Edwards Aquifer Authority
2022 Work Plan

2022 Cost Estimate for Edwards Aquifer Authority Work Plan

EAHCP Section	Conservation Measure	Table 7.1	Estimated 2022 Costs[a]
5.1.1	Refugia	$1,678,597	$1,447,937[h]
5.1.2	VISPO [b]	$4,172,000[c]	$2,509,976[d]
5.1.3	RWCP	$1,973,000	$0
5.1.4	Stage V	NA	NA
5.5.1	ASR Leasing & Forbearance [b]	$4,759,000	$5,776,493
	ASR O&M	$2,194,000	$0
5.7.2	Water Quality Monitoring	$200,000	$60,000[f]
6.3.1	Biological Monitoring	$400,000	$755,774 [e]
6.3.3	Ecological Model	$25,000	$0
6.3.4	Applied Research	$0	$250,000
FMA §2.2	Program Management	$750,000	$1,302,061[g]
Total		$16,151,597	$12,102,240

a. Estimated annual work plan cost per Funding and Management Agreement § 4.4.
b. Expected to change as leases transition to forbearance agreements through 2021 and 2022. Estimate presented based on best available data to date
c. Dollars in Table 7.1 of the EAHCP were calculated from a volume goal of 40,000 acre-feet (ac-ft). The volume goal was amended to 41,795 ac-ft in 2019 and Table 7.1 dollars are no longer applicable.
d. Amount is TBD. Standby payments will be made totaling the estimated cost in the table if program is not triggered by October 1, 2021. If triggered, VISPO program suspension payments will be $9,987,551.
e. Includes Critical Period Monitoring if required.
f. Includes updated Water Quality Monitoring costs for 2022 activities
g. Includes updated Program Management costs for 2022 activities
h. Includes unspent funds from 2021 to be used towards operational and research effort costs

2022 Amendments to Edwards Aquifer Authority (EAA) Work Plan and Funding Application

Amendment #	Date EAHCP Committee Approved	Conservation Measure Amended	Y/N Funding Application Change	Funding Application Change ($)	Date EAA Board Approved	Comments
0	5/20/2021	Original Work Plan	NA	NA	NA	Original Work Plan
0	10/14/2021	Original Funding Application	NA	NA	11/9/2021	Original Funding Application
1	10/14/2021	Water Quality Monitoring and Program Management	N	N	11/9/2021	Updated Water Quality Monitoring and Program Management with known activities and 2022 costs
2	12/16/2021	Water Quality Monitoring, Applied Research, and Refugia	N	N	n/a	Updated changes to projected activities to Water Quality Monitoring, Applied Research, and Refugia (no change in annual costs)
3	5/19/2022	Water Quality Monitoring and Refugia	Y	$281,562	6/14/2022	Updated Refugia and Water Quality Monitoring with known activities and 2022 costs

5.1.1 Refugia Program

Introduction

The U.S. Fish and Wildlife Service's (USFWS) San Marcos Aquatic Resources Center (SMARC) and Uvalde National Fish Hatchery (UNFH) 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 Edwards Aquifer Habitat Conservation Plan (EAHCP). The tasks and subtasks that follow provide the details for the services to be performed in 2022, which provide for the maintenance of a refugia population of the Covered Species (Table 1), including salvage, propagation, and restocking of the species (if species-specific habitat triggers occur and species are extirpated), plus research conducted on the Covered Species.

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
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 pterophila*	Petition Rescinded
Texas troglobitic water slater	*Lirceolus smithii*	Petitioned

Long-term Objective

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, prey, competitors, pathogens, parasites; or on their habitat, including food, water, and shelter.

2022 Assumptions

As work plans are developed almost a year prior to implementation, it is possible that methods described herein will be contingent on the status of the current year's activities or authorization from the HCP process. If conditions change, this work plan may need to be amended to accommodate realized outcomes.

The following potential situations could necessitate methodology adjustments.

- Target numbers for standing and refugia stocks to be housed at both the UNFH and SMARC deviate from those established by the USFWS-EAA Refugia Contract (Contract # 16-822-HCP).
- Species capture rates fall short of historic values.
- Mortality rates of specimens held in captivity exceed historic values.
- Staff member vacancies occur at either of the two Service facilities during the performance period.
- A pandemic or other emergency prevents scheduled collections.

Target for 2022 (Deliverables and Methods by Task):

Task 1. Refugia Operations

Standing Stocks: 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 contains the target species numbers.

Table 2. Target refugia numbers and census by species.

Species	Standing Stock	Refugia Stock	Salvage Stock	Anticipated SMARC census (Jan 2022)	Anticipated SMARC census (Dec 2022)	Anticipated UNFH census (Jan 2022)	Anticipated UNFH census (Dec 2022)
Fountain darter (Comal)	1000	1000 including specimens within the standing stock	2000	*	*	*	*
Fountain darter (San Marcos)	1000	1000 including specimens within the standing stock	2500	500	500	500	500
Texas wild-rice	430	430 including specimens within the standing stock	1500	215	215	215	215
Texas blind Salamander	500	500 including specimens within the standing stock	500	250	250	60	60
San Marcos salamander	500	500 including specimens within the standing stock	500	250	250	250	250
Comal Springs salamander	500	500 including specimens within the standing stock	500	135	150	105	135
Peck's cave amphipod	500	500 including specimens within the standing stock	500	250	250	250	250
Comal Springs riffle beetle	500	500 including specimens within the standing stock	500	75	75	75	75

Comal Springs dryopid beetle	500	500 including specimens within the standing stock	500	*	*	*	*
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	*	*	*	*

We will not collect Comal fountain darters until we have a better understanding of their mortality rates
*catch rates and hatchery survival are uncertain given the rarity of the species

Collection: In 2022, the USFWS will collect Covered Species as required to reach and maintain target standing and refugia stock numbers as shown in Table 2. The USFWS will coordinate species collections with other ongoing HCP activities (e.g. Biological Monitoring Program) so that collections for refugia do not adversely impact other efforts. The USFWS will carry out species collections through a variety of passive and active collection methods and will minimize aquatic invasive species transfer by conducting collections in accordance a Hazard Analysis Critical Control Point plan. The USFWS will document and report collection efforts to the EAA. The USFWS will distribute captured organisms between the SMARC and UNFH facilities in order to ensure redundancy and to expedite the obligation to establish and maintain two refugia populations at separate locations. The USFWS will hold all species in respective quarantine areas until their health has been assessed. Staff will incorporate quarantined organisms into the general refugia population once they have determined that such specimens are healthy and free from invasive species. The USFWS will share reports, including test results, produced as part of the quarantine process.

The following sections briefly describe planned 2022 collection, maintenance, and propagation efforts for each species.

Fountain Darters:

Collection: In 2022, the USFWS will collect Fountain Darters from the San Marcos River in coordination with the Spring and Fall Biomonitoring events. This will be more efficient than separate collection events and will reduce habitat disturbance. For refugia purposes, USFWS staff will retain Fountain Darters collected by biomonitoring staff via drop nets. Staff will collect fish proportionally from the three sections of the San Marcos River: 1) Upper = Spring Lake, 2)

Middle = Spring Lake dam to Rio Vista dam, and 3) Lower = below Rio Vista dam to Cape's dam. The USFWS will thoroughly investigate unusual mortality events. The USFWS will include summary reports to the EAA as part of the monthly reports. Collections will target sufficient fish so to account for regular, expected mortality, such that the captive population should remain at or above the target.

Due to the detection of largemouth bass virus (LMBV) in Comal fountain darters throughout the Comal River, the USFWS will maintain all fountain darters from Comal River in quarantine facilities, in consideration of other species on the two stations. We have continued concern over higher mortality rates of incoming Comal fountain darters, as no root cause has been identified despite extensive testing and evaluation with the USFWS Fish Health Unit. Until we have a better understanding of the high mortality rates of incoming Comal fountain darters we will conduct limited collections from the wild, unless salvage is needed.

As part of quarantine procedures, the USFWS will send a subset of fish (maximum of 60 per river) to the Southwestern Fish Health Unit or equivalent facility for pathogen (bacteria, virus, and parasite) testing prior to incorporating collected animals into the general refugia population. The USFWS will follow standardized methods outlined within USFWS and AFS-FHS (2016) and AFS-FHS (2005) protocols and provide Fish Health reports to the EAA.

Maintenance: The USFWS will monitor water quality (i.e., temperature, pH, dissolved oxygen, total dissolved gasses) and record these data weekly. Staff will feed fountain darters a mix of live and frozen foods reared or purchased. The USFWS will rear zooplankton and amphipods in ponds and tanks for food. We do not generally examine food items for pathogens. However, if they are suspect and tested for pathogens, the USFWS will include all diagnostic results to the EAA within monthly reports.

Propagation: The USFWS will maintain standing and refugia stocks for each river to produce captive-bred fish for research purposes, as necessary and approved. Staff will maintain fish by their geographical collection location. If reintroduction is warranted, the USFWS will communally spawn subsets from each geographical location. The USFWS will cull subset groups to an equal number of progeny prior to release.

Texas wild-rice:

Collection: USFWS staff will collect Texas wild-rice tillers from San Marcos River reaches (Figure 1), with a break during summer months when collected wild rice does not fare well due to heat stress. In 2022, staff will target stands that are not already part of the refugia population or require supplementation in collections for SMARC and UNFH. The refugia populations will reflect the wild populations in both their respective proportion, based on the most recent Texas wild-rice survey data, and historical genetic diversity (2021 genetic assessment and Wilson et al. 2016). During tiller collection, the USFWS will record the geographic coordinates, area coverage, and depth of the stand or individual plant. USFWS staff will collected tillers by

wading and SCUBA diving. The USFWS will consider georeferenced aerial imagery to help identify distinct TWR stands used for tiller collection.

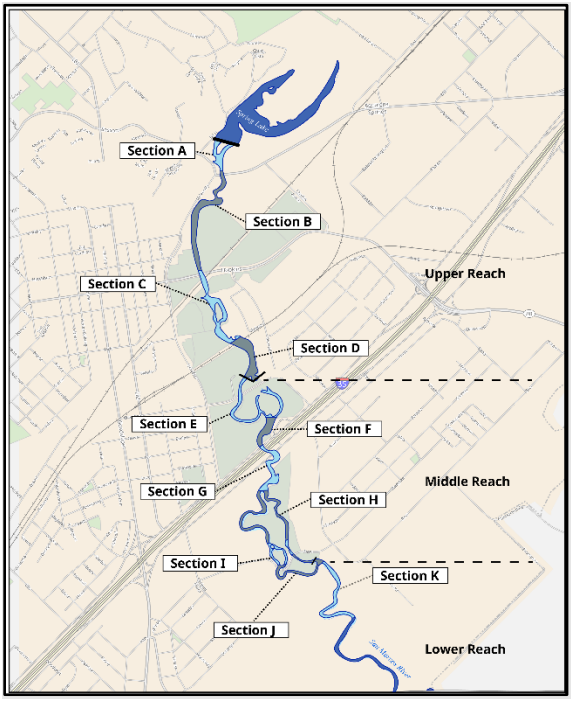

Figure 1. Letters define designated San Marcos River reaches where Texas wild rice is collected for refugia populations.

Maintenance: Once tillers have successfully rooted, USFWS staff will tag and maintain with their collection date and location information.

Propagation: USFWS staff will maintain plants to prevent sexual reproduction within the refugia population, unless EAHCP triggers occur. If reintroduction is warranted, USFWS staff will produce seeds and tillers from each geographical location. During reintroduction, staff will transplant refugia plants produced from seeds and tillers to their original source location, delineated by river section (Figure 1).

Texas blind salamanders:

Collection: USFWS will collect Texas blind salamanders using nets and traps. Staff will deploy traps quarterly for approximately 14 consecutive days with traps checked every 2-4 days to collect Texas blind salamander individuals from Primers Fissure, Johnson's well, Rattlesnake cave, and Rattlesnake well (Table 5). To avoid oversampling these habitats, staff will only collect 1/3 of salamanders observed from each of these locations during quarterly sampling events. Staff will also collect salamanders from a driftnet on Diversion Springs in Spring Lake fished throughout the year during times when we are not actively trapping in caves and wells. We will retain all specimens from this site, under the assumption that any Texas blind

salamander leaving a spring orifice that enters a stream or lake environment will ultimately succumb to predation. We will check these sites up to three times per week when applicable. Staff will transport all specimens alive and maintain them in the SMARC or UNFH refugia. Texas State University staff generally check drift nets on Sessom Creek and Texas State University Artesian Well; Texas State University transfers live Texas blind salamanders to SMARC according to their permits, when appropriate. USFWS staff may periodically check nets on these sites when they are not being checked by Texas State University staff.

As part of quarantine procedures, USFWS staff will swab all large Texas blind salamanders. If they are too small to be swabbed, then we will do a representative batch swab of group-housed salamanders once they are large enough to be safely swabbed. USFWS staff will process these samples at SMARC or other facility to screen for *Batrachochytrium dendrobatidis* (Bd, commonly referred to as chytrid fungus) and *Batrachochytrium salamandrivorans* (Bsal) prior to specimen incorporation into the general refugia population. Staff will retain duplicate swabs in case further testing is warranted. Staff will hold all salamanders 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 salamanders) have regularly 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 yet been documented in North America. Staff would retain such salamanders in quarantine until further study and recommendations from FWS Fish Health.

Maintenance: USFWS staff will individually tag salamanders to retain information on collection location, date, and other life history events. Staff will monitor water quality and record data weekly. Staff will feed salamanders live and frozen foods, either reared or purchased. Staff will utilize ponds and tanks to produce amphipods on site.

Propagation: Staff will maintain standing and refugia stocks to encourage reproduction. Staff will maintain all progeny separately by generations. If reintroduction is warranted, an attempt will be made to produce offspring from each geographical location.

San Marcos salamanders:

Collection: USFWS staff will collect San Marcos salamanders quarterly from below Spring Lake dam and with SCUBA teams in Spring Lake (Table 5). Staff will check the drift net on Diversion Springs routinely and keep specimens from this location as space in quarantine and need allows. We will avoid collections close to the HCP Biological Monitoring Program assessment events. Staff will transport all specimens alive and maintain these in the SMARC and UNFH refugia.

As part of quarantine procedures, USFWS staff will swab all large San Marcos Salamanders. If they are too small to be swabbed, then we will do a representative batch swab of group housed salamanders once they are large enough to be safely swabbed. USFWS staff will process these samples at SMARC or other facility to screen for *Batrachochytrium dendrobatidis* (Bd, commonly referred to as chytrid fungus) and *Batrachochytrium salamandrivorans* (Bsal) prior to

specimen incorporation into the general refugia population. Staff will retain duplicate swabs in case further testing is warranted. Chytrid testing will occur in batches where groups of five swabs will be pooled for analysis. Staff will hold all salamanders 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 salamanders) have regularly tested positive for Bd. Positive testing for Bsal will be treated more cautiously as it has not yet been documented in North America. Staff would retain such salamanders in quarantine until further study and recommendations from FWS Fish Health.

Maintenance: Staff will monitor water quality and record data weekly. Staff will feed salamanders live foods, either reared or purchased, mixed with purchased frozen food sources if necessary. Staff will utilize ponds and tanks to produce amphipods on site.

Propagation: USFWS staff will maintain salamander standing and refugia stocks to encourage reproduction. We will separate all progeny by generation. If reintroduction is warranted, staff will employ pairwise and group mating to produce offspring. Staff will initiate stocking once juveniles have reached 30 mm total length.

Comal Springs salamanders:

Collection: USFWS staff will collect Comal Springs salamanders quarterly from Comal Spring Runs 1-3 and Spring Island and surrounding areas (Table 5) by hand, with dipnets, using snorkelers. We will coordinate with the HCP biological monitoring program in order to ensure that, to the degree practicable, refugia collections do not overlap with specific EAHCP long-term monitoring locales. In the event overlap of sampling areas is unavoidable, we will collect Comal salamanders at a rate of no more than 10% of salamanders observed in those specific locales per daily sampling trip. We will employ a SCUBA team for a portion of these collection efforts if necessary.

As part of quarantine procedures, USFWS staff will swab all large Comal Springs salamanders. If they are too small to be swabbed, then we will do a representative batch swab of group housed salamanders once they are large enough to be safely swabbed. USFWS staff will process these samples at SMARC or other facility to screen for *Batrachochytrium dendrobatidis* (Bd, commonly referred to as chytrid fungus) and *Batrachochytrium salamandrivorans* (Bsal) prior to specimen incorporation into the general refugia population. Staff will retain duplicate swabs in case further testing is warranted. Chytrid testing will occur in batches where groups of five swabs will be pooled for analysis. Staff will hold all salamanders 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 salamanders) have regularly 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 yet been documented in North America. Staff would retain such salamanders in quarantine until further study and recommendations from FWS Fish Health.

Maintenance: Staff will monitor water quality and record data weekly. Staff will feed salamanders live and frozen foods, either reared or purchased. Staff will utilize ponds and tanks to produce amphipods on site.

Propagation: USFWS staff will maintain salamander standing and refugia stocks to encourage reproduction. We will separate all progeny by generation. If reintroduction is warranted, staff will employ pairwise and group mating to produce offspring. Staff will initiate stocking once juveniles have reached 30 mm in total length.

Comal Springs riffle beetle:

Collection: USFWS staff will collect Comal Spring riffle beetle for standing and refugia stocks four times a year from a variety of locations, including Spring Run 1, Spring Run 3, the Western Shore, and areas surrounding Spring Island (Table 5). Staff will collect riffle beetles with cotton lures following EAHCP standard operating procedures (Hall 2016) and from wood, as needed. Staff will follow protocols established by the CSRB Work Group in 2019:

1. Staff will not sample the same spring orifice two times in a row.
2. Staff will collect all riffle beetle adults and larvae from lures.
3. Standing stock numbers will be reduced to 75 per station until USFWS has established sufficient propagation methods, and we have better understanding of population numbers to derive meaningful standing stock targets.

The Comal Springs Riffle Beetle Work Group Standing will evaluate standing stock numbers yearly. Additional collections for research purposes may be required outside of standing stock collections.

Maintenance: USFWS staff will maintain specimens by collection date. Staff will hold Comal Springs riffle beetles within custom built aquatic holding units and feed them detrital matter and matured biofilms colonized on cotton lures, wood dowels, and leaf matter.

Propagation: Propagation methods for this species are being developed.

Peck's cave amphipod:

Collection: USFWS will conduct Peck's cave amphipod collection for standing stock four times annually (Table 5). Staff will collect adult Peck's cave amphipods with drift nets and by hand at a variety of locations (drift nets: Spring Run 3, N = 2; Spring Island and associated Spring Lake habitats: hand collection).

Maintenance: Staff will maintain specimens by collection date within custom-built aquatic holding units and feed amphipods with commercial flake fish food.

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

Comal Springs dryopid beetle:

Collection: USFWS will collect Comal Springs dryopid beetles primarily through the use of wooden lures and hand picking from submerged wood found in the Comal Spring system. If staff find dryopid beetles on cotton lures used for Comal Spring riffle beetles, these will also be retained (Table 5). We will potentially conduct two trapping events with bottle traps in Panther Canyon Well during the year as access to the well and staff time allows. Staff will check these traps weekly for a month.

Maintenance: USFWS will combine collected Comal Springs dryopid beetles, regardless of collection location. Staff will hold Comal Spring dryopid beetles within custom built aquatic holding units and feed them detrital matter and matured biofilms colonized on cotton lures, wood dowels, and leaf matter.

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

Edwards Aquifer diving beetle:

Collection: Staff will collect Edwards Aquifer diving beetles with drift nets (Table 5). Staff will set drift nets at a variety of locations where the species has been collected in the past (Texas State University Artesian Well N = 1; and Diversion Springs N = 1). USFWS staff will deploy and check drift nets at the Artesian Well when as Texas State University allows.

Maintenance: USFWS will combine collected Edwards Aquifer diving beetles, regardless of collection location. Staff will transfer captured specimens to the SMARC or UNFH and house them in custom-made aquatic holding systems. Edwards Aquifer diving beetles are predators; staff will feed them small invertebrates (e.g., ostracods).

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: Texas troglobitic water slaters are primarily found in Artesian Well on Texas State Campus. Recent research by Will Coleman (Texas State University) suggests that this is a deep aquifer species, rarely found at the surface. Mr. Coleman was unable to keep any alive, as all specimens he collected were injured. USFWS will continue to work with invertebrate experts to determine what might be the optimum way to collect this species. USFWS staff will deploy and check drift nets in the Artesian Well as Texas State University allows.

Maintenance: Staff will transfer captured specimens to the SMARC and house them in custom aquatic holding systems. Staff will feed Texas troglobitic water slaters detrital matter, matured biofilms colonized on cotton lures, and flake fish food to supplement their diet.

Propagation: Staff need to determine propagation methods for this species, to be conducted as part of normal refugia operations.

Table 5. A tentative schedule for all species sampling during 2022. Collections listed here are subject to change with extenuating circumstances such as weather and coordination with external partners. USFWS will notify EAA and partners of sampling dates as they become known or changed.

Edward's Aquifer Species Collection Plan 2022			
Date (month)	**Interval**	**Location**	**Target Species**
January	14 Consecutive days with traps checked 2-3 times a week	Rattlesnake Cave & Rattlesnake Well	Texas blind salamander
January	1 day sampling event, hand pick from downed wood	Landa Lake	Comal Springs dryopid beetle
February	14 Consecutive days with traps checked 2-3 times a week	Primer's Fissure & Johnson's Well	Texas blind salamander
February	Set lures	Spring Run, Landa Lake	Comal Springs riffle beetle, Comal Springs dryopid beetle, Peck's cave amphipod, Texas troglobitic water slater
February	1 day sampling event	San Marcos River	Texas wild rice
February	1 day sampling event	San Marcos River	Texas wild rice
March	Check nets T and F every week	Diversion Springs	Texas Blind salamander, San Marcos salamander
March	Collect Lures	Spring Run, Landa Lake	Comal Springs riffle beetle, Comal Springs dryopid beetle, Peck's cave amphipod, Texas troglobitic water slater
March	1 day sampling event, hand pick	Landa Lake	Peck's Cave amphipod
March	1 day sampling event	Comal Springs	Comal Springs salamander

Edward's Aquifer Species Collection Plan 2022			
Date (month)	**Interval**	**Location**	**Target Species**
March	1 day sampling event, hand pick from downed wood	Landa Lake	CSDB
April	Check 2 consecutive weeks	Rattlesnake Cave & Rattlesnake Well	Texas blind salamander
April	1-2 day sampling event	Spring Lake and below dam	San Marcos salamander
April	1 day sampling event	San Marcos River	Texas wild rice
April	Throughout, coincide with bio-monitoring	San Marcos River	Fountain darters
April	Drift net, donated from bio-monitoring	Comal Springs	PCA
May	Set lures	Spring Runs, Landa Lake	Comal Springs riffle beetle, Comal Springs dryopid beetle, Peck's cave amphipod, Texas troglobitic water slater
May	14 Consecutive day with traps check 2-3 times a week	Primer's Fissure & Johnson's Well	Texas blind salamander
May	1-day sampling event	San Marcos River	Texas wild-rice
June	Collect lures	Spring Runs, Landa Lake	Comal Springs riffle beetle, Comal Springs dryopid beetle, Peck's cave amphipod, Texas troglobitic water slater
June	Check nets T and F every week	Diversion Springs	Texas Blind salamander, San Marcos salamander
June	1 day sampling event, hand pick	Landa Lake	Peck's Cave amphipod

Edward's Aquifer Species Collection Plan 2022			
Date (month)	**Interval**	**Location**	**Target Species**
June	1 day sampling event	Comal Springs	Comal Springs salamander
June	Set lures	Western Shore	Comal Springs riffle beetle, Comal Springs dryopid beetle, Peck's cave amphipod, Texas troglobitic water slater
July	14 Consecutive days with traps check 2-3 times a week	Rattlesnake Cave & Rattlesnake Well	Texas blind salamander
August	Set lures	Western Shore	Comal Springs riffle beetle, Comal Springs dryopid beetle, Peck's cave amphipod, Texas troglobitic water slater
August	14 Consecutive days with traps check 2-3 times a week	Primer's Fissure & Johnson's Well	Texas blind salamander
August	1-2 day sampling event	Spring Lake and below dam	San Marcos salamander
September	Check nets T and F every week	Diversion Springs	Texas Blind salamander, San Marcos salamander
September	1 day sampling event, hand pick	Landa Lake	Peck's Cave amphipod
September	1 day sampling event	Comal Springs	Comal Springs salamander
September	Collect lures	Western Shore	Comal Springs riffle beetle, Comal Springs dryopid beetle, Peck's cave amphipod, Texas troglobitic water slater
October	14 Consecutive days with traps checked 2-3 times a week	Rattlesnake Cave & Rattlesnake Well	Texas blind salamander

Edward's Aquifer Species Collection Plan 2022			
Date (month)	**Interval**	**Location**	**Target Species**
October	Throughout, coincide with bio-monitoring	San Marcos River	Fountain darters
October	Drift net, donated from bio-monitoring	Comal Springs	Peck's Cave amphipod
October	1 day sampling event	San Marcos River	Texas wild-rice
October	1 day sampling event, hand pick from downed wood	Spring Runs, Landa Lake	Comal Springs dryopid beetle
November	14 Consecutive days with traps checked 2-3 times a week	Primer's Fissure & Johnson's Well	Texas blind salamander
November	1 day sampling event, hand pick	Landa Lake	Peck's cave amphipod
November	1 day sampling event	Comal Springs	Comal Springs salamander
November	Set lures	Spring Runs, Landa Lake	Comal Springs riffle beetle, Comal Springs dryopid beetle, Peck's cave amphipod, Texas troglobitic water slater
December	Check nets T and F every week	Diversion Springs	Texas Blind salamander, San Marcos salamander
December	1 day sampling event	San Marcos River	Texas wild rice
December	Collect lures	Spring Runs, Landa Lake	Comal Springs riffle beetle, Comal Springs dryopid beetle, Peck's cave amphipod, Texas troglobitic water slater

Refugia Stocks:

Collection: Standing Stock numbers contribute to Refugia Stock numbers. Collections will continue until Standing stock targets are attained. In the event that Refugia Stock triggers, outlined in the contract, are reached and Standing Stock are not at full capacity, USFWS will conduct special targeted collections to increase Standing Stock.

