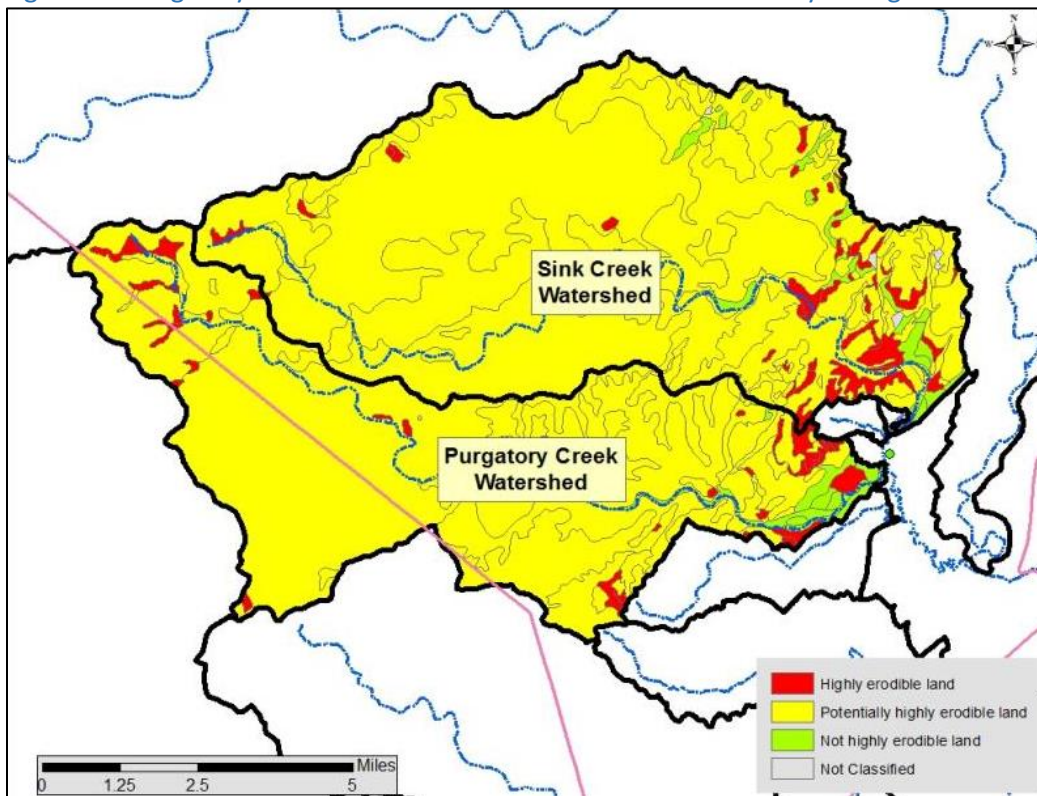


Figure B4. Purgatory Creek and Sink Creek Watershed Soil Erodibility Ratings



APPENDIX C. PHOTOGRAPHS COMPARING REACHES WITHIN SESSOM CREEK

Figure C1. Severe bed and bank erosion with exposed wastewater line in Reach 2



Figure C2. Threatened wastewater line in Reach 2 above the Loquat-Canyon intersection



Figure C3. Canyon Road threatened by stream erosion in Reach 2



Figure C4. Reach 2 below Windmill Tributary – eroding streambank with poor riparian condition



Figure C5. Severely eroded flume at TX ST outfall – Site of RPS Project #10



Figure C6. Eroding and erosive outfall from “The Gulch” tributary near RPS project #10 site



Figure C7. Scour hole below drop structure – Site of RPS project #9 (RPS photo)



Figure C8. Representative example of Sessom Creek above Reach 2 – On private property



Figure C9. Concrete channel in Reach 1 – Downstream of Reach 2



Figure C10. Bank erosion and undermined concrete channel bed in Reach 1



Figure C11. Bank failure in Windmill Tributary



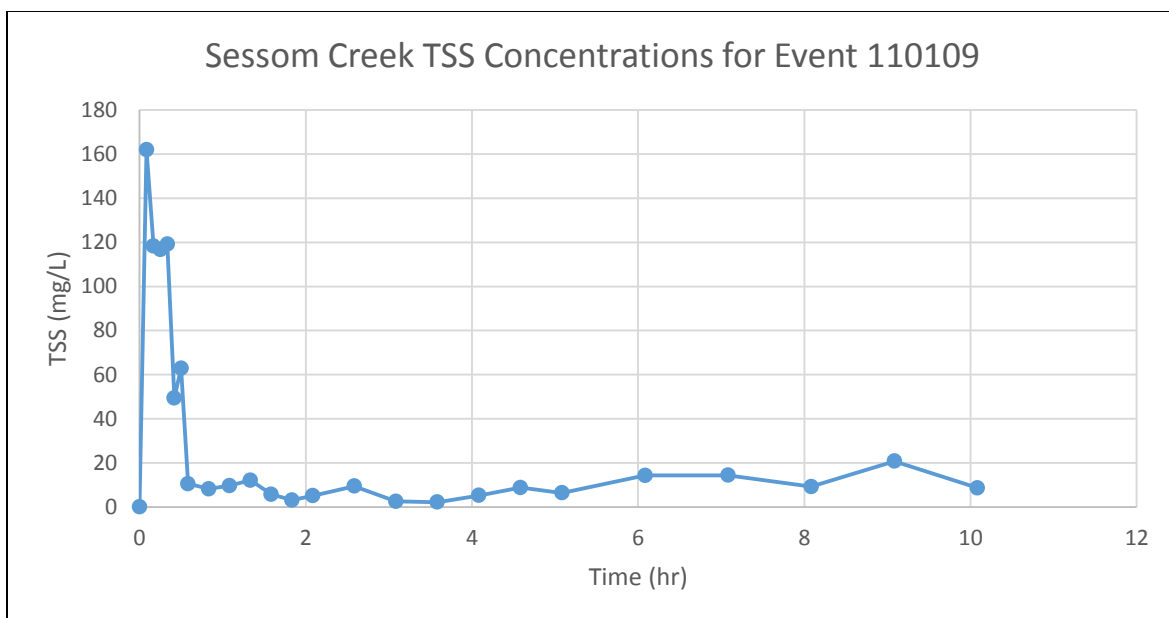
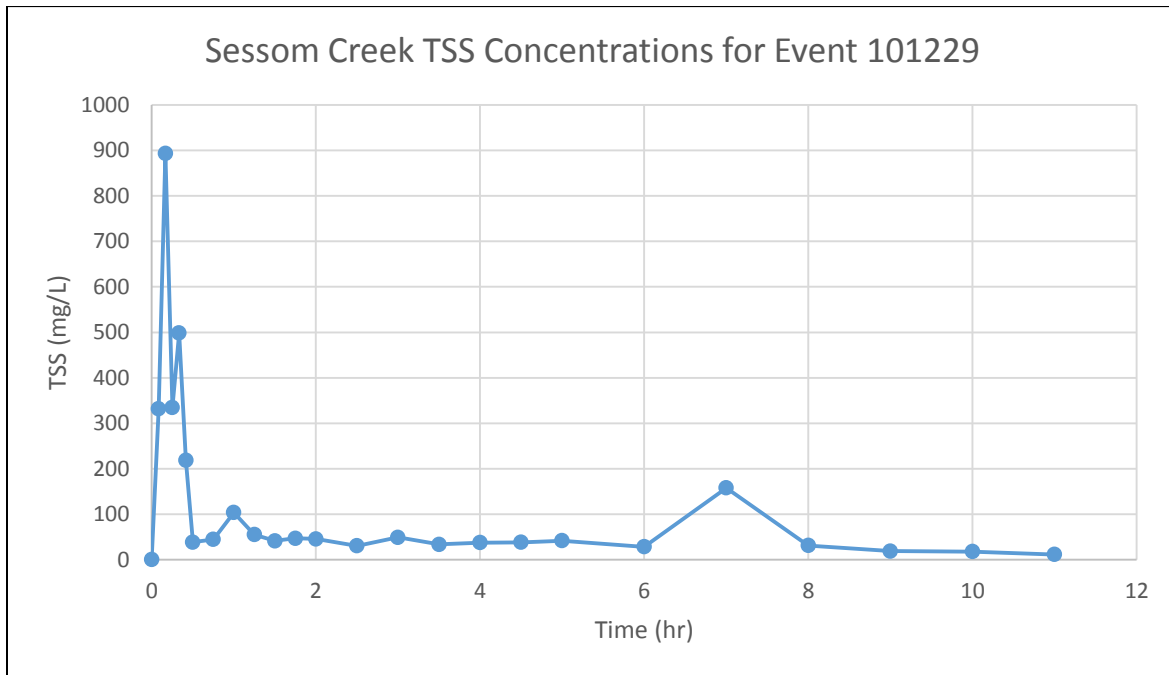
Figure C12. Collapsed wastewater line support in Windmill Tributary

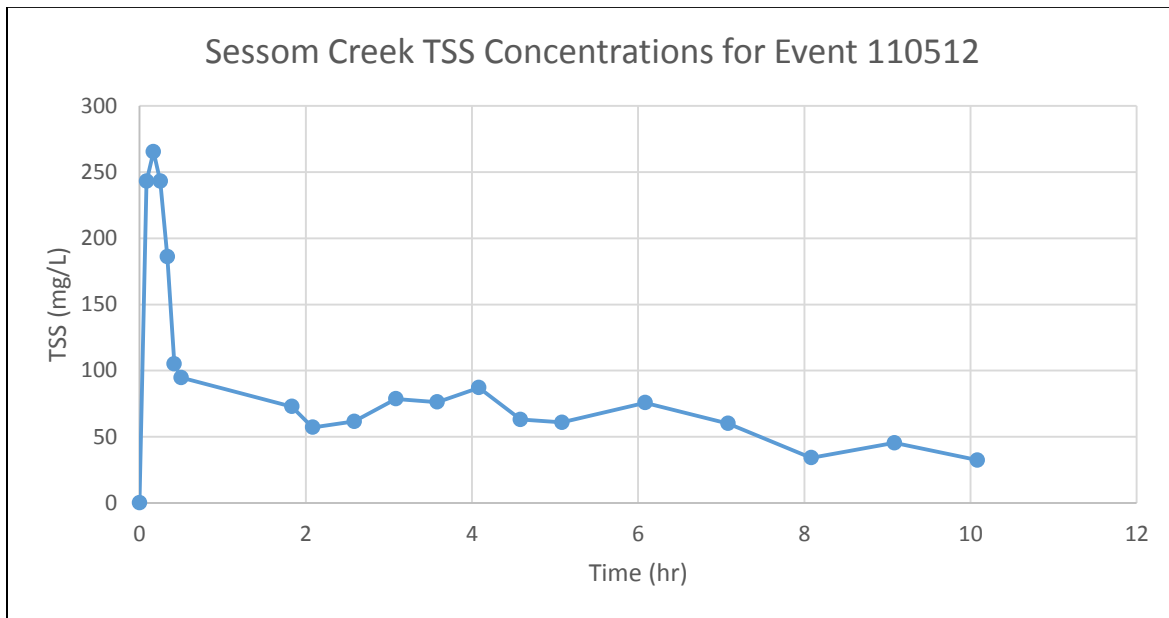
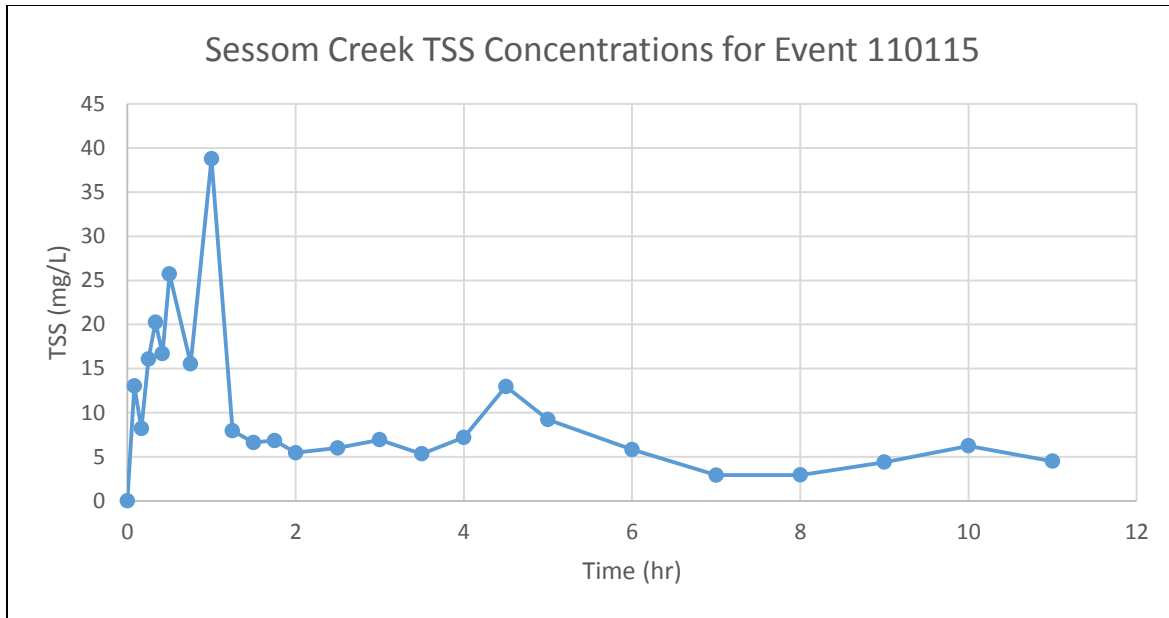


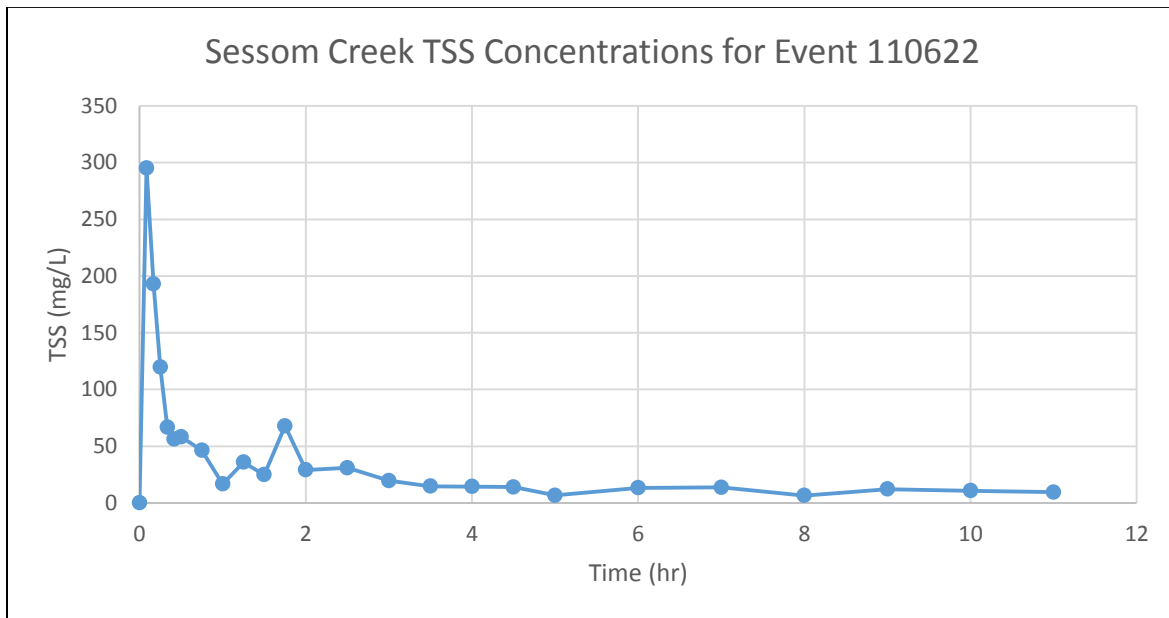
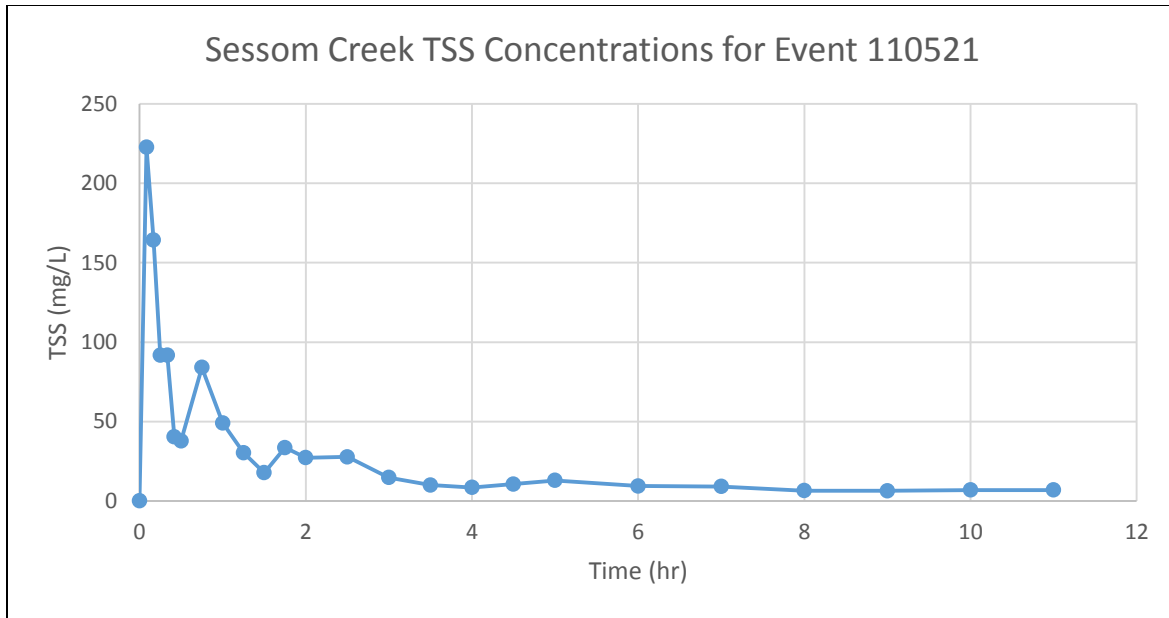
APPENDIX D. SESSOM CREEK STORMWATER RUNOFF MONITORING DATA FROM TEXAS STATE UNIVERSITY

