June 23, 2017

Roland Ruiz
General Manger
Edwards Aquifer Authority
900 East Quincy
San Antonio, Texas 78215

Re: 2018 Work Plans and Budget for the Edwards Aquifer Habitat Conservation Plan (EAHCP)

Mr. Ruiz,

On behalf of the Implementing Committee for the EAHCP, I am attaching the Work Plans and Budgets for 2018 to support your Board's review and approval of the 2018 EAHCP budget.

In accordance with Article 4 of the Funding and Management Agreement, Work Plans and Budgets must be submitted for each of the conservation measures by their respective Implementing Committee member. Work Plans were initially drafted in mid-March and the Implementing Committee has reviewed and discussed these plans at their May and June meetings. Additionally, the Science Committee reviewed all Work Plans with scientific components and provided comments that were incorporated into the final versions of the Work Plans. All of the Work Plans were approved by consensus by the Implementing Committee on June 15, 2017.

In the coming weeks, the Permittees will use their internal procurement process to identify contractors for the activities listed in these Work Plans in order to assemble a Funding Application that will be submitted to the Edwards Aquifer Authority Board of Directors by October 1, 2017 for approval. The Funding Application budget will be based on the selected contractors for the work.

Please let me know if you have any questions or require any additional information.

Sincerely,

Nathan Pence
Program Manager
Edwards Aquifer Habitat Conservation Plan

Edwards Aquifer Authority
2018 Work Plan

2018 Edwards Aquifer Authority Work Plan Budget

HCP Section	Conservation Measure	Table 7.1	Available budget for 2018*	Estimated 2018 Budget	Difference
5.5.1	ASR - Leasing	$4,759,000	$4,759,000	$5,472,002	($713,002)
	ASR – O&M	$2,194,000	$2,194,000	$1,233,358	$960,642
5.1.3	Regional Water Conservation Program	$1,973,000	$4,507,750	$4,507,750	$0
5.1.2	Voluntary Irrigation Suspension Program Option	$4,172,000	$4,172,000	$4,172,000	$0
5.1.4	Stage V	$0	$0	$0	$0
6.3.1	Biological Monitoring	$400,000	$408,275	$408,275	$0
5.7.2	Water Quality Monitoring	$200,00	$285,300	$310,800	($25,500)
6.3.3	Ecological Modeling	$50,000	$0	$0	$0
6.3.4	Applied Research	$450,000	$450,000	$450,000	$0
5.1.1	Refugia	$1,678,597	$1,678,597	$1,519,634	$158,963
FMA §2.2	Program Management	$750,000	$910,000	$910,000	$0
	Science Review Panel	$100,000	$269,750	$269,750	$0
	Total	**$16,526,797**	**$19,634,672**	**$19,253,569**	**$381,103**

***Reflects Permittees' commitments to changes in 7.1 Budgets incurred by future-year borrowing, within year transferring, and carrying forward from previous years.*

5.5.1 Edwards Aquifer Authority and San Antonio Water System Aquifer Storage and Recovery Work Plan

Section 5.5.1 of the Edwards Aquifer Habitat Conservation Plan (EAHCP) assigns acquiring leases and options of water permits for use in the San Antonio Water System (SAWS) Aquifer Storage and Recovery (ASR) to the Edwards Aquifer Authority (EAA). SAWS will operate the ASR infrastructure and retain control of day-to-day operations of the ASR facility related to EAHCP water injection and recovery. The EAA will ensure compliance with EAHCP requirements through management of the Interlocal Contract between the EAA and SAWS for the Use of the Twin Oaks Aquifer Storage and Recovery Project for Contribution to Springflow Protection, which became effective August 14, 2013. The contract outlines the responsibilities of both parties, including administration and implementation.

Long-term Objective:
The objective of SAWS Twin Oaks ASR (ASR now run out of H_2O Oaks facility) system is to deliver 126,000 acre-feet of Edwards Aquifer groundwater best managed to offset pumping from Edwards Aquifer wells during a repeat of the drought of record and acquire an additional 50,000 acre-feet of agricultural, municipal, industrial groundwater withdrawal rights to be made available for physical storing or crediting the Regional ASR balance; or as forbearance.

Target for 2018:
The ASR contract between EAA and SAWS will continue to be implemented. EAA is the leasing agent for ASR leases and will continue providing SAWS with notices of availability of HCP groundwater. By the end of 2017, EAA will have noticed to SAWS 32,583.01 acre-feet for injection into the ASR, the maximum allowed for injection under Tier 2 (10-year moving annual average of Edwards Aquifer recharge below 572,000 acre-feet/year) as set out in the SAWS and EAA Interlocal ASR Contract and the EAHCP. In year 2018, the total amount of water secured from multi-year leases is 17,675 acre-feet and can potentially increase to as high as 40,594 acre-feet if current 1-year ASR lease participants agree to allow their leases to roll-over into 2018 for an additional year.

Since the implementation of the ASR program, staff has realized potential areas for improvement of the program which can streamline the implementation process as well as decrease cost associated with the need to secure primarily unrestricted groundwater for the program. In 2017 staff will begin to address issues within the current ASR program pertaining to the following: triggers associated with the 10-year annual Edwards Aquifer recharge average, Tiers (leasing for filling and forbearance), and use of base irrigation groundwater as forbearance water in the program. By the end of 2017 or early 2018, the ASR Program is expected to undergo changes by way of the HCP adaptive management process that are to be ready for implementation by year 2019.

ASR Program:
Description of the SAWS ASR: The SAWS Twin Oaks ASR is an underground storage reserve in the Carrizo sand aquifer in southern Bexar County. As a SAWS water management project, it is designed to store Edwards water when demand is less than available supply. The stored water is

returned to San Antonio for use when demand is high and Edwards supply is restricted by Critical Period Management and other drought-related limitations.

The capacity and capabilities of the SAWS ASR are such that it can be used to meet SAWS ratepayer expectations and, if operated as described in the EAHCP, will play a significant role as a Phase I activity to protecting the Covered Species at Comal and San Marcos Springs.

Operations: The Edwards Aquifer Habitat Conservation Plan Program Interlocal Contract between the Edwards Aquifer Authority and The San Antonio Water System for the Use of the Twin Oaks Aquifer Storage and Recovery Project for contribution to Springflow Protection, effective August 14, 2013, takes elements of the HCP's ASR flow protection strategy and places them into an operations contract.

Injection: Storage of HCP groundwater shall be at the discretion of SAWS and will be dependent on operating conditions. All HCP groundwater made available to SAWS before June 30th, 2017, will be physically stored or credited as if stored, and will be used to meet any forbearance from the Aquifer should triggers defined in the Interlocal Contract occur in 2018.

Forbearance and Recovery: Forbearance of Edwards Aquifer pumping from certain wells will occur when the ten-year rolling recharge average is less than 500,000 acre-feet and the ten-day average of aquifer levels measured at the J-17 index well drop below 630 feet mean sea level (MSL). The annual amount of water to be recovered from the ASR during a repeat of the drought of record is outlined in Exhibits E & F of the Interlocal Contract. Changes to the Presumptive Forbearance Schedule outlined in Exhibit E may be approved as outlined in Section 5.3 of the Interlocal Contract.

Leasing: The EAA has secured enough water necessary for annual storage into the ASR system for year 2018. As the overall ASR storage goal nears fulfillment, and current market conditions and procedural requirements are assessed, new operational strategies are expected to be developed as a result of the adaptive management process. The focus by staff will then be geared towards securing the additional 50,000 acre-feet required by the HCP - to be used as either lease or forbearance options.

Monitoring:
The EAA will actively manage the Interlocal Contract with SAWS. Status reports and updates will be provided regularly to the Implementing Committee.

ASR Regional Advisory Group: Per section 5.5.1 of the HCP, a 12-person SAWS ASR Regional Advisory Group will meet to advise SAWS as SAWS makes the decisions relating to the operation of the ASR facility relevant to the EAHCP. Membership on the Regional Advisory Group will include: four representatives from the San Antonio Water System, the EAHCP Program Manager; one representative each from the EAA, EAA permit holder for irrigation purposes, small municipal pumpers, the spring cities, environmental interests, industrial pumpers, and downstream interests.

Budget:
Table 7.1

$4,759,000 – Lease Options
$2,194,000 – O&M
$6,953,000 – Total

Estimated 2018 budget*
$ 5,472,003 – Leases
$ 1,233,358 – O&M (this amount may vary)
$ 6,272,002 – Total

*Actual expenditures for 2018 will be determined by the terms of the Interlocal Contract depending on the quantity of HCP groundwater physically stored, the amount of active water leases, and the cost of eligible operation and maintenance activities. Budgeted money that is not spent will be placed in the reserve fund.

5.1.3 Regional Water Conservation Program

Long Term Objective:
To reduce withdrawals from the Edwards Aquifer by 10,000 acre-feet, realized through implementation of conservation measures that will conserve 20,000 acre-feet of water.

Background: Conservation is one of four springflow protection measures of the Edwards Aquifer Habitat Conservation Plan (EAHCP) intended to reduce aquifer withdrawals, and subsequently increase aquifer level and springflow. The concept is to reduce aquifer withdrawals by 10,000 acre-feet and the EAHCP contemplates using a Regional Water Conservation Program (RWCP) to achieve this goal.

In order to provide an immediate benefit to the aquifer and springflow, several entities within the EAA jurisdictional area have agreed to make Initial Commitments (ICC) to the EAA Groundwater Trust. The initial contribution of water rights was placed in the Groundwater Trust for a period of ten years (Table 1). An Initial Commitment of 10,000 acre-feet was solicited from EAA permit holders to remain in the EAA Groundwater Trust for a period of ten years.

The Initial Commitment is returned to the permit holders through the implementation of conservation initiatives and technical assistance provided by the EAHCP. As conservation savings accrue, one-half of the savings are realized by the party participating in the RWCP and the other half is placed in the Groundwater Trust for the remaining term of the EAHCP ITP; allowing the original donors to have their donated water returned on a pro-rata basis. Consequently, 20,000 acre-feet of conservation savings are necessary for full return of the Initial Commitments.

Table 1: Initial Commitment Contracts.

Entity	Acre-Feet of Water Donated (acre-feet)	Current ICC in Trust (acre-feet)
San Antonio Water System	8,000	1,008.2
City of San Marcos	300	37.2
Texas State University	100	15.9
TOTAL	8,400	1,061.3

These ICC are to be returned to the permit holder at the end of 10 years or when an equal amount is identified as conserved and in reserve by the RWCP. ICC will be returned to the permit holder in a proportion equal to their contribution. As of 2018 the total ICC is 1,061.3 acre-feet.

In late 2015, a leak repair program with SAWS was negotiated and executed, that will fulfill the goal of the 10,000 acre-feet in the EAA Groundwater Trust by 2020. The contract covers the remainder of the ITP and is estimated to conserve almost 20,000 acre-feet accrued over the first five years. The SAWS leak repair program consists of hiring a contractor to expand the number of leaks feasible for system repairs. Regular progress reports from SAWS to EAHCP staff provide number of leaks repaired and an estimate of the overall savings within the time-period of reporting. An annual report is provided to communicate the overall savings realized throughout the year.

Table 2: SAWS – EAA 5-year water savings commitment and fiscal obligation.

Water	2016	2017	2018	2019	2020	Total
Estimated Savings (AF)	4,745	4,745	4,745	4,745	632	19,612
Commitment to the Groundwater Trust (AF)	2,372.5	2,375.5	2,372.5	2,372.5	316	9,806
Payment	$4,507,750	$4,507,750	$4,507,750	$4,507,750	$600,400	$18,631,400

With the payment of $950 per acre-foot of water conserved that has been used as a standard for other RWCP participants, the contract will cost $18,631,400 while sharing the remaining 9,800 acre-feet into the Groundwater Trust necessary to complete the 10,000 acre-foot goal.

Target for 2018:
With the execution and implementation of the contract with SAWS in 2016, the RWCP will have effectively met its conservation goal by 2020. The Regional Water Monitoring Committee submitted a letter communicating to the Implementing Committee in fall of 2017 the finalization of the RWCP.

Monitoring:
As part of this contact, SAWS is obligated to transfer to the EAA groundwater trust half of the water saved under this program. SAWS will provide a total of three summary reports capturing and quantifying yearly milestones.

Budget:
Table 7.1:
$1,973,000

Available budget for 2018:
$4,507,750

Estimated 2018 budget:
$4,507,750

5.1.2 Voluntary Irrigation Suspension Program Option

Long-term Objective:
The goal of VISPO is to enroll 40,000 acre-feet (AF) of permitted irrigation rights (base and/or unrestricted) that will remain unused in years of severe drought. Permit holders have the option of enrolling in a five – year or ten – year program and will be compensated based on the amount of water enrolled and the program selected. Table 1 below shows the payments for the five and ten year VISPO programs. If the water level at the J-17 index well in San Antonio is at or below 635 feet on October 1 of any year, program participants are contractually obligated to suspend the use of their enrolled water for the following year - beginning on January 1.

Table 1: VISPO Enrollment Options

Years	Fee	1	2	3	4	5
5*	Stand-by	50.00	50.75	51.51	52.28	53.06
	Suspension**	150.00	152.25	154.53	156.84	159.18
10	Stand-by	57.50	57.50	57.50	57.50	57.50
	Suspension**	172.50	172.50	172.50	172.50	172.50

Years	Fee	6	7	8	9	10
5*	Stand-by	N/A	N/A	N/A	N/A	N/A
	Suspension**	N/A	N/A	N/A	N/A	N/A
10	Stand-by	70.20	70.20	70.20	70.20	70.20
	Suspension**	210.60	210.60	210.60	210.60	210.60

*****The amount of each payment escalates at 1.5% annually over the five years of the program.
**Suspension payment is made in addition to stand-by payment.

Table 2: Enrollment concluded on October 6, 2014, with a total enrollment of 40,921 acre-ft. The table below reflects the current distribution of enrolled water and is reflective of amendments made to VISPO agreements

Program	**Atascosa (AF)**	**Bexar (AF)**	**Comal (AF)**	**Hays (AF)**	**Medina (AF)**	**Uvalde (AF)**	**Total (AF)**
5-year	354	884	0	123	3,483	20,457	25,301
10-year	0	1,573	0	0	7,953	6,094	15,620
Total	354	2,457	0	123	11,436	26,551	40,921

Table 3: VISPO did not trigger for 2017; therefore, all enrolled water can be used by the permit holders, requiring only standby payments.

Enrollment Year	**5 – year**	**10 – year**	**Total**
2013	$496,086	$622,367	$1,118,453
2014	$814,482	$267,162	$1,081,644
***2016**	$0	$8,625	$8,625
		Grand Total	**$2,208,722**

*Reflects 2016 change of a 5-year agreement to a 10-year agreement effective year 2017

Target for 2018:
At the end of year 2018 there will be 42 VISPO agreements totaling approximately 9,489 acre-feet that will expire. In the fall of year 2017 and throughout 2018 staff will be soliciting permit holders to renew current VISPO agreements or will seek new permit holders to participate in the program. For year 2018 staff will observe J-17 on October 1, 2017 and respond by making payments in a timely fashion and monitor pumping to confirm compliance.

Budget:
Table 7.1:
$4,172,000

Estimated 2018 budget*:
$4,172,000

*Since VISPO enrollment is full, expenses for 2018 will be determined by whether or not a trigger condition exists on October 1, 2017.

Table 4: If VISPO does not trigger, the 2018 expenses will be standby only:

Enrollment Year	**5 – year**	**10 – year**	**Total**
2013	$503,488	$622,367	$1,125,855
2014	$826,658	$267,162	$1,093,820
2016	$0	$8,625	$8,625
		Grand Total	**$2,228,300**

Table 5: If VISPO does trigger, the 2018 expenses will include standby and suspension payments as follows:

Enrollment Year	**5 – year**	**10 – year**	**Total**
2013	$2,013,875	$2,489,468	$4,503,343
2014	$3,306,631	$1,068,648	$4,375,279
2016	$0	$34,500	$34,500
		Grand Total	**$8,913,122**

5.1.4 Edwards Aquifer Authority Stage V Critical Period Management

Stage V Critical Period Management was developed and included in the Edwards Aquifer Habitat Conservation Plan to help decrease withdrawals and maintain adequate spring flows at both Comal and San Marcos Springs during times of drought. On February 14, 2012, the Edwards Aquifer Authority (EAA) Board of Directors voted to amend its Critical Period Management (CPM) Program to include the new emergency Stage V. Implementation of Stage V results in a reduction of 44% to municipal, industrial and irrigation permit holders in both pools of the Edwards Aquifer who are authorized to withdraw more than 3 acre-feet per year. Stage V became effective as a rule on March 18, 2013 when the Incidental Take Permit was issued by the U.S. Fish and Wildlife Service. Stage V was first triggered in the Uvalde Pool on March 28, 2013, when the 10-day average at the J-27 index well dropped below 840 feet mean sea level. Stage V reductions remained in effect for 798 days and expired on June 4, 2015.

Target for 2018:
EAA staff monitors daily aquifer levels in both the San Antonio and Uvalde Pools of the Edwards Aquifer region. If the 10-day average for J-27 or J-17 and Comal springflow levels in reaches the designated trigger for Stage V, the EAA General Manager will issue a Notice of Commencement for implementation in five newspapers within the EAA jurisdiction. Notice will also be posted at the EAA's office and on the EAA website. All affected permit holders will also be provided written notice of implementation of Stage V and the requirement to reduce pumping by 44%.

Permit Holder Assistance: The EAA provides an online Critical Period Calculator to assist permit holders in calculating CPM reductions as they apply to each individual permit holder's total authorized withdrawal amount throughout the year. EAA staff also assists permit holders through "one-on-one" customer service offerings as may be necessary.

Triggers: The triggers for Stage V in the San Antonio Pool are as follows: the 10-day average at the J-17 index well in San Antonio falls below 625 mean sea level (msl) and the 10-day average at Comal Springs falls below 45 cubic feet per second (cfs); or the 3-day average at Comal Springs falls below 40 cfs. In the Uvalde Pool, Stage V is triggered when the 10-day average at the J-27 index well falls below 840 msl (see attachment I Critical Period Triggers Chart).

Reporting: By rule, permit holders are required to report their annual groundwater use to the EAA by January 31 for all groundwater used the preceding year. Permit holders who use more Edwards groundwater than authorized annually are subject to enforcement action.

Budget:
No budget allocated in Table 7.1

6.3.1 Biological Monitoring Program for the Comal and San Marcos Aquatic Ecosystems

Long-term objective:
Since 2000, the Edwards Aquifer Authority (EAA) has conducted an extensive biological monitoring program in the Comal and San Marcos spring systems. This program was referred to as the Variable Flow Study (VFS). In 2013, the elements of the VFS were incorporated into the Biological Monitoring Program (BioMP) for the Edwards Aquifer Habitat Conservation Plan.

The purpose of the BioMP is "to monitor changes to habitat availability and population abundance of the Covered Species that may result from Covered Activities" (EAHCP § 6.3.1). Another benefit of the BioMP is to collect data that can be used in the applied environmental research studies (EAHCP § 6.3.4) and provide data and information for the ecological model development described in EAHCP § 6.3.3. The BioMP includes: (1) Comprehensive Sampling, (2) any triggered Critical Period monitoring, (3) any high flow triggered monitoring (4) and any EAHCP-specific sampling required by Section 6.4.

Target for 2018:
For 2018, the BioMP for the Comal and San Marcos Aquatic Ecosystems will continue to use the standard operating procedures adopted in 2016 for Comprehensive, Critical Period, and EAHCP Low-Flow Sampling and for the EAHCP Baseline, Disturbance components of Biological Monitoring and Take Determination.

The standard operating procedures, program changes adopted from the 2016 Expanded Water Quality Monitoring Program Work Group and the Biological Monitoring Program Work Group became the standard operating procedures for biological monitoring that were first used in 2017.

In 2017, the standard operating procedures for the BioMP were the same as in 2016, with the following modifications:

1. Replacing the previously conducted macroinvertebrate food source monitoring with Texas Commission on Environmental Quality/Texas Parks & Wildlife Rapid Bio-Assessment (RBA) protocols for macroinvertebrate community health, conducted at the same time as fixed drop-net sampling for fountain darters at five reaches in the Comal system and four reaches in the San Marcos system.
2. Flow-partitioning within Landa Lake conducted by the EAA, but not through the EAHCP.
3. During the "Water Quality Grab Sampling" component of the BioMP, the method detection limit (MDL) for soluble reactive phosphorus were reduced from 50 µg/l to at least 5 µg/l.

Also in 2017, the EAA shared data with other entities conducting monitoring within the spring systems, such as the Guadalupe-Blanco River Authority & TCEQ Clean Rivers Program in the Comal and San Marcos rivers, the EAHCP Biological and Water Quality Monitoring Programs and the EAA Aquifer Science Department's groundwater and spring orifice-sampling programs.

Literature Review

The purpose of the literature review is to familiarize the Contractor with the Biomonitoring program's history and recent relevant studies, to include compilation and annotation of historical data and information related to spring water quality and variable flow and to the composition, diversity and distribution of aquatic biota in subterranean, orifice and spring pool/run habitats with a focus on the sensitivity of indicator species and Covered Species to variable flow, water quality and habitat conditions.

Aquatic Vegetation Mapping
The Contractor will conduct aquatic vegetation mapping in four representative reaches in the Comal Springs system and in three representative reaches in the San Marcos Springs system during Comprehensive mapping using a GPS unit with real-time differential correction with sub-meter accuracy.

Texas wild-rice Mapping
The Contractor will map all Texas wild-rice from Spring Lake downstream to the confluence of the Blanco River on an annual basis. The annual mapping will occur during the summer (August) Comprehensive Biomonitoring sampling event. The location of every stand of wild-rice will be recorded using a GPS unit with real-time differential correction with sub-meter accuracy.

In addition, during both the Spring and Fall Comprehensive sampling events, Texas wild-rice areas in Sewell Park identified as vulnerable, as well as, sections of the San Marcos River upstream and downstream of I-35 be mapped

Fountain Darter Sampling
The Contractor will conduct drop and dip netting and visual aquatic surveys with SCUBA during the Spring and Fall sampling events. Additional dip net sampling will be conducted during the Summer sampling event. Aquatic vegetation as per Task 2 will be mapped in the reaches prior to drop and dip net activities.

Drop Net Sampling
Drop netting will be used to sample fountain darters in identified reaches of the rivers in specific aquatic vegetation types that have been selected through stratified
Fountain darters will be identified, counted, measured, examined for condition and returned to the river at the point of collection. Other fish will be identified and released, or preserved and identified in a laboratory. Live ramshom snails will be counted, measured, and destroyed. Exotic Asian snails and Asian clam will be identified, general abundance recorded, then destroyed. Furthermore, the vegetation type, height, areal coverage, substrate type, mean column velocity, velocity at 15 centimeters (cm) above the bottom, water temperature, conductivity, and dissolved oxygen levels will be recorded at each location.

Dip Net Sampling
The Contractor will conduct dip net timed surveys, as well as presence/absence surveys in specified sections throughout the spatial extent of both systems. Fountain darters collected by dip net monitoring will be examined for condition. Timed surveys will be conducted in all habitat types within each section, moving upstream during the sampling process, up to a depth of 1.4 m, with prime darter habitat receiving the most effort.

Presence/absence surveys will be conducted by taking 4 dip net sweeps at 50 permanent sample site locations within the 4 representative reaches at Comal Springs (Upper Spring reach (5 locations), Landa Lake reach (20 locations), Old Channel reach (20 locations), and New Channel reach (5 locations)), and the 50 permanent sample site locations within the three representative reaches in San Marcos Springs (Spring Lake Dam reach (15 locations), City Park reach (20 locations), and I-35 reach (15 locations)).

Visual Fountain Darter survey
Visual aquatic surveys will be conducted using SCUBA in a fixed location in Landa Lake to identify fountain darters at depths deeper than conventional sampling methods allow.

Comal Springs Invertebrate Sampling
The Contractor will conduct sampling for Comal Springs invertebrates during the Spring and Fall sampling events.

- One drift net each will be placed over the main spring orifice of Spring Run 1, Spring Run 3, and Spring Run 7 at Comal Springs. All endangered invertebrates will be identified and counted in the field, and returned to the orifice they were collected upon completion of the 24-hour sample period. All other invertebrates will be preserved and transported to an off-site laboratory for taxonomic classification. Coordination with the USFWS San Marcos Aquatic Resources Center (ARC) will take place each time to assist with refugia collections when needed.
- The Comal Springs riffle beetle cotton lure standard operating procedure, or a suggested (and EAHCP staff approved) alternate method, and quantitative survey methods will be utilized to conduct Comal Springs riffle beetle sampling in 3 locations (Spring Run 3, western shoreline of Landa Lake, and Spring Island area). Ten springs within each of the 3 locations will be identified by the Contractor.
- The Comal Springs riffle beetle cotton lure standard operating procedure and cotton lure quantitative survey method allow Comal Springs riffle beetles to be identified, counted, and returned to their spring of origin. Other spring invertebrates collected on the lures will also be noted. These include two other riffle beetles (*Microcylloepus* sp. and *Stenelmis* sp.), Comal Springs dryopid beetles (Stygoparnus comalensis), and Peck's cave amphipod (*Stygobromus pecki*).

Salamander Visual Observations
The Contractor will conduct salamander sampling during each Spring and Fall sampling event. Comal Salamander surveys will be timed and conducted by observation from the surface or dive mask and snorkel at Spring Run l, Spring Run 3, Spring Island spring runs, and at the eastern outfall at Spring Island.

San Marcos salamander surveys follow the quantitative sampling method described in Nelson, J. (M.S. Thesis, Texas State University, 1993). Observations for the San Marcos salamander will be done by dive mask and snorkel or SCUBA for three, 5-minute timed surveys per area. San Marcos salamanders will be counted, measured and the overall substrate where they were found documented.

- In both systems, sampling will require turning over rocks in the sample site for set periods of time in order to expose the salamanders and obtain a visual count. Whenever possible, all rocks will be returned to their original location. For this monitoring, salamanders will only be observed and no collections will occur.

Comal Springs Discharge Measurements
The Contractor will conduct discharge measurements on Comal Springs during the Spring and Fall sampling events. Discharge measurements will be conducted at Spring Runs 1, 2, and 3, Upper Spring Run Reach, and the Old Channel below Elizabeth Street and will be used to establish the contributions of each major spring run to total discharge in the river and to establish the relative proportion of water flowing in the Old and New Channels.

Water Quality Sampling
The Contractor will maintain and download existing thermistors located throughout each system. Standard water quality parameters (water temperature, conductivity compensated to 25 ^{0}C, pH, dissolved oxygen, water depth at sampling point, and observations of local conditions) will be sampled during drop net sampling and fish community sampling activities.

Fixed Station Photography
The Contractor will photo document each established, fixed station photograph site. Photographs involve an upstream, across, and downstream picture of the reach and capture key changes in the habitat in the reach.

Macroinvertebrate Community Assessment
The macroinvertebrate community assessment will be conducted using rapid bioassessment (RBA) protocol as described in "Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological Assemblage and Habitat Data." TCEQ RG-416. 2014. The RBAs will be conducted in 5 reaches in the Comal and 4 reaches in the San Marcos at the drop-net fountain darter sites. One composite sample will be collected from each reach (i.e. 9 samples total across both systems). Macroinvertebrate community assessments will be conducted during comprehensive and critical period sampling events.

Fish Community Sampling
The Contractor will collect fish once per year in odd numbered years in conjunction with routine Biological Monitoring sampling from both the Comal and San Marcos river systems and to test the fish for contaminants. The fish will be collected at 2 locations within each system, for a total of 4 sampling sites. For each river system, one site will be located near the spring orifices, or in the far upper reaches of the system, and the second site will be located at the most downstream biomonitoring reach for each system (Lower River Reach – Comal; I-35 Reach – San Marcos).

At each of the 4 locations, 2 fish species (fountain darter and a predator species such as largemouth bass, warmouth, or rock bass) will be collected at the locations for comparison. The length, weight, and sex of each individual fish will be recorded prior to using the entire body to create a composite, homogenate fish sample.

SAN MARCOS SYSTEM

Two locations within Spring Lake associated with San Marcos Salamander surveys (Big Riverbed and Hotel Area) will be sampled for fish as well as one location just upstream of the dam near the eastern spillway. All three locations will involve SCUBA transect surveys.
Three additional SCUBA transects are in each river section (Upper, Mid, and Lower) of the San Marcos River, located in representative deep areas where seining has proven to be inefficient. The exact location of the SCUBA transects within each section may change slightly based on conditions at the time of the sampling event.

COMAL SYSTEM
Three locations within Landa Lake will be sampled via SCUBA transect surveys. In particular, one of the SCUBA transects in Landa Lake will be in the same location as the ongoing fountain darter belt transect survey. In addition, SCUBA transects will be conducted within the Upper Spring Run, Old Channel, and New Channel sections of the Comal River.
In addition to SCUBA surveys, three locations (Upper Spring Run, New Channel, and Old Channel) will be sampled via seines to evaluate and track fish populations in the Comal River. Fish within each transect will be identified, measured, examined for disease, and native fish returned to the river. Exotics will be removed from the system as per scientific permit. In addition to collected data on fish, each seine haul will include data on the velocity, depth, substrate composition, in-stream coverage, climatic conditions, and mesohabitat typing of the site at the time of the observation.

EAHCP Habitat Baseline and Disturbance Determination
This determination is intended to fulfill Section M 1a and 2a of the Incidental Take Permit.

Document Baseline Habitat Conditions

For the covered HCP species, the Contractor will use January 1 of the contract year GIS mapping, bio-monitoring data and other existing sources to establish occupied habitat for the HCP Covered Species. Specific to Item M (la and 2a) of the ITP, only occupied habitat within the Comal and San Marcos Springs/River ecosystems will be included.

Document HCP Mitigation Areal Extent Per Project

The Contractor will work with staff and contractors from the City of New Braunfels, City of San Marcos and Texas State University, coordinating through EAA staff, to describe in GIS map form, representing a snapshot in time on December 31 of the contract year, the areal extent of all direct HCP mitigation and restoration activities in the Comal and San Marcos springs systems.

If GIS files of the project/affected areas are unavailable, the Contractor will either: l) map those areas directly with high grade GPS in real-time, or 2) use existing areal imagery to pinpoint and outline locations with subsequent, supplemental GPS ground truth mapping. The Contractor will ensure that areas represented on all maps are representative of actual mitigation, not concept areas.

Assessment of Net Disturbance

The Contractor will evaluate the baseline maps versus the HCP project maps and quantify the area of direct disturbance that may have potential effects from mitigation and restoration activities as described in Item M (la and 2a) of the ITP. The focus will be on quantifying the direct impacts (removal of non-native vegetation, etc.) via areal coverage of habitat, but will also describe potential indirect impacts (turbidity, etc.) qualitatively. This analysis will not extend beyond comparisons of areal coverage of occupied habitat.

Annual "Take" Estimate
The Contractor shall estimate Take for each of the Covered Species utilizing the information generated by Subtask 12.1, 12.2 and 12.3, the information and guidance in Chapters 4 and 6 of the HCP, the Biological and Conference Opinion issued by USFWS, and any other relevant information. The purpose of this Take estimation is to ensure compliance with Section H of the ITP.

CRITICAL PERIOD SAMPLING
The Critical Period Monitoring component will be performed on both systems and be based upon established flow trigger levels for each system. The type and extent of sampling conducted is dependent on the respective trigger level and is designed to be duplicative of full biomonitoring sampling and will include species-specific sampling based on the flow triggers.

High/Low Flow Monitoring
The Contractor will conduct high flow critical period monitoring only after the following triggering criteria are met:

a) The daily average flow exceeds 385 cubic feet per second (cfs) in the San Marcos aquatic ecosystem or 500 cfs in the Comal aquatic ecosystem (total flow through the ecosystem as measured at the USGS gauging station located immediately downstream of the ecosystem); and
b) After conducting a joint visual inspection of the aquatic ecosystem with the Contractor, EAA staff determines that high flow critical period monitoring is warranted and approved.

Before high flow critical period monitoring is conducted, the sampling parameters must be recommended by the Contractor and pre-approved by EAA staff, based on professional judgment, and may include any parameter from the full biomonitoring sampling, with the exception of gill net sampling.

The Comal and San Marcos springs systems flow-based triggers are associated with specific sampling parameters.

San Marcos System Sampling
Low flow Critical Period Monitoring for the San Marcos River triggers at 120 cfs, with Texas wild-rice vulnerable stand monitoring as described in Task 3 of the Comprehensive Sampling Program. Monitoring will occur at 5 cfs declines or a maximum of once per week. The first Full Sampling Event is triggered at 100 cfs, with subsequent declining Full Sampling Events triggering at 85, 60, 25, and 100 cfs for a total of five declining Full Sampling Events. In

addition, two recovery Full Sampling Events would be conducted as the system rebounds from the low-flow period. Between Full Sampling Events, habitat evaluations, per every 5 cfs decline, would be conducted again not to exceed weekly monitoring.

Comal System Sampling
Low flow Critical Period Monitoring for the Comal River triggers at 200 cfs. This triggers the first Full Sampling Event with 4 subsequent Full Sampling Events being triggered at 150, 100, 50, and 10-0 cfs, respectively. Two recovery Full Sampling Events are scheduled as the flows rebound and stabilize from drought conditions. The Comal system also has habitat evaluations scheduled between Full Sampling Events; however, at 10 cfs increments again not to exceed weekly observation. An additional component for the Comal system is the detailed riffle beetle habitat evaluation and spring orifice condition documentation that is triggered at 120 cfs and continued at 10 cfs increments during decline.

A review of historic flow records indicates that the lower the flow, the lower the chance an even lower flow event will occur, thus reducing the chances of a complete decline and recovery as outlined above. Typically, both systems rebound from drought conditions due to a tropical depression rainfall event or some other weather pattern that produces a large amount of rainfall over the watershed. Flows typically come up rapidly and require a period of stabilization before the collection of biological data is meaningful.

Gill Net Evaluation
In addition to the full sampling activities outlined in 14.1 and 14.2, the Contractor will conduct gill net evaluations in the immediate vicinity of the fountain darter SCUBA surveys in Spring Lake and Landa Lake. The Spring Lake evaluation will be triggered at 85 cfs and lower triggers. The Landa Lake assessment will be triggered at 100 cfs and lower triggers. The survey is designed to examine exotic fish concentrations and stomach content analyses with respect to predation of listed species. The number of each species (native and non-native) collected in the gill net and the data will be recorded and converted to catch per unit effort.

Water Quality Grab Sampling
The Contractor will collect water quality grab samples at the established triggers in Subtasks 14.1 and 14.2 at 18 stations longitudinally distributed in the San Marcos system and 12 stations longitudinally distributed in the Comal system. The samples will be from the surface, mid-depth and near bottom.