Maintenance: USFWS will conduct maintenance in a similar manner described for standing stocks.

Propagation: Propagation for stocking is not anticipated during 2022.

Salvage Stocks:

Collection: If specific salvage triggers defined in the EAHCP are reached, the Refugia Program, in consultation with the EAA, will accommodate salvaged organisms no more than twice during the 12-year contract period. If triggers for multiple species are simultaneously reached, species collections during salvage operations will be prioritized based upon the perceived impacts of reduced river and spring flow and habitat degradation on Covered Species (i.e. EAHCP triggers). Those species that are river obligate species (i.e., fountain darters and Texas wild rice) or that occupy spring orifice and interstitial ground water habitats (i.e., San Marcos and Comal Springs salamanders, Peck's cave amphipods, Comal Springs dryopid beetles) are presumed to be affected first as flows decrease. Those that reside solely within the aquifer (i.e., Edwards Aquifer diving beetles, Texas troglobitic water slaters and Texas blind salamanders) are presumed to be affected subsequently.

Maintenance: The Refugia Program will maintain organisms collected during salvage operations at the SMARC or UNFH for up to one-year or until their disposition is determined. The Refugia Program may suspend or terminate research if space is required for salvaged organisms. Research may also be suspended if personnel are directed to collect and maintain salvage stocks.

Propagation: Likewise, production of species would be limited to no more than twice during the 12-year contract period if species extirpation occurs. USFWS propagated species at the SMARC or UNFH would be held for up to one year or less if stocking is required. We may suspend or terminate research activities if space is required to house cultured species. Research may also be suspended if personnel are needed to reproduce, maintain, or stock progeny.

Construction/Renovation/Infrastructure/Facility:

The USFWS will report any non-routine maintenance for the program buildings to the EAA as they occur.

The USFWS will institute all reasonable and practical security measures to safeguard EAA refugia facilities, equipment, and species.

For 2022, the refugia is asking for the use of $160,000 Task 1 rollover funds to make improvements to the refugia systems at both the Uvalde National Fish Hatchery ($80,000) and

the San Marcos Aquatic Resource Center ($80,000). Six monitor and control units and the associated equipment will be purchased for each facility. These units will record water parameters and controlling equipment (chillers, CO_2 injectors) on up to 12 systems at each facility. These systems will assist in maintaining water parameters and alert staff if values deviate from specified levels. In addition to the controllers, CO_2 injection systems will be installed to assist in maintaining a consist pH and reduce calcium buildup on equipment. Mechanical filters and UV sterilizers will be added to the systems for increased flexibility, where each system can function as flow-through or 100% recirculating. Were needed, old water pumps will be replaced with more energy efficient pumps. These improvements will minimize the potential for catastrophic system failure, alert staff to problems with individual systems, and add redundancy into the functioning of the refugia systems.

In addition to the amount above we are asking for $5,282.03 from Task 1 roll over funds for the purchase of a portable water velocity meter to be used for field measurements.

Staffing/Labor/Personnel:

The two program Leads (Research and Husbandry/Collections) will mentor and train lower-graded employees, oversee facility maintenance and repair, develop, and implement budgets, and organize activities that relate to all contract activities. The program leads will manage and coordinate research, propagation, culture, and field activities related to the refugia. The leads are expected to provide proper and efficient use of facilities and staff resources. These leads will work with the Center Director and the Deputy Director to ensure that contractual obligations are met in a timely manner. In coordination with the Deputy Center Director, they will prepare all the required written materials required for the reimbursable agreement reporting. Likewise, the leads 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 leads will continue to work and communicate regularly with partners, USFWS personnel and other researchers to meet USFWS and contract goals.

Under the direction of the Lead Biologist at UNFH, five biological science technicians, two at SMARC and three at UNFH, will continue to assist with the collection, daily upkeep, maintenance, propagation, and research efforts for the ten species at the SMARC and UNFH. This includes maintaining culture and experimental production systems, keeping records along with entering, filing, and collating data. The technicians 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.

Under the direction of the Lead Biologist at SMARC, an SCA Student Intern will be hired to conduct the San Marcos fountain darter historical tissue archive research project. This SCA intern will catalog and organize all historical darter collections at SMARC and UNFH and will start the process of assessing the collections suitability in future genetic analysis.

Under the direction of the Lead Biologist at UNFH, two SCA interns will be hired to assist with day-to-day husbandry tasks; one located at SMARC and the other at UNFH.

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 will practice biosecurity procedures in Refugia and Quarantine areas and conduct appropriate biosecurity procedures on field equipment.

Bd/Bsal Testing:

Water from sampling locations, water bodies in the SMARC and UNFH area, and the wells at the SMARC and UNFH will be test for Bd/Bsal. Wild stock and F1 salamanders in refugia will be tested for Bd/Bsal to determine the extent of Bd occurrence in the Standing/Refugia stock. Extended Bd/Bsal testing will ensure that any salamander brought on station would not further contribute to or modify the occurrence of Bd/Bsal in the locations salamanders are sampled from.

Husbandry Pilot Studies:

PCA Exclusion – Peck's cave amphipod does not readily produce offspring that survive to adulthood mostly due to cannibalism by the brooding female. EARP staff currently separate brooding females from main housing and put them into a separate container to reduce cannibalism by the larger population, but cannibalism still occurs by the brooding female. Exclusion chambers will be constructed to separate the offspring from the brooding female. The success of each exclusion chamber design will be assessed by comparing the number of offspring recovered. Each design will be compared to each other and to the currently used brooding chamber.

CSRB Dowel Condition – It takes about a month for a dowel to develop sufficient biofilm to support Comal Springs riffle beetles. This extended time period can cause delays in research and potential lack of food sources for refuge populations if materials are not replenished on a strict schedule or if a system were to fail. We suspect the time required for biofilm to develop on the dowels will decrease if more surface area is available for biofilms to develop. Dowels will be etched and set to condition alongside dowels that are not etched, under the same conditions. The

dowels will be checked daily, and the number of days floating will be recorded. Pictures of biofilm development will be taken weekly. Preliminary testing shows that dowels that are etched sink faster than dowels that are not etched. This study will quantify the number of days required for etched dowels to develop biofilm relative to unetched dowels. If etched dowels develop biofilm faster than unetched dowels (days floating) and produce equal or better biofilm (subjective assessment using photos), then etching dowels will be incorporated into the Comal Spring Husbandry SOP.

Fountain Darter Diet - Fountain darters (*Etheostoma fonticola*) from the Comal and San Marcos Rivers have been successfully bred and reared in captivity at both the Uvalde National Fish Hatchery and the San Marcos Aquatic Resources Center. However, the survival rate during the first few weeks after hatch is often variable and low. Low survival of recently hatched fish can often be attributed to several factors, such as improper diet nutrition of the broodstock, improper diet nutrition of the hatchlings, improper prey size for the hatchlings, tank design, and pathogens. For this project we will focus on comparing diet size. We will rear San Marcos River fountain darters and monitor survival, body length, body depth, and mouth gape of the fish from hatching to 1-month-old, relative to three different diets: 1) current SOP diet of recently hatched live *Artemia* (~400-500um length), 2) live rotifers (~150 – 350 um length), and 3) a mix of live rotifers and *Artemia*. Results from this study will allow us to improve the fountain darter rearing SOP for the EARP and can lead to future work on nutritional needs.

Task 2. Research

The Research Plan for 2022 will involve a series of projects designed to improve culture protocols and the health, survival, and propagation of captive populations. We have nearly all we need for a fully functioning Fountain Darter *ex situ* refuge, but an evaluation of the genetic diversity in the standing stock is needed. We will assess the quality of historical samples for future DNA analysis to assess the genetics of wild and refugia populations over time. To inform refugia collections, we will conduct a population genetic analysis of Comal Spring riffle beetles. Progress will continue to be made in Comal Spring riffle beetle propagation through a continuation of 2021 pupation trials. A handbook will be generated describing the advancements made toward successful collection and pupation. Salamander reproductive disfunction will be further investigated through habitat modification and Bd treatment trials. If successful, Bd treatment trials for aquatic salamanders will reduce refugia mortality and allow for transfers between SMARC and UNFH.

The total cost for proposed 2022 research, given the following projects, is approximately $515,969. Call for proposals from external partners to continue San Marcos salamander reproduction and Comal Springs riffle beetle pupation work will advertised and, if appropriate for Refugia needs, will be funded in 2022.

The following section describes the basic components of each of these proposed 2022 activities.

Project 1:

Title: Propagation of Comal Springs riffle beetles
Species: *Heterelmis comalensis*
Principal: BIO-WEST with FWS staff
Overview: A fully functional refugia requires predictable propagation. Based on evidence gleaned from previous research, we will calculate a target number of beetles then scale-up earlier attempts, propagating CSRB larvae at suitable densities with wild cultivated biofilm to test if we are able to meet our predicted targets.
Budget: $93,747.71
Benefit to the Refugia: This research will provide confirmation of progress toward a fully function refugium for this species.
Expected Results: We will produce a report for the EAA.

Project 2:

Title: Genetic assessment of Comal Springs riffle beetle
Species: *Heterelmis comalensis*
Principle/Co PI: FWS Staff
Overview: Little is known about the population structure and genetic diversity of the Comal Springs Riffle Beetle. A population-wide assessment can provide population metrics to inform future conservation and refugia needs. FWS will work with a partnering biologist, who is conducting an n-mixture model study on the abundance of Comal Springs riffle beetles, to collect adult Comal Springs riffle beetles across spring openings in Landa Lake and the Comal River. FWS staff will use high-throughput genome wide sequencing to make population measurements at the genetic level.
Budget: $ 141,344.64
Benefit to the Refugia: In combination with the occurrence study, the genetic assessment of the entire Comal Springs Riffle Beetle population will provide valuable information to the level of genetic variation and population structure in the wild. We do not yet know the extent of movement across spring openings at Landa Lake or how much genetic diversity is shared. The existence of distinct sub-populations would require different levels of representation in the refugia in order to reflect wild populations. Additionally, a range-wide genetic assessment can provide an estimate of the effective number of breeders, which would provide information to the minimum number of individuals that would need to be kept in refugia to accurately represent the wild population. This effort will greatly contribute to achieving a more complete refugia.
Expected Results: A report will be presented to the EAA and a peer-reviewed publication will be submitted.

Project 3:

Title: Handbook for the captive propagation of Comal Springs riffle beetles
Species: *Heterelmis comalensis*
Principal/Co PI: FWS Staff; BIO-WEST Support
Overview: The SMARC, BIO-WEST, and collaborating researchers have completed many investigations into the life history, collection, and husbandry of the Comal Springs Riffle Beetle. At this point in time, a document is needed that summarized the body of work that has been completed to date and provides a handbook for Riffle Beetle collection and captive holding. FWS and BIO-WEST will gather the data collected from field observations and collections and combine that with the data gathered through captive holding observations and research to develop a guide outlining what we know about Riffle Beetle life history and captive husbandry.
Budget: $59,735.15
Benefit to the Refugia: This document will provide SMARC biologists and partners with background knowledge of life history, as well as a standard set of SOPs for collection and captive husbandry. This document will be used as a training and reference tool for future SMARC staff and FWS partners.
Expected Results: A Report and an SOP for propagating Comal Springs riffle beetles will be presented to the EAA and a peer-reviewed publication will be submitted, if appropriate.

Project 4:

Title: Improve efficacy of tagging of small-bodied salamanders using p-Chip tags
Species: *Eurycea nana*
Principal/Co-PI: FWS staff
Overview: Previous tagging studies at the SMARC have shown improved efficacy of visible implant elastomer (VIE) tags over passive integrated transponder (PIT) or visible implant alpha (VIA) tags for use in salamanders, being most effective in Texas blind salamanders. Although VIE tags can be used in smaller-bodied salamanders, there is a higher tag reading error rate and tag rejection rate. P-Chip tagging, a new tagging technology, is successfully used in small-bodied fish with very little morbidity or mortality. Additionally, the tags can be scanned and read without having to extensively handle the individual, reducing stress and potential physical harm. SMARC staff will test tag retention and readability of p-Chip tags in the small-bodied salamander, *Eurycea nana*.
Budget: $21,858.40
Benefit to the Refugia: Increased success in tagging small-bodied salamanders , and the ability to track each organism as an individual can improve refugia efforts and reduce stress to captive held animals. p-Chips are much smaller and less invasive than currently used tagging methods, which could reduce stress and potential morbidity to tagged individuals. Tracking organisms as individuals will inform basic life history aspects such as longevity and number of reproductive events per year. In future efforts, the genetic

information of each individual can be collected non-lethally and associated with the individual's p-Chip ID. This will assist in developing higher level restocking strategies through ensuring the genetic diversity of refugia produced F1 offspring is representative of wild populations. Additionally, the refugia would no longer need to separate individuals by year or collection site, increasing refugia space for more individuals.
Expected Results: The results of the study will be presented as a report to the EAA, an updated tagging SOP, and a peer-reviewed publication (if applicable).

Project 5:

Title: Continuation of San Marcos salamander habitat modification and propagation manual (carry over from 2021)
Species: *Eurycea nana*
Principal: FWS staff
Overview: This study will continue 2021 efforts assess the effects of habitat manipulation on reproductive success of San Marcos salamanders. A San Marcos salamander propagation handbook will be developed. The handbook will provide a protocol for San Marcos salamander propagation with the best available information gathered through research and husbandry efforts.
Budget: $21,126.59
Benefit to the Refugia: Continued refinement of salamander reproduction and propagation. Information gained will guide additional research and inform reintroduction strategy.
Expected Results: The results of the study will be presented as a report to the EAA.

Project 6:

Title: Fountain darters tissue catalog and DNA viability
Species: *Etheostoma fonticola*
Principal/Co-PI: FWS staff, SCA Student
Overview: An SCA Student, under the direction of SMARC Staff will inventory and catalog the many fountain darter tissue samples that have been preserved and kept on station from the 1990s to now. Taking inventory of these tissues and extracting their DNA would provide a valuable resource to compare genetic diversity in the San Marcos and Comal Springs fountain darter populations over time as well as compare contemporary diversity to historical diversity.
Budget: $29,818.60
Benefit to the Refugia: Provide the resources necessary to make comparisons between historic and contemporary population level genetic diversity of fountain darters.
Expected Results: The results of the study will be presented as a report to the EAA and a peer-reviewed journal article.

Project 7:

Title: Testing Bd treatments for aquatic salamanders
Species: *Eurycea nana*

Principal/Co-PI: FWS
Overview: Chytrid fungus, such as *Batrachochytrium dendrobatidis* (Bd), is a health concern for amphibians, including the aquatic salamanders associated with the Edwards Aquifer. Bd infections in amphibians are usually associated with reddened skin and tissue degradation of the toes and tail. In aquatic salamanders, issues with osmoregulation are also observed. Although San Marcos salamanders routinely test positive for Bd, we have yet to investigate Bd infections' potential impact on long-term aquatic salamander health. A common mortality observed in San Marcos salamanders held in refugia is rupturing of the abdominal cavity, potentially related to Bd infections. We will investigate the efficacy of Bd treatment options that have been pilot tested in other aquatic salamanders. We will record Bd infection status pre- and post-treatment as well as any long-term effects of treatment.
Budget: $35,736.78
Benefit to the Refugia: We will identify a treatment method for Bd in aquatic salamanders and develop an SOP for treating salamanders when they are collected and brought into the refugia.
Expected Results: Bd positive individuals will be Bd negative post treatment.

Project 8:

Title: Continuation of Comal Springs riffle beetle *Staphylococcus* exposure
Species: *Heterelmis comalensis*
Principal/Co-PI: Dr. Camila Carlos-Shanley (Texas State University)/FWS
Overview: Previous research has shown distinct differences in the microbial community of wild and captive held riffle beetles and biofilm food materials. Additionally, potentially harmful bacteria spp. (such as *Staphylococcus aureus*) were identified in higher abundance in captive held beetles. It is unclear if the increased relative abundance of bacteria, like *S. aureus*, is detrimental to beetle larvae survival and subsequent pupation. In 2021, we tested beetle survival after *Staphylococcus* exposure. This 2022 effort is continuation of the 2021 efforts. Samples were sent off for sequencing in 2021 but were lost in shipping. There are larvae from each treatment group on hand to continue the sequencing effort. The aim is to sequence the microbiome of the larvae exposed to *staphylococcus*, *Bacillus*, and a no bacteria added control to determine how high untypical bacteria exposure impacts the microbiome, which then can be correlated to overall survival and pupation rates of larvae in each treatment.
Budget: $19,557.43
Benefit to the Refugia: Determine if more strict biosecurity measures need to be in place to reduce bacterial exposure to beetle larvae. This study would also add to the overall understanding of how changes in the microbiome impact beetle survival and pupation in captivity.
Expected Results: There will be significant differences in the microbial communities of each treatment group.

Task 3. Species Propagation and Husbandry

Development and refinement of SOPs for animal rearing and captive propagation: SMARC and UNFH will 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, SMARC and UNFH will further develop draft Captive Propagation Plans for all species.

Task 4. Species Reintroduction

Reintroduction Plan for term of contract:
SMARC and UNFH continue to refine the Reintroduction Strategy as new information becomes available.

Reintroduction Plan for 2022: None

Any anticipated triggers being prepared for: Given current weather predictions, spring flows, and the Edwards Aquafer water level, no anticipated triggers are anticipated during the 2022 performance period.

Task 5. Reporting

5.1 Species specific Propagation plans (SOPs): Refine throughout year as needed
5.2 Species specific Genetic Management plans: Texas wild-rice, contingent on when genetic study results are finished.
5.3 Species specific Reintroduction plans: Refine as needed
5.4 2022 EAHCP Annual Program reporting– A year-end report of 2022 activities will be provided to the EAA no later than 1/31/2022.
5.5 Program reporting as required by ITP and TPWD. TPWD Scientific Research Permit Report will be filed July 31, 2022.
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
- Professional Scientific Meetings

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

Cost estimate:

U.S. Fish and Wildlife Service 2022		**Task Budget Amount**	**Total Task Budget Amount**
TASK 1	**Refugia Operations**		$836,473.48
	SMARC Refugia & Quarantine Bldgs.		
	Equipment & Building Maintenance	$ 15,000	
	Utilities	$ 14,000	
	UNFH Refugia & Quarantine Bldgs.		
	Equipment & Building Maintenance	$ 15,000	
	Utilities	$ 35,000	
	SMARC Species Husbandry and Collection Salaries	$ 150,851	
	UNFH Species Husbandry and Collection Salaries	$ 185,000	
	Water Quality System	$ 12,000	
	Divers Salaries	$ 3,500	
	Fish Health	$ 10,000	
	SMARC Reimbursable	$ 100,000	
	UNFH Reimbursable	$ 145,283	
	Subtotal	*$685,634*	
	Admin Cost Subtotal	*$150,839.48*	
TASK 2	**Research**		$515,968.84
	BIO-WEST: CSRB Propagation (2021 Rollover)	$ 49,451.71	
	BIO-WEST: CSRB Propagation	$ 30,000	

U.S. Fish and Wildlife Service 2022		Task Budget Amount	Total Task Budget Amount
	BIO-WEST: CSRB Handbook contribution	$ 22,000	
	Texas State Research	$ 19,557.43	
	USFWS Research		
	Materials	$ 142,790.90	
	SMARC Staff	$ 142,839.54	
	UNFH Staff	$ 16,285.69	
	Subtotal	*$ 422,925.28*	
	Admin costs for Task 2	*$ 93,043.56*	
TASK 3	**Species Propagation and Husbandry**	-	-
	Subtotal	-	
TASK 4	**Species Reintroduction**	-	-
	Subtotal	-	
TASK 5	**Reporting**		$ 78,506.68
	SMARC Staff	$ 35,770.08	
	UNFH Staff	$ 28,579.66	
	Subtotal	*$ 64,349.74*	
	Admin costs for Task 5	*$ 14,156.94*	
TASK 6	**Meetings and Presentations**		$ 16,987.08
	SMARC Staff	$ 10,811.78	
	UNFH Staff	$ 3,112.06	
	Subtotal	*$ 13,923.84*	
	Admin costs for Task 6	*$ 3,063.24*	
	TOTAL	**$1,447,936.08**	

Projected (2022) Budget Summarized by Task:

Task 1: $836,473.48
Task 2: $515,968.84
Task 3: $0
Task 4: $0
Task 5: $78,506.68
Task 6: $16,987.08

Projected (2022) Subcontractor Expenses Summarized by Task

Task 1:
Task 2: BIO-WEST $101,451.71
Task 2: Texas State University $19,557.42
Task 3: $0
Task 4: $0
Task 5: $0
Task 6: $0

Timeline of 2022 Milestones

January	Continue with species collection
	2022 Specific Research Study Plans finalized
May/June	Subcontract research awards executed
July	Submit and renew TPWD permit
September to	Draft Research Reports
December	Draft Annual report

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5.1.2 Voluntary Irrigation Suspension Program Option

Long-term Objective:

The goal of VISPO is to enroll 41,795 acre-feet (AF) of permitted irrigation rights (base and/or unrestricted) that will remain unused in years of severe drought based on the USFWS approved 2019 amendment. Permit holders are enrolled in five-year and ten-year VISPO agreements and will be compensated based on the amount of water enrolled and the program selected. Permit holders enrolled in 10-year agreements are paid a standby fee of $70.20/ac-ft per year every year of the term regardless of aquifer conditions and an additional fee of $210.60/ac-ft per year will be paid for each year when temporary pumping suspensions are required. Permit holders enrolled in 5-year agreements are paid a standby fee of $54/ac-ft per year every year of the term regardless of aquifer conditions and an additional fee of $160/ac-ft per year will be paid for each year when temporary pumping suspensions are required. Beginning January 1, 2021, a total of 41,795 ac-ft was fully enrolled of which 26,175 ac-ft are 5-year agreements and 15,620 ac-ft are 10-year agreements. The enrollment goal of 41,795 ac-ft has been completed and will remain fully enrolled until a large portion of the 5-year and 10-year VISPO agreements will begin to expire December 31, 2023. Permit holders will be offered the opportunity to renew their VISPO forbearance agreements prior to their expiration.

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. The determination for a VISPO trigger will be made on October 1, 2021; if it does not trigger, all enrolled water can be used by the permit holders in 2022. If it triggered, all enrolled water will be unpumped. Annual VISPO payouts are through 2021 are reflected in Table 5.1.2-1.

Table 5.1.2-1: VISPO Total Payout by Year

Year	Payment Type	Total Enrolled (AF)	Total
2014	Stand-by	22,388	$1,201,938
2015	Suspension	40,921	$8,677,262
2016	Stand-by	40,921	$2,188,500
2017	Stand-by	40,921	$2,209,000
2018	Stand-by	40,921	$2,228,300
2019	Stand-by	39,646	$2,320,309
2020	Stand-by	39,803	$2,333,415
2021	Stand-by	41,795	$2,508,070
		Grand Total	$23,666,794

Target for 2022:
The total volume goal of 41,796 ac-ft in VISPO agreements will continue to be maintained and managed by EAA staff. VISPO payments for year 2022 will be determined by the October 1, 2021 J-17 index well water level.

Cost Estimate:
Table 7.1:
$4,172,000

Estimated 2022 cost if Standby:
Standby: $2,509,976

Estimated 2022 cost if Suspension:
Suspension: $9,987,551

5.1.3 Regional Water Conservation Program

Long-term Objective:
Conservation measures will be implemented to conserve 20,000 acre-feet of water to reduce withdrawals from the Edwards Aquifer by 10,000 acre-feet. The concept is to reduce aquifer withdrawals by 10,000 acre-feet using a Regional Water Conservation Program (RWCP).

