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	$329,050	($43,750)
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**	**$19,271,819**	**$362,853**

***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 33,334 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:
$329,050*

*2018 EAHCP Sampling will be performed by an outside contractor; estimated annual costs $285,300. Real Time Instruments (RTI): $43,750.

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.

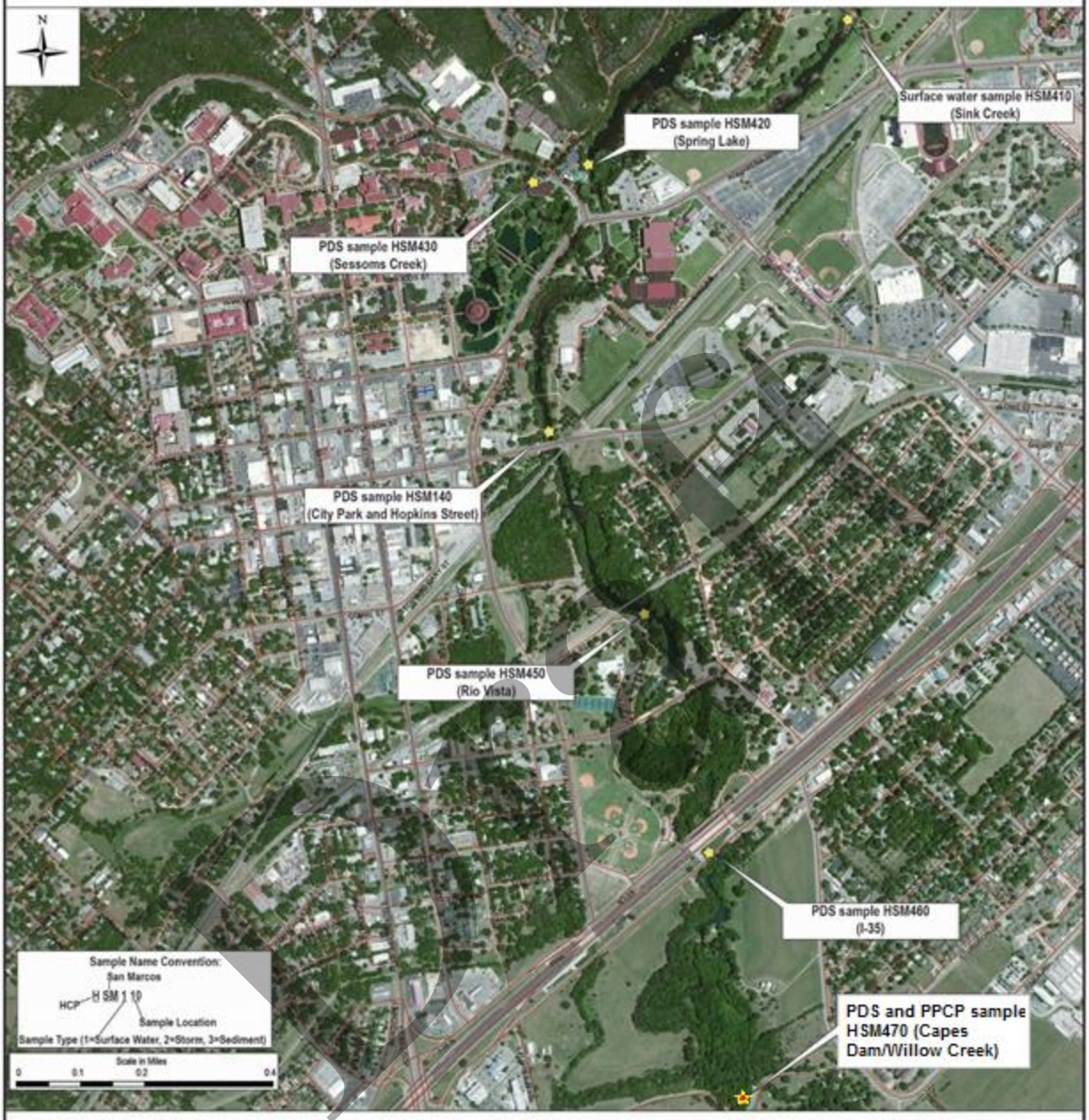
Explanation

★ 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 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.