EAHCP Low Flow Sampling
To protect the Covered Species, Chapter 6 of the EAHCP contains specific flow requirements for both systems that trigger sampling events. This sampling is in addition to the Comprehensive and Critical Period components and consists of an increased frequency of sampling for aquatic vegetation, Texas wild-rice mapping, as well as additional sampling of fountain darters, Comal Springs riffle beetles, and salamanders.

Budget:
Table 7.1:
$400,000

Available budget for 2018:
$408,275

Estimated 2018 budget:
$408,275

*2018 EAHCP BioMP will be performed by an outside contractor; estimated annual costs for the BioMP m is $408,275. The cost of any Critical Period monitoring component of the BioMP, as established by the former EAA Variable Flow Study, will continue to be paid by the EAA.

5.7.2 Water Quality Monitoring Program Strategy for Comal Springs and San Marcos Springs

Long-term objective:
This work plan details the sampling strategy and protocols for surface water quality monitoring in 2018 for the Edwards Aquifer Habitat Conservation Plan (EAHCP) Section 5.7.2 implemented by the Edwards Aquifer Authority (EAA), utilizing contractors. The goal of the water quality monitoring program, first implemented in 2013, is to detect water quality impairments that may negatively impact the listed species. In the event certain constituents of concern are detected at levels indicating the potential for adverse effects, the Implementing Committee member with jurisdictional authority will be consulted to identify sources and consider Best Management Practices (BMPs) to reduce and/or eliminate the constituents of concern. If necessary, additional testing could be included in the current or following year to assist in determining the source of contamination and the Science Committee could be consulted to assist with BMP identification and source determination.

In 2015, the EAHCP received the *National Academy of Sciences (NAS) Report 1*(2015), containing recommendations for EAHCP's Monitoring, Modeling and Applied Research programs, including the Expanded Water Quality Monitoring Program. From *Report 1*, a list of water quality monitoring recommendations was presented to the NAS Recommendation Review Work Group (NAS Work Group). Based on the NAS Work Group assessment at its February 18, 2016, meeting, the Implementing Committee convened the 2016 EAHCP Expanded Water Quality Monitoring Program Work Group (WQWG) to carry out a holistic review of the Expanded Water Quality Monitoring Program, considering the recommendations of NAS, the NAS Work Group, the input of the Science Committee, the Permittees, and subject matter experts. The purpose of the WQWG was to produce a final report for review by the Implementing Committee, developed through a consensus-based decision-making process. The WQWG held meetings from March to May 2016. This work plan contains the recommendations of the WQWG.

Target for 2018:
For 2018, the contractors will use the same sampling locations used in 2017 as shown in the attached figures. However, changes in springflow, surface water runoff, land use, site security, and access may dictate minor modification to sample collection locations and schedules as sampling efforts progress. Any minor changes resulting from these factors will be noted in the field sample sheets and dedicated field books. Should logistics or safety issues require any significant changes to this work plan, the sampling contractors shall report those issues to the EAA. Subsequently, the EAA will present those changes to the Science and Implementing Committees for review and approval as needed prior to their implementation. An overview of the approved Scope of Work can be seen in Table 1 below.

Table 1. Overview of the Approved Scope of Work

Sampling Method	Frequency
Surface Water Passive Sampling	• February, April, June, August, October, and December ○ Add Pharmaceuticals and Personal Care Products membrane only at the bottom of the channel in both systems

Stormwater Sampling	• Reduced to one sampling event per year
	  ○ Test only for Integrated Pest Management Plan chemicals in odd numbered years at the Comal River system (Upper Springs and New Channel)
	  ○ Test full suite in even numbered years as currently done in both systems
	• Add two samples to the rising limb of the hydrograph for a total of five samples per location
	  ○ Priority given to locations at tributary outflows

Sediment Sampling	Biennially in even numbered years from both systems
Fish Community Sampling	Biennially in odd years from both systems

Comal Springs

Comal Springs discharges an average of 291 cubic feet second (cfs) into Landa Lake, located within the city of New Braunfels, Texas. Comal Springs is considered a spring complex with multiple discharge points along the 4,500-foot reach of Landa Lake. The springs issue from the Edwards Group limestone along the 4,500-foot section of the northeast-southwest trending escarpment formed by the Comal Springs Fault. Landa Lake forms the headwaters of the Comal River which flows approximately two miles before entering the Guadalupe River.

Discharge measurements have been collected from Comal Springs since 1933, and the EAA has been collecting water quality samples for more than ten years. In recent years, the EAA has been collecting samples from Spring 1, Spring 3, and Spring 7 on a quarterly basis during normal flow conditions and monthly when the San Antonio pool critical period triggers have been reached. Spring 1, Spring 3, and Spring 7 discharge into Landa Lake and make up part of the Comal Springs complex. Figure 1 indicates these historical groundwater sampling locations. Water quality samples are collected and analyzed for: dissolved oxygen (DO), pH, conductivity, and temperature in the field and for alkalinity[1]. Samples are also submitted to the EAA contract laboratory for analysis of cations, anions, nutrients, metals, VOCs, SVOCs, herbicides and pesticides, bacteria, TOC, PCBs, phosphorous, and caffeine. This list of parameters is defined as the water quality analytical list (WQAL).

Sampling Methods

All samples will be collected following the EAA's *Field Sampling Plan* or the contractors' established methodology upon approval by the EAA. Samples shall be analyzed by a NELAP

[1] Alkalinity analysis are conducted within eight hours of sample collection.

accredited contract laboratory. To date, no requests to deviate from the EAA's *Field Sampling Plan* have been received or approved.

Surface Water Passive Sampling for Comal Springs
Passive samples will be collected during the 2018 sampling effort using a passive diffusion type sampling device. Devices will be obtained from Amplified Geochemical Imaging LLC (AGI) or equivalent to the AGI device for functionality and analytical parameters. Sample locations for passive diffusion samples (PDS) are provided in Figure 2. Specifically, at the sample points below.

Upper Springs (near Bleiders Creek);
Upper Landa Lake - (near Spring Island);
Lower Landa Lake - (above outfalls);
Upper Old Channel - (Elizabeth Street); and
USGS Gauge - (above San Antonio Street Bridge).

The passive sampling effort will be performed in February, April, June, August, October, and December. The devices will be installed for two-week periods at the same locations as the sediment samples. When conducting passive sampling, the contractor will also perform six pharmaceuticals and personal care product (PPCP) sampling events using a PPCP-specific diffusion sampler placed only at the most downstream sample site (USGS Gauge - above San Antonio Street Bridge). The general parameter set for PDS samples is listed in Appendix A, under *Analytical Parameters for Passive Diffusion Samplers, Comal and San Marcos Springs* and general parameter set for PPCP is listed in Appendix A under *Analytical Parameters for Pharmaceuticals and Personal Care Products, Comal and San Marcos Springs.*

Stormwater Sampling Program for Comal Springs
One stormwater sampling event will be performed in 2018 to evaluate stormwater quality from the urban landscape. A stormwater sampling event will be triggered when the flow rate at the U.S. Geological Survey (USGS) Comal Springs gauging station (#08169000) increases by 5% due to precipitation, or there is a 20% change in three of the five water quality parameters measured in the downstream real time water quality monitoring probe. In 2018, stormwater samples will be collected from five stormwater sampling locations during a stormwater sampling event. Five samples will be collected at Upper Springs (near Blieders Creek) and New Channel (below confluence with Dry Comal Creek) with the remaining sites sampled three times. Sampling times will be spaced to reflect changes in the stream hydrograph (one to three during initial rise or first flush, one at peak flow, and once during the recession limb). Stormwater samples will be analyzed using the methods found in Appendix A under *Analytical Parameters for Storm Water Comal and San Marcos Springs - Even Years.*

The following locations will be sampled for stormwater as indicated on Figure 3:

Upper Springs – (near Blieders Creek);
New Channel – (below confluence with Dry Comal Creek);
Upper Old Channel – (at Elizabeth Street);
Lower Old Channel – (above Hinman Island); and

Comal River – (above confluence with Guadalupe River).

Sediment Sampling for Comal Springs
One sediment sample will be collected during 2018 at each of the PDS sampling locations (Figure 2). Three samples will be collected from each sample site and composited into a single sample for analysis (to minimize VOC loss, it is recommended the compositing process be performed at the laboratory). Sediment samples will be analyzed for the analytical parameters provided in Appendix B.
Fish Community Sampling for Comal Springs
Fish Community Sampling will not occur in 2018 since collecting fish is conducted during odd numbered years in conjunction with routine Biological Monitoring sampling.

Real Time Instrument Water Quality Data Logging Program for Comal Springs
Continuous water quality monitoring stations will continue in 2018 at the following locations indicated on Figure 4:

Spring Run 3;
Spring 7;
Landa Lake; and
New Channel (above confluence with Dry Comal Creek).

Monitoring will be performed using a data logging sonde capable of collecting data on 15 minute intervals. The parameters measured will include temperature, dissolved oxygen, pH, turbidity, and conductivity. These data will be evaluated to identify short-term and long-term water quality variations of the spring system as well as changes in water quality related to stormwater runoff. This monitoring effort will continue to be performed by EAA staff in 2018.

In 2018, an additional water quality data logging point will be installed at the Old Channel of the Comal River. The additional station will help with the timing of storm sample collection as well as improved monitoring at the Old Channel of the Comal River. Costs for this are included in Appendix C of this document. The location of the proposed new monitoring point is located off Golf Course Road.

San Marcos Springs
Located in San Marcos, Texas, on the campus of Texas State University, San Marcos Springs discharges an average of 176 cfs into Spring Lake. The springs issue from the Edwards Group limestone along the northeast-southwest trending escarpment formed by the San Marcos Springs Fault. Spring Lake forms the headwaters of the San Marcos River. Discharge measurements have been collected from San Marcos Springs since 1957, and the EAA has been collecting water quality samples for more than ten years.

In recent years, the EAA has been collecting samples from Deep Spring and Hotel Spring on a quarterly basis during normal flow conditions and monthly when the San Antonio pool critical period triggers have been reached. Both Deep and Hotel springs are in the bed of Spring Lake and make up part of the San Marcos Springs complex. Figure 5 indicates these historical groundwater sample locations at San Marcos Springs. Water quality samples are collected and

analyzed for: DO, pH, conductivity, and temperature, in the field and for alkalinity[2]. Samples are also submitted to the EAA contract laboratory for analysis of cations, anions, nutrients, metals, VOCs, SVOCs, herbicides and pesticides, bacteria, TOC, PCBs, phosphorous, and caffeine. This list of WQAL parameters is identical to the list of parameters analyzed for at Comal Springs.

Sampling Methods
All samples will be collected following the EAA's *Field Sampling Plan* or the contractors' established methodology upon approval by the EAA. Samples shall be analyzed by a NELAP accredited contract laboratory. To date, no requests to deviate from the EAA's *Field Sampling Plan* have been received or approved.

Surface Water Passive Sampling for San Marcos Springs
Passive samples are to be collected during the 2018 sampling effort using a PDS. Devices will be obtained from AGI or equivalent to the AGI device for functionality and analytical parameters. Sample locations for PDS samples are provided in Figure 6. Specifically, at the sample points that follow.

The passive sampling effort will be performed in February, April, June, August, October, and December. The devices will be installed for two-week periods at the same locations as the sediment samples. When conducting passive sampling, the contractor will also perform six PPCP sampling events using a PPCP specific diffusion sampler placed only at the most downstream sample site (Capes Dam/Willow Creek). The general parameter set for PDS samples is listed in Appendix A under *Analytical Parameters for Passive Diffusion Samplers, Comal and San Marcos Springs*, and general parameter set for PPCP is listed in Appendix A under *Analytical Parameters for Pharmaceuticals and Personal Care Products, Comal and San Marcos Springs.*

Stormwater Sampling Program for San Marcos Springs
One stormwater sampling event will be performed in 2018 to evaluate stormwater quality from the urban landscape. A stormwater sampling event will be triggered when the flow rate at the USGS San Marcos gauging station (#08170500) increases by 5% due to precipitation, or there is a 20% change in three of the five water quality parameters measured in the downstream real time water quality monitoring probe. In 2018 three stormwater samples will be collected from each stormwater sampling location during a stormwater sampling event except for Sessom and Sink Creeks where five samples will be collected. Sampling times will be spaced to reflect changes in the stream hydrograph (one to three during initial rise or first flush, one at peak flow, and once during the recession limb).

Stormwater samples will be analyzed using the methods found in Appendix A, under *Analytical Parameters for Storm Water Comal and San Marcos Springs - Even Years*. The following locations will be sampled for stormwater as indicated on Figure 7:

Sink Creek;
Sessom Creek;

[2]Alkalinity analysis will be conducted within eight hours of sample collection.

Dog Beach Outflow;
Hopkins Street Outflow;
Purgatory Creek (above San Marcos River);
IH-35 Reach; and
Capes Dam/Willow Creek (above San Marcos River).

Sediment Sampling for San Marcos Springs
One sediment sample will be collected during even numbered years at each of the PDS sampling locations (Figure 6). Three samples will be collected from each sample site and composited into a single sample for analysis (to minimize VOC loss, it is recommended the compositing process be performed at the laboratory). Sediment samples will be analyzed for the analytical parameters provided in Appendix B. Results of sediment sampling analyses will be used to formulate future sediment sampling at Spring Lake and the San Marcos River. Sediment sample intervals will likely vary in subsequent sample years based on the results of each year of sediment analyses.

Fish Community Sampling for San Marcos Springs
Fish Community Sampling will not occur in 2018 since collecting fish is conducted during odd numbered years in conjunction with routine Biological Monitoring sampling.

Real Time Instrument Water Quality Data Logging Program for San Marcos Springs
Continuous water quality monitoring stations will continue in 2018 at the following locations indicated on Figure 8:

USGS gauging station;
Rio Vista Dam;
Lucio Park; and
Texas Park and Wildlife Department Fish Hatchery.

Monitoring will be performed using a data logging sonde capable of collecting data on 15 minute intervals. The parameters measured will include temperature, dissolved oxygen, pH, turbidity, and specific conductance. These data will be evaluated to identify short-term and long-term water quality variations of the spring system as well as changes in water quality related to stormwater runoff. Continuous water quality monitoring stations will be operated and maintained by EAA.

Monitoring:
The contractors will compile and present sampling results in an annual report to the EAA. The report will include an evaluation of analytical data, graphs of results that exceed comparative or regulatory standards, a discussion of water and sediment quality, laboratory reports and field data sheets, photographs, sampling locations and rationale, description of sampling methods, and a description and rationale for any deviations from the Water Quality Sampling Plan due to logistics or safety issues. The report is to be submitted in hard copy and electronically and will be reviewed internally by EAA. The deadline for submittal to the EAA is December 21, 2018.

Data compilation, analysis and reporting

All data collected as a result of the 2018 EAHCP Water Quality Monitoring Plan will be compiled and analyzed, and the results will be presented to the Implementing Committee by February 15, 2019; prior to inclusion in the annual EAHCP Annual Report that is required by Sections 6.2.4 and 9.3 of the EAHCP and Section 11.1c of the Implementing Agreement. The report will include an evaluation of all analytical data, including graphs, key photographs, and a general summary of results.

Changes to the Work Plan
In summary, the work plan has changed from 2016. Funding is needed to add a single real time instrument water quality data logger at the Old Channel of the Comal River. Funding is also requested for maintenance and replacement needs for existing real time instruments, as well as data transmission and web hosting fees. Detail for the real-time instruments is listed in Appendix C.

Science Committee Review
This 2018 Water Quality Work Plan will be reviewed by the Science Committee prior to implementation. The Science Committee will be asked to confirm the need for the following additions or changes to the Water Quality Work Plan.

An additional real time instrument for water quality data logging will be added to the Old Channel of the Comal River sampling area in 2018.

Budget:
Table 7.1:
$200,000

Available budget for 2018:
$285,300

Estimated 2018 budget:
$320,300*

*2018 EAHCP Sampling will be performed by an outside contractor; estimated annual costs $285,300. Real Time Instruments (RTI): $25,500.

Figure 1
Comal Springs Groundwater Sample Locations

Most of the historical EAA sampling records for Comal Springs pertains to the locations known as Spring 1, Spring 3, and Spring 7 (spring vents). Other locations at Comal Springs may have a limited sample record.

Samples are collected monthly during low flow conditions (critical period), and quarterly during normal conditions.

Explanation

★ Historical Groundwater (Spring) Sample Location

Prepared by:

EDWARDS AQUIFER AUTHORITY

Figure 2
Comal Springs Passive Diffusion and Pharmaceuticals and Personal Care Products Locations

Comal Springs HCP Related Sample Points

Passive Diffusion Samplers (PDS)

Notes:
PDS devices are to be placed at the locations listed herein, for a two-week time period in the months of February, April, June, August, October, and December.

PDS devices will be from Amplified Geochemical Imaging, LLC, or equivalent and shall provide analyses for: TPH, BTEX, 1,3,5 and 1,2,4-trimethylbenzene, MTBE, phenanthrene, naphthalene 1-methyl naphthalene, octane, cis and trans-1,2,-dichloroethene, 1,1-dichloroethane, chloroform, 1,1,1-trichloroethane, 1,2-dichloroethane, carbon tetrachloride, trichloroethene, tetrachloroethene, chlorobenzene, 1,4-dichlorobenzene, 1,1,2-trichloroethane, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, 1,3-dichlorobenzene, and 1,2-dichlorobenzene.

Explanation

- Passive Diffusion Sampler Location
- Passive Diffusion Sampler and Pharmaceutical Personal Care Product Location

Prepared by:

EDWARDS AQUIFER AUTHORITY

Figure 3
Comal Springs Storm Water Sample Locations

Comal Springs HCP Related Sample Points

Analytical Parameter List (HCP)

Surface Water = GWQP, VOC, SVOC, Pesticides, Herbicides, PCBs, Tot. Phos., TOC, DOC, Kjeldahl, Metals
Storm Water = GWQP, VOC, SVOC, Pesticides, Herbicides, PCBs, Tot. Phos., TOC, DOC, Kjeldahl, Metals
Sediment = GWQP, VOC, SVOC, Pesticides, Herbicides, PCBs, Tot. Phos., TOC, DOC, Metals

Notes:
Pesticides = Organochlorine and Organophosphorus;

GWQP = Alkalinity, Bicrbonate, Carbonate, Ca, Mg, Na, K, Chloride, Sulfate, F, Si, Sr, Bromide, Nitrate (as N), pH, TDS, and TSS; as applicable.

Surface water samples collected twice annually.
Storm water samples collected twice annually.

Explanation

Storm Water Sample Location

Prepared by:

EDWARDS AQUIFER AUTHORITY

Figure 4
Comal Springs Real Time Water Quality Station Locations

Comal Springs HCP Related Sample Points

Analytical Parameter List (HCP)

Surface Water = GWQP, VOC, SVOC, Pesticides, Herbicides, PCBs, Tot. Phos., TOC, DOC, Kjeldahl, Metals
Storm Water = GWQP, VOC, SVOC, Pesticides, Herbicides, PCBs, Tot. Phos., TOC, DOC, Kjeldahl, Metals
Sediment = GWQP, VOC, SVOC, Pesticides, Herbicides, PCBs, Tot. Phos., TOC, DOC, Metals

Notes:
Pesticides = Organochlorine and Organophosphorus;

GWQP = Alkalinity, Bicrbonate, Carbonate, Ca, Mg, Na, K, Chloride, Sulfate, F, Si, Sr, Bromide, Nitrate (as N), pH, TDS, and TSS; as applicable.

Surface water samples collected twice annually.
Storm water samples collected twice annually.

Explanation

- Continuous (Real Time) Water Quality Station
- Proposed Continues (Real Time) Water Quality Station for Addition in 2018)

Prepared by:

EDWARDS AQUIFER AUTHORITY

Figure 5
San Marcos Springs Groundwater Sample Locations

Most of the historical EAA sampling records for San Marcos Springs pertains to the locations known as Hotel and Deep (spring vents). Other locations at San Marcos Springs may have a limited sample record.

Samples are collected monthly during low flow conditions (critical period), and quarterly during normal conditions.

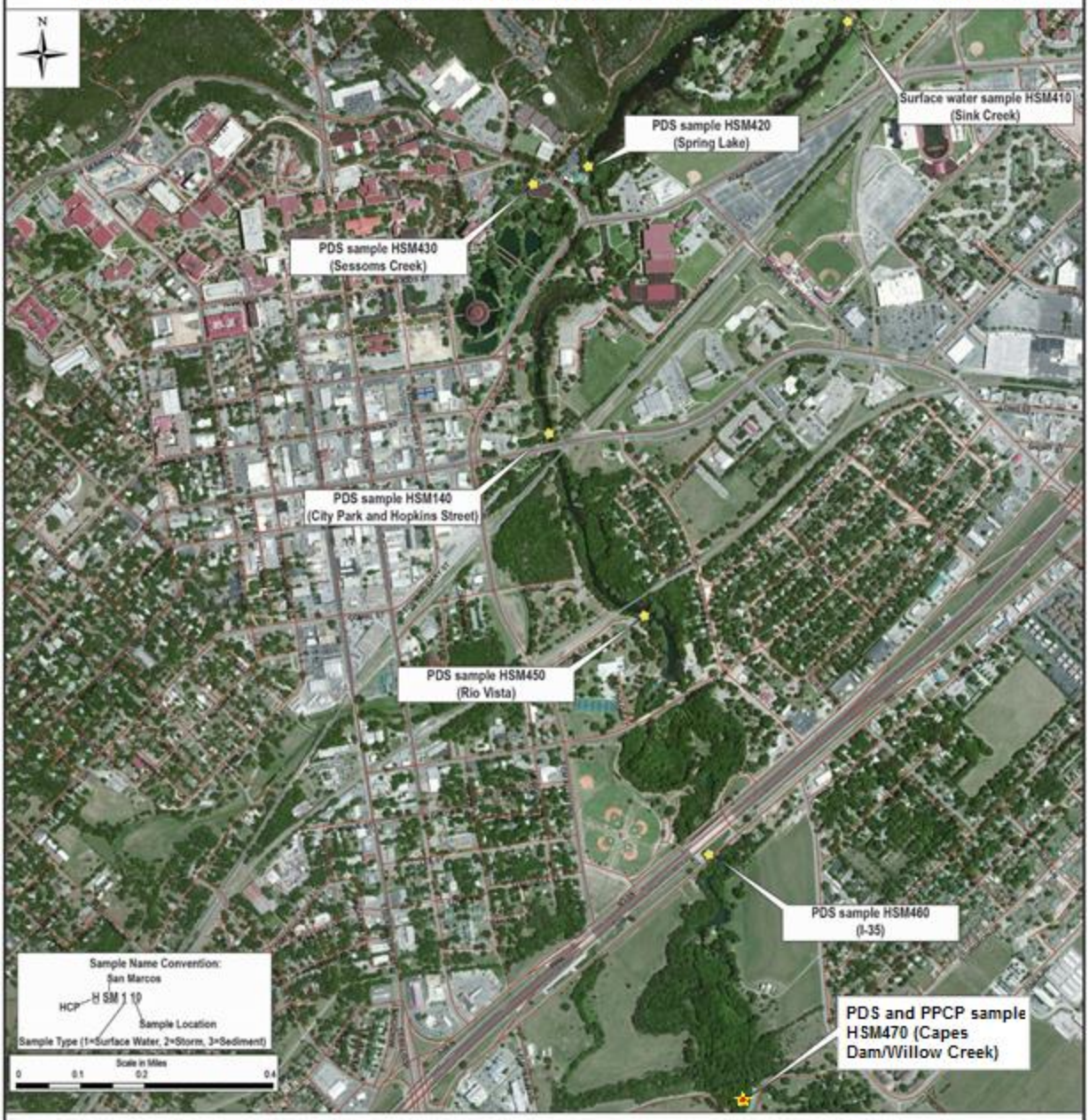
Explanation

★ Historical Groundwater (Spring) Sample Location

Prepared by:

EDWARDS AQUIFER AUTHORITY

Figure 6
San Marcos Springs Passive Diffusion Sampler and Pharmaceuticals and Personal Care Products



San Marcos Springs HCP Related Sample Points

Passive Diffusion Samplers (PDS)

Notes:
PDS devices are to be placed at the locations listed herein, for a two-week time period in the months of February, April, June, August, October, and December.

PDS devices will be from Amplified Geochemical Imagaing, LLC, or equivalent and shall provide analyses for: TPH, BTEX, 1,3,5 and 1,2,4-trimethylbenzene, MTBE, phenanthrene, naphthalene 1-methyl naphthalene, octane, cis and trans-1,2,-dichloroethene, 1,1-dichloroethane, chloroform, 1,1,1-trichloroethane, 1,2-dichloroethane, carbon tetrachloride, trichloroethene, tetrachloroethene, chlorobenzene, 1,4-dichlorobenzene, 1,1,2-trichloroethane, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, 1,3-dichlorobenzene, and 1,2-dichlorobenzene.

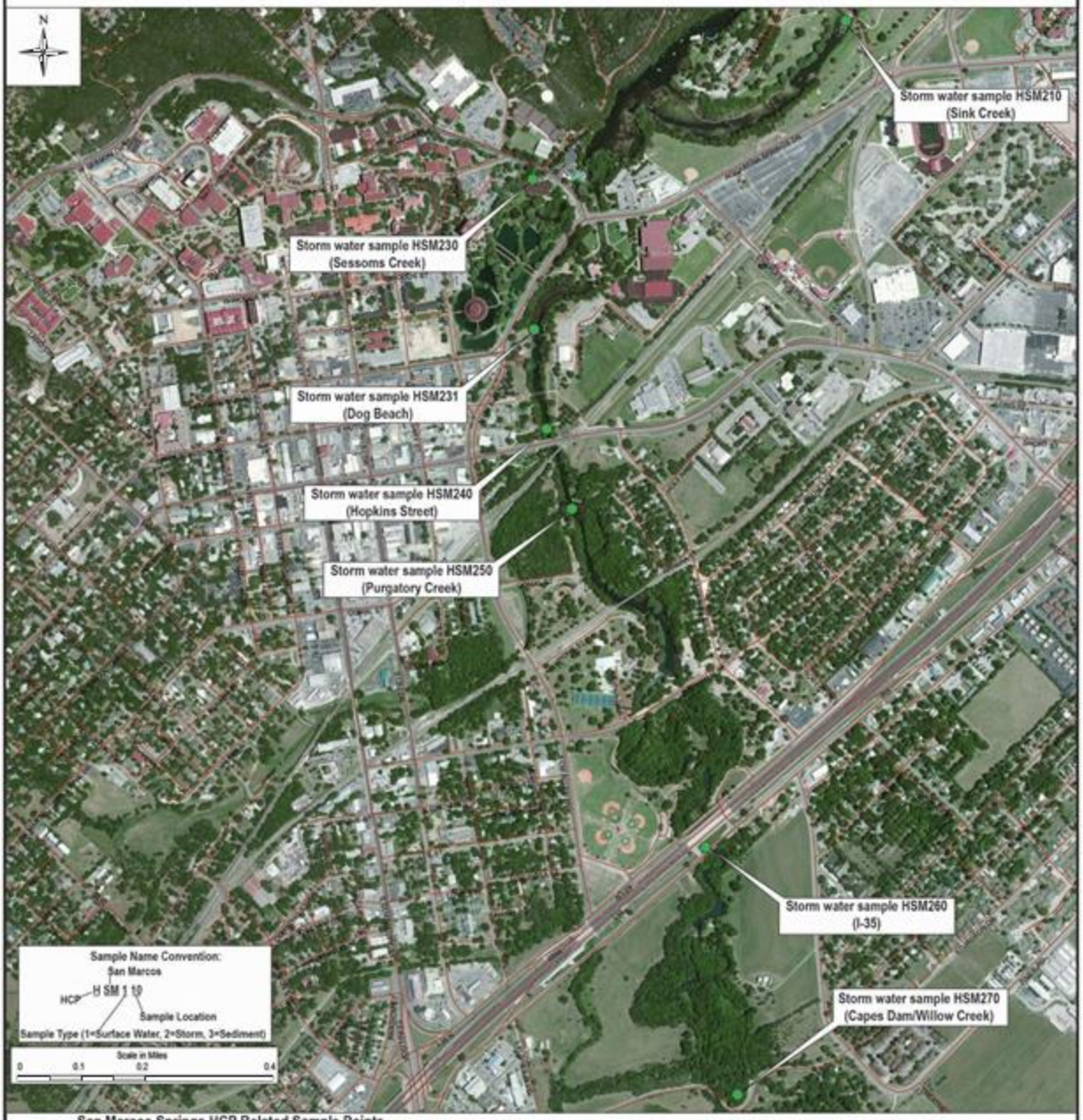
Explanation

- Passive Diffusion Sampler Location
- Passive Diffusion Sampler and Pharmaceutical Personal Care Product Location

Prepared by:

EDWARDS AQUIFER AUTHORITY

Figure 7
San Marcos Springs Storm Water Sample Locations



San Marcos Springs HCP Related Sample Points

Analytical Parameter List (HCP)

Surface Water = GWQP, VOC, SVOC, Pesticides, Herbicides, PCBs, Tot. Phos., TOC, DOC, Kjeldahl, Metals
Storm Water = GWQP, VOC, SVOC, Pesticides, Herbicides, PCBs, Tot. Phos., TOC, DOC, Kjeldahl, Metals
Sediment = GWQP, VOC, SVOC, Pesticides, Herbicides, PCBs, Tot. Phos., TOC, DOC, Metals

Notes:
Pesticides = Organochlorine and Organophosphorus;

GWQP = Alkalinity, Bicrbonate, Carbonate, Ca, Mg, Na, K, Chloride, Sulfate, F, Si, Sr, Bromide, Nitrate (as N), pH, TDS, and TSS; as applicable.

Surface water samples collected twice annually.
Storm water samples collected twice annually.

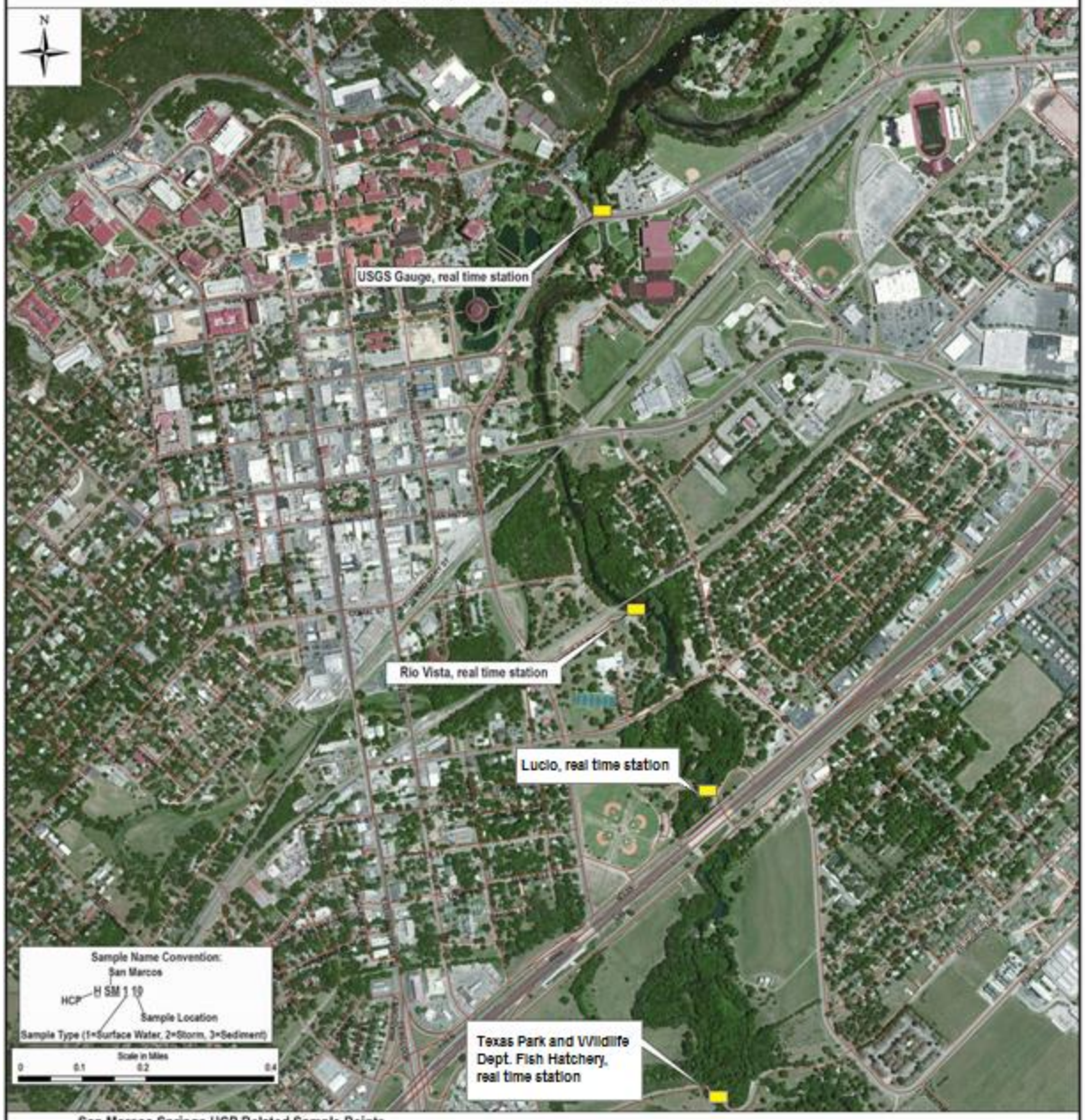
Explanation

Storm Water Sample Locations

Prepared by:

EDWARDS AQUIFER AUTHORITY

Figure 8
San Marcos Springs Real Time Water Quality Station Locations



San Marcos Springs HCP Related Sample Points

Analytical Parameter List (HCP)

Surface Water = GWQP, VOC, SVOC, Pesticides, Herbicides, PCBs, Tot. Phos., TOC, DOC, Kjeldahl, Metals

Storm Water = GWQP, VOC, SVOC, Pesticides, Herbicides, PCBs, Tot. Phos., TOC, DOC, Kjeldahl, Metals

Sediment = GWQP, VOC, SVOC, Pesticides, Herbicides, PCBs, Tot. Phos., TOC, DOC, Metals

Notes:
Pesticides = Organochlorine and Organophosphorus;

GWQP = Alkalinity, Bicrbonate, Carbonate, Ca, Mg, Na, K, Chloride, Sulfate, F, Si, Sr, Bromide, Nitrate (as N), pH, TDS, and TSS; as applicable.

Surface water samples collected twice annually.
Storm water samples collected twice annually.