Several entities within the Edwards Aquifer Authority (EAA) jurisdictional area agreed to make Initial Commitments to the EAA Groundwater Trust to provide an immediate benefit to the aquifer and springflow. The EAA maintains contracts with three communities to conserve water under the RWCP through 2028. The City of Uvalde began implementing its toilet replacement program in 2013 to conserve 57.450 ac-ft of water. In 2014, the City of Universal City began implementing its leak detection program to conserve 163.684 ac-ft of water and in 2016, SAWS began implementing a five-year Leak Detection and Repair Program. The SAWS Leak Detection and Repair Program satisfies the total remaining RWCP goal for water committed into the EAA Groundwater Trust for the remainder of Incidental Take Permit (TE-63663A-1).

The estimated total savings of 20,053 ac-ft of conserved water was achieved from all three communities in 2020. One-half of the conserved water (10,027.13 ac-ft) has been placed in the EAHCP Groundwater Trust through the RWCP to remain unpumped through 2028.

Target for 2022:
None. This conservation measure was achieved in 2020 and 10,027.13 ac-ft has been placed in the EAHCP Groundwater Trust.

Cost estimate:
Estimated 2022 cost:
$0

5.1.4 Edwards Aquifer Authority Stage V Critical Period Management

Stage V Critical Period Management was developed to help decrease withdrawals and maintain adequate springflows 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 ac-ft 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.

2022 Implementation:

EAA staff monitors daily aquifer levels in both the San Antonio and Uvalde Pools of the Edwards Aquifer Region, and if at any time, the 10-day average for aquifer or springflow levels in either pool 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); or 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.

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.

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 runs out of H_2O Oaks facility) system is to deliver 126,000 acre-feet of Edwards Aquifer groundwater. This water is best managed to offset pumping from Edwards Aquifer wells during a repeat of a drought similar to the drought of record and acquire an additional 50,000 acre-feet of agricultural, municipal, industrial groundwater withdrawal rights to either be made available for physical storing in / crediting to the Regional ASR balance or may be forborne.

Target for 2022:
The ASR contract between EAA and SAWS will continue to be implemented. EAA is the agent for ASR enrollments and in year 2020 issued its final notice of availability of EAHCP groundwater to SAWS for injection resulting in the completion of the storage goal of 126,000 acre-feet. Effective in 2021, a total of 50,000 acre-feet of groundwater rights was secured by EAA staff to be used as forbearance water and will go unpumped during a repeat of a drought of record. Future water acquired by the EAA through contractual agreements will be necessary to maintain the 50,000 ac-ft balance due to expiring leases occurring annually. The 50,000 ac-ft balance will be utilized for forbearance purposes during a repeat of a drought of record as outlined in the EAHCP. During a drought of record, the stored ASR water may be used by SAWS to offset forbearance and the EAA will also forbear the use of the 50,000 acre-feet of groundwater under its control.

ASR Program:

Description of the SAWS ASR: The SAWS H_2Oaks ASR is an underground storage reserve in the Carrizo Aquifer in southern Bexar County. As a SAWS water management project, it is designed to store Edwards Aquifer 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 protecting the Covered Species at Comal and San Marcos Springs.

Operations: The EAHCP Program Interlocal Contract between the EAA and SAWS 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 EAHCP's ASR flow protection strategy and places them into an operations contract.

Injection: Storage of EAHCP groundwater shall be at the discretion of SAWS and will be dependent on operating conditions. All EAHCP groundwater made available to SAWS before June 30th, 2020, was 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 2022.

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. The ten-year rolling recharge average reported April 9, 2021 was 555,780 acre-feet and the ten-day average of aquifer levels measured at the J-17 index well as of April 9, 2021 was 655.1 ft msl.

Leasing: In 2018, EAA staff began marketing long-term (ten-year) forbearance agreements with regional permit holders and in 2020 completed the enrollment goal for years 2021 through 2028. In 2021 the total amount of water available under long-term leases was 14,562 acre-feet and 35,438 acre-feet in forbearance agreements for a total of 50,000 acre-feet. On December 31, 2021 a total of 1,164 acre-feet in ASR leases will expire and will be re-enrolled as forbearance agreements effective in year 2022. EAA staff will continue to maintain and manage 50,000 acre-feet of groundwater withdrawal rights under leases and forbearance agreements. This water will remain unused during a repeat of drought of record conditions.

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 EAHCP, 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.

Cost estimate:

Table 7.1:	Estimated 2022 cost:
$4,759,000 – Lease Options	$5,776,493 – Lease & Forbearance Options
$2,194,000 – O&M	$0 – O&M
$6,953,000 – Total	$5,776,493 – Total

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

This work plan details the sampling strategy and protocols for water quality monitoring in 2022 for the Edwards Aquifer Habitat Conservation Plan (EAHCP) (Section 5.7.2) implemented by the Edwards Aquifer Authority (EAA). Water quality monitoring of the Comal and San Marcos springs complexes and their associated surface waters has occurred since 2013 under implementation of the EAHCP. During this time period, the program has employed a variety of sampling strategies: stormwater, surface water, sediments, fish tissue, and passive samplers aimed at a range of environmental contaminants.

The water quality monitoring program underwent a formal review as part of 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. Subsequently, a work group was formed in 2016 to assess recommendations presented in the NAS report. The result was a scope of work that was executed from 2017 – 2020.

Beginning in 2021, additional refinements to the program are being implemented. The primary changes from the previous implementation include discontinuing stormwater and passive sampling, adding surface water sampling, and modifying the analyte list. Table 1 presents an overview of the core activities comprising the EAHCP Water Quality monitoring program. Additionally, as needs arise, other water quality sampling activities may occur as developed through the EAHCP committees and included in the Annual Work Plan.

Target for 2022:
Water quality monitoring activities for 2022 include sampling activities for surface water, groundwater, and sediment in addition to operation of the real-time network. Specific actions for each sample type are discussed below. Analyte lists and maps follow this discussion. All samples will be collected following the EAA's *Field Sampling Plan* and analyzed by a NELAP accredited contract laboratory.

Groundwater sampling:

Groundwater samples will be collected from Spring 1, Spring 3, Spring 7 (Comal), Deep and Hotel (San Marcos) springs during the Spring and Fall under normal flow conditions (Figures A1 and A2). Groundwater samples will be collected by directly filling a bottle or using a previously decontaminated peristaltic pump with the intake portion of the pump placed in the spring orifice to minimize surface water contamination. Samples will be submitted to a contract laboratory for analysis of cations, anions, nutrients, metals, VOCs, SVOCs, herbicides and pesticides, bacteria, TOC, PCBs, and PPCPs. The analyte list for laboratory analyses along with the methods are shown in Table 4. During the collection event, field parameters will be collected that include dissolved oxygen, pH, conductivity, temperature, and alkalinity.

In addition to the biannual groundwater sampling, sucralose will be measured on a monthly basis at Spring 3 and Hotel, and PPCPs will be measured on an every other month basis at Spring 3 and Hotel. These samples will be collected by directly filling bottles at the source of spring flow. During the collection event, field parameters will be collected that include dissolved oxygen, pH, conductivity, and temperature.

Table 1. EAHCP Water Quality monitoring program core activities.

Sample Type	Activity
Surface water	Twice annual sampling in conjunction with Biological Monitoring activities Laboratory analyses are focused on bacteria and nutrients Locations include upper and lower stations at each spring system
Groundwater	Twice annual sampling in conjunction with EAA springs sampling activities Laboratory analyses are focused on geochemical analytes and industrial, commercial, and emerging contaminants. The analytes include cations, anions, nutrients, metals, VOCs, SVOCs, herbicides, pesticides, bacteria, TOC, PCBs, and PPCPs Locations include Spring 1, Spring 3, Spring 7 (Comal), Hotel, and Deep (San Marcos)
Sediment	Every other year sampling in even numbered years Laboratory analyses are focused on PAHs Locations include 6 San Marcos and 5 Comal stations
Fish Tissue	Every other year sampling in odd numbered years Laboratory analyses are focused on metals and PPCPs in two fish species Locations include upper and lower stations at each spring system
Real-time network	Continuous, telemetered measurements Analytes include temperature, dissolved oxygen, and conductivity Locations include 3 San Marcos and 3 Comal stations

Surface water sampling:

Surface water samples will be collected from upper and lower river stations at both systems. For Comal Springs, Landa Lake near Spring Island will serve as the upper location, and the lower station is downstream of the Old and New Channel confluence. In San Marcos, Spring Lake near Hotel spring will serve as the upper location, and the downstream location is located at the most downstream real-time water quality monitoring station. Samples at each location will be collected on a biannual basis during normal flow conditions in conjunction with the Biological Monitoring program (Spring and Fall). Water samples will be taken from flowing parts of the stream on the upstream side of the sample collector. A previously decontaminated Kemmerer or similar device will be used to collect samples at approximately mid-depth in the water column. Samples will be submitted to a contract laboratory for analysis of nutrients, chlorophyll a, and

bacteria (Table 5). During the collection event, field parameters will be collected that include dissolved oxygen, pH, conductivity, and temperature.

Fish Tissue sampling:

Fish tissue samples collected in 2021 will be shipped to the appropriate laboratory and analyzed for pharmaceutical and personal care products (PPCPs). Shipping was delayed in 2021 due to COVID restrictions. Given the delay, only fish tissue samples from largemouth bass will be analyzed, removing Gambusia from the analysis.

Sediment sampling:

Sediment samples will be collected once from four locations within the Comal and six locations in San Marcos (Figures 3 and 4). Three samples will be collected at each sample site and composited into one sample for analysis. Sediment samples will be analyzed for the parameters shown in Table 6.

Real Time Instrument Water Quality Data Logging:

Continuous water quality monitoring stations will continue in 2021 at three locations in the Comal and three locations in San Marcos. The network consists of Insitu AquaTroll sondes measuring dissolved oxygen, conductivity, temperature, and turbidity (Sessom Creek only). Measurements are collected every fifteen minutes and telemetered in real-time. The Sessom Creek site logs data on five-minute intervals to support turbidity measurements at this location.

Quality control procedures:

Field collection methods and quality control procedures for the discrete sampling types are guided by the EAA's Field Sampling Plan. The anticipated number of samples and field quality control samples sent for analyses in 2022 are shown in Table 2. Brief descriptions of the intent of the quality control tests are described below.

Table 2. Sample amounts for 2022 water quality activities.

Sample type	Field Samples	Equipment blank	DI blank	Lab duplicate	Field duplicate	Total samples
Groundwater	18	2	2			22
Sucralose	24	1	3		2	30
Surface water	8	2	2		4	16
Sediment	10			2		12

Both equipment blanks and DI blanks use reagent grade ASTM II deionized water to assess external contamination of environmental samples. Equipment blanks examine the contamination introduced through the sampling procedure. These are conducted by transferring the deionized water through equipment that has been decontaminated for field use. DI blanks consist of deionized water sent directly to the laboratory and are designed to examine sample container and other laboratory contamination.

Lab and field duplicates are intended to assess the precision and repeatability of the analytical procedure and homogeneity of the environmental sample type. Laboratory duplicates consists of a single well-mixed sample split into two samples for analysis. Field duplicates consists of a second sample collected immediately after an initial sample.

Additionally, all laboratory quality control data including matrix spikes and surrogate blanks will be reported.

Monitoring:
A summary report presenting the 2022-year findings will be prepared by EAA staff and included in the EAHCP annual report. The report will include an evaluation of the analytical data and its quality, discussions of results, and a description and rationale for any deviations from the Work Plan described here. The report will be completed in February 2023.

Data collected as part of the 2022 EAHCP Water Quality monitoring program will be kept electronically with the EAA. Data from quality controlled discrete sample types (surface water, groundwater, sediment, and fish tissue) will be housed by EAHCP staff in delimited file types that include all discrete measurements from the program beginning in 2013. Quality controlled time series data associated with the real-time network are housed with existing aquifer time-series data by the EAA.

Cost Estimate:
Costs for laboratory analyses are shown in Table 3 and are based on estimates provided by commercial laboratories in 2020-2021. Field supplies costs in Table 3 cover field collection and analysis equipment including calibration standards and Kemmerer device.

Table 3. 2022 EAHCP Water Quality monitoring program costs.

Sample type	Total samples	Cost per sample	Total Costs
Groundwater	22	$1,080	$23,760
Sucralose	30	$195	$5,850
Fish Tissue	4	$565	$2,260
Surface water	16	$225	$3,600
Sediment	12	$150	$1,800

Field Supplies			$5,000
		Total	**$42,270***

*This amount does not include surplus monies made available for additional Water Quality Monitoring needs but will not exceed the $60,000 listed in the funding table on Page 2.

Sample location maps and analyte lists

Figure 1. Groundwater sampling locations for Comal.

Figure 2. Groundwater sampling locations for San Marcos.


Hotel Spring
Deep Spring
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 Comal Springs may have a limited sample record.
Samples are collected biannual basis during normal flow conditions and more frequently when dictated by research intrests.
Expanation
Historical Groundwater (Spring) Sample Location
N
Miles
0
0.1
0.2
0.3
0.4
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Prepared by:
EDWARDS AQUIFER
AUTHORITY

Figure 3. Sediment sampling locations and real time water quality stations for the Comal.

Figure 4. Sediment sampling locations and real-time water quality stations for the San Marcos.

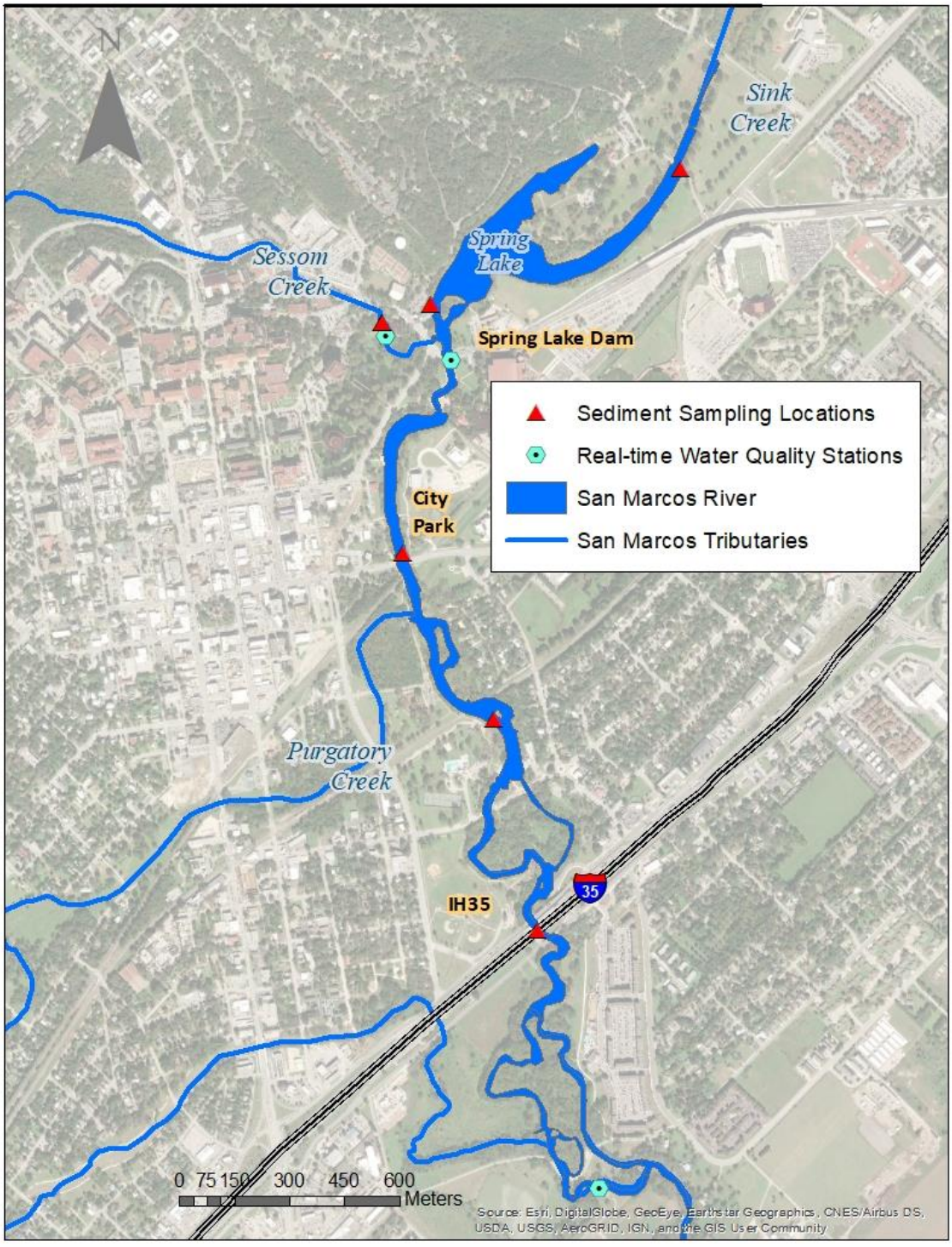


Table 4. Analytical parameters for groundwater samples.

Analyses
Volatile Organic Compounds (VOCs)
Semi-volatile Organic Compounds (SVOCs)
Organochlorine Pesticides
Polychlorinated Biphenyls (PCBs)
Organophosphorous Pesticides
Herbicides
Metals (Al, Sb, As, Ba, Be, B, Cd, Cr (total), Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, Tl, V, 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*)
PPCPs

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	PPCPs	LC-MS/MS

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.

Table 5. Analytical parameters for surface water samples

Analyses
Chlorophyll a
Soluble Reactive Phosphorous
Phosphorus (total)
Total Organic Carbon (TOC),
Dissolved Organic Carbon (DOC)
Kjeldahl Nitrogen
Bacteria Testing (*E coli*)
Nitrates and Ammonium

Method	**Method Description**	**Protocol**
365.4	Phosphorus,	Total EPA
9060	Organic Carbon,	Total (TOC) SW846
351.2	Nitrogen, Total Kjeldahl	MCAWW
445.0	Chlorophyll a	Fluorescence
8141a	Organophosphates	SW846
353.2	Nitrates	
350.3	Ammonia	

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.

Table 6. Analytical parameters for sediment samples

Analytes
Benzo[a]anthracene
Chrysene
Benzo[a]pyrene
Benzo[b]fluoranthene
Benzo[k]fluoranthene
Fluoranthene
Dibenz(a,h)anthracene
Indeno[1,2,3-cd]pyrene
Pyrene
Phenanthrene
Fluorene
Benzo[g,h,i]perylene

Analytes
Anthracene
Acenaphthene
Acenaphthylene
Benzo[g,h,i]perylene
Carbazole
2-Methylnaphthalene
Naphthalene
Total Organic Carbon (TOC)

8270C - SVOCs GC/MS SW8310

9060 Organic Carbon, Total (TOC) SW846

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.

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

Long-term Objective:
Since 2000, the Edwards Aquifer Authority (EAA) has undertaken biological monitoring of the Comal and San Marcos spring systems. In 2013, the elements of the program were incorporated into the Biological Monitoring Program (BioMP) for the Edwards Aquifer Habitat Conservation Plan (EAHCP).

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). 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 2022:
The 2022 BioMP for the Comal and San Marcos aquatic ecosystems will continue to include Baseline and Critical Period Monitoring along with a Net Disturbance impact assessment and overall Take Determinations. The 2022 BioMP will continue to use the standard operating procedures adopted in 2016 because of the Biological Monitoring Work Group (EAHCP 2016) in addition to what is noted in this document. These standard operating procedures were instituted for the BioMP beginning in 2017.

Monitoring:
Aquatic Vegetation Mapping: The contractor will conduct aquatic vegetation mapping in the four long-term monitoring reaches in the Comal Springs system and in the three long-term monitoring reaches in the San Marcos Springs system. The comprehensive mapping is conducted using a GPS unit with real-time differential correction with sub-meter accuracy.

Zebra Mussel Monitoring: The contractor will conduct zebra mussel monitoring using passive techniques in both the Comal and San Marcos rivers.

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 (July-August). The location of every stand of Texas wild-rice will be recorded using a GPS unit with real-time differential correction with sub-meter accuracy.

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 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 among dominant aquatic vegetation species that have been selected through stratified random sampling. 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 rams-horn snails will be counted, measured, and destroyed. Exotic Asian snails and Asian clam will be identified, general abundance recorded, then destroyed. The number of crayfish and grass shrimp per drop net will be noted. Furthermore, vegetation species, vegetation height, vegetative areal coverage, substrate type, water depth, mean column velocity, velocity at 15 centimeters (cm) above the bottom, water temperature, conductivity, pH, and dissolved oxygen levels will be recorded for each drop net.

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 gill condition. Additionally, total length of collected individuals will be measured during timed dip net surveys. Timed surveys will be conducted in all habitat types up to a depth of 1.4 m, within each section, moving upstream during the sampling process with prime darter habitat receiving the most effort.

Presence/absence surveys will be conducted by taking 4 dip net sweeps at 50 random 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 random 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 (SMARC) will take place each time to assist with refugia collections when needed.

The Comal Springs riffle beetle (CSRB) 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 three locations (i.e., Spring Run 3, western shoreline of Landa Lake, and Spring Island area). Ten springs within each of the three locations will be identified for sampling by the contractor. If possible, the same ten springs from the previous year will be sampled.

The CSRB cotton lure standard operating procedure, cotton lure quantitative survey method, and recommendations generated during the CSRB workgroup describe the appropriate protocols for CSRB to be identified, counted, and returned to their spring of origin. Other spring invertebrates

collected on the lures will also be noted including the Comal Springs dryopid beetle (*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°C, pH, dissolved oxygen [mg/l], 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 Sampling and Critical Period Monitoring events.

Fish Community Sampling:

SAN MARCOS SYSTEM—Fish will be sampled at two locations within Spring Lake associated with San Marcos salamander surveys (Big Riverbed and Hotel Area) and one location just upstream of the eastern spillway. Two different SCUBA techniques will be used to document the fish within the three locations, mesohabitat and microhabitat surveys. Three additional SCUBA survey locations will occur in the San Marcos River (Upper, Mid, and Lower), located in representative deep areas where seining has proven to be inefficient. The exact location of the SCUBA sampling within each section may change slightly based on conditions at the time of the sampling event.

In addition to SCUBA, fish in the San Marcos River will be sampled among five sites within three reaches (Upper: Sewell, Veteran's Park, Middle: Crook's Park, and Lower: San Marcos Wastewater Treatment plant and Smith property) via seines within wadeable habitats. Multiple seine hauls will occur along a river transect perpendicular to the flow. Within each seine haul, fish 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 fish data, habitat data will be collected for each seine haul including current velocity, water depth, substrate composition, in-stream coverage, climatic conditions, and mesohabitat type.

COMAL SYSTEM—Fish will be sampled at three locations within Lake via SCUBA surveys. In particular, one of the SCUBA survey locations in Landa Lake will be in the same as the ongoing fountain darter belt transect survey. In addition, SCUBA surveys will be conducted within the Upper Spring Run, Old Channel, and New Channel sections of the Comal River. Two different SCUBA techniques will be used to document the fish within the three locations, mesohabitat and microhabitat surveys..

In addition to SCUBA surveys, three locations (Upper Spring Run, New Channel, and Old Channel) will be sampled via seines among wadeable habitats to evaluate and track fish populations in the Comal River. Multiple seine hauls will occur along a river transect perpendicular to the flow. Within each seine haul, fish will be identified, measured, examined for disease, and native fish returned to the river. Exotics will be removed from the system per scientific permit requirements. In addition to fish data, each seine haul will include habitat measurements (i.e. current velocity, water depth, substrate composition, in-stream coverage, climatic conditions, and mesohabitat type).

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

DOCUMENT BASELINE HABITAT CONDITIONS—The contractor will use January 1 of the contract year GIS mapping, biomonitoring data and other existing sources to establish occupied habitat for the EAHCP 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 EAHCP 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 EAHCP 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 EAHCP 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 the BioMP, the information and guidance in Chapters 4 and 6 of the EAHCP, 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 Monitoring: 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 10-0 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, 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 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 Sampling and Critical Period Monitoring 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.

Cost estimate:
Table 7.1:
$400,000

Estimated 2022 cost:
$755,774*

*Includes Critical Period Monitoring if required

6.3.3 Ecological Modeling

Long-term Objective:
The development of a mechanistic ecological model (Ecomodel) is assigned to the Edwards Aquifer Authority per section 6.3.3 of the 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.

Target for 2022:
No Ecological Modeling work is anticipated in 2022.

Cost estimate:
Table 7.1:
$25,000

Estimated 2022 cost: *
$0

*There is no proposed budget for 2022.

6.3.4 Applied Research

Long-term Objective:
Applied research adds a valuable component to the EAHCP to better understand the ecological dynamics for all Covered Species.

Target for 2022:
Savings from past years will be applied to perform research to support a better understanding of existing Conservation Measures and address questions recommended to the Implementing Committee by the Springflow Habitat Protection Work Group as "First Priority for study" and "First Priority for developing monitoring plans for data collection during future low-flow periods". Work to address the questions in these priority groupings will be taken on by EAHCP staff in 2022. Recommendations from the Science Committee may be sought through this process particularly during development of environmental monitoring programs that assess species and their habitats during unique low-flow hydrological conditions as well as the analysis of the EAHCP QUAL2E water quality model's ability to predict water temperatures in the Comal River Old Channel during the low-flow period of 2014. Additional support addressing questions related to the impact of recreation may also be sought following an assessment of existing data in both the Comal and San Marcos systems. Additionally, Year 1 of a multi-year Comal Springs riffle beetle population study effort will commence. The population study is being conducted at the recommendation of the Comal Springs Riffle Beetle Work Group.