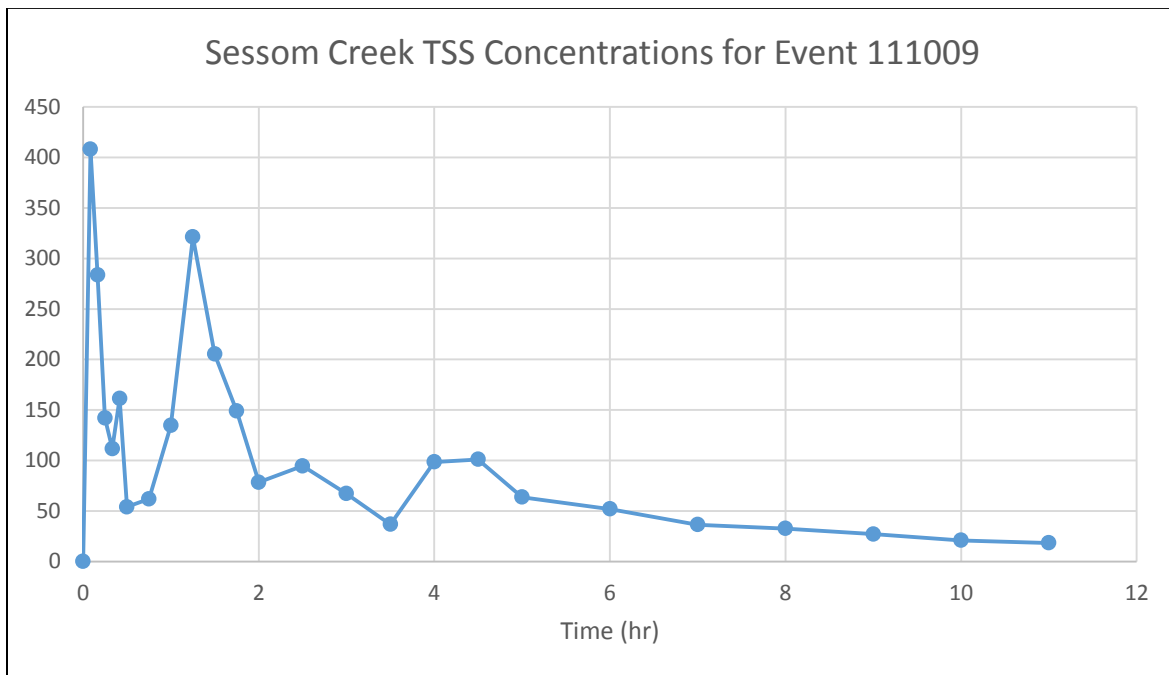
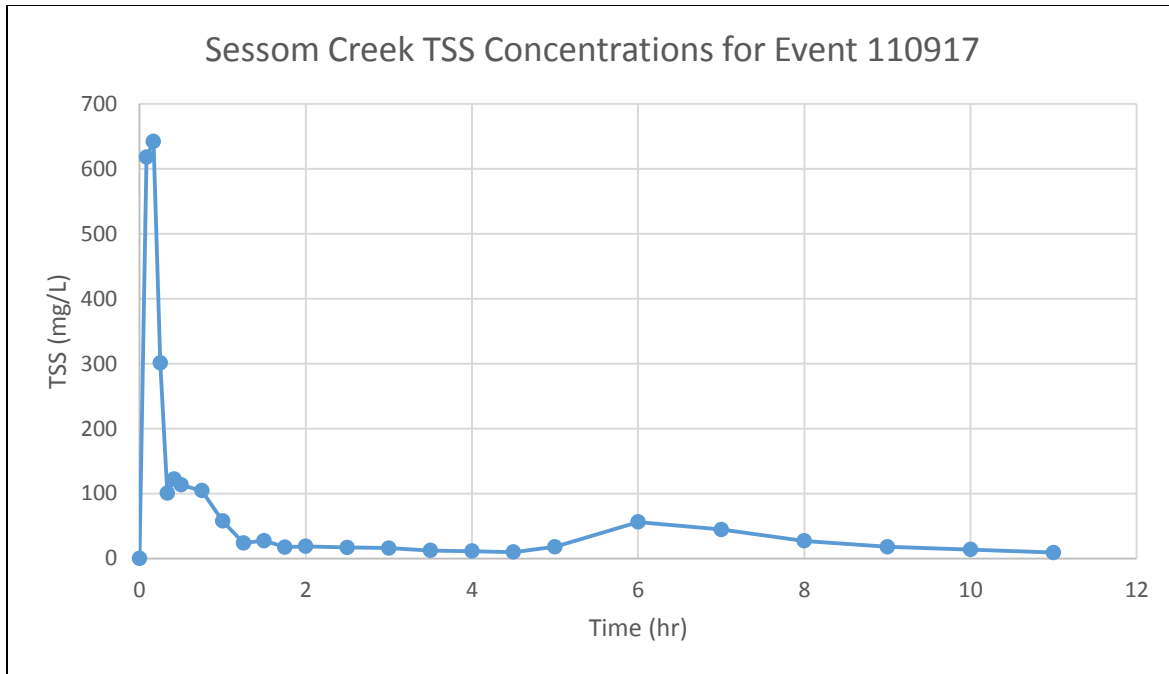
Unpublished data from Professor Benjamin Schwartz, Texas State University Department of Aquatic Biology, provided via Edwards Aquifer Authority, 2017

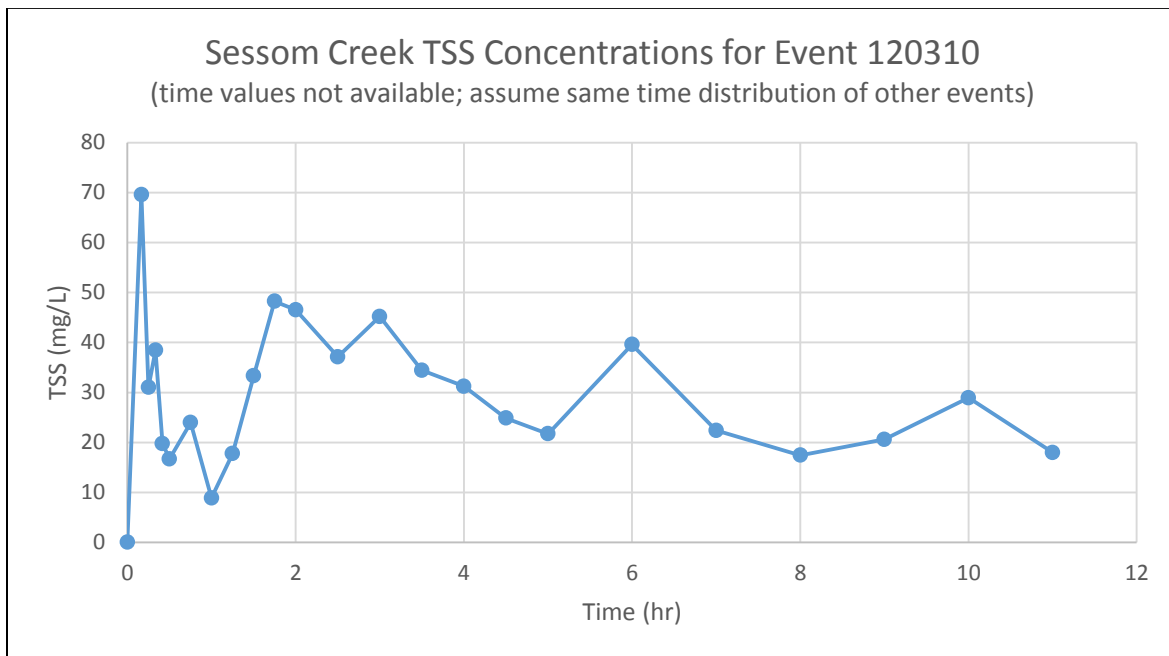
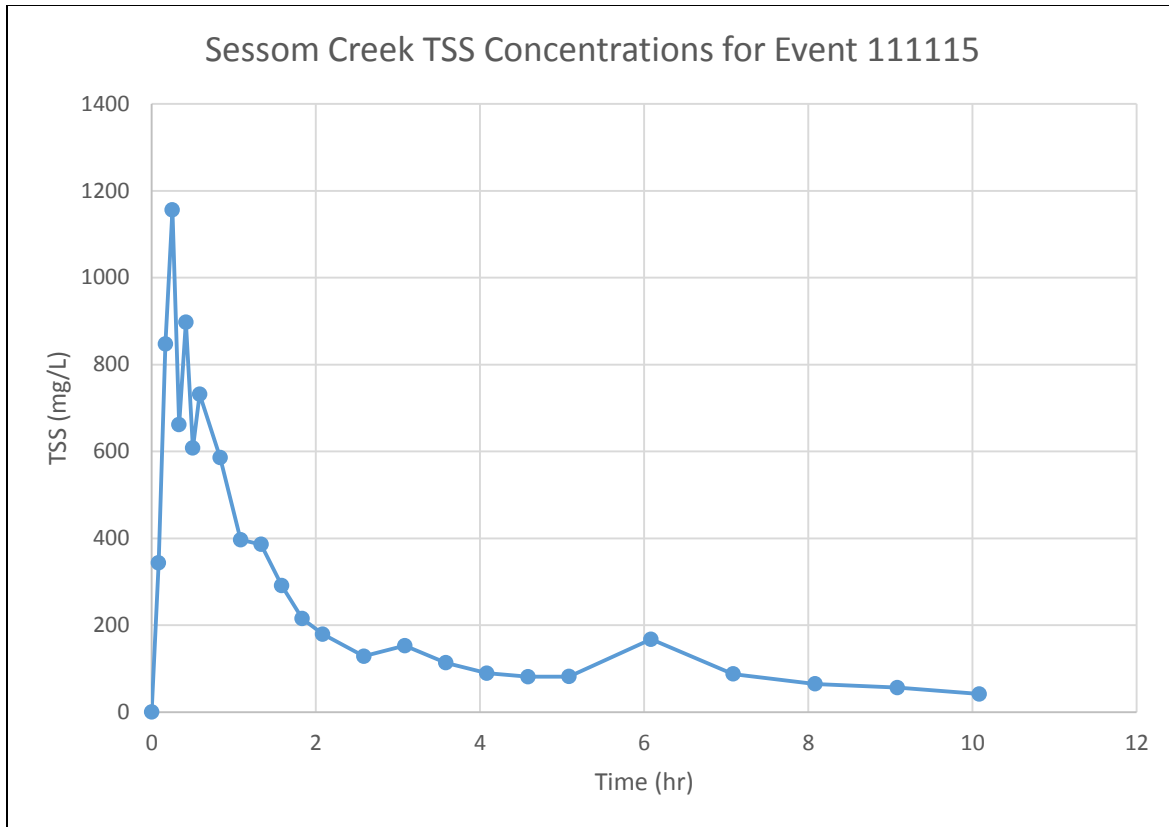
Calculation of Event Mean Concentration (EMC) values was not possible as no flow data was available. Plots are provided of TSS concentration vs. time. It appears the first sample was typically taken 5 minutes into the runoff event, and this is assumed for events where time values were not provided.

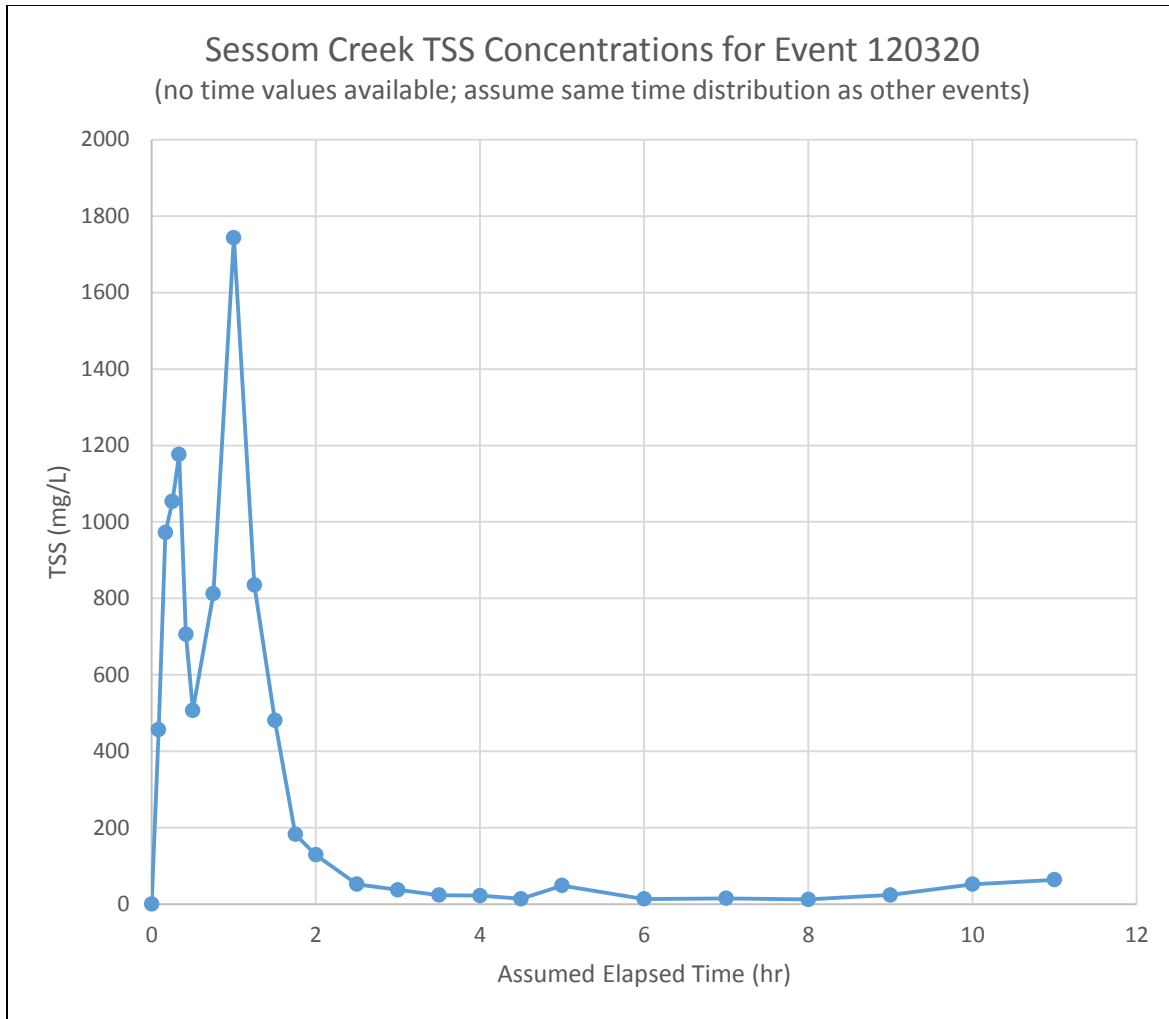












Appendix E. Theory, Data, and Methodologies for Estimating Loads and Load Reduction Credits for Stream Restoration and Stormwater Management Projects