Explanation

Continuous (Real Time) Water Quality Station Location

Prepared by:

EDWARDS AQUIFER AUTHORITY

Appendix A

Analytical Parameters for Assessing Water Quality from Stormwater Comal and San Marcos Springs – Even Years

Analyses
Volatile Organic Compounds (VOCs)
Semi-volatile Organic Compounds (SVOCs)
Organochlorine Pesticides
Polychlorinated Biphenyls (PCBs)
Organophosphorous Pesticides
Herbicides
Metals (Al, Sb, As, Ba, Be, Cd, Cr (total), Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, Tl, and Zn)
General Chemistry (GWQP) Total Alkalinity (as CaCO3), Bicarbonate Alkalinity (as CaCO3), Carbonate Alkalinity (as CaCO3); (Cl, Br, NO_3, SO_4, Fl, pH, TDS, TSS, Ca, Mg, Na, K, Si, Sr, CO_3,)), and Total Suspended
Phosphorus (total)
Total Organic Carbon (TOC),
Dissolved Organic Carbon (DOC)
Kjeldahl Nitrogen
Bacteria Testing (*E coli*)
Caffeine

Method	**Method Description**	**Protocol**
8260B	Volatile Organic Compounds	(GC/MS) SW846
8270C	Semivolatile Organic Compounds	(GC/MS) SW846
8081B	Organochlorine Pesticides	(GC) SW846
8082A	Polychlorinated Biphenyls (PCBs)	by Gas Chromatography SW846
8141A	Organophosphorous Pesticides	(GC) SW846
8151A	Herbicides	(GC) SW846
6010B	Metals	(ICP) SW846
6020	Metals	(ICP/MS) SW846
7470A	Mercury	(CVAA) SW846
300.0	Anions,	Ion Chromatography
340.2	Fluoride	MCAWW
365.4	Phosphorus,	Total EPA
9040C	pH	SW846
9060	Organic Carbon,	Total (TOC) SW846
SM 2320B	Alkalinity	SM
SM 2540C	Solids,	Total Dissolved (TDS) SM
SM 2540D	Solids, Total Suspended (TSS)	SM
351.2	Nitrogen, Total Kjeldahl	MCAWW
1694	Caffeine	

Protocol References:

EPA = US Environmental Protection Agency

MCAWW = "Methods For Chemical Analysis Of Water And Wastes", EPA-600/4-79-020, March 1983 And Subsequent Revisions.

SM = "Standard Methods For The Examination Of Water And Wastewater",

SW846 = "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.

Analytical Parameters for Assessing Water Quality from Stormwater Comal Springs – Odd Years

Analyses
Atrazine
Azoxystrobin
Bifenthrin
Chlorothanlonil
Diclofop-methyl
Indoxacarb
Iprodione
Oxadiazon
Prodiamine
Thiophanate-methyl

Analyses
Mancozeb
Foramsulfuron
Trifloxysulfuron

Method	Method Description	Protocol
EPA 8270D	Atrazine	(GC/MS/MS) SW846
EPA 8321B	Azoxystrobin	(LC – MS/MS) SW846
EPA 8081B	Bifenthrin	(GC-ECD) SW846
EPA 8081B	Chlorothanlonil	(GC-ECD) SW846
EPA 8270D	Diclofop-methyl	(GC/MS/MS) SW846
EPA 8321B	Indoxacarb	(LC – MS/MS) SW846
EPA 8081B	Iprodione	(GC-ECD) SW846
EPA 8081B	Oxadiazon	(GC-ECD) SW846
EPA 8081B	Prodiamine	(GC-ECD) SW846
EPA 8321B	Thiophanate-methyl	(LC – MS/MS) SW846
EPA 630.1	Mancozeb	(GC)
DuPont Method	Foramsulfuron	Not available
DuPont Method	Trifloxysulfuron	Not available

Protocol References:
EPA = US Environmental Protection Agency
SW846 = "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.

Number of required QA/QC Samples for Stormwater Sampling, and Sediment Sampling

QA/QC Samples (Dupes/EQ Blanks)	Equip. Blanks	Dupes	Total
Comal Surface Water=	2	2	4
San Marcos Surface Water=	2	2	4
Comal Storm Water=	2	4	6
San Marcos Storm Water=	2	6	8
Comal Sediments=	1	1	2
San Marcos Sediments=	1	1	2
Total Costs QA/QC Samples	**10**	**16**	**26**

Analytical Parameters for Passive Diffusion Samplers, Comal and San Marcos Springs

PDS devices are to be placed at the locations listed Figures 1 and 4, for a two-week time period in the months of February, April, June, August, October, and December.
PDS devices will be from Amplifed Geochemical Imagaing, LLC, or equivalent and shall provide analyses for the following: TPH, BTEX, 1,3,5 and 1,2,4-trimethylbenzene, MTBE, phenanthrene, naphthalene1-methyl naphthalene, octane, cis and trans-1,2,-dichloroethene, 1,1-dichloroethane, chloroform, 1,1,1-trichloroethane, 1,2-dichloroethane, carbon tetrachloride, trichloroethene, tetrachloroethene, chlorobenzene, 1,4-dichlorobenzene, 1,1,2-trichloroethane, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, 1,3-dichlorobenzene, and 1,2-dichlorobenzene.

Analytical Parameters for Pharmaceuticals and Personal Care Products, Comal and San Marcos Springs

PPCP diffusion samplers are to be placed at the locations listed Figures 1 and 5, for a four-week time period in the months of February, April, June, August, October, and December.
17-a-Estradiol, 17-a-Ethynylestradiol, 17-b-Estradiol, Diethylstilbestrol, Epitestosterone, Estriol, Estrone, Progesterone, Testosterone, Bisphenol A, Diclofenac, Gemfibrozil, Ibuprofen, Iopromide, Naproxen, Salicylic Acid, Triclosan, Acetaminophen, Amoxicillin, Atenolol, Atorvastatin, Azithromycin, Caffeine, Carbamazepine, Ciprofloxacin, Cotinine, DEET, Diazepam, Fluoxetine, Galaxolide (HHCB), Meprobamate, Methadone, Oxybenzone, Phenytoin (Dilantin), Praziquantel, Primidone, Quinoline, Sucralose, Sulfamethoxazole, TCEP, TCPP, TDCPP, and Trimethoprim

Appendix B
Analytical Parameters for Assessing Water Quality from Sediment Sample Locations, Comal and San Marcos Springs

Analyses
Volatile Organic Compounds (VOCs)
Semi-volatile Organic Compounds (SVOCs)
Organochlorine Pesticides
Polychlorinated Biphenyls (PCBs)
Organophosphorous Pesticides
Herbicides
Metals (Al, Sb, As, Ba, Be, Cd, Cr (total), Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, Tl, and Zn)
General Chemistry Total Alkalinity (as CaCO3), Bicarbonate Alkalinity (as CaCO3), Carbonate Alkalinity (as
Phosphorus (total)
Total Organic Carbon (TOC),
Dissolved Organic Carbon (DOC)
Bacteria Testing (*E coli*)

Method	**Method Description**	**Protocol**
8260B	Volatile Organic Compounds	(GC/MS) SW846
8270C	Semivolatile Organic Compounds	(GC/MS) SW846
8081B	Organochlorine Pesticides	(GC) SW846
8082A	Polychlorinated Biphenyls (PCBs)	by Gas Chromatography SW846
8141A	Organophosphorous Pesticides	(GC) SW846
8151A	Herbicides	(GC) SW846
6010B	Metals	(ICP) SW846
6020	Metals	(ICP/MS) SW846
7470A	Mercury	(CVAA) SW846
300.0	Anions,	Ion Chromatography
340.2	Fluoride	MCAWW
365.4	Phosphorus,	Total EPA
9040C	pH	SW846
9060	Organic Carbon,	Total (TOC) SW846
SM 2320B	Alkalinity	SM
SM 2540C	Solids,	Total Dissolved (TDS) SM
SM 2540D	Solids, Total Suspended (TSS)	SM

Protocol References:
EPA = US Environmental Protection Agency
MCAWW = "Methods For Chemical Analysis Of Water And Wastes", EPA-600/4-79-020, March 1983 And Subsequent Revisions.
SM = "Standard Methods For The Examination Of Water And Wastewater",
SW846 = "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.

Appendix C
Estimated Costs for Addition of a Real Time Water Quality Monitoring Instrument at Comal Springs, and Ongoing Costs for Operation and Maintenance

Three new Eueka, Manta 2 Probe, equipped to monitor: DO, pH, Temperature, Conductivity, and Turbidity with Associated Netronix Telemetry System.	$6,000.00 each for a total of $12,000
Annual maintenance costs for equipment, to include batteries (as needed), repairs, and calibration standards (estimated costs are for six total instruments, which includes the proposed new addition in Comal Springs)	$7,000.00
Annual data contract to include cellular data fees, and web hosting at Netronix site (estimated costs are for six total instruments, which includes the proposed new addition in Comal Springs)	$5,500.00
Installation costs for proposed new unit to be located on the Comal Springs system	$1,000.00
Total Estimated Costs for Real Time Water Quality Instrumentation calendar year 2018	**$25,500.00**

6.3.3 Ecological Modeling

The development of a mechanistic ecological model (Ecomodel) is assigned to the Edwards Aquifer Authority (EAA) per section 6.3.3 of the Edwards Aquifer Habitat Conservation Plan (EAHCP). The purpose of the Ecomodel is to evaluate potential adverse effects to Covered Species and their critical habitat, and to the extent such effects are determined to occur, quantify their magnitude and develop alternate strategies. The Ecomodel, documentation and EAHCP Staff training was completed in 2017.

With the completion of the Ecomodel in 2017, no contractor work products or expenditures are scheduled for 2018.

Budget:

Table 7.1:
$50,000

Available budget for 2018:
$0

Estimated 2018 Budget:
$0

6.3.4 Applied Research

Section 6.3.4 of the Edwards Aquifer Habitat Conservation Plan (EAHCP) includes Applied Research as a "valuable" component of the Phase I package and states that the "Edwards Aquifer Authority (EAA) will contract for the research activities."

Long Term Objective:
2018 and 2019 represent the final two years for the Applied Research program of the EAHCP. In prior years, the Applied Research program has primarily undertaken study of the Comal Springs riffle beetle, fountain darter, and submerged aquatic vegetation. Much of the information generated as part the program has gone towards creating the Ecological Model (EcoModel) which was completed in 2017.

In addition to finalizing the EcoModel, 2017 represents the first year of a long-term Refugia contract with USFWS. The contract outlines specific research tasks related to species collection methods and techniques, species husbandry, species propagation, species genetics, and species reintroduction methods. It is anticipated that all future research on these topics will take place as part of the Refugia research program and not the Applied Research program.

Given the completion of the EcoModel and startup of long-term Refugia operations, a workgroup of EAHCP science committee members (Research workgroup) met to discuss the Applied Research project schedule for 2018 and 2019.

Target for 2018:
The Research workgroup identified several projects which can be found in the final workgroup report. Projects undertaken as part of the Applied Research program will be developed from this final workgroup report. At present, individual projects targeted for 2018 have not been prioritized.

Additional Research Facility
In 2018, the EAA is entering the final year of a five-year contract with Texas State University (TEXAS STATE) that allows Applied Research contractors to use the Freeman Aquatic Building (FAB) raceways, two concrete ponds and wet lab (with living streams and aquaria) for EAHCP research. The TEXAS STATE facilities meet the needs of providing source water, quarantine capabilities, endangered species handling, and infrastructure/resource needs. The EAA pays the utility costs for use of the facilities and EAHCP staff coordinates the projects for timing and availability of resource needed (tank, living stream, trough, raceway, or pond).

Monitoring:
EAHCP staff receives monthly status reports from selected contractors and will visit with selected contractors on-site to evaluate the progress and methodology compliance of Applied Research projects.

Budget:
<u>Table 7.1:</u>
$450,000

<u>Available budget for 2018:</u>

$450,000

Estimated 2018 budget:
$450,000*

*The EAA pays the utility costs for use of the facilities ($25,000 is budgeted for facility use). There is no annual fee for the use of the FAB for Applied Research.

2018 EAHCP Refugia Work Plan

Introduction

The U.S. Fish and Wildlife Service (USFWS) San Marcos Aquatic Resources Center (SMARC) and Uvalde National Fish Hatchery (UNFH), and BIO-WEST Incorporated (BIO-WEST) will provide refugia, salvage, reintroduction, and monitoring services in fulfillment of the Refugia Contract (Contract # 16-822-HCP) between the Edwards Aquifer Authority (EAA) and the USFWS.

This annual work plan and associated cost estimate have been developed per the requirements of contract number 16-822-HCP for the Implementation of the Refugia Program under the EAHCP. The tasks and subtasks that follow provide the details for the services to be performed in 2018, which provide for the maintenance of a refugia population of the Covered Species (Table 1) including the salvage, propagation, and restocking of the species, if species-specific habitat triggers occur and species are extirpated.

Table 1: Eleven species identified in the EAHCP and listed for coverage under the ITP.

Common Name	Scientific Name	ESA Status
Fountain darter	*Etheostoma fonticola*	Endangered
Comal Springs riffle beetle	*Heterelmis comalensis*	Endangered
San Marcos gambusia	*Gambusia georgei*	Endangered*
Comal Springs dryopid beetle	*Stygoparnus comalensis*	Endangered
Peck's Cave amphipod	*Stygobromus pecki*	Endangered
Texas wild-rice	*Zizania texana*	Endangered
Texas blind salamander	*Eurycea rathbuni*	Endangered
San Marcos salamander	*Eurycea nana*	Threatened
Edwards Aquifer diving beetle	*Haideoporus texanus*	Petitioned
Comal Springs salamander	*Eurycea* sp.	Petitioned
Texas troglobitic water slater	*Lirceolus smithii*	Petitioned

*The San Marcos gambusia was last collected in the wild in 1983, and may already be extinct.

Long-term Objective

A series of refugia held at the SMARC and UNFH will preserve the capacity for the Covered Species to be re-established at the Comal and San Marcos rivers in the event of the loss of population due to a catastrophic event such as the loss of spring flow or a chemical spill.

Background: Section 5.1.1 of the EAHCP requires the EAA to provide a series of refugia, with back-up populations, to preserve the capacity for these species to be re-established in the event of the loss of population due to a catastrophic event.

The concept of refugia is to house and protect adequate populations of the Covered Species and to conduct research activities to expand knowledge of their habitat requirements, biology, life histories, and effective reintroduction techniques. Actions and funding contained within this work plan will be limited to the Covered Species listed in the EAHCP and those associated

species that have significant impact on the Covered Species such as predators, competitors, pathogens, parasites, food, cover, and shelter.

2018 Assumptions

As work plans are developed almost a year prior to implementation, it is possible that methods described herein may be contingent on the status of the current year's activities or authorization from the HCP process.

- Target numbers for the standing and refugia stocks to be housed at both the UNFH and SMARC are established by the USFWS-EAA Refugia Contract (Contract # 16-822-HCP).
- Species capture and mortality rates will be similar to historic values.
- Mortality rates of specimens held in captivity will be similar to historic values.
- Target species collection numbers from the 2017 work plan are reached.
- Construction and renovation will not be interrupted or unexpectedly delayed due to weather, equipment, procurement related delays, or other unforeseen issues.
- Staffs remain employed at the two Service facilities throughout the performance period.

Target for 2018 (Deliverables and Methods by Task):

Task 1. Refugia Operations

Standing Stocks The standing stocks at the SMARC and UNFH will be considered standing stocks under the executed contract (Contract # 16-822-HCP) and will be held in Service facilities until EAA specific Refugia and Quarantine facilities are complete and functional. USFWS staff will take all appropriate steps to collect and maintain standing/refugia stocks at their respective target captive population size in order to provide refugia for all the Covered Species. Table 2 displays the target species numbers.

Table 2. Species target refugia numbers and census.

Species	Standing Stock	Refugia Stock	Salvage Stock	Anticipated SMARC census (1/1/2018)	Anticipated SMARC census (12/31/2018)	Anticipated UNFH census (1/1/2018)	Anticipated UNFH census (12/31/2018)
Fountain Darter (Comal)	1000	1000 including specimens within the standing stock	2000	600	1000	600	1000
Fountain Darter (San Marcos)	1000	1000 including specimens within the standing stock	2500	600	1000	600	1000
Texas Wild-Rice	430	430 including specimens within the standing stock	1500	197	238	133	149
Texas Blind Salamander	500	500 including specimens within the standing stock	500	20	40	10	30
San Marcos Salamander	500	500 including specimens within the standing stock	500	250	500	250	500
Comal Springs Salamander	500	500 including specimens within the standing stock	500	50	100	50	100
Peck's Cave Amphipod	500	500 including specimens within the standing stock	500	250	450	250	450
Comal Springs Riffle Beetle	500	500 including specimens within the standing stock	500	250	500	250	500
Comal Springs Dryopid Beetle	500	500 including specimens within the standing stock	500	35*	45*	12*	24*
Edwards Aquifer Diving Beetle	500	500 including specimens within the standing stock	500	*	*	*	*
Texas Troglobitic Water Slater	500	500 including specimens within the standing stock	500	*	*	*	*

*catch rates and hatchery survival are uncertain given the rarity of the species

Collection: In 2018, we will collect Covered Species as required to reach and maintain target standing and refugia stock numbers as shown in Table 2. Species collections will be coordinated with other ongoing HCP activities (e.g. Biological Monitoring Program) so that collections for refugia do not impact other efforts adversely. Species specific collections will be carried out through a variety of passive and active collection methods. Prior to collections, Hazard Analysis Critical Control Point (see Appendix A 2017 Work Plan) will be conducted to minimize aquatic invasive species transfer. Catch per unit effort will be documented for each species and reported to the EAA in the year-end report. Captured specimens will be divided between the SMARC

and UNFH facilities in order to ensure redundancy and to expedite the obligation to establish and maintain two equally sized refugia populations at separate locations. All species will be held in respective quarantine areas until their health has been assessed. Once it is determined that specimens are free from pathogens, parasites, and invasive species they will be incorporated into the general refugia population. USFWS will share reports, including test results, produced as part of the quarantine process. Species-specific collection plans closely follow those detailed within the 2017 Work Plan; however, collection efforts may vary depending upon what occurs during 2017 collection efforts. The following sections briefly describe planned 2018 collection, maintenance, and propagation efforts for each species.

Fountain Darters:

Collection: Fountain darters will be collected primarily using dip nets to obtain and maintain target numbers (N = 1,000 per river). Approximately 20% of the fountain darters collected annually succumb to natural mortality. If unusual mortality events occur, they will be thoroughly investigated and summary reports will be conveyed to the EAA as part of the monthly reports. As a result, fish collections will target additional fish so that as individuals perish the remainder within the captive population should not decrease below the target number between collection events. Specimens will be collected along a longitudinal gradient. Approximately equal proportions of fish from upper, middle, and lower reaches in the Comal (upper = below Landa Lake dam to confluence of new and old channels, middle = from new and old channel confluence to City Tube Chute, lower = City Tube Chute to confluence of the Guadalupe River) and San Marcos (upper = Spring Lake, Middle = Spring lake dam to Rio Vista dam, lower = below Rio Vista dam to Capes dam) rivers will be collected. Fountain darters will not be collected from Landa Lake given the past detection of largemouth bass virus. If largemouth bass virus is detected in the downstream reaches below Landa Lake, fountain darters will be maintained within quarantine facilities. Fountain darters will be collected primarily during the spring and fall to minimize thermal stress during capture and transport. As part of quarantine procedures, a subset of fish (N = 60) will sent to Dexter Fish Health Unit or equivalent facility for pathogen (bacteria, virus, and parasite) testing prior to specimen incorporation into the general refugia population following standardized methods outlined within USFWS and AFS-FHS (2016) and AFS-FHS (2005); reports will be provided to EAA.

Maintenance: Tank and system maintenance such as acid washing and system sterilization will occur semi-annually or as needed to ensure proper system function. Water quality (i.e. temperature, pH, dissolved oxygen, total dissolved gasses) will be monitored and recorded weekly. Fountain darters will be fed live foods reared or purchased. Ponds will be utilized to produce zooplankton and amphipods. Ponds will be managed to maintain idealized zooplankton assemblages and densities. Amphipods will be collected from other managed ponds and raceways (see Cantu et al. 2009). Black worms will be purchased when necessary along with other food resources (i.e. blood worms, black worms, brine shrimp, etc.) if the need arises. Food items are not routinely examined for pathogens. However, if they are suspect and tested for pathogens all diagnostic results will be conveyed to the EAA within monthly reports.

Propagation: Standing and refugia stocks for each river will be maintained to discourage reproduction unless HCP triggers occur. Fish will be maintained by their geographical locations. If reintroduction is warranted, subsets from each geographical location will be communally

spawned. Subset groups will be culled to an equal number of progeny prior to release.

<u>Texas wild rice:</u>

Collection: Texas wild rice tillers will be collected from specific San Marcos River reaches, with a break during summer months when wild rice does not fare well due to heat stress (Fig. 1). Tillers will be collected in a proportional manner to mirror the genetic diversity currently and historically available within the population (Table 3; Wilson et al. 2016). During tiller collection, the GPS coordinates, area coverage, and depth of the stand or individual plant will be recorded so the exact location of the clone is known. For larger stands, tillers will be collected at the beginning, middle and end of the stand, or every 20% of the stand's total length for the largest stands. Although tiller collection in most river reaches will be done by wading some river reaches require the use SCUBA gear. Texas wild rice seeds from the river will also be collected monthly or when available and stored at both facilities. Seed stocks will be replaced every six months when seeds are available.

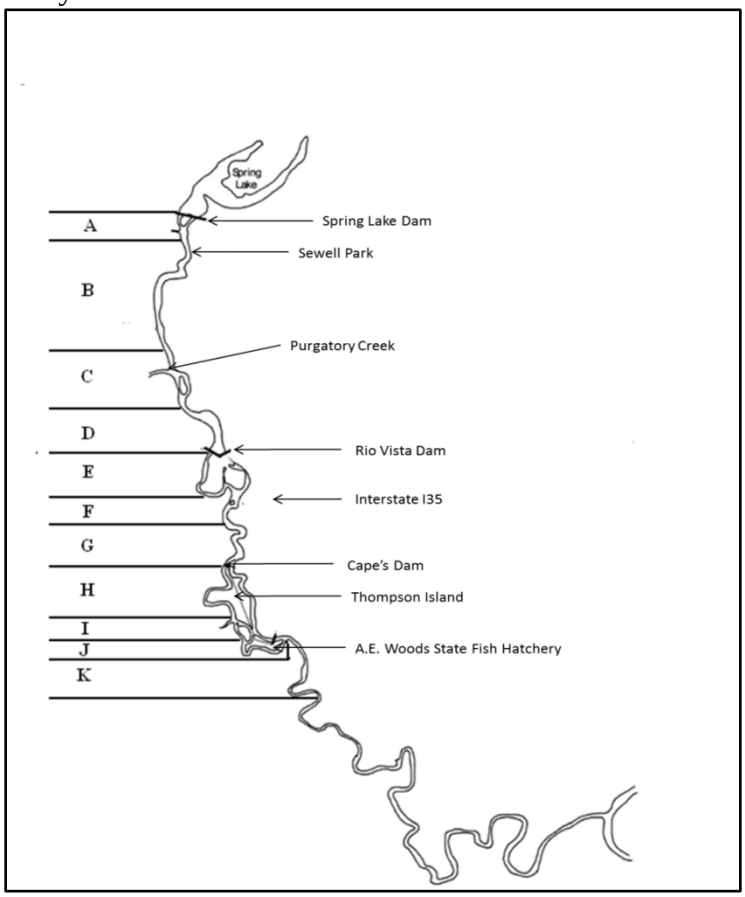


Figure 1. Letters define designated San Marcos River reaches where Texas wild rice is collected for refugia populations.

Maintenance: Once tillers have been successfully rooted they will be tagged and maintained so that their collection location is known.

Propagation: Plants will be maintained by their geographical locations. Plants will be

maintained so sexual reproduction does not occur within the refugia population, unless HCP triggers occur. If reintroduction is warranted, seeds and tillers from each geographical location will be produced. Plants produced from seeds and tillers would be transplanted back within their original geographic location.

Table 3. The number of Texas wild rice plants needed at the SMARC and UNFH to obtain the total target number of 430. Each San Marcos River reach is denoted by a letter and the proportion of specimens needed per reach is estimated from Wilson et al. (2016). Based on Wilson et al. (2016) no plants will be collected from sections I, L, M (, shaded-out). Viability of plants in section G, H, J, and K (*) are still being assessed due to flood/scouring events, best efforts will be made to collect in these areas without over taxing the plants. Projected numbers are based on an anticipated mortality of 20% for newly acquired plants and 10% for mature refugia stock.**

River Section	Estimated Stock Jan 2018	Number of plants collected in 2018*	Anticipated 2018 EOY Census
SMARC			
A	19	10	25
B	94	20	101
C	34	5	35
D	5	5	8
E	5	4	8
F	23	10	29
G*	3	5*	7
H*	2	5*	6
I**	-	-	-
J*	9	5*	12
K*	3	5*	7
L**	-	-	-
M**	-	-	-
UNFH			
A	28	0	25
B	40	30	60
C	16	10	23
D	5	5	8
E	3	4	6
F	10	10	17
G*	7	5*	10
H*	3	5*	7
I**	-	-	-
J*	6	5*	9
K*	3	5*	7
L**	-	-	-
M**	-	-	-

Texas blind salamanders:

Collection: Texas blind salamanders will be collected through the use of nets and traps. Traps will be deployed quarterly for five consecutive days to collect Texas blind salamander specimens from Primers Fissure, Johnson's well, Rattlesnake cave, and Rattlesnake well (Table 5). To avoid oversampling these habitats, only 1/3 of salamanders observed from each of these locations will be collected during quarterly sampling events. Concurrently, salamanders will also be collected from Sessoms Creek, Texas State University Diversion Springs, and a third outlet near Diversion Springs (Spring Lake Outflow). These latter sites will be fished continuously until refugia target specimen numbers are met, given the assumption that any Texas blind salamander leaving a spring orifice that enters a stream or lake environment will ultimately succumb to predation. These sites will be checked for specimens up to three times per week where applicable. All specimens will be transported live and maintained in the SMARC and UNFH refugia. Approximately 5% of the Texas blind salamanders collected annually succumb to natural mortality. As a result, salamander collections will continue until the captive population exceeds target numbers by at least 12 individuals at both the SMARC and UNFH.

Maintenance: Specimens will be maintained by collection location. As part of quarantine, all salamanders of each species will be non-lethally cotton swabbed. These samples will be sent to Dexter Fish Health Unit to screen for *Batrachochytrium dendrobatidis* (Bd, commonly referred to as chytrid) and *Batrachochytrium salamandrivorans* (Bsal) prior to specimen incorporation into the general refugia population. All salamanders will be held in quarantine for at least 30 days and until test results have returned. Chytrid (Bd) fungus has caused mortalities in amphibian species; however, some species appear to have innate immunity. Previous tests of wild caught salamanders at SMARC (both Texas Blind and San Marcos) have almost always tested positive for Bd. Clinically, the salamanders appear normal and do not have any lesions or signs of disease. Positive testing for Bsal will be treated more cautiously as it has not been documented in this area before; these salamanders would remain in quarantine until further study and recommendations from FWS Fish Health. Salamander tank and system maintenance such as acid washing and system sterilization will occur annually or as needed to ensure proper system function. Water quality will be monitored and recorded weekly. Salamanders will be fed live foods reared or purchased. Ponds will be utilized to produce amphipods. Amphipods will be collected from other managed ponds and raceways (see Cantu et al. 2009). Black worms will be purchased when necessary along with other food resources (i.e. blood worms, brine shrimp, etc.) if the need arises.

Propagation: Standing and refugia stocks will be maintained to encourage reproduction. Salamanders will be maintained by their geographical locations. All progeny will be maintained separately by generations. If reintroduction is warranted, an attempt will be made to produce offspring from each geographical location.

San Marcos salamanders:

Collection: San Marcos salamanders will be collected up to quarterly from below Spring Lake dam (western shore), Diversion Springs, areas surrounding Diversion Springs, and Spring Lake Outflow (Table 5). Collection efforts will be coordinated with the HCP Biological Monitoring Program. A SCUBA team will be used for a portion of these collection efforts. These sites will be checked for specimens regularly. All specimens will be transported live and maintained in the

SMARC and UNFH refugia. Approximately 30% of the San Marcos salamanders collected annually succumb to natural mortality. As a result, salamander collections will target additional specimens so that as individuals perish the remainder within the captive population should not decrease below the target number between collection events.

Maintenance: Specimens will not be maintained by collection location. As part of quarantine, all salamanders of each species will be non-lethally cotton swabbed. These samples will be sent to Dexter Fish Health Unit to screen for *Batrachochytrium dendrobatidis* (Bd, commonly referred to as chytrid) and *Batrachochytrium salamandrivorans* (Bsal) prior to specimen incorporation into the general refugia population. All salamanders will be held in quarantine for at least 30 days and until test results have returned. Chytrid (Bd) fungus has caused mortalities in amphibian species; however, some species appear to have innate immunity. Previous tests of wild caught salamanders at SMARC (both Texas Blind and San Marcos) have almost always tested positive for Bd. Clinically, the salamanders appear normal and do not have any lesions or signs of disease. Positive testing for Bsal will be treated more cautiously as it has not been documented in this area before; these salamanders would remain in quarantine until further study and recommendations from FWS Fish Health. Salamander tank and system maintenance such as acid washing and system sterilization will occur annually or as needed to ensure proper system function. Water quality will be monitored and recorded weekly. Salamanders will be fed live foods reared or purchased. Ponds will be utilized to produce amphipods. Amphipods will be collected from other managed ponds and raceways (see Cantu et al. 2009). Black worms will be purchased when necessary along with other food resources (i.e. blood worms, brine shrimp, etc.) if the need arises.

Propagation: Standing and refugia stocks will be maintained to discourage reproduction. If reintroduction is warranted, pairwise mating will be employed to produce offspring. Stocking will occur once juveniles have reached 30 mm total length.

***Comal Springs salamanders*:**

Collection: Comal Springs salamanders will be collected quarterly from Comal Spring runs 1-3 and Spring Island and surrounding areas (Table 5). Close coordination with the HCP biological monitoring program will take place to ensure that to the degree practicable, refugia collections do not overlap with specific HCP long-term monitoring locales. In the event overlap of sampling areas is unavoidable, Comal salamanders for refugia will be collected at a rate of no more than 10% of salamanders observed in those specific locales per daily sampling trip. A SCUBA team will be used for a portion of these collection efforts as necessary. Annual natural mortality will be recorded. As a result, salamander collections will target additional salamanders so that as individuals perish the remainder within the captive population should not decrease below the target number between collection events.

Maintenance: Specimens will not be maintained by collection location. As part of quarantine, all salamanders of each species will be non-lethally cotton swabbed. These samples will be sent to Dexter Fish Health Unit to screen for *Batrachochytrium dendrobatidis* (Bd, commonly referred to as chytrid) and *Batrachochytrium salamandrivorans* (Bsal) prior to specimen incorporation into the general refugia population. All salamanders will be held in quarantine for at least 30 days and until test results have returned. Chytrid (Bd) fungus has caused mortalities

in amphibian species; however, some species appear to have innate immunity. Previous tests of wild caught salamanders at SMARC (both Texas Blind and San Marcos) have almost always tested positive for Bd. Clinically, the salamanders appear normal and do not have any lesions or signs of disease. Positive testing for Bsal will be treated more cautiously as it has not been documented in this area before; these salamanders would remain in quarantine until further study and recommendations from FWS Fish Health. Salamander tank and system maintenance such as acid washing and system sterilization will occur annually or as needed to ensure proper system function. Water quality will be monitored and recorded weekly. Salamanders will be fed live foods reared or purchased. Ponds will be utilized to produce amphipods. Amphipods will be collected from other managed ponds and raceways (see Cantu et al. 2009). Black worms will be purchased when necessary along with other food resources (i.e. blood worms, brine shrimp, etc.) if the need arises.

Propagation: Standing and refugia stocks will be maintained to discourage reproduction. If reintroduction is warranted, pairwise mating will be employed to produce offspring. Stocking will occur once juveniles have reached 30 mm total length.

Comal Springs riffle beetle:

Collection: Comal Spring riffle beetle collection will occur quarterly and be coordinated with the HCP Biological Monitoring Program (Table 5). Riffle beetles will be collected with cotton lures. Cotton lures will be deployed in a variety of locations (Spring Runs 1, 2, 3, N = 10-15 lures per spring run; western shore of Landa Lake, N = 5 lures; Spring Island and associated Spring Lake habitats N = 15-20 lures) following EAHCP standard operating procedures (Hall 2016). Coordination with the HCP biological monitoring program will take place to ensure that to the degree practicable, refugia collections do not overlap with specific HCP long-term monitoring locales. In the event overlap of specific routine sampling locations is unavoidable, Comal Springs riffle beetles for refugia will be collected at a rate of no more than 25% of beetles observed per lure in those specific locales per daily sampling trip. Lures will be allowed to mature biofilms for four weeks. Riffle beetles will be collected during the fourth week and lures will be removed. Approximately 50% of the Comal Springs riffle beetles collected annually succumb to natural mortality. As a result, invertebrate collections will target additional specimens so that as individuals perish the remainder within the captive population should not decrease below the target number between collection events.

Maintenance: Specimens will not be maintained by collection location. Comal Springs riffle beetles will be maintained within custom built aquatic holding units and fed detrital matter and matured biofilms colonized on cotton lures.

Propagation: Propagation methods for this species are being developed.

Peck's Cave amphipod:

Collection: Peck's Cave amphipod collection will occur five times annually (Table 5). Adult Peck's cave amphipods will be collected through the use of drift nets and hand collection. Drift nets will be deployed in a variety of locations (Spring Run 3, N = 2; Spring Island and associated Spring Lake habitats, hand collection). Approximately 50% of the Peck's Cave amphipod collected annually succumb to natural mortality. As a result, invertebrate collections will target

additional specimens so that as individuals perish the remainder within the captive population should not decrease below the target number between collection events.

Maintenance: Specimens will not be maintained by collection location. Peck's Cave amphipods will be maintained within custom built aquatic holding units and fed commercial flake fish feeds.

Propagation: Propagation methods for this species are being developed as part of standard refugia operations.

Comal Springs dryopid beetle:

Collection: Comal Spring dryopid beetle collection will occur quarterly (Table 5). Dryopid beetles will be collected through the use of cotton lures concurrently with Comal Spring riffle beetle and during independent sampling trips. Cotton lures will be deployed in a variety of locations (Sessoms Creek N = 5 to 10 lures; Spring Island and associated Spring Lake habitats, 10 to 15 lures). In addition to cotton lures, wooden dowel rods will concurrently be tested as a lure technique for dryopid beetles. All lures (cotton or wooden) will be allowed to mature biofilms for four weeks. Dryopid beetles will be collected during the fourth week and lures will be removed. If collection numbers need to be supplemented or low flows decrease upwelling locations in other areas, bottle traps will also be deployed into Panther Canyon Well. Bottle traps will be checked weekly for a month.

