EDWARDS AQUIFER
HABITAT CONSERVATION PLAN

2016 Annual Report

Submitted to
The U.S. Fish & Wildlife Service

March 24, 2017

On behalf of
The Edwards Aquifer Habitat Conservation Plan Permittees

Prepared by Blanton & Associates, Inc.
Environmental Consulting • Planning • Project Management

Edwards Aquifer

Habitat Conservation Plan

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EXECUTIVE SUMMARY

Edwards Aquifer Habitat Conservation Plan

The Edwards Aquifer Habitat Conservation Plan (EAHCP)[1] is a cooperative effort to protect the water of the southern portion of the Edwards Aquifer both for people in the region and the endangered species[2] that inhabit the aquifer, and aquatic spring environments whose water largely emanates from the aquifer. This effort began when regional stakeholders and the U.S. Fish & Wildlife Service (Service or USFWS) initiated the Edwards Aquifer Recovery Implementation Program (EARIP) in 2006. The Texas Legislature mandated participation in the process by the Edwards Aquifer Authority (EAA), Texas Commission on Environmental Quality (TCEQ), Texas Department of Agriculture (TDA), Texas Parks & Wildlife Department (TPWD), and Texas Water Development Board (TWDB). The EARIP process led to the creation of the planning group known as the Edwards Aquifer Recovery Implementation Program Habitat Conservation Plan, which has now transitioned to the implementation group known as the EAHCP. The EAHCP was completed in November 2012 and led to the approval of an Incidental Take Permit (ITP) under the federal Endangered Species Act of 1973 (ESA) issued by the USFWS in March 2013. The ITP has been amended once, and a copy of the amended ITP is included in **Appendix A1** of this Annual Report. This Annual Report has been prepared for submittal to the USFWS, as required by the ITP.

The Permittees under the EAHCP are the EAA, the City of New Braunfels (CONB), the City of San Marcos (COSM), Texas State University (Texas State), and the City of San Antonio acting by and through its San Antonio Water System (SAWS) Board of Trustees.

Covered Species Protected by the EAHCP

The EAHCP addresses the conservation needs of seven endangered species, one threatened species, and three species that have been petitioned for listing, as shown below in **Table ES-1**. Under the EAHCP, the Covered Species are covered by the ITP issued by the USFWS. The ITP allows "take" of the Covered Species listed in **Table ES-1**, as that term is defined in the ESA. [3]

[1] All acronyms and abbreviations in this Annual Report are defined in the **LIST OF ACRONYMS AND ABBREVIATIONS** located on pages xxiv - xxvi.

[2] All aquatic animal and plant species referenced in this Annual Report are listed in the **LIST OF ALL SPECIES OF MANAGEMENT INTEREST REFERENCED** located on pages xxvii - xxviii.

[3] "Take," as defined by the ESA, means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." "Harm" is also defined in the implementing regulations as "an act which actually kills or injures wildlife; such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly interfering with essential behavioral patterns including breeding, feeding and sheltering" (50 CFR 17.3). Disturbing or destroying occupied endangered species habitat could be a violation of the ESA if an individual of the species is prevented from breeding, feeding or sheltering and if this ultimately leads to the death or injury of the individual. If it is not possible to change a proposed action to avoid take of a listed species, a non-federal entity may request a permit under Section 10(a)(1)(B) to allow an exception for activities that may incidentally impact species. The USFWS may issue such permits, under the limited circumstances described in Section 10(a). Plants (e.g., Texas wild-rice) are treated differently under the ESA and are not subject to the take rules.

Table ES-1. Covered Species Under the EAHCP ITP

Common Name	Scientific Name	Federal Status	Associated Springs in the EAHCP
Fountain Darter	*Etheostoma fonticola*	Endangered	Comal & San Marcos
San Marcos Gambusia	*Gambusia georgei*	Endangered	San Marcos
Comal Springs Dryopid Beetle	*Stygoparnus comalensis*	Endangered	Comal
Comal Springs Riffle Beetle	*Heterelmis comalensis*	Endangered	Comal & San Marcos
Peck's Cave Amphipod	*Stygobromus pecki*	Endangered	Comal
Texas Wild-Rice	*Zizania texana*	Endangered	San Marcos
Texas Blind Salamander	*Eurycea (+Typhlomolge) rathbuni*	Endangered	San Marcos
San Marcos Salamander	*Eurycea nana*	Threatened	San Marcos
Texas Cave Diving Beetle*	*Haideoporus texanus*	Petitioned	Comal & San Marcos
Comal Springs Salamander	*Eurycea sp.*	Petitioned	Comal
Texas Troglobitic Water Slater	*Lirceolus smithii*	Petitioned	San Marcos

* Also known as the "Edwards Aquifer Diving Beetle."

Geographic Area Covered by the EAHCP

As shown in **Figure ES-1**, the ITP provides incidental take coverage for authorized activities in all or parts of Uvalde, Medina, Atascosa, Bexar, Comal, Guadalupe, Hays and Caldwell counties, Texas. This area is the Plan Area in which pumping from the Edwards Aquifer is regulated by the EAA and affects the springs and spring ecosystems inhabited by the Covered Species. The Plan Area also includes the recreational areas associated with the Comal Springs and the San Marcos Springs that are under the jurisdiction of the CONB, and the COSM and Texas State, respectively.

Effects on Covered Species in 2016

Chapter 5.0 – 2016 ANNUAL TAKE ESTIMATES, and **Appendix N,** of the Annual Report provide an overview of net disturbance percentages and a summary of incidental take for 2016 (**Table ES-2**). In the Comal Springs system, only the fountain darter had a net disturbance when considering the project footprint for EAHCP Conservation Measures overlaid on occupied habitat. The net disturbance was 3.3 percent of the total occupied habitat for the fountain darter in the Comal system. No project footprints overlapped with any of the occupied habitat for the endangered Comal Springs invertebrates. In the San Marcos system, only the fountain darter had a net disturbance calculated at 4.1 percent of its total occupied habitat. For the San Marcos salamander, Texas blind salamander and Comal Springs riffle beetle (CSRB), there were no EAHCP Conservation Measures conducted in 2016 that directly impacted any documented occupied habitat or spring orifices where Texas blind salamander collections have been made over the years. In summary, the net disturbance in 2016 was under the 10 percent disturbance rule as outlined ITP Condition M[a]).

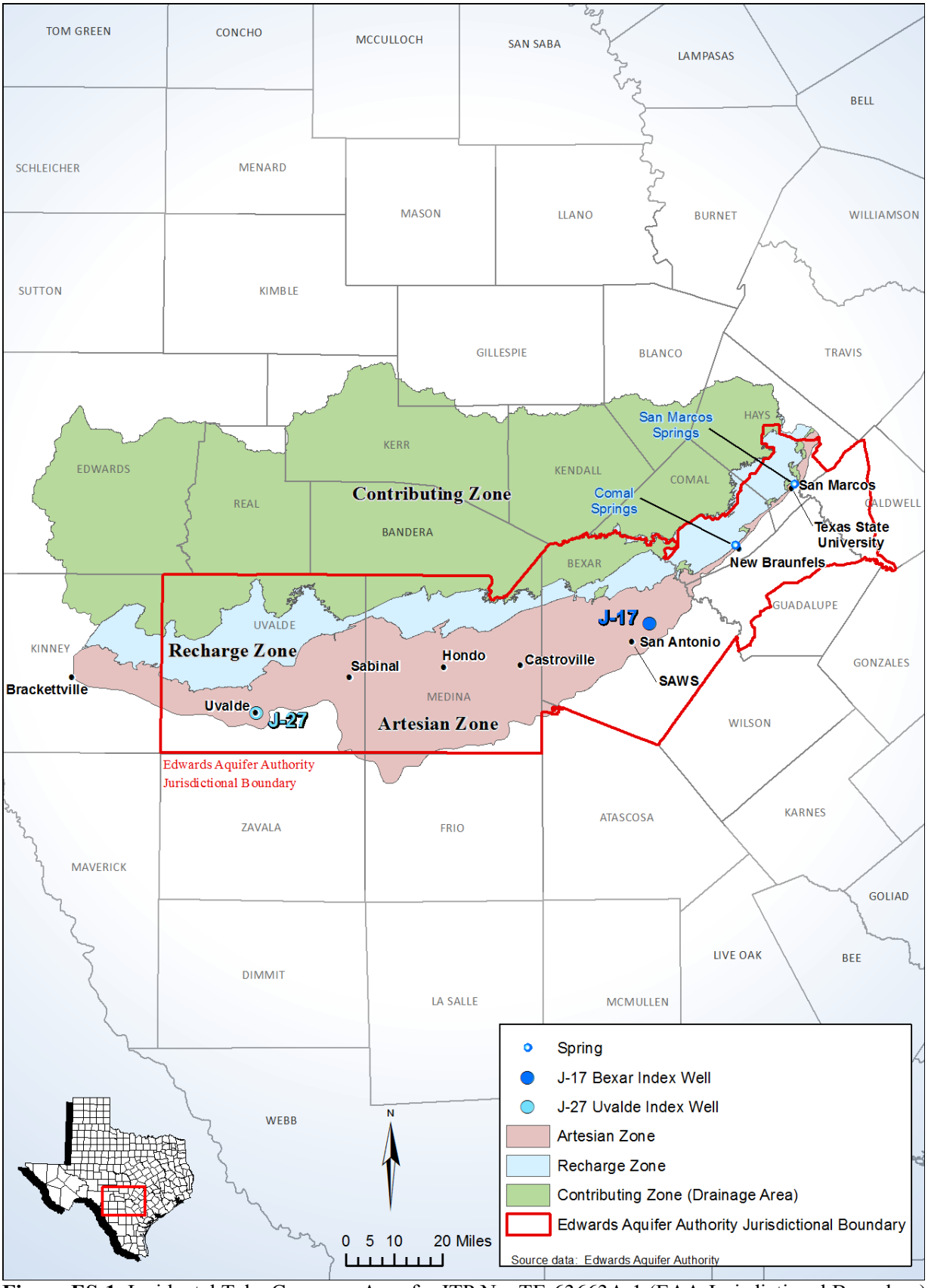

Figure ES-1. Incidental Take Coverage Area for ITP No. TE-63663A-1 (EAA Jurisdictional Boundary).

Table ES-2 also shows the calculated incidental take on the Comal system with respect to the EAHCP Covered Species. There was no incidental take for the Comal invertebrates in 2016. The calculated value for the fountain darter was less in 2016 than observed during the drought conditions experienced in both 2013 and 2014. The primary cause for no calculated take for the invertebrates and decrease for the fountain darter relative to drought years was the above average discharge conditions throughout most of 2016, which resulted in full inundation of surface habitats within CSRB occupied habitat, and inundated habitat and constant water temperatures for the fountain darter. The 2016 incidental take for the fountain darter in the Comal system was slightly higher than reported in 2015 most notably because of aquatic vegetation disturbance in the New Channel. For the San Marcos system, incidental take for the fountain darter went down slightly in 2016 compared to 2015. This decrease relative to the fountain darter was influenced by slightly reduced spring to fall aquatic vegetation impacts in all three LTBG reaches. Additionally, higher than average flow conditions experienced the entire year eliminated the need for recreational exclusion structures in designated State Scientific Areas (SSAs) in 2016. This modification eliminated any project footprint over San Marcos salamander habitat and thus the reason no impacts were noted for this species in 2016 compared to previous years.

2016 Edwards Aquifer Conditions, Management, and Notable Conditions

In 2016, the Comal and San Marcos springs complexes reaped the benefits from record rainfall in 2015 and above average rainfall in 2016. Statewide, precipitation records were set for the 2015 calendar year (41.2 inches), four-month (March-June, 20.2 inches), three-month (April-June, 16.7 inches), two-month (April-May, 13.0 inches), and one-month (May, 9.1 inches) time increments (NOAA 2016).

Springflows across the Edwards Aquifer Artesian Zone responded accordingly. **Figure ES-2** shows the frequency distribution of average annual springflows at Comal and San Marcos springs over the 60-year period of record. Yearly springflows for 2016 at Comal (346 cubic feet per second [cfs]) were near the 80th percentile of the distribution, while San Marcos yearly flows (276.5 cfs) were at the 98th percentile. In fact, at San Marcos, 1992 is the only calendar year with higher springflows recorded than in 2016. The large amounts of precipitation and subsequent streamflow have aided in system recovery from the prolonged drought ending in 2015.

Figure ES-3. shows time series of springflows at both complexes for the last four years. Note, more water exited Comal and San Marcos springs in 2016 than in the years 2013 and 2014, combined.

Table ES-2. Summary of Impacted Habitat (m^2) and Net Disturbance and Incidental Take for EAHCP Covered Species Compared Against ITP Maximum Permit Amounts

Covered Species Per System	EAHCP Mitigation/Restoration		EAHCP Measures/ Drought	Combined Impacted Habitat 2016 TOTAL (m2)	Incidental Take		2016 Incidental Take Total	ITP Maximum Permit Amount	ITP Permit Maximum Minus (Combined First Four Years)
	Impacted Habitat (m2)	Net Disturbance % Of Total Occupied Habitat	Impacted Habitat (m2)		EAHCP Mitigation/Restoration	EAHCP Measures/ Drought			
COMAL SYSTEM									
Fountain Darter	3,002	3.3%	3,637	**6,639**	4,503	5,456	**9,959**	797,000	748,386
Comal Springs Riffle Beetle	0	0.0%	0	**0**	0	0	**0**	11,179	8,933
Comal Springs Dryopid Beetle	0	0.0%	0	**0**	0	0	**0**	1,543	1,528
Peck's Cave Amphipod	0	0.0%	0	**0**	0	0	**0**	18,224	18,060
SAN MARCOS SYSTEM									
Fountain Darter	3,652	4.1%	3,697	**7,349**	5,478	5,545	**11,023**	549,129	496,190
San Marcos Salamander	0	0.0%	0	**0**	0	0	**0**	263,857	261,264
Texas Blind Salamander	0	0.0%	0	**0**	0	0	**0**	10	10
Comal Springs Riffle Beetle	0	0.0%	0	**0**	0	0	**0**	N/A	N/A

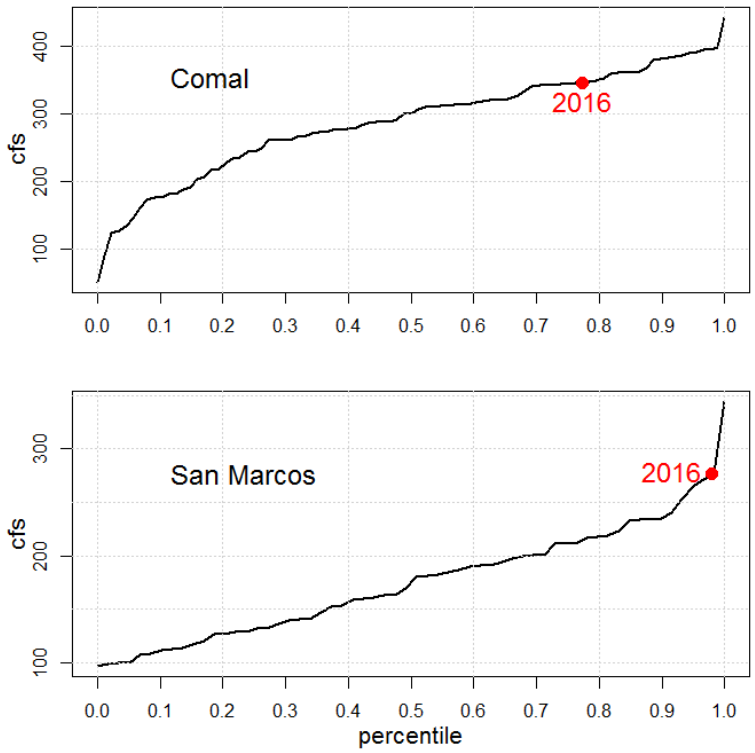

Figure ES-2. Frequency distribution of average annual springflows at Comal and San Marcos springs.

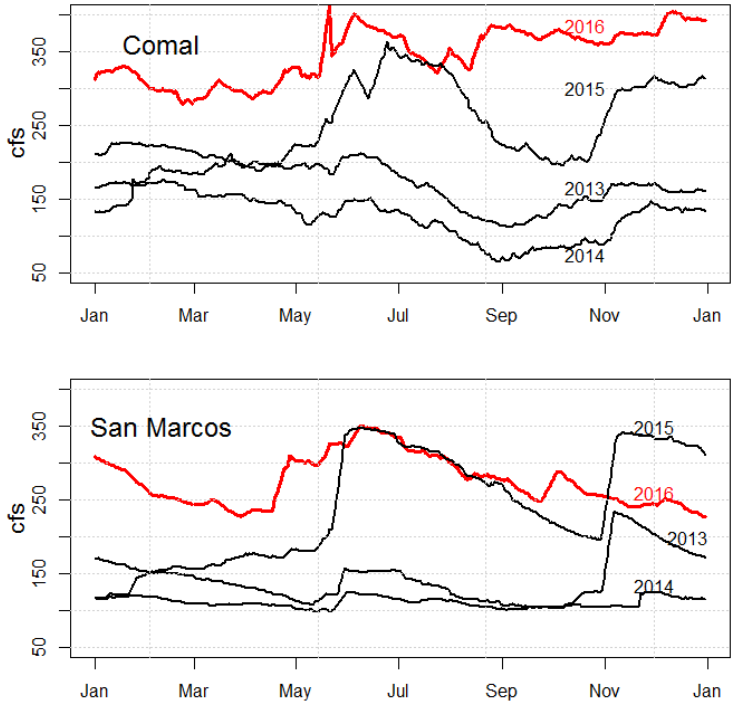

Figure ES-3. Springflow time series for years 2013 through 2016 at Comal and San Marcos springs.