Underlying Theory of Stream Response to Urbanization

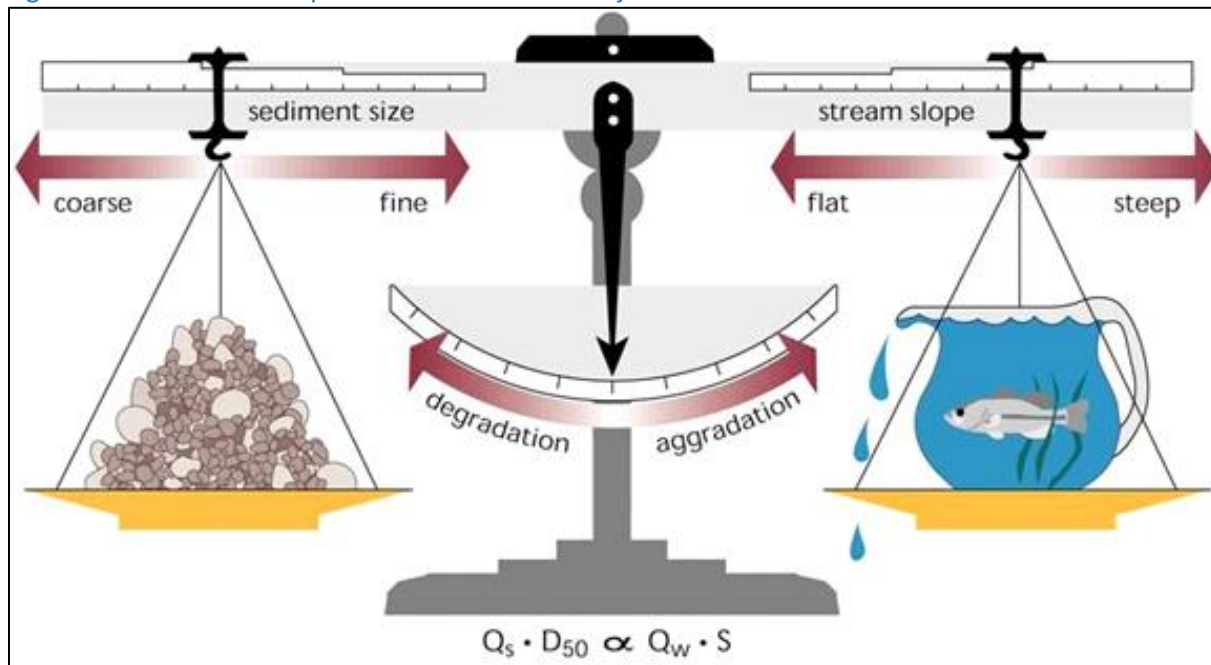
For design of successful stream restoration projects, it is important to identify underlying causes of the stream instability, high erosion rates and sediment loads. While upland runoff loads, especially construction site runoff, can be significant concerns, it is the contention of the authors that the instability and high sediment loads in Sessom Creek are primarily due to watershed hydrology. It is well known that urbanization can significantly affect watershed hydrology by increasing the frequency and magnitude of runoff flows:

- From the San Marcos WQPP (JGLLC, 2015), a fully impervious site would experience nearly twice the frequency of runoff events and generate more than 30 times the runoff volume of an undeveloped site, on an annual average basis.
- From TCEQ (2005), a 20% impervious site is predicted to generate almost 7 times more runoff than an undeveloped site, on an annual average basis, a 50% impervious site more than 15 times more, and a 100% impervious site 30 times more.
- Modeling studies in Maryland reported that urbanization can increase two year peak discharges by 1.3 to 7.7 times, and that the variability in these predictions is largely controlled by the extent of impervious cover associated with urbanization in each subwatershed (EPA, 2011).
- Urbanization can increase the duration of erosive flows up to 100 times (MacRae, 1996).

Lane's Geomorphic Model (Figure E1, Lane, 1955) provides a semi-quantitative explanation of the correlation between watershed conditions and stream response. A stable stream system, or one that is in "equilibrium," has channel dimensions (profile, plan form, cross section) such that flow and sediment transport are in balance. Urban streams are often in a state of dis-equilibrium because the increase in the frequency and magnitude of runoff flows (largely attributable to impervious cover and a more efficient conveyance system) have "tipped the scales" such that the stream responds by:

- Degrading (downcutting and/or widening)
- Steepening
- Eroding and transporting smaller particles (which are more damaging to aquatic systems)

Figure E1. Lane's Geomorphic Model of Channel Adjustment



From Lane, E.W., 1955

In their classification and characterization of stream geomorphology, Raymond Chan & Associates (1996) further elaborated on equilibrium theory and the hydrologic implications of urbanization:

- Equilibrium, or “regime” theory states that stream dimensions form in response to a continuum of flow events in accord with the events that perform the most work (the produce of mass of sediment moved by an event multiplied time its frequency).
- Events with a recurrence interval of 1.5 to 2 years theoretically perform the most work, and typically represent “bankfull” conditions, i.e., flow is constrained within the active channel without being connected to the adjacent floodplain.
- Although large, catastrophic events (recurrence interval RI approximately 100 years) are capable of performing considerable work, they have a low frequency of occurrence and the total amount of work performed is relatively low.
- Similarly, smaller events (RI < 1.01 years), which occur frequently, have a low capacity to perform work and consequently, the total amount of work performed is also relatively low.
- However, under urbanization, the increase in runoff is such that flood frequency diminishes with return period. Events that perform the most work may have a recurrence interval of 2 to 3 months, rather than 1.5 to 2 years, and the geomorphically dominant events may shift to the mid-bankfull flows.

That the rate and severity of sub-bankfull flows due to urbanization are primary causes of channel instability and erosion has been acknowledged by others, with sub-bankfull flow increases by a factor of 10 reported, even at relatively low levels of imperviousness (CWP, 2001). Once a watershed exceeds about 10% imperviousness, channel instability is expected (USEPA, 2017). In a study of Austin streams, increases in an excess stream power erosion index (ESP) of approximately 2 to 11 times were reported, as watershed impervious cover increased from 5% to 75% (HDR-KEC, 2011). TCEQ (2005) states that stream erosion can account for 90% of the sediment load in urban watersheds.

An important point from the findings is that impervious cover can be a good predictor of impacts, especially for urban and urbanizing watersheds. From EPA (2011):

- One might use the term “generic” to describe urban streams, making the point that despite important differences in catchment geology, climate and vegetation, the condition of urban streams is overwhelmingly controlled by the altered timing and volume of water from the urbanized catchment.
- Therefore, it is likely that stormwater impacts are the primary driver behind the often-reported correlations between stream condition and *catchment imperviousness*. (JGLLC emphasis)

As can be surmised, streams may eventually reach a new equilibrium state after disturbances (e.g., urbanization) have ceased. Although the evolution of a channel to a new equilibrium state may take hundreds to thousands of years, the period of highest geomorphic activity is typically within 5 to 10 years of the initiation of development, and the rate of geomorphic activity approaches pre-development levels with 20 to 30 years (Raymond Chan and Associates, et al., 1996).

Is it Appropriate to Apply Equilibrium Theory to Sessom Creek?

There is little or no geomorphic data available for Sessom Creek, but there is a need to characterize it for the successful development of solutions. There is data available for Austin creeks, which could reasonably be applied to Sessom Creek. An important finding from the Raymond Chan report (1996) is that Austin streams appear to behave in a manner consistent with regime theory, and that sub-bankfull flows ($RI < 1.001$ years) are the geomorphically dominant events for the urbanized Austin watersheds. It is hypothesized that Sessom Creek also behaves in the same manner and, furthermore, that Sessom Creek has characteristics that are similar to, or overlapping with those in the Austin area, in terms of geomorphology, climate, soils, land uses, and impervious cover:

- The Austin dataset reflected a wide range of stream morphology, including alluvial, rock bed and rock controlled stream systems (Figure E2); designations by Raymond Chan and Associates, 1996). Sessom Creek falls within those categories, with Reach 2 being primarily an alluvial system, reaches above and below Reach 2 a combination of alluvial, rock bed, and rock controlled systems.
- Using ecoregion as an additional surrogate for geomorphic region, both are in or near the boundaries of the same ecoregions, i.e., Edwards Plateau and Texas Blackland Prairies (Griffith, et al., 2007)
- The San Marcos and Austin climate is similar, e.g., both are in the same EPA Rainfall Region (EPA, 1986), annual average rainfall is similar (33 in/yr for San Marcos vs 32 for Austin, per TCEQ, 2005), the 1-year, 3-hour rainfall events are similar (1.94 inches volume for San Marcos vs 1.93 for Austin, per TCEQ, 2005), and both are in the same Rainfall Energy Factor range (“R” factor of 250-300 per USDA, 1978).
- Residential, commercial, transportation, and open space land uses predominate in both, with overlapping impervious cover ranges (Figure E3).
- Both have similar soils, with Hydrologic Soil Groups C and D often predominately, and overlapping soil erodibility and loss ratings in the stream corridors where stream restoration projects would be located (Kf of 0.15-0.24 for Sessom vs 0.05-0.28 for Austin dataset; T rating of 1-5 for Sessom vs 2-5 for Austin stream corridors, per NRCS Web Soil Survey data).

Figure E2. Stream Channel Geomorphic Classifications
(Raymond Chan and Associates, 1996)

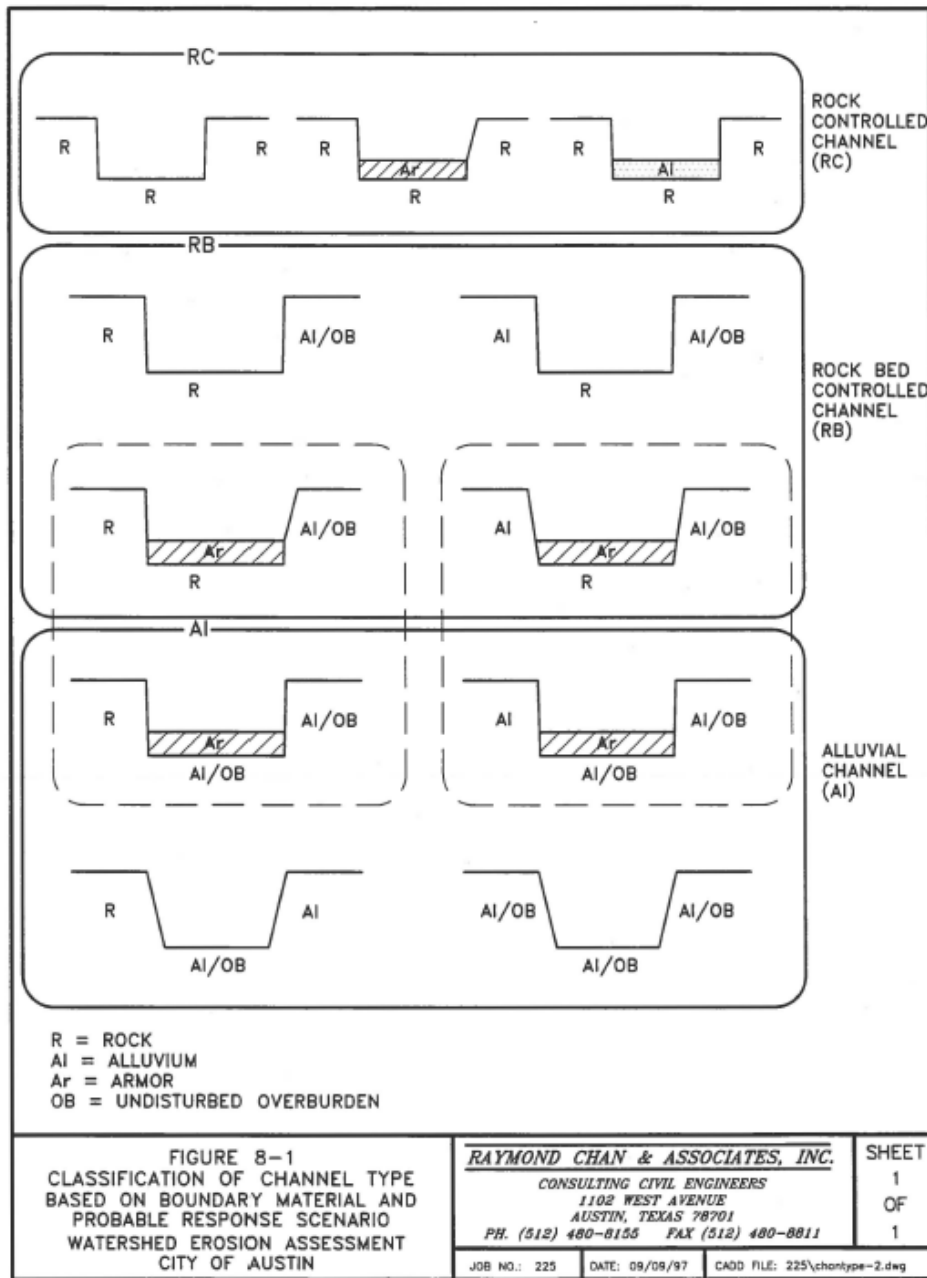
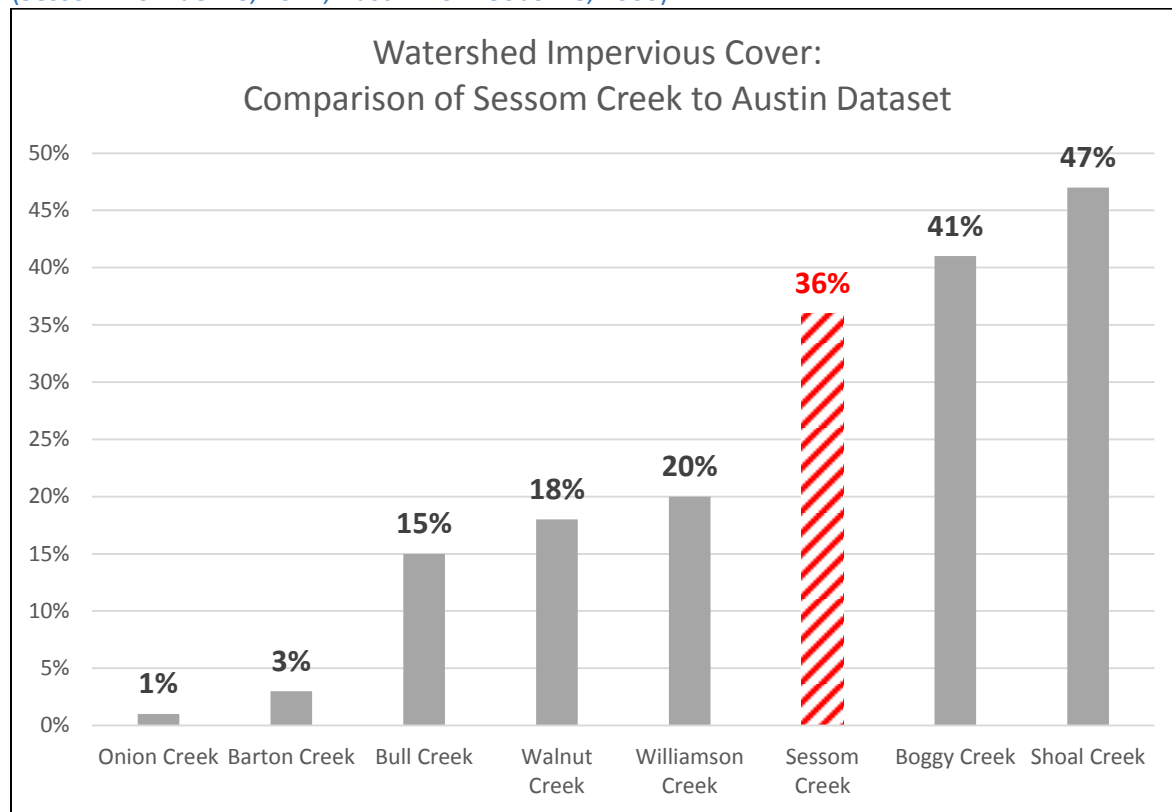


Figure E3. Comparison of Watershed Impervious Cover Values for Sessom Creek and Austin Watersheds (Sessom from JGLLC, 2017; Austin from Osborne, 2000).