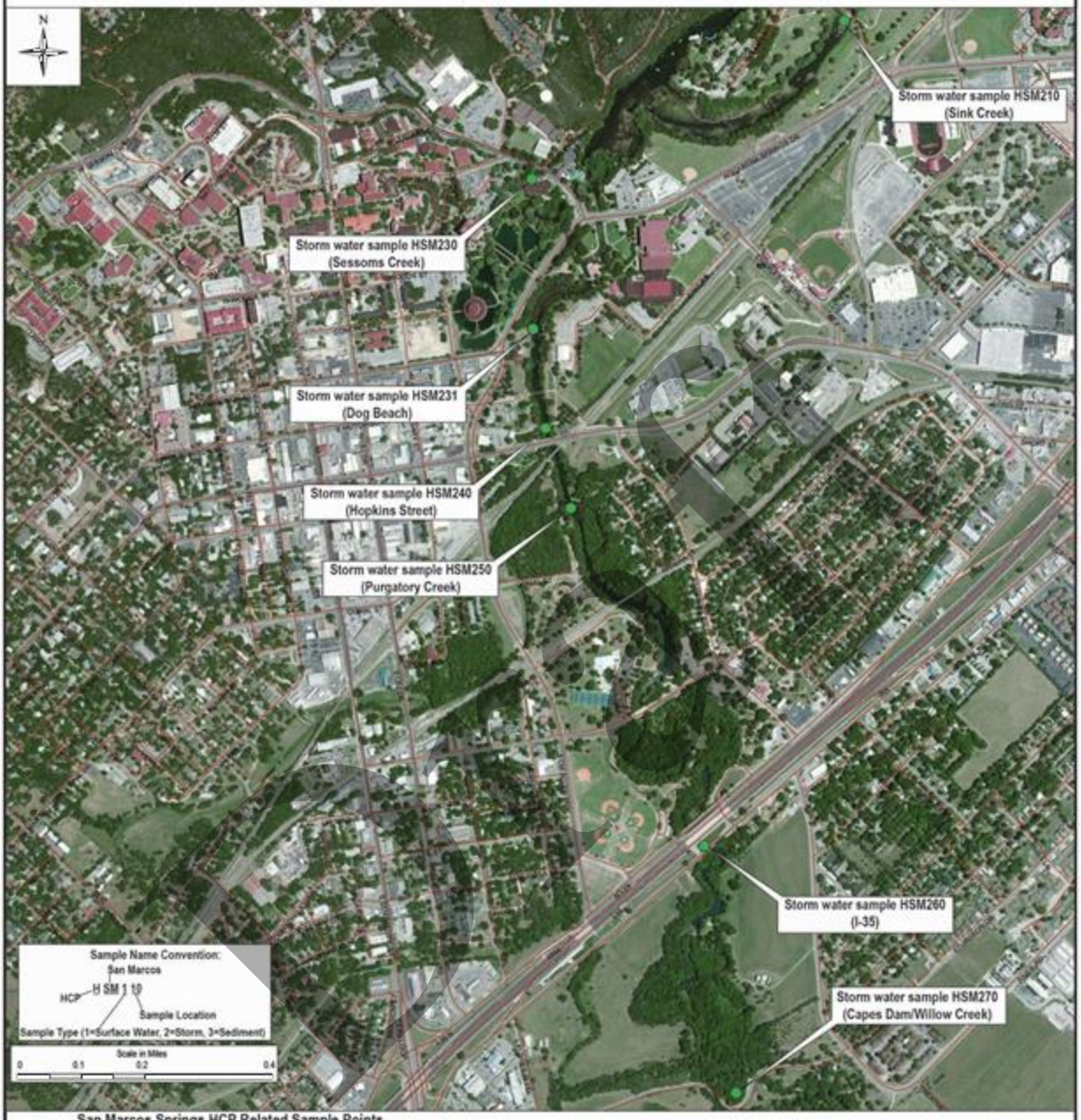
Explanation

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

Prepared by:

EDWARDS AQUIFER AUTHORITY

Figure 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.