EAHCP 2016 Budget and Expenditures

The EAHCP Expense Report located in **Appendix H** of this Annual Report shows Table 7.1 of the EAHCP funding amounts for 2016 totaling $18,292,597. These amounts can be compared to the EAA Board-approved 2016 Program Funding Applications totaling $21,240,198.

Actual expenses for 2016 were $17,920,965. A significant amount of unspent funds in the ASR leasing, ASR Operations and Maintenance, and Refugia budgets account for the majority of the difference between total approved budget and actual expenses.

The report also breaks down the adopted budget, Program Funding Applications budget, and actual expenses. By the end of 2016, the reserve balance for the EAHCP was $37,619,716, which includes unspent funds accumulated since the inception of the EAHCP.

The EAHCP Expense Report also shows the actual revenue for 2016 of $17,438,751 compared to the budgeted revenue of $17,510,436, which is a variance of only $71,685. Approximately 95 percent of the actual revenue comes from Aquifer Management Fees (AMFs).

EAHCP Activities Completed in 2016

As stated above, the five Permittees under the EAHCP are the EAA, CONB, COSM, Texas State, and SAWS. The TPWD is an additional cooperating agency, or Partner. These are the primary agencies, or Partners, working to implement the EAHCP. The Permittees are each tasked with certain responsibilities for implementation of the EAHCP, as directed by the ITP. During Phase I of implementing the EAHCP, the Permittees are undertaking various measures for flow protection, habitat protection, and other measures identified in the EAHCP.

The ITP requires an annual report be submitted to the USFWS to show progress towards permit implementation. **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, of this 2016 Annual Report describes permit actions by the Permittees and the TPWD, including subsections discussing their *EAHCP Obligations*, *2016 Compliance Actions*, and *Proposed Activities for 2017*.

In Year 2016, EAHCP implementation gained momentum in data management and modeling, research, and public involvement. As discussed previously, the near drought of record conditions from 2014 and 2015 subsided giving the Permittees and the EAHCP some flexibility to focus on fine-tuning the EAHCP, and enhancing programs as well.

Highlights of major EAHCP accomplishments for 2016 are summarized below.

Springflow Protection Measures –

With regard to the four EAHCP springflow protection elements (the Voluntary Irrigation Suspension Program Option [VISPO], the Regional Water Conservation Program [RWCP], the Critical Period Management Program [CPMP] – Stage V, and the Aquifer Storage and Recovery [ASR] leasing program), the EAHCP is making headway to complete all four of these elements prior to Year 2023, which is the tenth year of the ITP and five years in advance of the Year 2028.

a. *VISPO* – In 2016, EAHCP staff did not initiate efforts to enroll new participants in the VISPO as the goal of 40,000 acre-feet (ac-ft) was achieved in 2014 and no more water was needed at this time.

b. *RWCP* – In early 2016, the EAHCP and SAWS reached an agreement, which completes the RWCP goals of conserving 20,000 ac-ft of water. By investing in increasing SAWS' Leak Detection and Repair Program, SAWS projects it will conserve enough water to meet the RWCP commitment by the Year 2020. The five-year contract with SAWS, in conjunction with work in the cities of Uvalde and Universal City, have guaranteed over 10,000 ac-ft of Edwards Aquifer water to be left unpumped through the term of the ITP.

c. *CPMP – Stage V* – This element was approved by the EAA Board of Directors in early 2013, and has been implemented as necessary. There were no CPMP stages triggered in 2016.

d. *ASR leasing program* – The ASR leasing program is another springflow protection measure that gained a lot of ground in meeting its program goals in 2016. A combination of increased outreach and a rainy spring resulted in Edwards Aquifer groundwater withdrawal rights holders leasing their unused water to the ASR leasing program. This element is the cornerstone of the EAHCP to ensure that the Comal Springs flow during a repeat of the drought of record. This past year, Edwards Aquifer permit holders leased over 33,000 ac-ft of EAHCP water to the ASR leasing program bringing the total EAHCP ASR water stored to 55,000 ac-ft. Once the program goal is achieved through the ASR, there could be as much as 126,000 ac-ft stored and available to ease the effects of a drought of record.

- **Habitat Restoration: Comal and San Marcos Spring Systems –**

  a. *Nonroutine Adaptive Management Process* – The EAHCP broke new ground in 2016 by triggering its first Nonroutine Adaptive Management Process (AMP) as it continues to work to improve its submerged aquatic vegetation (SAV) restoration program. The Adaptive Management Report and Proposal provided to the Implementing Committee (IC) outlined a variety of amendments to the SAV restoration program. Those changes included alterations to the overall Long-Term Biological Goals (LTBGs) associated with fountain darter habitat and the flow partitioning to the Old Channel and the New Channel of the Comal River. As part of the AMP in 2016, the EAHCP also clarified the EAHCP Key Management Objective regarding "proportional expansion" and created "restoration reaches" for the Comal and San Marcos rivers. In 2017, the Partners will implement the amendments to the SAV restoration programs. This work will be reflected in the 2017 Annual Report.

  b. *Comal Springs Systems* –
  Bank Stabilization Project – The Bank Stabilization Program was completed in 2016. Contractors under the guidance of the CONB reworked about 1,000 feet (ft) of river bank between the Landa Park Pool and the Landa Park Golf Course. This construction project will help slow the "sloughing-off" of sediment from the river bank that had reduced fountain darter habitat in previous years. A new berm was placed at the top of the riverbank to send stormwater into the channel while preventing erosion. At the bottom of the bank, contractors placed an anchor system composed of wire enclosures filled with rock. On top of the anchors, contractors

tied a stone cap into the slope for additional anchoring and aesthetic purposes. The combination of the 2015 Flow-Split Management Project and the 2016 Bank Stabilization Project will enhance the habitat for the endangered fountain darter and will protect stream water quality.

Vegetative Restoration in the Old Channel, Landa Lake, and Upper Spring Run – Aquatic vegetation restoration activities in 2016 included removal of non-native aquatic vegetation and planting of target native aquatic plants as well as monitoring, mapping, and maintenance of restored areas. A summary of 2016 restoration results follows.

i. *New Channel* – While no new work was completed in the New Channel Restoration reaches in 2016, these reaches were mapped for vegetation coverage.
ii. *Old Channel* – In 2016, a total of 705 m^2 was planted in eight restoration plots, bringing the four-year total area planted in the LTBG reaches to 3,378 m^2.
iii. *Landa Lake* – In 2016, 236 $m^2$of area was planted bringing the four-year total of area planted to 2,927 m^2.
iv. *Upper Spring Run* – 620 $m^2$was planted in the Upper Spring Run LTBG Reach.

c. *San Marcos Springs Systems* –
Texas wild-rice Enhancement and Restoration – Restoration activities in 2016 involved removal of non-native plant species, propagation of new Texas wild-rice plants, and continued monitoring of new stands. COSM staff estimates that since 2013, Texas wild-rice has increased through plantings and natural expansion to an estimated 3,338.8 m^2 within specified work sites. Since 2015, Texas wild-rice continued to expand by an estimated 798.6 m^2 at those same sites.

Riparian Restoration – The COSM focused aquatic vegetation treatment (e.g., removal and planting) efforts from the following seven work sites throughout 2016: Spring Lake; Sewell Park; City Park; Hopkins Street-Bicentennial Park; Cypress Island; Rio Vista Dam; and Interstate Highway (IH)-35. The Spring Lake, Rio Vista Dam, and IH-35 work sites were new for 2016.

Texas Commission on Environmental Quality (TCEQ) Texas Environmental Excellence Award (TEEA) – For their volunteer-driven riparian restoration program, the TCEQ presented the COSM and Texas State with the TEEA in the Civic and Community Engagement category. The EAHCP has developed solutions to mitigate bank erosion along the river by planting native riparian vegetation. The volunteer-driven riparian restoration program has worked so well that the State of Texas has recognized it with an environmental excellence award.

- **Refugia –** In 2015, the EAA entered into a contract to provide Salvage Refugia Operations located at the San Antonio Zoo. The contract terminated December 31, 2016. During the contract period, the contractor purchased and renovated three shipping containers to be used as research facilities (pods), with final construction and use occurring in 2016. The Covered Species were collected and held at the Zoo where the contractor conducted studies to inform proper husbandry techniques (see Salvage Refugia Report **Appendix K2**).

In 2016, the EAA Board of Directors also approved a contract with the USFWS for a Long-Term Refugia Operation. As part of the EAHCP, a Long-Term Refugia is required to be put in place to preserve endangered species living in the Comal and San Marcos springs areas in the event a repeat of the drought of record occurred and could impact their natural habitat. The selected contractors will be capturing seven different endangered species from their current habitat and bringing them to the USFWS' San Marcos Aquatic Resource Center (SMARC) located in San Marcos, Texas, and Uvalde National Fish Hatchery (UNFH), located in Uvalde, Texas.

- **Development of Integrated EAHCP Database –** The EAHCP also moved forward with efforts to improve data management. The EAHCP team, along with outside vendors, EAA staff, and various committees, developed a new data management system focused solely on the EAHCP. The EAHCP team migrated 16 years of biological monitoring datasets, including all aquatic vegetation mapping, fountain darter, macroinvertebrate, salamander, fixed station photography and Texas Master Naturalist datasets, as well as three years of water quality datasets from both the San Marcos and Comal Springs surveys, including stormwater, surface water, sediment, and passive diffusive sampling into the database. In addition to housing the EAHCP administrative and scientific record, the new database provides Permittees, Partners and EAHCP staff with an efficient, secure and accurate record from which to produce information to make decisions regarding program direction, and to evaluate the effectiveness of how the EAHCP is meeting its outlined goals.

- **Applied Research –** The EAHCP initiated efforts to learn about a species that had not been studied to date. Three research projects designed to gain knowledge about the endangered CSRB were launched in 2016. One goal of the research is to understand the tolerance of the CSRB to varying water temperatures or dissolved oxygen (DO) concentrations because low flows in the Edwards Aquifer during dry periods can raise water temperatures and reduce DO. The CSRB life history study has provided the first reliable, non-intrusive means of determining the gender of a CSRB, which has allowed the researchers to match pairs for reliable breeding and rearing studies. To date, the CSRB research team has been able to discover how many eggs are laid in a clutch and time required for hatching. The research team is currently raising larvae to determine the number of larval instars prior to pupation, as well as the time required for adults to emerge from the pupae. Knowing about these species will help the EAHCP to make more informed decisions on overall programs.

- **EAHCP Program Activity –** The EAHCP completed another active year, with program staff facilitating more than 20 public meetings. This included regular meetings of the IC, SC and SH, as well as topical based Work Groups to inform program decisions.

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LIST OF ACRONYMS AND ABBREVIATIONS

ac-ft	acre-foot/acre-feet
AMF	Aquifer Management Fee(s)
AMP	Adaptive Management Process
ARWG	Applied Research Work Group
ASR	Aquifer Storage and Recovery
BioMP	Biological Monitoring Program
BIO-WEST	BIO-WEST, Inc.
BioWG	Biological Monitoring Program Work Group
BMP(s)	best management practice(s)
CC	Conservation Crew
cfs	cubic feet per second
COI	Certificate of Inclusion
CONB	City of New Braunfels
COSM	City of San Marcos
Cotton Lure WG	Cotton Lure Standard Operating Procedure Work Group
CPMP	Critical Period Management Program
CPS Energy	City Public Service Energy
CSRB	Comal Springs riffle beetle
yd^3	cubic yards
°C	degrees Celsius
DEHP	Bis(2-ethylhexyl) phthalate
D4S	Diving for Science
DO	dissolved oxygen
EAA	Edwards Aquifer Authority
EAHCP	Edwards Aquifer Habitat Conservation Plan
EARDC	Edwards Aquifer Research and Data Center
EARIP	Edwards Aquifer Recovery Implementation Program
EPA	U.S. Environmental Protection Agency
ESA	federal Endangered Species Act of 1973
FAB	Freeman Aquatic Building
FMA	Funding and Management Agreement
ft	foot/feet
ft^3	cubic feet
GBRA	Guadalupe-Blanco River Authority
HAZMAT	Hazardous Material
HCP	Habitat Conservation Plan
HHW	Household Hazardous Waste
IA	Implementing Agreement
IC	Implementing Committee
IH	Interstate Highway
ILA	Interlocal Agreement
ILC	Interlocal Contract
IPMP	Integrated Pest Management Plan

ITP	Incidental Take Permit
lbs	pounds
LDC	Land Development Code
LID	Low Impact Development
LTBG	Long-Term Biological Goals
m	meter(s)
m^2	square meters
MCL	maximum contaminant level
MCWE	Meadows Center for Water and the Environment
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
msl	mean sea level
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µS/cm	micro-Siemens per centimeter
NAS	National Academy of Sciences
NAS *Report 1*	*National Academy of Sciences – Review of the Edwards Aquifer Habitat Conservation Plan: Report 1*
NAS *Report 2*	*National Academy of Sciences – Review of the Edwards Aquifer Habitat Conservation Plan: Report 2*
NAS RRWG	NAS Recommendations Review Work Group: Report 1
NBU	New Braunfels Utilities
No.	Number
NOA	Notice of Availability
NRA	Nueces River Authority
NTU	nephelometric turbidity units
NWF	National Wildlife Federation
oz.	ounce
PAH	non-polycyclic or polycyclic aromatic hydrocarbon
PEC	probable effect concentration
RCMC	Regional Conservation Monitoring Committee
Region L	South-Central Texas Regional Water Planning Group
RTI	Real Time Instrumentation
RWCP	Regional Water Conservation Program
SARA	San Antonio River Authority
SAV	submerged aquatic vegetation
SAWS	San Antonio Water System
SC	Adaptive Management Science Committee
SCUBA	Self Contained Underwater Breathing Apparatus
SCTWAC	South Central Texas Water Advisory Committee
Service	U.S. Fish & Wildlife Service
SH	Adaptive Management Stakeholder Committee
SMARC	San Marcos Aquatic Research Center
SMRF	San Marcos River Foundation
SOP	Standard Operating Procedure

sp./spp.	species (singular)/species (plural)
SRP	Science Review Panel
SRP/NAS	Science Review Panel/National Academy of Sciences
SSA	State Scientific Area
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TDA	Texas Department of Agriculture
TEC	threshold effect concentrations
TEEA	Texas Environmental Excellence Award
Texas State	Texas State University
TP	total phosphorus
TTU	Texas Tech University
THC	Texas Historical Commission
TSS	total suspended solids
TPWD	Texas Parks & Wildlife Department
TWDB	Texas Water Development Board
TxDOT	Texas Department of Transportation
UNFH	Uvalde National Fish Hatchery
UPRR	Union Pacific Railroad
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish & Wildlife Service
USGS	U.S. Geological Survey
UTSA	University of Texas at San Antonio
VISPO	Voluntary Irrigation Suspension Program Option
WPP	watershed protection plan
WQP	Water Quality Monitoring Program
WQPP	Water Quality Protection Plan
WQWG	Water Quality Monitoring Program Work Group
WRIP	Water Resources Integration Program

LIST OF ALL SPECIES OF MANAGEMENT INTEREST REFERENCED[4]

Common Name	Scientific Name
Covered Species Under Incidental Take Permit No. TE-63663A-1 and the Edwards Aquifer Habitat Conservation Plan	
Comal Springs dryopid beetle	*Stygoparnus comalensis*
Comal Springs riffle beetle	*Heterelmis comalensis*
Comal Springs salamander	*Eurycea sp.*
Fountain darter	*Etheostoma fonticola*
Peck's Cave amphipod	*Stygobromus pecki*
San Marcos gambusia	*Gambusia georgei*
San Marcos salamander	*Eurycea nana*
Texas blind salamander	*Eurycea (=Typhlomolge) rathbuni*
Texas cave diving beetle (or Edwards Aquifer diving beetle)	*Haideoporus texanus*
Texas troglobitic water slater	*Lirceolus smithii*
Texas wild-rice	*Zizania texana*
Species included in the Submerged Aquatic Vegetation Objectives	
Arrowhead	*Sagittaria*
Fanwort (or Cabomba)	*Cabomba caroliniana*
Mosses, liverworts & allies	*Bryophytes*
Pondweed	*Potamogeton illinoensis*
Seedbox (or water-primrose)	*Ludwigia*
Umbrella water-pennywort (or manyflower marshpennywort)	*Hydrocotyle umbellata*
Native Aquatic Plant Species Used in Restoration	
Creeping primrose-willow	*Ludwigia repens*
Delta arrowhead	*Sagittaria platyphylla*
Giant cutgrass	*Zizaniopsis miliacea*
Grassleaf mudplantain	*Heteranthera dubia*
Native Species	
Painted river prawn	*Macrobrachium carcinus*
Non-native Animal and Plant Species	
Armored catfish	Loricariidae
Chinaberry	*Melia azedarach*
Chinese privet	*Ligustrum sinense*
Chinese tallow	*Triadica sebifera*
East Indian hygrophila	*Hygrophila polysperma*
Giant ramshorn snail	*Marisa cornuarietis*
Giant reed	*Arundo donax*
Gill parasite (no common name)	*Centrocestus formosanus*
Hydrilla	*Hydrilla verticillata*
Japanese honeysuckle	*Lonicera japonica*
Japanese privet (or Japanese ligustrum)	*Ligustrum japonicum*
Nutria	*Myocastor coypus*
Red-rimmed melania	*Melanoides tuberculatus*

[4] Sources for common and scientific names are Integrated Taxonomic Information System; https://www.itis.gov and PLANTS National Database; https://plants.usda.gov/java/.