Maintenance: Specimens will not be maintained by collection location. Comal Spring dryopid beetle will be maintained within custom built aquatic holding units and fed detrital matter and matured biofilms colonized on cotton lures.

Propagation: Propagation methods for this species are being developed as part of normal refugia operations.

Edwards Aquifer diving beetle:

Collection: Drift nets will be used to collect Edwards Aquifer diving beetle (Table 5). Drift nets will be set at a variety of locations where the species has been collected in the past (Sessoms Creek N = 1; Texas State University Artesian Well N = 1; and Diversion Springs N = 1 to 2). Drift nets will be deployed and checked weekly over the course of the year.

Maintenance: Specimens will not be maintained by collection location. Captured specimens will be transferred to the SMARC and housed in custom made aquatic holding systems. Initially the species will be fed small invertebrates (e.g. ostracods), given they are predators.

Propagation: Propagation methods for this species are to be determined and will be conducted as part of normal refugia operations.

Texas troglobitic water slater:

Collection: Drift nets will be used to collect the Texas troglobitic water slater (Table 5). We intend to set drift nets (Sessoms Creek; N = 1, Texas State University Artesian Well N = 1; and Diversion Springs N = 1 to 2) weekly as necessary. Drift nets will be checked weekly over the

course of the year. Lures will also be placed in Spring Lake and allowed to mature a biofilm for four to six weeks. A SCUBA team will be required to set and retrieve these Spring Lake lures.

Maintenance: Captured specimens will be transferred to the SMARC and housed in custom made aquatic holding systems. Initially the species will be fed detrital matter and matured biofilms colonized on cotton lures.

Propagation: Propagation methods for this species are to be determined and will be conducted as part of normal refugia operations.

Table 5. All species sampling schedule for 2018. Abbreviations: T = Tuesday, F = Friday, TSU = Texas State University.

Edward's Aquifer Species Collection Plan 2018			
Date (month)	**Interval**	**Location**	**Target Species**
Continuous	Check nets T and F every week	Diversion Springs and well outflow, Sessoms Creek and TSU well	Texas Blind salamander, Edward's Aquifer diving beetle, and troglobitic water slater
Continuous	Check lures/Set new lures on a 4 week cycle	Sessoms Creek	Comal Springs dryopid beetle
Continuous	Check lures/Set new lures on a 4 week cycle	Spring Runs and Landa Lake	Comal Springs dryopid beetle
January	Check every T & F for 2 consecutive weeks	Rattlesnake Cave & Rattlesnake Well	Texas blind salamander
February	Check every T & F for 2 consecutive weeks	Primer's Fissure & Johnson's Well	Texas blind salamander
February	1-2 day sampling event	Comal Springs	Comal Springs salamander
February/March	Set lures (1 day)-Feb, 4 weeks later Retrieve lures (2 days)-March	Spring Runs and Landa Lake	Comal Springs riffle beetle
March	1-2 day sampling event	Diversion Springs, western shore, & below dam	San Marcos salamander
March/April	Set lures-March, 4 weeks later Retrieve lures-April	Spring Lake	Texas troglobitic water slater

April	Check every T & F for 2 consecutive weeks	Rattlesnake Cave & Rattlesnake Well	Texas blind salamander
April	Hand pick/drift net (1 day)	Spring Runs and Landa Lake	Peck’s cave amphipod
May	Check every T & F for 2 consecutive weeks	Primer's Fissure & Johnson's Well	Texas blind salamander
May	1-2 day sampling event	Comal Springs	Comal Springs salamander
May	2 days	San Marcos River and Comal River	Fountain darters
May/June	Set lures (1 day)-May, 4 weeks later Retrieve lures (2 days)-June	Spring Runs and Landa Lake	Comal Springs riffle beetle
June	Hand pick/drift net (1 day)	Spring Runs and Landa Lake	Peck’s cave amphipod
July	Check every T & F for 2 consecutive weeks	Rattlesnake Cave & Rattlesnake Well	Texas blind salamander
July	Hand pick/drift net (1 day)	Spring Runs and Landa Lake	Peck’s cave amphipod
August	Check every T & F for 2 consecutive weeks	Primer's Fissure & Johnson's Well	Texas blind salamander
August	Bottle traps every week (if needed to supplement numbers or due to low flow)	Panther Canyon	Comal Springs dryopid beetle
August	1-2 day sampling event	Comal Springs	Comal Springs salamander
August/September	Set lures (1 day)-Aug, 4 weeks later Retrieve lures (2 days)-Sept	Spring Runs and Landa Lake	Comal Springs riffle beetle
September	1-2 day sampling event	Diversion Springs, western shore, & below dam	San Marcos salamander

September/October	Set lures-Sept, 4 weeks later Retrieve lures-Oct	Spring Lake	Texas troglobitic water slater
October	Check every T & F for 2 consecutive weeks	Rattlesnake Cave & Rattlesnake Well	Texas blind salamander
October	Hand pick/drift net (1 day)	Spring Runs and Landa Lake	Peck's cave amphipod
October	2 days	San Marcos River and Comal River	Fountain darters
November	Check every T & F for 2 consecutive weeks	Primer's Fissure & Johnson's Well	Texas blind salamander
November	Hand pick/drift net (1 day)	Spring Runs and Landa Lake	Peck's cave amphipod
November	1-2 day sampling event	Comal Springs	Comal Springs salamander
November/December	Set lures (1 day)-Nov, 4 weeks later Retrieve lures (2 days)-Dec	Spring Runs and Landa Lake	Comal Springs riffle beetle

Refugium Stocks:

Collection: Species collections will be ongoing until refugia stocks target numbers are obtained as shown in Table 2.

Maintenance: Maintenance will be conducted in a similar manner described for standing stocks.

Propagation: Texas blind salamander, Comal Springs riffle beetle, Comal Springs dryopid beetle, Edwards Aquifer diving beetle, and Texas troglobitic water slater may be propagated to further advance culture techniques. Propagation for stocking is not anticipated during 2018.

Salvage Stocks:

Collection: If HCP species-specific salvage triggers are reached in consultation with the EAA, the SMARC will accommodate salvaged organisms no more than two times during the 12-year period. If triggers for multiple species are reached simultaneously species collections during salvage operations will be prioritized based upon the perceived species-specific effect of reduced river and spring flow and habitat degradation (i.e. EAHCP triggers). Those species that are river obligate species (e.g. fountain darter and Texas wild rice) or that occupy spring orifice and interstitial ground water habitats (e.g. San Marcos and

Comal Springs salamander, Peck's Cave amphipod, Comal Springs dryopid beetle) as opposed to those that reside solely within the aquifer (e.g. Edwards Aquifer diving beetle, Texas troglobitic water slater and Texas blind salamander) are presumed to be affected first as flows decrease.

Maintenance: Organisms collected during salvage operations would be maintained at the SMARC for a limited duration (up to one-year) or until their disposition was determined. Research may be suspended or terminated if space is required for salvaged organisms. Research may also be suspended if personnel are directed to collection and maintain salvage stocks.

Propagation: Likewise, production of species would be limited to no more than two times during the 12-year period once species extirpation is determined. Species produced at the SMARC would be held for a limited time (up to one year) or less if stocking is required. Research activities may be suspended or terminated if space is required to house cultured species. Research may also be suspended if personnel are directed to reproduce, maintain, or stock salvage stocks or standing stock progeny.

Construction/Renovation/Infrastructure/Facility:

It is anticipated that construction on the Refugia and Quarantine spaces at UNFH will be completed during December 2017-January 2018. UNFH staff will install tanks upon construction completion. After systems are set up, covered species will be moved into the spaces.

Construction on the SMARC Refugia and Quarantine buildings will continue into 2018 with anticipated completion during March 2018. SMARC staff inspector will continue weekly reports until construction completion.

After construction is complete the SMARC Center Director will develop and maintain a list of warranty problems during the 1-year warranty period, forwarding items, as they occur, to the Contracting Officer (CO) and the USFWS Project Manager (COR).

As detailed within the EAA contract with the USFWS (Contract No. 16-822-HCP) all invoices from the USFWS to the EAA for the construction services shall be billed on the last business day of the month and sent monthly and shall provide an itemization of the expenses incurred and all supporting documentation.

All reasonable and practical security measures will be instituted by SMARC and UNFH staff to safeguard EAA refugia facilities, equipment, and species.

Anticipated Equipment Purchases 2018 not including construction and renovation materials:

U.S. Fish and Wildlife Service						
	Task	**Equipment**	**Quantity**	**Cost/Unit**	**Total**	**Total Task Budget Amount**
1	Refugia Operations					$350,400
	SMARC Quarantine bldg.					
		Fiberglass tanks	20	$ 3,000	$ 60,000	
	SMARC Rearing bldg.					
		Fiberglass tanks	10	$ 3,000	$ 30,000	
	UNFH Renovation Holding House (Rearing bldg.)					
		Fiberglass tanks	20	$ 3,000	$ 60,000	
		1 HP Chiller Units	9	$ 6,600	$ 59,400	
	UNFH Renovation Tank House (Quarantine bldg.)					
		Fiberglass tanks	10	$ 3,000	$ 30,000	
	SMARC Reimbursibles				$69,000	
	UNFH Reimbursibles				$42,000	
2	Research					$20,000
		PVC/Fittings			$ 10,000	
		Custom net/trap components misc. supplies			$ 5,000	
		Misc. supplies			$ 5,000	
3	Species Propagation and Husbandry	N/A				$0
4	Species Reintroduction	N/A				$0
5	Reporting	N/A				$0
6	Meetings and Presentations	N/A				$0
Total					**$ 370,400**	

Staffing/Labor/Personnel:

The Supervisory Fish Biologists (SFBs) at both the SMARC and UNFH will continue in their duties including, but not limited to: supervising, mentoring, and training lower-graded employees, authorize purchases, oversee facility maintenance and repair, develop and implement budgets, organize and maintain outreach materials and activities that relate to all contract activities. The SFBs will manage and coordinate propagation, culture, and field activities related to the refugia. The SFBs are expected to provide proper and efficient use of facilities and staff resources. The SFBs will work with the Center Director to ensure that contractual obligations are met in a timely manner. In coordination with the Center Director, they will prepare all the required written materials required for the reimbursable agreement reporting. Likewise, the SFBs will also prepare oral presentations to be used as briefing statements, outreach presentations, internal reports, work summaries, and technical presentations at professional meetings. The two SFBs will continue to work and communicate regularly with partners, Service personnel and other researchers to effectively meet Service and reimbursable agreement goals.

Under the management of a lead supervisory biologist at both facilities, it is expected that the three Biological Science Technicians will continue to assist with the collection, daily upkeep, maintenance, and propagation efforts for the nine species at the SMARC and UNFH. This

includes maintaining experimental and culture production systems, keeping records along with entering, filing, and collating data. The incumbents will also generate basic summary statistics and graphic analyses of data and document program accomplishments through the composition of Standard Operating Procedures (SOPs), reports, and manuscripts.

Permitting:
Both the UNFH and SMARC operate under the USFWS Southwest Region's Federal Fish and Wildlife Permit for Native, Endangered, and Threatened Species Recovery (number TE676811-3) and the Texas Parks and Wildlife Scientific Research Permits (UNFH SPR-1015-222, SMARC SPR-0616-153).

Biosecurity:
Both the UNFH and SMARC operate under the SMARC BioSecurity Plan (2014) (Exhibit E of 16-822-HCP). Specimen Collection, Hazard Analysis Critical Control Points, Quarantine, & Specimen Transfer: San Marcos Aquatic Resources Center Standard Operating Procedure.

Task 2. Research

The Research Plan for 2018 will involve a series of activities ranging from 1) continuing and expanding upon on-going species-specific studies for *Stygoparnus comalensis*, *Stygobromus pecki*, and *Heterelmis comalensis*; 2) conducting research specific to captive propagation refinement for San Marcos salamanders; and 3) reexamining invertebrate collection methodologies concurrent with testing new designs. The following section describes the basic components of each of these proposed 2018 activities.

Continuation of Life History Studies:
Project 1:

Title: Continued evaluation of life stage development, diet, and environmental stimuli directly related to the successful captive propagation of Comal Springs Dryopid Beetles (*Stygoparnus comalensis*).

Species: Comal Springs dryopid beetle

Principal/Co-PI: BIO-WEST, input by Randy Gibson, Dr. Lindsay Campbell

Overview: At present (2017), objectives for *S. comalensis* applied refuge research are to, 1) determine conditions that contribute to the production of eggs, 2) determine where and how eggs are deposited and egg morphology, 3) determine incubation duration of eggs, 4) study the rate of larval development, 5) document the morphology of larval instars, and 6) determine factors that contribute to pupation. However, not all aspects of research commenced in 2017 are expected to be completed by the end of 2017 primarily due to the relatively long life cycle of *S. comalensis* and limited availability of test subjects.

Ongoing 2017 research is expected to be able to produce eggs and larvae of *S. comalensis* and determine where and how eggs are deposited, the conditions that contribute to the production of eggs, egg size and morphology, and how long eggs incubate before hatching. However, it is unlikely that larvae will have completed development leaving the remaining tasks incomplete at the conclusion of 2017.

Objectives and Methods: Life history studies will be continued into 2018 with an

expansion into evaluating additional life history characteristics, diet and environmental stimuli that may affect the captive propagation of this species. The major objectives of 2018 research for *S. comalensis* are to:

- continue studies of factors contributing to egg production to optimize this phase of cultivation;
- continue studies of factors contributing to eggs successfully hatching to optimize this phase of cultivation;
- continue research documenting growth rate and instars of larvae,
- initiate studies on adult diet to optimize adult survival;
- initiate studies on larval diet in an effort to optimize diet for each larval instar in an effort to achieve higher survivability of larvae as it is possible that nutritional requirements change as larvae develop;
- if appropriate, study factors that contribute to pupation and eclosure into adults; and
- if appropriate, estimate the overall life span.

The last two bullets start with "if appropriate" which is directly tied to the uncertainty of pupation for this species. Literature documents that development for dryopid larvae can take 2-5 years before pupating (Ulrich 1986). Subterranean species tend to have development exasperated for durations much longer than their epigean relatives (Culver and Pipan 2009), therefore it is possible that *S. comalensis* larvae require longer than 5 years to complete development; potentially much longer. It is anticipated that last two tasks will require study into the future to fully describe the life span of *S. comalensis*. Specific methods for each 2018 activity will be developed towards the conclusion of 2017 research in order to maximize the knowledge gained from ongoing experimentation.

Expected Results: In compilation with 2017 findings, 2018 results will provide information on the life cycle of *S. comalensis* necessary to promote effective and efficient captive propagation of this species. The key life history aspects will be a better understanding of reproduction and the growth, development, diet, and environmental stimuli that affect life stages relative to success in captivity. The main deliverable will be a final report that includes an updated standard operating procedure (SOP) for rearing Comal Springs dryopid beetles through their various life stages. The SOP will include instructions for rearing, descriptions of equipment used, environmental stimuli incorporated, and other husbandry requirements and recommendations for future studies.

Project 2:

Title: Continued evaluation of life stage development including life span description and sex determination of Peck's Cave Amphipods (*Stygobromus pecki*).

Species: Peck's Cave Amphipod

Principal/Co-PI: BIO-WEST, input by Randy Gibson, Dr. Lindsay Campbell

Overview: At present (2017), objectives for *S. pecki* applied refuge research are to: 1) determine how many molts must occur before it becomes possible to distinguish individuals from other *Stygobromus* species and better understand the morphology of each developmental stage; 2) estimate how many molts must occur before sexual maturity is reached; 3) estimate how frequently a female can produce a brood and the typical size of a brood; and 4) to better understand sexual dimorphism for the purpose of

creating individual breeding pairs. Ongoing 2017 research is expected to yield several answers and solutions pertaining to the captive propagation and life history of *S. pecki*. It is anticipated that average incubation time of eggs will be determined, neonates will be produced, reared to an old enough age so that species specific characteristics can be discerned, with morphology and development documented along with timing of developmental events. It is also possible that certain aspects of sexual dimorphism and female brood size and frequency will be better understood. However, it is unlikely that all aspects of 2017 research will be completed in 2017 as literature documents that subterranean amphipods (like other subterranean species) have a much slower rate of development and reproduction than epigean species typically taking at least a year to mature (Crawford and Tarter 1979).

Objectives and Methods: Life history studies will be continued into 2018 with an expansion into evaluating additional life history characteristics that may affect the captive propagation of this species. The major objectives of 2018 research are to:

- complete the estimate how many molts must occur before sexual maturity is reached;
- complete research on how frequently a female can produce broods and the typical size of broods;
- estimate life span of *S. pecki*, if possible; and
- initiate research into sex determination and sex ratios in *S. pecki*. This final objective is expected to be of great utility to captive propagation as sex ratio in amphipods is a plastic and quantitative trait, therefore it is possible under certain conditions to rear amphipods of only one sex; a situation not desirable for propagation. Specific methods for each 2018 activity will be developed towards the conclusion of 2017 research in order to maximize the knowledge gained from ongoing experimentation.

Expected Results: In compilation with 2017 findings, 2018 results will provide information on the life cycle of *S. pecki* in order to promote effective and efficient captive propagation of this species. The key life history aspects will be a better understanding of the life span, sexual maturity, how many and what size of broods can be produce, sex determination, and sex ratios in captivity versus the wild. The main deliverable will be a final report that includes an updated standard operating procedure (SOP) for rearing Peck's Cave amphipods through their various life stages. The SOP will include instructions for rearing, descriptions of equipment used, environmental stimuli incorporated, and other husbandry requirements and recommendations for future studies.

Project 3:

Title: Continuation of Comal Springs riffle beetle (*Heterelmis comalensis*) life history studies.

Species: Comal Springs riffle beetle
Principal/Co-PI: BIO-WEST, input by Randy Gibson, Dr. Lindsay Campbell.

Overview: The primary goal of the second year of study (2017) was to identify factors contributing to pupation. As of April 2017, pupa have been experimentally produced via this study. As the first pupation event took approximately four months, it is anticipated that expanding the knowledge base on factors leading to successful pupation may extend beyond 2017. Therefore, research activities directed at understanding the successful

production of *H. comalensis* adults in captivity are anticipated for 2018. These activities will be further defined using 2017 results but are anticipated to involve continued investigation of pupation and life-stage specific diets.

San Marcos Salamander propagation refinement
Species: *Eurycea nana*
Principal: Dr. Lindsay Campbell, Kelsey Anderson
Overview: Salamanders will be sexed and then separated in different tanks by sex for eight weeks. After the separation period, salamanders will then be combined into either equal sex-ratio groups (i.e. 4 females/4 males, at least 3 replicate groups) or individual pairs (3-9 pairs) to initiate mating. After two weeks males will be removed from tanks and materials conducive to egg deposition will be placed in tanks.
Expected Information gathered:

- time to courtship behavior once combined
- time to oviposition to occur after sexes combines
- number of females to successfully lay eggs
- number of eggs laid
- number of eggs to successfully hatch
- length of time until eggs hatch
- length of time until larvae absorb egg sacks
- time until larvae begin to feed
- differences between pairwise vs group mating in these categories

Invertebrate Collection Techniques
Species: *Stgoparnus comalensis*, *Stygobromus pecki*, *Haideoporus texanus*, *Lirceolus smithii*
Principal: Amelia Everett, Dr. Lindsay Campbell
Overview: Evaluate existing invertebrate collection techniques, locations, seasonality for effectiveness, patterns, and drawbacks based on collected data from previous year. Investigate new invertebrate collection techniques and test new designs in an effort to enhance the effectiveness and efficiency.
Expected Information gathered:

- CPUE by location, type of net/lure
- Alternative net/lure design for each species generated, tested

Task 3. Species Propagation and Husbandry

Development and refinement of SOPs for animal rearing and captive propagation: Continue to refine SOPs for all species as needed for updates to reflect new protocols that are instituted for each species throughout the year. As new information becomes available about genetic management, further develop draft Captive Propagation Plans for all species.

Task 4. Species Reintroduction

Reintroduction Plan for term of contract:
Further revise the draft Reintroduction Strategy presented in 2017. Compose additional Captive

Propagation Plans.

Reintroduction Plan for 2018: None

Any anticipated triggers being prepared for: Given current weather predictions, spring flows, and the Edwards Aquafer water level none are anticipated during the 2018 performance period.
2018 Activity: Draft sub-contract for services provided by BIO-WEST.

Task 5. Reporting

5.1 Species specific Propagation plans (SOPs): Refine throughout year as needed
5.2 Species specific Genetic Management plans: None during 2018
5.3 Species specific Reintroduction plans: Revise draft plan presented in 2017
5.4 2018 EAHCP Annual Program reporting 12/31/2018 – A year-end report of 2018 activities will be provided to the EAA no later than 12/31/2018.
5.5 Program reporting as required by ITP and TPWD. TPWD Scientific Research Permit Report will be conveyed to the EAA July 31, 2018.
5.6 Descriptions and photographs of procedures from collections to restocking – Photographs and documentation of collection and restocking will be included in the monthly report to the EAA CSO along with the year-end report.
5.7 Summaries of any data analyses, research, or genetic analyses – Research projects and results of collection efforts will be provided to the EAA in the monthly reports, year-end documentation, and stand-alone documents (agreed upon by Center director and HCP CSO).
5.8 Description of terms and conditions of any permits received – As permits are received, their contents will be conveyed to the EAA.
5.9 Monthly electronic reports to HCP CSO: A monthly report of all activities will be provided to the HCP CSO. We anticipate providing the report by the 10th of each month for the previous month's activities.

Task 6. Meetings and Presentations

Planning or coordination meetings:
- Yearly planning meeting with SMARC and UNFH staff

- Public meetings
  - EAA Board
    - End of year report
    - Present research results
  - Implementing Committee
    - End of year summary
  - Stakeholder Committee
    - End of year summary
  - Science Committee
    - Methods for research projects
    - Present research results

Monitoring:
Monitoring will be conducted through the use of progress reports and site visits to the refugia as well as through collaborative management by the EAHCP CSO.

Budget: Projected 2018 budget.

U.S. Fish and Wildlife Service 2018

	Task	Contractor Name	Task Budget Amount	Total Task Budget Amount
1	**Refugia Operations**			**$1,013,855**
	SMARC Refugia Bldg.			
	*Construction			
	**Equipment		$60,000	
	Utilities		$59,512	
	SMARC Quarantine Bldg.			
	*Construction			
	**Equipment		$30,000	
	Utilities		$22,888	
	UNFH Renovation Refugia Bldg.			
	*Construction			
	**Equipment		$119,400	
	Utilities		$54,167	
	UNFH Renovation Quarantine Bldg.			
	*Construction			
	**Equipment		$30,000	
	Utilities		$20,833	
	SMARC Species Husbandry and Collection			
	Fish Biologist (GS-12, 2088 hrs)		$50,571	
	Fish Biologist (GS-07, 2088 hrs)		$28,509	
	Fish Biologist (GS-07, 2088 hrs)		$28,509	
	Fish Biologist (GS-07, 2088 hrs)		$28,509	
	Fish and Wildlife Administrator (GS-14, 261 hrs)		$19,961	
	SMARC Staff (GS-11, 522 hrs)		$23,818	
	Maintenance technician (WG-5, 522 hrs)		$13,932	
	UNFH Species Husbandry and Collection			
	Fish Biologist (GS-12, 2088 hrs)		$41,861	
	Fish Biologist (GS-07, 2088 hrs)		$28,286	
	Fish Biologist (GS-07, 2088 hrs)		$28,286	
	Fish Biologist (GS-07, 2088 hrs)		$28,285	
	Supervisory Fish Biologist (GS-12, 261 hrs)		$10,534	
	UNFH Staff (GS-06, 522 hrs)		$27,679	
	SMARC Reimbursibles		$69,000	
	UNFH Reimbursibles		$42,000	
	Subtotal		$866,542	
	Admin costs for Task 1		$147,312	
2	**Research**			**$398,970**
	Dryopid beetle life history	BIO-WEST	$90,000	
	Peck's Cave amphipod life history	BIO-WEST	$85,000	
	Riffle beetle	BIO-WEST	$15,000	
	Captive propagation refinement salamanders		$64,000	
	Invertebrate collection refinement		$87,000	
	Subtotal		*$341,000*	
	Admin costs for Task 2		*$57,970*	
3	**Species Propagation and Husbandry**		*$0*	**$0**
	Subtotal		*$0*	
4	**Species Reintroduction**		*$0*	**$0**
	Subtotal		*$0*	
5	**Reporting**			**$91,482**
	Draft Annual Report		$36,190	
	Annual Workplan and Cost Estimate		$26,000	
	Status Reports		$16,000	
	Subtotal		*$78,190*	
	Admin costs for Task 5		*$13,292*	
6	**Meetings and Presentations**		$13,100	**$15,327**
	Subtotal		*$13,100*	
	Admin costs for Task 6		*$2,227*	
	Subtotal sum (SMARC & UNFH)		$1,519,634	
	TOTAL		**$1,519,634**	

**= Remainder of 2017 construction costs detailed within the 2017 work plan will be applied to 2018 if needed. This would occur through an amendment to the 2017 work plan. Budget totals for the construction and renovation projects at UNFH and SMARC are not anticipated to increase.*

*** = Equipment to be purchased during 2018. Funding applied via 2017 workplan amendment in anticipation of completed construction and renovation.*

Projected (2018) Budget Summarized by Task:

Task 1: $866,542.00
Task 2: $341,000.00
Task 3: $0.00
Task 4: $0.00
Task 5: $78,190.00
Task 6: $13,100.00

Projected (2018) Subcontractor Expenses Summarized by Task

Task 1: Dexter Fish Health Unit Dexter NM $8,000.00 (Health Diagnostics)
Task 2: BIO-WEST TBD estimated at $150,000.00 to $190,000.00.
Task 3: $0
Task 4: $0
Task 5: $0
Task 6: $0

Timeline of 2018 Milestones (List major deliverables)

January	Continue with species collection
	Subcontract drafted
	2018 Specific Research Study Plans Drafted
February	Subcontract executed
	2018 Specific Research Study Plans finalized
March	Construction completed on SMARC Refugia and Quarantine buildings
	Submit and renew TPWD permit
September to	Draft Research Reports
December	Draft Annual report

Chad Furl, PhD Chief Science Officer Edwards Aquifer Authority

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Ken Ostrand, PhD Center Director SMARC, UNFH US Fish and Wildlife Service

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FMA § 2.2 EAHCP Program Management

Section 2.2 of the Funding and Management Agreement (FMA) assigns "general management and oversight" of the Edwards Aquifer Habitat Conservation Plan (EAHCP) to the Edwards Aquifer Authority (EAA). Section 5.6.5 of the FMA allows the EAA to use EAHCP funds for administrative costs and employee salaries, so long as all incurred costs and salaries are 100% related to "general management and oversight" of the EAHCP.

Long-term Objectives: To manage and oversee day-to-day operations and administration, in coordination with the Applicants, of the EAHCP; resulting in a valid and continued Incidental Take Permit (ITP) from the United States Fish and Wildlife Service (USFWS) for designated Covered Activities. Additionally, to prepare for and gather information to be used in the Phase II Strategic Adaptive Management decision-making process.

Program Management: In 2018, EAHCP staff will continue to coordinate and monitor the work outlined in the Biological Monitoring, Water Quality Monitoring, Applied Research, ASR, VISPO, and Regional Water Conservation Program work plans. Under the direction of the Chief Science Officer, EAHCP staff will oversee the continued development and operations of the Refugia program which will also include all Refugia research activities. In 2018, the EAHCP staff will continue to update the EAHCP database.

Additionally, in 2018, EAHCP staff will continue the following activities:

Program Manager: The EAHCP Program Manager will execute duties as assigned in the FMA and:

- Serve on the ASR Advisory Committee,
- Facilitate the Adaptive Management Process for all Routine, Nonroutine and Strategic AMP decisions,
- Facilitate and coordinate all meetings of the EAHCP Implementing, Science and Stakeholder Committees (and possible Subcommittees and Work Groups as created by the Implementing and Stakeholder Committees) and the meetings of the Science Review Panel – the National Academy of Sciences (NAS) committee.

EAHCP Staff: The EAHCP staff will continue the following activities:

- Prepare for all meetings of the EAHCP Implementing, Science, and Stakeholder Committees, (and possible Subcommittees and Work Groups as created by the Implementing and Stakeholder Committees) and the meetings of the Science Review Panel – the National Academy of Sciences,
- Prepare materials for all Adaptive Management Process activities,
- Procure and execute contracts,
- Oversee contract tracking and compliance,
- Process and pay all contractor's invoices,
- Process and pay all
- Oversee the City of New Braunfels and San Marcos/Texas State University work plan activities,

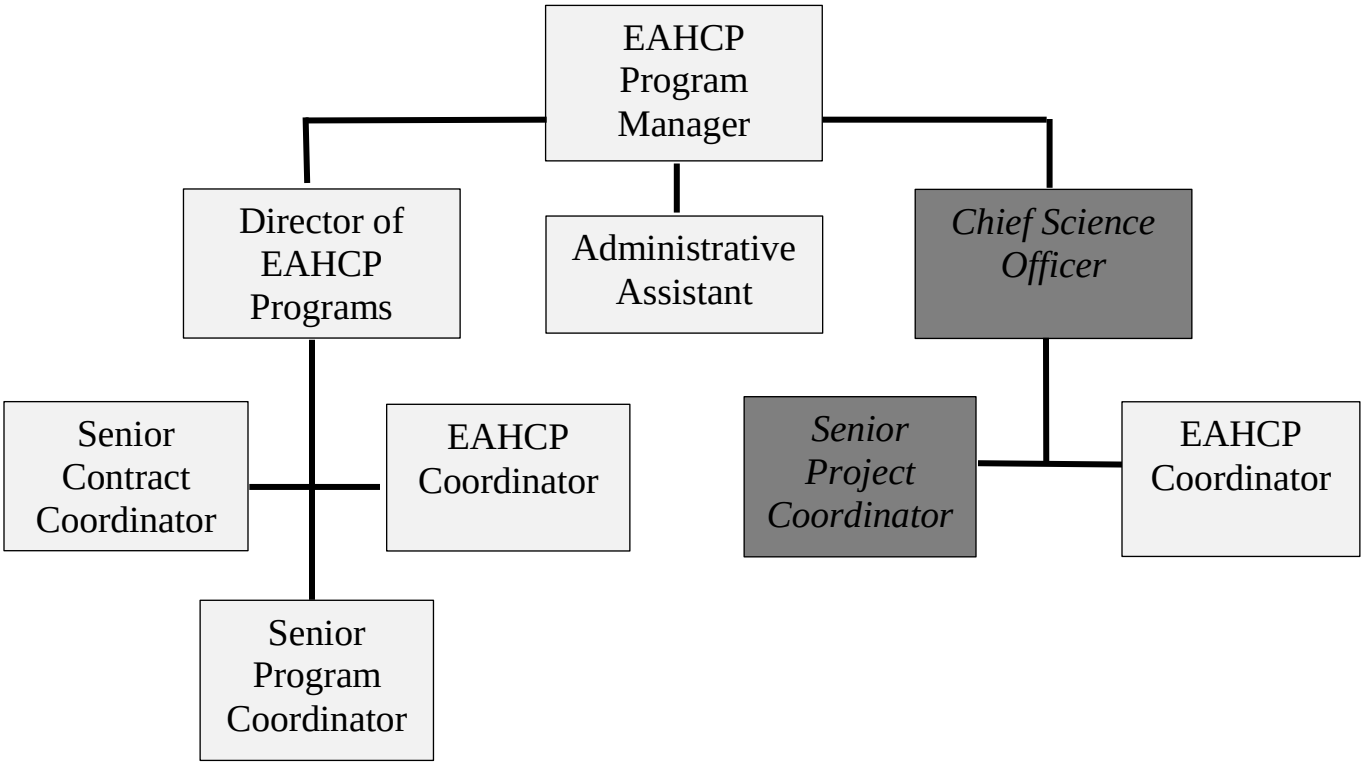
- Oversee and coordinate research activities at the Texas State University Freeman Aquatic Building,
- Coordinate 2018 work plan amendments and the development of 2019 work plans,
- Draft and submit to the USFWS amendments, informational memorandums, and clarifications to the Incidental Take Permit and EAHCP,
- Participate in public outreach initiatives,
- Publish the EAHCP Steward newsletter,
- Enhance the EAHCP.org website,
- Prepare and compile all Permittees' information for the annual report to USFWS, and
- Track and assist EAHCP Permittees with maintaining compliance with secondary implementation permits, such as: U.S. Army Corps of Engineers, Texas Parks and Wildlife Department, Texas Commission on Environmental Quality, General Land Office, and Texas Historical Commission permits.

Adaptive Management Program (AMP): EAHCP staff, under direction of the Program Manager, will manage the adaptive management decision making process as defined in the Funding and Management Agreement. Specifically, Article 7 defines the procedures for the AMP. In 2018, EAHCP staff will compile all relevant completed research, modeling and other data to be used in the AMP, which could lead to Phase II activities. Also, EAHCP staff will serve as a liaison to USFWS in the AMP process.

EAHCP Implementing, Science and Stakeholder Committees and Work Groups and subcommittees: EAHCP staff, under the direction of the Program Manager, will continue to manage the meetings and activities of all EAHCP Committees and any subcommittees or Work Groups. The Implementing and Science Committees will meet according to approved schedules and the Stakeholder Committee will meet quarterly.

Science Review Panel/National Academy of Sciences: In 2018, EAHCP staff will continue to provide support for the meetings of the National Academy of Sciences (NAS) and will assist NAS in the development of its third report. In December 2018, the NAS committee will produce its third and final report on its evaluation of the Phase I conservation measures and its identification of the biological and hydrological questions that the ecological and hydrologic models should be used to answer. In 2019, EAHCP staff will evaluate the recommendations from this third report.

Staffing in 2018: In summary, the EAHCP staff consists of the Program Manager, Director of EAHCP programs, Senior Contract Coordinator, Senior Program Coordinator, two EAHCP Coordinators, and the Administrative Assistant. EAA funds the Chief Science Officer and Senior Project Coordinator staff positions. The structure of the existing EAHCP staff positions and EAA-funded positions are illustrated in the chart on the next page.



- Positions Paid from EAA General Budget

Budget

The following table summarizes the estimated EAHCP Program Management budget for 2018.

	Table 7.1	**2018**
Program Management	$750,000	$910,000
Science Review Panel/National Academy of Sciences	$100,000	$269,750
Total Budget	**$850,000**	**$1,179,750**

Specifically, the staffing expenses and operational expenses for 2018 are set out in the tables below.