For the purpose of estimating sediment loads, using TSS as a reasonable estimator, monitoring and modeling data are available for Austin streams, and it is hypothesized that the data reflects equilibrium theory, i.e., as urbanization increases runoff flows, dominant discharges shift to less than bankfull flows, with increased stream erosion and higher TSS or sediment loading rates. It is proposed to develop procedures for predicting TSS loads from the Austin data, and applying those procedures to Sessom Creek. An important finding of the Austin data is that, despite the wide range of watershed conditions, impervious cover is a good predictive variable.

Sources of Data for Developing Predictive Procedures

Historic monitoring data collected by the USGS and the City of Austin is available that can be used to characterize watershed hydrology and water quality. In particular, a University of Texas Master of Engineering and Public Affairs thesis (Osborne, 2000) provided monitoring and modeling data that can be used to estimate loads, using Total Suspended Solids (TSS) as a reasonable indicator of sediment loads.

It should be noted that the watersheds in the dataset did have a range of stormwater controls implemented, but the type and extent of controls varied widely. For the highly urbanized watersheds of Boggy and Shoal Creeks, very few controls would be present, as most development preceded the City's stormwater regulations. More controls would be present in the other watersheds, but not necessarily those that provide good hydrologic control of erosive flows, which is of fundamental importance when assessing their potential effectiveness. The authors know of many controls in those watersheds that

provide little or no hydrologic control, e.g., swales, flood detention ponds, and water quality ponds with less than 24 hour drawdown time. No definitive dataset of the controls was currently available, thus it would be difficult to account for them in a deterministic manner. At this time, it is recommended to discount the potential effect of stormwater controls on the Austin dataset.

Predicting Watershed and Stream TSS Loads

It is assumed that stream restoration projects can reduce the in-stream component of the sediment load, which is primarily the result of stream erosion processes, but not the upland runoff load. The in-stream load can then be estimated as:

$$L_{IS} = L_T - L_U$$

Where L_{IS} = Load from in-stream component

L_T = Total watershed load (upland runoff + in-stream)

L_U = Load from upland runoff

The total watershed load L_T can be estimated using the data from the Osborne thesis, as presented in Tables D1 and D2. The data represents watershed hydrology and water quality that account for both upland and instream processes, with baseflow and stormwater components separated out. From the calculated values in Table D2, stormflows constitute virtually all of the TSS load generated in a watershed, thus the baseflow contribution can be ignored. In order to develop a predictive relationship, the tabulated data was statistically analyzed, with two findings:

- (1) No statistically significant relationship between TSS loads and watershed area was found (Figure D3). This is important because the Sessom Creek watershed and its subwatersheds are smaller than the watersheds in the Osborne dataset, which could preclude use of that data if a relationship existed.
- (2) TSS loading rates (lb/ac/yr) are significantly correlated to watershed impervious cover (Figure D4). This is not unexpected, as impervious cover can significantly alter watershed hydrology.

Given that unit loading rate is correlated to impervious cover, the total load can be calculated as:

$$L_T = DA * L_{Unit}$$

Where L_T is the total watershed load (lb/yr)

DA is the watershed drainage area (ac)

L_{Unit} is the unit loading rate (lb/ac/yr)

Using the equation presented in Figure 2 gives:

$$L_T = DA * (5271.41 * IC + 404.76)$$

Note that UNIT LOADING RATE is a function of impervious cover, with the unit lb/ac/yr. To calculate the TOTAL LOAD, the unit loading rate must be multiplied times area, i.e.:

$$lb/ac/yr * ac = lb/yr$$

Table E1. Watershed Characteristics and Hydrology (from Osborne, 2000)

Station	USGS Drainage Area (ac)	Impervious Cover	Avg. Flowrate (cfs)	Pct. Baseflow	Pct. Stormflow	Annual Avg. Baseflow (cfs)	Annual Avg. Stormflow (cfs)
Barton Hwy 71	57,408	3%	49	39%	61%	19.11	29.89
Barton Lost Creek	68,480	3%	61.74	34%	66%	20.99	40.75
Boggy Hwy 183	8,384	41%	7.45	6%	94%	0.45	7.00
Bull Loop 360	14,272	15%	14.92	31%	69%	4.63	10.29
Onion Driftwood	79,360	1%	57.07	46%	54%	26.25	30.82
Shoal 12th Street	7,872	47%	7.03	7%	93%	0.49	6.54
Walnut Webberville Rd	32,832	18%	32.64	21%	79%	6.85	25.79
Williamson Oak Hill	4,032	20%	4.21	18%	82%	0.76	3.45

Table E2. Watershed Water Quality - Total Suspended Solids (from Osborne, 2000)

Station	Avg. Baseflow TSS (mg/L)	Avg. Stormflow TSS (mg/L)	Calculated Annual Average TSS Load (lb/yr)			
			Baseflow	Stormflow	Total	Pct. Stormflow
Barton Hwy 71	2.96	301.7	111,439	17,765,894	17,877,333	>99%
Barton Lost Creek	3.47	324.79	143,503	26,073,483	26,216,986	>99%
Boggy Hwy 183	3.19	1933.48	2,809	26,675,321	26,678,130	~100%
Bull Loop 360	3.58	1016.79	32,621	20,622,202	20,654,823	~100%
Onion Driftwood	2.25	431.24	116,368	26,182,223	26,298,591	~100%
Shoal 12th Street	9.33	1324.5	9,045	17,059,884	17,068,930	~100%
Walnut Webberville Rd	4.57	1562.18	61,712	79,358,630	79,420,342	~100%
Williamson Oak Hill	NA	472.82	NA	3,215,716	3,215,716	~100%

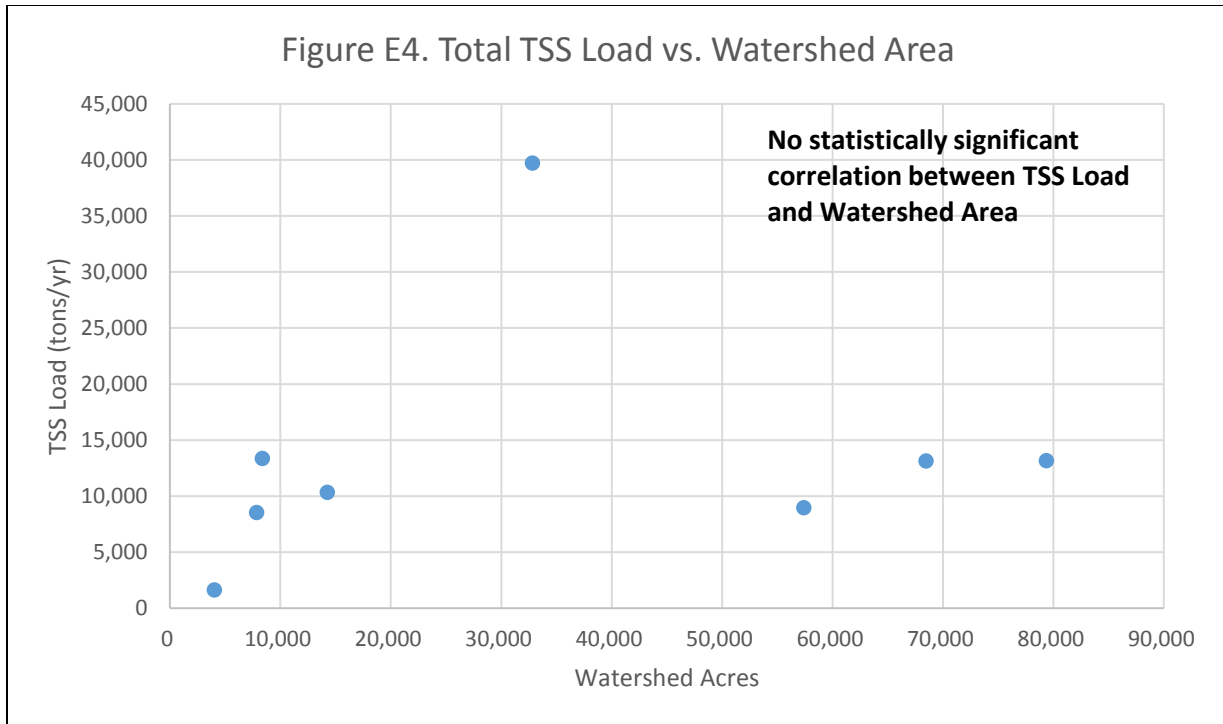
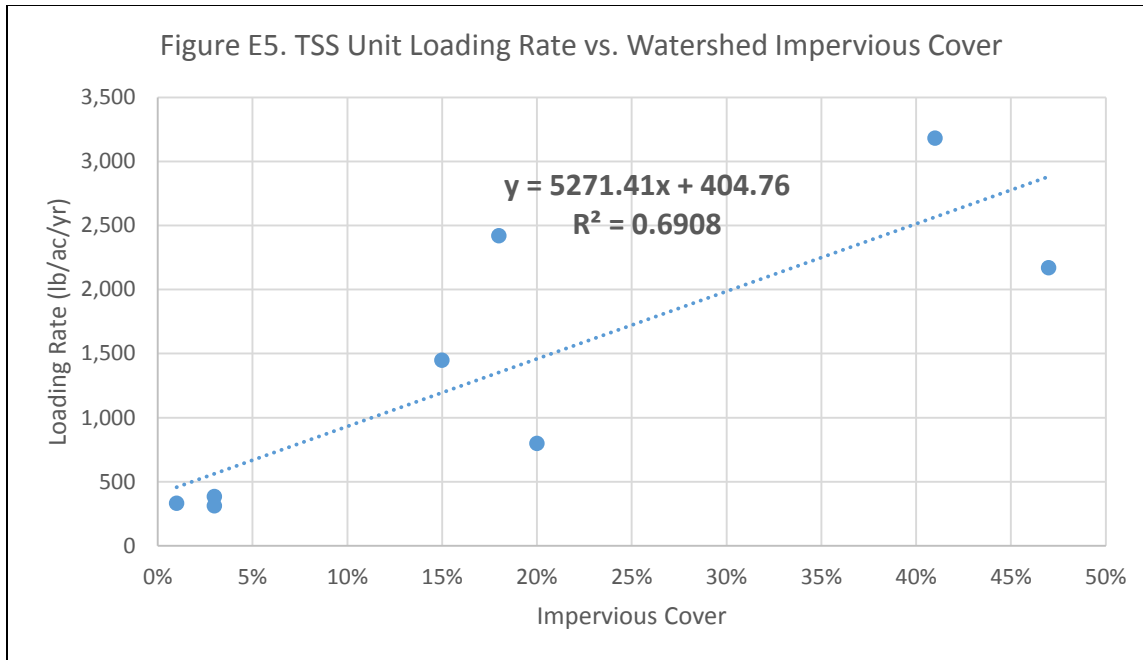


Table E3. Unit Loading Rates vs Watershed Impervious Cover

Station	Impervious Cover	TSS Unit Loading Rate (lb/ac/yr)
Barton Hwy 71	3%	311
Barton Lost Creek	3%	383
Boggy Hwy 183	41%	3,182
Bull Loop 360	15%	1,447
Onion Driftwood	1%	331
Shoal 12th Street	47%	2,168
Walnut Webberville Rd	18%	2,419
Williamson Oak Hill	20%	798



The upland load (L_u) can be estimated using the spreadsheet model developed for the San Marcos Water Quality Protection Plan (JGLLC, 2015), which was previously applied to the Adaptive Management Process for comparing the City Park, Veramendi, Hopkins, and Downtown ponds (EAHCP, 2017). The spreadsheet is a continuous simulation model that estimates upland runoff loads as a function of watershed area and impervious cover, and can also model stormwater BMPs.

Example 1 Calculations

Stream restoration of the middle reach of Sessom Creek (identified as Reach 2) has been proposed. The reach length is approximately 2800 feet. At the upstream end of the reach the drainage area is approximately 77 acres with existing impervious cover of 23% (could increase to 35% in the future). At the downstream end the total drainage area is approximately 258 acres with existing impervious cover of 34% (could increase to 45% in the future). Estimate the total, instream, and upland TSS loads for the reach.

The total load equation is:

$$L_T = DA * (5271.41 * IC + 404.76)$$

Applying to Reach 2:

	Upstream End	Downstream End
Drainage Area (ac)	77	258
Existing Impervious Cover (%) Upstream	23%	34%
Existing TSS Unit loading rate (lb/ac/yr) Upstream	1617	2197
Existing L_T Total TSS Load (lb/yr)	124,523	566,836
Potential Future Impervious Cover (%) Upstream	35%	45%
Potential Future TSS Unit loading rate (lb/ac/yr) Upstream	2250	2777
Potential L_T Total TSS Load (lb/yr)	173,231	716,439

Existing Conditions

The total load within the reach is 566,836 – 124,523, or:

$$L_T = 442,313 \text{ lb/yr}$$

From the WQPP spreadsheet model, the TSS load for the 258 acres watershed is 61,547, or:

$$L_U = 61,547 \text{ lb/yr}$$

Thus, the in-stream load is 442,313 – 61,547, or:

$$L_{IS} = 389,766 \text{ lb/yr}$$

Potential Future Conditions

$$L_T = 543,208 \text{ lb/yr}$$

$$L_U = 79,961 \text{ lb/yr}$$

$$L_{IS} = 463,247 \text{ lb/yr}$$

Potential Modifications to Procedure accounting for Schwartz data and Sessom Wet Pond

Stormwater event data collected in Sessom Creek by Texas State University staff is provided in Appendix D. Though it is not possible to calculate Event Mean Concentration (EMC) values (as flow data was not available), the data may indicate that TSS concentrations are lower than those in the Austin dataset, which could equate to lower sediment loads. The Austin dataset (Table E2) reports mean TSS concentrations of between approximately 300 – 1900 mg/L; recall that these are *average*, not *peak* concentrations. The Schwartz data reports *peak* TSS concentrations for individual events of approximately 40 – 1700 mg/L. However, it is our understanding that the Schwartz data was collected below the Sessom Creek wet pond (Figure E6), thus it may not be representative of runoff originating upstream, where Reach 2 and the Windmill Tributary are located. Though the pond is small, estimated to have a permanent pool volume (PPV) of < 0.10-inch, modeling by JGLLC indicates that it could reduce TSS concentrations and loads in the range of 15 - 50%. If these estimates are correct, upstream concentrations could be similar to the Austin dataset. The estimates were made using the WQPP BMP spreadsheet model (JGLLC, 2015), and are approximations because:

- The actual size of the pond is not known, as the record drawings (Baker-Aicklen & Associates, 2004) do not surface area or volume information. From available imagery and GIS data, in conjunction with the record drawings, permanent pool volumes of between 0.01 – 0.03-inch (approximately 14,000 – 43,000 ft³) appear reasonable, but sediment accumulation could reduce those further. For modeling purposes, a range between 0.005 - 0.03-inch is assumed. The volumes equate to an annual average hydraulic residence time (HRT) of between 1.6 – 3 days, which is primarily a measure of how long water resides in the pond *between* (not *during*) rainfall/runoff events.
- The efficiency of the diversion structure at routing runoff to the wet pond is not well known. It may function as a broad-crested weir (28 feet length per record drawings), except that a low flow outlet is present that may reduce diversion rates, if it is not clogged. For modeling purposes, diversion flow rates of 40 to 400 cfs were assumed, as well as discounting the structure, i.e., assuming all runoff is routed to the pond.

- Given the small size of the wet pond and the potentially high flow rates in Sessom Creek, resuspension of trapped sediment in the pond may be possible, which could reduce its overall removal efficiency. Resuspension is not specifically accounted for in the spreadsheet model.
- The hydrology of the Sessom Creek watershed is not well known, and no gaging data known to be available.