List of All Species of Management Interest Referenced (Continued)

Common Name	Scientific Name
Tapegrass (or eelgrass)	*Vallisneria spiralis*
Taro (or elephant ear)	*Colocasia esculenta*
Tilapia	*Oreochromis* spp.
Watercress	*Nasturtium officinale*
White mulberry	*Morus alba*

LIST OF DEFINED TERMS FOR DISCUSSIONS INCLUDED IN THE EAHCP 2016 ANNUAL REPORT

Term or Phrase	Term or Phrase Definition and Source
Conservation Measure	Specified projects to be implemented by the Permittees in order to protect the Covered Species and their habitat from impacts of flood and drought.
Critical period	A period of specific aquifer vulnerability that is managed by varying aquifer levels and springflows, which trigger increasing withdraw restrictions.
Critical period sampling	High flow and low flow specific sampling to evaluate disturbance and recover, as well as declining or improving conditions linked to flow. High flow (after a flood event) sampling must be approved by EAA staff working with the contractor. Low flow sampling is linked to a series of flow triggers.
Defined period of extreme drought Drought/drought conditions Extreme drought conditions	In the EAHCP, management protocols are based off of the "Drought of Record," which refers to the six-year drought that occurred from 1951 through 1956. Reference to drought or extreme drought is in perspective of similar experiences.
Destructive scour Scour	The removal of sediment such as sand or rocks, and vegetation due to swiftly moving water from flood or severe storm event.
High flow	Referencing a flood event or severe storm event that could have negatively impacted the Covered Species and their habitat. System monitoring association with high flow must be approved by EAA staff and is not quantitatively defined in the EAHCP.
Instars	An insect developmental stage between larvae to adult. Each instar is a separate moult.
Long Term Biological Goal (LTBG) Reach	River segments in both the Comal and San Marcos river that are specifically specified in the EAHCP and hold quantitative goals associated with specific plants regarded as fountain darter habitat.
Negative impacts	Generic term associated with impacts to the Covered Species and their habitat through reduced springflow, flood, contaminated runoff, excess recreation in protected areas, and other potentially threatening activities to the Comal and San Marcos springs ecosystems.
Low flow(s) Low flow conditions Extreme low flow	A period of springflow that decreases below the long-term average significantly. Specifically, low-flow is specified in the Comal system as 130 cfs or lower, and in the San Marcos system as 120 cfs or lower.
Texas wild-rice Reach	River segments in the San Marcos river specified in the EAHCP that provide quantitative goals associated with Texas wild-rice restoration.
Restoration Reach	River segments in both the Comal and San Marcos river created out of the 2016 AMP to satisfy the EAHCP Key Management Objective of proportionally expanding SAV restoration beyond the LTBG reaches.

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1.0 BACKGROUND AND 2016 EDWARDS AQUIFER CONDITIONS, MANAGEMENT, AND NOTABLE CHALLENGES, EAHCP OVERSIGHT, AND COORDINATION

The Edwards Aquifer Habitat Conservation Plan (EAHCP)[5] was approved by the U.S. Fish & Wildlife Service (Service or USFWS) as a regional plan to protect the Edwards Aquifer and the federally-listed species[6] associated therewith while helping to ensure stability of the Edwards Aquifer as a water supply for the region (RECON et al. 2012). After approval of the EAHCP, the Service issued an Incidental Take Permit (ITP) under the federal Endangered Species Act of 1973 (ESA), with an effective date of March 18, 2013.

The permit is ITP Number (No.) TE-63663A-1 (as amended January 20, 2015), and was issued to five cooperating Permittees: the Edwards Aquifer Authority (EAA); the City of New Braunfels (CONB); the City of San Marcos (COSM); Texas State University (Texas State); and the City of San Antonio acting by and through its San Antonio Water System (SAWS) Board of Trustees. The permit authorizes certain "Covered Activities" (EAHCP Chapter 2.0), even under circumstances where the activities may incidentally cause "take" of a Covered Species. The EAHCP identifies four categories of activities that may result in incidental take: "(1) the regulation and use of the Edwards Aquifer; (2) recreational activities in the Comal and San Marcos springs and river ecosystems; (3) other activities in, and related to, the Comal and San Marcos springs and river ecosystems; and (4) activities involved in and related to the implementation of the minimization and mitigation measures in these ecosystems" (EAHCP §2.1). The Adaptive Management Process (AMP) may also result in incidental take (EAHCP §2.8). As mentioned previously, the ITP has been amended once since it was issued by the USFWS. A copy of the amended ITP is contained in **Appendix A1** of this report.

The ITP provides incidental take coverage for authorized activities in Uvalde, Medina, Atascosa, Bexar, Comal, Guadalupe, Hays, and Caldwell counties, Texas, within the EAA's jurisdictional boundary, which is the area in which pumping from the Edwards Aquifer is regulated by the EAA (**Figure 1.0-1**).

The species covered under the EAHCP are listed in **Table 1.0-1**.

Table 1.0-1. Covered Species Under the EAHCP ITP

Common Name	Scientific Name	Federal Status	Associated Springs in the EAHCP
Fountain Darter	*Etheostoma fonticola*	Endangered	Comal & San Marcos
San Marcos Gambusia	*Gambusia georgei*	Endangered	San Marcos
Comal Springs Dryopid Beetle	*Stygoparnus comalensis*	Endangered	Comal
Comal Springs Riffle Beetle	*Heterelmis comalensis*	Endangered	Comal & San Marcos
Peck's Cave Amphipod	*Stygobromus pecki*	Endangered	Comal & San Marcos
Texas Wild-Rice	*Zizania texana*	Endangered	San Marcos
Texas Blind Salamander	*Eurycea (=Typhlomolge) rathbuni*	Endangered	San Marcos
San Marcos Salamander	*Eurycea nana*	Threatened	San Marcos
Texas Cave Diving Beetle*	*Haideoporus texanus*	Petitioned	Comal & San Marcos
Comal Springs Salamander	*Eurycea sp.*	Petitioned	Comal & San Marcos
Texas Troglobitic Water Slater	*Lirceolus smithii*	Petitioned	San Marcos

* Also known as the "Edwards Aquifer Diving Beetle."

[5] All acronyms and abbreviations in this Annual Report are defined in the **LIST OF ACRONYMS AND ABBREVIATIONS** located on pages xxiv - xxvi.

[6] All aquatic animal and plant species referenced in this Annual Report are listed in the **LIST OF ALL SPECIES OF MANAGEMENT INTEREST REFERENCED** located on pages xxvii - xxviii.

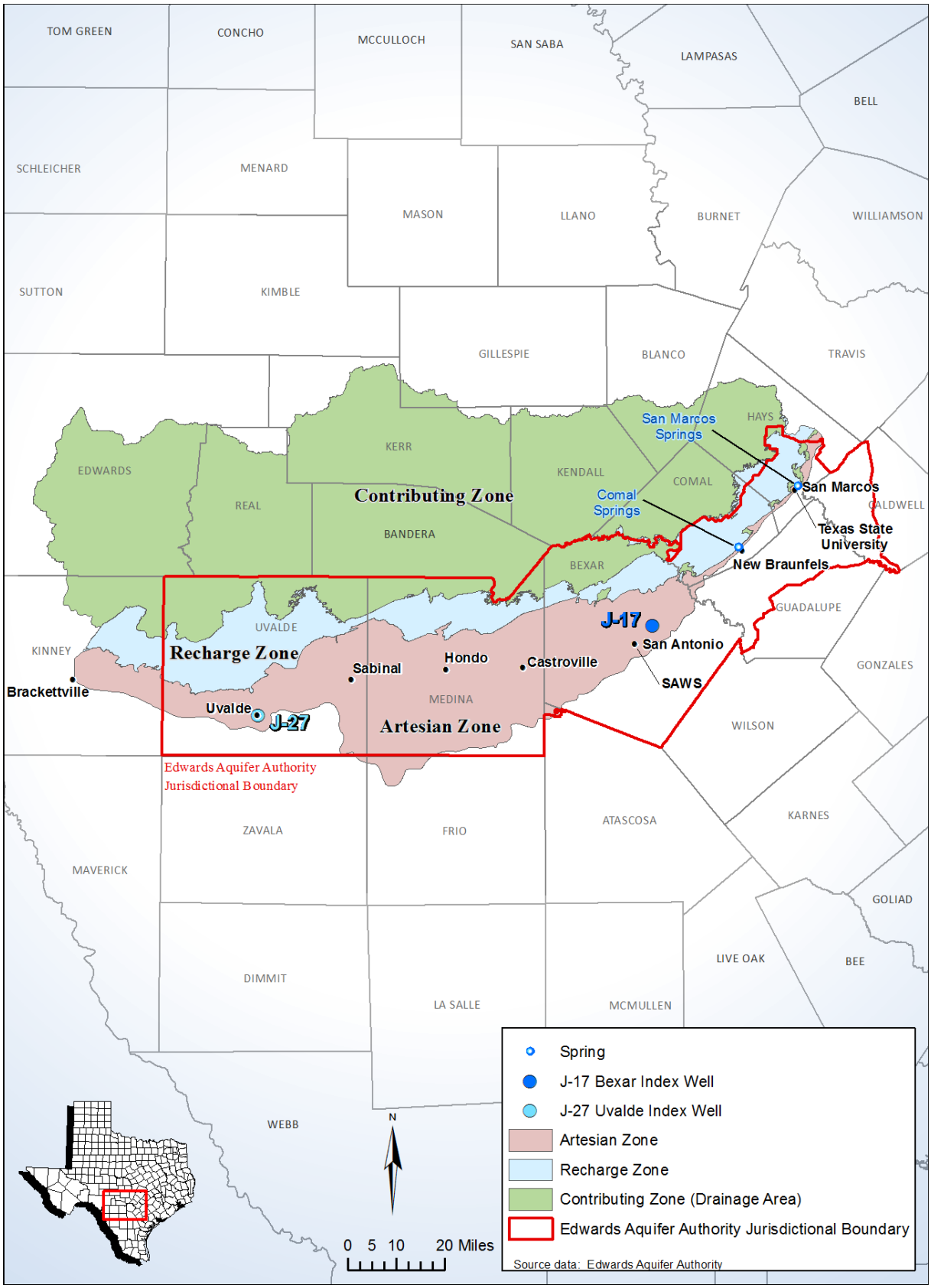

Figure 1.0-1. Incidental Take Coverage Area for ITP No. TE-63663A-1 (EAA Jurisdictional Boundary).

1.1 Incidental Take Permit Requirements

The ITP lists many requirements and conditions, among which are the elements to be included in the Annual Reports. The ITP requires an Annual Report be submitted to the USFWS Austin Ecological Services Office and to the USFWS Albuquerque Region 2 Office by March 31 of each year, for the preceding calendar year. As specified by Condition U of the ITP (see **Appendix A1**), "The report will document the Permittees' activities and permit compliance for the previous year, thus documenting progress toward the goals and objectives of the Edwards Aquifer Recovery Implementation Program (EARIP) Habitat Conservation Plan (HCP) and demonstrating compliance with the terms and conditions of this incidental take permit."

The Annual Report must include the following:

- EAA permitted withdrawals;
- Reference well levels;
- Springflows at Comal and San Marcos springs;
- Aquifer recharge;
- Aquifer discharge from wells and springflow;
- Critical period management reductions;
- Water quality data;
- Location of sampling sites;
- Methods for data collection and variables measured;
- Frequency, timing, and duration of sampling for these variables;
- Description of the data analysis and who conducted the analysis.

The ITP additionally requires documentation of the following EAHCP management activities:

- Adaptive management undertaken during the year;
- Expenditures by the EAA on implementation activities;
- Proposed activities for the next year;
- Report on the status of implementation of minimization and mitigation measures and their effectiveness;
- Interim updates and final copies of any research, thesis or dissertation, or published studies accomplished in association with the EARIP or EAHCP;
- Description of species-specific research and management actions undertaken with specific reference to the biological goals and objectives identified for each species;
- Any changes to the Biological Goals and Key Management and Flow-related Objectives of the HCP and the reasons for such changes;
- Any changes to the objectives for the monitoring program;
- Effects on the Covered Species or Permit Area;
- Evaluation of progress towards achieving the Biological Goals and Objectives;
- Any recommendations regarding actions to be taken.

Table 1.1-1 identifies each condition of the ITP as it is stated in the ITP, and provides a reference for the EAHCP Permittees' efforts in 2016 as documented in this Annual Report to comply with these conditions.

This document serves as the Annual Report for the calendar year 2016. The comments received on earlier drafts of the 2016 Annual Report are included in **Appendix B**.

Table 1.1-1. ITP Conditions and EAHCP 2016 Annual Report References Documenting Permittee Compliance Efforts

ITP Condition	ITP Condition Subsection	ITP Condition Title	Annual Report Chapter, Section, Subsection, or Appendix Reference
D.		Acceptance of the permit serves as evidence that the Permittees agree to abide by all conditions stated. Terms and conditions or the permit are inclusive. Any activity not specifically permitted is prohibited. Please read through these conditions carefully as violations of permit terms and conditions could result in your permit being suspended or revoked. Violations of your permit terms and conditions that contribute to a violation of the Endangered Species Act (ESA or Act) could also subject Permittees to criminal or civil penalties.	**1.0**
E.		The authorization granted by this Permit will be subject to full and complete compliance with and implementation of the EARIP HCP and all specific conditions contained herein. The Permit terms and conditions shall supersede and take precedence over any inconsistent provisions in the HCP or other program documents.	**1.0**
F.		This permit does not include incidental take coverage for any federal facility which withdraws groundwater from the Edwards Aquifer.	**1.0**
G.		COVERED SPECIES: This permit only authorizes incidental take of animal species, or impacts to plant species of the following 11 species: 1) Fountain Darter, 2) San Marcos Gambusia, 3) Comal Springs Dryopid Beetle, 4) Comal Springs Riffle Beetle, 5) Peck's Cave Amphipod, 6) Texas Wild Rice, 7) Texas Blind Salamander, 8) San Marcos Salamander, 9) Texas cave diving beetle, 10) Comal Springs Salamander, 11) Texas Troglobitic Water Slater	**1.0** (**Table 1.0-1**)
H.		INCIDENTAL TAKE AUTHORIZATION: The following amount of incidental take is authorized by this permit over the 15 year permit term.	**5.0** (**Table 5.0-1**)
	1.	No more than 797,000 fountain darters in Comal Springs, Landa Lake and the Comal River, and no more than 549,129 fountain darters in the San Marcos Springs, Spring Lake, and San Marcos River.	**5.0** (**Table 5.0-1**)
	2.	No more than 11,179 Comal Springs riffle beetles.	**5.0** (**Table 5.0-1**)
	3.	No more than 1,543 Comal Springs dryopid beetles.	**5.0** (**Table 5.0-1**)
	4.	No more than 18,224 Peck's cave amphipod.	**5.0** (**Table 5.0-1**)
	5.	No more than 10 Texas Blind salamanders.	**5.0** (**Table 5.0-1**)
	6.	No more than 263,857 San Marcos salamanders.	**5.0** (**Table 5.0-1**)
	7.	Incidental take of the Texas cave diving beetle will be provided for individuals of the species killed, harmed, or harassed by springflows with monthly averages above 50.5 cfs (1.43 cms) during HCP Phase I; and by springflows with monthly averages above 51.2 cfs (1.45 cms) during Phase II at San Marcos Springs, if and when this species is listed as threatened or endangered and as long as the HCP is fully implemented. Take limits will be exceeded if these minimum flow rates are not met.	Not applicable as species not listed during report period.