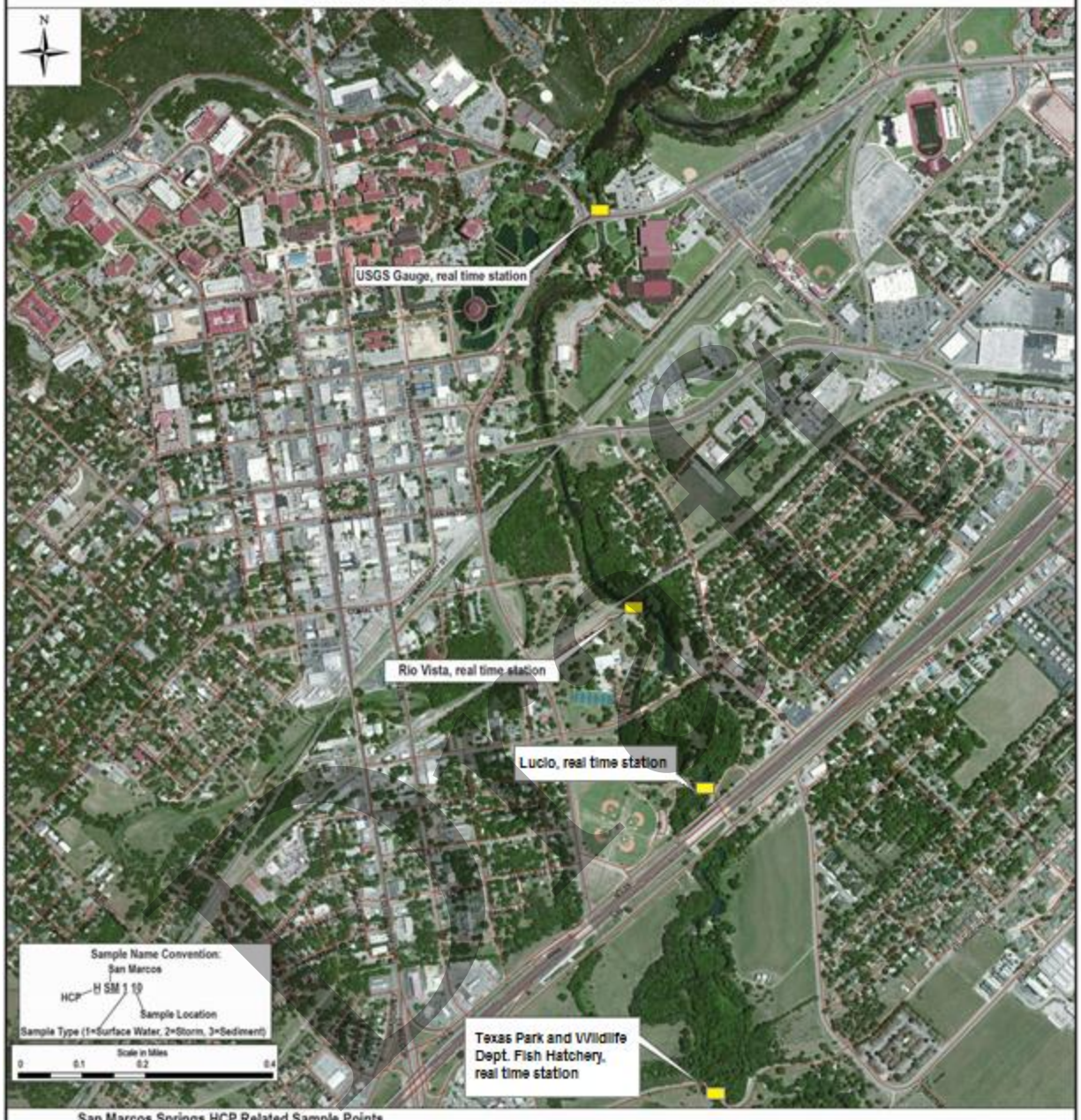
Explanation

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 $18,000
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)	$6,000.00
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)	$10,000.00
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	**$35,000.00**

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.

Texas wild rice:

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.