Staffing Expenses	
Salaries	530,494
Fringe/Benefits	175,440
Total	**705,934**

Staffing and Operational Expenses	
Staffing	705,934
Meeting Expenses[3]	$20,000
Travel	$3,000
Office Supplies	$3,000
Professional Development / Memberships	$3,000
Printing	$2,000
Professional Contracted Services (PCS)	
PCS – Other	$69,566
PCS – Historical/Archeological Consultation [4]	$2,500
PCS – Annual Report	$40,000
PCS – Permit Oversight[5]	$10,000
PCS – Science Committee Compensation	$18,000
PCS – Outreach/Newsletter[6]	$33,000
Total Expenditure	**$910,000**

[3] Meeting expenses for Implementing, Stakeholder and Science Committees as well as ad-hoc work groups. Also, includes reimbursement expenses for Science Committee members travel costs.
[4] Contract for costs to obtain Texas Historical Commission permits for conservation and mitigation measures activities.
[5] Contract for costs to obtain U.S. Army Corps of Engineers, Texas Parks and Wildlife Department, and Texas Commission on Environmental Quality permits for conservation and mitigation measures activities.
[6] Contract to produce the EAHCP bi-monthly newsletter and monthly EAHCP ASR newsletter.

City of New Braunfels
2018 Work Plan

2018 City of New Braunfels Work Plan Budget

HCP Section	Conservation Measure	Table 7.1	Available Budget for 2018	Estimated 2018 Budget	Delta from Available Budget
5.2.1	Flow Split Management	$0	$0	$0	$0
5.2.2.1/ 5.2.2.3	Old Channel Aquatic Vegetation Restoration & Maintenance	$100,000	$100,000	$100,000	$0
5.2.2.2/ 5.2.2.3	Landa Lake/ Comal River Aquatic Vegetation Restoration & Maintenance	$50,000	$50,000	$50,000	$0
5.2.3	Management of Public Recreation	$0	$0	$0	$0
5.2.4	Decaying Vegetation Removal and Dissolved Oxygen Management	$15,000	$15,000	$15,000	$0
5.2.5/5.2.9	Non-Native Animal Species Control	$75,000	$75,000	$55,000	($20,000)
5.2.6/ 6.3.6	Monitoring and Reduction of Gill Parasites	$75,000	$75,000	$30,000	($45,000)
5.2.7	Prohibition of Hazardous Material Transport Routes	$0	$0	$0	$0
5.2.8	Native Riparian Habitat Restoration (Riffle Beetle)	$25,000	$25,000	$35,000	$10,000
5.2.10	Litter and Floating Vegetation Management	$0	$0	$30,000	$30,000
5.2.11	Golf Course Management	$0	$0	$0	$0
5.7.1	Native Riparian Habitat Restoration	$100,000	$50,000	$50,000	$0
5.7.5	Management of Household Hazardous Waste	$30,000	$30,000	$30,000	$0
5.7.6	Impervious Cover/ Water Quality Protection	$100,000	$100,000	$125,000	$25,000
	Totals	**$570,000**	**$520,000**	**$520,000**	**$0**

5.2.1 Flow Split Management

Long-term Objective:
To sustain flow rates in the Old Channel of the Comal River that compliment Old Channel aquatic vegetation restoration efforts, minimize channel scouring, and maximize the quality of fountain darter habitat.

Target for 2018:
Maintain flow rates in the Old and New Channels of the Comal River to meet objectives specified in the revised Table 5-3 of the EAHCP (**Table 1**).

Priority will be given to achieving target flow rates in the Old Channel and, secondly, to flow rates in the New Channel. City of New Braunfels staff will monitor streamflow conditions via USGS streamflow gages and operate the flow-control gate between Landa Lake and the Old Channel to achieve flow targets. Maintenance activities associated with the flow-control gate will be conducted as needed to ensure continued operability.

Table 1. EAHCP Table 5-3 (revised)

Total Comal Springflow (cfs)	Old Channel (cfs)		New Channel (cfs)	
	Fall, Winter	Spring, Summer	Fall, Winter	Spring, Summer
350+	65	60	280+	290+
300	65	60	235	240
250	60	55	190	195
200	60	55	140	145
150	55		95	
100	50		50	
80	45		35	
70	40		30	
60	35-40		25	
50	35-40		15	
40	30		10	
30	20		10	

Methodology:
The City of New Braunfels will manage the flow-split program according to flow rates specified in revised Table 5-3. A standard operating procedure has been developed by the City of New Braunfels to guide adjustments to the flow-control gate and to achieve flow-split targets. City of New Braunfels staff will monitor real-time streamflow conditions at USGS gages in the Comal River system and adjust the flow-control gates, as needed, to meet flow-split streamflow targets. The primary 48” culvert gate and the new back-up culvert gates will be operated conjunctively to meet target flow rates. Floating vegetation and debris will be manually removed from the control gate and screen from a canoe or boat. Floating vegetation is managed and funded under task of 5.2.10: Litter and Floating Vegetation Management. The flow control gate will be exercised routinely to maintain functionality of the gate.

Monitoring:
Flow rates in the Old Channel, New Channel, and Comal River will be based on real-time streamflow data provided by the USGS gages in the Comal River. City of New Braunfels staff will monitor streamflow on a weekly basis, at minimum. Adjustments to the flow-control gate will be made on an as-needed basis to meet flow-spilt management objectives. City of New Braunfels staff will monitor the flow-control gate and intake screen on a regular basis to assess for vegetation build-up and debris that have the potential to restrict flow into the culvert between Landa Lake and the Old Channel. When required, trash racks and vegetation barrier booms will be cleaned to prevent accumulations of vegetation and debris.

Budget:
Table 7.1:
$0

Available budget:
$0

Estimated 2018 budget :
$0

5.2.2.1/ 5.2.2.3 Old Channel Aquatic Vegetation Restoration and Maintenance

Long-term Objective:
To achieve native aquatic vegetation coverage goals for the Old Channel Long-Term Biological Goal (LTBG) reach and the Old Channel Environmental Restoration & Protection Area (ERPA) reach as set forth in the revised EAHCP tables 4.1 and 4.1.1, respectively. The overall intent of native aquatic vegetation plant restoration is to provide high quality habitat for the fountain darter.

Target for 2018:
The Old Channel LTBG reach and the Old Channel ERPA are considered high priority areas for the protection of fountain darters. **Figure 1** illustrates the Comal Springs/ River ecosystem and identifies the Old Channel LTBG reach (shown along the Old Channel in red) and the Old Channel ERPA (shown in light green and labeled as the Old Channel Restoration Reach). The 2018 annual aquatic plant restoration goals, as well as the long-term goals, for the Old Channel LTBG reach and the Old Channel ERPA are specified by reach and vegetation type in **Table 2**. Continued efforts will also be made in 2018 to remove, suppress, and potentially eliminate non-native *Hygrophila* from the Old Channel LTBG reach and the Old Channel ERPA.

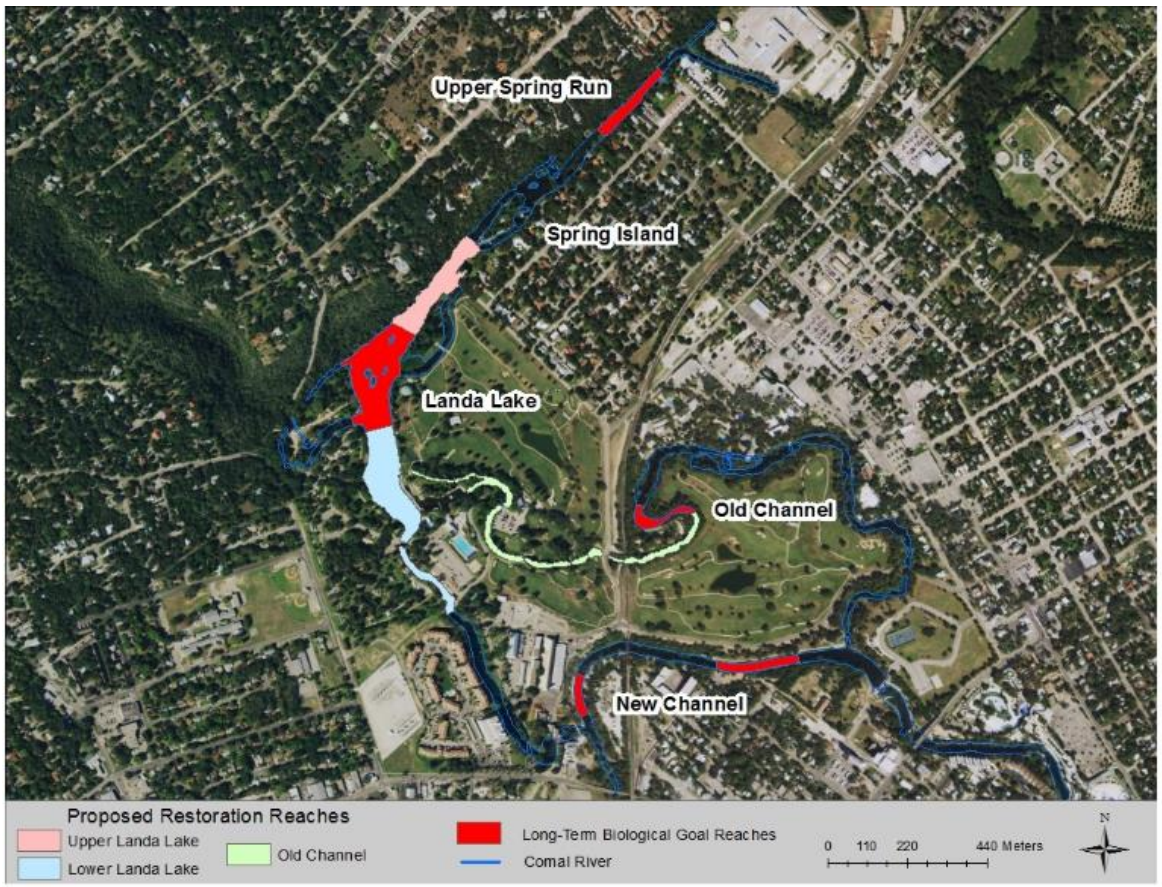


Figure 1: Long-term biological goal reaches and restoration reaches for the Comal System. The Old Channel ERPA restoration reach is shown in green. The Old Channel LTBG reach is shown in red.

Table 2: Annual and long-term aquatic vegetation restoration goals, in meters squared (m^2), within Old Channel LTBG & ERPA restoration reaches.

Reach	Aquatic Vegetation Species	Meters squared of aquatic vegetation (m^2)	Annual Restoration Goal	Approximate # of plantings needed to meet annual goal
		Long-term Goal	**2018**	**2018**
LTBG Reaches				
Old Channel	*Ludwigia*	425	75	1,125-1,500
	Cabomba	180	30	600
	Sagittaria	450	75	900
Restoration Reaches				
Old Channel ERPA	*Ludwigia*	850	75	1,125-1,500
	Cabomba	200	25	500
	Sagittaria	750	25	300
	Vallisneria	750	0	0
	Potamogeton	100	10	60

Methodology:

Non-Native Vegetation Management:
Non-native aquatic vegetation (i.e. *Hygrophila*) will be removed to minimize competition with native submerged aquatic vegetation (SAV). Large-scale removal of non-native SAV will be completed by using a 4-step method that involves 1) initial removal of plant and root mass, 2) secondary removal and clearing of remaining plant and root mass approximately one week following initial removal, 3) allowing for a grace period of 2-3 weeks to allow areas to settle and remaining roots to grow, 4) a final, detailed effort to remove all remaining roots from the area.

Aquatic vegetation gardening will occur on a monthly basis in areas where non-native vegetation has previously been removed on in order to identify and remove re-emergent non-native SAV. Small, localized growth of non-native SAV will be removed by selectively extracting visible plant and root mass.

Native SAV Restoration:
Target SAV species will be planted within the Old Channel LTBG reach and the Old Channel ERPA to increase the coverage of individual plant species per the annual restoration goals set forth in **Table 2**. An approximate number of plants needed to achieve the annual goals is also included in **Table 2**. Individual plant species will be planted where planting space is available and in locations within the channel where light exposure, flow velocities, and substrate provide the best conditions for the individual plant types.

Ludwigia will continue to be propagated in-situ within Landa Lake in order to provide plant stock for 2018 restoration efforts. In-situ propagation of *Ludwigia* will be conducted by collecting stem cuttings from *Ludwigia* plants present within the Comal River system. The cuttings will be placed in pots filled with substrate collected from within the Comal River system. The potted cuttings are then placed in Mobile Underwater Plant Propagation Trays (MUPPTs) that will be situated in a shallow portion of Landa Lake and allowed to produce roots and plant mass.

Ludwigia plants propagated in the MUPPTs, as well as *Ludwigia* cuttings, will be planted in suitable locations within the Old Channel LTBG reach to achieve an annual target of 75 m^2 of additional *Ludwigia* coverage and within the Old Channel ERPA to achieve 75 m^2 of additional *Ludwigia* coverage. Slightly more than the targeted coverage of *Ludwigia* will be planted in order to account for plant die-off. Approximately 15-20 *Ludwigia* plants are needed to achieve 1m^2 of coverage. Therefore, approximately 1,125-1,500 *Ludwigia* plants will be planted in both the Old Channel LTBG and the ERPA reach to achieve target annual coverage.

Cabomba typically thrives in deep, low-velocity areas and will be planted in the most suitable locations in the Old Channel LTBG reach to achieve an annual target of 30 m^2 of additional *Cabomba* coverage and within the Old Channel ERPA to achieve 25 m^2 of additional *Cabomba* coverage. *Cabomba* will be planted using stem cuttings and/ or with individual rooted plants. Stemmed cuttings will be collected from the New Channel where *Cabomba* is abundant. The cuttings will be bundled into fist-sized bundles wrapped with rubber bands to keep bundles together. The *Cabomba* cutting bundles are typically 12 to 32 inches in length and will be planted at a depth of 2/3 their length, if possible, in soft, silty sediment. This planting depth prevents *Cabomba* from loosening and floating away and ensures multiple nodes are buried to encourage maximum development of root structure. Rooted *Cabomba* will also be utilized for planting. Rooted plants will be dug up individually from areas where *Cabomba* is abundant. The rooted plants will then be planted individually into silty streambed substrate. Both the stemmed cuttings and rooted plants will be planted in a grid-pattern at 1ft centers. Significantly more than the targeted coverage of *Cabomba* will be planted in order to account for plant die-off. Approximately 20 *Cabomba* plantings are needed to achieve 1m^2 of coverage. Therefore, approximately 600 *Cabomba* plants will be planted in the Old Channel LTBG reach and 500 plants planted in the Old Channel ERPA to achieve target annual coverage.

Sagittaria will be planted in the most suitable locations in the Old Channel LTBG reach to achieve an annual target of 75 m^2 of additional *Sagittaria* coverage at full grow out and within the Old Channel ERPA to achieve 25 m^2 of additional *Sagittaria* coverage at full grow out. *Sagittaria* will be planted as transplants harvested from Landa Lake and other areas where dense *Sagittaria* stands exist. The leaves of the transplants will be trimmed prior to planting to decrease buoyancy and drag. A few *Sagittaria* plants can form a dense colony within several months. *Sagittaria* has been observed to be slightly tolerant of lower light levels allowing it to be planted in deeper water and in shady locations. Approximately 12 *Sagittaria* plants are needed to achieve 1m^2 of coverage. Therefore, approximately 900 *Sagittaria* plants will be planted in the Old Channel LTBG and 300 planted in the ERPA reach to achieve target annual coverage.

Potamogeton will be planted in the most suitable locations in the Old Channel ERPA reach to achieve an annual target of 10 m^2 of additional *Potamogeton* coverage. *Potamogeton* is suited to locations with high velocities and as such planting efforts in the Old Channel will be focused in fast-flowing areas to fill this niche. *Potamogeton* will be planted using bare- root rhizomes that are harvested from the Comal River system. Approximately six rhizome sections will need to be planted to achieve 1m^2 of *Potamogeton* coverage. Therefore, approximately 60 *Potamogeton* rhizomes will be planted in the Old Channel ERPA reach to achieve the target annual coverage.

Competition between native plants has been observed where Vallisneria and Sagittaria will encroach on and take over *Ludwigia* and *Cabomba* stands. To minimize the effects of competition and to promote the growth and spread of *Ludwigia* and *Cabomba*, buffers will be created around planted Ludwigia and Cabomba stands.

Following planting of native SAV, gardening and maintenance will occur on a monthly basis between March and October to assess health of plants and to identify and remove any non-native vegetation that is beginning to establish within planting areas.

Monitoring:
As discussed in previous sections, areas where non-native vegetation removal has occurred will be routinely monitored for the re-establishment of non-native vegetation. Planted areas will also be monitored to assess expansion, die-off, and competition by non-native species. Once native aquatic vegetation is established in an area, monitoring will be conducted on a less frequent basis.

Vegetation mapping in both the Old Channel LTBG reach and the Old Channel ERPA will be conducted to evaluate SAV coverage and to assess the progress of aquatic vegetation restoration efforts. Mapping will occur in January, April, and October. The October mapping event will be used as a basis for assessing overall SAV coverage with respect to meeting long-term vegetation goals and developing annual restoration goals for 2019 and subsequent years.

Budget:
Table 7.1:
$100,000

Available budget:
$100,000

Estimated 2018 budget:
$100,000

5.2.2.2/5.2.2.3 Comal River/ Landa Lake Aquatic Vegetation Restoration and Maintenance

Long-term Objective:
To achieve native aquatic vegetation coverage goals for the Landa Lake, New Channel, and Upper Spring Run LTBG reaches and the Upper/ Lower Landa Lake restoration reaches as set forth in revised HCP tables 4.1 and 4.1.1, respectively. The overall intent of native aquatic vegetation plant restoration is to provide high quality habitat for the fountain darter.

Target for 2018:
Figure 2 illustrates the Comal Springs/ River ecosystem and identifies the Landa Lake, New Channel, and Upper Spring Run LTBG reaches as well as the Upper/ Lower Landa Lake restoration reaches. The annual aquatic plant restoration goals for the Landa Lake, New Channel, and Upper Spring Run LTBG reaches and the Upper/ Lower Landa Lake restoration reaches are specified by reach and vegetation type in **Table 3**. No aquatic vegetation restoration is scheduled to occur in the Upper and Lower Landa Lake restoration reaches in 2018. In addition to planting the target native aquatic plants, continued efforts will be made in 2018 to remove, suppress, and potentially eliminate non-native *Hygrophila* from the Landa Lake, New Channel, and Upper Spring Run LTBG reaches and the Upper/ Lower Landa Lake restoration reaches.

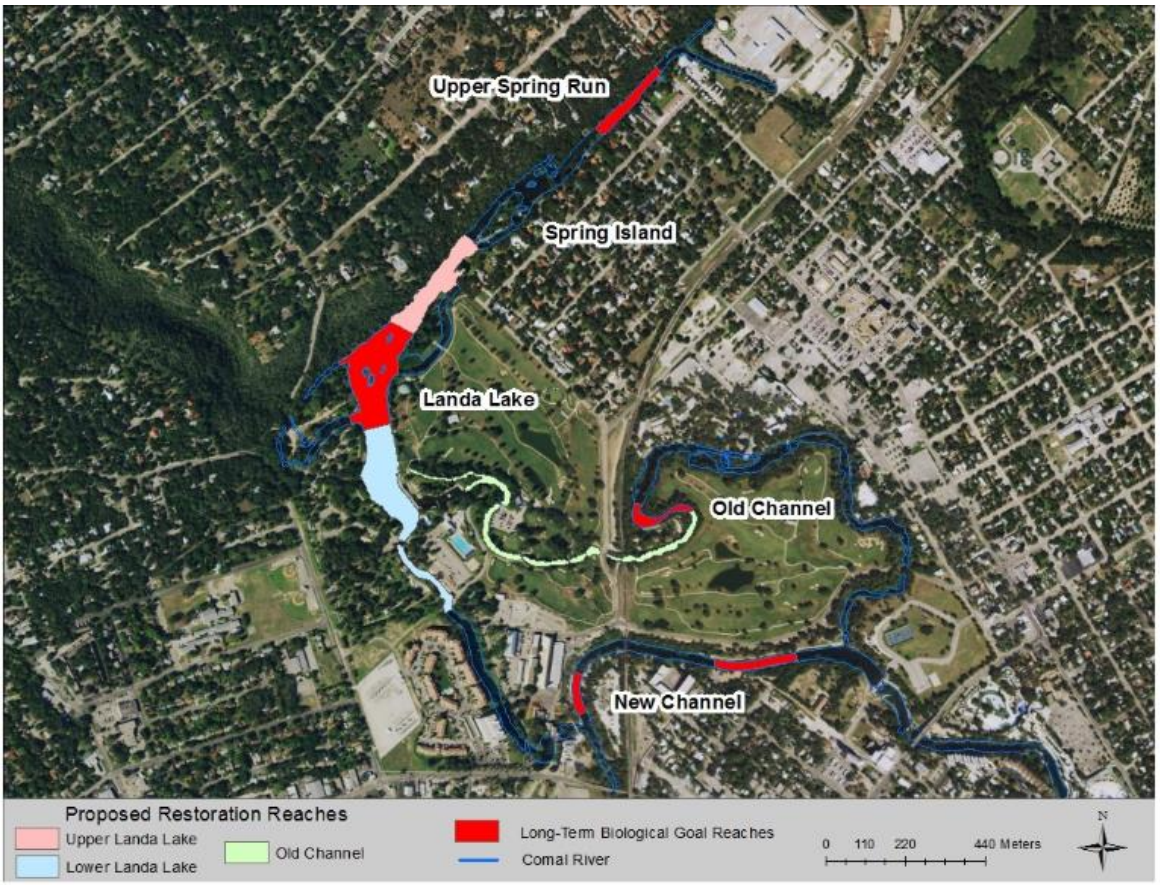


Figure 2: Long-term biological goal reaches and restoration reaches for the Comal System. The Upper and Lower Landa Lake restoration reaches are shown in light red and blue (respectively). The Landa Lake, New Channel, and Upper Spring Run LTBG reaches are shown in red.

Table 3: Annual and long-term aquatic vegetation restoration goals, in meters squared (m^2), within Landa Lake, New Channel, and Upper Spring Run LTBG reaches and Upper/ Lower Landa Lake restoration reaches.

Reach	Aquatic Vegetation Species	Meters squared of aquatic vegetation (m^2)	Annual Restoration Goal	Approximate # of plantings needed to meet annual goal
		Long-term Goal	2018	2018
LTBG Reaches				
Landa Lake	*Ludwigia*	900	75	1,125-1,500
	Cabomba	500	50	1,000
	Sagittaria	2,250	0	0
	Vallisneria	12,500	100	*
	Potamogeton	25	5	30
New Channel	*Ludwigia*	100	15	225-300
	Cabomba	2,500	20	400
	Sagittaria	0	-	-
Upper Spring Run	*Ludwigia*	25	5	75-100
	Cabomba	25	5	100
	Sagittaria	850	5	60
Restoration Reaches				
Landa Lake Upper	*Ludwigia*	25	-	-
	Cabomba	250	-	-
	Sagittaria	250	-	-
Landa Lake Lower	*Ludwigia*	50	-	-
	Cabomba	125	-	-
	Sagittaria	100	-	-
	Potamogeton	22,500	-	-

*Vallisneria will not be planted but will be allowed to naturally expand, as needed, to increase coverage.

Methodology:

Non-Native Vegetation Management:
Non-native aquatic vegetation (i.e. *Hygrophila*) will be removed to minimize competition with native submerged aquatic vegetation (SAV). Large-scale removal of non-native SAV will be completed by using a 4-step method that involves 1) initial removal of plant and root mass, 2) secondary removal and clearing of remaining plant and root mass approximately one week following initial removal, 3) allowing for a grace period of 2-3 weeks to allow areas to settle and remaining roots to grow, 4) a final, detailed effort to remove all remaining roots from the area.

Aquatic vegetation gardening will occur on a monthly basis in areas where non-native vegetation has been previously removed in order to identify and remove re-emergent non-native SAV. Small, localized growth of non-native SAV will be removed by selectively extracting visible plant and root mass.

Native SAV Restoration:
Target SAV species will be planted within the Landa Lake, New Channel, and Upper Spring Run LTBG reaches to increase the coverage of individual plant species per the annual restoration goals set forth in **Table 3**. An approximate number of plants needed to achieve the annual goals is also

included in **Table 3**.Individual plant species will be planted in locations within the channel where light exposure, flow velocities, and substrate provide the best conditions for the individual plant types.

Ludwigia will continue to be propagated in-situ within Landa Lake in order to provide plant stock for 2018 restoration efforts. In-situ propagation of *Ludwigia* will be conducted by collecting stem cuttings from *Ludwigia* plants that exist within the Comal River system. The cuttings will be placed in pots filled with substrate collected from within the Comal River system. The potted cuttings will then be placed in Mobile Underwater Plant Propagation Trays (MUPPTs) and placed in a shallow portion of Landa Lake and allowed to produce roots and plant mass.

Ludwigia plants propagated in the MUPPTs, as well as *Ludwigia* cuttings, will be planted in suitable locations within the Landa Lake reach to achieve an annual target of 75 m^2 of additional *Ludwigia* coverage at full grow out, within the New Channel reach to achieve an annual target of 15 m^2 of additional *Ludwigia* coverage at full grow out, and within the Upper Spring Run to achieve and annual target of 5 m^2 of additional *Ludwigia* coverage at full grow out. Slightly more than the targeted coverage of *Ludwigia* will be planted in order to account for plant die-off. Approximately 15-20 *Ludwigia* plants are needed to achieve 1m^2 of coverage. Therefore, approximately 1,125-1,500, 225-300, and 75-100 *Ludwigia* plants will be planted in the Landa Lake LTBG, New Channel LTBG, and the Upper Spring Run LTBG reaches, respectively to achieve target annual coverage in each reach.

Cabomba typically thrives in deep, low-velocity areas and will be planted in the most suitable locations in the Landa Lake LTBG reach to achieve an annual target of 50 m^2 of additional *Cabomba* coverage at full grow out, within the New Channel LTBG reach to achieve an annual target of 20 m^2 of additional *Cabomba* coverage at full grow out and within the Upper Spring Run LTBG reach to achieve an additional 5 m^2 of *Cabomba* coverage at full grow out. *Cabomba* will be planted using stem cuttings and/ or individual rooted plants. Stemmed cuttings will be collected from the New Channel and / or the spring-fed pool. The cuttings will be bundled into fist-sized bundles wrapped with rubber bands to keep bundles together. The *Cabomba* cutting bundles are typically 12 to 32 inches in length and will be planted at a depth of 2/3 their length, if possible, in soft, silty sediment. This planting depth prevents *Cabomba* from loosening and floating away and ensures multiple nodes are buried for production of good root structure. Rooted *Cabomba* will also be utilized and will be harvested from areas in the Comal River system where *Cabomba* is abundant. The rooted plants will then be planted individually. Both the stemmed cuttings and rooted plants will be planted in a grid-pattern at 1ft centers. Significantly more than the targeted coverage of *Cabomba* will be planted in order to account for plant die-off. Approximately 20 *Cabomba* plantings are needed to achieve 1m^2 of coverage. Therefore, approximately 1,000, 400, and 100 *Cabomba* plants will be planted in the Landa Lake LTBG, New Channel LTBG, and the Upper Spring Run LTBG reaches, respectively to achieve target annual coverage in each reach.

Sagittaria will be planted in the most suitable locations in the Upper Spring Run LTBG reach to achieve an annual coverage target of 5m^2 of additional *Sagittaria* coverage at full grow out *Sagittaria* will be planted as transplants harvested from Landa Lake. The leaves of the transplants will be trimmed prior to planting to decrease buoyancy and drag. Approximately 12 *Sagittaria* plants are needed to achieve 1m^2 of coverage. Therefore, approximately, and 60 *Sagittaria* plants will be planted in the Upper Spring Run LTBG reach to achieve target annual coverage.

Potamogeton will be planted in the most suitable locations in the Landa Lake LTBG reach to achieve an annual target of 5 m^2 of additional *Potamogeton* coverage at full grow out. *Potamogeton* will be planted using bare-root rhizomes that are harvested from the Comal River system.

Approximately six rhizome sections need to be planted to achieve $1m^2$ of *Potamogeton* coverage. Therefore, approximately 30 *Potamogeton* rhizomes will be planted in the Landa Lake LTBG reach to achieve the target annual coverage.

Competition between native plants has been observed where Vallisneria and Sagittaria will encroach on and take over *Ludwigia* and *Cabomba* stands. To minimize the effects of competition and to promote the growth and spread of *Ludwigia* and *Cabomba*, buffers will be created around planted Ludwigia and Cabomba stands.

Following planting of native SAV, gardening and maintenance will occur on a monthly basis between March and October to assess health of plants and to identify and remove any non-native vegetation that is beginning to establish within planting areas.

Monitoring:
As discussed in previous sections, areas where non-native vegetation removal has occurred will be routinely monitored for the re-establishment of non-native vegetation. Planted areas will also be monitored to assess expansion, die-off, and competition by non-native species. Once native aquatic vegetation is established in an area, monitoring will be conducted on a less frequent basis.

Seasonal vegetation mapping in the Landa Lake, New Channel, and Upper Spring Run LTBG reaches and the Upper/ Lower Landa Lake restoration reaches will be conducted to evaluate SAV coverage and to assess progress of aquatic vegetation restoration efforts. Mapping is conducted by circling the perimeter of vegetation stands with a kayak equipped with a Trimble GPS unit. Mapping will occur in January, April, and October. The October mapping event will be used as a basis for assessing overall SAV coverage with respect to meeting long-term vegetation goals and developing annual restoration goals for 2019 and subsequent years.

Budget:
Table 7.1:
$50,000

Available budget:
$50,000

Estimated 2018 budget:
$50,000

5.2.3 Management of Public Recreation

Public recreational use of the Comal River ecosystems include swimming, wading, tubing, boating, canoeing, kayaking, golfing, scuba diving, snorkeling and fishing. To minimize the impacts of incidental take resulting from recreation, the City of New Braunfels will continue to implement existing recreation control measures as specified in Section 5.2.3(1) of the HCP and will seek voluntary participation in the Certificate of Inclusion (COI) program from outfitters who facilitate recreation activities within the Comal River system.

Long-term Objective:
To minimize and mitigate the impacts of recreation on endangered species habitat within the Spring Runs, Landa Lake and the Comal River.

Target for 2018:
Inform river recreation Outfitters of the EAHCP COI program.

Continue to enforce existing restrictions that limit recreational access to Landa Lake, Spring Runs, and the Old Channel of the Comal River.

Methods:
The City will continue to work in conjunction with EAHCP program staff to develop COI program documents and strategies. The City will reach out to local river outfitters to inform them of the COI program once a framework for the COI program is established. The COI will include the minimum requirements as specified in Section 5.2.3 (2) a-h.

The City will continue to enforce existing recreational access restrictions on Landa Lake, Spring Runs, and the Old Channel utilizing trained Park Rangers.

Monitoring:
Monitor the status of participating outfitters to comply with the minimum COI outfitter standards and requirements set forth in section 5.2.3 of the EAHCP.

Budget:
Table 7.1:
$0

Available budget:
$0

Estimated 2018 budget:
$0

5.2.4 Decaying Vegetation Removal and Dissolved Oxygen Management

Long-term Objective:
Maintain adequate dissolved oxygen (DO) levels within Landa Lake for the protection of the biological community, including the fountain darter. Minimize and mitigate oxygen consumption caused by decaying vegetation.

Target for 2018:
Implement recommendations included in the comprehensive DO management plan for Landa Lake that was developed in 2017. Recommendations include:

- Displacement of floating vegetation mats, as needed, that form on Landa Lake to prevent oxygen consumption by decaying vegetation (Management of floating/ decaying vegetation will be funded and accomplished through Task 5.2.10: Litter and Floating Vegetation Management);
- Deployment of DO monitoring sensors in summer time (July through September) to collect baseline DO data in select fountain darter habitat areas;
- If low-flow conditions (<80cfs total Comal system discharge) occur, implement expanded DO monitoring at select locations (additional funding will be necessary);
- Refine and update the DO management plan as needed based upon ongoing EAHCP data collection.

Continued DO monitoring will provide additional information regarding the spatial variability of DO concentrations throughout Landa Lake as well as the potential for DO levels, especially diel DO fluctuations, to impact fountain darter populations. Monitoring data will inform future plans for mitigation of low DO levels in Landa Lake. The 2017 DO management plan is expected to be presented to the EAHCP Science Committee in late 2017 or early 2018 for consideration and input. DO management goals and proposed DO mitigation strategies that deviate from those set forth in the HCP will be evaluated through the HCP Adaptive Management Process.

Methods and Monitoring:
Aquatic vegetation conditions and floating vegetation mats will be visually observed as part of Task 5.2.10 for signs of stress or decay on a monthly basis (January-February; November-December) and on a weekly basis from March- October since floating aquatic vegetation build-up in Landa Lake is consistently greatest in the summer-time months. Floating aquatic vegetation has the potential to cause oxygen depletion from the decomposition of the mat itself and from reduced atmospheric reaeration. Should floating vegetation mats reach impactive levels (if mats cover >25% of the mid-lake area or if individual mats are >3 meters diameter), displacement or removal of the vegetation mats will take place within one week of identification as part of Task 5.2.10.

Real-time DO monitoring is conducted by Edwards Aquifer Authority (EAA) staff at Spring Run 3, Spring 7, Landa Lake, and the New Channel. These stations will continue to be monitored and funded by EAA during 2018. In addition, four logging DO sensors (e.g., comparable to MiniDOT sensors available from Precision Measurement Engineering [PME Inc. Vista, CA] that have been used in prior years) will be installed between July and September 2018 in key documented fountain darter habitat in Landa Lake. To provide a system-wide perspective, one additional sensor will be placed in the Upper Spring Run reach and one in the Old Channel Environmental Restoration and Protection Area (ERPA) during that same time period. The six sensors will be downloaded and cleaned routinely, as needed, to prevent fouling. The main objective of this 2018 summer-time data

collection is to establish more spatially explicit baseline conditions during what is anticipated to be the most stressful DO conditions (summer) on the system, particularly during low-flow events.

If low spring-flow conditions (<80cfs) occur and vegetation decay or low DO is evident, intensive displacement or removal of decaying vegetation will be implemented as appropriate under task 5.2.10. Intensive refers to the frequency of vegetation mat management being more than once per week. Displacement and/or removal will be conducted in the least disruptive method tested to be effective, to limit any additional DO stress from stirring, turbidity, etc.

Additionally, if low spring-flow (<80cfs) conditions occur in 2018, DO monitoring under task 5.2.4 will be expanded spatially to six logging DO sensors located in key fountain darter habitat areas in Landa Lake, as well as one in the Upper Spring Run area, one near Spring Island, and one in the Old Channel ERPA. The nine total sensors will be downloaded and cleaned routinely, as needed, to prevent fouling. The main objective of this expanded monitoring is to more closely track the spatial extent of potential DO concerns in concert with increased biological sampling (via the HCP Critical Period Biological Monitoring) to assist and inform important management decisions regarding potential salvage operations for the fountain darter. Should low-flow conditions (<80cfs) occur in 2018, additional funding will be necessary to implement this additional DO monitoring under task 5.2.4.