Table 1.1-1. ITP Conditions and EAHCP 2016 Annual Report References Documenting Permittee Compliance Efforts

ITP Condition	ITP Condition Subsection	ITP Condition Title	Annual Report Chapter, Section, Subsection, or Appendix Reference
	8.	Incidental take of the Texas troglobitic water slater will be provided for individuals of the species killed, harmed, or harassed by springflows with monthly averages above 50.5 cfs (1.43 cms) during HCP Phase I; and by springflows with monthly averages above 51.2 cfs (1.45 cms) during Phase II at San Marcos Springs, if and when this species is listed as threatened or endangered and as long as the HCP is fully implemented. Take limits will be exceeded if these minimum flow rates are not met.	Not applicable as species not listed during report period.
	9.	Incidental take of the Comal Springs salamander will be provided for individuals of the species killed, harmed, or harassed by springflows with monthly averages above 27 cfs (0.76 cms) during HCP Phase I and by continuous springflows to 45 cfs (1.27 cms) during Phase II at Comal Springs if and when this species is listed as threatened or endangered, as long as the HCP is fully implemented. Take limits will be exceeded if these minimum flow rates are not met.	Not applicable as species not listed during report period.
I.		The endangered San Marcos gambusia has not been collected since 1982 and may no longer exist in the wild, but the Service will provide incidental take coverage for individuals of this species resulting from the covered activities if the species is located or becomes established within the Permit Area, as long as the HCP is fully implemented.	Not applicable as species neither located nor established during report period.
J.		COVERED AREA: This permit only authorizes incidental take of covered species within all of Bexar, Medina, and Uvalde counties, and parts of Atascosa, Comal, Caldwell, Hays, and Guadalupe counties (Permit Area).	**1.0** (**Figure 1.0-1**)
K.		The EAA will support and coordinate with the U.S. Fish and Wildlife Service (Service) on the work relating to the San Marcos Aquatic Resource Center's operation and maintenance of a series of off-site refugia at the Service's San Marcos, Uvalde, and Inks Dam facilities (Section 6.4 of the HCP). The support of the refugia will augment the existing financial and physical resources of these facilities, and provide supplementary resources for appropriate research activities, as necessary, to house and protect adequate populations of Covered Species and expanded knowledge of their biology, life histories, and effective reintroduction techniques. The use of this support will be limited to the Covered Species in the EARIP HCP.	**3.1.2**
L.		COVERED ACTIVITIES FOR WHICH THE INCIDENTAL TAKE IS AUTHORIZED - BY PERMITTEE	**3.0**
	1.	Edwards Aquifer Authority (EAA)	**3.1**
	2.	City of New Braunfels (CONB)	**3.2**

Table 1.1-1. ITP Conditions and EAHCP 2016 Annual Report References Documenting Permittee Compliance Efforts

ITP Condition	ITP Condition Subsection	ITP Condition Title	Annual Report Chapter, Section, Subsection, or Appendix Reference
	3.	City of San Marcos (COSM)	**3.3**
	4.	Texas State University (TXSTATE)	**3.4**
	5.	San Antonio Water System (SAWS)	**3.5**
M.		The Permittees are jointly responsible for the following measures that specifically contribute to recovery and for which incidental take is authorized:	**3.0**
	1.	Comal Springs, Landa Lake, and the Comal River:	**3.2**
	2.	San Marcos Springs, Spring Lake, and the San Marcos River:	**3.3** and **3.4**
N.		Upon locating a dead, injured, or sick individual of the covered species, or any other endangered or threatened species, the Permittee is required to contact the Service's Law Enforcement Office in Austin, Texas, (512) 490-0948 for care and disposition instructions. Extreme care should be taken in handling sick or injured individuals to ensure effective and proper treatment. Care should also be taken in handling dead specimens to preserve biological materials in the best possible state for analysis of cause of death. In conjunction with the care of sick or injured endangered/threatened species, or preservation of biological materials from a dead specimen, the Permittee and any contractor/subcontractor has the responsibility to ensure that evidence intrinsic to the specimen is not unnecessarily disturbed.	No events meeting this description were reported for 2016.
O.		Conditions of the permit shall be binding on, and for the benefit of, the Permittees and any successors and/or assignees. If the permit requires an amendment because of change of ownership, the Service will process it in accordance with regulations (50 CFR 13.23). Any new Permittee must meet issuance criteria per regulations at 50 CFR 13.25. The covered activities proposed or in progress under the original permit may not be interrupted, provided the conditions of the permit are being followed.	No changes in ownership, or interruptions in Covered Activities, to report.
P.		If, during the tenure of the permit, the project design and/or the extent of the habitat impacts is altered, such that there may be an increase in the anticipated take of covered species, the Permittees are required to contact the Service's Austin Ecological Services Office (ESFO) and obtain an amendment to this permit before commencing any construction or other activities that might result in take beyond that authorized by this permit. If authorized take is exceeded, all activities that are shown to cause take must immediately cease and any take above that authorized shall be reported to the Austin Ecological Services Field Office (505/490-0057) within 48 hours.	No increases in anticipated take, or exceedance of authorized take, to report.

Table 1.1-1. ITP Conditions and EAHCP 2016 Annual Report References Documenting Permittee Compliance Efforts

ITP Condition	ITP Condition Subsection	ITP Condition Title	Annual Report Chapter, Section, Subsection, or Appendix Reference
Q.		If actions associated with implementation of the EARIP HCP are shown to result in incidental take of listed species not covered by this permit, those activities that are shown to cause take must immediately cease and any take that has occurred shall be reported to the Austin Ecological Services Field Office (505/490-0057) within 48 hours.	No events meeting this description were reported for 2016.
R.		CHANGED CIRCUMSTANCES	**4.0** and **Appendices A2** through **A13**
T.		MONITORING REQUIREMENTS	**3.0**
	1.	The Permittees will monitor compliance with the HCP and provide an annual report as described below.	**1.1**
	2.	The Permittees will develop a monitoring program to determine whether progress is being made toward meeting the long-term biological goals and objectives.	**3.1.7**
	3.	The Permittees will develop and oversee a monitoring program to identify and assess potential impacts, including incidental take, from Covered Activities and provide a better understanding and knowledge of the species' life cycles and desirable water quality- and springflow-related habitat requirements of the Covered Species (Section 6.3 of the HCP).	**3.1.6**
U.		Annual Reporting:	See discussion below
	1.	The EARIP Applicants will provide an annual report, due on March 31 of each year	**1.1**
	2.	The report will document the Permittees' activities and permit compliance for the previous year, thus documenting progress toward the goals and objectives of the EARIP HCP and demonstrating compliance with the terms and conditions of this incidental take permit. The annual report will include:	**1.1**
	a.	EAA Permitted withdrawals	**Appendix E**
	b.	Reference well levels	**Appendix D**
	c.	Springflows at Comal and San Marcos Springs	**Appendix D**
	d.	Aquifer recharge	**Appendix D**
	e.	Aquifer discharge from wells and springflow	**Appendix D**
	f.	Critical period management reductions	**3.1.5**
	g.	Water quality data	**Appendix C**
	h.	Location of sampling sites	**Appendix C**
	i.	Methods for data collection and variables measured	**Appendix C**

Table 1.1-1. ITP Conditions and EAHCP 2016 Annual Report References Documenting Permittee Compliance Efforts

ITP Condition	ITP Condition Subsection	ITP Condition Title	Annual Report Chapter, Section, Subsection, or Appendix Reference
	j.	Frequency, timing, and duration of sampling for the variables	**Appendix C**
	k.	Description of the data analysis and who conducted the analysis	**Appendix C**
	3.	The report will document HCP Management activities, including:	See discussion below
	a.	Adaptive management activities undertaken during the year	**3.1.11.2** and **4.0**
	b.	Expenditures by the EAA on implementation activities	**1.3**
	c.	Proposed activities for the next year	**Appendix J4**
	d.	Report on the status of implementation of minimization and mitigation measures and their effectiveness	**3.0**
	e.	Interim updates and final copies of any research, thesis or dissertation, or published studies accomplished in association with the EARIP or HCP	**3.1.7** and **7.0**
	f.	Description of species-specific research and management actions undertaken with specific reference to the biological goals and objectives identified for each species	**2.0**, **3.1.1**, **3.1.11.2**, **3.2.1**, **3.2.2**, **3.3.1**, **3.3.8**, **4.2**, and **Appendices A2** through **A13**
	g.	Any changes to the Biological Goals and Key Management and Flow-related Objectives of the HCP and the reasons for such changes	**2.0**, **3.1.11.2**, **3.2.1**, **3.2.2**, **3.3.1**, **3.3.8**, **4.2**, and **Appendices A2** through **A13**
	h.	Any changes to the objectives for the monitoring program	No changes during report period.
	i.	Effects on the Covered Species or Permit Area	No changes during report period.

Table 1.1-1. ITP Conditions and EAHCP 2016 Annual Report References Documenting Permittee Compliance Efforts

ITP Condition	ITP Condition Subsection	ITP Condition Title	Annual Report Chapter, Section, Subsection, or Appendix Reference
	j.	Evaluation of progress toward achieving the Biological Goals and Objectives.	**2.0**, **3.1.1**, **3.1.11.2**, **3.2.1**, **3.2.2**, **3.3.1**, **3.3.8**, **4.2**, and **Appendices A2** through **A13**
	k.	Any recommendations regarding actions to be taken	**6.0**
	4.	Information provided in the annual report will be used to determine what, if any, adaptive management strategies should be implemented to most effectively implement the conservation program outlined in the EARIP HCP and to ensure that management changes in response to new, appropriate data are implemented in a timely fashion.	**6.0**

1.2 2016 Edwards Aquifer Conditions, Management and Notable Conditions – Springflows

Springflow, well discharge, and recharge data are included in the 2015 Hydrological Reports (**Appendices D1-D5**). **Appendix E** contains a listing of all EAA permitted wells.

In 2016, the Comal and San Marcos springs complexes reaped the benefits from record rainfall in 2015 and above average rainfall in 2016. Statewide, precipitation records were set for the 2015 calendar year (41.2 inches), four-month (March-June, 20.2 inches), three-month (April-June, 16.7 inches), two-month (April-May, 13.0 inches), and one-month (May, 9.1 inches) time increments (NOAA 2016).

Springflows across the Edwards Aquifer Artesian Zone responded accordingly. **Figure 1.2-1** shows the frequency distribution of average annual springflows at Comal and San Marcos springs over the period of record. Yearly springflows for 2016 at Comal (346 cubic feet per second [cfs]) were near the 80th percentile of the distribution, while San Marcos yearly flows (276.5 cfs) were at the 98th percentile. In fact, at San Marcos, 1992 is the only calendar year with higher springflows recorded than in 2016 over the 60-year period of record. The large amounts of precipitation and subsequent streamflow have aided in system recovery from the prolonged drought ending in 2015.

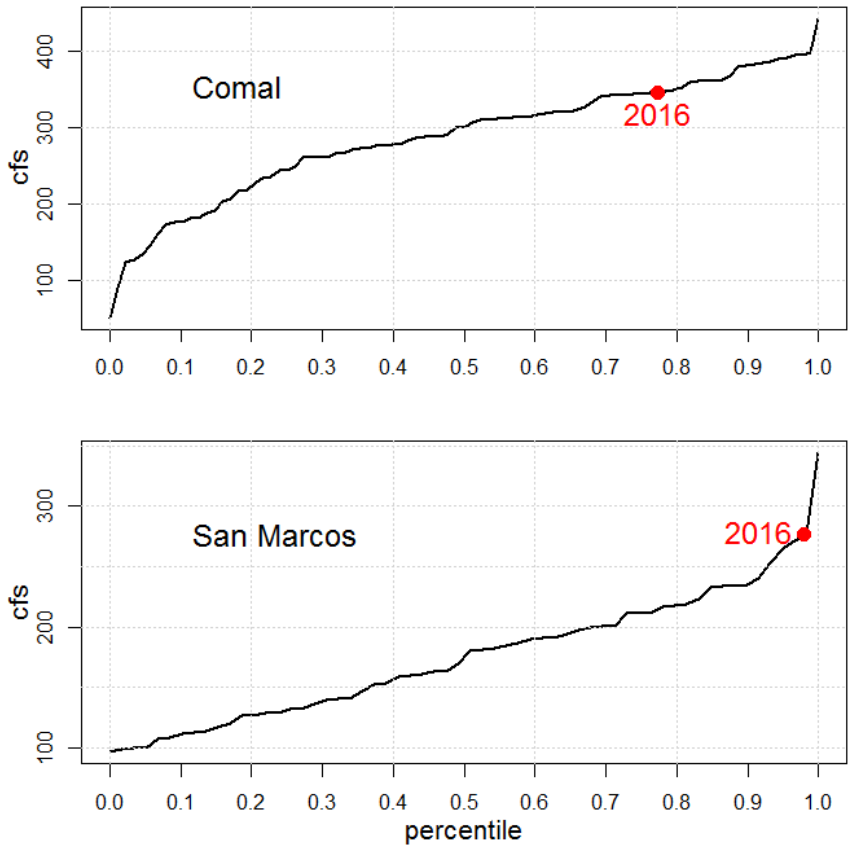

Figure 1.2-1. Frequency distribution of average annual springflows at Comal and San Marcos springs.

Average annual springflow shown in **Figure 1.2-1** was calculated by averaging daily values within years. Eighty-nine complete years of data were included in the distribution for Comal Springs (1928-2016), and 60 years were included in the San Marcos Springs distribution (1957-2016). These data are available at: http://data.edwardsaquifer.org/csv_san.php and http://data.edwardsaquifer.org/csv_comal.php.

Figure 1.2-2 shows time series of springflows at both complexes for the last four years. Note, more water exited Comal and San Marcos springs in 2016 than in the years 2013 and 2014, combined.

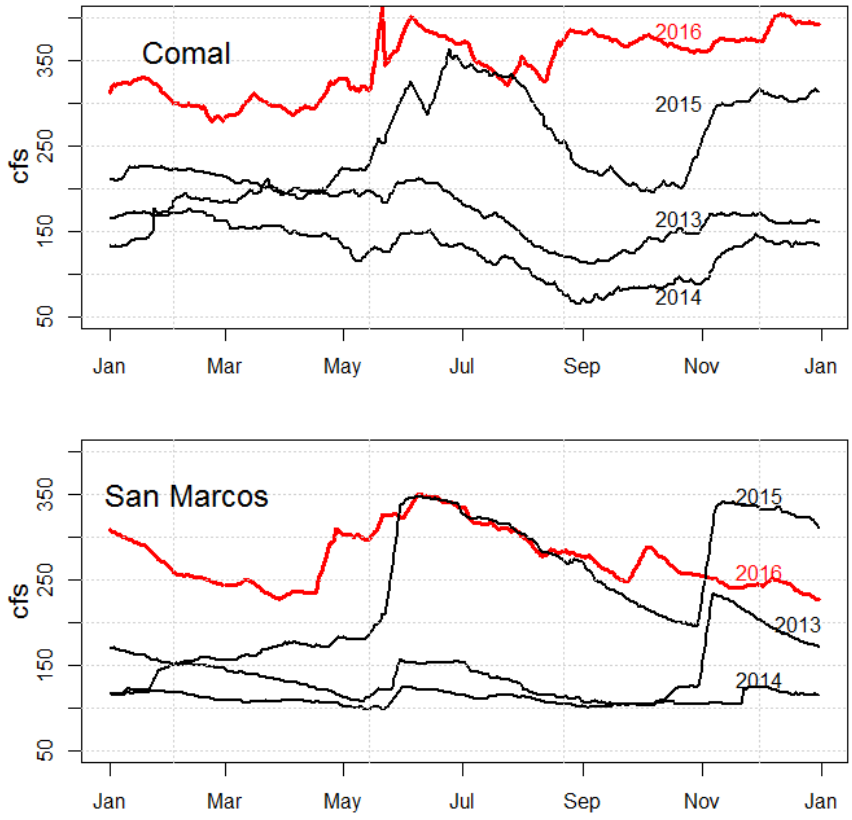

Figure 1.2-2. Springflow time series for years 2013 through 2016 at Comal and San Marcos springs.

1.3 2016 Financial Report

As specified in Section 4.6 of the Funding and Management Agreement (FMA), each year the EAA Board of Directors approves each Permittee's Program Funding Application's budget. The Program Funding Applications are the mechanism by which the Permittees request funding to implement the Conservation Measures or other EAHCP Program-related activities. The EAA Board of Directors approved the 2016 Program Funding Applications budgets for each of the Permittees during at their meeting on November 17, 2015.

Throughout the course of 2016, the EAA Board of Directors approved one amendment to the EAHCP budget to meet the needs of the program. Specifically, the items amended and adjusted were the RWCP for the

EAA, Non-Native Animal Species Control, Gill Parasite Control, Restoration – Riparian Zone & Native Vegetation, Low Impact Development (LID)/Best Management Practices (BMPs) Management and Household Hazardous Waste Management in New Braunfels. Other transfers between various accounts for reclassification of expenditure needs had a net impact of $0 on the budget and did not require EAA Board of Directors approval. The amendment and transfers are identified in the EAHCP Expense Report located in **Appendix H** of this Annual Report.

The EAHCP Expense Report shows Table 7.1 of the EAHCP funding amounts for 2016 totaling $18,292,597. These amounts can be compared to the EAA Board-approved 2016 Program Funding Applications totaling $21,240,198. **Figure 1.3-1** reflects the 2016 EAA Board-approved 2016 Program Fund Applications, by budget and EAHCP activity.