Cost estimate:
Table 7.1:
$0

Estimated 2022 cost:
$250,000

FMA § 2.2 EAHCP Program Management

Section 2.2 of the Funding and Management Agreement (FMA) assigns "general management and oversight" of the 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 USFWS for designated Covered Activities.

Program Activities in 2022:
EAHCP staff will continue to coordinate and monitor habitat protection measures completed by the City of New Braunfels and City of San Marcos/Texas State University in their respective 2022 Work Plans. The springflow and supporting measures are described in this 2022 EAA Work Plan.

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

- Manage EAHCP day-to-day activities;
- Facilitate program correspondence with the USFWS;
- Manage program activities in response to a 2028 ITP renewal including oversight of a contract for facilitated workshops;
- Serve on the ASR Advisory Committee;
- Facilitate the Adaptive Management Process (AMP) for all Routine and Nonroutine decisions; and
- Facilitate and coordinate all meetings of the EAHCP Implementing and Stakeholder committees and possible Subcommittees and Work Groups as created by the Implementing, Science and Stakeholder committees.

EAHCP Chief Science Officer and support staff will continue the following activities:

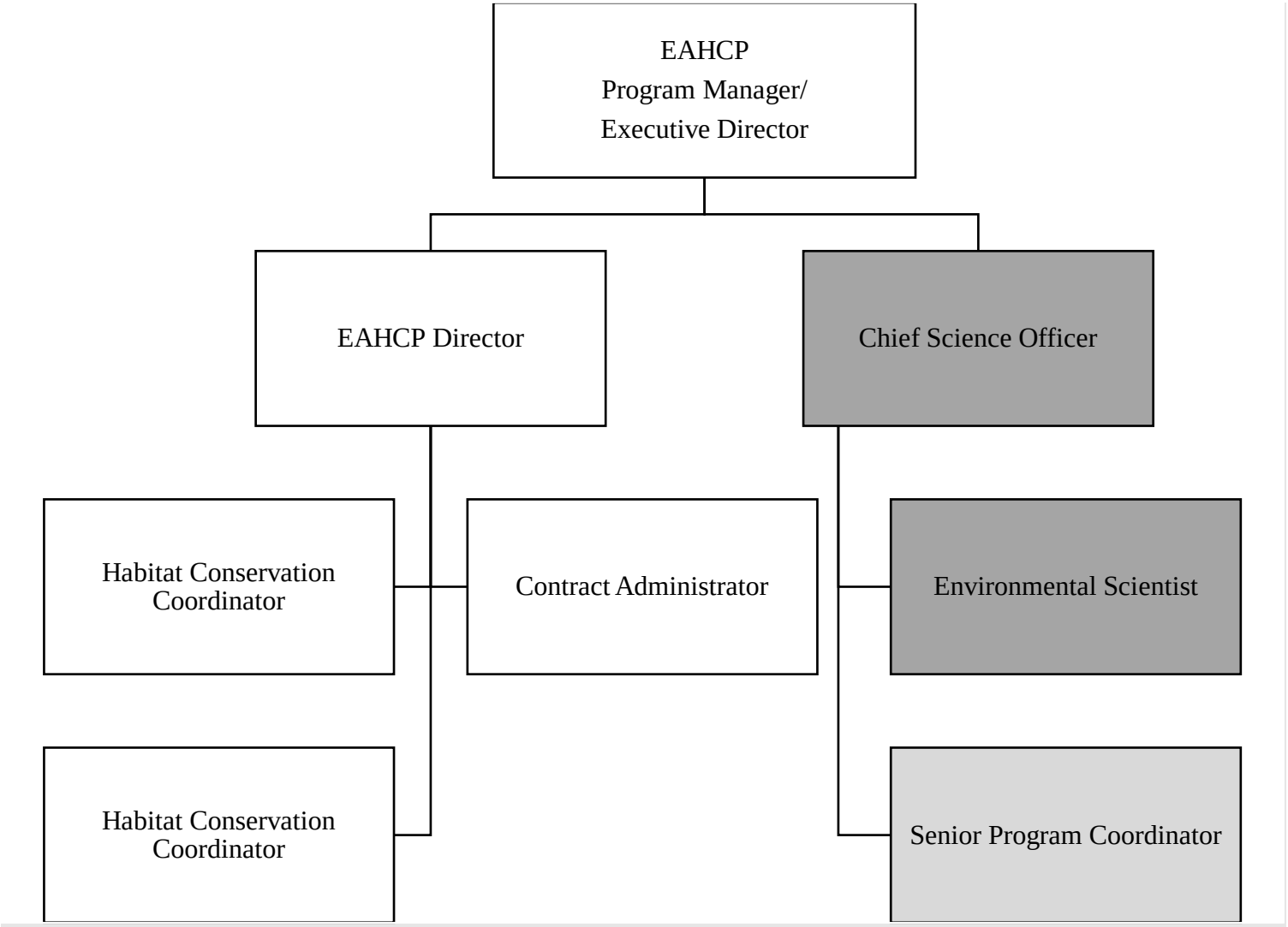
- Manage Refugia Work Plan activities including operations and research;
- Manage applied research;
- Manage biological monitoring;
- Manage and perform water quality monitoring;
- Update and maintain biological and water quality monitoring databases;
- Prepare for all meetings of the EAHCP Science Committee and EAHCP Implementing, and Stakeholder committees at the request of the Program Manager; and
- Prepare for all meetings of the Comal Springs Riffle Beetle Work Group, Research Work Group, and other possible Subcommittees and Work Groups as created by the Implementing, Science and Stakeholder committees at the request of the Program Manager.

EAHCP Administrative Staff will continue the following activities:

- Oversee the City of New Braunfels and San Marcos/Texas State University Work Plan activities;
- Coordinate 2022 Work Plan and funding application amendments for the EAA, City of New Braunfels, and San Marcos/Texas State University;
- Coordinate the development of 2023 Work Plans and funding applications for EAA, City of New Braunfels, and San Marcos/Texas State University;
- Process City of New Braunfels and San Marcos/Texas State University reimbursement's from EAA for habitat protection measures;
- Procure and execute contracts for support measures and program administration;
- Oversee EAA contract tracking and compliance;
- Process EAA contractor's invoices for support measures and program administration;
- Coordinate and prepare for all meetings of the EAHCP Implementing, Science, and Stakeholder committees, (and possible Subcommittees and Work Groups as created by the Implementing, Science and Stakeholder committees);
- Coordinate and prepare correspondence with all EAHCP Implementing, Science, and Stakeholder committee members and Work Groups members under the direction of the EAHCP Program Manager;
- Prepare materials for all AMP activities consistent with Article 7 of the FMA and under the direction of the EAHCP Program Manager;
- Support the EAHCP Program Manager in correspondence to the USFWS including informational memorandums, clarifications, and amendments to the ITP and EAHCP;
- Participate in public outreach initiatives;
- Coordinate and publish the monthly EAHCP Steward newsletter and podcast;
- Maintain the content of the EAHCP 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.

Staffing in 2022:
The EAHCP staff consists of the Program Manager, EAHCP Director, Contract Administrator, and two EAHCP Coordinators. EAA funds the Chief Science Officer and the Environmental Scientist staff positions. One position remains vacant but could be filled in 2022. The structure of the existing EAHCP staff positions and EAA-funded positions – **the Threatened and Endangered Species Team** - are illustrated in the chart on the next page.

Threatened and Endangered Species Team



Positions Paid from EAA General Budget
Vacant Position

Cost estimate:

EAHCP Program Management Costs for 2022

Description of Expense	Estimated 2022 Costs
Salaries and Fringe Benefits	$ 725,561
Office Supplies	$ 1,500
Non-Capital Assets	$ 6,000
Meeting Expenses	$ 20,000
Conferences, Seminars, and Training	$ 20,000
Memberships	$ 2,000
Printing	$ 8,000
Professional Contracted Services	
Annual Report	$ 55,000
Historical/Archeological Consultation	$ 42,000
Permit Oversight	$ 35,000
Outreach/Newsletter	$ 40,000
Science Committee Compensation	$ 20,000
Other	$ 327,000
Estimated 2022 Total	**$1,302,061**

Table 7.1:
$750,000

Estimated 2022 cost:
$1,302,061

City of New Braunfels
2022 EAHCP Work Plan

2022 City of New Braunfels Work Plan Budget

EAHCP Section	Conservation Measure	Table 7.1	Estimated 2022 Budget
5.2.1	Flow Split Management	$30,000	$0
5.2.2.1/ 5.2.2.3	Old Channel Aquatic Vegetation Restoration & Maintenance	$100,000	$50,000
5.2.2.2/ 5.2.2.3	Landa Lake/ Comal River Aquatic Vegetation Restoration & Maintenance	$50,000	$100,000[1]
5.2.3	Management of Public Recreation	$0	$0
5.2.4	Decaying Vegetation Removal and Dissolved Oxygen Management	$15,000	$15,000
5.2.5/5.2.9	Non-Native Animal Species Control	$75,000	$45,000
5.2.6/ 6.3.6	Monitoring and Reduction of Gill Parasites	$75,000	$10,000
5.2.7	Prohibition of Hazardous Material Transport Routes	$0	$0
5.2.8	Native Riparian Habitat Restoration (Riffle Beetle)	$25,000	$25,000
5.2.10	Litter and Floating Vegetation Management	$0	$35,000
5.2.11	Golf Course Management	$0	$0
5.7.1	Native Riparian Habitat Restoration	$100,000	$125,000
5.7.5	Management of Household Hazardous Waste	$30,000	$40,385
5.7.6	Impervious Cover/ Water Quality Protection	$150,000	$15,000
	Totals	**$650,000**	**$ 460,385**

[1] The increase of $50,000 in the budget for this Conservation Measure will be offset by a $50,000 decrease in the 2022 budget Old Channel Aquatic Vegetation Restoration Conservation Measure (EAHCP § 5.2.2.1).

2022 City of New Braunfels Work Plan and Funding Application Amendment

Amendment #	Date EAHCP Committee Approved	Conservation Measure Amended	Y/N Funding Application Change	Funding Application Change ($)	Date EAA Board Approved	Comments
0	5/20/2021	Original Work Plan	N	NA	11/09/2021	
1	5/19/2022	5.2.10: Litter and Floating Vegetation Mgmt	Y	+$10,000	6/14/2022	The City put this project out for bid in Oct 2021. The City received two responses and selected the lowest bidder, Atlas Environmental, at $34,720.

5.2.1 Flow Split Management

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

Target for 2022:
Maintain flow rates in the Old and New Channels of the Comal River to meet objectives specified in the revised Table 5-3 of the EAHCP (**Table 1**).

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

Table 1. EAHCP Table 5-3 (revised)

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

Methodology:
The City of New Braunfels will manage the flow-split program according to flow rates specified in revised Table 5-3 (**Table 1**). A standard operating procedure has been developed by the City of New Braunfels to guide adjustments to the flow-control gate and to achieve flow-split targets. City of New Braunfels staff will monitor real-time streamflow conditions at USGS gages in the Comal River system and adjust the flow-control gates, as needed, to meet flow-split streamflow targets. The primary 48" culvert gate and the new back-up culvert gates will be operated conjunctively to meet target flow rates. Floating vegetation and debris will be manually removed from the control gate and screen from a canoe or boat. Vegetative material removed from the intake structure will be placed along the banks of Landa Lake and/ or returned to Landa Lake. Floating vegetation is managed and funded under task of EAHCP § 5.2.10: Litter and Floating Vegetation

Management. The flow control gate will be exercised routinely to maintain functionality of the gate.

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

Budget:
Table 7.1:
$30,000

Available budget:
$30,000

Estimated 2022 budget:
$0

5.2.2.1 / 5.2.2.3 Old Channel Aquatic Vegetation Restoration and Maintenance

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

Target for 2022:

SAV restoration efforts in 2022 will include the planting of target SAV species in an effort to achieve annual SAV restoration goals and to maintain existing SAV coverage. **Figure 1** depicts the Comal River system and identifies individual Old Channel restoration reaches. The 2022 annual SAV restoration goals, as well as the EAHCP long-term SAV coverage goals, for the Old Channel LTBG and ERPA reaches are specified by reach and vegetation type in **Table 2**. Efforts will also be made in 2022 to monitor for and remove re-emergent non-native *Hygrophila* from the Old Channel LTBG and ERPA reaches.

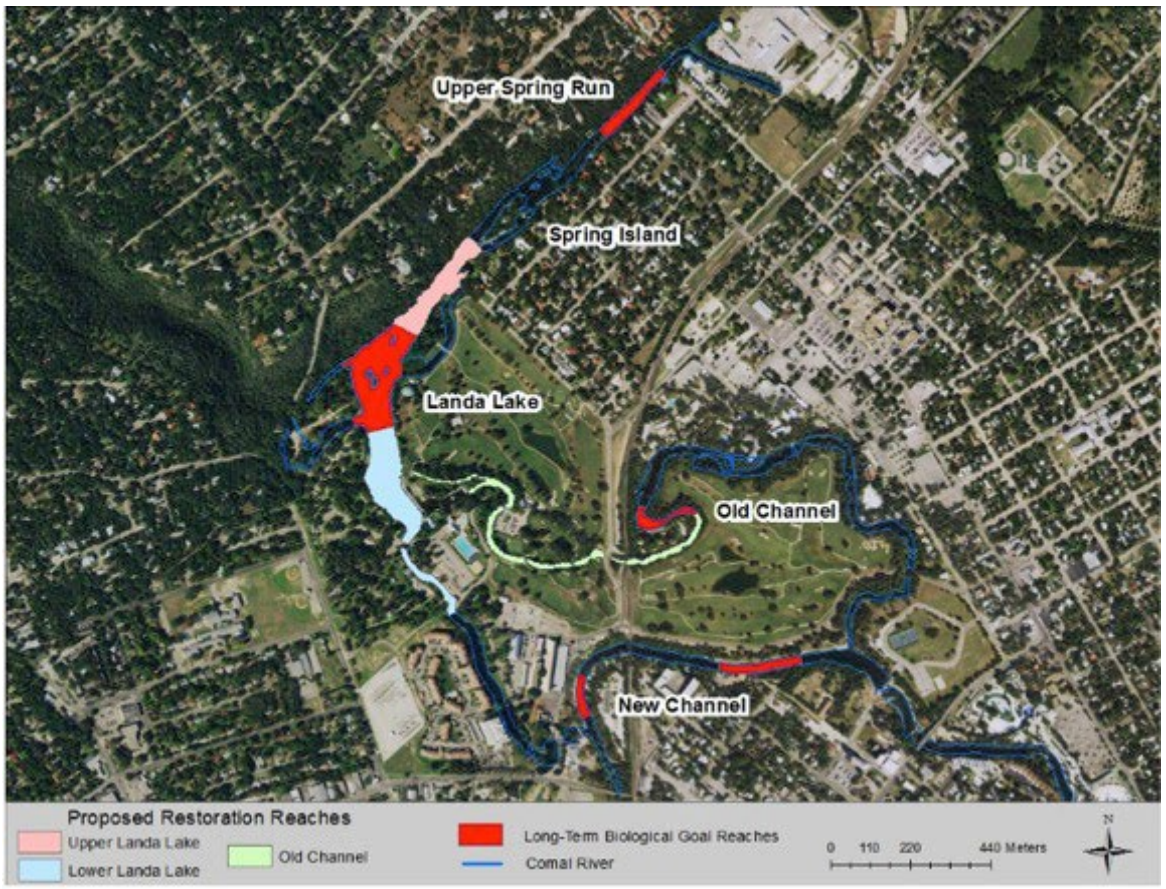


Figure 1: LTBG and restoration reaches for the Comal River System. The Old Channel ERPA restoration reach is shown in green and the Old Channel LTBG reach in red.

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

Reach	Aquatic Vegetation Species	Meters squared of aquatic vegetation (m^2)	Annual Restoration Goal	Approximate # of plantings needed to meet annual goal
		Long-term Goal	2022	2022
LTBG Reaches				
Old Channel	*Ludwigia*	425	50	750-1,000
	Cabomba	180	15	300
	Sagittaria	450	25*	300*
Restoration Reaches				
Old Channel ERPA	*Ludwigia*	850	15	225-300
	Cabomba	200	10	200
	Sagittaria	750	15*	180*
	Vallisneria	750	0	-
	Potamogeton	100	5	30

**Sagittaria* coverage will be monitored and planting will occur only as needed given its propensity to naturally expand.

Methodology:

Non-Native SAV Management:

Non-native SAV (i.e. *Hygrophila*) has largely been removed from the Old Channel between Landa Lake and the downstream limits of the Old Channel LTBG reach. SAV gardening will occur on a monthly basis throughout the Old Channel LTBG and Restoration reaches to identify and remove re-emergent non-native SAV. Small, localized growth of non-native SAV will be removed by selective physical extraction of visible plant and root mass.

Native SAV Restoration:

Target SAV species will be planted within the Old Channel LTBG and ERPA reaches to increase the coverage of individual aquatic plant species per the annual restoration goals set forth in **Table 2**. The approximate number of plants needed to achieve the annual goals is also included in **Table 2**. Individual plant species will be planted where space is available and in locations within the channel where light exposure, flow velocities, and substrate provide the most suitable conditions. Supplemental plantings of *Ludwigia* and *Cabomba* will be planted in existing restoration plots in the Old Channel LTBG and ERPA reaches, as necessary, to maintain existing coverage and/ or to replace any losses in coverage due to floods, natural competition or other factors.

Ludwigia will continue to be propagated in-situ within Landa Lake to provide plant stock for 2022 restoration efforts. In-situ propagation of *Ludwigia* will be conducted by collecting stem cuttings from *Ludwigia* plants present within the Comal River system. The cuttings will be placed in pots filled with substrate collected from within the Comal River system. The potted cuttings will be placed in Mobile Underwater Plant Propagation Trays (MUPPTs) that will be situated in a shallow portion of Landa Lake and allowed to produce roots and plant mass in advance of planting.

Ludwigia plants propagated in the MUPPTs, as well as *Ludwigia* cuttings, will be planted in suitable locations within the Old Channel LTBG and ERPA reaches to achieve an annual target of $50m^2$ and $15m^2$ of additional *Ludwigia* coverage, respectively. Slightly more than the targeted coverage of *Ludwigia* will be planted in order to account for plant die-off. Approximately 15-20 *Ludwigia* plants are needed to achieve $1m^2$ of coverage. Therefore, approximately 750-1,000 *Ludwigia* plants will be planted in the Old Channel LTBG reach and 225-300 within the Old Channel ERPA Restoration reach to achieve target annual coverage. Supplemental plantings of *Ludwigia* will be planted within existing restoration plots within the Old Channel LTBG and ERPA reaches, as needed, to maintain existing coverage of *Ludwigia*.

Cabomba typically thrives in deep, low-velocity areas and will be planted in the most suitable locations in the Old Channel LTBG and ERPA reaches to achieve an annual target of $15m^2$ and $10m^2$ of additional *Cabomba* coverage, respectively. *Cabomba* will be planted using stem cuttings and/ or with individual rooted plants. Stemmed cuttings will be collected from the New Channel and/ or the Spring-fed pool where *Cabomba* is abundant. The cuttings will be bundled into fist-sized bundles wrapped with rubber bands to keep bundles together. The *Cabomba* cutting bundles are typically 12 to 32 inches in length and will be planted at a depth of 2/3 their length, if possible, in soft, silty sediment. This planting depth prevents *Cabomba* from loosening and floating away and ensures multiple nodes are buried to encourage maximum development of root structure. Rooted *Cabomba* will also be utilized for planting. Rooted plants will be dug up individually from areas where *Cabomba* is abundant. The rooted plants will then be planted individually into silty streambed substrate. Both the stemmed cuttings and rooted plants will be planted in a grid-pattern at 1ft centers. Approximately 20 *Cabomba* plantings are needed to achieve $1m^2$ of coverage. Therefore, approximately 300 and 200 *Cabomba* plants will be planted in the Old Channel LTBG and Old Channel ERPA reaches, respectively. Significantly more plantings than required to meet the targeted coverage of *Cabomba* will be planted to account for plant die-off. Supplemental plantings of *Cabomba* will be planted within existing restoration plots within the Old Channel LTBG and ERPA reaches, as needed, to maintain existing coverage of *Cabomba*.

Sagittaria coverage will be monitored throughout the year to determine the extent of natural expansion and whether planting will be required to meet annual and long-term SAV goals. Based on existing coverage of *Sagittaria* in the Old Channel and its aggressive growth habit, it is not anticipated that *Sagittaria* will be planted in 2022. *Sagittaria* will be planted only as needed, in the most suitable locations in the Old Channel LTBG and ERPA reaches to achieve annual targets of $25m^2$ and $15m^2$ of additional *Sagittaria* coverage at full grow out. *Sagittaria* will be planted as transplants harvested from Landa Lake and in the Old Channel where dense *Sagittaria* stands exist. The leaves of the transplants will be trimmed prior to planting to decrease buoyancy and drag. A few *Sagittaria* plants can form a dense colony within several months. *Sagittaria* has been observed to be slightly tolerant of lower light levels allowing it to be planted in deeper water and in shady locations. Approximately 12 *Sagittaria* plants are needed to achieve $1m^2$ of coverage. Therefore, approximately 300 and 180 *Sagittaria* plants will be planted in the Old Channel LTBG and ERPA reaches, respectively, as needed, to achieve target annual coverage.

Potamogeton will be planted only as needed in the Old Channel ERPA reach to achieve an annual target of $5m^2$ of additional *Potamogeton* coverage at full grow out. It is expected that increases in *Potamogeton* will be achieved through natural expansion. If required, *Potamogeton* will be planted using bare-root rhizomes that are harvested from the Comal River system. Approximately six rhizome sections need to be planted to achieve $1m^2$ of *Potamogeton* coverage. Therefore, approximately 30 *Potamogeton* rhizomes will be planted in the Old Channel ERPA reach to achieve the target annual coverage.

Competition between native plants has been observed in the Old Channel where *Potamogeton* and *Sagittaria* have encroached on and taken over *Ludwigia* and *Cabomba* stands, resulting in loss of Ludwigia and *Cabomba* coverage. To minimize the effects of competition and to promote the growth and spread of *Ludwigia* and *Cabomba*, prioritized plot areas will be established for these species. The plots will be established by first clearing an area of *Sagittaria* and then planting Ludwigia/ Cabomba. Plant material that is removed during this activity will be collected and removed from the lake/ river. The plots will be maintained by removing *Sagittaria* that begins to encroach into the plots.

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

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

Vegetation mapping in both the Old Channel LTBG reach and the Old Channel ERPA will be conducted to evaluate SAV coverage and to assess the progress of aquatic vegetation restoration efforts. Mapping is conducted by circling the perimeter of vegetation stands with a kayak equipped with a Trimble GPS unit. Mapping will occur in January, April, and October. The October mapping event will be used as a basis for assessing overall SAV coverage with respect developing annual restoration goals for 2022 and subsequent years.

Budget:
Table 7.1:
$100,000

Available budget:
$100,000

Estimated 2022 budget:
$50,000

*The decrease of $50,000 in the 2022 budget for this Conservation Measure will be used to fund the Comal River/ Landa Lake Aquatic Vegetation Restoration Conservation Measure (EAHCP § 5.2.2.2).

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

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

Target for 2022:
Efforts in 2022 will include the planting of target native SAV to achieve annual aquatic vegetation restoration goals and to maintain existing SAV coverage. **Figure 2** illustrates the Comal Springs/ River ecosystem and identifies the Landa Lake, New Channel and Upper Spring Run LTBG reaches as well as the Upper/ Lower Landa Lake restoration reaches. The annual aquatic plant restoration goals for the Landa Lake, New Channel, and Upper Spring Run LTBG reaches and the Upper/ Lower Landa Lake restoration reaches are specified by reach and vegetation type in **Table 3**. In addition to planting the target native aquatic plants to meet annual goals, continued efforts will be made in 2022 to monitor for the re-establishment of non-native *Hygrophila* in Landa Lake, New Channel, and Upper Spring Run LTBG reaches and the Upper/ Lower Landa Lake restoration reaches. Any identified *Hygrophila* will be removed from the lake/ river.

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

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

Reach	Aquatic Vegetation Species	Meters squared of aquatic vegetation (m^2)	Annual Restoration Goal	Approximate # of plants needed to meet annual goal
		Long-term Goal	2022	2022
LTBG Reaches				
Landa Lake	*Ludwigia*	900	35	525-700
	Cabomba	500	25	500
	Sagittaria	2,250	0	0
	Vallisneria	12,500	50	*
	Potamogeton	25	0	-
New Channel	*Ludwigia*	100	5	75-100
	Cabomba	2,500	15	300
	Sagittaria	0	0	0
Upper Spring Run	*Ludwigia*	25	5	75-100
	Cabomba	25	5	100
	Sagittaria	850	5**	60
Restoration Reaches				
Landa Lake Upper	*Ludwigia*	25	0	0
	Cabomba	250	10	200
	Sagittaria	250	25**	300
Landa Lake Lower	*Ludwigia*	50	5	75-100
	Cabomba	125	0	-
	Sagittaria	100	10**	120
	Vallisneria	22,500	-	-

**Vallisneria* will not be planted but will be allowed to naturally expand, as needed, to increase coverage.
***Based on Fall 2021 mapping of SAV, coverages exceed the long-term coverage goal. No planting will be necessary unless declines in coverage are observed throughout the season.