Given the model results and inherent uncertainties, it is reasonable to assume that the Austin data can be applied to Sessom Creek without modification, at this time. This issue may be revisited during the preliminary engineering phase of the project.

Figure E6. Sessom Creek Wet Pond and Lower Sessom Creek Area



Sediment Reduction Credit for Stream Restoration Projects

Limited monitoring and modeling data exist for estimating the sediment reduction credit for stream restoration projects, and large uncertainty exist in the estimates. This has led to the use of simplifying assumptions, usually in terms of load reduction efficiency or load removed per stream length. The Chesapeake Bay region has been a leader in allowing credit for stream restoration projects, and use default assumptions such as 50% sediment load reduction, or between 11 and 310 lb per ft per year removal. For the Sessom project, it is proposed that a 50% load reduction credit be assumed.

Example 2 Calculations

From Example 1, the existing in-stream TSS load for Reach 2 in Sessom Creek is estimated to 389,766 lb/yr. Assuming a 50% reduction credit, what is the estimated load reduction for the stream restoration project?

$$\text{Credit} = L_{IS} * 50\% = 389,766 * 50\% = 194,883 \text{ lb/yr}$$

For the 2800 feet length reach, this equates to a credit of 70 lb/ft/yr, well within the 11 – 310 lb/ft/yr credit used in the Chesapeake Bay region.

For future conditions, the instream load is estimated as 463,247 lb/yr. Assuming the same 50% reduction rate:

$$\text{Credit} = L_{IS} * 50\% = 463,247 * 50\% = 231,624 \text{ lb/yr}$$

This equates to a credit of about 83 lb/ft/yr, also well within the 11 – 310 lb/ft/yr credit used in the Chesapeake Bay region.

Sediment Reduction Credit for Stormwater BMPs

As stated earlier, the spreadsheet model developed for the WQPP (JGLLC, 2015) can be used to estimate upland runoff loads and BMP effectiveness. Effectiveness can be quantified in terms of pollutant removal and control of erosive “channel forming” flows, the later if the BMP is sized per the “Stream Protection Volume” (SPV) recommendations in the WQPP, with a 48 hour drawdown time for the SPV.

Example 3 Calculations

A biofiltration pond is under consideration for the Windmill Tributary. The drainage area to the pond is approximately 46 acres with existing impervious cover of 26%. From the WQPP, the recommended Stream Protection Volume (SPV) for 26% impervious cover is 0.32-inch, which equates to approximately 54,000 cubic feet. With a 48 hour drawdown time, the BMP is predicted to capture 91% of the annual average runoff, and remove 85% of the annual average TSS load. Using the procedures described above, the total TSS load in the watershed (both upland runoff and stream erosion) is estimated as:

$$L_T = DA * (5271.41 * IC + 404.76) = 46 * (5271.41 * 0.26 + 404.76) = 81,665 \text{ lb/yr}$$

With an 85% load removal efficiency, the estimated load removal is:

$$L_R = 81,665 * 85\% = 69,415 \text{ lb/yr}$$

Appendix F. Methodology for Preparing the Cost Estimate by Task

Task	Subtask Amount	Total Task Amount
Construction Cost		\$1,113,041
Engineering (25% of construction cost except additional surveying cost)		\$378,260
<i>Subtask Preliminary Engineering</i>	\$45,000	
<i>Subtask Design</i>	\$213,782	
<i>Subtask Construction Phase Services</i>	\$19,478	
Project Management Services (2% of construction cost):		\$22,261
Construction Inspection Services (2.6% of construction cost)		\$28,939
Tree mitigation (1% of construction cost)		\$11,130
Utility Relocation (2% of construction cost):		\$22,261
Printing of bid documents		\$1,500
Contingency for Change Orders and Current Level of Uncertainty (20% of construction cost)		\$222,608
TOTAL	\$278,260	\$1,800,000
EAHCP Contribution	\$212,893	\$1,500,000
City of San Marcos Contribution	\$65,367	\$300,000

Available funding served as the starting point for the cost estimate. The WQPP team used a cost-estimating tool and several information sources in the process of preparing the estimate:

- Project costs from built projects (primarily City of Austin stream restoration projects)
- Unpublished data by Complete Watershed Solutions, LLC

A construction cost was calculated through iterative use of the cost-estimating tool. Based on industry guidelines, engineering costs were estimated to be 25% of the construction cost. Engineering includes the PER, the design and contract documents, and construction phase services. The PER will identify, from a high-level, opportunities and constraints within Reach 2 and the Windmill Tributary.

The cost estimating tool includes recommended percentages for certain project tasks. The contingency amount (20%) was chosen by us and is intended to be conservative. This is in acknowledgement of project uncertainties at this early stage. This estimate assumes that all improvements are located on City owned property and that no real estate costs are necessary.

WORK GROUP OVERVIEW

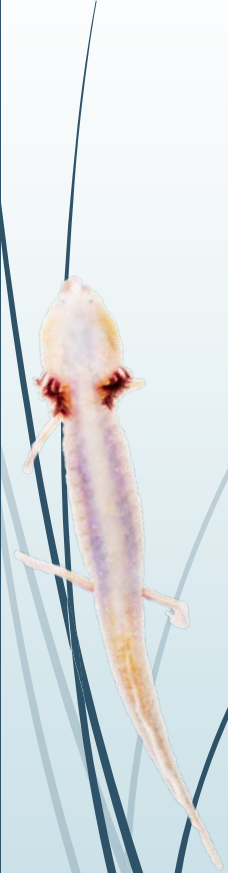


CHARGE

- ▶ Considering the EAHCP staff recommendation of the Sessom Creek watershed as the top priority for implementing projects; and
- ▶ Reviewing and prioritizing the proposed list of water quality protection projects identified for the chosen watershed.

MEMBERSHIP

- ▶ Glenn Longley Science Committee
- ▶ Charlie Kreidler Science Committee
- ▶ Jackie Poole Science Committee
- ▶ Shaun Condor City of San Marcos
- ▶ Aarin Teague San Antonio River Authority
- ▶ Ben Schwartz Texas State University



TODAY'S MEETING



PURPOSE

- ▶ To provide expert input for a possible Nonroutine Adaptive Management Process (AMP) action
 - ▶ AMP action will consist of a *proactive* sediment mitigation strategy, versus simply a *reactive* sediment removal strategy

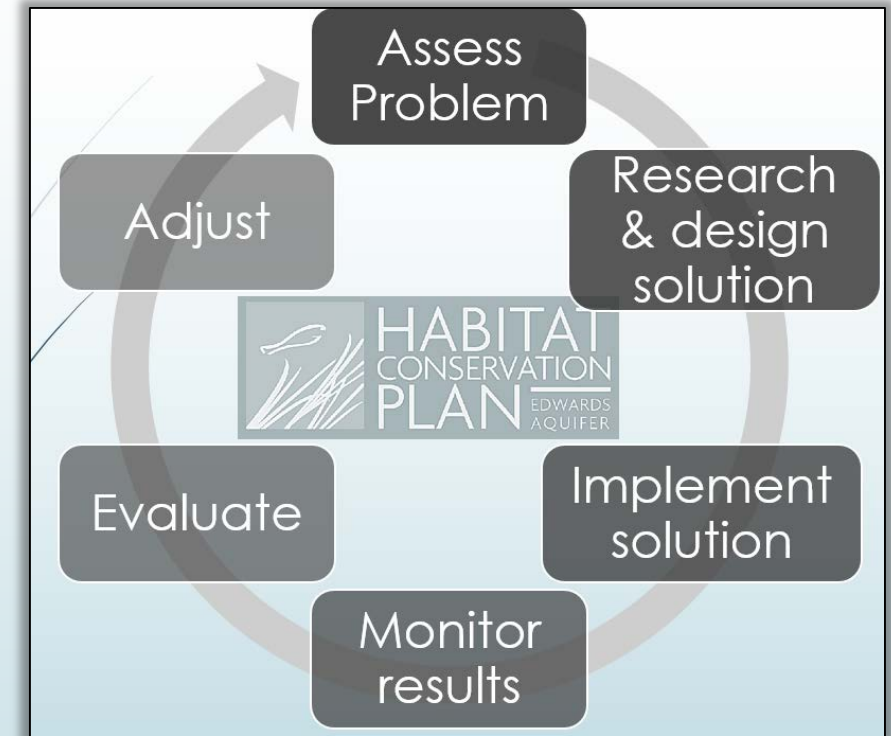
GOALS

- ▶ To discuss and possibly endorse the middle Sessom Creek as a preferred target for EAHCP funding and implementation, taking into account compliance and resource limitations
- ▶ To discuss and possibly endorse prioritized list of specific projects to be implemented

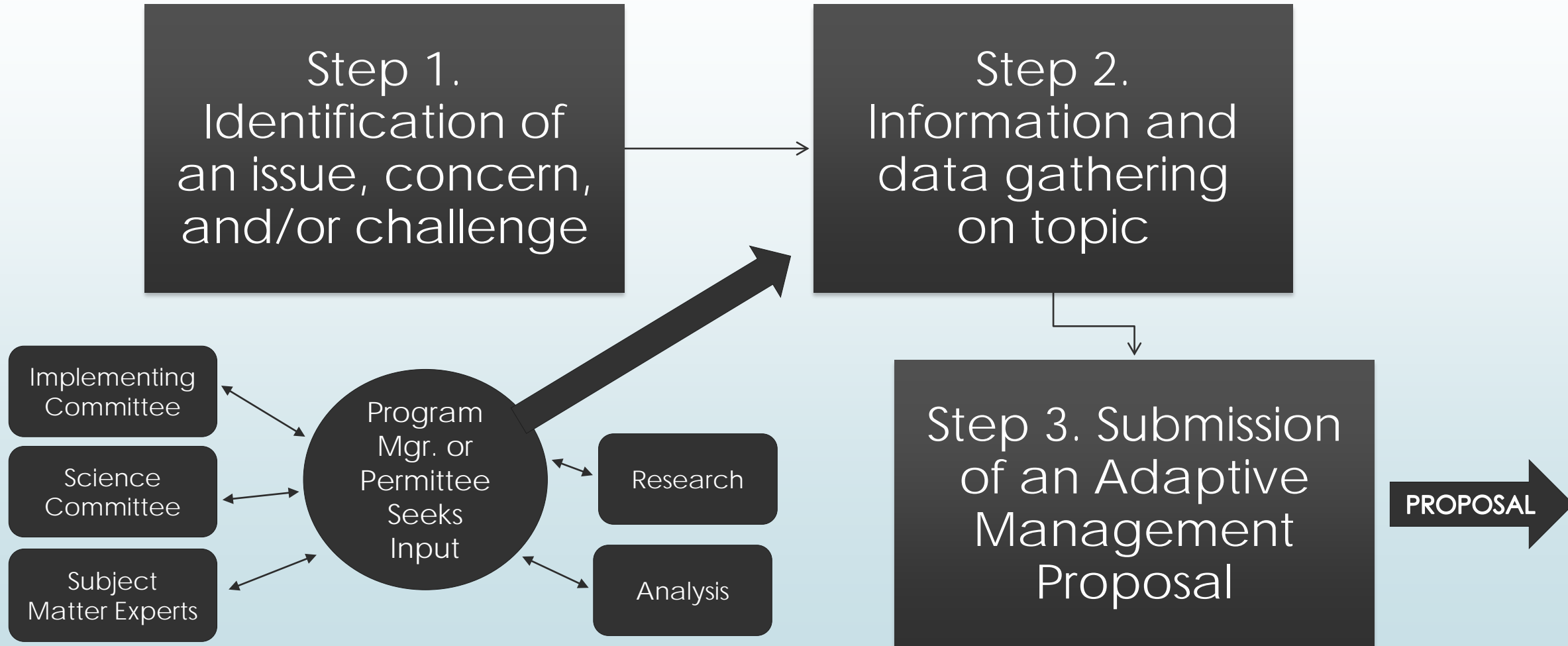


ADAPTIVE MANAGEMENT & THE HCP

- ▶ “Adaptive Management Process,” or AMP is a mechanism to make changes in response to new information
 - ▶ (e.g., generated through research, or experience with implementation)
- ▶ Including water quality protection projects as a sediment mitigation strategy is a change in response to experience with implementation.



EAHCP ADAPTIVE MANAGEMENT PROCESS



EAHCP ADAPTIVE MANAGEMENT PROCESS

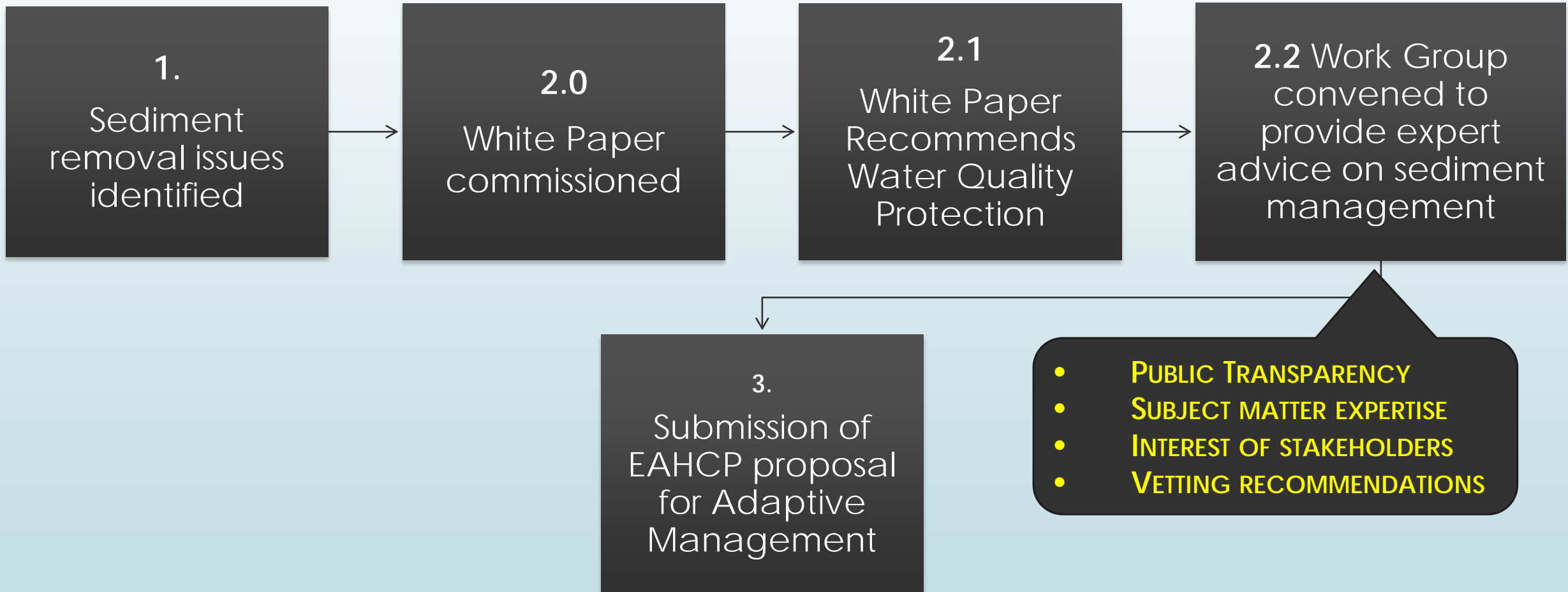


Step 4. Committee
Review Process



Step 5. Change to
Management—
Methodology,
Clarification, Minor or
Major Amendment

EAHCP ADAPTIVE MANAGEMENT PROCESS: *SEDIMENT REMOVAL & WATER QUALITY PROTECTION IN THE SAN MARCOS*



SEDIMENTATION & THE SAN MARCOS



PHYSICAL IMPACTS

- Natural scouring impeded by 5 U.S. Soil Conservation Service upstream flood control dams and construction in the upper San Marcos watershed (Earl & Wood, 2002)
- Monitoring since 1990 reveals sediment production has increased from 160 m³/year to 920 m³/year due to above factors (Earl & Wood, 2002)



SEDIMENTATION & THE SAN MARCOS



ECOLOGICAL IMPACTS

- ▶ Texas wild-rice (*Zizania texana*) shows enhanced growth in fine sediment (Power, 1996); however, current sedimentation rates are greatly increased over historical levels
- ▶ Deposition of sediments on or around Texas wild-rice stands causes direct mortality by smothering or burying stands (EARIP, 2012)
- ▶ Change in scour regime and increased sedimentation also contributes to increases in invasive exotic aquatic and riparian vegetation species (Earl & Wood, 2002)