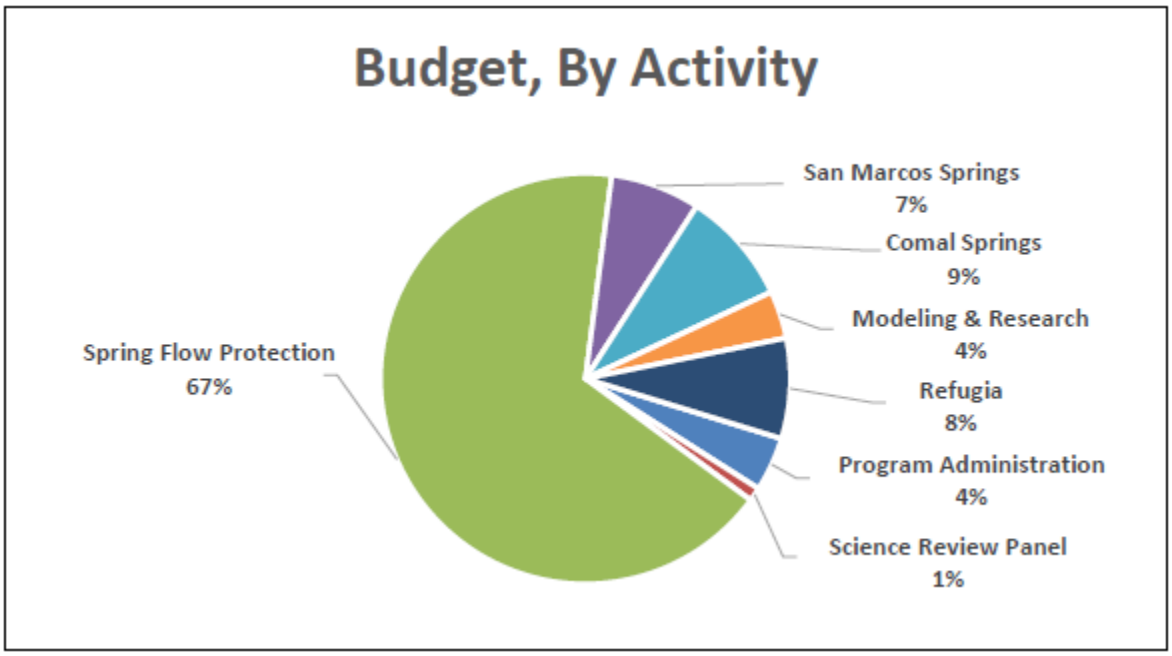

Figure 1.3-1. 2016 EAA Board-approved 2016 Program Fund Applications, by budget and EAHCP activity.

The 2016 actual expenses were $17,920,965. A significant amount of unspent funds in the ASR leasing, ASR Operations and Maintenance, and Refugia budgets accounts for the majority of the difference between total approved budget and actual expenses. **Figure 1.3-2** shows the 2016 actual expenses by each EAHCP activity.

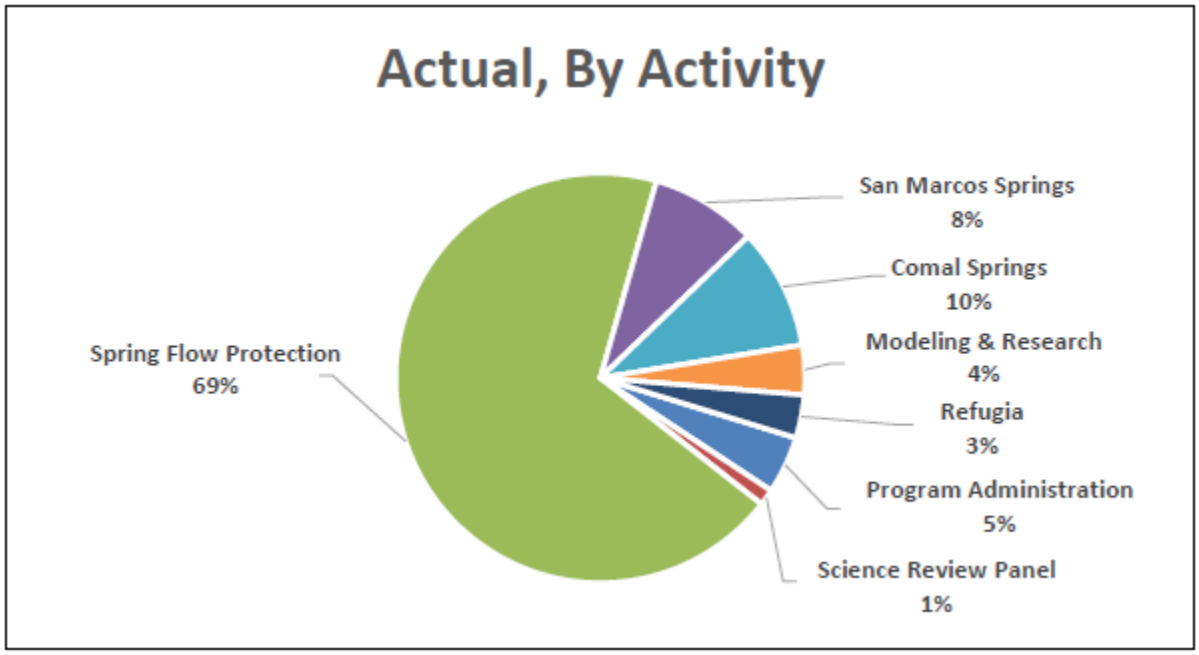

Figure 1.3-2. 2016 actual expenses by EAHCP activity.

The report also breaks down the adopted budget, Program Funding Applications budget, and actual expenses. By the end of 2016, the reserve balance for the EAHCP was $37,619,716, which includes unspent funds accumulated since the inception of the EAHCP (**Figure 1.3-3**).

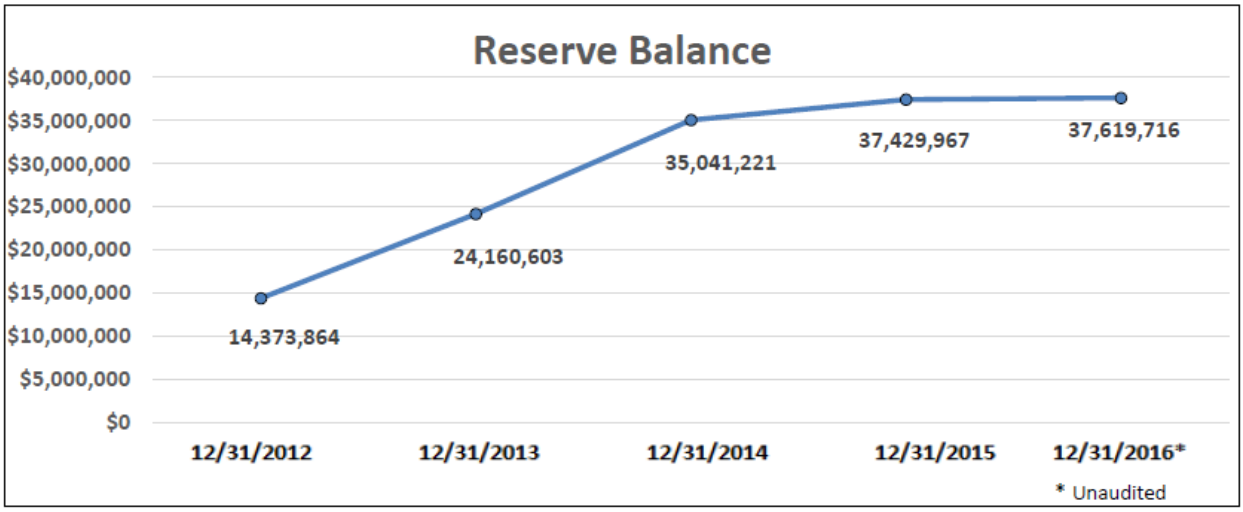

Figure 1.3-3. Reserve balances for EAHCP since program inception.

The EAHCP Expense Report also shows the actual revenue for 2016 of $17,438,751 compared to the budgeted revenue of $17,510,436, which is a variance of only $71,685. Approximately 95 percent of the actual revenue comes from Aquifer Management Fees (AMFs).

1.4 2016 EAHCP Committee Activities

Article Seven of the FMA establishes the roles of four committees for the EAHCP: the Implementing Committee (IC); the Adaptive Management Stakeholder Committee (SH); the Adaptive Management Science Committee (SC); and the Science Review Panel/National Academy of Sciences (SRP/NAS) (EAA et al. 2012). The activities of these four committees and their Work Groups in 2016 are described in the following subsections.

Also, Section 5.1.3 of the EAHCP establishes the role and responsibilities of the Regional Conservation Monitoring Committee (RCMC) (RECON Environmental, Inc. et al. 2012). The activities of this committee in 2016 are also discussed in the following subsections.

1.4.1 Activities of the Implementing Committee

The IC supervises implementation of the EAHCP and ensures compliance with documents such as the ITP, EAHCP and FMA. There are five voting members of the IC who represent the five Permittees, and one representative of the Guadalupe-Blanco River Authority (GBRA) who serves as a non-voting member. **Table 1.4-1** lists the members of the IC for 2016. The IC met eight times in 2016, and the agendas and minutes for those meetings are provided in **Appendix I1**.

Table 1.4-1. Members of the Implementing Committee for 2016

Member	Entity	Alternate
Roland Ruiz*	EAA	Brock Curry
Steve Ramsey/Greg Malatek**	CONB	Greg Malatek/Robert Camareno
Darren Thompson***	SAWS	Donovan Burton
Andrew Sansom	Texas State	Sherri Lara/Brad Smith
Tom Taggart	COSM	Melani Howard
Todd H. Votteler, Ph.D.	GBRA	Charlie Hickman

* Committee Chair
** Committee Vice Chair
*** Committee Secretary

Table 1.4-1 also reflects the IC membership and alternate changes (Greg Malatek as the new CONB IC Member, and Brad Smith as the new alternate for Texas State) announced at the October 2016 IC meeting.

Highlights of the IC meetings in 2016 are listed below.

- January 21, 2016:
  - Election of 2016 IC officers through ratification of an adopted officer succession plan;
  - Presentation of the *2015 Net Disturbance and Take Estimate Report*;
  - Presentation and approval of the amended 2016 CONB Bank Stabilization Work Plan and CONB Funding Application;
  - Presentation and approval of the amended 2016 Regional Water Conservation Program (RWCP) Work Plan and EAA Funding Application.

- February 18, 2016:
  - Discussion and approval of creating a Water Quality Monitoring Work Group, appointing Work Group members, approving the Work Group's charge, and approving a proposed timeline for the Work Group;
  - Discussion and approval of creating a Biological Monitoring Work Group, appointing Work Group members, approving the Work Group's charge, and approving a proposed timeline for the Work Group.
- March 17, 2016:
  - Open discussion with the SH members on various topics;
  - Presentation and discussion of EAHCP staff's role in the oversight of acquiring and maintaining state and federal permits for implementing all EAHCP Mitigation Measures;
  - Presentation on development of the EAHCP Data Management Program;
  - Presentation and approval of the *EAHCP 2015 Annual Report* for submittal to USFWS.
- May 19, 2016:
  - Discussion and approval to authorize the Program Manager to submit a letter of clarification to the USFWS pertaining to the meeting frequency of the Aquifer Storage and Recovery (ASR) Advisory Committee;
  - Presentation on EAHCP Data Management Program progress, timeline, and approach;
  - Presentation and discussion of the EAA 2017 Work Plans;
  - Presentation and discussion of the CONB 2017 Work Plans;
  - Presentation and discussion of the COSM and Texas State 2017 Work Plans.
- June 23, 2016:
  - Presentation and discussion of the refugia contract summary;
  - Presentation and discussion of an EAA summary of well permitting and pumping history from 2008 – 2014;
  - Presentation of an overview of the EAHCP Budget;
  - Presentation and adoption of the report of the 2016 Expanded Water Quality Monitoring (WQWG) and Biological Monitoring Work Groups (BioWG);
  - Approval of the 2017 EAA Work Plans;
  - Approval of the 2017 CONB Work Plans;
  - Approval of the 2017 COSM and Texas State Work Plans.
- September 15, 2016:
  - Discussion and approval of the Submerged Aquatic Vegetation (SAV) Nonroutine AMP Proposal submitted to the IC in the SH Committee Report;
  - Approval to direct the Program Manager to submit the necessary documentation to the USFWS based on the approved SAV AMP Proposal on behalf of the IC.
- October 20, 2016:
  - Presentation and approval of the amended 2017 CONB Work Plans: Flow Split Management, Old Channel Restoration, and Comal River Aquatic Vegetation;
  - Presentation and approval of the amended 2017 COSM and Texas State Work Plans: Texas wild-rice Enhancement, Control of Non-native Plan Species, Designation of Permanent Access Points, and Sediment Removal;

- Presentation and approval of the 2017 Funding Applications to be submitted to the EAA Board of Directors;
- Discussion and appointment of the 2017 IC officers.

- December 15, 2016:
  - Joint meeting of the IC, SH and SC.

1.4.1.1 2016 EAHCP Expanded Water Quality and Biological Monitoring Program Work Groups

In 2015, the EAHCP received the National Academy of Sciences' (NAS) *Review of the Edwards Aquifer Habitat Conservation Plan: Report 1* (NAS *Report 1*). This review focused on the EAHCP's hydrologic and ecological models, water quality and biological monitoring, and applied research programs, and provided recommendations for all EAHCP programs. Those recommendations were subsequently presented to, and considered by, the NAS Recommendations Review Work Group: Report 1 (NAS RRWG) (NAS 2015).

On February 18, 2016, based upon the NAS RRWG's assessment of those recommendations, the IC created the 2016 EAHCP Expanded WQWG and the 2016 EAHCP BioWG to produce final reports for the IC with their assessments of the NAS *Report 1* and NAS RRWG's recommendations for those two EAHCP monitoring programs. The two Work Groups convened an initial joint meeting on March 15, 2016, and then continued separate Work Group efforts to fulfill the IC's charges to each Work Group. They later re-convened in a joint meeting on May 20, 2016, to approve each of the Work Groups' reports for submittal to the IC, and to conclude their work. Copies of the joint Work Group meeting agendas and minutes can be found in **Appendix I2**. A separate discussion of each Work Group's efforts in 2016 and their final reports follows.

2016 Expanded Water Quality Monitoring Program Work Group

As stated previously, the IC created the WQWG on February 18, 2016, to review the NAS and NAS RRWG recommendations in response to NAS *Report 1*. In addition to creating the WQWG, the IC appointed Ken Diehl (SAWS), Melani Howard (COSM and Texas State), Dr. Charlie Kreitler (EAHCP SC), Steve Raabe (SH/SARA), Ben Schwartz (Texas State) and Mike Urrutia (GBRA) to serve as members of the WQWG. At this meeting, the IC also charged the WQWG with carrying out a holistic review of the Expanded Water Quality Monitoring Program (WQP), taking into account the recommendations of the NAS and NAS RRWG, and the input of the SC, the Permittees, and subject matter experts, to produce a final report for IC review.

The WQWG met five times from March through May 2016, which includes two joint meetings with the BioWG. At their final meeting on May 20, 2016, in a joint meeting with the BioWG, the WQWG by consensus approved the draft *Report of the 2016 Expanded Water Quality Monitoring Program Work Group*. Copies of the WQWG's charge, meeting agendas and minutes, and final report can be found in **Appendix I3. Table 1.4-2** below summarizes the WQP Scope of Work modifications recommended by the WQWG and approved by the IC.

Table 1.4-2. Water Quality Monitoring Scope of Work Modifications from 2016 Expanded Water Quality Monitoring Program Work Group

Sampling Method	Water Quality Scope of Work Modifications
Surface water (base flow)	Remove from program: • Sampled by Clean Rivers Program • No significant detects • EAA BioMP collects field and nutrients water quality at low and high flow
Sediment	Remove in odd years, reduce to once per year: • Data will change little throughout the year • Biological monitoring data do not suggest impact to Covered Species • Provides information on water quality trends in toxic parameters
Real-time monitoring	Add one sampling station per system: Valuable source of continuous information that is ecologically relevant Field parameters collected every 15 minutes: dissolved oxygen (DO), conductivity, turbidity, temperature, pH
Stormwater	Reduce to one sampling event each year; test for herbicide and pesticide compounds included in the COSM and CONB Integrated Pest Management Plans (IPMPs) associated with golf courses, including atrazine in odd years, full suite in even years as currently done; the addition of two stormwater samples at each existing stormwater sampling location to the initial rise of the hydrograph, while keeping the same 3 original samples as identified (onset, peak, and tail) in the original Scope of Work, for a total of 5 samples per location: • Turnover rate, dilution • Lack of significant detects
PDS	Add pharmaceuticals and personal care products membrane only at furthest downstream site: • Passive diffuse sampler provides a sensitive index for contamination in the spring systems
Groundwater (well)	Remove from program: • Purpose is to detect movement of bad water line • Already sampled by EAA
Tissue sampling	Add to program, one sample in odd years: • Represents direct link to Covered Species • Parameters and species to be established (work with experts) • Provides new information and data • Species to be sampled will be determined in consultation with experts

2016 EAHCP Biological Monitoring Program Work Group

The IC also created the BioWG on February 18, 2016, and appointed Tyson Broad (Texas Tech University [TTU]), Jacqueline Duke (EAHCP SC/Baylor University), Mark Enders (CONB), Rick Illgner (EAA) and Doyle Mosier (SC) to serve as members of the BioWG. At this meeting, the IC also charged the BioWG with carrying out a holistic review of the Biological Monitoring Program (BioMP), taking into account the recommendations of the NAS and NAS RRWG, and the input of the SC, the Permittees, and subject matter experts, to produce a final report for IC review.

The BioWG met four times from March through May 2016, which includes two joint meetings with the WQWG. At their final meeting on May 20, 2016, in a joint meeting with the WQWG, the BioWG by

consensus approved the draft *Report of the 2016 Biological Monitoring Program Work Group*. Copies of the BioWG's charge, meeting agendas and minutes, and final report can be found in **Appendix I4.**

The presentations of the WQWG and BioWG final reports to the IC and the IC's actions on these final reports as noted previously, completed the charges for these Work Groups. These Work Groups did not continue to function in 2016 after IC action on their final reports.