At the conclusion of 2018, EAHCP DO monitoring data (EAA real-time sondes, CONB DO sensor data, HCP biological monitoring data, any special studies, etc.) will be evaluated in the context of informing whether refinements and/or updates may be necessary to the working comprehensive DO management plan. The deliverables for this task will include a revised and updated comprehensive DO management plan, with an appendix summarizing 2018 activities and observed DO conditions.

Budget:
Table 7.1:
$15,000

Available Budget
$15,000

Estimated 2018 budget:
$15,000 (assumes low-flow conditions of <80cfs do not occur in 2018)

5.2.5/5.2.9 Non-Native Animal Species Control

The City of New Braunfels will continue to implement a program to reduce non-native animal species in the Comal River system. The non-native animal species that will be targeted include the suckermouth armored catfish, tilapia, nutria, and ramshorn snail. Since this work plan has two components identified within the HCP, each component has been broken out to facilitate the development of the work plan and budgets.

Long-term Objective:
Reduce populations of non-native animal species to minimize their direct and indirect impacts to the Covered Species and the Comal River ecosystem.

Target for 2018:
Continue existing program to remove non-native invasive species, including tilapia, nutria, and suckermouth armored catfish from the Comal River system utilizing removal methods proven successful in previous years. Continue to record counts and biomass of removed species.

Methods:
Invasive species including armored catfish, tilapia, and nutria will be removed from Landa Lake during 5-6, three-day removal sessions. These sessions will occur approximately from February to October. The EAHCP specifically mentions the need to conduct non-native removal efforts during the winter. In 2018, a removal session will occur in the winter (February). The winter removal session data will be compared to removal data from the remainder of 2018. Non-native removal data from previous years will also be evaluated to determine the optimal season to conduct removal. If the removal schedule adhered to in prior years (5-6 removal sessions between Feb and Oct) is effective, an adaptive management process may need to be initiated in order to address specific language in the EAHCP.

Gill nets will be the primary method for capturing tilapia within Landa Lake. Gill nets will be set primarily at the southern end of Landa Lake (**Figure 3**). Fyke nets will also be utilized in Landa Lake during each trapping session to capture non-native fishes. Fyke nets are passive traps that have 50-foot leads that guide fish into a 12-foot long by 3-foot wide hoop net. Fyke nets will be set in the Pecan Island slough area of Landa Lake (**Figure 3**). Snorkelers equipped with spears will also target non-native fishes early in the morning and late in the afternoon (times of high fish activity) in areas of high fish density (**Figure 3**).

Upon removal from the water, all invasive fish will be eviscerated, in accordance with state laws. The carcasses will be measured (in inches) and weighed (in pounds). Total biomass of the removed fishes will be calculated. Total length of non-native fishes will also be measured to determine if, over time, the removal of adults affects target population demographics. An attempt will also be made to determine the sex of each individual to develop a sex ratio of the species being removed during the project's timeline.

Box traps baited with carrots, sweet potatoes, and apples will be utilized to capture nutria. Traps will be placed in areas frequented by nutria (evident by slides, scat, chewed vegetation, lake-wall erosion and damage, and other observations). The traps will be checked in the late afternoon and again the next morning at approximately 7:30 am. Captured nutria will be euthanized. Removed nutria will be measured (in inches) and whole body weighed (in pounds)**.**

Approximate locations that will be targeted for non-native species removal are shown in **Figure 3** below. Trapping locations will be adjusted, as needed, based on capture rates and successes of previous removal efforts.

Figure 3. Primary non-native species target areas

Monitoring:

Removed fish species will be counted, weighed and measured. Over the past few years, each fish species has shown a significant decrease in average length and weight as compared to 2013. This decrease in size may indicate that removal efforts are suppressing the populations' ability to gain adult mass and capacity to breed. The removal program will continue to assess trends in fish size to track the effectiveness of the removal program.

The HCP Biological Monitoring program will also assess the status of non-native species populations and any impacts of non-native removal to the Covered Species.

Reduction of Non-Native Species Introduction and Live Bait Prohibition

Long-term Objective:
Minimize the introduction of non-native species to the Comal River system.

Target for 2018:
The City will enact an ordinance designed to control introductions of non-native aquatic organisms to the Comal River system. The ordinance will specifically address the usage of live bait and aquarium dumping.

Methods:
City staff will draft an ordinance prohibiting aquarium dumping and the possession of certain live bait species. The City will consult with Texas Parks and Wildlife on the regulation of live bait. The ordinance will be presented to City Council for consideration.

Monitoring:
It is anticipated that the HCP Biological Monitoring program will detect the presence of newly introduced species.

Budget:
Table 7.1:
$75,000

Available budget:
$75,000

Estimated 2018 budget:
$55,000

5.2.6/6.3.6 Monitoring and Reduction of Gill Parasites

Long-term Objective:
To conduct monitoring and acquire data on host snail (*M. tuberculatus*) density and distributions and gill parasite cercariae water column concentrations.

Target for 2018:
Continue existing gill parasite monitoring program that includes snail distribution and density monitoring and cercariae water column concentration monitoring. Analyze monitoring data to determine the overall effect and potential threat of the gill parasite on the fountain darter. Data collected in 2018 and in previous years will be used to inform management decisions regarding the gill parasite in the Comal River system.

Methods:
Host snail distribution and density monitoring:

Snail distribution and density monitoring will be conducted at the same four sampling reaches as in previous years. These monitoring reaches include:

- Upper Spring Run (USR)–from Spring Run 4 and Blieders Creek to the northern tip of Pecan Island.

- Landa Lake (LL)–from the northern tip of Pecan Island downstream to the Landa Park Drive Bridge near the dam.

- New Channel Reach (NCR)–from the Landa Park Drive Bridge downstream past the old power plant to Clemens Dam.

- Old Channel Reach (OCR)–from Landa Lake culverts downstream to the confluence with the New Channel just upstream of Clemens Dam.

One host snail survey will be conducted in 2018 using one biologist and one technician (survey team) utilizing dip nets. Each reach will be covered as thoroughly as possible in an attempt to replicate the average effort expended per crew in previous years. Locations with high densities of *M. tuberculatus* will be recorded. A GPS point will be taken to mark the location of every individual sample site. At each recorded sample site, 2–4 dip net sweeps will be taken utilizing specially designed snail dip nets. To most efficiently cover all available habitats, a staggered sampling approach will be used. If no *M. tuberculatus* are collected during the first two dips, the team will move to a new location. Similarly, if >50 *M. tuberculatus* are collected in the first two dips, the area will be considered "high density" and the team will move to a new location. A four-dip maximum will be conducted at any given sampling site. Every *M. tuberculatus* over approximately 17 mm (the smallest size thought to be infected with the parasite) will be counted, as well as any giant ramshorn snails (*Marisa cornuarietis*). All captured *M. tuberculatus* and *M. cornuarietis* collected during the course of sampling will be retained and destroyed. The survey team will continue survey efforts until they have covered all four sampling reaches. The presence or absence of another exotic snail and trematode host, *Tarebia granifera*, will also be recorded at each site.

To quantify the density of *M. tuberculatus* in "hot spot" areas of the system, density sampling will be conducted in areas identified within high abundance areas shown.

Density sampling will be conducted using a custom-designed snail density quadrat developed for this study. The device consists of a 0.25 square-meter (m^2) quadrat constructed of .5-inch PVC pipe with sheet metal attached which creates a 4-inch fence that can be pushed into the substrate to prevent the quadrat from moving. Snails within the quadrat will be removed with a snail dip net until no more snails were found. All *M. tuberculatus* will be enumerated and measured to the nearest millimeter for comparison of length-frequency data among years. Three quadrat samples will be conducted near each high-density area within the USR, LL, and NCR.

Cercariae Monitoring

To quantify density of drifting gill parasite (*C. formosanus*) cercariae in the Comal River study area, the same 3 transects (LL, OCR, RVP) sampled in 2015-2017 will be sampled in 2018. **Figure 4** illustrates the cercariae moniotinrg locations. It is felt that these 3 sites adequately represent the system as a whole and allow for efficient long-term monitoring of drifting cercariae.

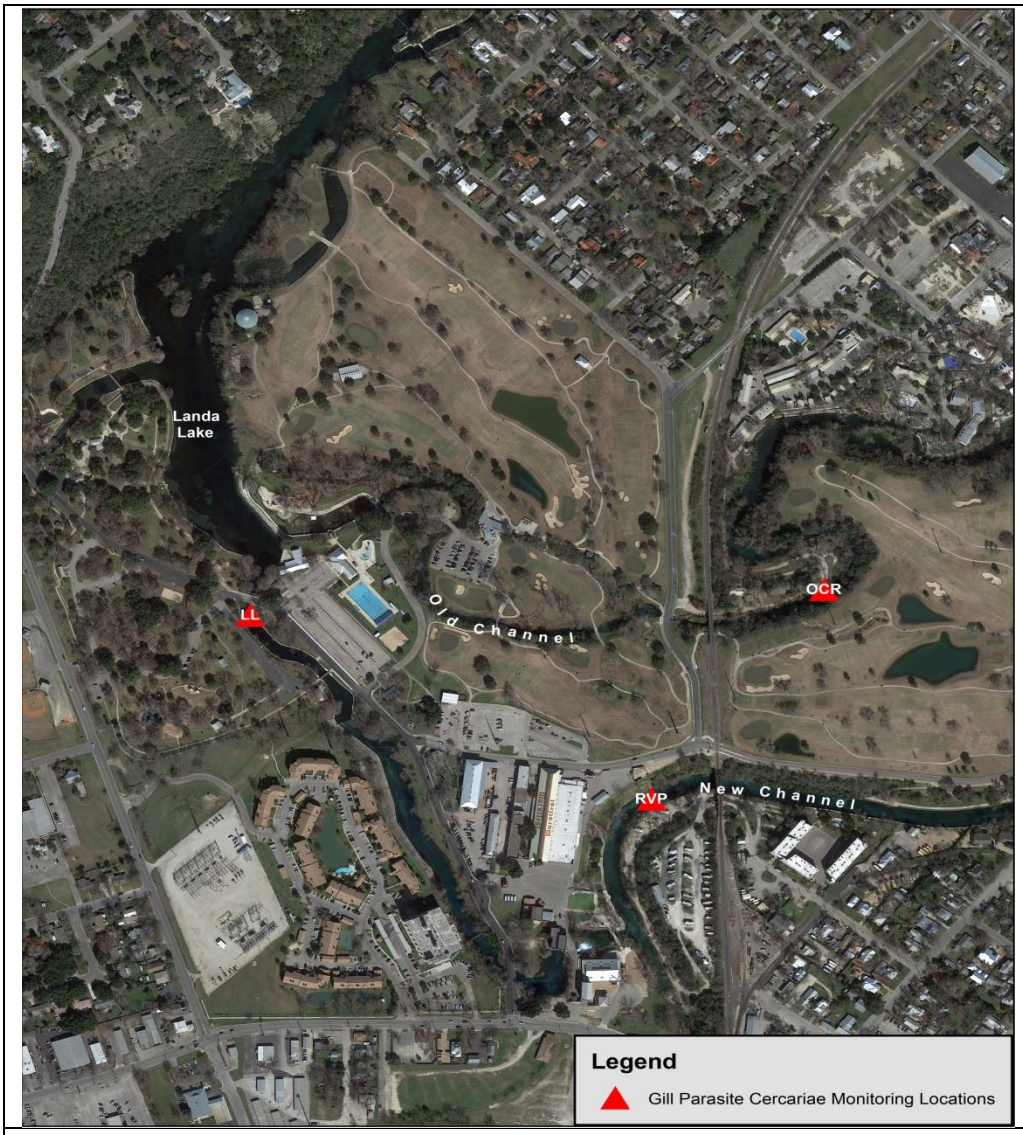


Figure 4. Gill parasite cercariae monitoring locations

At each of the selected transect locations, 5-L water samples will collected from six points that are evenly distributed throughout the water column both horizontally and vertically. For each transect, three sampling stations will be established that are equally spaced across the stream channel perpendicular to flow. At each of these stations, two 5-L samples will be collected, one approximately 5 cm from the surface and one at 60% of the depth at that location. Samples will be collected using a modified livewell pump attached to a standard flow/depth measurement rod and buckets marked at the 5-L volume. At the time of collection, each water sample will be immediately treated with 5 milliliters (ml) of formaldehyde to kill parasite cercariae, thus facilitating their capture (live cercariae can wiggle through the filter device). Filtration will involve passing the sample through a specialized filter apparatus containing three progressively finer nylon filters, the final filter having pores of 30 microns. After filtration of each sample, the 30- micron filter containing cercariae will be removed from the filtration apparatus and placed in a Petri dish. Each sample will then be stained with Rose Bengal solution and fixed with 10% formalin, at which

point the Petri dish was closed and sealed with Parafilm for storage. Cercariae on each filter will later be counted using high-power microscopy at the BIO-WEST laboratory.

In 2018, cercarial monitoring will be conducted three times (in winter, spring, and summer). Monitoring will occur more frequently when spring flow declines below 150 cfs or other springflow triggers that are developed.

Budget:
Table 7.1:
$75,000

Available budget:
$75,000

Estimated 2018 budget:
$ 30,000

5.2.7 Prohibition of Hazardous Materials Transport Across the Comal River and Its Tributaries

The City of New Braunfels will continue to prohibit the transport of hazardous materials on routes crossing the Comal River and its tributaries.

Long-term Objective:
To minimize the potential for accidental spills or releases of hazardous materials into the Comal River system that may cause negative impacts to the Covered Species.

Target for 2018:
Maintain signage installed in 2016 and monitor for the presence of trucks carrying hazardous cargo on routes crossing the Comal River and its tributaries.

Methods:
City of New Braunfels Ordinance No. 93-7 effectively restricts the transport of hazardous cargo within Loop 337 and IH-35 and therefore, over roadways crossing the Comal River. Hazardous cargo route prohibition signage was installed in 2016 at key roadways near the headwaters of Landa Lake and the Comal River.

Monitoring:
The City of New Braunfels Police Department will monitor for trucks carrying hazardous cargo on prohibited routes per City ordinance.

Budget:
Table 7.1:
$0

Available budget:
$0

Estimated 2018 budget:
$0

5.2.8 Native Riparian Habitat Restoration (Comal Springs Riffle Beetle)

Long-term Objective:
Establish a healthy, functioning riparian area along Spring Run 3 and the western shoreline of Landa Lake to benefit the Comal Springs Riffle Beetle. Establish native riparian vegetation to increase the stability of the bank, decrease erosion/ sedimentation, and increase the amount of usable habitat and food sources.

Target for 2018:
Create a riparian buffer along the southeast side of Spring Run 3 (**Figure 5**). Monitor the riparian zone along Spring Run 3 and the Western shoreline of Landa Lake twice annually. Continue to maintain previously restored areas along Spring Run 3 and the Western shoreline of Landa Lake and continue removal of re-emergent non-native vegetation.

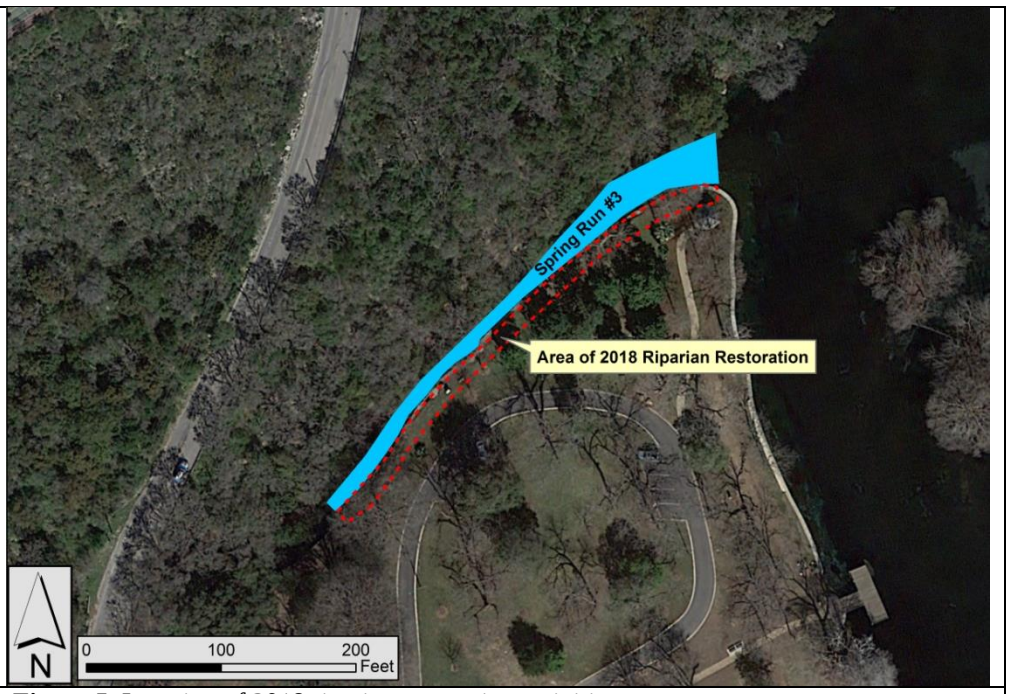


Figure 5. Location of 2018 riparian restoration activities.

Methods:
To date, riparian restoration efforts have been focused on the northwest bank of Spring Run 3 and along the western shoreline of Landa Lake. In 2018, CoNB will plan to begin work to establish native riparian vegetation and increase the riparian buffer along the southeast bank of Spring Run 3. The first step is to develop a riparian restoration plan that takes into consideration the heavy pedestrian and visitor traffic that occurs in this area. The riparian restoration plan must also take into account existing stormwater flowpaths in this area. Riparian restoration work must also consider the alignment of a pervious walking trail that has been proposed as part of the Landa Park Master Plan. Riparian restoration work will occur following the planning phase. Native plants will be selected based on root structure, light requirements, growth habits and deer-resistance. Candidate native plant species may include those in **Table 4**. The plant species presented in Table 4 were chosen based on the results of previous restoration efforts. Protective fencing will be installed around planting areas to protect young vegetation from deer and foot traffic. Temporary irrigation will be installed, as needed, to help plants establish.

Continue to remove re-emergent, non-native plant species within the riparian zone along the northwest bank of Spring Run 3 and along the western shoreline where non-native plants have previously been removed.

Table 4. Candidate riparian plantings

Sun Species	Shade Species
Turks Cap (*Malvaviscus arboreus var. drummondii*)	Turks Cap
Frostweed (*Verbesina virginica)*	Frostweed (*Verbesina virginica)*
Yellow Bidens (*Bidens laevis)*	Emory Sedge (*Carex emoryi*)
Swamp Milkweed (*Asclepias incarnata*)	Boneset/ Mistflower (*Ageratina havanensis*)
Switchgrass (*Panicum virgatum*)	Elderberry (*Sambucus canadensis)*
Bushy bluestem (*Andropogon glomeratus*)	Giant spiderwort (*Tradescantia gigantean)*
Emory Sedge (*Carex emoryi*)	Texas aster (*Symphyotrichum drummondii texanum)*
Sweetscent (*Pluchea odorata*)	Red salvia (*Salvia coccinea*)
Elderberry (*Sambucus canadensis)*	Buttonbush (*Cephalanthus occidentalis*)
Yellow compass plant *(Silphium integrifolium radulum*)	
Texas bluebells (*Eustoma exaltatum*)	

Monitoring:
Monitoring of the riparian zone along Spring Run 3 and the western shoreline of Landa Lake will occur twice/ year, once in late spring/ early summer (Apr-June) and once in the fall (October) to assess for the re-emergence of non-native vegetation and status of native plants. Existing vegetation will be mapped using a GPS unit.

Budget:
Table 7.1:
$25,000

Available budget:
$25,000

Estimated 2018 budget:
$35,000 (includes approx. $5,000 for restoration design, $25,000 for riparian restoration, and $5,000 for monitoring).

5.2.10 Litter and Floating Vegetation Control

Long-term Objective:
Minimize the impacts of floating vegetation mats and litter on aquatic vegetation and endangered species habitat in Landa Lake, the Spring Runs, and the upper portion of the Old Channel. Mitigate low dissolved oxygen levels in Landa Lake caused by decaying vegetation. Minimize shading of and negative impacts to aquatic vegetation caused by floating vegetation mats.

Target for 2018:
Dislodge floating vegetation mats and remove litter from applicable portions of the Comal River system to prevent negative impacts to flow control structures, aquatic vegetation, and endangered species habitat. In the event of low-flow conditions or receipt of depressed dissolved oxygen levels in Landa Lake, the removal of, and/or increased efforts to dislodge, floating vegetation mats will be initiated to prevent oxygen consumption by decaying vegetative material.

Methods:
Floating Vegetation Mat Management: Perform maintenance of floating vegetation mats in Landa Lake by dislodging mats and facilitating migration of the mats downstream of Landa Lake. Maintenance of floating vegetation mats will occur on a weekly basis between March and September and on an as-needed basis during the remainder of the year. Floating vegetation mats will be dislodged from flow control structures, the Three Islands area, fishing pier and other locations where vegetation mats accumulate and negatively impact native aquatic vegetation. Additional efforts to remove floating and decaying vegetation will occur during low-flow conditions (<80cfs) and/ or when low dissolved oxygen levels are observed in order to further mitigate impacts to dissolved oxygen and native aquatic vegetation.

Litter Management: (March 1st to October 30th). Litter pickup within the riparian zone along the Old Channel and the Spring Runs will occur on a bi-monthly basis (twice/ month) between March 1st and October 30th. Litter will also be removed from within the Old Channel and Spring Runs to the extent that it can be removed with a 10ft trash grabber. Removed litter will be quantified and reported on a monthly basis.

Monitoring:
Monitor litter and floating vegetation mats in applicable areas on a weekly basis and more frequently if low-flow conditions occur. DO concentrations will be monitored by EAA and as part of Task 5.2.4 (Decaying Vegetation Removal and Dissolved Oxygen Mgmt). City staff will monitor contractor efforts and coordinate additional efforts when deemed necessary.

Budget:
Table 7.1:
$0

Available budget:
$0

Estimated 2018 budget:
$30,000*

*$20,000 will be the base contract amount for routine floating vegetation mat and litter management. $10,000 will be reserved to increase floating vegetation mat removal if low-flow conditions are realized.

5.2.11 Golf Cou+rse Management and Planning

The City of New Braunfels will implement their existing Integrated Pest Management Plan (IPMP) for Landa Park Golf Course. This process will incorporate public input and the Golf Course Advisory Board. The golf course IPMP will incorporate environmentally sensitive techniques to minimize chemical application, continue to improve water quality, and reduce negative effects to the ecosystem. Expanded water quality sampling targeted at Golf Course operations will be conducted as described in Section of 5.7.2 of the HCP.

Long-term Objective:
Management of the golf course and grounds to minimize negative effects to the aquatic ecosystem in Landa Lake and the Comal River.

Target for 2018:
Continue to implement and update the existing IPMP.

Methods:
The golf course and grounds will be maintained in an aesthetically pleasing, yet environmentally sensitive manner. It is the responsibility of the Golf Course Manager to maintain the course and grounds in accordance with the new IPMP. The IPMP describes chemicals and methods for controlling pests (i.e. insects, weeds, and other living organisms requiring control) on the golf course in a way that minimally impacts the environment.

Monitoring:
The EAHCP Water Quality Monitoring Program includes base flow and storm sampling at designated locations along the Comal River both up- and downstream of the Landa Park Golf Course. Samples are analyzed for various herbicides and pesticides per the IPMP to control pests and weeds. Detections of any pesticides and herbicides utilized for golf course maintenance operations may warrant the need for revisions to the existing IPMP.

Budget:
Table 7.1:
$0

Available budget:
$0

Estimated 2018 budget:
$0

5.7.1 Native Riparian Habitat Restoration

Long-term Objective:
Increase the area and density of native riparian vegetation, reduce non-native riparian vegetation, and prevent streambank erosion in areas immediately adjacent to the Comal River to compliment aquatic vegetation restoration efforts and improve water quality.

Target for 2018:
Remove non-native riparian vegetation along the golf course side of the Old Channel between Elizabeth Street and the downstream end of the Old Channel LTBG reach (**Figure 6**). Install sediment control structures along the streambanks to control erosion in areas where non-native vegetation is being removed. Increase the coverage and density of native vegetation in the riparian areas between the Golf Course Road bridge and Elizabeth Street where invasive plants were removed in 2017 (**Figure 6**). Maintain areas where non-native plants were removed in previous years to prevent re-establishment.

Figure 6. Location of 2018 riparian restoration activities.

Methods:
Invasive Species Management:

Non-native riparian vegetation (primarily *Ligustrum sp.*, Elephant Ear, Chinese Tallow, Chinaberry, Arundo cane) will be removed along the golf course side of the Old Channel between Elizabeth Street and the Old Channel LTBG reach utilizing herbicide applications and hand-removal methods. The number of trees removed and the area of Elephant Ears treated will be documented. Removed vegetation will be utilized to form sediment capture structures in riparian areas with high erosion potential. In areas where riparian vegetation consists of only non-native species, a portion of the non-natives will be left in place until native species are planted in order to

minimize the potential for erosion. Monitor areas where non-native plants were removed in previous years. Re-treat and remove re-emergent non-native vegetation.

Elephant ears are present and abundant on City and private properties along the banks of Landa Lake, upstream of the Old Channel. Control of elephant ears and non-native riparian plants in the area of Landa Lake is not currently included as a measure in the EAHCP. The need to control elephant ears around Landa Lake will be evaluated to determine if elephant ear control is needed around Landa Lake in order to maintain suppressed levels of elephant ears in the riparian zone along the Old Channel.

Native Plant Restoration:

Plant native riparian plants along the Old Channel between Golf Course Rd bridge and Elizabeth Street in areas were non-natives were removed in previous years. Native plants will be selected based on sun exposure, proximity to the stream, growth habit, and ability to withstand deer browsing. Candidate native plant species may include those in **Table 5** based on the success of previous restoration efforts.

Table 5. Candidate riparian plantings

Trees and Shrubs	Herbaceous
American Beautyberry (*Callicarpa Americana)*	Bushy Bluestem (*Andropogon glomeratus*)
Bald Cypress (*Taxodium dischitchum)*	Coral Honeysuckle (*Lonicera sempervirens*)
Bee Brush (*Eysenhardtia texana)*	Creeping Spotflower (*Acmella repens*)
Black Walnut (*Juglans nigra)*	Emory Sedge (*Carex emoryi*)
Burr Oak (*Quercus macrocarpa)*	Frog Fruit (*Phyla nodiflora*)
Buttonbush (*Cephalanthus occidentalis)*	Frostweed (*Verbesina virginica)*
Elderberry (*Sambucus Canadensis)*	Horse Herb (*Calyptocarpus vialis*)
Eve's Necklace (*Styphnolobium affine)*	Inland Sea Oats (*Chasmanthium latifolium*)
Fragrant Sumac (Rhus aromatica)	Switchgrass (*Panicum virgatum*)
Green Ash (*Fraxinus pennsylvanica)*	Texas Lantana (*Lantana urticoides*)
Mexican Buckeye (*Ungnadia speciosa)*	Turks Cap (*Malvaviscus arboreus var. drummondii*)
Mexican Plum (*Prunus Mexicana)*	Water Willow (*Decodon verticillatus*)
Mountain Laurel (*Sophora secundiflora*)	White Boneset (*Eupatorium serotinum*)
Possum Haw Holly (*Ilex ambigua)*	Yellow Bidens (*Bidens sp.*)
Red Buckeye (*Aesculus pavia)*	Woodland Sedge (*Carex blanda*)
Red Mulberry (*Morus rubra)*	Zexmania
Dwarf Palmetto (*Sabal Minor*)	
Soapberry (*Sapindus drummondii)*	
Sycamore (*Platanus occidentalis)*	

Monitoring:
Monitor changes of solar exposure to the Old Channel as a result of non-native riparian plant removal. Previously restored riparian areas will be monitored for the re-emergence of non-native vegetation and success of native plantings. Sediment capture structures will be monitored for effectiveness. Monitor native riparian plantings for success.

Budget:
Table 7.1:
$100,000

Available budget:
$50,000 (available budget less than Table 7.1 due to funds utilized to fund the Bank Stabilization Project in 2016)

Estimated 2018 budget:
$50,000

5.7.5 Management of Household Hazardous Wastes

Long-term Objective:
To minimize the potential for improper disposal of hazardous wastes and associated negative impacts to endangered species in the Comal River system.

Target for 2018:
Hold three household hazardous waste (HHW) collection events in New Braunfels. Continue to partner with New Braunfels Utilities (NBU) on the Operation MedSafe drug recovery program.

Methods:
Conduct three HHW collection events that incorporate an education and outreach component. The HHW events are coordinated by City's Solid Waste Division in conjunction with Comal County. Each HHW event costs approximately $40,000-$45,000 which includes event set-up and HHW disposal costs. The cost of the first two HHW events is shared evenly between the City and Comal County. The third event is funded largely by the EAHCP ($30,000) with the remaining cost paid for by the City ($10,000-$15,000).

The HHW collection events are held at the New Braunfels City Hall. Hazardous waste that is collected during the HHW collection events will be hauled off and disposed of by Clean Harbors.

The City is currently exploring the feasibility of implementing a HHW drop-off facility that will accept HHW on an ongoing basis throughout the year. A feasibility study, funded in part by the Alamo Area Council of Governments (AACOG) and TCEQ, has been conducted and indicates that a dedicated HHW drop-off facility is in fact feasible. The feasibility study will be presented to City Council for approval of a resolution to utilize the study as a guidance document for planning of a dedicated HHW drop-off facility. Currently, it is expected that a HHW drop-off facility will be opened within three years. The facility will likely be open to the public 1-2 days/ week for the drop-off of HHW.

The New Braunfels Police Department partners with NBU to host an annual medicine drop-off event in New Braunfels. The CONB website also contains information about the Operation MedSafe event and tips on proper disposal of medications and drugs.

The EAHCP adaptive management process may be initiated in future years to consider changes to the EAHCP with respect to management of HHW in New Braunfels.

Monitoring:
The volume of hazardous waste material collected and the number of participants for each HHW collection event will be documented.

Budget:
<u>Table 7.1:</u>
$30,000

<u>Available budget:</u>
$30,000

<u>Estimated 2018 budget:</u>
$ 30,000

5.7.6 Impervious Cover/Water Quality Protection

Long-term Objective:
Reduction and control of non-point source pollutant discharges to Landa Lake and the Comal River system. To increase the implementation of Low Impact Development (LID) projects and provide incentives to reduce impervious cover.

Target for 2018:
The City will implement and further develop water quality management strategies identified in the Water Quality Protection Plan (WQPP): Phase I developed in early 2017. Specific activities to be completed in 2018 include the design and construction of a stormwater treatment project at the North Houston Ave (at Landa Lake), design of a stormwater treatment project for the Landa Park Golf Course parking lot, solicitation of federal 319 grant funding, a stream buffer assessment and support of stormwater controls at the Headwaters at the Comal project. In previous years, the framework for an LID rebate program had been developed. The LID rebate program has been put on hold as the activities listed above for implementation in 2018 are thought to be more feasible and provide more immediate benefit to water quality in the upper reaches of the Comal River system.

Methods:
Stormwater Treatment Projects:

The WQPP that was developed in 2017 includes evaluation criteria for seven water quality retrofit projects within the Comal River watershed. The potential water quality projects are presented in **Table 6**.

Table 6. Water quality retrofit evaluation criteria

Design Data	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**
Location	Elizabeth Ave at Landa Lake	North Union Street From Dallas St to Edgewater	North Houston Ave at Landa Lake	Golf Course Club House	Overflow Parking along Elizabeth Ave	Fredericksburg Road Storm Drain Outfall into Landa Park	Landa Park Aquatic Complex Parking Lot
Recommended Measure	Rain Garden	Linear Roadside Rain Garden	Rain Garden	Grass/gravel pavers, function as filter strip	Grass/gravel pavers	Storm Drain Underground Vault	Permeable Pavers
Approx. Drainage area (acres)	5.0	4.0	4.3	0.26	1.2	5.4	1.5
Approx. Impervious cover (acres)	1.9	1.2	1.3	0.24	0	5	1.4
Approx. % Impervious Cover	38.0%	30.0%	30.2%	92.3%	0.0%	92.6%	93.3%
Measure width (feet)	30	8	30	20	20	NA	100
Measure length (feet)	50	300	70	150	800	NA	160
Measure footprint (sq ft)	1500	2400	2100	3000	16,000	NA	16000
Measure depth (ft)	1.5	1	1	NA	NA	NA	NA
Measure Volume (cubic feet)	2250	2400	2100	NA	NA	NA	NA
Runoff depth treated (inches)	0.34	0.52	0.44	NA	NA	NA	NA
TSS lbs per year managed	875	720	700	170	15	2200	170
Estimated measure cost/SF	$33.00	$40.00	$33.00	$8.00	$6.00	NA	$15.00
Cost per Unit						$60,000.00 12'x6'x84	
Total Measure Cost	$71,156	$138,000	$99,619	$34,500	$138,000	$86,250	$345,000
Cost/TSS lbs managed/year	$81	$192	$142	$203	$9,200	$39	$2,029
Maintenance Requirements	MINIMAL to MODERATE: Vegetation management required, occassional sediment/debris removal	MINIMAL to MODERATE: Vegetation management required, occassional sediment/debris removal	MINIMAL to MODERATE: Vegetation management required, occassional sediment/debris removal	MODERATE: Vegetation management, rejuvenation may be necessary, inspect two times per year	MODERATE: Vegetation management, rejuvenation may be necessary, inspect two times per year	MODERATE: Inspect four times per year, removal of sediment and debris	MODERATE: Semi-annual inpsection, vacuuming required based on infiltration loss/sediment load.

The City will design and construct a stormwater treatment facility at the end of North Houston Ave (Site 3) in 2018. Currently, stormwater runoff from North Houston Avenue flows directly into the Upper Spring Run of Landa Lake untreated. The project will involve removal of approximately 2,000 ft^2 of existing asphalt pavement. The existing asphalt pavement will be replaced with a rain garden or permeable surface that will be designed to infiltrate and treat stormwater runoff prior to entering Landa Lake at the Upper Spring Run. The stormwater treatment facility is expected to prevent approximately 700 lbs/ year of sediment, solids, and associated pollutants from entering Landa Lake. Design of the stormwater control will occur in early 2018 and will be followed by construction. The City of New Braunfels will assume responsibility of ongoing maintenance of the stormwater facility to ensure maximum sediment and pollutant removal.