HCP SEDIMENT REMOVAL MEASURES

***Sediment Removal
below Sewell Park***
(§5.3.6) – City of San
Marcos



and

***Sediment Removal in
Spring Lake and
Spring Lake to City
Park*** (§5.4.4) – Texas
State University



Edwards Aquifer Recovery Implementation Program

Habitat Conservation Plan

November 2012

Prepared For
Dr. Robert L. Gulley
Program Manager
Edwards Aquifer Recovery Implementation Program

Prepared By
RECON Environmental, Inc.
Hicks & Company
Zara Environmental LLC
BIO-WEST

HCP SEDIMENT REMOVAL TO DATE



Table 3. Sediment Removal Cost for Spring Lake and the San Marcos River

Year	HCP Task & Entity	Locations	Sediment Removed			Cost
			Area (m ²)	Volume (m ³)	Est. Load (lb)*	
2013	5.3.6 (COSM) and 5.4.4 (TXST)	Below Sewell Park (Bicentennial Park and City Park) and Spring Lake	106 (86 COSM) (20 TXST)	48 (44 COSM) (4 TXST)	169,509	\$151,800
2014	5.3.6 COSM	Below Sewell Park (Bicentennial Park and City Park)	77	20	70,629	\$180,000
2015	5.3.6 COSM	Below Sewell Park (Bicentennial Park and City Park)	284	85	300,173	\$219,450
2016	5.3.6 COSM	Below Sewell Park (Rio Vista Park)	92	28	98,880	\$193,042
TOTAL			559	181	639,192	\$744,292

HCP SEDIMENT REMOVAL TO DATE



JULY 2015



AFTER OCTOBER 2015 FLOOD

SEDIMENT REMOVAL COMPARISON



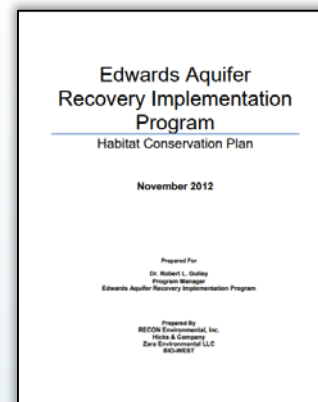
Metric	HCP Sediment Removal To Date	Proposed Stream Restoration and Stormwater BMPs
Pounds of TSS Removed per year	159,780	1.5x More
Total Capital Cost	\$744,292	Initial Investment 2x Greater
Annualized Cost (\$/yr.)	\$186,073	About Half the Cost
Annualized Cost per pound TSS removed	\$1.16	About One-third the Cost

HCP SEDIMENT REMOVAL TO DATE



- Sediment removal has proven costly, time-intensive, and problematic
- *Reactive* approach to managing sediment loading
- Removing sediment in the river vs. protecting water quality impacts from sedimentation (see EARIP, 2012, Appendix Q – Recommendation #2)

IMPERVIOUS COVER/ WATER QUALITY PROTECTION CONSERVATION MEASURE

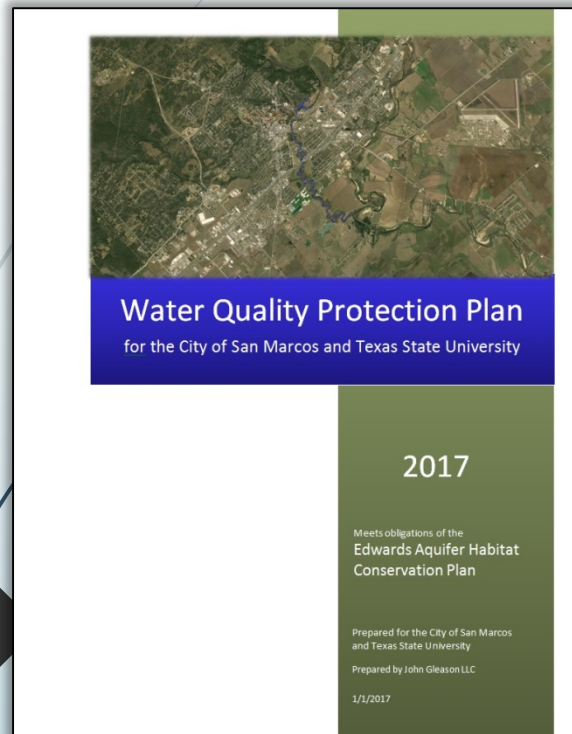


- HCP includes measure for the City of San Marcos to establish program to protect water quality and reduce the impact of impervious cover
- From 2013-2017 the City developed a *Water Quality Protection Plan* ("WQPP"), pursuant to this measure, which offers possible solutions to address sediment removal issues

2017 WATER QUALITY PROTECTION PLAN



“WQPP”



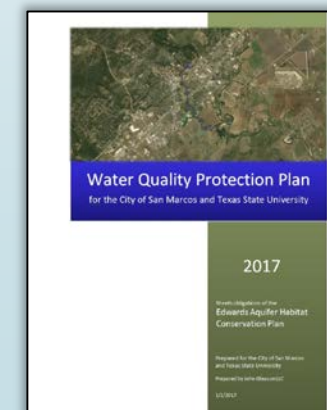
- Comprehensive, detailed & specific
 - Land Development Regulations (CodeSMTX)
 - Programs use developer \$ to finance public BMPs
 - Land Conservation opportunities

- Stormwater controls
 - BMP requirements for new development
 - Retrofit projects for existing development
 - Many potential retrofits identified citywide
 - Two are partially constructed
 - Multiple funding sources (COSM, 319, EAA)
 - Includes stream restoration projects

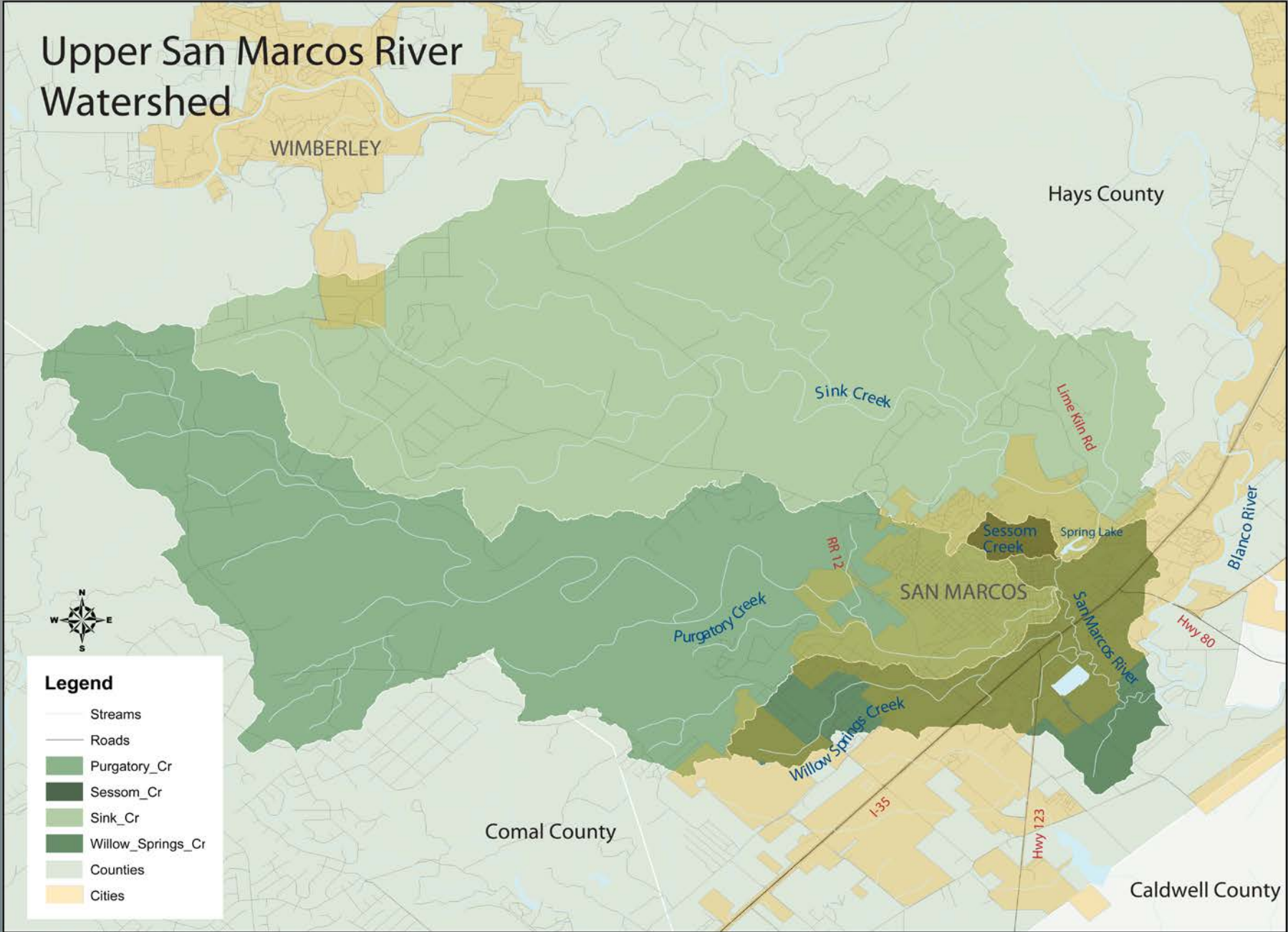
4. PRESENTATION AND POSSIBLE ENDORSEMENT OF
EAHCP STAFF RECOMMENDATION OF THE SESSOM
CREEK WATERSHED AS THE PRIORITY FOR THE
CITY OF SAN MARCOS IMPERVIOUS COVER/WATER
QUALITY PROTECTION MEASURE

WATERSHED PRIORITIZATION

- ▶ Primary tributaries to the upper San Marcos River include:
 - ▶ Sessom Creek
 - ▶ Willow Springs Creek
 - ▶ Purgatory Creek
 - ▶ Sink Creek



BOUNDARIES OF CONTRIBUTING WATERSHEDS TO THE UPPER SAN MARCOS RIVER



WATERSHED PRIORITIZATION

Analysis Criteria

Percent Impervious Cover

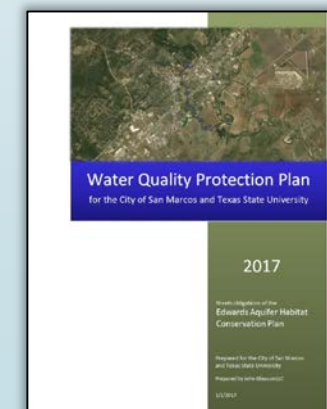
Percent Highly Erodible Soils

Channel Slope

Total Suspended Solids (TSS) Data

Endangered Species Habitat

Presence/Locations of Dams



EVALUATION OF WATERSHEDS

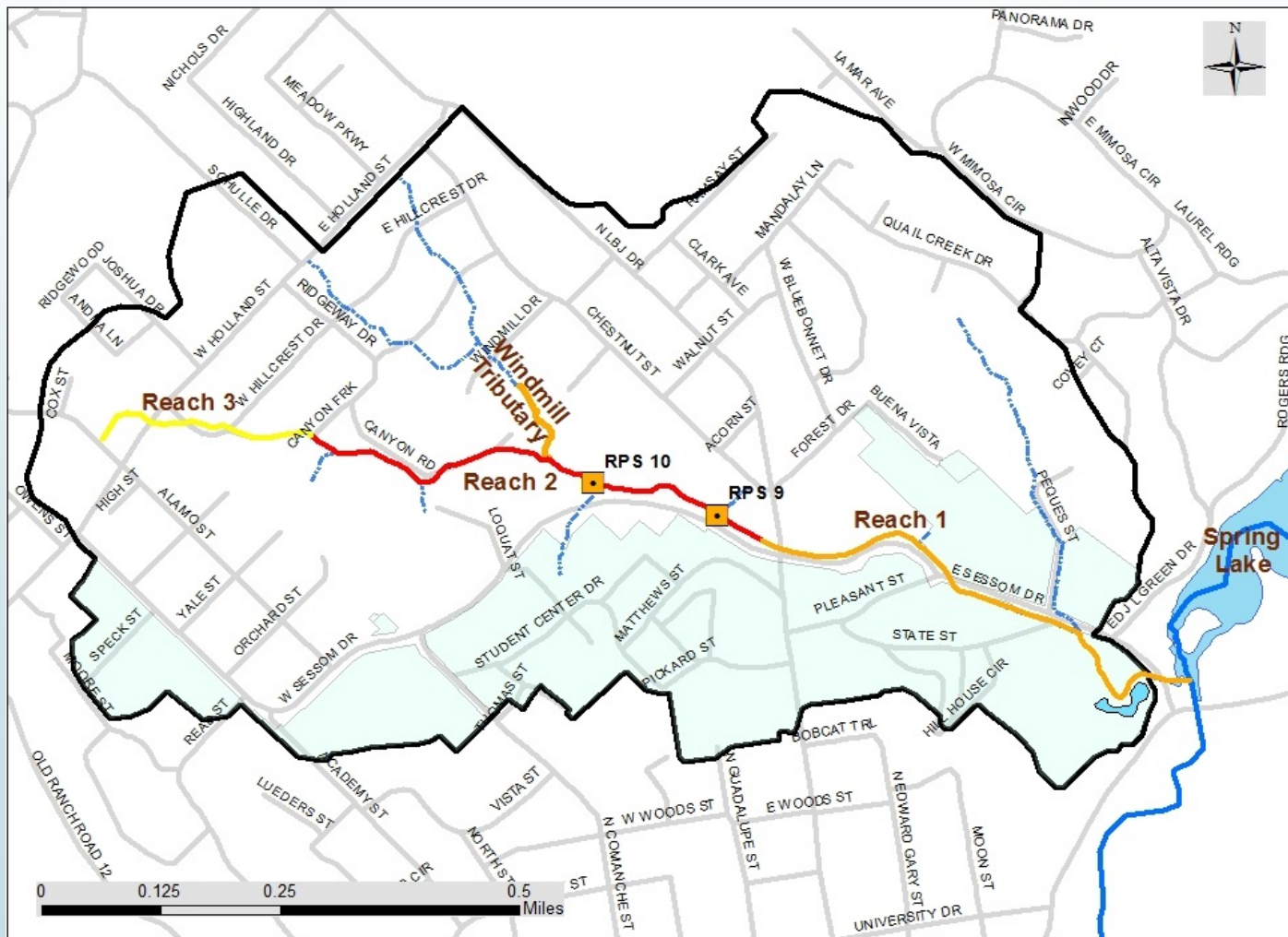
Analysis Criteria	Sessom	Willow Springs	Purgatory	Sink
Percent Impervious Cover	36%	24%	3%	1%
Percent Highly Erodible Land	44%	8%	4%	4%
Average Channel Slope	3%	< 1%	< 1%	< 1%
Peak TSS Concentration Recorded	1700 mg/L	X	X	X
Endangered Species critical habitat	Yes	No	No	Yes
Presence of Dams	No	No	Yes	Yes



SESSOM CREEK OVERVIEW

- ▶ Watershed area of about 400 acres; length over one mile
- ▶ Runs along northern edge of Texas State campus
- ▶ Land use includes single family residential and multi-family in the headwaters and retail/commercial/educational land coverage in the lower watershed
- ▶ Impervious cover is estimated at 36%
- ▶ Most development pre-dates stormwater detention and water quality treatment requirements; thus, rapid runoff occurs during storm events
- ▶ In response to the changed hydrologic regime, the stream is down-cutting and widening, threatening adjacent land and structures and increasing sediment loading to the river

CONCEPTUAL RESTORATION OF THE SESSOM CREEK WATERSHED



REACH DESIGNATIONS

- **Reach 3/ Upper:** Headwaters (~ N Holland St) to Canyon Fork Rd.
- **Reach 2/Middle:** Canyon Fork Rd to N LBJ
- **Reach 1/Lower:** N LBJ to confluence

SESSOM CREEK EXISTING CONDITIONS



Bed and bank erosion with exposed wastewater line in Reach 2



Threatened wastewater line in Reach 2 above the Loquat-Canyon intersection

SESSOM CREEK EXISTING CONDITIONS



Canyon Road threatened by stream erosion in Reach 2



Reach 2 below Windmill Tributary – eroding streambank with poor riparian condition