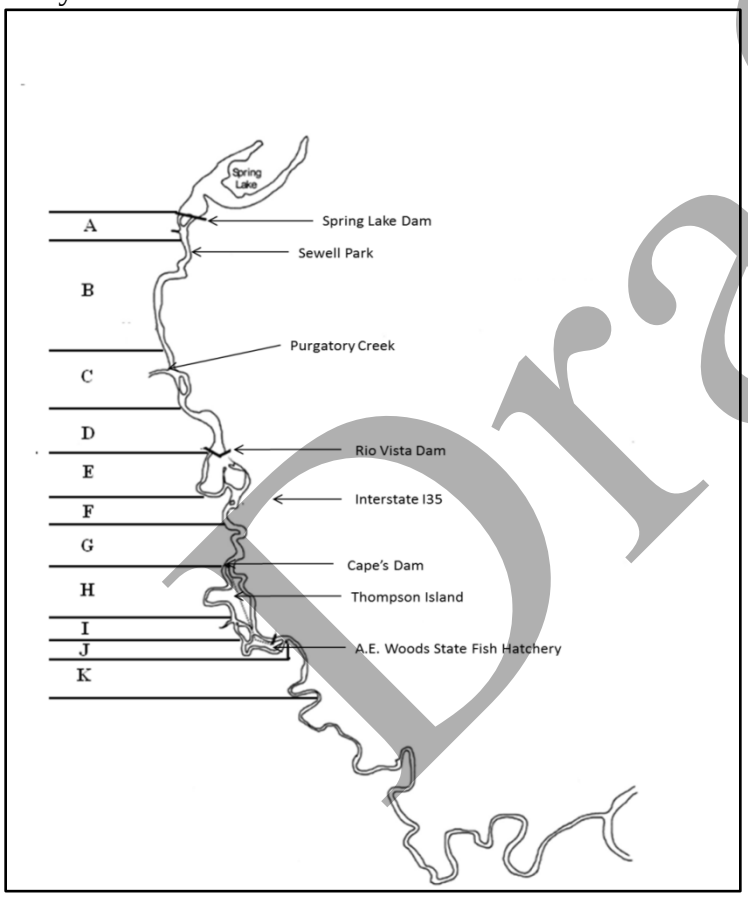


Figure 1. Letters define designated San Marcos River reaches where Texas wild rice is collected for refugia populations.

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 December	Draft Research Reports
	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,

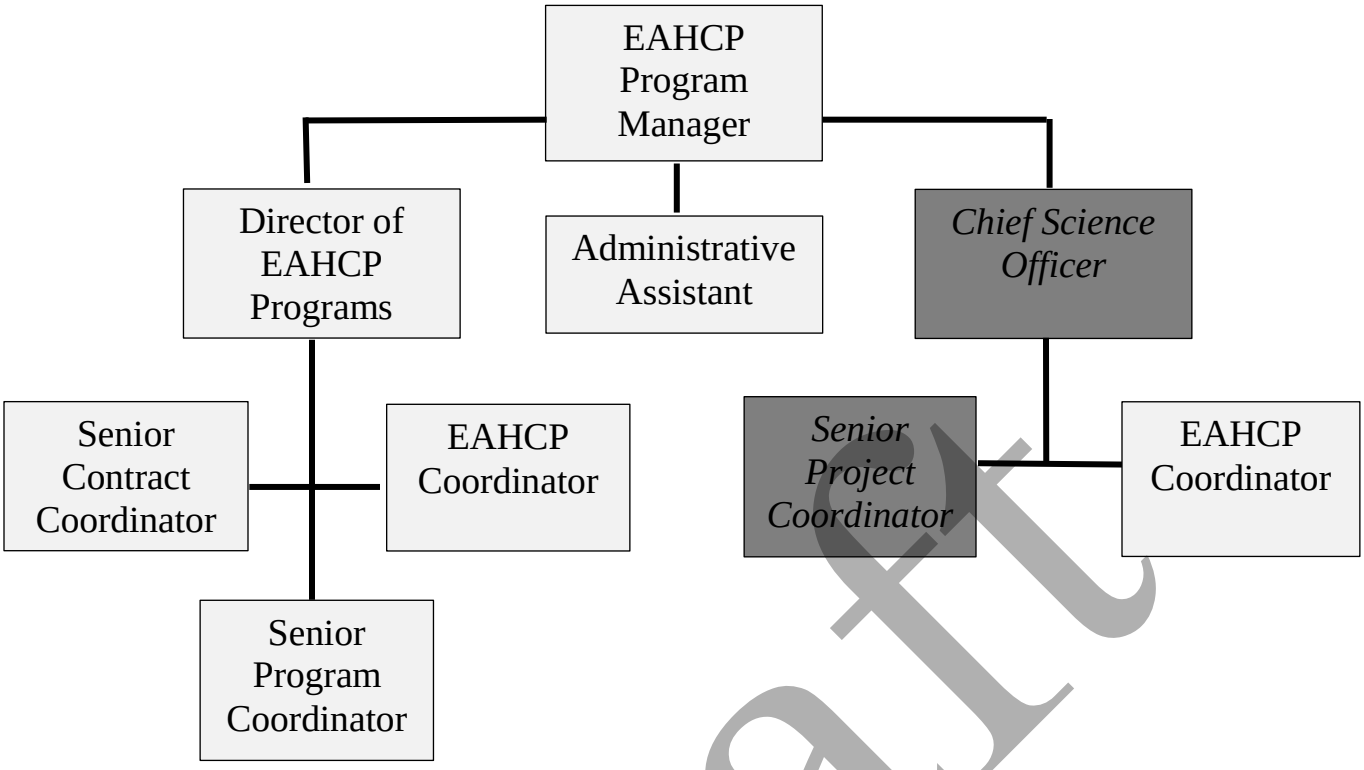
- Oversee and coordinate research activities at the Texas State University Freeman Aquatic Building,
- Coordinate 2018 work plan amendments and the development of 2019 work plans,
- Draft and submit to the USFWS amendments, informational memorandums, and clarifications to the Incidental Take Permit and 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.