The City will also design a stormwater treatment project to treat stormwater runoff from the Landa Park Golf Course parking lot (Site 4). The parking lot is heavily utilized and drains directly to the Old Channel. The project will involve replacement of the existing asphalt surface with a permeable parking surface that will infiltrate and filter stormwater runoff prior to entering the Old Channel. The project is expected prevent approximately 170 lbs/ year of sediment, solids, and associated pollutants from entering the Old Channel. Construction of the project will occur in 2019.

319 Non-point source program grant solicitation:

The City will utilize a consultant to pursue grant funding to support future water quality projects. Grant funding will be sought through the Texas Commission on Environmental Quality's (TCEQs) non-point source grant program as well as through other potential grant sources. EAHCP project funds can potentially be utilized a match on a grant. Potential grant opportunities and projects will be identified and grant applications will be prepared and submitted.

Stream zone buffer assessment:

The City will utilize a consultant to assess existing stream buffer requirements and propose ordinances or other regulatory mechanisms that the City can consider to protect stream zones including the Comal River, Dry Comal Creek, and Bleiders Creek and their tributaries. Stream buffer requirements from other cities will be evaluated. A literature search will also be conducted to define the benefit of stream zone buffers and to support the implementation and adoption of stream buffer requirements in New Braunfels.

Headwaters at the Comal project funding support:

New Braunfels Utilities (NBU) will be moving forward with Phase II of the Headwaters at the Comal project (previously known at the Comal Conservation Center) in 2018. The overall project involves restoration of a 16 acre NBU Service Facility located at the confluence of Bleiders Creek and the Upper Spring Run of Landa Lake. Restoration activities include removal of approximately 12 acres of existing asphalt (completed in Phase I), native plant restoration to return the existing paved area to native conditions (completed in Phase I), construction of stormwater controls, construction of green stormwater infrastructure, and interpretative centers. The Headwaters at the Comal will serve as an educational facility that will promote environmental stewardship and demonstrate the importance of native vegetation and stormwater controls.

Phase II will involve the installation of green stormwater infrastructure including permeable parking areas, permeable pavers and rainwater harvesting systems. Design for these measures has been completed but funding has not yet been secured. The City of New Braunfels will support the project by utilizing EAHCP funds dedicated for task 5.7.6 to help sponsor the installation green

stormwater infrastructure (i.e. permeable pavement). The overall cost to implement green stormwater infrastructure at the Headwaters project is approximately $215,000.

Budget:
Table 7.1:
$100,000

Available budget:
$100,000

Estimated 2018 budget:
$125,000

$100,000 – Design and construction of stormwater treatment project at N. Houston Ave.
$5,000 – Design of a stormwater treatment project at the Landa Park Golf Course parking lot
$5,000 – Solicit grant funding for future water quality projects
$5,000 – Stream zone buffer assessment
$10,000 – Sponsor permeable pavement installations at the Headwaters at the Comal project
$125,000

City of San Marcos/Texas State University
2018 Work Plan

2018 San Marcos/Texas State University Work Plan Budget

HCP Section	Conservation Measure	Table 7.1	Available budget for 2018 (7.1a)	Estimated 2018 Budget	Difference (from available)
5.3.1/5.4.1	Texas wild-rice Enhancement	$100,000	$100,000	100,000 TxSt 28,000 SMARC $128,000 Total	$(28,000)[4]
5.3.6/5.4.4	Sediment Removal	$25,000	$50,000	$0	$50,000[3]
5.3.8/5.4.3/ 5.4.12	Control of Non-Native Plant Species	$50,000	$50,000	68,165 TxSt 42,671 EBR $110,836 Total	($60,836)[3]
5.3.3/5.4.3	Management of Floating Vegetation Mats and Litter	$80,000	$80,000	$50,000[1]	$30,000[3,4]
5.3.5/5.3.9/ 5.4.11/5.4.13	Non-Native Species Control	$35,000	$35,000	$26,747	$8,000[4]
5.3.7	Designation of Permanent Access Points/Bank Stabilization	$20,000	$20,000	$0	$20,000[2]
5.7.1	Native Riparian Restoration	$20,000	$20,000	$20,000	$0
5.3.2/5.4.2	Management of Recreation in Key Areas	$56,000	$56,000	$56,000	$0
5.7.6	Impervious Cover/Water Quality Protection	$200,000	$230,000	$110,000	$0
5.7.5	Management of HHW	$30,000	$30,000	$30,000	$0
5.3.4	Prohibition of Hazardous Material Transport	$0	$0	$0	$0
5.7.3,4,5,7,8, 9 & 10	Various unfunded Measures	$0	$0	$0	$0
	Total	***$617,000***	***$671,000***	***$531,583***	***$75,164***

(1) Assumed amount due to rebidding contract; (2) goes toward spending overage on Bank Stabilization measure; (3) transfer$50,000 from Sediment Removal and $10,836 from Mgt of Litter to the Control of Nonnative Plants; (4) transfer $8,000 from Nonnative Species Control and $20,000 from Mgt of Litter to TWR Enhancement

5.3.1/5.4.1 Texas Wild-Rice Enhancement and Restoration

Long-term Objective:
To achieve 8,000 – 15,450 m^2 of Texas wild-rice (TWR) and maintain existing and restored areas of TWR as required in Table 4-10 & the revised **Tables 4-21** discussed in measure 5.3.8/5.4.3/5.4.12 (Control of Non-Native Plant Species).

Target for 2018:
In 2018, TWR enhancement (removal of non-natives and planting of TWR) focus on achieving the coverage shown in **Table 1** below.

Table 1: Long-term Biological Goal for Texas wild-rice (Table 4-10 in the EAHCP).

River Segment	EAHCP Cumulative Goals (m^2) (Table 4-10)	Goals for 2018 (m^2)*	Approximate range of individuals needed to meet annual goal
Spring Lake	1,000 – 1,5000	100	1,800 – 2,200
Spring Lake Dam to Rio Vista Dam	5,810 – 9,245	140	2,500 – 2,900
Rio Vista Dam to IH-35	910 – 1,650	125	2,300 – 2,700
Downstream of IH-35	280 – 3,055	-	-
TOTAL	8,000 – 15,450	365	5,000 – 5,400

*Coverage total from LTBG and Restoration Reaches presented in Table 1 of Control of Non-native Plant Species represent revised native SAV goals in the EAHCP.

In accordance with **Table 21** of the EAHCP revised through the Adaptive Management process directed by the submerged aquatic vegetation (SAV) recommendations (Section 3.1.2.2), SAV LTBG and Restoration Reaches include TWR goals. Within the LTBG reaches, 15 m^2 will be planted in the Spring Lake dam reach, 75m^2 in the City Park reach and 75m^2 in the IH-35 reach (see **Table 1** under Control of Non-Native Plant Species). The Restoration Reach at Cypress Island and the Expanded IH-35 reach will receive 50m^2 each. This total restoration equals 365 m^2 of total TWR enhancement in 2018. Efforts toward the annual goals may shift due to changes in the field, i.e. floods, natural expansion, recreational impacts, high flows effecting work in some reaches, etc. If a river segment is not workable due to continued high flows, or expansion of desired natives has met the annual goal (or other reason), then, after conferring with EAHCP staff, efforts will shift toward unmet goals from 2017.

Methodology:
The optimal conditions for TWR is sandy to coarse soils with water depths generally greater than 1 meter in areas of higher current velocity. In stands of TWR that have non-native plant species intermixed, the non-natives are removed and the original TWR stand is monitored for expansion. Similarly, for TWR stands occupying optimal (areas with adjacent non-native vegetation; the non-native plants are removed and the area is replanted with TWR. Finally, in optimal areas for

TWR that are unoccupied by TWR, any non-native vegetation that is present is removed and TWR planted and monitored to assess the success of transplants.

The process of planting begins by transporting potted TWR individuals from the Texas State University Freeman Aquatic Building (FAB) to the planting site. A diver and a handler carry the plants to the designated section, and while the diver digs a hole in the substrate using a trowel, the handler gives the diver a pot of TWR. The contents are removed from the pot and inserted into the hole. The diver works downstream to upstream in a linear pattern of planting. Individuals are placed about three feet apart and gardened as needed to remove invading plants. This process is adjusted as needed to meet the varying conditions of each planting site.

The production of Texas wild-rice occurs at the FAB at Texas State University and the U.S. Fish and Wildlife Service San Marcos Aquatic Resources Center (SMARC) with the FAB collecting and propagating from tillers and SMARC collecting and propagating from seed.

The FAB collects tillers of TWR by removing them from floating vegetation mats or from fragments attached to mature plants in the river. Fragments are transported to the raceways located at the FAB. Potting soil type used consists of a bulk soil comprised of a mixture of top soil and compost. Fragments are planted in an 8-inch pot. Soil is saturated with water and the fragments inserted into the soil. Small amounts of pea gravel are spread on top of the soil to provide anchoring and stability for seedlings. Density of fragments per pot ranges with species but is generally 3-10 individuals. The pots are placed into the raceways with pumps generating current velocity over the newly planted fragments. Plants remain in the raceways until roots are firmly established in the pots (i.e., generally 2 – 4 weeks).

SMARC collects mature seeds from the TWR panicle by gently pulling upwards until seeds are released. Mature seeds are defined as seeds that are plump, filled out and either green or brown in color. Seeds are placed in a plastic bag during collection and potted within 24 hours.

Potting soil type consists of a bulk soil comprised of a mixture of top soil, compost, orange sand (iron source), and cedar flakes. Nitrogen (nitrate) and phosphorus contents were 46 and 115 ppm (mg/kg), respectively. No additional nutrients are added to the soil. All TWR and other native aquatic plants are potted in this soil mixture.

When germination is observed, TWR seedlings less than or equal to 15 cm in height are removed from the pots, repotted in a 255 cm^3 pot, and placed in different 0.3 x 0.6 x 2.4 m or 0.9 x 0.9 x 3.0 m tanks. Prior to all transplanting of TWR seedlings, the soil is saturated with water and the plant roots are inserted into the soil. Small amounts of pea gravel are spread on top of the soil to provide anchoring and stability for seedlings.

Production of plants at the FAB and SMARC is incorporated into this Work Plan budget (TWR Enhancement & Removal of non-natives).

These methodologies may be adjusted as more is learned about collection and planting procedures.

Monitoring:
All planted areas are monitored via quadcopter and scuba divers. This data is mapped and analyzed via GIS. Monitoring thus far has shown that invasive plants move into cleared areas more quickly than TWR, so cleared areas are now planted with either TWR or an approved native plant (see conservation measure 5.3.8/5.4.3/5.4.12 Control of Non-Native Plant Species). Seeds and tillers are collected following the protocol of 50% tiller and 50% seed to help maintain genetic diversity in TWR grown at FAB and SMARC. Documented seed collection from all reaches in the upper SMR is a critical component of this effort. Documentation is mainly from sections A and B of the river (above Lion's club) because seed production downstream of the Lion's club is not as abundant (<10% of the seed source, with a goal of ~1000 seeds per month). The seeds are stored in a moist environment for six months. Because Texas wild rice seeds are recalcitrant and short lived, after six-months seeds are removed from storage and germinated for restoration purposes. SMARC is currently the only partner propagating TWR from seed for restoration efforts. Once seedlings are vigorous enough for transport (6-10 weeks old), seedlings are picked up by the contractor and transferred to their raceways at the FAB, then planted in the river. Using seedlings provides genetic diversity to the TWR population in the river since all other TWR used for restoration are "tillers" (i.e. genetic duplicates, clones).

Maintenance
If monitoring reveals regrowth of nonnative plants in previously treated areas, these will be removed and replanted with natives as needed.

Budget:
Table 7.1:
$100,000

Available budget for 2018
$100,000

Estimated 2018 budget:
$128,000*

*$100,000 TxSt & $28,000 SMARC

Transfer $8,000 from Nonnative Species Control and $20,000 from Mgt of Litter to TWR Enhancement

5.3.6/5.4.4 Sediment Removal

This conservation measure will be revised in September 2017 based on results of adaptive management process.

The City of San Marcos (COSM) and Texas State University (TXSTATE) are partnering to remove sediment from the river bottom in support of the native SAV planting program from Spring Lake to IH-35.

Long-term Objective:

The removal of sediment in support of native aquatic planting activities has proved to be both unnecessary and overly expensive. From 2013 to 2015, three of the six required sites have received only 158 m^3 of sediment removal costing approximately $555,000. In 2017, COSM and TXSTATE will be working closely with EAHCP staff to develop and submit an Adaptive Management Proposal to the Implementing Committee for approval of an Amendment to the EAHCP regarding this conservation measure.

The goal of the AMP is to analyze how to reduce sediment loading at the source. An extensive list of best management practices (BMPs) has been identified through the COSM Water Quality Protection Plan (WQPP) process. Funds from the COSM and the EPA 319 grant will be leveraged with the remaining EAHCP Sediment Removal and Impervious Cover/Water Quality Protection measure funds to successfully implement these projects.

The COSM and TXSTATE plan is to combine the Sediment Removal and Impervious Cover/Water Quality Protection into one conservation measure that includes a prioritized list of BMPs within the upper San Marcos River watershed that will help control sediment and other contaminated runoff. Sessom Creek is a highly urbanized steep watershed that contributes a heavy load of sediment during rain events; in the 2015 October flood, Sessom Creek dumped sediment on TWR stands and other native plant stands down to City Park.

The COSM and TXSTATE will utilize a subcommittee of the EAHCP Science Committee to prioritize the list of projects in the Watershed Protection Plan (WPP) and WQPP.

The EAHCP commitment for the combined effort (Sediment Removal and Impervious Cover/Water Quality Protection) will not exceed $1,500,000. This will include (1) continued design of Sessom BMPs in 2018; (2) construction of Sessom BMPs starting spring of 2019; and (3) potential purchase of Sessom property or conservation easement.

The COSM and TXSTATE commitment includes approximately $2,000,000 to provide; (1) design of wastewater relocation and erosion/sediment control; (2) Sessom wastewater line rehab and relocation spring 2019; and (3) construction of BMPs and associated land management tasks that control erosion, minimize sedimentation, and reduce pollutants. The COSM staff engineer will participate in the prioritization of the BMPs.

Additionally, TXSTATE has received 319 funds from the TCEQ. These funds will be accessed as available for design work in 2018 for the prioritized BMPs. The Meadows Center for Water

and the Environment is the point of contact for the EPA 319 funds and will participate in the prioritization of BMPs.

Target for 2018:
This process will depend upon a successful resolution through the EAHCP AMP and proper Amendments to USFWS.

Method:
TBD

Budget:
Table 7.1:
$25,000

Available budget for 2018:
$50,000*

Estimated 2018 budget:
$0

*****Transfer funds to the Control of Non-natives conservation measure.

5.3.8/5.4.3/5.4.12 Control of Non-Native Plant Species

Long-term Objective:
To decrease the density of invasive aquatic and littoral plants or eliminate as possible through monitored removal in and along the San Marcos River.

Target for 2018:
Non-native aquatic plants will be removed and replaced with native aquatic plants in association with Texas wild rice enhancement as described in conservation measure 5.3.1/5.4.1. The littoral zone will be replanted as needed to stabilize the bank. The riparian zone will be re-planted to cover a minimum of 15 meters in width where possible. The COSM will install fencing to protect the new plantings while they mature.

To maintain the desired state, re-growth of invasive species will continue to be removed from the treated aquatic, littoral and riparian zones. Existing stands and seed sources will also be targeted as shown in Figures 2 – 4

Methodology:
Non-Native Aquatic Plant Removal
In 2018, aquatic vegetation treatment (i.e., removal and planting) efforts will focus on sites shown in **Figure 1** below.

The amount of non-native aquatic vegetation to be removed in the San Marcos River in 2018 is based on non-native vegetation species removal records since 2013. Removal to date is approximately 500 m^2 for *Hygrophila polysperma*, 1,000 m^2 for *Hydrilla verticillata* , and roughly 10 m^2 for *Nasturtium officinale*.

Divers remove invasive aquatic plants by hand, allowing them to drift into a seine set up 50 feet downstream. Once full, the seine is pulled to the shore and plant debris is transferred to a litter for transfer to the work truck. There, the plants are shaken to remove trapped fauna which are returned to the river. The plants are then disposed at the COSM or Spring Lake composting facility. Denuded areas are planted with native aquatic vegetation within a week. This process may be adjusted as more efficient and effective practices are developed.

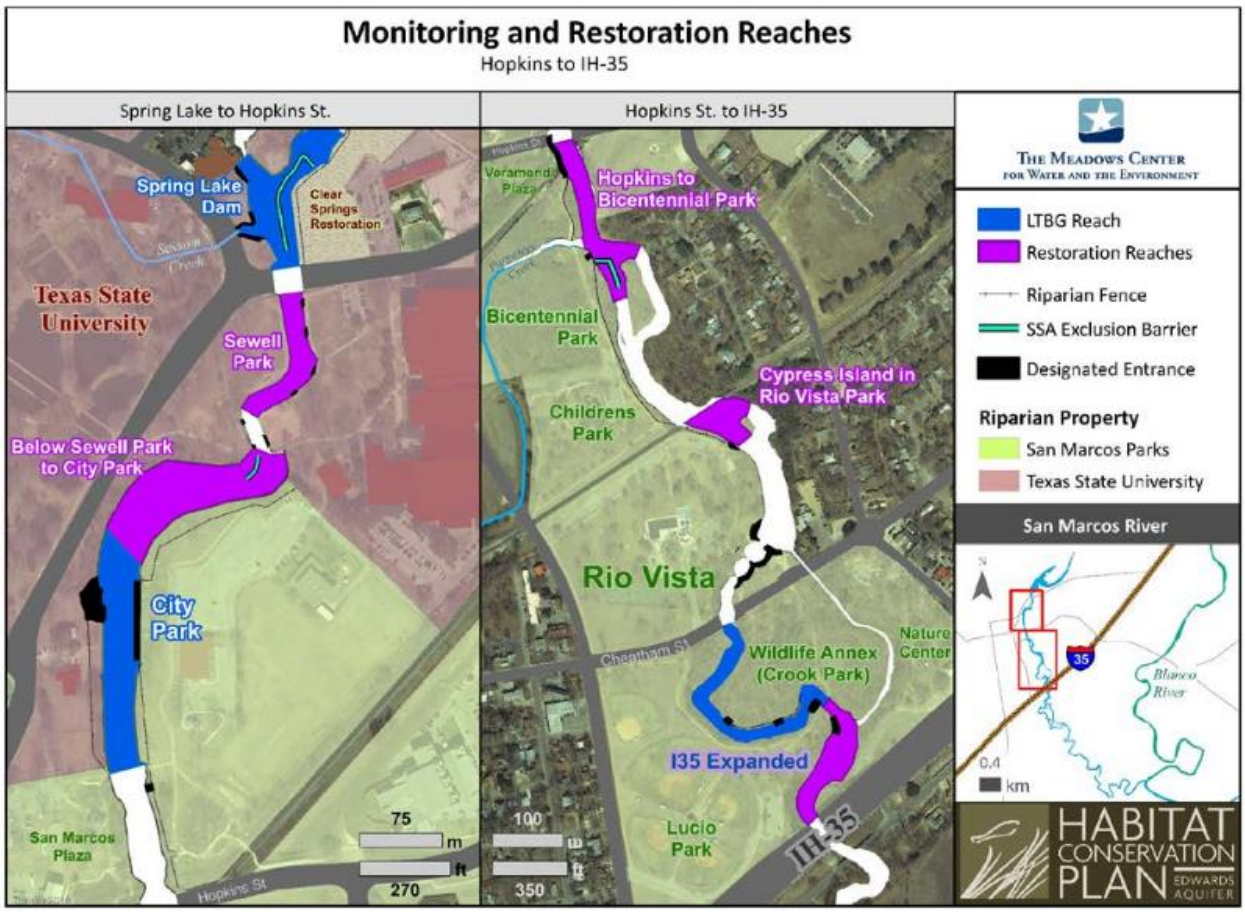


Figure 1: Long-term biological goal (LTBG) reaches and restoration reaches for the San Marcos system.

SAV Restoration

In 2016 the SAV and TWR restoration progress in the San Marcos River was evaluated. Based on the results, the Long Term Biological Goals (LTBG) were adjusted and restoration goals were proposed for newly defined reaches. The official annual goals are shown in **Table 1**.

Table 1: Annual aquatic vegetation restoration goals, in meters squared (m^2) within San Marcos LTBG reaches and newly defined restoration reaches.

Reaches	Species	Aquatic vegetation (m^2)	Restoration Goal	Approximate # of individuals per m^2 needed to meet annual goal
		Goal	2018	2018
LTBG Reaches				
Spring Lake Dam	*Ludwigia repens*	200	10	270 - 310
	Cabomba caroliniana	25	5	230 - 270
	Potamogeton illinoensis	1000	25	790 - 830

	Sagittaria platyphylla	100	20	210 - 250
	Hydrocotyle verticillata	50	5	125 - 165
	Zizania texana	700	15	280 - 320
City Park	*Ludwigia repens*	1000	20	560 - 600
	Cabomba caroliniana	50	10	470 - 510
	Potamogeton illinoensis	2000	100	3100 - 3300
	Sagittaria platyphylla	300	15	150 - 190
	Hydrocotyle verticillata	10	0	-
	Zizania texana	1750	75	1300 - 1700
IH-35	*Ludwigia repens*	200	5	125 - 165
	Cabomba caroliniana	300	5	230 - 270
	Potamogeton illinoensis	300	25	790 - 830
	Sagittaria platyphylla	100	10	90 - 130
	Hydrocotyle verticillata	50	10	270 - 310
	Zizania texana	600	75	1300 - 1700
Restoration Reaches				
Sewell Park	*Ludwigia repens*	25	0	-
	Cabomba caroliniana	25	0	-
	Potamogeton illinoensis	150	0	-
	Sagittaria platyphylla	25	0	-
	Hydrocotyle verticillata	10	0	-
	Zizania texana	0	0	-
Below Sewell to City Park	*Ludwigia repens*	50	0	-
	Cabomba caroliniana	50	0	-
	Potamogeton illinoensis	500	0	-
	Sagittaria platyphylla	700	0	-
	Hydrocotyle verticillata	20	0	-
	Zizania texana	2300	0	-

Hopkins St to Snake Island	*Ludwigia repens*	50	0	-
	Cabomba caroliniana	50	0	-
	Potamogeton illinoensis	475	0	-
	Sagittaria platyphylla	750	0	-
	Hydrocotyle verticillata	10	0	-
	Zizania texana	950	0	-
Cypress Island to Rio Vista Falls	*Ludwigia repens*	50	10	270 - 310
	Cabomba caroliniana	50	5	-
	Potamogeton illinoensis	150	10	-
	Sagittaria platyphylla	50	5	-
	Hydrocotyle verticillata	0	0	-
	Zizania texana	350	50	-
IH-35 expanded	*Ludwigia repens*	50	10	270 - 310
	Cabomba caroliniana	100	25	1000 - 1400
	Potamogeton illinoensis	250	25	790 - 830
	Sagittaria platyphylla	450	25	265 - 305
	Hydrocotyle verticillata	50	0	-
	Zizania texana	450	50	970 - 1010

Production of native (SAV) will continue at the FAB. The FAB collects tillers of native aquatic plants by removing them from floating vegetation mats or from fragments attached to mature plants in the river. Fragments are transported to the raceways located at the FAB and potted in an 8-inch pot using a bulk soil comprised of a mixture of top soil and compost. Soil is saturated with water and the fragments inserted into the soil. Small amounts of pea gravel are spread on top of the soil to provide anchoring and stability for seedlings. Density of fragments per pot ranges with species but is generally 3-10 individuals. The pots are placed into the raceways with pumps generating current velocity over the newly planted fragments. Plants remain in the raceways until roots are firmly established in the pots (i.e., generally 2 – 4 weeks).

Funding for the production of SAV at the FAB is incorporated into this Work Plan budget.

Natives are planted using a team that includes a diver. The diver digs a hole in the substrate and is handed potted native plants until the denuded area is planted at approximately 20% coverage.

The pots are removed before planting and handed back to the assistant for reuse. Planting natives soon after removal of non-natives is needed to deter re-invasion. The estimated number of native species (not including TWR) planted in the San Marcos River downstream of Sewell Park to IH-35 is 25,000 individuals from (December 2016 – October 2017). Environmental conditions determine where various species are planted. *Cabomba* and *Sagittaria* are native species that have shown to have greater success in finer substrates (silt) with areas of slower moving water. *Cabomba* is generally planted in areas of greater depth whereas *Sagittaria* can become emergent so can be planted in a wide range of depths.

Little knowledge is currently available for optimum habitat characteristics for the native aquatic vegetation species, *Ludwigia repens* in the San Marcos River. *Ludwigia repens* has been planted in a wide variety of habitat types ranging from areas with shallow depths, high velocities over coarse substrates to areas with more slackwater habitats over silt substrate to determine which habitat results in greatest rates of expansion and persistence. Approximately 12,279 *Ludwigia repens* individuals were planted since 2013 constituting an estimated 550 m^2. In 2015, < 1 % of the total area treated in work sites was occupied by *Ludwigia repens*. Beginning in 2016, *Ludwigia repens* was planted just upstream of IH35 where a persistent stand occurs and it seems to be successfully expanding. The river conditions for successful establishment in the San Marcos River is still being determined for this species.

In 2017, through the adaptive management process, *Hydrocotyle* was accepted as an approved native species to plant in the San Marcos River. *Hydrocotyle* can become a littoral species, persisting in areas of shallow water. Therefore, this species is utilized to replant river margins or in areas of very shallow water depths. Outside expertise will be contacted to provide information for the use of alternative aquatic plant species that would perform well in lentic conditions while providing good habitat for the fountain darter. These will be planted in test plots to determine their viability and used as needed after triggering the adaptive management process.

Non-Native Littoral and Riparian Plant Removal

Removal of littoral plants and other small caliper invasive plants in the riparian zone is also included in this budget. Figure 1 below exhibits GPS locations of large stands of elephant ear in 2013. Figure 2 reveals the remaining stands left to be treated in 2018. These remaining stands have caused a continuous regrowth problem both up and downstream of their locations. The treated area (areas with no elephant ear stands) in Figure 2 will continue to be monitored. Monitoring is a labor-intensive effort because it requires a close survey for small re-growth elephant ear and other invasives such as ligustrum, Chinese tallow, chinaberry over an extensive area. Figures 3 & 4 reveal the locations of large invasive tree stands close to the San Marcos River that provide a continual seed source for the re-growth in treated areas. Until seed sources can be eliminated, regrowth cannot be minimized, and labor hours will remain close to current levels.

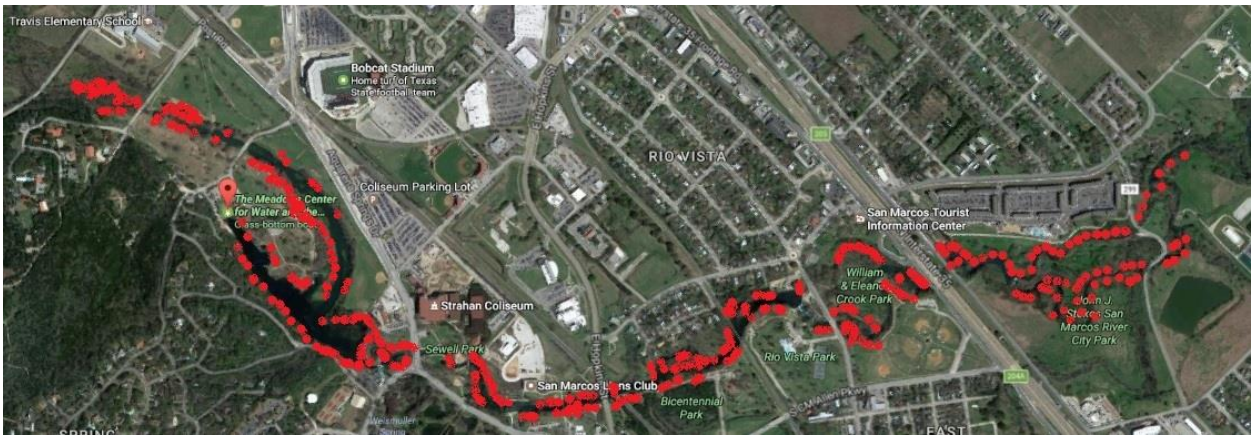


Figure 1. Large elephant ear stand locations in 2013.

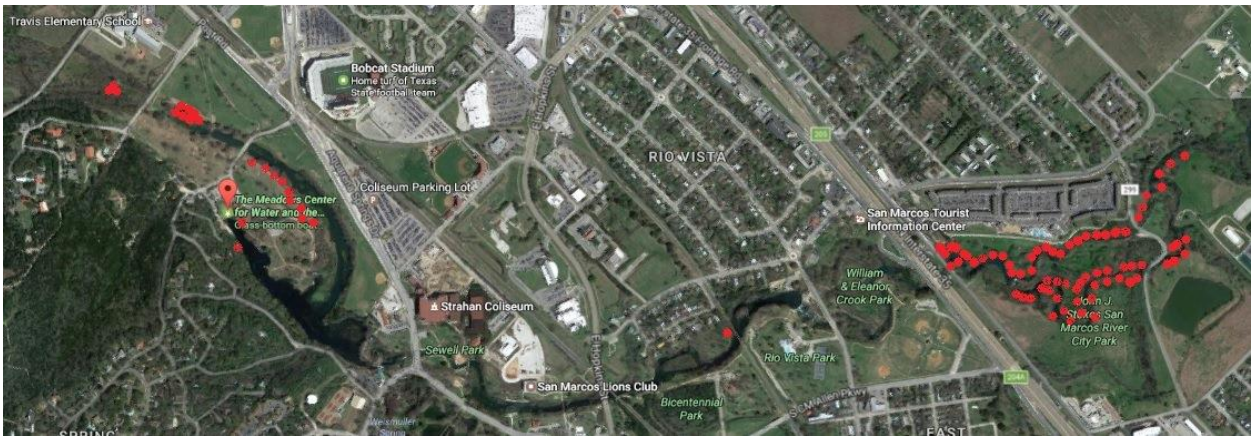


Figure 2. Remaining large elephant ear stands in 2018.

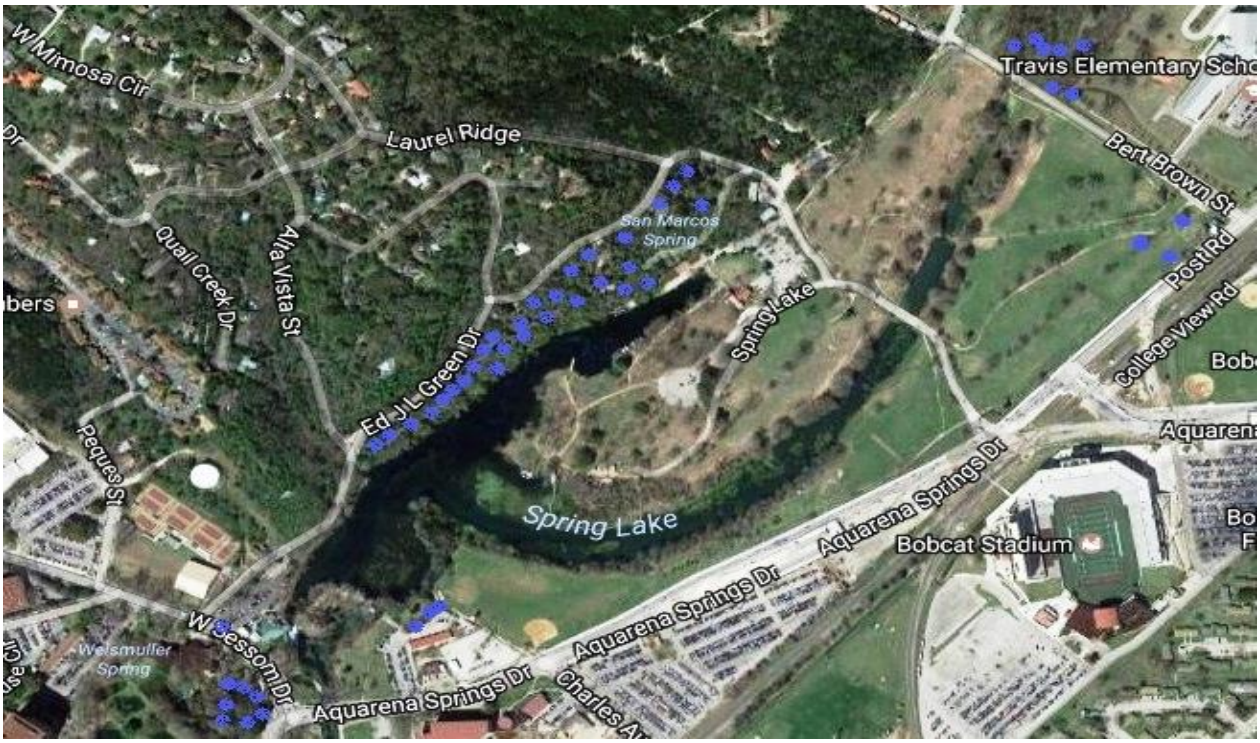


Figure 3. Remaining known seed sources adjacent to EAHCP upper work areas in 2017.

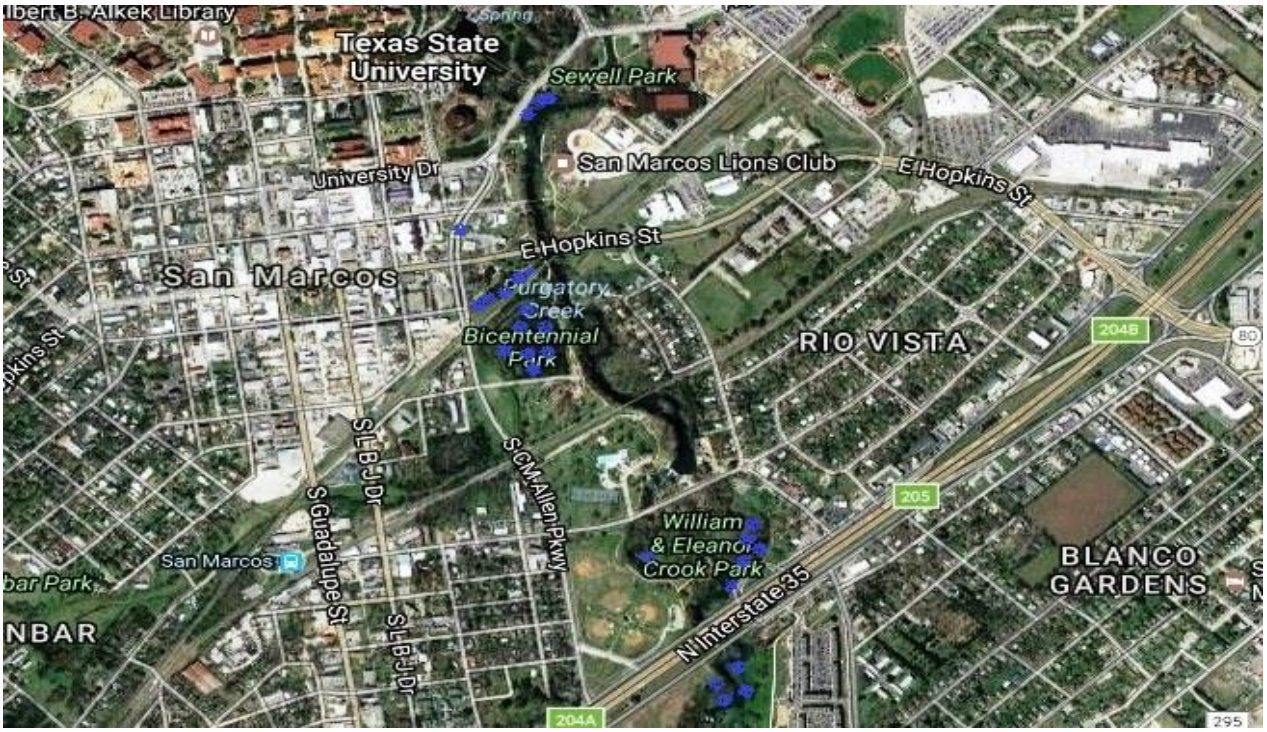


Figure 4. Remaining known seed sources adjacent to EAHCP lower work areas in 2017.