SESSOM CREEK EXISTING CONDITIONS



Severely eroded flume at TX ST outfall –
Site of RPS Project #10



Eroding and erosive outfall from "The
Gulch" tributary near RPS project #10 site

SESSOM CREEK EXISTING CONDITIONS



Scour hole below drop structure – Site of RPS project #9 (RPS photo)



Representative example of Sessom Creek in Reach 3 – On private property

SESSOM CREEK EXISTING CONDITIONS



Concrete channel in Reach 1 –
Downstream of Reach 2



Bank erosion and undermined concrete
channel bed in Reach 1

SESSOM CREEK EXISTING CONDITIONS

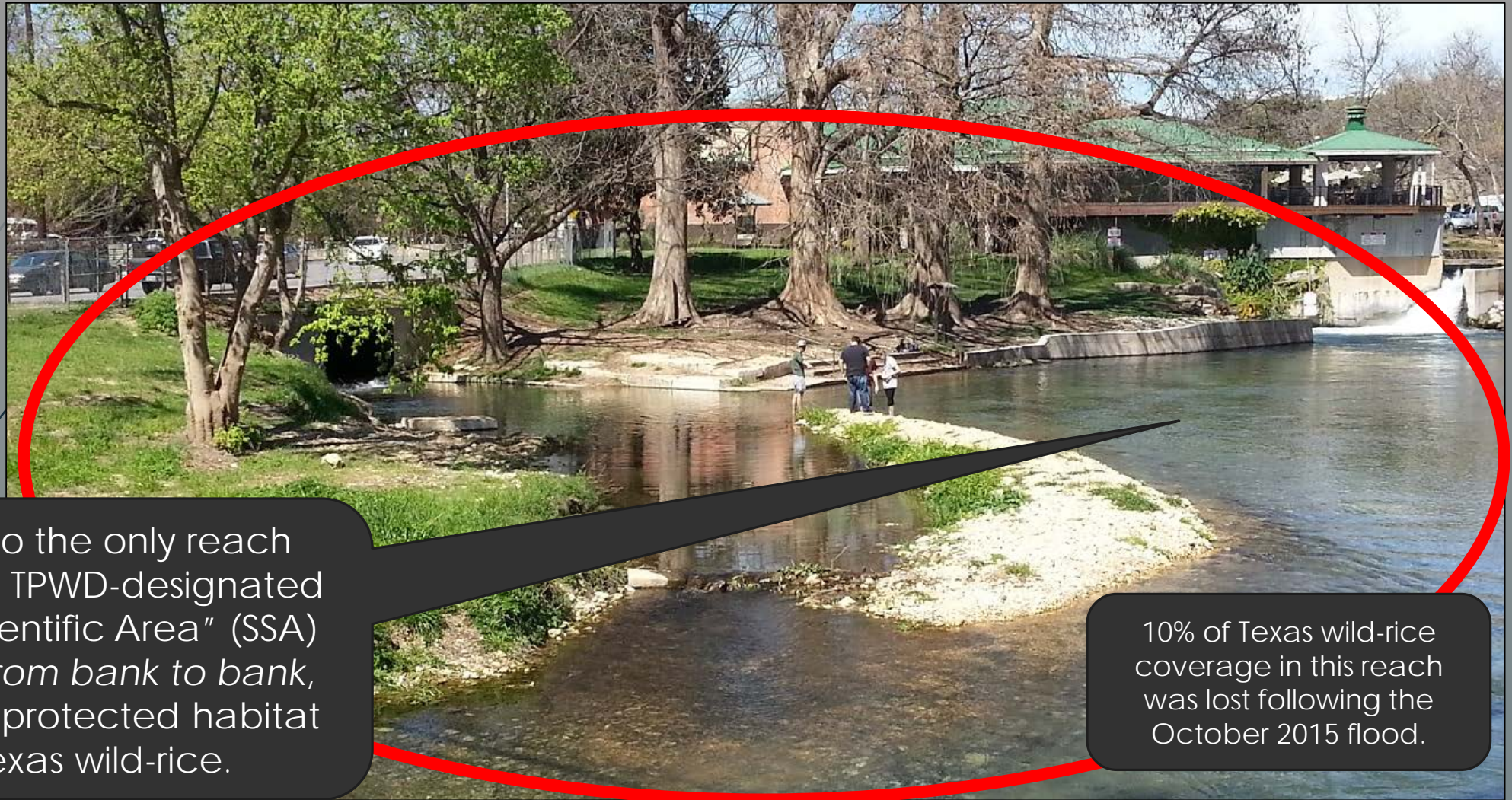


Bank failure in Windmill
Tributary



Collapsed wastewater line support in
Windmill Tributary

SESSOM CREEK CONFLUENCE



This is also the only reach where the TPWD-designated "State Scientific Area" (SSA) extends *from bank to bank*, providing protected habitat for Texas wild-rice.

10% of Texas wild-rice coverage in this reach was lost following the October 2015 flood.

Creek erosion results in excessive sediment loads to habitat, as evidenced by the sediment bar. Hartigan, Sherman, & Gleason, 2017


SESSOM CREEK CONFLUENCE

BIO-WEST, 2016




SAN MARCOS RIVER
San Marcos, Texas
Aquatic Vegetation Study
Texas Wild Rice, August 2016

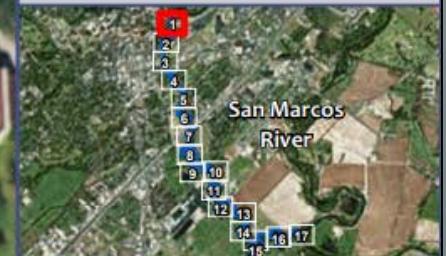
FULL SYSTEM MAP

 San Marcos River's Edge

Vegetation Types

 Zizania

Zizania Cover for Full System = 7703.8 m²



0 50 100 200 Feet

0 20 40 Meters




www.bio-west.com
512.990.3954

Page 1 of 17

Projection: UTM, NAD 83, 14 North
Map Revised: November 6, 2016

WILLOW SPRINGS CREEK



Willow Springs Creek near Senior Activity Center



Willow Springs Creek above McKie Street, below concrete channel



Willow Springs Creek below McKie Street and concrete channel; some incision of channel, but good floodplain connection and riparian zone

PURGATORY CREEK



Purgatory Creek above Mitchell Street; stable stream system



Purgatory Creek below Mitchell Street; bank erosion and sediment bar, possible due to flow hydraulics of bridge culverts



Purgatory Creek above Comal Street near confluence with San Marcos River

SINK CREEK



Sink Creek below Lime Kiln Road

WATERSHED PRIORITIZATION

SUMMARY – WHY SESSOM?

- HIGHEST % OF IMPERVIOUS COVER
- HIGHEST % OF HIGHLY ERODIBLE SOILS
- LACK OF EROSION IN OTHER WATERSHEDS
- HIGHEST % OF AVERAGE CHANNEL SLOPE
- ENDANGERED SPECIES HABITAT WITHIN THE WATERSHED
- ENDANGERED SPECIES HABITAT AT THE CONFLUENCE
- PARTNERS WITH COSM WASTEWATER LINE RELOCATION PROJECT

WORK GROUP ACTION:
POSSIBLY ENDORSE
THE PROPOSED PRIORITIZATION
OF THE SESSOM CREEK WATERSHED

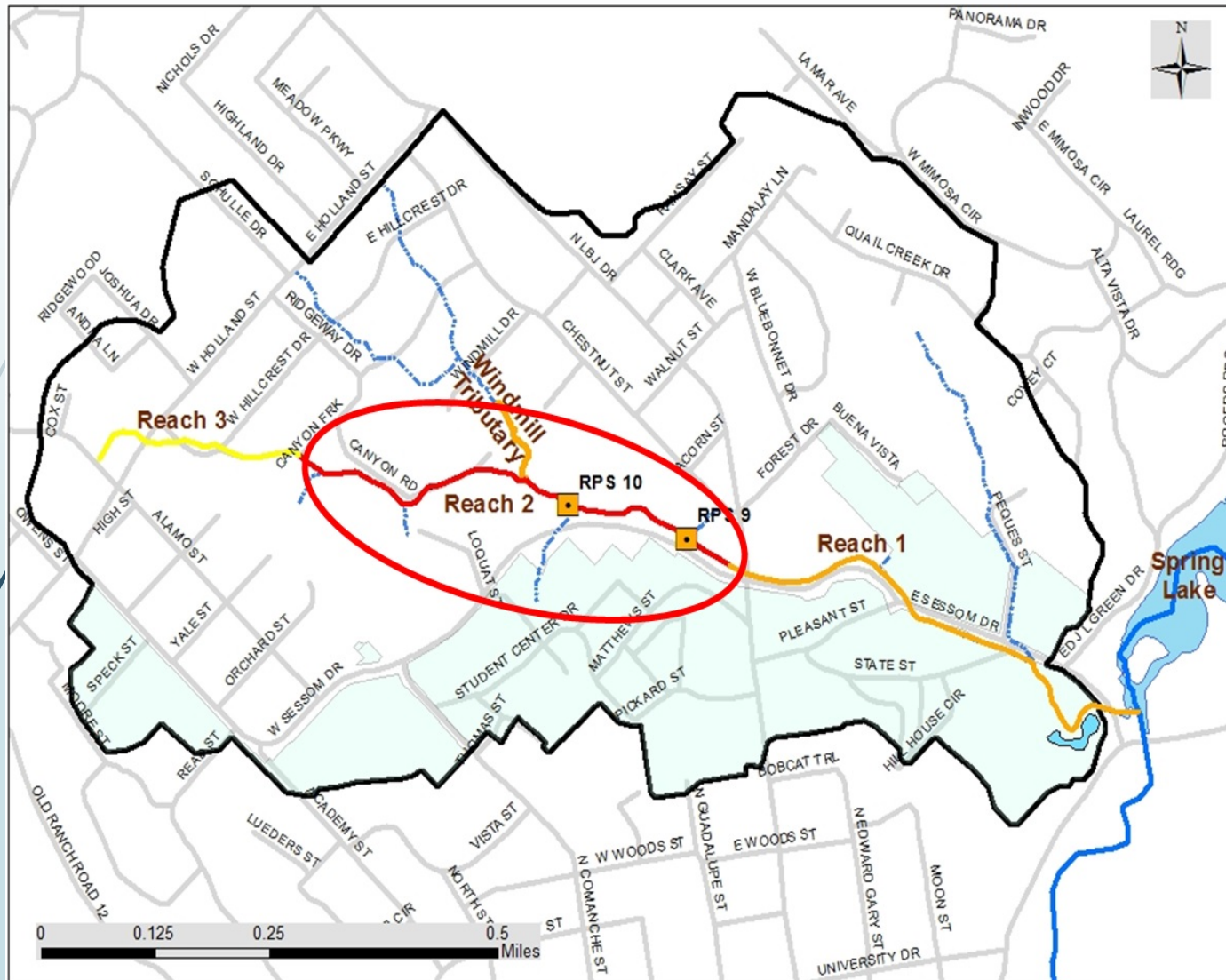
**5. PRESENTATION AND POSSIBLE ENDORSEMENT
OF PRIORITIZING THE PROPOSED LIST OF
WATER QUALITY PROTECTION PROJECTS
IDENTIFIED FOR IMPLEMENTATION IN THE
CHOSEN WATERSHED.**



REACH 2/MIDDLE POTENTIAL PROJECTS

- Stream Restoration for Sessom Creek Mainstem Reach 2, including repairs at sites 9 and 10 **(Project 2)**
- Stream Restoration of Windmill Tributary **(Project 3A)**
- Stormwater BMP for the Windmill Tributary with limited stream restoration **(Project 3B)**