Methodology:

Non-Native Vegetation Management:

Non-native SAV (i.e. *Hygrophila*) will be removed, as needed, to minimize competition with native SAV. Large-scale removal of non-native SAV will not be required in 2022 as non-native SAV has largely been eliminated from Landa Lake and the Upper Spring Run area. Restoration areas will be monitored for the re-establishment of non-native SAV. Small, localized growth of non-native SAV will be removed by selective physical extraction of visible plant and root mass.

Native SAV Restoration:

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

channel where light exposure, flow velocities, and substrate provide the best conditions for the individual plant types. Supplemental plantings of *Ludwigia* and *Cabomba* will be planted in existing restoration plots within the Landa Lake, New Channel, and Upper Spring Run LTBG reaches, as necessary, to maintain existing coverage or to replace any drastic losses in coverage due to floods, natural competition or other factors.

Ludwigia will continue to be propagated in-situ within Landa Lake in order to provide plant stock for 2022 restoration efforts. In-situ propagation of *Ludwigia* will be conducted by collecting stem cuttings from *Ludwigia* plants that exist within the Comal River system. The cuttings will be placed in pots filled with substrate collected from within the Comal River system. The potted cuttings will then be placed in Mobile Underwater Plant Propagation Trays (MUPPTs) and placed in a shallow portion of Landa Lake and allowed to produce roots and plant mass. *Ludwigia* plants propagated in the MUPPTs, as well as *Ludwigia* cuttings, will be planted in suitable locations within the Landa Lake LTBG reach to achieve an annual target of 35 m^2 of additional *Ludwigia* coverage at full grow out, within the New Channel LTBG reach to achieve an annual target of 5 m^2 of additional *Ludwigia* coverage at full grow out, and within the Upper Spring Run LTBG reach to achieve and annual target of 5 m^2 of additional *Ludwigia* coverage at full grow out. *Ludwigia* plants and cuttings will also be planted in suitable locations within Lower Landa Lake restoration reach to achieve an annual target of 5m^2 of additional *Ludwigia* coverage. Slightly more than the targeted coverage of *Ludwigia* will be planted to account for plant die-off. Based on previous restoration experience, approximately 15-20 *Ludwigia* plants are needed to achieve 1m^2 of coverage. Therefore, approximately 575-700, 75-100, 75-100 and 75-100 *Ludwigia* plants will be planted in the Landa Lake LTBG, New Channel LTBG, Upper Spring Run LTBG and Lower Landa Lake Restoration reaches, respectively, to achieve target annual coverage in each reach.

Cabomba typically thrives in deep, low-velocity areas and will be planted in the most suitable locations in the Landa Lake LTBG reach to achieve an annual target of 25 m^2 of additional *Cabomba* coverage at full grow out, within the New Channel LTBG reach to achieve an annual target of 15m^2 of additional *Cabomba* coverage at full grow out and within the Upper Spring Run LTBG reach to achieve an additional 5 m^2 of *Cabomba* coverage at full grow out. *Cabomba* will also be planted in suitable locations within the Upper Landa Lake restoration reach, as needed, to achieve an annual target of 10 m^2 of additional *Cabomba* coverage. *Cabomba* will not be planting in the reaches where coverage has exceeded the long-term goal based on Fall 2020 SAV mapping. *Cabomba* will be planted using stem cuttings and/ or individual rooted plants. Stemmed cuttings will be collected from the New Channel and / or the spring-fed pool. The cuttings will be bundled into fist-sized bundles wrapped with rubber bands to keep bundles together. The *Cabomba* cutting bundles are typically 12 to 32 inches in length and will be planted at a depth of 2/3 their length, if possible, in soft, silty sediment. This planting depth prevents *Cabomba* from loosening and floating away and ensures multiple nodes are buried for production of good root structure. Rooted *Cabomba* will also be utilized and will be harvested from areas in the Comal River system where *Cabomba* is abundant. The rooted plants will then be planted individually. Both the stemmed cuttings and rooted plants will be planted in a grid-pattern at 1ft centers. Significantly more than the targeted coverage of *Cabomba* will be planted in order to account for plant die-off. Approximately 20 *Cabomba* plantings are needed to achieve 1m^2 of coverage. Therefore, approximately 500, 300, and 100 *Cabomba* plants will be planted in the Landa Lake LTBG, New Channel LTBG, and the Upper Spring Run LTBG reaches, respectively to achieve target annual coverage in each reach. Approximately 200 *Cabomba* plants will be planted in the Upper Landa Lake restoration reach to achieve target annual coverage in each reach.

Sagittaria will be planted only as-needed in the most suitable locations in the Upper Spring Run LTBG, Upper Landa Lake and Lower Landa Lake reaches only on an as needed basis to achieve an annual target of $5m^2$, $25m^2$ and $10m^2$ of additional *Sagittaria* coverage, respectively, at full grow out. Due to its aggressive growth habit, observed natural expansion and existing coverage, it is not anticipated that *Sagittaria* will be planted in 2022 within any of the restoration reaches. If needed, *Sagittaria* will be planted as transplants harvested from Landa Lake. The leaves of the transplants will be trimmed prior to planting to decrease buoyancy and drag. Approximately 12 *Sagittaria* plants are needed to achieve $1m^2$ of coverage.

There are no coverage targets for *Potamogeton* in 2022. *Potamogeton* will be planted only as needed to maintain target coverages in the Landa Lake LTBG reach. *Potamogeton* will be planted as needed using bare-root rhizomes that are harvested from the Comal River system. Approximately six rhizome sections need to be planted to achieve $1m^2$ of *Potamogeton* coverage.

Competition between native plants has been observed where *Vallisneria* and *Sagittaria* will encroach on and take over *Ludwigia* and *Cabomba* stands. To minimize the effects of competition and to promote the growth and spread of *Ludwigia* and *Cabomba*, buffers will be created around planted *Ludwigia* and *Cabomba* stands to the extent practicable. Any plant material that is removed during this activity will be collected and removed from the lake/ river.

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

Monitoring:
Routine monitoring will occur in order to identify re-establishment of non-native aquatic vegetation. Planted areas will also be monitored to assess expansion, die-off, and competition by native and non-native aquatic plant species. Once native aquatic vegetation is established in an area, monitoring will be conducted on a less frequent basis.

Seasonal vegetation mapping in the Landa Lake, New Channel, and Upper Spring Run LTBG reaches and the Upper/ Lower Landa Lake restoration reaches will be conducted to evaluate SAV coverage and to assess progress of aquatic vegetation restoration efforts. Mapping is conducted by circling the perimeter of vegetation stands with a kayak equipped with a Trimble GPS unit. Mapping will occur in January, April, and October. The October mapping event will be used as a basis for assessing overall SAV coverage with respect to developing annual restoration goals for 2022 and subsequent years.

Budget:
Table 7.1:
$50,000

Available budget:
$50,000

Estimated 2022 budget:
$100,000

*The increase of $50,000 in the budget for this Conservation Measure will be offset by a decrease in the 2022 budget Old Channel Aquatic Vegetation Restoration Conservation Measure (EAHCP § 5.2.2.1).

5.2.3 Management of Public Recreation

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

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

Target for 2022:
Continue to enforce existing restrictions that limit recreational access to Landa Lake, Spring Runs, and the Old Channel of the Comal River.

Inform river recreation Outfitters of the EAHCP COI program.

Methods:
The City will continue to enforce City Code Sections 86-4 and 142-5 that restrict recreational access to Landa Lake, Spring Runs, and the Old Channel. Trained Park Rangers will continue to patrol applicable areas to prevent illegal access to these waterbodies.

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

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

Budget:
Table 7.1:
$0

Available budget:
$0

Estimated 2022 budget:
$0

5.2.4 Decaying Vegetation Removal and Dissolved Oxygen Management

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

Target for 2022:
Collect DO data spatially throughout Landa Lake and the Upper Spring Run during low-flow periods (<100 cfs discharge at Comal Springs). Displace floating vegetation mats, as needed, that form on Landa Lake to prevent oxygen consumption by decaying vegetation (management of floating/ decaying vegetation will be funded and accomplished through the Litter and Floating Vegetation Management Conservation Measure [EAHCP § 5.2.10]). Remove decaying vegetation from Landa Lake and Upper Spring Run during low-flow conditions (<100 cfs), as needed, to mitigate low DO levels caused by low-springflow and decaying vegetation.

Methods and Monitoring:

Approximately six logging DO sensors (e.g., comparable to MiniDOT sensors available from Precision Measurement Engineering [PME Inc. Vista, CA] that have been used in prior years) will be installed in key documented Fountain Darter habitat areas in Landa Lake during periods when Comal Springs discharge decreases below 100 cfs. The sensor data will be downloaded, and the equipment will be cleaned routinely, as needed, to prevent fouling. The main objective of this data collection is to continuously monitor DO conditions during low-flow events and prompt DO mitigation activities.

Aquatic vegetation conditions and floating vegetation mats will be visually observed on a regular basis (i.e. weekly at minimum) to assess for signs of stress, die-off. Floating aquatic vegetation and dead aquatic vegetation has the potential to cause oxygen depletion from the decomposition of the vegetation itself and from reduced atmospheric reaeration. Should vegetation die-off be observed due to low-flow or if floating vegetation mats reach impactive levels (if mats cover >25% of the mid-lake area or if individual mats are >3 meters diameter), displacement or removal of the decaying vegetation or vegetation mats will take place within one week of identification as part of Litter and Floating Vegetation Management Conservation Measure (EAHCP § 5.2.10).

If low springflow conditions (<100cfs) occur and vegetation decay or low DO is evident, intensive displacement or removal of decaying vegetation will be implemented, as appropriate, under EAHCP § 5.2.10. Intensive refers to the frequency of vegetation mat management being more than once per week. Displacement and/or removal will be conducted in the least disruptive method tested to be effective, to limit any additional DO stress from stirring, turbidity, etc.

Budget:
Table 7.1:
$15,000

Available Budget
$15,000

Estimated 2022 budget:
$15,000

*To be utilized only if low-flow conditions (<100cfs) are realized at Comal Springs.

5.2.5/5.2.9 Non-Native Animal Species Control

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

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

Target for 2022:
Continue existing program to remove non-native invasive species, including tilapia, nutria, sailfin catfish and suckermouth armored catfish from the Comal River system utilizing removal methods proven successful in previous years. Continue to record counts and biomass of removed species per removal effort.

Methods:
Invasive species will be removed from Landa Lake and portions of the Comal River during routine removal sessions that will occur year-round.

Tilapia sailfin catfish and suckermouth armored catfish will be targeted throughout the Comal River system by divers with spears and spearguns. Upon removal from the water, all invasive fish will be eviscerated, in accordance with state laws, and disposed of. The carcasses will be measured (in inches) and weighed (in pounds). Total biomass of the removed fishes will be calculated. Total length of non-native fishes will also be measured to determine if, over time, the removal of adults affects target population demographics.

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

Monitoring:
The non-native species removal program will involve obtaining and recording the following information:

- Date of removal.
- Number of hours worked.
- Type of species removed.
- Removal method.
- Number of individuals caught/speared.
- Total weight of individuals removed.
- Length of individuals removed.

The data provided will be used by CONB and EAHCP staff to generate catch per unit effort and to determine the effectiveness of the removal program.

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

Reduction of Non-Native Species Introduction and Live Bait Prohibition

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

Target for 2022:
The City will enforce Ordinance No. 2019-42, City Code Section 142-4 and 142-6 enacted to control introductions of non-native aquatic organisms to the Comal River system.

Methods:
The City will uphold the ordinance prohibiting aquarium dumping and the use of non-native aquatic bait species.

Monitoring:
The EAA Biological Monitoring program and routine non-native removal sessions will detect the presence of newly introduced species.

Budget:
Table 7.1:
$75,000

Available budget:
$75,000

Estimated 2022 budget:
$45,000

5.2.6/6.3.6 Monitoring and Reduction of Gill Parasites

Long-term Objective:
To assess the threat of the gill parasite (*Centrocestus formosanus*) and the intestinal fluke parasite (*Haplorchis pumilio)* on fountain darter populations by monitoring parasite cercariae concentrations in the water column.

Target for 2022:
Perform parasite water column cercariae monitoring at four established monitoring transects. Analyze monitoring data to determine the overall effect and potential threat of the gill parasite and *H. pumilio* to fountain darter populations.

Methods:
To quantify the concentrations of drifting parasite cercariae in the Comal River study area, three transects (LL, OCR, RVP) that were previously sampled in 2015-2021 will be sampled in 2022. In addition, monitoring will also occur at a fourth transect at Pecan Island (PI) that was established in 2020 at the downstream end of the Pecan Island slough. The monitoring will occur once in late summer of 2022 in order to remain consistent with timing of previous years' monitoring.

Figure 3 illustrates the parasite cercariae monitoring locations. The four sampling transects are considered locations that adequately represent the Comal Spring system and are efficient for long-term monitoring of drifting cercariae.

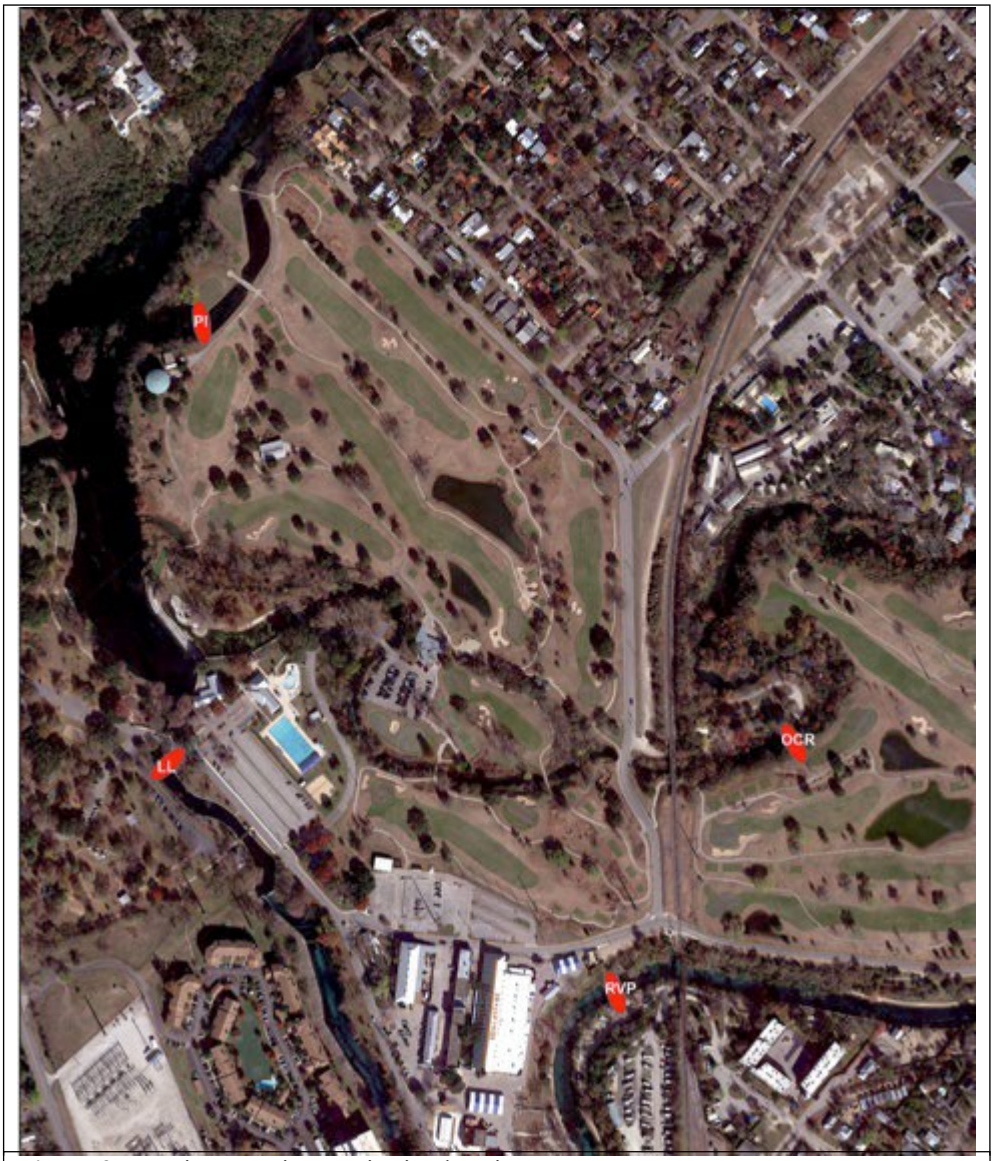


Figure 3. Parasite cercariae monitoring locations

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

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

Budget:

Table 7.1:
$75,000

Available budget:
$75,000

Estimated 2022 budget:
$10,000

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

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

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

Target for 2022:
Maintain existing HazMat transport signage and monitor for the presence of trucks carrying hazardous cargo on routes crossing the Comal River and its tributaries.

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

Monitoring:
Hazardous cargo restriction signage will be monitored and replaced/ repaired as needed. The City of New Braunfels Police Department will monitor for trucks carrying hazardous cargo on prohibited routes per City ordinance.

Budget:
Table 7.1:
$0

Available budget:
$0

Estimated 2022 budget:
$0

5.2.8 Native Riparian Habitat Restoration (Comal Springs riffle beetle)

Long-term Objective:
Establish a healthy, functioning riparian area along Spring Runs 1, 2 & 3, and the western shoreline of Landa Lake to benefit the Comal Springs riffle beetle (*Heterelmis comalensis*). Establish native riparian vegetation to increase the stability of the bank, decrease erosion/ sedimentation and increase the amount of available food sources (i.e. course particulate organic matter) for the riffle beetle.

Target for 2022:

Remove non-native vegetation along Spring Run 1 and Spring Run 2 (**Figure 4**). Plant and establish native vegetation to increase the density and area of the riparian zone along the Spring Runs.

Monitor and maintain previously restored riparian areas along Spring Run 3 and the western shoreline of Landa Lake. Plant additional native riparian plant species within the riparian buffer area, as needed, to increase the density of vegetative coverage in this area. Remove any re-emergent non-native vegetation and maintain sediment control berms. Replace/ maintain sediment control berms and install new berms, as needed.

Figure 4. Location of 2022 riparian restoration activities in Landa Park along Spring Run 1 (left) and Spring Run 2 (right).

Methods:

Invasive Species Management:

Non-native riparian vegetation along the banks of Spring Runs 1 & 2 will be treated using mechanical and chemical treatment methods. Non-native trees will be cut and removed, and remaining tree stump treated with aquatic-approved herbicide. Non-native vegetation along the Spring Runs is limited to only a few *Ligustrum* trees.

Native Plant Restoration:

Install sediment control berms in locations where non-native vegetation is removed/ treated. Following the successful treatment/ removal of non-native vegetation and installation erosion control berms, native riparian vegetation will be planted. Native plants will be selected based on sun exposure, proximity to the stream, growth habit, and ability to withstand deer browsing. Candidate native plant species may include those in **Table 4.**

Monitoring/ Maintenance:

Monitor the riparian zone along Spring Run 3 and the western shoreline of Landa Lake twice/ year, once in late spring/ early summer (April-June) and once in the fall (October) to assess for the re-emergence of non-native vegetation and to monitor the status of native plants and erosion control berms.

Mechanically remove any observed re-emergent, non-native invasive plants within the riparian zone along Spring Run 3 and along the western shoreline, as needed.

Plant supplemental native plants, as needed, to increase density of riparian buffer area. Native plants will be selected based on root structure, light requirements, drought tolerance, growth habits and deer-resistance. Candidate native plant species may include, but will not be limited, to those in **Table 4**. Re-construct erosion control berms as needed.

Monitor the stability and condition of existing sediment capture berms located along the Western Shoreline of Landa Lake. Repair and replace failing berms and install new berms as needed to help capture sediment prior to reduce sedimentation in Landa Lake.

Table 4. Candidate riparian plantings

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

Table 4. Candidate riparian plantings

American Beautyberry (*Callicarpa americana)*
Bald Cypress (*Taxodium distichum)*
Bee Brush (*Eysenhardtia texana)*
Black Walnut (*Juglans nigra)*
Burr Oak (*Quercus macrocarpa)*
Buttonbush (*Cephalanthus occidentalis)*
Eve's Necklace (*Styphnolobium affine)*
Fragrant Sumac (*Rhus aromatica*)
Green Ash (*Fraxinus pennsylvanica)*
Mexican Buckeye (*Ungnadia speciosa)*
Mexican Plum (*Prunus mexicana)*
Mountain Laurel (*Sophora secundiflora*)
Possum Haw Holly (*Ilex ambigua)*
Red Buckeye (*Aesculus pavia)*
Red Mulberry (*Morus rubra)*
Dwarf Palmetto (*Sabal minor*)

Budget:
Table 7.1:
$25,000

Available budget:
$25,000

Estimated 2022 budget:
$25,000

5.2.10 Litter and Floating Vegetation Control

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

Target for 2022:
Dislodge floating vegetation mats and remove litter from applicable portions of the Comal River system to prevent negative impacts to flow control structures, aquatic vegetation, and endangered species habitat. In the event of low-flow conditions or receipt of depressed dissolved oxygen levels in Landa Lake, the removal of and/or increased efforts to dislodge floating vegetation mats will be initiated to prevent oxygen consumption by decaying vegetative material.

Methods:
Floating Vegetation Mat Management: Floating vegetation mats are commonly observed within Landa Lake and are composed primarily of macrophyte fragments, algae, bryophytes and terrestrial debris. The vegetation mats are naturally occurring and are the result of natural processes. Maintenance activities associated with floating vegetation mats in Landa Lake will involve

dislodging floating mats and facilitating migration of the mats downstream of Landa Lake. Any litter found within floating vegetation mats will be removed prior to dislodging. Maintenance of floating vegetation mats will occur on a weekly basis between March and September and on an as-needed basis during the remainder of the year. Floating vegetation mats will be dislodged from flow control structures, the Three Islands area, fishing pier and other locations where vegetation mats accumulate and negatively impact native aquatic vegetation. Additional efforts to displace and/ or remove floating and decaying vegetation will occur during low-flow conditions (<100cfs) and/ or when low dissolved oxygen levels are observed to further mitigate impacts to dissolved oxygen and native aquatic vegetation.

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

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

Budget:
Table 7.1:
$0

Available budget:
$0

Estimated 2022 budget:
$35,000

5.2.11 Golf Course Management and Planning

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

Long-term Objective:
To manage the golf course and grounds in a way that minimizes negative impacts to the aquatic ecosystem in Landa Lake and the Comal River.

Target for 2022:
Continue to implement the IPMP and update as needed.

Methods:
The golf course and grounds will be maintained in an aesthetically pleasing, yet environmentally sensitive manner. It is the responsibility of the Golf Course Manager to maintain the course and grounds in accordance with the new IPMP. The IPMP describes chemicals and methods for controlling pests (i.e. insects, weeds, and other living organisms requiring control) on the golf course in a way that does not negatively impact water quality or endangered species.

Monitoring:
The EAHCP Water Quality Monitoring Program monitors surface water, groundwater, and fish tissue for a range of contaminants to collect information on the water quality of Comal Springs and associated surface waters.

Budget:
Table 7.1:
$0

Available budget:
$0

Estimated 2022 budget:
$0

5.7.1 Native Riparian Habitat Restoration

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

Target for 2022:
Continue efforts to remove non-native riparian vegetation (i.e. *Ligustrum*, Chinese Tallow and Elephant Ears) from the banks of Landa Lake along the Landa Lake Golf Course, install sediment capture berms and plant native vegetation. The target work area for 2022 is the bank along the Landa Lake Golf Course downstream of Pecan Island to the Landa Lake Dam emergency spillway (**Figure 5**).

Figure 5. Location of 2022 riparian restoration activities along Landa Lake Golf Course in the vicinity of the NBU water tank.

Remove non-native vegetation (primarily Elephant Ear and *Brazilian vervain*) and plant native vegetation on a small island adjacent to "the Island" park owned by the Comal County Water Recreation District #1 (CCWRD#1) (**Figure 6**).