1.4.1.2 Comal Springs Riffle Beetle Cotton Lure Standard Operating Procedure Work Group

As requested by the EAHCP Program Manager, the Comal Springs Riffle Beetle Cotton Lure Standard Operating Procedure Work Group (Cotton Lure WG) met on March 25, 2016, to provide entities routinely working with the Comal Springs riffle beetle (CSRB) a process to discuss, develop, and adopt a Standard Operating Procedure (SOP) for the CSRB Cotton Lure methodology. Copies of the Cotton Lure WG's meeting agenda and final SOP can be found in **Appendix I5.** This Work Group did not continue to function after completing the SOP.

1.4.2 Activities of the Adaptive Management Stakeholder Committee

Table 1.4-3 lists the 27 SH representatives, their affiliations, the interests they represented, and their alternates for 2016.

Table 1.4-3. Members of the Adaptive Management Stakeholder Committee in 2016

Member	Affiliation	Representing	Alternate
Steve Raabe*	San Antonio River Authority (SARA)	SARA	Allison Elder
Myron Hess**	National Wildlife Federation (NWF)	Environmental Interest from the Texas Living Waters Project	No alternate named
Dianne Wassenich***	San Marcos River Foundation (SMRF)	Conservation organization	Annalisa Peace
Con Mims	Nueces River Authority (NRA)	NRA	Sky Lewey
No member named	Texas State	Texas State	Andy Sansom
Carl Adkins	Texas BASS Federation Nation	Recreational interest in the Guadalupe River Basin	Tim Cook
Bruce Alexander	East Medina County Special Utility District	Holder of an initial regular permit issued by the EAA for a retail public utility located west of Bexar County	No alternate named
Buck Benson	Alamo Cement/Pulman Law	Holder of an initial regular permit issued by the EAA for industrial purposes	Shanna Castro
Cindy Hooper	Texas Commission on Environmental Quality (TCEQ)	TCEQ	Cary Betz
Roger Biggers	New Braunfels Utilities (NBU)	Retail public utility in whose service area the Comal Springs or San Marcos Springs is located	Paula DiFonzo
Jim Bower	City of Garden Ridge	Holder of an EAA initial regular permit issued to a small municipality located east of San Antonio	No alternate named
Doris Cooksey	City Public Service (CPS) Energy	CPS Energy	Louisa Eclarinal
Rick Illgner	EAA	EAA	Elizabeth Woody
No member named	Texas Department of Agriculture (TDA)	TDA	No alternate named
Patrick Shriver	SAWS	SAWS	Steven Bereyso
Rader Gilleland	Gilleland Farms	Holder of an initial regular permit issued by the EAA for irrigation	Adam Yablonski
Renee Green	Bexar County	Bexar County	Kerim Jacaman
Melani Howard	COSM	COSM	Laurie Moyer
No member named	No affiliation named	Holder of a municipal surface water right in the Guadalupe River Basin	James Dodson

Table 1.4-3. Members of the Adaptive Management Stakeholder Committee in 2016

Member	Affiliation	Representing	Alternate
Glenn Lord	DOW Chemical	Holder of an industrial surface water right in the Guadalupe River Basin	Dwaine Schoppe
Cindy Loeffler	Texas Parks & Wildlife Department (TPWD)	TPWD	Colette Barron
Gary Middleton	South Central Texas Water Advisory Committee (SCTWAC)	SCTWAC	No alternate named
Kirk Patterson	Regional Clean Air and Water	Edwards Aquifer Region municipal ratepayers/general public	Carol Patterson
Ray Joy Pfannstiel	Guadalupe County Farm Bureau	Agricultural producer from the Edwards Aquifer Region	Gary Schlather
Greg Malatek	CONB	CONB	Robert Camareno
Gary Spence	Guadalupe Basin Coalition	Guadalupe River Basin municipal ratepayers/general public	Mike Dussere
Todd Votteler	GBRA	GBRA	Charlie Hickman

* Committee Chair
** Committee Vice Chair
*** Committee Secretary

The SH met in September 2016, and the agenda and minutes for that meeting are attached as **Appendix I6**. The SH also met jointly with the IC and SC on December 15, 2016.

Highlights of the SH meetings are noted below.

- September 15, 2016:
  - Discussion and approval of recommendation to the IC on the SAV Nonroutine AMP Proposal;
  - Discussion and approval of expedited process to develop and approve submission of Nonroutine AMP Stakeholder Report to the IC;
  - Presentation on implementation of the WQWG and BioWG Reports;
  - Presentation from EAA staff regarding the EAA five-year financial forecast and projected AMF.
- December 15, 2016:
  - Joint meeting of the IC, SH and SC.

1.4.3 Activities of the Adaptive Management Science Committee

The SC consists of eleven experts who have technical expertise in one or more of the following areas: (a) the Edwards Aquifer or its management; (b) the Comal Springs and River; (c) the San Marcos Springs and River; or (d) the Covered Species. The SC serves as an independent scientific panel to advise, consult, and provide recommendations to the SH and IC (**Table 1.4-4**). The SC met six times in 2016, and the agendas and minutes for those meetings are provided in **Appendix I7**.

Table 1.4-4. Members of the Adaptive Management Science Committee in 2016

Member	Affiliation	Expertise	Nominating Entity
Doyle Mosier, M.S.*	TPWD (Retired)	Instream Flows Aquatic Habitats	IC
Tom Arsuffi, Ph.D.**	TTU	Aquatic Biology Stream Ecology	IC
Janis Bush, Ph.D.	University of Texas at San Antonio (UTSA)	Plant Ecology Experimental Design	SH
Jacquelyn Duke, Ph.D.	Baylor University	Stream Ecology Riparian Ecohydrology	IC
Charlie Kreitler, Ph.D.	LBG-Guyton Associates (Retired)	Hydrogeology Groundwater Science	IC

Table 1.4-4. Members of the Adaptive Management Science Committee in 2016

Member	Affiliation	Expertise	Nominating Entity
Conrad Lamon, Ph.D.	Statistical Ecology Associates LLC	Ecological Modeling	IC
Glenn Longley, Ph.D.	Edwards Aquifer Research and Data Center (EARDC) (Retired)	Biologist Edwards Aquifer Specialist	SH
Robert Mace, Ph.D.	Texas Water Development Board (TWDB)	Hydrology Hydrogeology	Joint IC and SH
Chad Norris, M.S.	TPWD	Aquatic Biology Aquatic Invertebrate Specialist	SH
Jackie Poole, M.A.	TPWD (Retired)	Botany/Taxonomy Texas wild-rice Specialist	SH
Floyd Weckerly, Ph.D.	Texas State	Population Ecology Experimental Design	SH

* Committee Chair
** Committee Vice Chair

Highlights of the 2016 SC meetings are listed below.

- March 11, 2016:
  - Presentation and discussion of the proposed methodology for the 2016 Applied Research Study: *Evaluation of the Long-Term Elevated Temperature and Low Dissolved Oxygen Tolerances of Larvae and Adult Comal Springs Riffle Beetle*;
  - Presentation and discussion of the proposed methodology for the 2016 Applied Research Study: *Evaluation of the Trophic Level Status and Functional Feeding Group Categorization of Larvae and Adult Comal Spring Riffle Beetle*;
  - Presentation and discussion of the proposed methodology for the 2016 Applied Research Study: *Evaluation of the Life History of the Comal Springs Riffle Beetle from Egg to Adult*;
  - Presentation on the *2015 Take Estimates & Habitat Disturbance Report*;
  - Presentation of the 2015 Refugia Results: *Development of Husbandry and Captive Propagation Techniques for Invertebrate Species Covered Under the EAHCP*;
  - Presentation of the 2015 Applied Research Results: *Comal Springs Riffle Beetle Habitat Connectivity Study;*
  - Presentation of the 2015 Applied Research Results: *Ludwigia repens Interference Plant Competition Study*;
  - Presentation of the 2015 Applied Research Results: *Algae Dynamics Study*.
- May 13, 2016:
  - Presentation on the current status of the 2016 Applied Research Projects;
  - Presentation and approval of recommendation regarding the CONB 2017 Work Plans;
  - Presentation and approval of recommendation regarding the COSM and Texas State 2017 Work Plans;
  - Presentation of the 2015 Applied Research Results: *Suspended Sediment Impacts on Texas Wild-rice and Other Aquatic Plant Growth Characteristics, and Aquatic Macroinvertebrates Study*;
  - Presentation and endorsement of the 2017 Applied Research Projects strategy and ranking;
  - Presentation and approval of recommendation regarding the EAA 2017 Work Plans;
  - Presentation of the EAHCP Database Management Program's progress, timeline, and approach.

- June 22, 2016:
  - Presentation, discussion and endorsement of the *Report of the 2016 Expanded Water Quality Monitoring Program Work Group* and the *Report of the 2016 Biological Monitoring Program Work Group*;
  - Presentation and approval of the EAA 2017 Expanded Water Quality Monitoring Program and Biological Monitoring Program Work Plans;
  - Presentation on the proposed 2017 Applied Research Program Scopes of Work.
- September 9, 2016:
  - Presentation, discussion, and approval to the SH of the Nonroutine Adaptive Management proposal related to the SAV Conservation Measures in the Comal and San Marcos springs systems;
  - Presentation and endorsement of an expedited process to prepare and submit the *Nonroutine Adaptive Management Scientific Evaluation Report* to the SH;
  - Discussion of proposals received for the EAHCP 2017 Applied Research Program;
  - Presentation of the SOP for Sampling the CSRB.
- November 10, 2016:
  - Presentation on the status of the contract to establish EAHCP refugia operations;
  - Presentation of the 2015 Applied Research Results: *Suspended Sediment Impacts on Texas Wild-rice and Other Aquatic Plant Growth Characteristics, and Aquatic Macroinvertebrates Study*;
  - Presentation of the development of the EAHCP data management system, including review of data sets;
  - Discussion of the EAHCP Applied Research Program, including 2017 projects and future direction of the program;
  - Discussion of SC operation and endorsement of changes proposed in the November 3, 2016 memorandum: "Operation of the EAHCP Adaptive Management Science Committee";
  - Election of a new SC Chair and Vice Chair for 2017.
- December 15, 2016:
  - Joint meeting of the IC, SH, and SC.

1.4.4 Activities of the Science Review Panel/National Academy of Sciences

In December 2013, the EAA entered into a contract with the NAS to create an independent Science Review Panel (SRP) as defined in the EAHCP. The purpose of the SRP/NAS is to provide scientific advice in support of the EAHCP on four scientific initiatives: 1) ecological modeling; 2) hydrologic modeling; 3) biological and water quality monitoring; and 4) applied research. The twelve SRP/NAS members are selected by the NAS.[7]

Table 1.4-5 lists the SRP/NAS members for 2016. In 2016, the SRP/NAS met once from February 3 – February 4, 2016, at the EAA's offices in San Antonio, Texas. The agenda for that meeting is provided in **Appendix I8**.

[7] The NAS/National Research Council Committee is serving as the EAHCP SRP.

Table 1.4-5. Science Review Panel/National Academy of Sciences Members for 2016

Member	Affiliation	Area of Expertise
Danny Reible, Ph.D.*	TTU	Chemical Engineering
Jonathan Arthur, Ph.D.	Florida Geological Survey	Hydrogeology and Hydrochemistry
M. Eric Benbow, Ph.D.	Michigan State University	Entomology of Aquatic Ecosystems
Robin K. Craig, Ph.D., J.D.	University of Utah	Water Law
K. David Hambright, Ph.D.	University of Oklahoma	Biology and Water Quality
Lora Harris, Ph.D.	University of Maryland	Aquatic Ecosystems, with expertise in Ecological Modeling
Timothy K. Kratz, Ph.D.	University of Wisconsin—Madison	Aquatic Ecology
Andrew J. Long, Ph.D.	U.S. Geological Survey (USGS)	Hydrology
Jayanthan Obeysekera, Ph.D.	South Florida Water Management District	Hydrologic Modeling
Kenneth A. Rose, Ph.D.	Louisiana State University	Population Modeling
Laura Toran, Ph.D.	Temple University	Groundwater Monitoring and Modeling
Greg D. Woodside, P.G., C.HG.	Orange County Water District	Watershed Management and Planning

* Committee Chair

The SRP/NAS is proceeding with a multi-year, formal review process in three distinct phases. The final deliverable for each phase consists of a published report. Phase 1 was completed in February 2015 with the publication of NAS *Report 1* (NAS 2015). This review focused on the EAHCP's hydrologic and ecological models, water quality and biological monitoring, and applied research programs. In 2016, the EAHCP continued to evaluate and work with implementing the recommendations contained in NAS *Report 1*.

The second phase of the SRP/NAS process was initiated in September 2015, with the NAS' issuance of the *Study Announcement – Review of the Edwards Aquifer Habitat Conservation Program – Phase 2* (see **Appendix O1**). For this second report, the SRP/NAS is focusing on the adequacy of information to inform assessments of the EAHCP's scientific initiatives to ensure they are based on the best available science. The SRP/NAS will evaluate relationships among the EAHCP's Conservation Measures, Biological Objectives and Biological Goals.

In December 2015, BIO-WEST, Inc., (BIO-WEST) submitted an interim report to the EAHCP detailing the methodology of the Ecological Model. The SRP/NAS provided an evaluation of the Ecological Model in June 2016 in the form of an interim report titled *Evaluation of the Predictive Ecological Model for the Edwards Aquifer Habitat Conservation Plan: An Interim Report as Part of Phase 2* (NAS 2016a). A copy of the interim Phase 2 report is located in **Appendix O2**. The SRP/NAS' recommendations were incorporated after consideration by EAHCP staff, members of the Ecological Modeling team, and individuals from the SC.

On December 30, 2016, the SRP/NAS completed Phase 2 with the publication of the second report, titled *Review of the Edwards Aquifer Habitat Conservation Plan: Report 2* (NAS *Report 2*) (NAS 2016b) (**Appendix O3**). The EAHCP process to review NAS *Report 2* will occur in 2017. Details regarding Phase 3 will be made available after the publication of Report 2.

1.4.5 Regional Conservation Monitoring Committee

The EAHCP's RWCP provides EAA permit holders with a mechanism to implement water conservation programs to offset their current pumping from the Edwards Aquifer (EAHCP §5.1.3). The goal of the RWCP is to conserve 20,000 acre-feet (ac-ft) of permitted and exempt Edwards Aquifer withdrawals and leave half (or 10,000 ac-ft) of the conserved water un-pumped in the aquifer until the Year 2028. The EAHCP also requires the EAA to organize the RCMC comprised of representatives knowledgeable in water conservation from SAWS, CONB, COSM, and the City of Uvalde as a small water purveyor using water from the Edwards Aquifer. With the assistance of a RWCP Work Group created by the IC to advise them on ideas and methods to meet the required amount of conserved permitted or exempt Edwards water, efforts to implement the EAHCP RWCP have been on-going since 2013. Those successful efforts have now made it possible to achieve the RWCP goals prior to the Year 2023, which is the tenth year of the ITP and five years in advance of the established Year 2028 EAHCP goal.

The current membership of the RCMC consists of representatives from the EAA, SAWS, CONB, COSM and City of Uvalde. The RCMC met in November 2016, and highlights of that meeting are listed below.

- November 15, 2016:
  - Presentation of the total conservation achieved in the City of Uvalde's high efficiency/low flow toilet distribution program;
  - Presentation and update on the SAWS' RWCP contract with the EAA;
  - Presentation and discussion of the fulfilled RWCP goals;
  - Approval to authorize the EAHCP Program Manager to submit a "Statement of Program Finalization" to the IC as the obligations of the RWCP and the RCMC under the EAHCP are now fulfilled.

Copies of the RCMC meeting agenda and minutes, and the Statement of Program Finalization to the IC can be found in **Appendix I9**.

1.4.6 Committee and Work Group Support

During 2016, EAHCP staff successfully facilitated one Joint Committee Meeting (IC, SH and SC), seven IC meetings, five SC meetings, one SH meeting, and one RCMC meeting, and organized the meetings of three Work Groups.

Public accountability and the transparency of the EAHCP process are important guiding principles for EAHCP program management and continued to be so in 2016. Committee meetings represent an important opportunity to ensure that this public commitment is met. Accordingly, staff responsibilities for meeting facilitation included ensuring that committee meetings were conducted in accordance with the EAHCP, using the Texas Open Meetings Act as a guide to best practices for providing notice, holding open sessions, and providing records of meetings. Also, EAHCP staff hosted two spring system tours of the San Marcos River in 2016. Agendas and notices for all meetings were posted a minimum of one week in advance of the meeting date, meetings were held publicly with opportunities for public comment, and minutes were posted publicly.

Also included coordinating meeting logistics, such as reserving venues for meetings, preparing and providing meeting materials, and providing refreshments. For meeting venues, EAHCP Permittees and other regional Partners played an important role by providing courtesy meeting facilities and assisting with other accommodations as needed. Through the cooperation of the EAHCP Permittees and Partners in 2016, all SC meetings were held at the San Marcos Activity Center. IC meetings were held at the EAA, GBRA, and New Braunfels Civic Center.

In addition to their work involving standing EAHCP committees, in 2016 staff facilitated and executed the development of three *ad hoc* Work Groups – the BioWG, the WQWG, and the Cotton Lure WG. Between these three Work Groups, staff organized and facilitated eight additional public meetings.