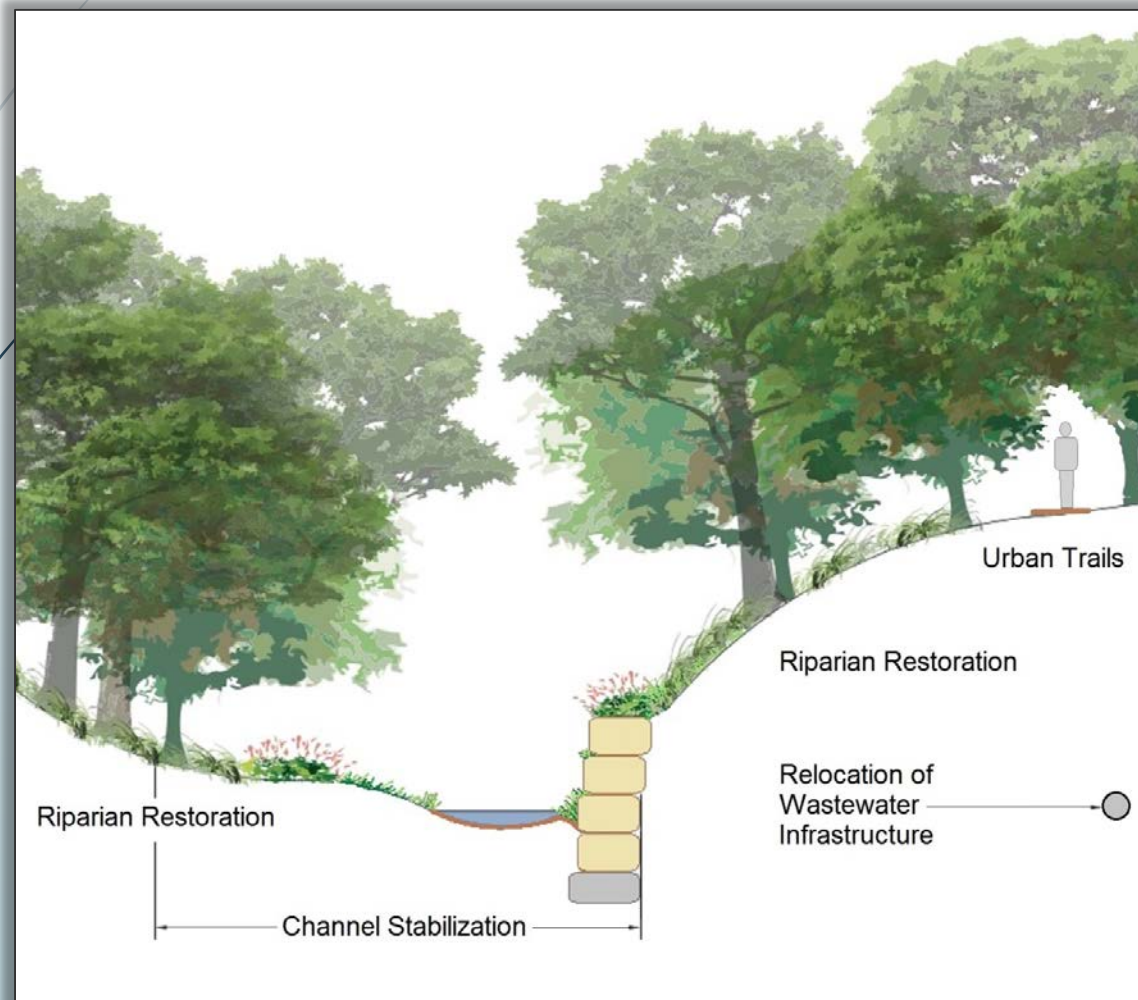
RATIONALE FOR REACH 2/MIDDLE



REACH PRIORITIZATION

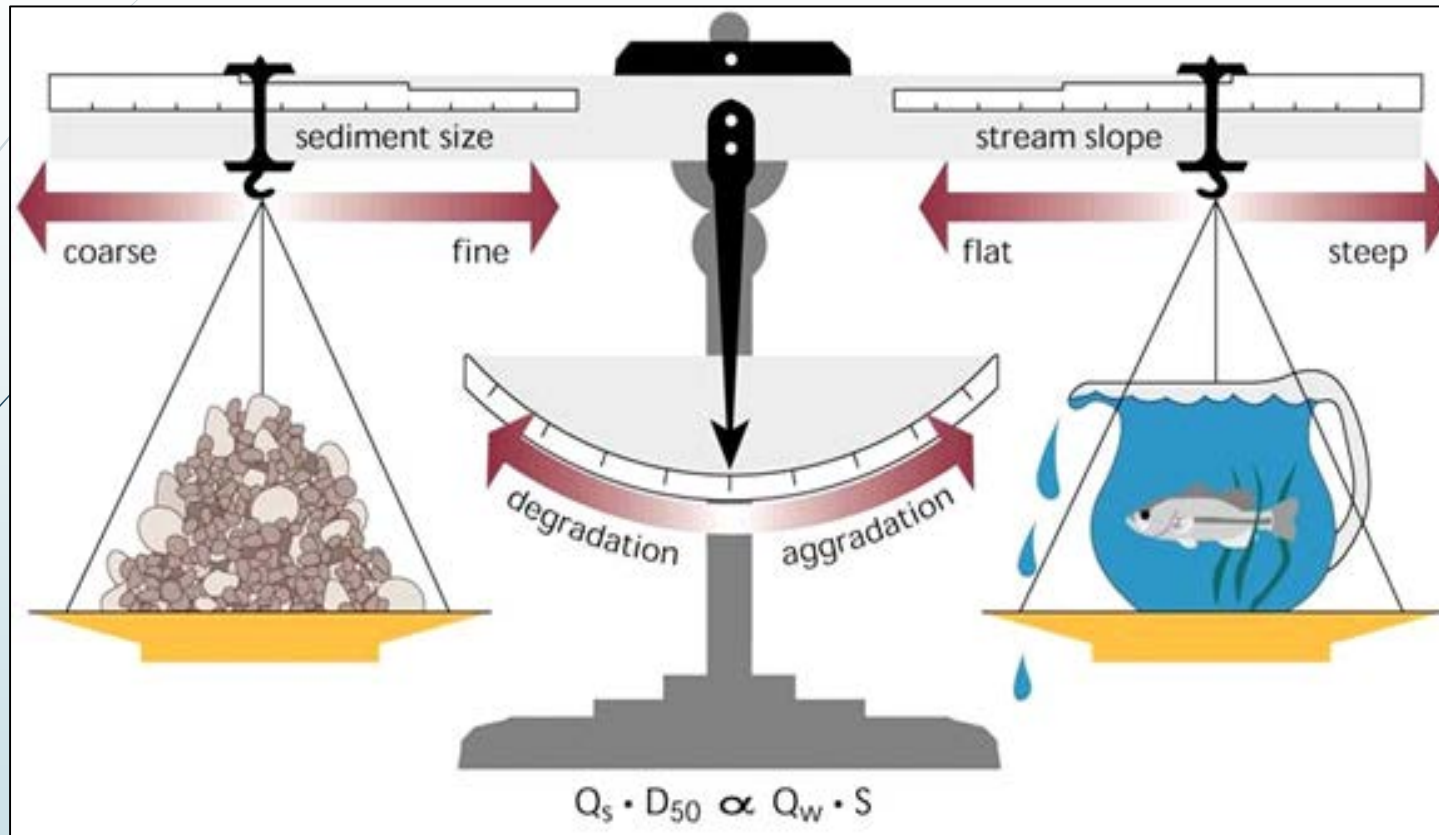
- ▶ **Reach 3/Upper:** Relatively stable, both concrete-lined and natural channel, with localized erosion problems
- ▶ **Reach 2/Middle:** Significant impacts—eroding streambanks, exposed wastewater lines, damaged drainage system components, unstable head cuts adjacent to creek, and undermining of Canyon Rd
- ▶ **Reach 3/Lower:** Mostly a concrete channel, threatened by erosion in several locations. Concrete channel effectively functions as a flume, rapidly transporting upstream sediments to the river

STREAM RESTORATION FOR REACH 2



- The proposed Stream Restoration project will be based on Natural Channel Design principles.
- Fluvial Geomorphology and Equilibrium Theory will be applied to create stable channels.

STREAM RESPONSES TO URBANIZATION



In Hartigan, Sherman, & Gleason, 2017; from Lane, E.W., 1955.

- As impervious cover increases, the frequency and magnitude of runoff flows increase.
- Stream responses include:
 - Degradation
 - Channel steepening
 - Erosion and transport of smaller particles.

EVALUATION CRITERIA

Metric	Method	Note
Sediment Loads and Load Reductions	Water Environment and Reuse Foundation (WERF) guidelines for sediment reduction credits.	Based on existing regional data.
Cost	Estimation of unit costs.	Overlap with wastewater line removal project.
Cost Effectiveness	Cost per pound of total suspended solids removed.	

MIDDLE REACH PROJECTS

Project 2

- **Stream Restoration for Sessom Creek Mainstem Reach 2:**
 - Stream restoration using Natural Channel Design is proposed for Mainstem Reach 2, an approximately 2,800 foot reach.
 - Will also include:
 - **Site 9**
 - ...will repair a scour hole located upstream of North LBJ drive
 - **Site 10**
 - ...will repair a localized erosion problem, and modify a severely eroding outfall from a Texas State University detention pond, identified in the WQPP as the "Gulch Pond."

Metric	Project 2. Stream Restoration of Reach 2 (including RPS 9 and 10)
Pounds of TSS Removed per year	216,998
Total Capital Cost	\$1,250,000
Annualized Cost (\$/yr)	\$74,183
Cost per pound TSS removed	\$0.35

MIDDLE REACH PROJECTS

Project 2 - Stream Restoration for Sessom Creek Mainstem Reach 2



Severely eroded flume at TX ST outfall – Site of RPS Project #10



Eroding and erosive outfall from "The Gulch" tributary near RPS project #10 site



Scour hole below drop structure – Site of RPS project #9 (RPS photo)

MIDDLE REACH PROJECTS

Project 3A

► Stream Restoration of Windmill Tributary:

- A stream restoration project using Natural Channel Design will be evaluated for approximately 525 feet of stream that is located below the Windmill Apartments

Metric	Project 3A. Stream Restoration of Windmill Tributary
Pounds of TSS Removed per year	800
Total Capital Cost	\$141,250
Annualized Cost (\$/yr)	\$9,270
Cost per pound TSS removed	\$11.59

MIDDLE REACH PROJECTS

Project 3B

- ▶ Stormwater BMP for the Windmill Tributary with limited stream restoration:
 - ▶ Pond system to capture sediment from the Windmill watershed while also providing significant control of erosive flows that are impacting Sessom Creek. Due to the steepness of the channel, a series of three extended detention ponds is proposed.

Metric	Project 3B. Stormwater BMP for Windmill Tributary w/ limited restoration
Pounds of TSS Removed per year	46,336
Total Capital Cost	\$197,015
Annualized Cost (\$/yr)	\$16,534
Cost per pound TSS removed	\$0.36

MIDDLE REACH PROJECTS

STAFF PROPOSED PRIORITIZATION

1

3

2

Metric	Project 1. Existing Sediment Removal Project	Project 2. Stream Restoration of Reach 2 (including sites 9 and 10)	Project 3A. Stream Restoration of Windmill Tributary	Project 3B. Stormwater BMP for Windmill Tributary w/ limited restoration
Pounds of TSS Removed per year	159,780	216,998	800	46,336
Total Capital Cost	\$744,292	\$1,250,000	\$141,250	\$197,015
Annualized Cost (\$/yr)	\$186,073	\$74,183	\$9,270	\$16,534
Cost per pound TSS removed	\$1.16	\$0.35	\$11.59	\$0.36

WORK GROUP ACTION:

POSSIBLY ENDORSE THE PROPOSED PRIORITIZED LIST
OF WATER QUALITY PROTECTION PROJECTS.

A dark grey arrow points to the right from the left edge of the slide. Below it, several thin, curved lines in shades of blue and grey sweep across the left side of the slide.

MAINTENANCE & MONITORING

- Responsibility for maintenance will be assumed by City of San Marcos
- Responsibility for monitoring will be assumed by EAHCP



NEXT STEPS

- ▶ Adaptive Management proposal will be submitted to Implementing, Science, and Stakeholder Committees, based on input provided by the Work group.
- ▶ Proposal will be addressed in August and September at scheduled committee meetings.
- ▶ Upon Implementing Committee approval, amendment of EAHCP will be submitted to USFWS.
- ▶ Preliminary Engineering Report will be completed by late Fall 2017.

REFERENCES



- ▶ BIO-WEST, Inc. (2016). Habitat Conservation Plan Biological Monitoring Program: San Marcos Springs/River Ecosystem. Prepared for the Edwards Aquifer Authority.
- ▶ Earl, R. A., & Wood, C. R. (2002). Upstream changes and downstream effects of the San Marcos River of central Texas. *The Texas Journal of Science*, 54, 69.
- ▶ EARIP. (2012). *Edwards Aquifer Recovery Implementation Program Habitat Conservation Plan*. San Antonio, Texas.
- ▶ Hartigan, P., Sherman, L., & Gleason, J. (2017). *Enhancing Sediment Management in the Upper San Marcos River: Strategy Analysis in Support of the Edwards Aquifer Habitat Conservation Plan*. Prepared for the Edwards Aquifer Authority.
- ▶ John Gleason LLC (2017). *Water Quality Protection Plan for the City of San Marcos and Texas State University*. Prepared for the City of San Marcos
- ▶ Power, P. (1996). Effects of current velocity and substrate composition on growth of Texas wild-rice (*Zizania texana*). *Aquatic Botany*, 55(3), 199-204.

Thank you!



(sediment loads and load reductions, cost, and cost effectiveness). Mr. Hartigan proceeded to present each of the individual projects under consideration and the various performance metrics calculated for them.

Dr. Teague commented that the research that went into the WERF guidelines was highly variable and based on a wide variety of case studies, meaning that following these guidelines should be understood to involve a high degree of uncertainty.

Ben Schwartz asked if there were any opportunities to install BMPs upstream of the middle reach to preemptively mitigate erosive flows hitting the middle reach. Mr. Hartigan answered that there were around a half a dozen smaller scale opportunities, including some major ones (e.g., “The Gulch” and “Sessom Creek Wet Pond”) that are under consideration through the Water Protection Plan (WPP) process. Dr. Schwartz commented that Dr. Weston Nowlin’s class studied the pond and found that there was no loss of loading in the pond and the average residence time was 12 minutes, with the caveat that this was an unpublished class project.

Open Intermission for Comments and Questions from the Public and the Work Group

Dr. Longley asked what the wastewater renovations plans are for the City. Mr. Condor answered that the City will put a stub out to the west of LBJ, bore a sewer line all the way west. Existing sewer will be cut out and filled with foam. Dr. Teague asked if the City has an MS4 permit; Ms. Howard answered that yes. Dr. Teague asked if the streets in the area affected provide the conveyance; Mr. Condor answered that there are no streets around the wastewater line work.

Ken Diehl commented that there is an MS4, 319, HCP, and funds from City for sewer relocation; there has been a significant effort to delineate those costs and activities, and this collaboration needs to be clear. Mr. Pence responded that as Program Manager it falls to him to ensure that HCP funds are being used appropriately; while the collaboration is complex and challenging, the team has been holding bimonthly planning and coordination meetings. It is on us as project managers to observe and maintain appropriate boundaries. While a challenge, Mr. Pence expressed he feels that this will pay off in the end.

Dr. Teague asked if there is a delineated floodplain associated with the project area (“AE zone” in FEMA terminology); Mr. Sherman responded that he does not believe there is, Mr. Condor and Mr. Hartigan also added that there is not. Dr. Teague asked about permitting costs and whether a Nationwide 27 permit would be required. Shaun Payne answered that the EAHCP is consulting with HDR to assess whether this will be necessary and it appears to be likely. Ms. Reinmund-Martinez added that this will become more clear over the course of the Preliminary Engineering Report exercise. Dr. Teague also asked whether any cultural resources are expected to be encountered during the work, which will also have impact on permitting. Ms. Reinmund-Martinez answered that the EAHCP is consulting with Amaterra to consider this question.

Dr. Kreitler commented that stream restoration addresses Sessom Creek, but does not address the urban runoff problem above the creek. Alicia answered that in the previous discussion the City would be considering projects in other areas upstream through 319 processes. Dr. Longley added the question of whether there have been any efforts to capture rainfall onto new development. Mr. Hartigan responded that there are some options being considered through other processes (besides EAHCP) but that overall the strategy of achieving equilibrium is itself a response to the reality of limitations on controlling existing hydrology.

Dr. Kreitler asked about the issue of flow velocity in relation to Texas wild-rice. Mr. Sherman responded it is not clear whether high or low velocity is the issue, since wild-rice may benefit from

clearing sediment. Ms. Howard commented that the primary problem at the confluence is not scouring, but rather deposition of sediment that can bury wild-rice stands.

Dr. Teague asked what a flood looks like in Sessom Creek; does the creek overbank? Dr. Schwartz responded that it goes quickly from no or base flow to inundating the road. When it overbanks, it's in the road in the lower reach. In the middle and upper reaches he has not observed how the creek behaves.

Mr. Diehl asked if there has been any consideration of land use restrictions associated with water quality protection (e.g., impervious cover limitations, conservation easements, etc.). Mr. Hartigan responded that the answer is yes in the recharge zone. The City has a 20% impervious cover limit in the recharge zone; San Marcos River Foundation (SMRF) also emphasizes land conservation. Dianne Wassenich stated the new Land Development Code which is being finalized should also include enhanced water quality protection measures, while SMRF is buying land above Spring Lake in rural areas. Mr. Hartigan commented that the City is adopting an increased focus on headwater protection which should play a role in preventing "future Sessoms."

Dr. Kreidler asked whether the group had consulted the City of Austin Department of Watershed Protection. Mr. Sherman answered that he has professional connections with the director of the department and is in correspondence with him.

Dr. Teague asked the elevation of the watershed. Mr. Sherman and Mr. Hartigan answered that they could provide this information to Dr. Teague later in the day if it would be helpful.

Dr. Schwartz asked if the City had talked to any of the apartment complexes to inquire whether they would be interested in working with the City on some of the smaller BMPs. Ms. Howard answered that there have been beginning efforts to engage the apartments with other projects (litter, etc.) but had not begun conversations about BMP work. Mr. Sherman commented that the situation is somewhat fortunate in that there is a lot of development left to go, allowing for some problems to be avoided. Once urbanization takes place, then all that is left is redevelopment regulations. Mr. Sherman added that he guessed he is hopeful for the day when we all have flying cars and streets can be taken out. Ms. Wassenich discussed redevelopment districts in the Land Development Code process and the problem with that is that even old apartment complexes are too profitable to incentivize redevelopment.

Mr. Hartigan commented that rigorous study was conducted by HDR for the City of Austin based on critical shear stress value for central Texas streams; if you capture this much volume and hold it for 48 hours, you obtain a stream protection curve factoring volume and stream protection and to control it for urbanization. A study is available, which Alicia will send to the Work Group along with the thesis referenced in the white paper.

Mr. Gleason noted that the majority proportion of sediment coming out of the watershed comes from the instream load and not upstream runoff, hence the strategic emphasis on stream restoration rather than upland sources.

Dr. Schwartz asked about the bike lane project and its relation to this work. Mr. Condor answered that the bike sidewalk will not run through the Sessom Creek watershed. Ms. Wassenich asked about whether pervious pavement was being considered; Mr. Condor answered that the City has been experiencing maintenance issues with this material, but is open to considering it. Mr. Sherman noted that current formulations are tricky to implement and he is not aware of satisfactory, cost effective substitutes. Mr. Diehl mentioned that load bearing has also cropped up as an issue with certain pervious pavement materials in relation to accessibility for large fire trucks, and that this should be considered.

Dr. Kreidler asked whether it might be an option to leave out option 3A since it seems least effective. Dr. Schwartz commented what happens if certain options are left out; would the City pick up the bill on what is left out? Ms. Howard and Ms. Reinmund-Martinez answered that the EAHCP could cover the cost of projects 2 and 3B.

Mr. Condor motioned to endorse the proposed prioritization of water quality protection projects; Jackie Poole seconded the motion. There was no opposition.

Mr. Diehl asked what the monitoring expectations are for the EAHCP; Dr. Furl answered that this is already underway through Expanded Water Quality Monitoring operations, but a specific project will also be undertaken through the Applied Research Program.

Dr. Schwartz commented that this comes down to Texas State University and the City continuing to work together and with the apartment complexes to retrofit existing sources of impervious cover. With the steep narrow stream channel, the issue of fixing the hydrology will persist.

6. Questions and comments from the public.

There were no public comments or questions.

7. Adjourn.

Ms. Reinmund-Martinez adjourned the meeting at 11:48 a.m.