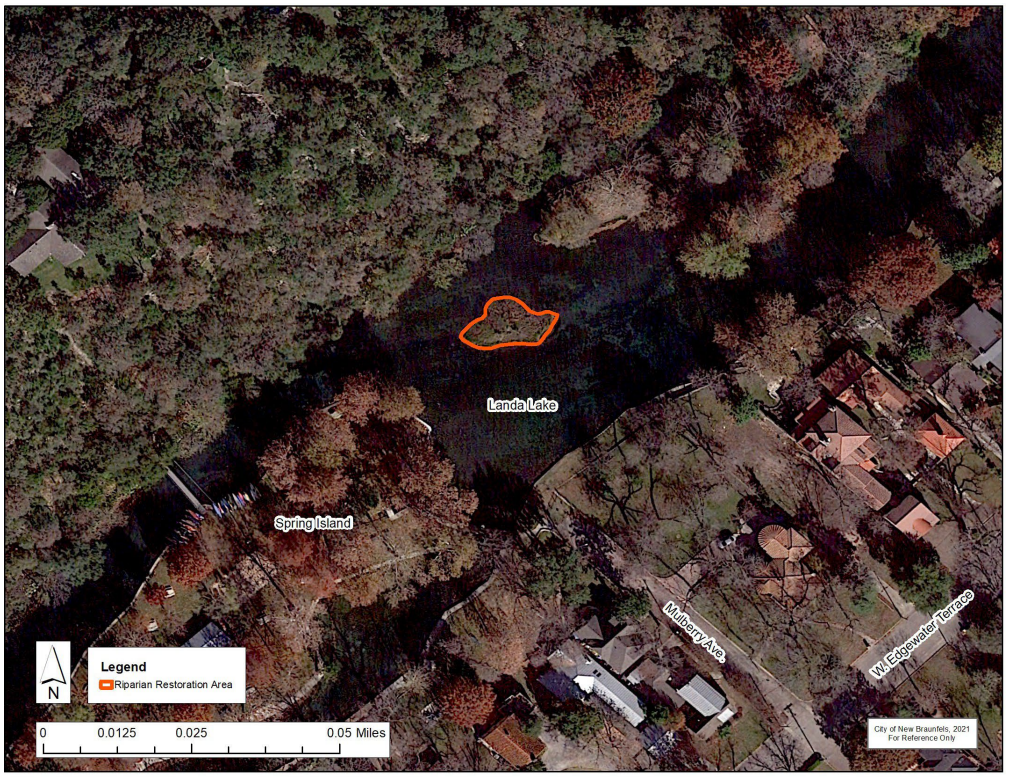


Figure 6. Location of 2022 riparian restoration activities on small island in the vicinity of the private island owned by the CCWRD #1

Plant native vegetation along the Mill Race of the Comal River in the vicinity of Landa Park Pavilion #16 and the USGS New Channel streamflow gaging station (**Figure 7**) to establish a riparian buffer zone.

Figure 7. Location of 2022 riparian restoration activities in Landa Park along the Mill Race of the Comal River near Pavilion 16.

Treat and remove non-native vegetation (primarily Arundo Cane) on the Wurstfest grounds along the banks of the New Channel of the Comal River (**Figure 8**), install sediment capture berms and plant native vegetation.

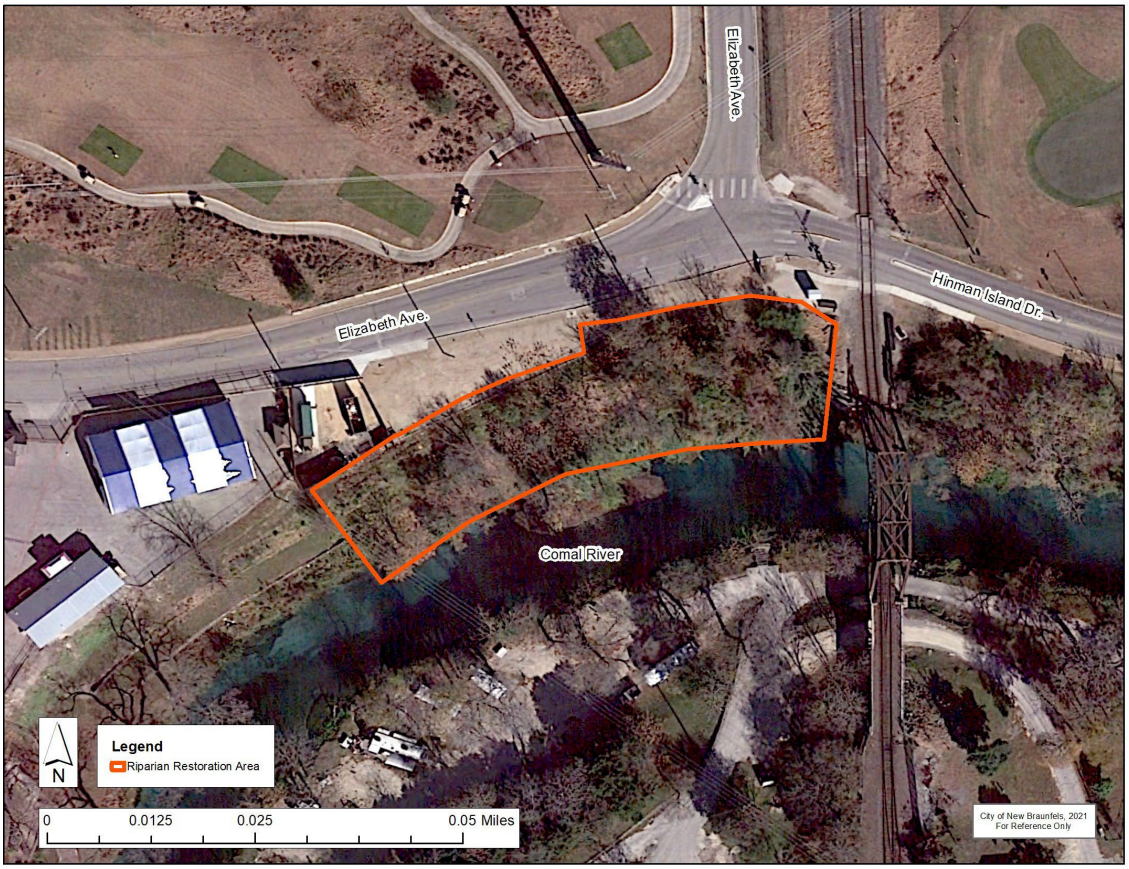


Figure 8. Location of 2022 riparian restoration activities on the Wurstfest grounds along the New Channel of the Comal River.

Monitor and maintain riparian areas where non-native riparian vegetation was treated/ removed in previous years to prevent re-establishment. Monitor and maintain previously planted areas to assess condition of riparian vegetation and promote the establishment/ growth of native vegetation. Plant additional native plants, and/ or grasses, as needed, to replace dead plantings or to vegetate bare areas. Maintenance of restored areas in Landa Park may include the installation of permanent fencing, as needed, to prevent disturbance of restored areas by park visitors.

Methods:

Invasive Species Management:

Non-native riparian vegetation will be treated with mechanical methods and/ or with use of an aquatic-approved herbicide. Elephant Ears will be treated in small sections to minimize overall herbicide usage and to minimize soil/ bank disturbance over large areas. Non-native trees will be cut and removed, and remaining tree stump treated with aquatic-approved herbicide.

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

Native Plant Restoration:

Install sediment control berms in locations where non-native plants are treated/ removed. Native plants will be planted following the successful treatment/ removal of non-native vegetation and installation erosion control berms. Native plants will be selected based on sun exposure, proximity to the stream, growth habit, and ability to withstand deer browsing. Candidate native plant species may include those in **Table 5 and 6.**

Table 5. Candidate riparian plantings for Landa Lake Golf Course and Landa Park

Trees and Shrubs	**Herbaceous**
American Beautyberry (*Callicarpa americana)*	Coral Honeysuckle (*Lonicera sempervirens*)
Bald Cypress (*Taxodium distichum)*	Creeping Spotflower (*Acmella repens*)
Bee Brush (*Eysenhardtia texana)*	Emory Sedge (*Carex emoryi*)
Black Walnut (*Juglans nigra)*	Frog Fruit (*Phyla nodiflora*)
Burr Oak (*Quercus macrocarpa)*	Frostweed (*Verbesina virginica)*
Buttonbush (*Cephalanthus occidentalis)*	Horse Herb (*Calyptocarpus vialis*)
Elderberry (*Sambucus canadensis)*	Inland Sea Oats (*Chasmanthium latifolium*)
Eve's Necklace (*Styphnolobium affine)*	Switchgrass (*Panicum virgatum*)
Fragrant Sumac (*Rhus aromatica*)	Texas Lantana (*Lantana urticoides*)
Green Ash (*Fraxinus pennsylvanica)*	Turks Cap (*Malvaviscus arboreus var. drummondii*)
Mexican Buckeye (*Ungnadia speciosa)*	Water Willow (*Decodon verticillatus*)
Mexican Plum (*Prunus mexicana)*	White Boneset (*Eupatorium serotinum*)
Mountain Laurel (*Sophora secundiflora*)	Yellow Bidens (*Bidens sp.*)
Possum Haw Holly (*Ilex ambigua)*	Woodland Sedge (*Carex blanda*)
Red Buckeye (*Aesculus pavia)*	Zexmenia (*Wedelia acapulcensis var. hispida)*
Red Mulberry (*Morus rubra)*	
Dwarf Palmetto (*Sabal minor*)	
Soapberry (*Sapindus drummondii)*	
Sycamore (*Platanus occidentalis)*	
Grasses	**Forbs**
Buffalo Grass (*Buchloe dactyloides)*	Texas Bluebonnet (*Lupinus texensis)*
Eastern Gamagrass (*Tripsacum dactyloides)*	Purple Prairie Clover (*Dalea purpurea)*
Green Sprangletop (*Leptochloa dubia)*	Partridge Pea (*Chamaechrista fasciculata)*
Prairie Wildrye (*Elymus canadensis)*	Texas Yellow Star (*Lindheimera texana)*
Switchgrass (*Panicum virgatum)*	Gayfeather (*Liatris mucronata)*
Little Bluestem (*Schizachyrium scoparium)*	White Prairie Clover (*Dalea candida)*
Blue Grama (*Bouteloua gracilis)*	Lemon Mint (*Monarda citridora)*
Sideoats Grama (*Bouteloua curtipendula)*	Plains Coreopsis (*Coreopsis tinctoria)*
Curly Mesquite (*Hilaria belangeri)*	Indian Blanket (*Gaillardia pulchella)*
Indiangrass (*Sorghastrum nutans)*	Tall Goldenrod (*Solidago altissima)*
Texas Cupgrass (*Eriochloa sericea)*	
Sand Dropseed (*Sporobolus cryptandrus)*	
Sand Lovegrass (*Eragrostis trichodes)*	
Big Bluestem (*Andropogon gerardii*)	
Cane Bluestem (*Bothriochloa barbinodis)*	
White Tridens (*Triden albescens)*	
Western Wheatgrass (*Pascopyrum smithii)*	
Bushy Bluestem (*Andropogon glomeratus)*	

Table 6. Candidate riparian plantings for Comal County Water Recreation District #1 Property

Trees	Perennials
American Sycamore (*Platanus occidentalis)*	Coral Honeysuckle (*Lonicera sempervirens*)
Bald Cypress (*Taxodium distichum)*	Creeping Spotflower (*Acmella repens*)
Eastern Red Cedar *(Juniperus virginiana*)	Emory Sedge (*Carex emoryi*)
Cedar Elm (*Ulmus crassifolia*)	Frog Fruit (*Phyla nodiflora*)
Burr Oak (*Quercus macrocarpa)*	Damianita (*Chrysactinia mexicana*)
Eastern Cottonwood (*Populus deltoides*)	Fall Aster (*Symphyotrichum oblongifolium)*
Retama (*Parkinsonia aculeata*)	Four Nerve Daisy (*Tetraneuris scaposa)*
Eve's Necklace (*Styphnolobium affine)*	Frogfruit (*Phyla nodiflora)*
Texas Redbud (*Cercis canadensis var. texensis*)	Texas Lantana (*Lantana urticoides*)
Anacacho Orchid Tree (*Bauhinia lunaroides*)	Turks Cap (*Malvaviscus arboreus var. drummondii*)
Mountain Laurel (*Sophora secundiflora*)	Horsetail Reed (*Equisetum hyemale)*
Texas Persimmon (*Diospyros texana*)	Meahly Blue Sage (*Salvia farinacea)*
American Sycamore (*Platanus occidentalis*)	Missouri Primrose (*Oenothera macrocarpa)*
	Orange Zexmenia (*Wedelia acapulcensis var. hispida*)
	Pidgeonberry (*Rivina humilis*)
	Rock Rose (*Pavonia lasiopetala*)
	Snake Herb (*Dyschoriste linearis*)
	Tropical Sage (*Salvia coccinea*)
Grasses	**Shrubs/ Understory Plants**
Woodland Sedge (*Carex blanda*)	American Beautyberry (*Callicarpa americana*)
Eastern Gamagrass (*Tripsacum dactyloides)*	Buttonbush (*Cephalanthus occidentalis*)
Lindheimer Muhly (*Muhlenbergia lindheimeri*)	Coralbean (*Erythrina herbacea*)
Bushy Bluestem (*Andropogon glomeratus)*	Elderberry (*Sambucus canadensis*)
Switchgrass (*Panicum virgatum)*	Evergreen Sumac (*Rhus virens*)
Little Bluestem (*Schizachyrium scoparium)*	Fragrant Mimosa (*Mimosa borealis*)
Sideoats Grama (*Bouteloua curtipendula)*	Fragrant Mistflower (*Ageratina havanensis*)
Inland Sea Oats (*Chasmanthium latifolium*)	Indigobush (*Amorpha fruticosa*)
	Kidneywood (*Eysenhardtia texana*)
Misc	Mexican Buckeye (*Ungnadia speciosa*)
Lindheimer Marsh Fern (*Thelypteris ovata*)	Palmetto (*Sabal minor*)
Maidenhair Fern (*Adiantum capillus*)	Possumhaw (*Ilex decidua*)
Beargrass (*Nolina lindheimeriana*)	Red Buckeye (*Aesculus pavia*)
Texas Sotol (*Dasylirion texanum*)	Skunkbush (*Rhus aromatica var. trilobata*)
Alamo Vine (*Merremia dissecta*)	Texas Sage (*Leucophyllum frutescens*)
Coral Honeysuckle (*Lonicera sempervirens*)	Yaupon (*Ilex vomitoria*)
	Yellow Bells (*Tecoma stans)*

Monitoring:
Previously restored riparian areas will be monitored for the re-emergence of non-native vegetation and success of native plantings. Sediment capture structures will be monitored for effectiveness. Monitor native riparian plantings for success. A riparian habitat assessment will be conducted in the spring and fall to evaluate the condition of the riparian zone.

Budget:
Table 7.1:
$100,000

Available budget:
$100,000

Estimated 2022 budget:
$125,000

5.7.5 Management of Household Hazardous Wastes

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

Target for 2022:
Hold three household hazardous waste (HHW) collection events in New Braunfels. Continue to partner with New Braunfels Utilities (NBU) on the Operation MedSafe drug recovery program.

Methods:
Conduct three HHW collection events that incorporate an education and outreach component. The HHW events are coordinated by City's Solid Waste Division in conjunction with Comal County. The cost of each HHW event is approximately $40,000-$45,000 which includes event set-up and HHW disposal costs. The average cost of a HHW collection event is $40,385 based on HHW events held in 2018 and 2019. The cost of the first two HHW events is shared evenly between the City and Comal County. The EAHCP program will fund the third event.

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

The City is continuing to explore the feasibility of implementing a HHW drop-off facility that will accept HHW on an ongoing basis throughout the year. Currently, it is expected that a HHW drop-off facility will be opened within three years. The facility will likely be open to the public 1-2 days/ week for the drop-off of HHW.

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

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

Budget:
Table 7.1:
$30,000

Available budget:
$30,000

Estimated 2022 budget:
$40,385

5.7.6 Impervious Cover/Water Quality Protection

Long-term Objective:
To reduce non-point source pollutant discharges to Landa Lake and the Comal River system.

Target for 2022:

The City will begin planning for construction of a bioretention basin that is anticipated to be constructed at the Landa Park Aquatics Center parking lot in 2023. Design plans for this project were completed in 2020. The construction of the bioretention basin is in coordination with the City's project to renovate the parking lot.

Methods:

The City will work with the design engineer to secure required City permits for the project and address any comments resulting from City permit review. The City will solicit for a construction contractor in late 2022 to prepare for construction commencement in early 2023. The design engineer will prepare applicable bid documents and assist with the contractor solicitation.

Budget:
Table 7.1:
$150,000

Available budget:
$150,000

Estimated 2022 budget:
$15,000

City of San Marcos/Texas State University

2022 Work Plan

Amendment #0; Implementing Committee approval on October 14, 2021 and EAA Board approval on November 9, 2021

2022 San Marcos/Texas State University Work Plan Budget

EAHCP Section	Conservation Measure	Table 7.1	Estimated 2022 Budget
5.3.1/5.4.1	Texas wild-rice Enhancement	$100,000	$20,000[A]
5.3.6/5.4.4	Sediment Management	$25,000[B]	$0
5.3.8/5.4.3.1/5.4.12	Control of Non-Native Plant Species	$50,000	$160,000/$40,000 Total is $200,000[A]
5.3.3/5.4.3	Management of Floating Vegetation Mats and Litter	$80,000	$30,000/ $10,434/ $6,687 Total is $47,121[A]
5.3.5/5.3.9/5.4.11/5.4.13	Non-Native Species Control	$35,000	$23,256[A]
5.3.7	Designation of Permanent Access Points/Bank Stabilization	$20,000	$0
5.7.1	Native Riparian Restoration	$20,000	$20,000
5.3.2/5.4.2	Management of Recreation in Key Areas	$56,000	$56,000
5.7.6	Impervious Cover/Water Quality Protection	$200,000[B]	$1,100,000[C]
5.7.5	Management of HHW	$30,000	$30,000
5.3.4	Prohibition of Hazardous Material Transport	$0	$0
5.3.4/5.4.5,8,9/5.7.3,4	Unfunded Measures	$0	$0
	Total	***$616,000***	***$1,496,377***

A.) Difference of $80,000 (Texas wild-rice), $32,879 (Floating Veg Mats and Litter), and $11,744 (Non-Native Species Control) will go towards the Control of Non-Native Plants 2022 budget.

B.) Sediment Management funding ($25,000) has gone towards the Impervious Cover and Water Quality Protection Conservation Measure (5.7.6) per the 2017 Sediment Removal and Impervious Cover/Water Quality Protection nonroutine adaptive management. However, due to over expenditures in 2013, 2014, and 2015, there is no more funding available in the Sediment Management Conservation Measure.

C.) Funding will cover Sessom Creek Phase 1 channel restoration and construction administration services as well as bid oversight of Sessom Creek Phase 2.

2022 City of San Marcos/TxState Work Plan and Funding Application Amendments

Amendment #	Date EAHCP Committee Approved	Conservation Measure Amended	Y/N Funding Application Change	Funding Application Change ($)	Date EAA Board Approved	Comments
0	5/20//2021	Original Work Plan	NA	NA	NA	Original Work Plan
0	10/14//2021	Original Funding Application	NA	NA	11/09/2021	Original Work Plan and Funding Application

5.3.1/5.4.1 Texas Wild-Rice Enhancement and Restoration

Long-term Objective:
To achieve 8,000 – 15,450 m^2 of Texas wild-rice (TWR) and maintain existing and restored areas of TWR as required by the EAHCP.

Target for 2022:
The target area for planting TWR in 2022 is in the lower section of Spring Lake above both spillways to enhance the current TWR populations and in the expanded area below I-35. (Figure 1). The area between Hopkins Street and Cypress Island was designated as a primary work zone in 2021 and received extensive *Hydrilla* removal resulting in large areas denuded of submerged vegetation. From Spring Lake Dam to IH-35, TWR will be encouraged to expand naturally through the continued removal of invasive species within and around the perimeter of TWR stands or planted as needed. These efforts work towards attaining the 2027 biological goals as shown in Table 1.

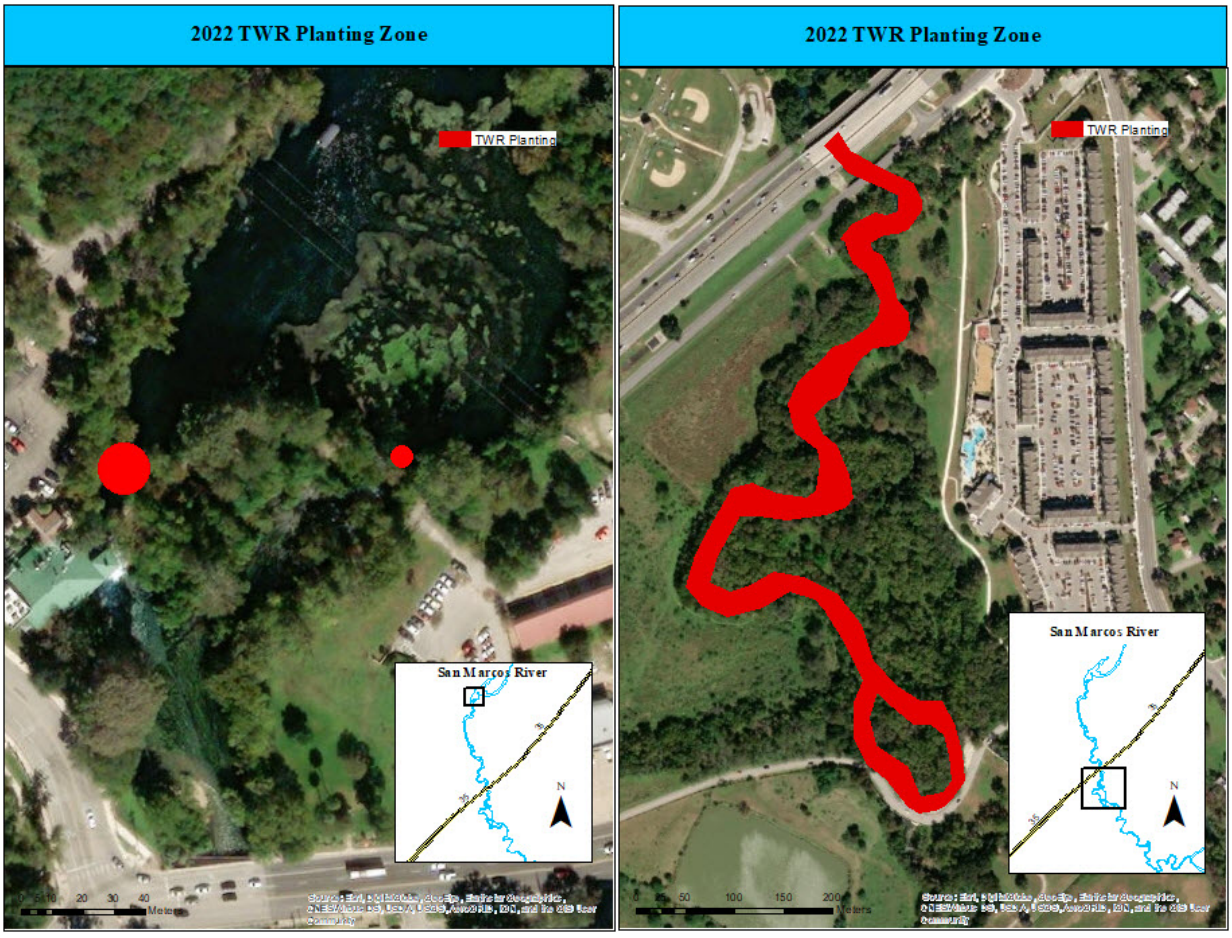


Figure 1. Proposed TWR planting sites for 2022

Table 1. TWR coverage in 2013, 2020, and 2027 long-term biological habitat goals

Reach	2013	2020	2027 Goal
Spring Lake	47	221	1000
Spring Lake Dam	376	1496	700
Sewell Park	945	1598	1100
Below Sewell-City Park	1733	3712	2300
City Park	351	2677	1750
Below City-Hopkins	NA	2224	NA
Hopkins St-Snake Island	718	1042	950
Snake Island-Cypress	NA	136	NA
Cypress Island-Rio Vista	0	353	350
IH-35 (Upper & Lower)	361	975	1050
Below IH-35	125	153*	280

*Spring 2021 MCWE Mapping

Methodology: The optimal conditions for TWR are sandy to coarse soils with water depths generally greater than 1 meter in areas of higher current velocity. In stands of TWR that have non-native plant species intermixed, the non-natives are removed and the original TWR stand is monitored for natural expansion. Natural expansion refers to a native species' capacity to become reestablished in denuded areas after removal of non-natives have taken place, which is dependent on the continued maintenance (gardening) of non-native species thereafter. Similarly, for TWR stands adjacent to non-native vegetation; the non-native plants are removed and TWR is planted as necessary.

Removal of non-natives around existing TWR stands occurs by hand, with divers allowing the non-native plants to drift into a seine, bag or catch net set up downstream before being removed, if river access is possible, or putting them directly into a skiff. The removed vegetation is moved to the shore and plants are shaken to remove trapped fauna which are documented and returned to the river. The remaining plant matter is then disposed at the COSM or Spring Lake composting facility when appropriate. Denuded areas are monitored, and any regrowth of non-native plants is removed. If TWR does not expand, natives may be planted to secure the area (5.3.8/5.4.3/5.4.12).