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2.0 BIOLOGICAL GOALS AND OBJECTIVES FOR COVERED SPECIES

The Biological Goals and Objectives of the EAHCP are set out in Section 4.1 of the EAHCP. The identification of biological goals and objectives is one of five components in the "5-Point Policy" outlined in the HCP Handbook Addendum (USFWS and NMFS 2000), and identified in the current HCP planning handbook (USFWS and NMFS 2016). Long-term biological goals are the rationale behind the minimization and mitigation strategies and, conversely, minimization and mitigation measures are the means for achieving the long-term biological goals and objectives.

Section 4.1 of the EAHCP includes details for all Covered Species in sections covering the long-term biological goals, key management objectives, flow-related objectives, historical and present day perspective, and methods and discussion. The long-term biological goals, key management objectives, and flow-related objectives are subject to change under limited circumstances set out in the FMA, and they are summarized in **Appendix A2**. The EAHCP Biological Goals and Objectives summarized in **Appendix A2** reflect the clarifications of, and/or amendments made to, the EAHCP in 2016 through the AMP. This process is discussed in further detail in **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.1.11.2** – Amendments, Informational Memoranda, and Clarifications, and in **Chapter 4.0** – ADAPTIVE MANAGEMENT PROCESS ACTIVITIES FOR 2016, **Section 4.2** – Nonroutine Decisions, of this Annual Report.

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3.0 PLAN IMPLEMENTATION IN 2016

Communication and cooperation among and between all stakeholders in the Edwards Aquifer Region were critical in developing the EARIP HCP. These two factors continue to play a significant role in guiding operation of the EAHCP by the Permittees, Partners, stakeholders and the USFWS. Also, equally meaningful is the on-going collaboration that takes place between the Permittees, Partners, Stakeholders and USFWS to help address developments that are identified through the process of implementing the EAHCP. Continual and focused communications with the USFWS, as occurred before, during, and after the Nonroutine AMP regarding the SAV in 2016, are invaluable to the program, and the commitment to open and regular communications by the USFWS and the Permittees remains unchanged.

Section 10(a)(2)(A) of the ESA requires that any application for an ITP be accompanied by an HCP. HCPs must describe the measures the applicant will undertake to monitor, minimize, and mitigate the impacts of the taking of listed species (USFWS and NMFS 1996, 2016). This chapter of the Annual Report discusses the progress achieved in 2016 towards meeting the measures outlined in the EAHCP, and the efforts to comply with the ITP requirements.

Chapter 3.0 – PLAN IMPLEMENTATION IN 2016, of this Annual Report describes permit actions by each of the Permittees and the TPWD, including subsections discussing their *EAHCP Obligations*, *2016 Compliance Actions*, and *Proposed Activities for 2017*.

The following sections describe the activities implemented in 2016 pursuant to the ITP and its conditions, as described in **Appendix A1** of this report. All measures were implemented according to the reviewed and approved 2016 Work Plans. The latest versions of the 2016 Work Plans and the 2017 Work Plans are included in this Annual Report as **Appendices J1** through **J4**, respectively.

3.1 Edwards Aquifer Authority

The EAA is a special regional management district established by the 73rd Texas Legislature in May 1993, with the passage of the EAA Act to preserve and protect the Edwards Aquifer. As established by the Legislature, the EAA is governed by a 15-member elected board of directors representing stakeholder interests within an eight-county area, including all or parts of Uvalde, Medina, Atascosa, Bexar, Comal, Guadalupe, Hays, and Caldwell counties, plus two appointed members – one from Medina or Uvalde counties, and one from the SCTWAC. The SCTWAC also provides regular input to the EAA and, as directed by statute, provides a status report biennially in even-numbered years.

Geologists, hydrogeologists, environmental scientists, biologists, environmental technicians, educators, and administrative staff collaborate daily to fulfill the EAA's statutory mission of managing and protecting the Edwards Aquifer to the benefit of approximately two million South Texans who rely on the Aquifer as their primary source of water.

The EAA is responsible for the following measures under the EAHCP:

- Applied Research (EAHCP §6.3.4)
- Refugia (EAHCP §5.1.1, §6.4.2, §6.4.3, and §6.4.4)

- Voluntary Irrigation Suspension Program Option (EAHCP §5.1.2)
- Regional Water Conservation Program (EAHCP §5.1.3)
- Critical Period Management Program – Stage V (EAHCP §5.1.4)
- Expanded Water Quality Monitoring (EAHCP §5.7.2)
- Biological Monitoring (EAHCP §6.3.1, §6.4.3, and §6.4.4)
- Groundwater Modeling (EAHCP §6.3.2)
- Ecological Modeling (EAHCP §6.3.3)
- Impervious Cover and Water Quality Protection (EAHCP §5.7.6)

3.1.1 Applied Research (EAHCP §6.3.4)

EAHCP Obligations:

The Applied Research Program of the EAHCP is one of the contributing components of the AMP that is part of the administration of the EAHCP. The AMP proactively addresses the level of uncertainty that often exists in the management of natural resources through a process of experimentation and verification. Specifically, the AMP envisioned in the EAHCP a process for examining alternative strategies for meeting the Biological Goals and Objectives, and then, if necessary, adjusting the minimization and mitigation measures in Chapter 5 of the EAHCP according to what was learned through the AMP.

Pursuant to its role informing AMP deliberations, the primary focus of the EAHCP Applied Research Program is evaluating effects and effectiveness monitoring. Through applied research studies evaluating effects and effectiveness, the Applied Research Program enhances understanding of the ecology of the Comal and San Marcos aquatic ecosystems, supports the development of the EAHCP Ecological Model, provides scientifically-rigorous information to program management concerning the EAHCP's success in meeting its stated Biological Goals and Objectives, and provides improved data and information to support refugia operations.

2016 Compliance Actions:

The initial stage of the Applied Research Program conducted studies prescribed in the EAHCP to fill critical gaps in data. As the new data was acquired, additional applied research questions were developed by the SC to better inform management of the systems support and compliance with the EAHCP's requirements. The studies carried out in 2016 are listed below.

Applied Research Program Activities for 2016

- *Evaluation of the long-term elevated temperature and low dissolved oxygen tolerances of larvae and adult Comal Springs riffle beetle*
  Rationale and role of this study in the EAHCP process: This study builds on previous short-term, elevated temperature and low DO studies on the CSRB and surrogate species of riffle beetles that only examined adult riffle beetles. Temperature and DO were altered more slowly than in previous studies in order to determine the elevated temperature and low DO levels that result in observable stress and ultimately intolerance for CSRB and surrogate riffle beetle larvae and adults. This study

gathered and evaluated data that may be useful in management decisions, and may be necessary for the development of a CSRB component of the Ecological Model.

- *Evaluation of the trophic level status and functional feeding group categorization of larvae and adult Comal Springs riffle beetle*
  Rationale and role of this study in the EAHCP process: In order to better understand the environmental needs of the CSRB in their natural habitat, the food source, trophic level and functional feeding group categorization of the CSRB need to be established for both the larvae and the adults. This study evaluated these questions using analysis of stable isotope concentrations in larvae and adult CSRB. This study gathered and evaluated important data regarding a deeper understanding of the CSRB. Such data may be useful in management decisions for species protection, and could help in the event the EAHCP decides to develop a CSRB component of the Ecological Model.

- *Evaluation of the life history of the Comal Springs riffle beetle from egg to adult: Phase 1*
  Rationale and role of this study in the EAHCP process: Although the general life history of the CSRB is known, specific aspects such as determining gender, successful breeding, egg-laying, time to hatch, number of instars, pupation, and time to emerge as an adult are not known. This is a two-year study designed to fill in those CSRB life history data gaps. This study gathered and evaluated data that may be useful in management decisions, and may be necessary for the development of a CSRB component of the Ecological Model.

  The *Evaluation of the life history of the Comal Springs riffle beetle from egg to adult: Phase 1 Final Report* can be found in **Appendix K1**.

Development of the Integrated EAHCP Database

Pursuant to the recommendations of the 2015 Applied Research Work Group (ARWG) and the NAS *Report 1*, in 2016 the EAHCP team initiated the development of a database to house and integrate all data collected through the program, specifically data collected through the Variable Flow, Biological Monitoring, and Expanded Water Quality Monitoring programs. The goals of the EAHCP database were the following:

1) provide security for the data collected in support of the EAHCP and its administrative and scientific record;
2) provide a quality-assured and quality-controlled database for all EAHCP data;
3) provide a complete and integrated source of data for both planned and ad hoc analyses.

With the use of specialized software, the EAHCP team migrated 16 years of biological monitoring datasets, including all aquatic vegetation mapping, fountain darter, macroinvertebrate, salamander, fixed station photography and Texas Master Naturalist datasets, as well as three years of water quality datasets from both the San Marcos and Comal Springs surveys, including stormwater, surface water, sediment, and passive diffusive sampling into the "Aquarius Samples" database.

Also, in November 2016 staff made a presentation at the Aquatic Informatics National Conference in Orlando, Florida. For more information regarding this presentation, please refer to **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.1.11** – Program Management**,** of this Annual Report.

Science Committee Role in Applied Research Planning and Procurement

The process for planning and scheduling Applied Research adopted in 2015 was utilized in 2016. This process involves incorporating greater SC input and review of the Applied Research projects. Additionally, the Schedule for 2016 developed by the ARWG, which included SC members, was the basis from which the 2016 studies were selected.

Additionally, as requested by the SC in 2015 – and mentioned in the EAA's Challenges Observed and Identified Solutions section of the 2015 Annual Report – EAHCP staff worked to improve competition in the Applied Research program. Staff took time to expand the distribution reach through a diverse array of academic mailing lists throughout the country.

Freeman Aquatic Building Update

In 2014, rather than constructing a facility at the San Marcos Aquatic Research Center (SMARC) as was envisioned in the EAHCP, appropriate facilities at the Freeman Aquatic Building (FAB) on the campus of Texas State were renovated and utilized. This modified infrastructure project provided a cost-effective alternative. In 2016, to maximize efficiencies and utilization of facilities, laboratory experiments conducted under the Applied Research Program were housed in both the FAB and the SMARC as logistical requirements dictated.

Proposed Activities for 2017:

The Applied Research Program is a dynamic program in which existing research and data gaps are evaluated by EAA staff, the SC, and additional subject matter experts. In 2015, the ARWG developed an Applied Research Project Schedule, which provided priorities to inform research development through the year 2019. Additional applied research activities may be conducted as deemed necessary and appropriate through the AMP. The SC remains an integral component of the development of research methodologies, as well as helping to resolve unforeseen conditions or challenges that may arise during applied research activities.

In 2017, the following applied research projects are scheduled:

1) Evaluation of the life history of the CSRB, Phase II;
2) Statistical analysis of the San Marcos and Comal springs aquatic ecosystems biomonitoring datasets

3.1.2 Refugia (EAHCP §5.1.1, §6.4.2, §6.4.3, and §6.4.4)

EAHCP Obligations:

Pursuant to Sections 5.1.1, 6.4.2, 6.4.3, and 6.4.4 of the EAHCP, the EAA will support and coordinate with the USFWS on the work relating to the SMARC fish hatchery operation and maintenance of a series of off-

site refugia. ITP Condition K requires that "the support of the refugia will augment the existing financial and physical resources of these facilities, and provide supplementary resources for appropriate research activities, as necessary, to house and protect adequate populations of Covered Species and expand knowledge of their biology, life histories, and effective reintroduction techniques."

2016 Compliance Actions:

Salvage Refugia Operations

The Salvage Refugia Project has two primary objectives: 1) establish short-term refugia for Covered Species; and 2) perform research on species husbandry. For the first objective, salvage refugia consisted of captive populations, in secure facilities, for nine of the eleven threatened, endangered, or candidate species covered by the ITP in accordance with the EAHCP. Because of their limited geographic distributions, the aquifer-dependent species are vulnerable to extirpation in all or parts of their range due to natural or human-induced habitat impacts (e.g., drought-induced reductions in springflows or catastrophic events, such as a chemical spill). Establishing refugia for the Covered Species is necessary to provide back-up populations that can be used to re-establish endemic populations of the species in the event of population loss or depletion in the wild.

The second objective of the EAA Salvage Refugia Project was to perform research to expand current knowledge of the Covered Species' biology, natural histories, husbandry techniques, and effective re-introduction strategies. This research was to build on previous research and experience of the USFWS SMARC, Texas State, and other researchers, and will focus on testing and/or refining husbandry techniques for the species in a captive environment.

On June 10, 2015, the EAA entered into a contract to provide Salvage Refugia Operations located at the San Antonio Zoo. The contract terminated December 31, 2016. During the contract period, the contractor purchased and renovated three shipping containers to be used as research facilities (pods), with final construction and use occurring in 2016. The final report is provided in **Appendix K2**. Photos of a completed research pod can be seen in **Figure 3.1-1**.

Figure 3.1-1. Salvage refugia research pod.

A mandate for the Salvage Refugia Program was to develop a *Salvage Refugia Research Plan* laying out the various research topics and proposed methods that the refugium team would undertake to build knowledge necessary for the effective operation of the Salvage Refugia Facility, such as determining best collection methods for obtaining salvage stock of species, such as the Comal Springs dryopid beetle and the Texas blind salamander, that are difficult to obtain in large numbers. Photos of species collection efforts can be seen in **Figure 3.1-2**. In 2016, the refugium team collected the Covered Species found in **Table 3.1-1**.

Figure 3.1-2. Species sampling.

Table 3.1-1. 2016 Species Collection Log

Common Name	Scientific Name	Total No. Captured	Total No. Released at Time of Collection	Total No. Delivered to Zoo
Comal Springs Riffle Beetle	*Heterelmis comalensis*	330 Adults/ 121 Larvae	178 Adults/ 87 Larvae	152 Adults/ 34 Larvae
Peck's Cave Amphipod	*Stygobromus pecki*	189	148	41
Texas Blind Salamander	*Eurycea rathbuni*	20	10	10
Texas Troglobitic Water Slater	*Lirceolus smithii*	72	57	15

The final *Salvage Refugia Research Plan* can be viewed under **Appendix K2**.

Long-Term Refugia Operations

Efforts toward ITP compliance regarding refugia continued and on March 15, 2016, the EAA selected an outside party to provide Long-Term Refugia Operations for the remainder of the ITP term. After several years of contract negotiations, the EAA Board of Directors approved the contract with USFWS at their November 8, 2016 meeting.

The Contract's Scope of Work consists of the following tasks:

Task 1: Refugia Operations, Salvage Refugia, SMARC Quarantine Building., SMARC Rearing Building, and Uvalde National Fish Hatchery Renovation;

Task 2: Research, Collection, Research Plan, and Standard Operating Procedures;

Task 3: Species Propagation and Husbandry, and Collection;
Task 4: Species Reintroduction;
Task 5: Reporting, Draft Annual Report, Annual Work Plan and Cost Estimate, and Status Reports;
Task 6: Meetings and Presentations.

This project will provide a full refugia operation including Salvage and Long-Term Refugia programs, develop protocols for husbandry and propagation of the EAHCP Covered Species, help in understanding Covered Species' life cycles and reproduction, and develop understanding of genetic variation among the Covered Species.

Proposed Activities for 2017:

The Long-Term Refugia Operations contract begins on January 1, 2017. It is expected that construction and renovation of new and existing buildings, purchasing equipment for new and renovated buildings, increasing staff, and other activities could take several months to complete. However, salvage refugia capabilities will be fully operational by January 1, 2017. Due to the theft of the Texas blind salamanders prior to the execution of the EAHCP contract, the USFWS SMARC facility will include additional security measures in 2017.

3.1.3 Voluntary Irrigation Suspension Program Option (EAHCP §5.1.2)

EAHCP Obligations:

The Voluntary Irrigation Suspension Program Option (VISPO) is a voluntary springflow protection program designed to compensate irrigation permit holders for not pumping from the Edwards Aquifer during certain drought conditions. Participants may enroll in a five-year or ten-year program participation option. Enrollment commits the permit holder to suspend pumping of enrolled water for one calendar year if, on the previous October 1 trigger date, the aquifer level at the J-17 index well was at or below 635 feet mean sea level (ft msl). At all other times, a participant's use of enrolled water is not restricted. Participants are paid an annual standby fee for their enrollment in the program, and are provided an additional forbearance payment in years where water use suspension is mandated by the terms of their VISPO forbearance agreements.

Pursuant to Section 5.1.2 of the EAHCP, the EAA is responsible for administering the VISPO. The goal for this program is 40,000 ac-ft of enrolled EAA-issued irrigation permits. The target distribution for enrollment is 10,000 ac-ft/year in Atascosa, Bexar, Comal, and Hays counties, and 15,000 ac-ft/year each in Medina and Uvalde counties. This program accepts both "Base Irrigation Groundwater" and "Unrestricted Irrigation Groundwater" withdrawal rights. Unrestricted Irrigation Groundwater is not restricted as to its place or purpose of use, while Base Irrigation Groundwater is restricted to irrigation use.

2016 Compliance Actions:

Abundant rains in 2015 eliminated the need for VISPO to trigger in 2016. No new enrollment occurred in 2016 because VISPO program enrollment goals were attained in 2014, with a total combined enrollment of 40,921 ac-ft as shown in **Table 3.1-2** below. All VISPO participants were paid only the standby amount in 2016, with combined total VISPO payments amounting to $2,188,500 as presented in the table below.