Efforts to remove elephant ears may be greater in fall and winter before spring growth. Removal efforts will also extend to treat hot spots that contribute to regrowth.

The herbicide mix used for littoral removal is Aquaneat (glyphosate-based herbicide) for elephant ears and other non-native plants encountered in the littoral zone. This herbicide will be mixed with Aqua King Plus Surfactant and Turf Mark Blue, a blue dye. On the upland tree, shrub stumps and root buttresses, Relegate **(**Triclopyr-based herbicide) is used. The Relegate is mixed with glyphosate, Drexel Surf Ac 820 Surfactant and Turf Mark Blue, a blue dye. Chemicals are applied with a one-gallon pump-up sprayer set on a steady stream for a more precise target hit to minimize leaching and non-target plant damage. Roots of woody plants are scarred to expose the cambium layer before treated.

Monitoring:

For aquatic plants, newly planted areas are monitored monthly to evaluate success rate. Aquatic vegetation in work sites is mapped using geo-referenced imagery collected using a quadcopter in conjunction with Trimble GPS units prior to and post non-native vegetation removal and native planting to assess changes in the vegetation community through time. Work sites are separated into reaches to assess changes among and within reaches of the San Marcos River. The annual river inventory is done to identify presence and location of non-native vegetation and also to assess the expansion of native vegetation.

All planted areas are weeded (non-native species removed) and replanted as needed to deter re-invasion. An annual river inventory is conducted to identify the presence and location of new non-native vegetation establishment. Success is determined by measuring by the surface area cleared of non-natives and increased coverage by native SAV. Progress for non-native vegetation removal will be tracked with polygons containing the species removed, estimated area (m^2) and percent removed. A composite map depicting the routine maintenance required to remove large areas of non-native aquatic vegetation will also be generated using weekly polygons. The maps illustrating the degree of effort will be created by overlaying all the weekly polygons.

Maintenance:

If monitoring reveals regrowth of nonnative plants in previously treated areas, these will be removed and replanted with natives as needed.

Budget:

<u>Table 7.1:</u>

$50,000

<u>Available budget for 2018:</u>

$50,000

<u>Estimated 2018 budget:</u>

$110,836 *

*$68,165 TxSt & $42,671 EBR

Transfer $50,000 from Impervious Cover and $10,836 from Mgt of Litter

5.3.3/5.4.3 Management of Floating Vegetation Mats and Litter

Long-term Objective:
Minimize impacts of floating vegetation and litter on TWR stands and overall aquatic community within the San Marcos River, as well as keep springs clear to enhance San Marcos salamander habitat. Litter is also removed from portions of Sink, Sessom, Purgatory and Willow Creeks.

Existing vegetation management activities in Spring Lake will continue to follow the Spring Lake Management Plan (approved by the President's Cabinet) and the EAHCP, as described under Methodology.

Target for 2018:
Management activities include removal of vegetation mats that form on top of Texas wild-rice plants, particularly during low flows, and removal of litter from the littoral zone, stream bottom and portions of the tributaries. Texas State University will manage aquatic vegetation in Spring Lake through use of its harvester boat and hand cutting of SAV by divers authorized to dive in Spring Lake.

Methodology:
Spring Lake: Each week about five springs are gardened, with divers returning to garden the same springs every two to three weeks. During summer algal blooms, the springs are managed more frequently (up to four springs per day), primarily to remove algae. Texas State employees and supervised volunteers fin the area around the springs to remove accumulated sediment, and then clear a 1.5 meter radius around each spring opening in Spring Lake with a scythe. Over the next 1.5 meter radius around the spring opening, they shear vegetation to a height of 30 cm, and then to one meter over the following three meter radius. Plant materials are not collected, but rather carried away by the current. Cumulatively, about six meters of vegetation around each spring opening is modified. Mosses are not cut. The volume of plant material to be removed will vary by the amount of time between cuttings and season. The harvester boat will remove a range of 15 to 20 boatloads of plant material a month from Spring Lake. The harvester clears the top meter of the water column, cutting vegetation from sections one, two, and three once a week (See HCP Figure 5.2). The harvested vegetation is visually checked by the driver for fauna caught in the vegetation. If the driver observes fauna, he/she will stop work and return the animal(s) back into Spring Lake if appropriate. Texas State employees and supervised volunteers are trained to recognize the Covered Species through the Diving for Science program (Section 5.4.7.1), and avoid contact with them. Vegetation mats are removed from zones four and five on an as-needed basis (See HCP Figure 5-2). The total area cut equals about nine surface acres. The Spring Lake Area Supervisor also schedules cleanup of nuisance floating species such as water hyacinth and water lettuce from Spring Lake. The floating plants are collected by hand and shaken prior to removal from the river to dislodge any aquatic species caught in the plant. The plants are deposited into dump trucks and taken to the MCWE compost area. The activities described in this section are not funded by the EAHCP. They are fully supported by Texas State University.

San Marcos River: Floating vegetation in Texas wild-rice stands are pushed and/or lifted off the stands and removed. Inorganic litter is picked up weekly from the substrate, surface and littoral zones of the San Marcos River from Clear Springs Natural Area to City Park and from IH-35 to Stokes Island during the recreational season (May 1st to September 30th) and monthly during offseason. Litter is also removed from public lands within the four tributaries. City of San Marcos contractor removes litter from City Park to IH-35 following the same protocol.

Monitoring:
In the event of low flows, this activity will be monitored by the EAA contractor for potential impacts on listed species and will be suspended if impacts are observed. Volume of litter removed will be tracked.

Budget:
Table 7.1:
$80,000

Available budget for 2018:
$80,000

Estimated 2018 budget:
$50,000

Transfer $20,000 to TWR Enhancement & $10,836 to Non-native Plant Removal

5.3.5/5.3.9/5.4.11/5.4.13 Non-Native Species Control

Long-term Objective:
Reduction of non-native, invasive species in the San Marcos River to levels that minimize their possible impacts on Covered Species and the aquatic ecosystem.

Target for 2018:
Contractor will use methods that have proven to be successful in efficient removal of invasive species from Spring Lake to IH-35 (Figures 5 - 7). Contractor will measure length, weight and determine gender for fish species. The targeted species include suckermouth catfish, tilapia, nutria and two snail species, *Melanoides* and *Marisa cornuarietis.*

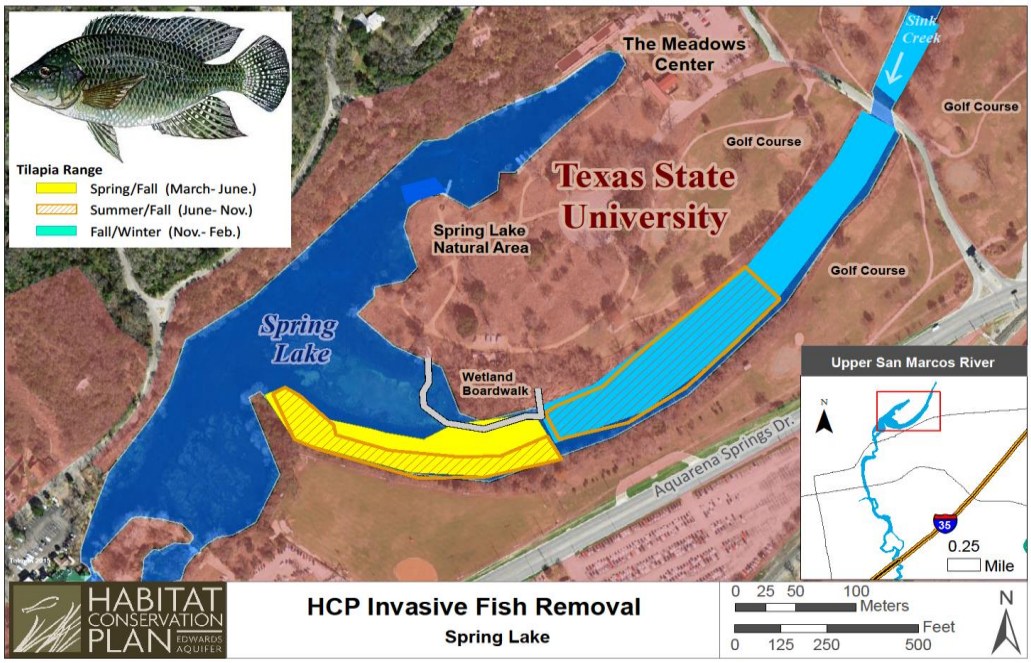


Figure 5. Tilapia removal in Spring Lake by location and season.

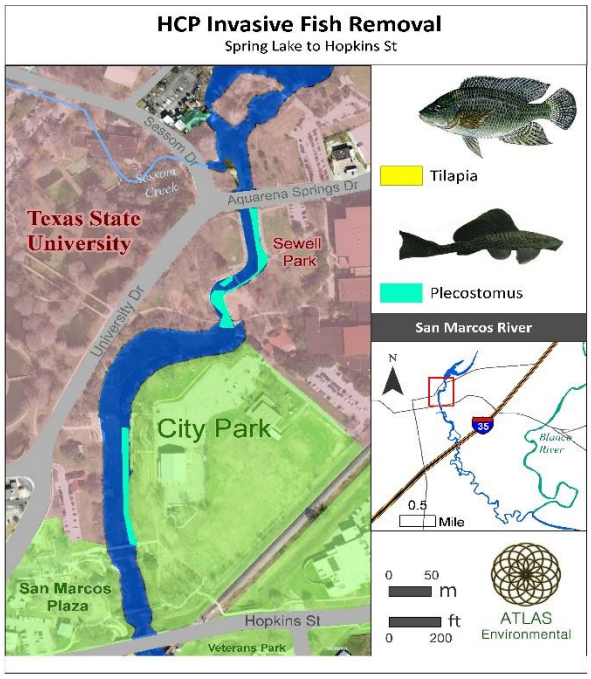


Figure 6. Suckermouth catfish frequent removal locations

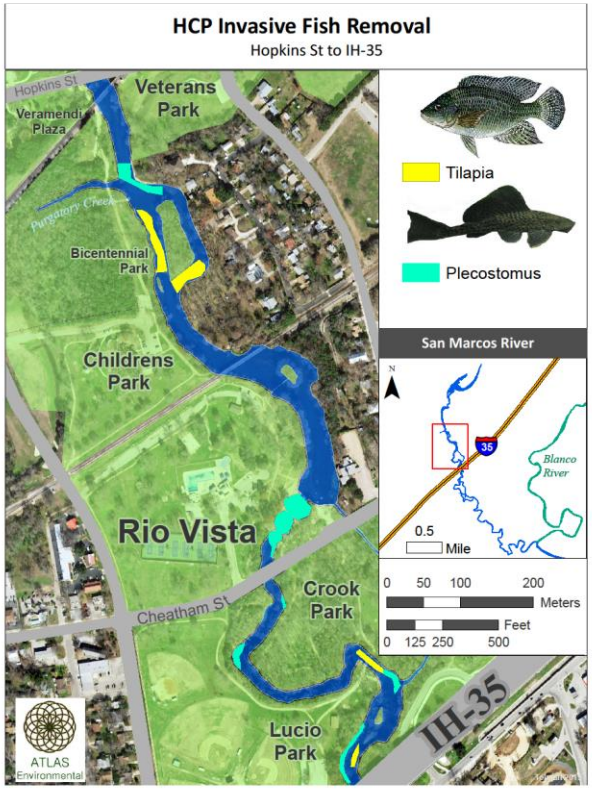


Figure 7. Tilapia and suckermouth catfish frequent removal locations.

Methodology:
Fyke nets, live trap cages, spear and bow fishing continue to be effective methods for fish removal. Contractor uses spearfishing tournaments to increase total removal, while saving costs and providing an educational awareness component to the community. Contractor will ensure that all methods avoid impacts to resident turtles and other native species.

Effective removal of *Melanoides* and *Marisa cornuarietus* is accomplished by determining the locations of highest snail density and using dip nets to remove the snails weekly. These species are best controlled by diving several hours after sunset to hand-pick the snails from the substrate and SAV.

City of San Marcos has an ordinance prohibiting the dumping of aquaria into the San Marcos River (Sec. 58.037).

Monitoring:
It is assumed that the integrated biological monitoring program will assess the status of non-native animal species to accompany trend data collected by contractor. Additionally, in order to monitor the reduction of overall non-native species abundance in the San Marcos ecosystem, the COSM and TXSTATE will compile information regarding the size (weight and total length) of the individual animals removed as well as a sex ratio (male:female). This information may assist in determining overall effectiveness of this conservation measures impact of species population dynamics.

A true quantitative measurement of population size would be difficult and require increased resources. By providing detailed information regarding these characteristics of removed animals the EAHCP staff and committees could determine a reduction in overall size and/or provide habitat destruction avoidance based on breeding habits by female fish species (i.e. tilapia nests in fountain darter habitat).

Budget:
Table 7.1:
$35,000

Available budget for 2018:
$35,000

Estimated 2018 budget
$27,000

Transfer $8,000 to Non-native plant removal

5.3.7 Designation of Permanent Access Points/Bank Stabilization

Long-term Objective:
Maintain integrity of structures that serve to control bank erosion, protect Texas wild-rice and listed species habitat in the recreation traffic areas.

Target for 2018:
The City of San Marcos completed the construction of bank stabilization/access points at seven locations along the San Marcos River in 2017. Quarterly monitoring will occur to ensure ongoing structural stability.

Monitoring:
A diver will measure possible undermining at each site twice yearly. The surface of each site will also be inspected for damage.

Budget:
Table 7.1:
$20,000

Available budget for 2018:
$20,000

Estimated 2018 budget:
$0

5.7.1 Native Riparian Habitat Restoration

Long-term Objective:
Establish a robust native riparian and water quality buffer community that benefits Covered Species through increasing the habitat and water quality within the San Marcos River down to city limits. The buffer will also prevent public access which causes bank erosion and impacts TWR stands. A zone of prohibitive vegetation along the uppermost edge of the riparian and water quality buffer community will be established to encourage river users to access the river via hardened access points. Private riverside landowner participation in this program will be encouraged and the EAHCP will provide the labor and plants as practical. EAHCP-funded contractor(s) will perform invasive removal and maintenance. Native plantings and maintenance will be done by volunteers during regular planting events.

Target for 2018:
HCP and COSM contractors, staff and volunteers will maintain all treated areas from Spring Lake to IH-35, and adjacent areas to address invasive seedbank source as appropriate. Volunteers will plant natives in previously worked areas during regular planting days as needed. Additional volunteer plantings will occur along the channel behind Snake Island contingent upon private landowners' participation response in 2017. Private landowners along the river above Cheatham Street have been contacted to determine interest in the development of a native vegetative buffer on their property. As budget allows, contractor will begin invasive removal downstream in Capes Park, Thompsons Island and Stokes Park (Section 5.3.8) (Figure 8). Efforts below IH-35 will focus on areas adjacent to and upstream of existing and proposed locations for Texas wild-rice stands.

Figure 8. New treatment zones along the San Marcos River

Methodology:
Contractor/staff use a glyphosate/trichlopyr herbicide mix to treat the stumps and/or roots. Volunteers complete all other native riparian habitat restoration as described above. Native plants used for restoration are purchased by the City of San Marcos (COSM) and propagated at the COSM Discovery Center. Treated and adjacent areas will be monitored for re-growth and seed sources. Roots will be scraped and treated with herbicide mix then monitored.

Monitoring:
Monitoring will occur monthly to check for re-growth and treat as needed. Maintenance will continue to be a mix of contract work funded by EAHCP and COSM, as well as volunteerism.

The City will continue to provide all fences to protect the sites as well as game cameras and other security measures as needed to prevent theft, vandalism and unauthorized access.

Maintenance:
If monitoring reveals regrowth of nonnative plants in previously treated areas, these will be removed and replanted with natives as needed.

Budget:
Table 7.1:
$20,000

Available budget for 2018:
$20,000

Estimated 2018 budget:
$20,000

5.3.2/5.4.2 Management of Recreation in Key Areas

Long-term Objective:
To minimize the impacts of incidental take resulting from recreation which includes, but is not limited to swimming, wading, tubing, boating, canoeing, kayaking, golfing, scuba diving, snorkeling and fishing.

Target for 2018:

1. Hire 10 Conservation Crew members that work 16 hours/week (Wed to Sun) from May to September with 2 – 3 members working prior to summer season and after to continue public outreach and recreation impact minimization efforts.

2. Continue the implementation of the following recreational management goals at a minimum:

a. Signage. Post signage at the City Park tube rental facility, Rio Vista Falls and at proposed hard access points along the river. Signs will have the same template and coloration so they are recognized up and down the river. Signs will cover the rules of the river and educate the public on the importance of the resource. **Kiosk signs have been produced, kiosks have been built -2018 target - place at each access point**.

b. Video Loop at City Park and Rio Vista Falls offering information about the river and safety rules while people are waiting for shuttle or tubes. Video was finished in 2016 for Lion's Club and will be updated and distributed electronically for increased exposure. Awaiting approval for placement of video at the Lion's Club. Contacting HEB for possible placement in the tubing aisle. **2018 target – install videos at these locations or others as possible.**

c. Posted maps showing trail, access points, fishing access and other amenities. Include a map at Stokes Park to help inform about the San Marcos River/Blanco confluence. **Map is complete and placed in the Discovery Center which serves as the trailhead to the San Marcos River.**

d. Work with the Tourist Information Bureau to include information on the endangered species and ongoing HCP projects at hotels/restaurants, bed and breakfast facilities, Chamber of Commerce, Visitor's Center, City of San Marcos internet site, etc. along with the recreational information**. 2018 target - Obtain approval, then work on design**.

e. Park Rangers. Include a section on river biology in the training of the park rangers so they can help disseminate the information. **2018 target – hold first session**

f. School Outreach. Implement an outreach program for San Marcos Consolidated Independent School District (SMCISD) so this information can be relayed to youth in San Marcos and indirectly to the parents. **This was completed through the production of an interactive river habitat card game that was introduced into the curriculum**

for SMCISD elementary schools. Also, the San Marcos Discovery Center is a facility dedicated to public education and outreach regarding the San Marcos River.

g. Continue to provide EAHCP presentations to TxState Outdoor Recreation class and Wildlife Society club and partner with TxState Geography Intern Program to increase volunteer participation.

h. Continue to provide outreach at booths including 72 degree festival, Concert Series (Earth & Water), Passport SMTX, Business Expo, Don't Mess with Texas Litter Cleanup.

j. Continue to educate the public during volunteer planting days.

k. Continue to educate the public engaged in water-based recreation on sustainable river behaviors that protect listed species and their habitats through interns and conservation crew program.

l. Introduce the COI program to qualified third parties conducting recreational activities in and along the San Marcos River. **Target date to be determined.**

Monitoring:
Litter removed from the river during the recreation season is tracked. For example, the 2016 litter total from Memorial Day to Labor Day:

Conservation Crew: (55-gallon bags): 597 river; 718 parks; 1315 total

HCP contractor: 135 55-gallon bags; 90 mesh bags (2.45 ft3)

City contractor: 190.44 tons

Grand Total: 190 tons + 1500 55-gallon bags

Budget:
Table 7.1:
$56,000

Available budget for 2018:
$ 56,000

Estimated 2018 budget:
$56,000

5.7.6 Impervious Cover/Water Quality Protection

This conservation measure will be revised in September 2017 based on results of adaptive management process.

Long-term Objective:

The removal of sediment in support of native aquatic planting activities has proved to be both unnecessary and overly expensive. From 2013 to 2015, three of the six required sites have received only 158 m^3 of sediment removal costing approximately $555,000. In 2017, COSM and TXSTATE will be working closely with EAHCP staff to develop and submit an Adaptive Management Proposal to the Implementing Committee for approval of an Amendment to the EAHCP regarding this conservation measure.

The goal of the AMP is to analyze how to reduce sediment loading at the source. An extensive list of best management practices (BMPs) has been identified through the COSM Water Quality Protection Plan (WQPP) process. Funds from the COSM and the EPA 319 grant will be leveraged with the remaining EAHCP Sediment Removal and Impervious Cover/Water Quality Protection measure funds to successfully implement these projects and prepare a manual that will establish the maintenance requirements for these water quality BMPs. The manual will help ensure that engineered components perform as designed and that landscaping remain viable. The manual will address inlets, outlets, underdrains, filtration media, erosion and sediment concerns, and landscaping.

The COSM and TXSTATE plan to combine the Sediment Removal and Impervious Cover/Water Quality Protection into one conservation measure that includes a prioritized list of BMPs within the upper San Marcos River watershed that will help control sediment and other contaminated runoff. Sessom Creek is a highly urbanized steep watershed that contributes a heavy load of sediment during rain events; in the 2015 October flood, Sessom Creek dumped sediment on TWR stands and other native plant stands down to City Park.

The COSM and TXSTATE will utilize a subcommittee of the EAHCP Science Committee to prioritize the list of projects in the Watershed Protection Plan (WPP) and WQPP.

The EAHCP commitment for the combined effort (Sediment Removal and Impervious Cover/Water Quality Protection) will not exceed $1,500,000. This will include (1) design of Sessom BMPs in 2018; (2) construction of Sessom BMPs starting spring of 2019; and (3) potential purchase of Sessom property or conservation easement.

The COSM and EAHCP commitment includes approximately $2,000,000 to provide; (1) design of wastewater relocation and erosion/sediment control; (2) Sessom wastewater line rehab and relocation Spring 2019; and (3) construction of BMPs that control erosion, minimize

sedimentation, and reduce pollutants. The COSM staff engineer will participate in the prioritization of the BMPs.

Additionally, the TXSTATE has received 319 funds from the TCEQ. These funds, will be accessed as available for design work in 2018 for the prioritized BMPs. The Meadows Center for Water and the Environment is assisting in implementation of the EPA 319 funds and will participate in the prioritization of BMPs.

Target for 2018:
This target will depend upon a successful resolution through the EAHCP AMP and proper Amendments to USFWS.

Monitoring:
TBD

Budget:
Table 7.1
$200,000

Available budget for 2018:
$230,000

Estimated 2018 budget:
$110,000

5.7.5 Management of Household Hazardous Waste

Long-term Objective:
Strengthen the COSM existing program that provides a place for citizens of San Marcos and Hays County to safely dispose of HHW and thus prevent loss of HHW into the river or recharge zone and thus impacting listed species.

Target 2018:
Target 2,750 participants for public outreach events. Staff will conduct these events and convert or dispose of the HHW between events. Fund outreach to surrounding communities within the San Marcos River watershed that cannot afford to partner in a HHWC program.

Methodology - open drop-off opportunities two days a week (Tuesday and Friday) from 12:00 noon to 3:30 p.m. to the public. Conduct HHWC events 1 to 2 times per year on a Saturday in north central Hays County and provide disposal for these events.

Monitoring:
Track the amount of HHW received and number of participants from San Marcos, Hays County, and surrounding communities. All necessary documentation will be turned in to TCEQ. Identify the HHW that comes from communities with the San Marcos River watershed and the cost of collecting, processing and disposing of HHW from these communities.

Budget:
Table 7.1:
$30,000

Available budget for 2018:
$30,000

Estimated 2018 budget:
$30,000

5.3.4 Prohibition of Hazardous Materials Transport Across the San Marcos River and Its Tributaries

Long-term Objective:
Reduce the potential of spill of hazardous materials in the San Marcos River and its tributaries through the designation of a hazardous materials route in COSM.

Target for 2018:
Long-term objective achieved.

Monitoring:
Bi-annual monitoring of hazmat traps on designated roadways to determine functionality and annual monitoring of all installed signage will be accomplished. Substandard conditions will be repaired or replaced as necessary.

Budget:
Table 7.1:
$0

Available budget for 2018:
$0

Estimated 2017 budget:
$0

5.7.3 Septic System Registration and Permitting Program

Long Term Objective:
To ensure an aerobic and anaerobic septic system registration, evaluation, and permitting program to prevent subsurface pollutant loadings from potentially being introduced to the San Marcos Springs ecosystem within city limits

Assumptions: The existing program is adequate to meet the intent of this Measure.

Target for 2018:
To have an accurate record of new and existing septic systems installed and modified in city jurisdiction. In addition, by ordinance, to have all owners of septic systems connect to municipal sewer lines as they become available.

Methodology - it is required by law that all septic systems are permitted by the local Designated Representative (DR), which is the City of San Marcos Environmental Health Department. Plans are submitted with the application and reviewed by the DR for TCEQ compliance. Once these requirements are met, the permit to construct is issued. The design, site evaluation, installation and inspections can only be performed by individual that are licensed by TCEQ. Before the installation or modification is approved, inspections are made by the DR to ensure that the system installed corresponds with the design. Once completed, a license to operate is issued to the property owner by the DR. All DRs are subject to TCEQ Compliance Reviews.

Monitoring:
The City of San Marcos Environmental Health Department reviews all applications and inspects the installations of all new and modified septic systems within the City's jurisdiction. The Department also monitors maintenance and responds to all complaints reported or observed.

Budget:
Table 7.1:
$0

Available budget for 2018:
$0

Estimated Budget:
$0

5.7.4 Minimizing Impacts of Contaminated Runoff

Long-term Objective:
The goal of this measure is to reduce the input of sediment and roadway contaminates into the San Marcos River. In order to leverage existing investment from the COSM, the EAHCP will assist in completing two ponds currently under construction. Both ponds are designed for high pollutant load reduction and have been identified as a priority management strategy.

Target for 2018:
All activities and funds associated with this measure have been completed. Both the Downtown and City Park ponds were designed and constructed in 2017 as required by the EAHCP.

Budget:
Table 7.1:
$0

Available budget for 2018:
$0

Estimated 2018 budget:
$0

5.4.5 Diversion of Surface Water

Long-term Objective:
Texas State University will curtail its permitted surface water diversions as a function of total San Marcos spring flow to protect the aquatic resources as specified under the HCP flow management strategy. Meet diversion restrictions specified under the HCP.

Target for 2018:
Restriction of surface pumping as specified under the HCP. Under TCEQ Certificates 18-3865 and 18-3866, Texas State University's total diversion rate from the headwaters of the San Marcos River for consumptive use is limited to 8.1 cfs (See HCP Section 2.5.5). The total diversion rate from Spring Lake is limited to 4.88 cfs; the total diversion rate from the San Marcos River at Sewell Park is limited to 3.22 cfs (See HCP Section 2.5.5.1 and 2.5.5.2 respectively).

Methodology - when flow at the USGS gauge at the University Bridge reaches 80 cfs, Texas State University will reduce the total rate of surface water diversion by 2 cfs, *i.e.*, to a total of approximately 6.1 cfs. This reduction in pumping will occur at the pump just below Spring Lake Dam in order to maximize the benefits to salamanders, Texas wild-rice, and other aquatic resources in the San Marcos River below Spring Lake Dam. The University will reduce the total rate of surface water diversion by an additional 2 cfs when the USGS gauge reaches 60 cfs. The additional 2 cfs reduction will be made from the pumps located in the slough arm of Spring Lake, and, therefore, maximize the benefits to the aquatic resources within the main stem San Marcos River below Spring Lake Dam. When the USGS gauge reaches 49 cfs, Texas State University will reduce the total diversion rate to 1 cfs. This further reduction will be made by restricting the pumps located in the Sewell Park reach. The diversion of water will be suspended when the springflow reaches 45 cfs.

Monitoring:
Pumping rates will be reported on a daily basis when any of the pumping restrictions are in force.

Budget:
<u>Table 7.1:</u>
$0

<u>Available budget for 2018:</u>
$0

<u>Estimated 2018 budget</u>:
$0

5.4.7 Diving Classes in Spring Lake

Long-term Objective:
Maintain the integrity of the ecology within Spring Lake through controlling access to Spring Lake in accordance to federal, state and local laws.

Assumptions: All diving activities in Spring Lake are governed by the Spring Lake Management Plan.

Target for 2018:
Implement the diving protocols as outlined in the Spring Lake Management Plan and the Edwards Aquifer HCP Incidental Take Plan.

Methodology - the Diving Safety Officer will monitor all diving activities in Spring Lake, assuring all guidelines contained in the Diving Safety Manual for Spring Lake and the EAHCP ITP are observed.

Monitoring:
The Lake Manager, with assistance from the Diving Safety Officer, will compile an annual summary of diving activities conducted in Spring Lake and provide to the Diving Control Board for its review.

Budget:
Table 7.1:
$0

Available budget for 2018:
$0

Estimated 2018 budget:
$0

5.4.8 Research Programs in Spring Lake

City ordinance and state law designate the public waters of Spring Lake as restricted to activities authorized by the University. Proposals for research projects in Spring Lake must be submitted to the Environmental Review Committee, through the Lake Manager, for review and approval.

Long-term Objective:
Maintain the integrity of the ecology within Spring Lake through controlling access to Spring Lake in accordance to federal, state and local laws. All research activities in Spring Lake are governed by the Spring Lake Management Plan.

Target for 2018:
Implement the protocols for research as specified in the Spring Lake Management Plan and the EAHCP ITP.

Methodology - Proposals for research projects in Spring Lake must be submitted to the Environmental Review Committee, through the Lake Manager, for review and approval.

Proposals for research projects must be submitted in writing and include:

1. Name and contact information of the responsible party conducting the research,
2. Purpose and expected outcomes of the activities, including a description of how the project contributes to science,
3. Description of activities, including, if appropriate, measures to be taken to minimize any impact on endangered species or their habitat, or any cultural resources found in the lake,
4. Methodology, including literature review,
5. Type of equipment used, how much; where it will be placed, and for how long it will remain in lake (see Equipment in Lake Section E of the Spring Lake Management Plan)
6. Expected impact, and
7. Timeline of Project

Monitoring:
The Lake Manager will compile an annual summary of the research conducted in the lake, including statements on the impact of these activities on the health of the lake.

Budget:
<u>Table 7.1:</u>
$0

<u>Available budget for 2018:</u>
$0

<u>Estimated 2018 budget:</u>
$0

5.4.10 Boating in Spring Lake and Sewell Park

Long-term Objective:
Maintain the integrity of the ecology within Spring Lake and San Marcos River through controlling access to Spring Lake in accordance to federal, state and local laws . All boating activities in Spring Lake are governed by the Spring Lake Management Plan and the EAHCP ITP.

Target for 2018:
Implement the protocols for boating as specified in the Spring Lake Management Plan in support of the EAHCP ITP.

Methodology – Follow the below protocol for all boats (canoe, kayak) used for educational activities, excluding glass bottom boats:

1. All boats must be properly washed/disinfected before being placed in lake and once they are removed (see Equipment in Lake in the Spring Lake Management Plan).
2. Participants must receive an orientation prior to boating including: instruction on safety, basic boat handling, and on-site rules and regulations. The orientation will cover information specific to Spring Lake's sensitivity and endangered species.
3. All boating events must be designed to keep participants away from glass bottom boat operations.

To minimize the impacts of boating on the Covered Species' habitat in Sewell Park, canoeing/kayaking classes in Sewell Park will be confined to the region between Sewell Park and Rio Vista dam. Students will enter/exit canoes/kayaks at specified access points to avoid impacting the flora and fauna along the bank. Classes will be no longer than two hours and up to three classes will be held per day. Classes will have a maximum of 20 students in 10 canoes. All classes will be supervised.

Monitoring:
The Lake Manager will compile an annual summary of boating activities conducted on the lake, including statements on the impact of these activities on the health of the lake.

Budget:
Table 7.1:
$0

Available budget for 2018:
$0

Estimated 2018 budget:
$0

5.4.9 Management of Athletic Fields and Grounds

Long-term Objective:
Management of the grounds to minimize and reduce negative effects to aquatic ecosystem in Spring Lake and the San Marcos River.

Target for 2018:
Continued implementation of the Grounds Management Plan and Integrated Pest Management Plan.

Methodology - the grounds will be maintained to meet the recreational function, yet in an environmentally sensitive manner. It is the responsibility of the Manager to maintain the grounds in accordance with the Integrative Pest Management Plan (IPM). This plan will describe the activities and materials to be used to control pests (i.e. insects, weeds, and other living organisms requiring control) in a way that minimally impacts the environment. The IPM updated as needed by the Grounds Manager, in consultation with the Lake Manager and the Environmental Review Committee. The Grounds Manager will consult with the Lake Manager on any unique situation that may arise outside of routine maintenance that could impact Spring Lake.

Monitoring:
Each year the Grounds Manager will report to the Lake Manager detailed information on maintenance activities and materials used during the year. The water quality monitoring program performed by the Edwards Aquifer Authority will sample for runoff from the fields.

Budget:
Table 7.1:
$0

Available budget for 2018:
$0

Estimated 2018 budget:
$0

Protocol for Implementation of HCP Measures Requiring Diving and/or Boating

All activities in Spring Lake must be submitted to the Spring Lake Environmental Review Committee and/or the Spring Lake Diving Control Board for approval as outlined in the Spring Lake Management Plan. This includes required training and orientation for any diving based activities in Spring Lake by the RSI Diving Safety Officer, using guidelines set out in the RSI Diving Safety Manual for Spring Lake and the San Marcos River. This includes an orientation that covers: instruction on safety, basic boat handling, and on-site rules and regulations. The orientation will cover information specific to Spring Lake's sensitivity, endangered species as well as cultural resources.

All personnel implementing any portion of the HCP for the City of San Marcos and Texas State University will undergo an orientation at the SMARC to ensure awareness of the listed species and safe procedures while working in and along the San Marcos River.