The contractor will grow TWR from both tillers and seeds provided by USFWS staff at the San Marcos Aquatic Research Center (SMARC). USFWS SMARC staff collect mature seeds from the panicle by gently pulling upwards until seeds are released. Mature seeds are plump, filled out, and either green or brown in color. Seeds are then placed in a plastic bag during collection and counted and potted by MCWE staff within 3-6 months following collection. TWR seeds are placed on top of inundated soil in 8-inch pots and covered with pea gravel to secure the seeds from floating in the water. Seeds are spread out evenly within each pot, and gently pushed into

the saturated soil and gravel mixture. Once TWR seeds have germinated they will be separated out and planted in a similar manner as TWR tillers. Tillers of TWR are collected by USFWS staff at SMARC by removing them from floating vegetation mats or from fragments attached to mature plants in the river. TWR tillers are transported from SMARC to the raceways located at the Freeman Aquatic Biology (FAB) and potted in soil that consists of a bulk mixture containing topsoil and mushroom compost. TWR tillers are planted in 8-inch pots with the soil being highly saturated with water so that the tillers can be inserted without causing damage to the roots. Density of fragments per pot is generally 3-5 individuals. The pots are placed into the FAB raceways with pumps generating current velocity over the newly planted fragments. Plants remain in the raceways until roots are firmly established in the pots.

The process of planting begins by transporting potted TWR individuals from the FAB to the planting site. A diver and a handler carry the plants to the designated section, and while the diver digs a hole in the substrate using a trowel, the handler gives the diver a pot of TWR. The contents are removed from the pot and inserted into the hole before returning the empty pot back to the handler for collection. The diver works downstream to upstream in a linear pattern of planting. Individuals are placed about 0.5 meters apart. This process is adjusted as needed to meet the varying conditions of each planting site and species.

Production of plants at the FAB is incorporated into this Work Plan budget (TWR Enhancement & Control of Non-Native Plants). These methodologies may be adjusted as more is learned about collection and planting procedures.

Monitoring:
All newly planted areas are monitored via quadcopter and/or visual observation to evaluate success rate. Both planting and removal efforts are mapped and quantified via GIS techniques. System-wide TWR coverage is also monitored annually through the EAA Biological Monitoring program. The data collected is used to evaluate TWR coverage and identify areas of concern.

Budget:
Table 7.1:
$100,000

Estimated 2022 budget:
$20,000

5.3.6/5.4.4 Sediment Management

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

Long-term Objective:
The removal of sediment in support of native aquatic planting activities has proven to be both ineffective and expensive. From 2013 to 2015, three of the six required sites have received only 158 m^3 of sediment removal costing approximately $555,000. In 2017, an Adaptive Management Proposal to amend this conservation measure in the EAHCP was approved.

The Sediment Removal and Impervious Cover/Water Quality Protection are combined into one conservation measure that addresses sediment control within the upper San Marcos River watershed to minimize sediment and other contaminated runoff. The primary focus is the Sessom Creek watershed, which contributes a heavy load of sediment during rain events; in the 2015 October flood, Sessom Creek dumped sediment on TWR stands and other native plant stands down to City Park.

The COSM will provide; (1) design of wastewater relocation and erosion/sediment control in Sessom Creek; (2) Sessom wastewater line rehab and relocation; and (3) construction of stormwater control (SWC) features and associated land management tasks that control erosion, minimize sedimentation, and reduce pollutants in the Sessom Creek watershed.

Target for 2022:
See discussion in Section 5.7.6 Impervious Cover/Water Quality Protection

Method:
See discussion in Section 5.7.6 Impervious Cover/Water Quality Protection

Budget:
Table 7.1:
$25,000*

Estimated budget for 2022:
$0

***Sediment Management funding ($25,000) has gone towards the Impervious Cover and Water Quality Protection Conservation Measure (5.7.6) per the 2017 Sediment Removal and Impervious Cover/Water Quality Protection nonroutine adaptive management. However, due to over expenditures in 2013, 2014, and 2015, there is no more funding available in the Sediment Management Conservation Measure.**

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

Long-term Objective:
To decrease the density of non-native aquatic and littoral plants or eliminate if possible, through monitored removal in and along the San Marcos River in an effort to enhance fountain darter habitat by increasing the distribution of native aquatic flora as assigned by the submerged aquatic vegetation (SAV) nonroutine adaptive management long-term goals.

Target for 2022:
In 2022, the removal of non-natives and planting of natives will adopt the following strategy to ensure best use of EAHCP funds and facilitate the achievement of long-term biological goals.

Hygrophila will be removed by the contractor following the top-down protocol. In 2022, this will coincide with *Hydrilla* removal, starting below the section finished in 2021 and continuing downstream.

Figure 2 (below) represents the 2022 work zone for removal of non-native aquatic plant species. The 2021 work zones will be reclassified as recovery zones in 2022. These recovery zones will be managed similarly to that described in the TWR enhancement and restoration measure (5.3.1/5.4.1) so that native species can expand either naturally or via planting while continuing to remove any regrowth of non-natives. Any maintenance zones will be regularly swept for remnant *Hydrilla* or *Hygrophila* regrowth and removed as necessary. The contractors will continue utilizing extended hours from May to October to take advantage of the longer periods of daylight, warmer weather, and to avoid hours of heavy river recreation.

To prevent regrowth, the top priority for 2022 will be maintaining the 2021 work zones due to the large dense areas of *Hydrilla* that have been removed. The 2021 work zone had a large removal effort for non-native vegetation resulting in the largest recovery zone. This area will be regularly worked from upstream to downstream via snorkeling and SCUBA diving to prevent regrowth. Secondary priority will be making downstream progress in the new 2022 work zones which will follow the method of removal from upstream to downstream.

The practice of removing non-native aquatic plant stands from upstream to downstream is reducing labor hours spent on gardening unwanted regrowth that results from non-native plant fragments drifting from upstream stands that reestablish in denuded areas and actively compete with newly planted or established native plant stands. This method also allows for increased natural expansion of native species in the absence of non-native species. Large homogenous stands of non-native aquatic vegetation will be targeted. Non-natives will be removed from mixed stands of native and non-native species and the area will be monitored for any regrowth. The plant species designated in Table 2 will be prioritized for planting after removal of non-native species, if necessary, depending on available habitat and history of the plant species'

success in the available habitat. If the prioritized species in Table 34 have not been successful in the habitat type to be planted, another species may be planted in its place. Plantings will not occur in areas impacted by intense recreation.

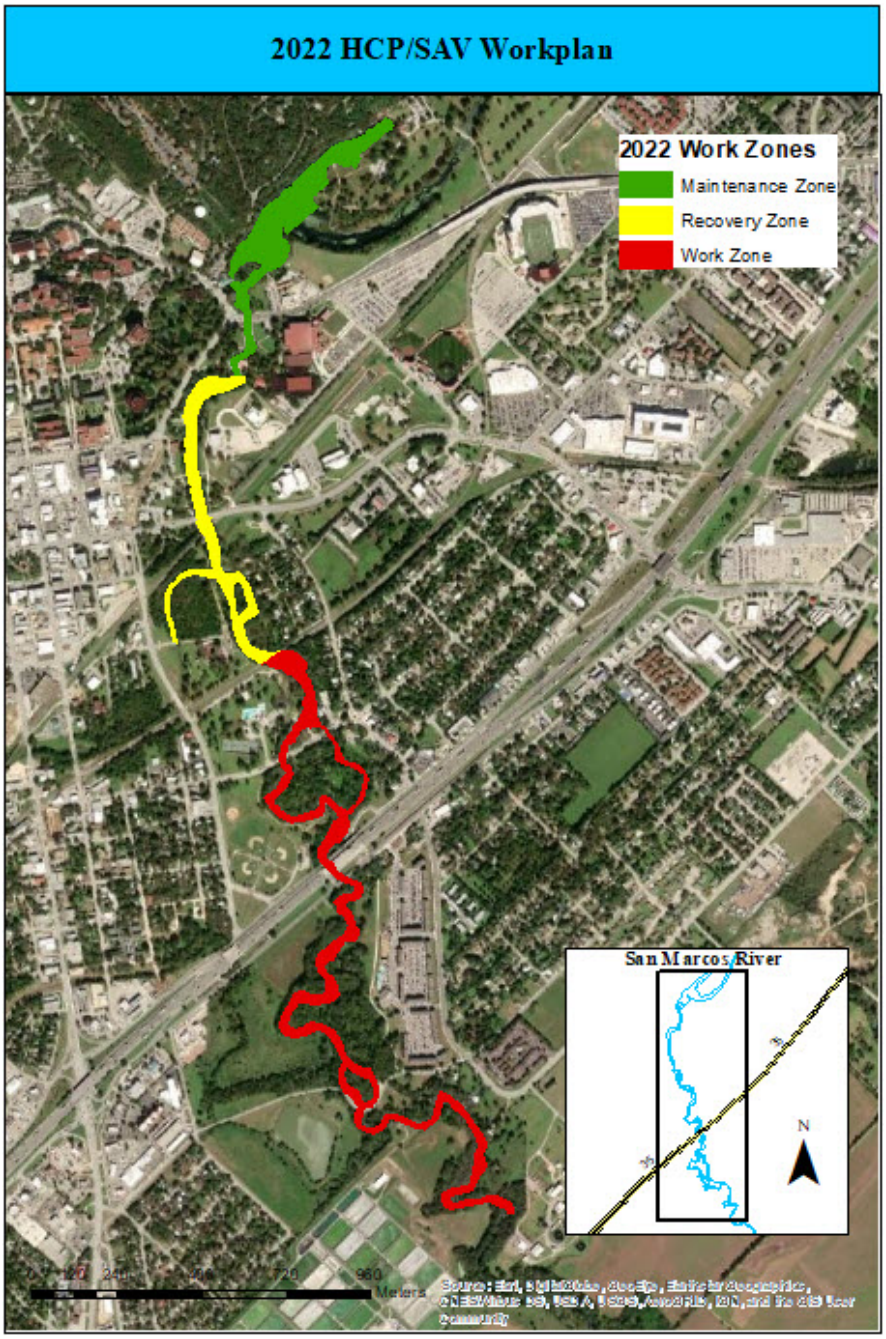


Figure 2. Proposed work zones for 2022 include the maintenance of *Hygrophila* and *Hydrilla* in Spring Lake, Spring Lake Dam, and Sewell Park, a recovery zone from the Below Sewell reach to at the railroad bridge just above the Cypress Island reach and the continued top-down removal of *Hygrophila* and *Hydrilla* starting at the railroad bridge just above the Cypress Island reach and extending to the wastewater treatment plant.

Methodology:

Non-Native Aquatic Plant Removal

Work efforts will focus on replacing non-native species within a given reach with natives, while placing emphasis on species diversity, species habitat preferences, and available fountain darter habitat at the time of planting. The goal will be to eliminate dense stands of non-native species that then allow for native species to maintain and/or increase their coverage through natural expansion.

Non-native aquatic plants will be removed and replaced with native aquatic plants in association with TWR enhancement as described in Conservation Measure 5.3.1/5.4.1. Divers remove non-native aquatic plants by hand. The removed vegetation is allowed to drift down and is captured by a seine, bag, catch net, or transferred directly into a skiff where access and conditions allow. Any removed vegetation is shaken to remove trapped fauna which are returned to the river before being disposed of at the COSM or Spring Lake composting facility. Denuded areas are then monitored for subsequent regrowth of non-native species, which are maintained as needed.

The upper San Marcos River was separated into eleven reaches from Spring Lake to the San Marcos wastewater treatment plant. *Hydrilla* and *Hygrophila* have been removed from seven of these reaches since 2013 with limited success. *Hydrilla* and *Hygrophila* were removed from these reaches regardless of reach location along the upper river, which left large areas of these species upstream of removed areas and resulted in the cleared areas being quickly repopulated with large stands of these non-native species. Beginning in 2018, EAHCP contractors began a systematic upstream to downstream *Hydrilla* removal strategy beginning in the Spring Lake Dam reach. Currently, there is very little *Hydrilla* within Spring Lake and it is managed to a level that the lake should not be an upstream source of *Hydrilla* fragments or tubers. Beginning in 2019, contractors used the same process of removal of *Hygrophila* in Spring Lake.

Hydrilla and *Hygrophila* are now being systematically removed reach by reach. Reaches that have been thoroughly cleared of large patches of these species for two or more years are considered maintenance zones while reaches in which large amounts of these species are being removed are designated as work zones. A work zone in which all *Hydrilla* and *Hygrophila* have been thoroughly removed during the previous year are considered a recovery zone. These recovery zones may still require additional effort to ensure the thorough removal of these species' root systems and tubers. *Hydrilla* tubers can remain viable for multiple years despite being buried over 12 inches beneath the sediment. Downstream reaches with large areas of *Hydrilla* and *Hygrophila* are considered future work zones. In 2022, Spring Lake, Spring Lake Dam, and Sewell Park will be considered in maintenance condition and the reaches from Below Sewell to the railroad tracks above Cypress Island will transition to recovery zones (Figure 2). This area will require significant effort to prevent *Hydrilla* from reestablishing due to its overall abundance in that reach before removal began. The remaining stretch of river cover under the

EAHCP, from the train tracks above Cypress Island to the San Marcos wastewater treatment plant will be considered a work zone for 2022. The extent of 2022 work zone is estimated to slightly exceed the maximum removal allowable for *Hydrilla* and *Hygrophila* habitat disturbance limits, but disturbance estimates will be calculated on a regular basis as to not exceed the limit.

Hydrilla and *Hygrophila* are removed by hand and, when possible, are collected from the river and transported to either the COSM or MCWE composting facilities. Areas of removal are then de-rooted, which includes meticulous removal of roots, small plants, and tubers. This process is repeated until no *Hydrilla* or *Hygrophila* are observed. After an area has been effectively de-rooted and no regrowth occurs, native plants are either planted or allowed to populate the cleared areas through natural expansion.

Planting of Native Species

The planting of native species begins once the designation of a work zone changes to recovery zone, as this maximizes reduction of invasive regrowth and subsequent outbreaks. This is expected to take 3-6 months from when the site is finished as a work zone, depending on the density and area of non-natives originally present in the site. Efforts primarily focus on preserving areas surrounding existing native species to allow for the natural expansion of those populations throughout the river system. In addition to the use of natural expansion, areas that have been stripped of all vegetation will be planted with native species best suited to that habitat type while ensuring a high level of biodiversity according to Table 2 is maintained overall. The goal provides species presence within all reaches to allow for natural expansion downstream of each population. The plant species designated in Table 2 below will be prioritized for planting after removal of non-native species depending on available habitat and history of the plant species' success in the available habitat at a given site. If the prioritized species has not been successful in the habitat type to be planted, another species will be planted in its place. An exception to this will include areas within Spring Lake where the *Hygrophila* will be removed and replaced by native expansion according to the appropriate substrate, flow, depth, and sunlight. Plantings will not occur in areas impacted by intense recreation.

Table 2: Current aquatic vegetation coverage relative to the overall restoration goals, in meters squared (m^2) within San Marcos LTBG reaches and restoration reaches.

Reaches	**Species**	**Coverage[#] (m^2)**	**Restoration Goal**
		Bio-West Mapping	**2027**
LTBG Reaches		**Oct 2020**	
Spring Lake Dam	*Ludwigia*	8.8	100
	Cabomba	11.0	50
	Potamogeton	103.6	200
	Sagittaria	39.6	200

Reaches	Species	Coverage[#] (m^2)	Restoration Goal
		Bio-West Mapping	2027
LTBG Reaches		**Oct 2020**	
	Hydrocotyle	86.8	50
City Park	*Ludwigia*	8.3	150
	Cabomba	26.5	90
	Potamogeton	220.2	1450
	Sagittaria	0.13	300
	Hydrocotyle	0	10
IH-35 Combined	*Ludwigia*	58.4	100
	Cabomba	117.8	150
	Potamogeton	0	400
	Sagittaria	352.6	600
	Hydrocotyle	17.2	100
Restoration Reaches		**Oct 2018**	
Sewell Park	*Ludwigia*	3.8	25
	Cabomba	3.4	25
	Potamogeton	113.8	150
	Sagittaria	0	25
	Hydrocotyle	0	10
Below Sewell to City Park*	*Ludwigia*	34	50
	Cabomba	12	50
	Potamogeton	578.8	500
	Sagittaria	478	700
	Hydrocotyle	43.5	20
Hopkins St to Snake Island	*Ludwigia*	2.4	50
	Cabomba	108.3	50
	Potamogeton	63.5	475
	Sagittaria	1258.6	750
	Hydrocotyle	0	10
Cypress Island to Rio Vista Falls	*Ludwigia*	18.24	50
	Cabomba	200.52	50
	Potamogeton	6.12	150
	Sagittaria	14.02	50
	Hydrocotyle	0	0
IH-35 Lower	*Ludwigia*	64.5	50
	Cabomba	63.4	100
	Potamogeton	0	250
	Sagittaria	384.52	450
	Hydrocotyle	27.18	50

*Below Sewell reach was mapped in Oct 2019 by Texas State University Geography interns

Production of native SAV will continue at the FAB at Texas State University as described in the TWR Enhancement section (5.3.1/5.4.1). Fragments and tillers of native aquatic plants removed

from floating vegetation mats or from fragments attached to mature plants in the river are used for propagation at FAB. Funding for the production of SAV at the FAB is incorporated into this Work Plan budget.

Native vegetation species are planted as described in the TWR Enhancement section (5.3.1/5.4.1) using a team that includes one or more divers and handler depending on depth and location. A hole is made in the substrate by a diver using a trowel, the handler gives the diver a pot of native SAV. The contents are removed from the pot and inserted into the hole before returning the empty pot back to the handler for collection. The diver works downstream to upstream in a linear pattern of planting. Individuals are placed about 0.25 meters apart and gardened as needed to remove invading plants. This process is adjusted as needed to meet the varying conditions of each planting site and species.

Environmental conditions at the time of planting determine which native species are planted. *Cabomba* and *Sagittaria* have exhibited greater success in finer substrates (silt) with areas of slower moving water. Both can be planted in a range of water depths. However, some reaches are challenging, such as Cypress Island, where only TWR and *Heteranthera* have shown success in outcompeting *Hydrilla*.

In the San Marcos River, *Ludwigia* has been planted in a wide variety of habitat types ranging from areas with shallow depths, high velocities over coarse substrates to areas with slack-water habitat over silt substrate to determine which habitat results in greatest rates of expansion and persistence. In 2019, *Ludwigia* patches expanded and contracted with fluctuations in recreational areas. This species' coverage expanded in reaches upstream of Hopkins Street, with many of the new patches being relatively small and occupying areas recently cleared of non-natives. This possibly occurred, because for the first time *Ludwigia* has multiple source populations upstream. *Hygrophila* has been observed to reduce the expansion of two native species: *Ludwigia* and *Potamogeton*. *Potamogeton* is an additional species that has struggled to become established in a few reaches: being almost undetectable from Cypress Island onward. Like *Ludwigia*, *Potamogeton* has been planted in numerous areas with varying substrate compositions in an attempt to determine the most suitable habitat type. It was observed to exhibit the best growth in the upper reaches with high flow and dense, coarse substrates (gravel/sand and clay).

In 2016, *Hydrocotyle* was accepted as an approved native species to plant in the San Marcos River. *Hydrocotyle*, like *Ludwigia*, can become a littoral species, persisting in areas of shallow water. Therefore, these species are utilized to replant river margins or areas of very shallow water depths or along riverbanks.

Monitoring:
For aquatic plants, newly planted areas are monitored monthly to evaluate success rates. All planted areas are weeded (non-native species removed) and replanted as needed to stabilize the substrate. All planting and removal areas are monitored via quadcopter and/or visual observation. Both planting and removal efforts are mapped and quantified via GIS techniques. Work sites are separated into reaches to assess changes among and within reaches of the San Marcos River and to identify presence of non-native vegetation and also to assess the expansion of native vegetation. SAV coverage is also monitored annually within LTBG reaches through the EAA BioMonitoring program. The data collected is used to evaluate native SAV coverage and identify areas of concern.

Non-Native Littoral Plant Removal

Removal of littoral plants and other small caliper invasive plants in the riparian zone is also included in this budget. Littoral invasive removal efforts will address seed source and regrowth of invasive plants from above Spring Lake to Stokes Park (Section 5.3.8). Removal efforts will also extend to treat hot spots that contribute to regrowth**.**

In 2022, removal efforts for littoral invasive species will continue to target the designated 2021 areas shown in **Figures 3 - 6** below. Most work areas are now in maintenance mode (blue) which require periodic regrowth removal. These seven regions have remaining spots of intense removal work. Addressing these seven zones will achieve a continuous buffer zone along the river that does not contribute seed source.

Figure 3. Spring Lake and Sink Creek Zones

Figure 3:

- The area along Sink Creek upstream of Bert Brown Road is still full of Chinese Tallow trees. This area must be worked on to reduce the amount of Chinese Tallow seedlings found every year along Sink Creek. Japanese Honeysuckle and an occasional Elephant Ear can also be found here.
- The western shoreline of Spring Lake is in a maintenance state, but the rest of the hillside has a number of invasive, exotic plant infestations. Cat's Claw Vine is prevalent at the top of the hill.
- The Spillway Island has several Chinaberry, Chinese Tallow, and Ligustrum that need to be removed. Erosion control berms composed of cut debris will be created.

These areas were worked as described in 2021, but the issues will continue into 2022. The four pink dots at the Spring Lake Natural Area trailhead represent stands of invasive trees that may still need to be addressed in 2022. The three green dots at Cypress Point represent an infestation of large ligustrum and chinaberry. This may also continue into 2022.

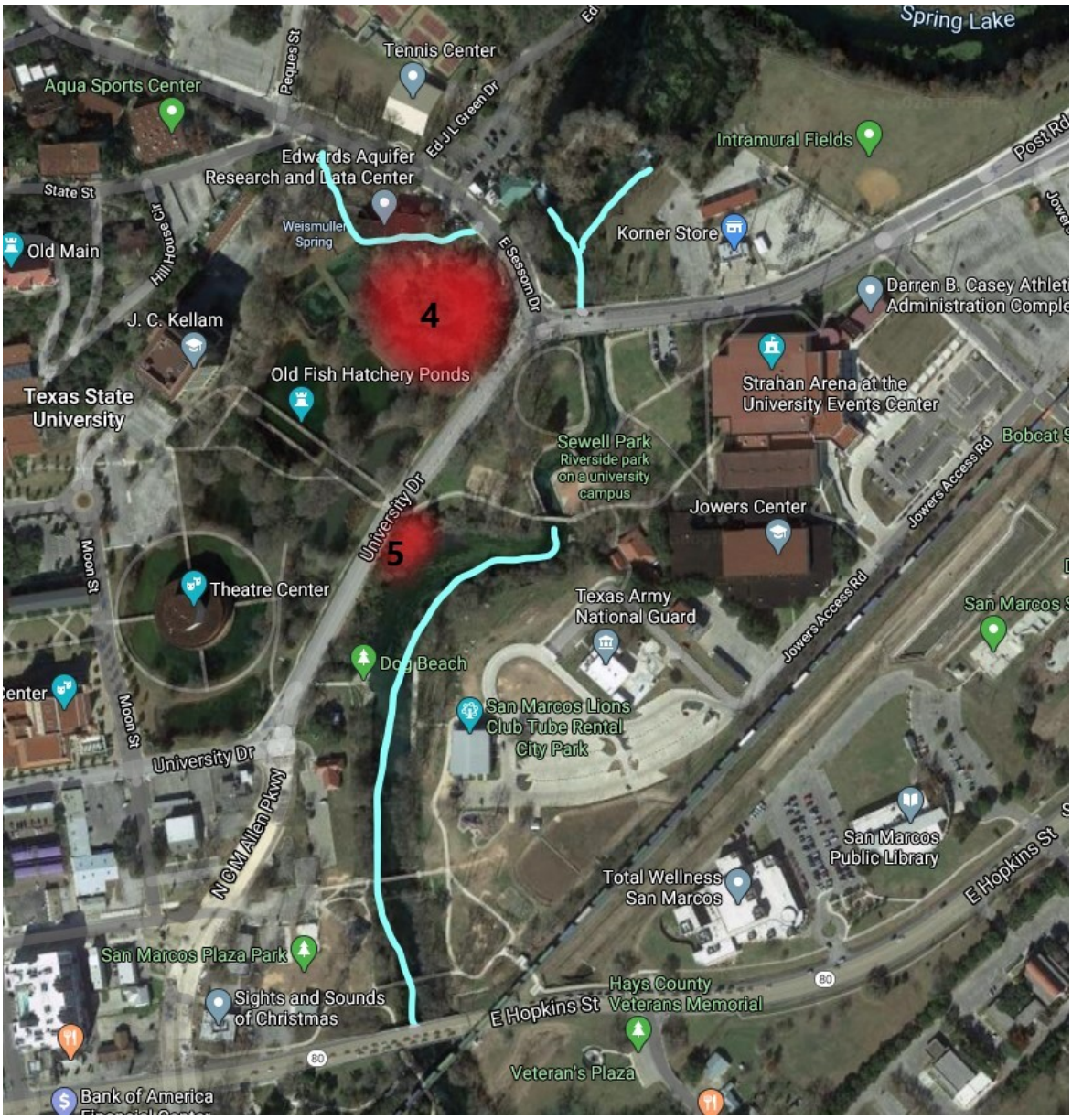


Figure 4. Freeman Aquatic Center, Headwaters, and City Park

Figure 4:

- The pond area adjacent to Sessom Creek at the Freeman Aquatic Center has a number of large Chinese Tallow, Ligustrum, Loquat, and Chinaberry. These had been paint marked in the past and the University was going to take them down, but that has not happened to date. They are an unnecessary seed source that continues to pose a threat to other nearby completed work. A couple of invasive, non-native trees still exist along the creek through here, but otherwise it is in a maintenance state. In 2022, this area will need further attention to ensure the elimination of these large trees.
- An area along University Drive, across from City Park has a large stand of Giant Reed – *Arundo donax.* If this stand continues to thrive unchecked, it could continue to grow and

occupy spaces where Ligustrum was removed. The river through this area is in a maintenance state with follow-up efforts for the Arundo donax during 2022 to ensure it is fully eradicated.

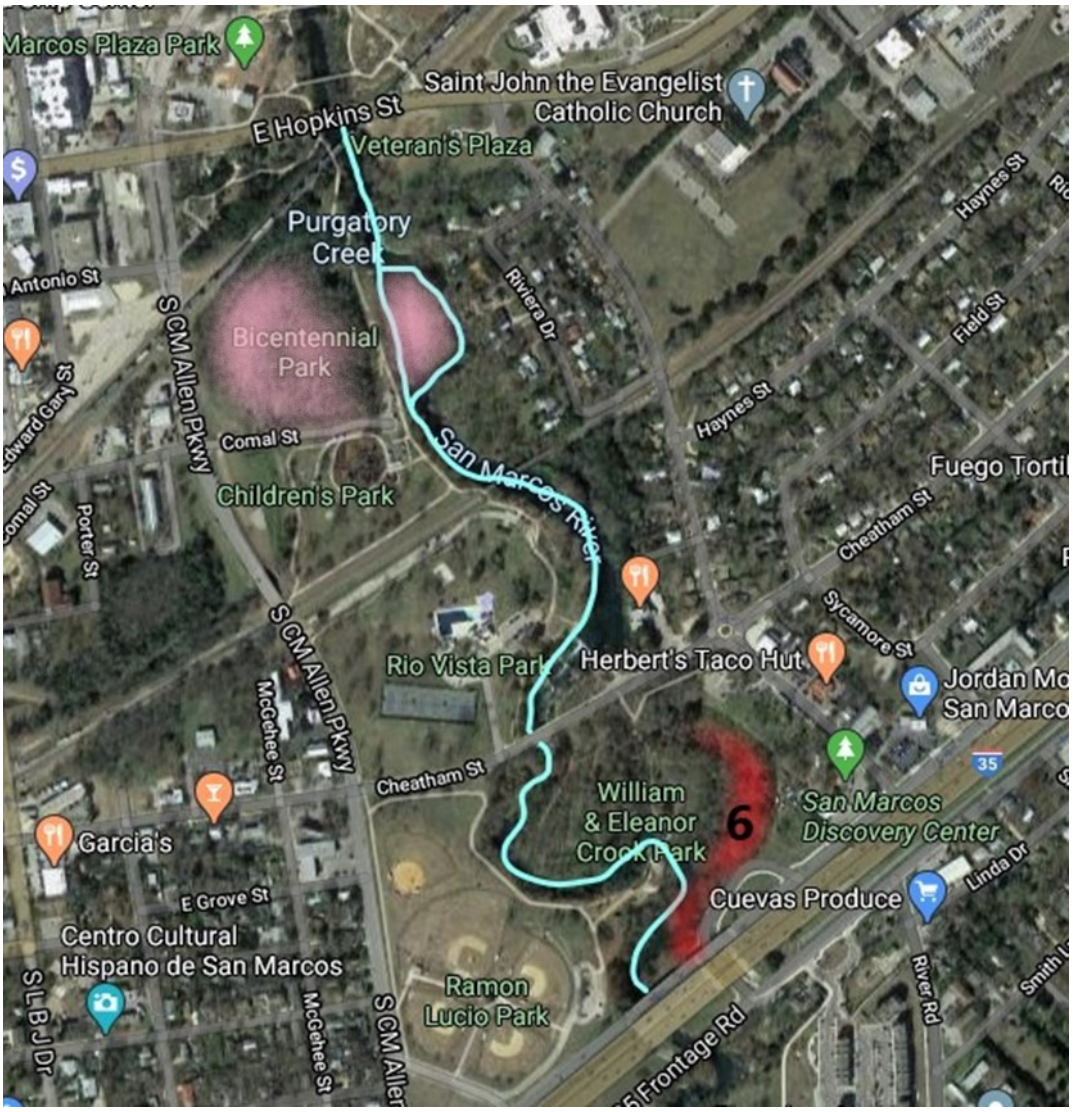


Figure 5. Veteran's Plaza, Bicentennial Park, Rio Vista Park, Ramon Lucio Park, Crook Park

Figure 5:

- The majority of the Crook Park site has now been completed and put into a maintenance state. The Cheatham site was completed by another contractor and Bicentennial Park and the adjacent Snake Island (shaded pink) will be collaborative areas and require multiple workdays in 2022, even after 2021 work has been performed. A small island right upstream of I-35 is full of Chinese Tallow and also needs to be worked on.

Figure 6. Stokes Park/SMRF Property

Figure 6:

- Good progress was achieved in 2021, to include the removal of invasive littoral plants on the private landowner's property. Work will continue in 2022 in Area 7 as the size and infestation level make it challenging.

Monitoring:

For aquatic plants, newly planted areas are monitored monthly to evaluate success rates. All planting and removal areas are monitored via quadcopter and/or visual observation by snorkelers and scuba divers. Both planting and removal efforts are mapped and quantified via GIS techniques. Work sites are separated into reaches to assess changes among and within reaches of the San Marcos River and to identify presence of non-native vegetation and also to assess the expansion of native vegetation.

Progress for non-native littoral vegetation removal will be tracked with polygons containing the species removed, estimated area (m^2) and percent removed. A composite map depicting the routine maintenance required to remove large areas of non-native aquatic vegetation will also be generated using weekly polygons.

Budget:
Table 7.1:
$50,000

Estimated 2022 budget:
$200,000: $160,000 for Texas State University (aquatic) and $40,000 for EBR (littoral)

5.3.3/5.4.3 Management of Floating Vegetation Mats and Litter

Long-term Objective:
Minimize impacts of floating vegetation and litter on TWR stands and overall aquatic community within the San Marcos River, as well as keep springs clear to enhance San Marcos salamander habitat.

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

Target for 2022:
Management activities include removal of litter from the littoral zone, stream bottom and portions of the major tributaries, and vegetation mats from Spring Lake Dam reach to Stokes Park. Contractors will continue to collaborate with other groups/contractors to maximize effectiveness and public involvement. Texas State University will manage aquatic vegetation in Spring Lake through use of its harvester boat and trained divers authorized to dive in Spring Lake. Additionally, invasive aquatic floating vegetation will be managed by Texas State University with the assistance of EAHCP contractors and volunteers from various organizations.

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

San Marcos River: Floating vegetation in TWR stands and other natives is lifted off the stands and removed as needed. Inorganic litter is picked up weekly from the substrate, surface and littoral zones of the San Marcos River from Upper Sewell Park to City Park and from IH-35 to Stokes Island during the recreational season (May 1st to September 30th) and monthly during offseason. Litter is also removed from public lands within the four tributaries.

Monitoring:
In the event of low flows, this activity will be monitored by the EAA contractor for potential impacts on listed species and will be suspended if impacts are observed. Volume of litter removed will be tracked. Removal of vegetation mats will be tracked with polygons delineating work areas and attribute data that include date and location.

Budget:
Table 7.1:
$80,000

Estimated 2022 budget:
$47,121

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

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

Target for 2022:
Contractor will use methods that have proven to be successful in efficient removal of invasive species from Spring Lake to IH-35. Contractor will measure length and weight for fish species. The targeted species include suckermouth catfish, tilapia, and two snail species, *Melanoides* and *Marisa cornuarietis.* Nutria are not frequently observed, and trapping is labor intensive, therefore, nutria will not be trapped unless seen more frequently in Spring Lake and river.

Methodology:
Spear and bow fishing continue to be most effective methods for fish removal. Contractor uses spearfishing tournaments, permitted through the municipality, to increase total removal, while saving costs and providing an educational awareness component to participants. Contractor ensures that all methods avoid impacts to resident turtles and other native species. Tournament participants are given a packet of information and are required to sign liability waivers. A free fish fry is held after the event and it should be noted that consumption of fish captured during the tournament is not condoned.

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

Pole-spearing tournaments were initially cleared by the COSM and for every upcoming tournament, the COSM departments are notified.

COSM has an ordinance prohibiting the dumping of aquaria into the San Marcos River (Sec. 58.037) and accepts unwanted aquatic fauna at the Discovery Center.

Monitoring:
In order to monitor the reduction of overall non-native species abundance in the San Marcos ecosystem, the contractor will compile information regarding the size (weight and total length) of the individual animals removed. This information may assist in determining overall effectiveness of this conservation measures impact of species population dynamics.

Budget:
Table 7.1:
$35,000

Estimated 2022 budget
$23,256

5.3.7 Designation of Permanent Access Points/Bank Stabilization

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

Target for 2022:
The COSM completed the construction of bank stabilization/access points at seven locations along the San Marcos River in 2014 with repairs made in 2017. If additional repairs are needed, the City of San Marcos will cover construction costs.

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

Budget:
Table 7.1:
$20,000

Estimated 2022 budget:
$0

5.7.1 Native Riparian Habitat Restoration

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

Target for 2022:
Contractor (funded through the EAHCP and COSM) and volunteers will maintain all treated areas from Spring Lake to Stokes Park to reduces invasive regrowth and tributaries with seedbank source as appropriate. Areas that will be focused on in 2022 include Meeks, Bicentennial, and Ramon Lucio. Volunteers plant natives in previously worked areas during regular planting days as needed. Initial invasive removal has been completed from headwaters to Stokes Park, so maintenance of all treated areas will be the primary focus with secondary seed source removals. Thompson's Island will be added as a new site for invasive removal after maintenance is complete. If possible, the private properties on river left from Bicentennial to Cheatham Street, will also be addressed. This would require contacting the private landowners to gain access.

Figure 7. Focus for Meeks property that will expand toward Bicentennial throughout 2022.

Methodology:
Contractor removes and treats invasive regrowth using a glyphosate/trichlopyr herbicide mix to treat the stumps and/or roots. On upland trees, shrub stumps and root buttresses, Relegate **(**Triclopyr-based herbicide) is used. The Relegate is mixed with glyphosate, Drexel Surf Ac 820 Surfactant and Turf Mark Blue, a blue dye. Roots are scraped and treated with herbicide mix then monitored. Volunteers complete all other native riparian habitat restoration as described above using plants propagated at the Discovery Center. Treated and adjacent areas will be monitored for re-growth and seed sources.

Monitoring:
Monitoring will occur monthly to check for re-growth and treat as needed. Maintenance will continue to be a mix of contract work funded by EAHCP and COSM, as well as volunteerism. The City will continue to provide all fences to protect the sites as well as game cameras and other security measures as needed to prevent theft, vandalism and unauthorized access.

Budget:
Table 7.1:
$20,000

Estimated 2022 budget:
$20,000

5.3.2/5.4.2 Management of Recreation in Key Areas

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

Target for 2022:

1. Hire nine Conservation Crew members that work approximately 15 hours/week (Wed to Sun) from mid-May to September with members working prior to summer season and after to continue public outreach, recreation impact minimization efforts, and assists the MCWE SAV team in their efforts to remove floating vegetation mats and non-native vegetation.

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

a. Signage. Signs have been posted in kiosks at most of the river access points. Signs cover the rules of the river and educate the public on the importance of the resource. Exclusion barriers are also established when flows are below 120 cfs and TWR stands are vulnerable (primarily during the recreation season).

b. Video loop at City Park offering information about the river and safety rules while people are waiting for shuttle or tubes. Video was finished and installed in 2016/2017 for Lion's Club and will be updated and distributed electronically for increased exposure.

c. Posted maps showing trail, access points, and other amenities. River maps are located at the Discovery Center which serves as the trailhead to the San Marcos River and help inform visitors and recreationists about the San Marcos River/Blanco River confluence.

d. EAHCP brochures have been placed at the Tourist Information Bureau for visitors.

e. Park Rangers. Training materials covering the river flora and fauna have been developed and provided for the training of the park rangers, so they can help disseminate the information.

f. School Outreach. Implement an outreach program for San Marcos Consolidated Independent School District (SMCISD) so this information can be relayed to youth in San Marcos and indirectly to the parents. The San Marcos Discovery Center is a facility dedicated to public education and outreach regarding the San Marcos River. Outreach efforts include the production of an interactive river habitat card game that was introduced into the curriculum for SMCISD elementary schools.

g. Coordinate with the Texas State University Outdoor Recreation center to help educate river users about endangered species and EAHCP assets on the San Marcos River.

h. Continue to provide outreach at booths including Concert Series (Earth & Water), Passport SMTX, Business Expo, Mermaid Society events, San Marcos Sustainability Fair, and Don't Mess with Texas Litter Cleanup.

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

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

l. Introduce the COI program to qualified third parties conducting recreational activities in and along the San Marcos River.

m. Monitor watercraft and educate recreationists about the invasive zebra mussels.

Monitoring:
Litter removed from the river during the recreation season is tracked. Also, the Conservation Crew will monitor boats and river structures for the presence of zebra mussels from Spring Lake Dam to IH-35.

Budget:
Table 7.1:
$56,000

Estimated 2022 budget:
$56,000

5.7.6 Impervious Cover/Water Quality Protection

Long-term Objective:
Establish a program to protect water quality and reduce the impacts from contaminated runoff based on recommendations listed in the *San Marcos Watershed Protection Plan*.

Target for 2022
The EAHCP commitment for a combined effort (Sediment Management and Impervious Cover & Water Quality Protection) includes construction of Sessom Creek Restoration Phase 1 starting in 2022, the completion of the Downtown Pond in 2020, and the completion of Sessom Restoration Phase 2 by 2023.

The most cost-effective strategy identified through the adaptive management process (AMP) in 2017 was implementation of stream restoration projects in the middle reach of Sessom Creek. Restoration will also address a tributary flowing into the middle reach, the Windmill Tributary, that is experiencing accelerated stream erosion and also contributing high sediment loads. Primary objectives of the AMP strategies are (1) reduce existing stream erosion, and (2) accelerate the natural re-stabilization process for Sessom Creek, i.e., to return it to a state of geomorphic equilibrium.

The preliminary recommendations address Phase 1, approximately 1400 linear feet of Sessom Creek, from above North LBJ Drive upstream to the Windmill Tributary confluence and Phase 2, approximately 565 linear feet from the confluence to the Loquat/Canyon intersection, plus 550 linear feet of Windmill Tributary. Stream and watershed restoration practices identified for each project reach include grade control, bank stabilization, gully control, stormwater management ponds, natural channel design, and riparian restoration.

In addition, the COSM has identified several other projects and concerns within the same geographic area. These include wastewater improvements, road repair and improvements, site-specific erosion repairs, and a water main project. These improvements will be funded by COSM and will work in concert with the stream restoration and stormwater management practices to the maximum extent practical. The wastewater improvement project is separate but is planned to occur concurrently with the other projects.

Target for 2022:
After completion of the removal of wastewater lines is accomplished in 2021, the creek restoration construction portion of Phase 1 will begin with potential completion in 2022. Phase 2 construction bid process will also occur in 2022.

Monitoring:
The EAA Sessom Creek Real-Time monitoring station will measure turbidity, DO, and temperature. Any changes due to Sessom Creek restoration will be monitored by this monitoring station.

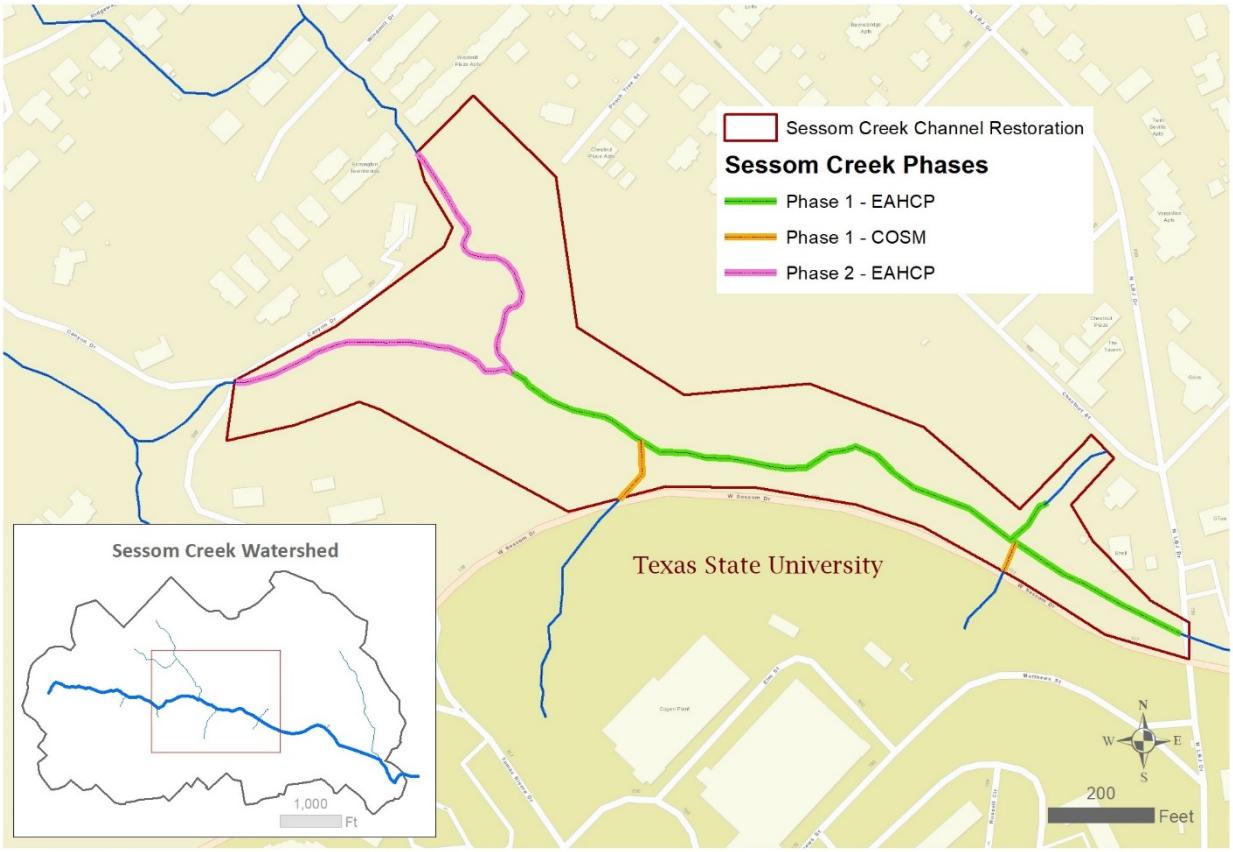


Figure 7. Sessom Creek Proposed Project Reaches - Phase 1 (green outline), Phase 2 (pink outline), Phase 3 (blue area)

Budget:
Table 7.1
$200,000

Estimated 2022 budget:
$1,100,000

***$1,528,200.00 was approved for this conservation measure in 2019, $1,037,862.00 remains as of the December 2020 invoice. Funding will cover Sessom Creek Phase 1 channel restoration and construction administration services as well as bid oversight of Sessom Creek Phase 2. Additional funds were spent on completion of the Phase 2 design in 2021. Phase 1 construction is expected to begin in late 2021 and continue into 2022.**

5.7.5 Management of Household Hazardous Waste

Long-term Objective:
Strengthen the COSM existing program that provides a place for citizens of San Marcos and Hays County to safely dispose of Household Hazardous Waste (HHW). This prevents the dumping of HHW into the river or recharge zone and thus impacting listed species.

Target 2022:
Target 3000 participants for public outreach events. Staff will conduct these events and convert or dispose of the HHW between events. Fund outreach to surrounding communities within the San Marcos River watershed that cannot afford to partner in a HHW collection program. Mailing quick fact flyers out with HHW information.

Methodology - Open drop-off opportunities two days a week (Tuesday and Friday) from 12:00 p.m.to 3:30 p.m. to the public.

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

Budget:
Table 7.1:
$30,000

Estimated 2022 budget:
$30,000

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

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

Target for 2022:
Texas Department of Transportation is expected to approve the route in 2021.

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

Budget:
Table 7.1:
$0

Available budget for 2022:
$0

Estimated 2022 budget:
$0

5.7.3 Septic System Registration and Permitting Program

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

Target for 2022:
To maintain an accurate record of new and existing septic systems installed and modified in city jurisdiction. In addition, city ordinance requires all owners of septic systems connect to municipal sewer lines as they become available.

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

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

Budget:
Table 7.1:
$0

Available budget for 2022:
$0

5.7.4 Minimizing Impacts of Contaminated Runoff

Long-term Objective:
The goal of this measure is to reduce the input of sediment and roadway contaminants into the San Marcos River. In order to leverage existing investment from the COSM, the EAHCP will assist in constructing two ponds (estimated to be complete in 2020). Both ponds are designed for high pollutant load reduction and have been identified as a priority management strategy.

Target for 2022:
All activities and funds associated with this measure have been completed.

Budget:
Table 7.1:
$0

Available budget for 2022:
$0

5.4.5 Diversion of Surface Water

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

Target for 2022:
Restriction of surface pumping as specified under the EAHCP. Under TCEQ Certificates 18-3865 and 18-3866, Texas State University's total diversion rate from the headwaters of the San Marcos River for consumptive use is limited to 8.1 cfs (See EAHCP Section 2.5.5). The total diversion rate from Spring Lake is limited to 4.88 cfs; the total diversion rate from the San Marcos River at Sewell Park is limited to 3.22 cfs (See EAHCP Section 2.5.5.1 and 2.5.5.2 respectively).

Methodology - When flow at the USGS gauge (08170500) at the University Bridge reaches 80 cfs, Texas State University will reduce the total rate of surface water diversion by 2 cfs, *i.e.*, to a total of approximately 6.1 cfs. This reduction in pumping will occur at the pump just below Spring Lake Dam in order to maximize the benefits to salamanders, TWR, and other aquatic resources in the San Marcos River below Spring Lake Dam. The University will reduce the total rate of surface water diversion by an additional 2 cfs when the USGS gauge reaches 60 cfs. The additional 2 cfs reduction will be made from the pumps located in the slough arm of Spring Lake, and, therefore, maximize the benefits to the aquatic resources within the main stem San Marcos River below Spring Lake Dam. When the USGS gauge reaches 52 cfs, Texas State University will reduce the total diversion rate to 1 cfs. This further reduction will be made by restricting the pumps located in the Sewell Park reach. The diversion of water will be suspended when the springflow reaches 45 cfs.

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

Budget:
Table 7.1:
$0

Available budget for 2022:
$0

5.4.7 Diving Classes in Spring Lake

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

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

Target for 2022:
Implement the diving protocols as outlined in the Spring Lake Management Plan, EAHCP, and the ITP with the following modifications: no more than 16 volunteer divers will be allowed in the lake per day, with no more than eight at one time.

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

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

Budget:
Table 7.1:
$0

Available budget for 2022:
$0

5.4.8 Research Programs in Spring Lake

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

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

Target for 2022:
Implement the protocols for research as specified in the Spring Lake Management Plan, EAHCP, and ITP.

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

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

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

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

Budget:
Table 7.1:
$0

Available budget for 2022:
$0

5.4.10 Boating in Spring Lake and Sewell Park

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

Target for 2022:
Implement the protocols for boating as specified in the Spring Lake Management Plan in support of the EAHCP and ITP.

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

1. All boats must be properly washed/disinfected before being placed in lake and once they are removed per the protocol defined in the Spring Lake Management Plan.
2. Participants must receive an orientation prior to boating including instruction on safety, basic boat handling, and on-site rules and regulations. The orientation will cover information specific to Spring Lake's sensitivity and endangered species.
3. All non-glass bottom boat activity must not interfere with routine glass bottom boat operations.

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

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

Budget:
Table 7.1:
$0

Available budget for 2022:
$0

5.4.9 Management of Golf Course and Grounds

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

Target for 2022:
Continued implementation of the Grounds Management Plan and Integrated Pest Management Plan. Texas State University recently completed conversion of the Golf Course to Intramural Recreation Fields. COSM will work with the Texas State Facilities to better understand how the change will affect the Grounds Management Plan and the Integrated Pesticide Management Plan.

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

Monitoring:
Each year the Grounds Manager will report to the Lake Manager detailed information on maintenance activities and materials used during the year.

Budget:
Table 7.1:
$0

Available budget for 2022:
$0