Table 3.1-2. VISPO Total Enrollment (in ac-ft), and Payments (in dollars)

Enrollment Option	Atascosa	Bexar	Comal	Hays	Medina	Uvalde	TOTALS
5-Year Base	354	829	0	67	2,920	14,532	18,702
5-Year Unrestricted	0	55	0	56	773	5,885	6,769
Subtotal	354	884	0	123	3,693	20,417	25,471
10-Year Base	0	1,451	0	0	6,152	4,183	11,786
10-Year Unrestricted	0	122	0	0	1,651	1,891	3,664
Subtotal	0	1,573	0	0	7,803	6,074	15,450
TOTALS	**354**	**2,457**	**0**	**123**	**11,496**	**26,491**	**40,921**
PAYMENTS	**$17,986**	**$135,381**	**$0**	**$6,346**	**$634,453**	**$1,394,334**	**$2,188,500**

Since VISPO did not trigger for 2016 and there are more than 10,000 ac-ft. of Unrestricted Irrigation Groundwater withdrawal rights in the program, EAA staff worked with many VISPO participants to place excess unrestricted water rights in the EAHCP ASR leasing program. On October 1, 2016, the Aquifer level at the J-17 index well was 678.1 ft msl; accordingly, VISPO enrollees were informed that suspension of water enrolled in VISPO would not be required in 2017.

Proposed Activities for 2017:

No new program enrollment will occur as the 40,000 ac-ft goal has been met. Since 2017 is not a trigger year, standby payments will be made by March 2017 to all participants. As previously mentioned, the EAA assisted VISPO participants in signing up for the ASR leasing program in 2016. Low commodity prices and competitive ASR lease rates have resulted in approximately 98 percent of water enrolled in VISPO that was also signed up for ASR leases in 2016 continuing into 2017.

3.1.4 Regional Water Conservation Program (EAHCP §5.1.3)

EAHCP Obligations:

The RWCP was included in the EAHCP to provide an opportunity for permit holders not currently engaged in conservation programs to have a mechanism for implementing water conservation to offset their current levels of pumping. This program includes municipal and industrial use permit holders, as well as exempt well owners.

The RWCP includes the following elements:

1) Lost water and leak detection;
2) High-efficiency plumbing fixtures and toilet distribution;
3) Commercial/industrial retrofit rebate;
4) Water reclamation.

Pursuant to Section 5.1.3 of the EAHCP, the goal of the RWCP is to conserve 20,000 ac-ft of permitted or exempt Edwards Aquifer water. Of this amount, 10,000 ac-ft will be held by the EAA in the Groundwater Trust where it will remain un-pumped for the term of the ITP to reduce stress on the Aquifer, and thereby reduce stress on Comal Springs and San Marcos Springs. The other 10,000 ac-ft of conserved groundwater will remain available for withdrawal by the participating entity.

2016 Compliance Actions:

The EAA continued to assist the City of Uvalde with implementation of their water conservation measures (primarily the distribution of high efficiency/low flow toilets and plumbing kits). In 2016, the installation of high-efficiency toilets and plumbing kits resulted in an estimated savings of 37 ac-ft; one-half of that amount (18.50 ac-ft) was transferred into the EAA's Groundwater Trust. At the writing of this report, the City of Uvalde had distributed approximately 526 high efficiency/low flow toilets and 532 plumbing kits to city residents.

According to the originally executed contract, the conservation program in Uvalde was to expire in October 2016; however, through conversations between the City of Uvalde and EAA, it was decided to extend the agreement until December 31, 2016. This extension provided additional time and resources for Uvalde to distribute additional toilets and plumbing kits to their residents. In total, the City of Uvalde conservation program saved over 100 ac-ft of Edwards water, with half (50 ac-ft) committed to the Groundwater Trust.

In 2016, SAWS began implementing their five-year Leak Detection and Repair Program as outlined in their agreement with EAA under the RWCP. This Leak Detection and Repair Program satisfies the total RWCP goal for water committed into the Groundwater Trust for the remainder of the ITP. The estimated savings are shown in **Table 3.1-3** with a total savings of 19,612 ac-ft of conserved water. One-half of the conserved water (9,806 ac-ft) will be placed in the Groundwater Trust through the RWCP to remain un-pumped through 2028.

Table 3.1-3. Estimated Savings (in ac-ft) of Conserved Water

Water	2016	2017	2018	2019	2020	TOTALS
Estimated Savings (ac-ft)	4,745.00	4,745.00	4,745.00	4,745.00	632.00	19,612.00
Groundwater Trust (ac-ft)	2,372.50	2,372.50	2,372.50	2,372.50	316.00	9,806.00

In the first year of implementation, SAWS reported a total of 4,253 ac-ft of water saved through increased leak repair capabilities as indicated in **Appendix K3**.

Proposed Activities for 2017:

In 2017, the EAA will continue administering the RWCP primarily through the SAWS Leak Detection and Repair Program. SAWS will report their provisional numbers to EAA in April and October of 2017. Final data will be included in an official report, which will be provided to the EAA in February of 2018.

Regional Conservation Monitoring Committee

The EAA is responsible for coordinating the activities of the RCMC. Representation on the RCMC includes one representative each from SAWS, the CONB, the COSM, and the City of Uvalde, as a small water purveyor that uses the Edwards Aquifer (as suggested in the EAHCP). It is the responsibility of the RCMC to provide technical input and expertise, seek additional RWCP funding, advise the EAA on the efficiency and significance of RWCP activities, consider each activity in the context of achieving the overall EAHCP goal for the RWCP, rank proposed activities, comment on the potential of each activity, consult with the EAA board regarding conserved water determinations, make specific recommendations regarding program implementation, and develop periodic updates tracking the program's progress.

The RCMC met on November 15, 2016 and discussed program status shown in **Table 3.1-4**. The RCMC unanimously approved authorizing the EAHCP Program Manager to submit a "Statement of Program Finalization" to the IC to communicate that the goals established for the RWCP in the EAHCP have been fully achieved. The meeting agenda and minutes for the November 15th RCMC meeting, and the "Statement of Program Finalization," are located in **Appendix I9**.

Table 3.1-4. RWCP Conservation and Groundwater Trust Totals

Entity	Program	Water Saved (AF)	Water Committed to Trust (AF)
Universal City	Leak Detection	327.0	163.5
City of Uvalde	HE Plumbing Distrib.	114.0	57.0
SAWS	Leak Repair	19,612.0	9,806.0
TOTALS		**20,053.0**	**10,026.5**

3.1.5 Critical Period Management Program – Stage V (EAHCP §5.1.4)

EAHCP Obligations:

Stage V of the EAA Critical Period Management Program (CPMP) mandates a 44 percent reduction in water use, and is applicable to permit holders in both the San Antonio and Uvalde pools. For the San Antonio Pool, Stage V is triggered when the ten-day average Aquifer level at the J-17 index well drops below 625 ft msl, or if the springflows at Comal Springs decline below 45 cfs based on a ten-day rolling average, or below 40 cfs based on a three-day rolling average. In the Uvalde Pool, Stage V is triggered when the Uvalde County Index Well J-27 Aquifer level drops below 840 ft msl.

2016 Compliance Actions:

Due to increased aquifer levels and springflows, no stage of the CPMP was triggered in 2016. **Table 3.1-5** and **Table 3.1-6** below show the requirements for all CPMP stages for both the San Antonio and Uvalde pools, respectively.

Table 3.1-5. CPMP Triggers, Stages, and Reductions for the San Antonio Pool of the Edwards Aquifer

Wells/Springs	Critical Period Stage I*	Critical Period Stage II*	Critical Period Stage III*	Critical Period Stage IV*	Critical Period Stage V**
J-17 Index Well Level (msl)	<660	<650	<640	<630	<625
San Marcos Springs Flow rate (cfs)	<96	<80	N/A	N/A	N/A
Comal Springs Flow rate (cfs)	<225	<200	<150	<100	<45** or <40**
Withdrawal Reduction	20%	30%	35%	40%	44%

* A change to a critical period stage with higher withdrawal reduction percentages, including initially into Stage I for the San Antonio Pool and Stage II for the Uvalde Pool, is triggered if the 10-day average of daily springflows at the Comal Springs or the San Marcos Springs, or the 10-day average of daily Aquifer levels at the J-17 or J-27 Index Wells, as applicable, drop below the lowest number of any of the trigger levels for that stage. A change from any critical period stage to a critical period stage with a lower withdrawal reduction percentage, including exiting from Stage I for the San Antonio Pool, and Stage II for the Uvalde Pool, is triggered only when the 10-day average of daily springflows at the Comal Springs and the San Marcos Springs, and the 10-day average of daily Aquifer levels at the J-17 or J-27 Index Wells, as applicable, are all above the same stage trigger level.

** In order to enter into Critical Period Stage V, the applicable springflow trigger is either less than 45 cfs based on a ten-day rolling average, or less than 40 cfs, based on a three-day rolling average. Expiration of Critical Period Stage V is based on a ten-day rolling average of 45 cfs or greater.

Table 3.1-6. CPMP Triggers, Stages, and Reductions for the Uvalde Pool of the Edwards Aquifer

Wells/Springs	Critical Period Stage I*	Critical Period Stage II*	Critical Period Stage III*	Critical Period Stage IV*	Critical Period Stage V**
J-27 Index Well Level (msl)	N/A	<850	<845	<842	<840
San Marcos Springs Flow rate (cfs)	N/A	N/A	N/A	N/A	N/A
Comal Springs Flow rate (cfs)	N/A	N/A	N/A	N/A	N/A
Withdrawal Reductions	N/A	5%	20%	35%	44%

* A change to a critical period stage with higher withdrawal reduction percentages, including initially into Stage I for the San Antonio Pool and Stage II for the Uvalde Pool, is triggered if the 10-day average of daily springflows at the Comal Springs or the San Marcos Springs, or the 10-day average of daily Aquifer levels at the J-17 or J-27 Index Wells, as applicable, drop below the lowest number of any of the trigger levels for that stage. A change from any critical period stage to a critical period stage with a lower withdrawal reduction percentage, including exiting from Stage I for the San Antonio Pool, and Stage II for the Uvalde Pool, is triggered only when the 10-day average of daily springflows at the Comal Springs and the San Marcos Springs, and the 10-day average of daily Aquifer levels at the J-17 or J-27 Index Wells, as applicable, are all above the same stage trigger level.

** In order to enter into Critical Period Stage V, the applicable springflow trigger is either less than 45 cfs based on a ten-day rolling average, or less than 40 cfs, based on a three-day rolling average. Expiration of Critical Period Stage V is based on a ten-day rolling average of 45 cfs or greater.

Proposed Activities for 2017:

In 2017, the EAA will continue to enforce CPMP restrictions, consistent with the agency's rules and as discussed in the EAHCP.

3.1.6 Expanded Water Quality Monitoring (EAHCP §5.7.2)

EAHCP Obligations:

The EAA will continue its historical groundwater and surface water quality monitoring programs. In addition to historical monitoring, the EAA will expand its water quality monitoring efforts to include stormwater and additional groundwater and surface water sampling as necessary around Landa Lake, the Comal River, Spring Lake, and the San Marcos River.

2016 Compliance Actions:

The EAA continued the Expanded Water Quality Monitoring Program (EAHCP §5.7.2), collecting additional samples and sample types to detect early signs of water quality impairments to the Comal and San Marcos river and spring systems. An overview of the associated data collected and sampling events for 2016, along with analytical parameters by sample type, can be seen in **Table 3.1-7** and **Table 3.1-8** below.

Table 3.1-7. Summary of Data Types and Water Quality Sampling Events for 2016

San Marcos River	Sample Dates
Surface Water/Base Flow	3/2/16; 9/9/16
Sediment	6/9/16
Stormwater	3/8/16; 11/3/16
Passive Diffusion Samplers	2/16, 4/16, 6/16, 8/16, 10/16, 12/16
Comal River	**Sample Dates**
Surface Water/Base Flow	3/1/16; 9/8/16
Sediment	6/8/16
Stormwater	4/12/16 through 4/13/16; 9/26/16 through 9/27/16
Passive Diffusion Samplers	2/16, 4/16, 6/16, 8/16, 10/16, 12/16

Table 3.1-8. Analytical Parameters by Sample Type

Analytical Parameter	Surface Water (Base Flow) Samples	Sediment Samples	Stormwater Samples	Passive Diffusion Sampling
Volatile Organic Compounds (VOCs)	Yes	Yes	Yes	No
Semi-volatile Organic Compounds (SVOCs)	Yes	Yes	Yes	No
Organochlorine Pesticides	Yes	Yes	Yes	No
Polychlorinated Biphenyls (PCBs)	Yes	Yes	Yes	No
Herbicides	Yes	Yes	Yes	No
Metals (Al, Sb, As, Ba, Be, Cd, Cr (total), Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, Tl, and Zn)	Yes	Yes	Yes	No
General Water Quality Parameters (GWQP; Total Alkalinity (as $CaCO_3$), Bicarbonate Alkalinity (as $CaCO_3$), Carbonate Alkalinity (as $CaCO_3$); Cl, Br, NO_3, SO_4, Fl, pH, TDS, TSS, Ca, Mg, Na, K, Si, Sr, CO_3,)	Yes	No TDS or Total Suspended Solids (TSS)	Yes	No
Phosphorus (total)	Yes	Yes	Yes	No
Total Organic Carbon (TOC)	Yes	Yes	Yes	No
Dissolved Organic Carbon (DOC)	Yes	Yes	Yes	No
Total Kjeldahl Nitrogen (TKN)	Yes	No	Yes	No

Table 3.1-8. Analytical Parameters by Sample Type

Analytical Parameter	Surface Water (Base Flow) Samples	Sediment Samples	Stormwater Samples	Passive Diffusion Sampling
Bacteria (*E. coli*)	Yes	No	Yes	No
Field Parameters (DO, pH, Conductivity, Turbidity, Temperature)	Yes	No	Yes	No
TPH, BTEX, 1,3,5 and 1,2,4- trimethylbenzene, MTBE, phenanthrene, naphthalene1-methyl naphthalene, octane, cis and trans-1,2,-dichloroethene, 1,1-dichloroethane, chloroform, 1,1,1-trichloroethane, 1,2-dichloroethane, carbon tetrachloride, trichloroethene, tetrachloroethene, chlorobenzene, 1,4-dichlorobenzene, 1,1,2-trichloroethane, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, 1,3-dichlorobenzene, and 1,2-dichlorobenzene.	No	No	No	Yes
Caffeine	Yes	No	Yes	No

Sampling activities were minimally affected by weather conditions in the area. No extreme low-flow[8] sampling was initiated at wells (EAHCP §6.4.3.3 and §6.4.4.3) as flows at Comal Springs did not drop below 30 cfs, or below 50 cfs at San Marcos Springs. Significant rainfall occurred during the first half of 2016. However, rainfall was sparse from July 2016 through the beginning of September 2016. Rain events were generally scattered in nature, and often too small in magnitude to generate sufficient runoff to sample. However, on September 26, 2016, the New Braunfels area received approximately 2.6 inches of rain and the EAA was able to safely obtain stormwater samples from the Comal River. On November 3, 2016, the San Marcos area received approximately 0.26 inches of rain and the EAA was able to safely obtain stormwater samples from the San Marcos River.

Summary of 2016 Results

EAA staff collected surface water (base flow), stormwater, sediment, and passive diffusion samples from the Comal and San Marcos systems. The sampling events met the requirements of the EAHCP and provided background data for these two systems. The limited number of detections above comparative standards is indicative of generally high water quality. However, the total non-polycyclic and polycyclic aromatic hydrocarbons (PAH) and selenium results that exceeded comparative standards were of concern.

Concentrations of bis(2-Ethylhexyl) phthalate (DEHP), 4, 4-DDE, and lead that were detected above a maximum contaminant level (MCL) for water, or probable effect concentration (PEC) for sediment, are listed in **Table 3.1-9**.

[8] For the EAHCP 2016 Annual Report, EAHCP staff developed a **LIST OF DEFINED TERMS FOR DISCUSSIONS INCLUDED IN THE EAHCP 2016 ANNUAL REPORT**, located on page xxix of this Annual Report, for words or phrases that have specific meaning with the context of discussion related to the EAHCP. This list was developed in response to comments received by the EAHCP staff from a Permittee, and was developed to add clarity and consistency as to the standard meaning and use of these words or phrases.

Table 3.1-9. Concentrations above Maximum Contaminant Level or Probable Effect Concentration

Sample Location	Month	Sampling Method	Detection	Concentration	MCL or PEC
HCS160[1]	9/16	Surface water/ base flow	DEHP[2]	10.1 J[3] µg/L[4]	6.0 µg/L
HCS240[5]	9/16	Stormwater	DEHP	9.28 J µg/L	6.0 µg/L
HCS270[6] Lead	9/16	Stormwater	DEHP	6.28 J µg/L	6.0 µg/L
HCS270 Peak	9/16	Stormwater	DEHP	6.74 J µg/L	6.0 µg/L
HCS270 Trail	9/16	Stormwater	DEHP	7.43 J µg/L	6.0 µg/L
HSM120[7]	3/16	Surface water/ base flow	DEHP	12.5 J µg/L	6.0 µg/L
HSM120	9/16	Surface water/ base flow	DEHP	6.04 J µg/L	6.0 µg/L
HSM130[8]	9/16	Surface water/ base flow	DEHP	11.3 J µg/L	6.0 µg/L
HSM 170[9]	9/16	Surface water/ base flow	DEHP	19 J µg/L	6.0 µg/L
HSM320	6/16	Sediment	Total PAH[10]	24.148 mg/kg[11]	22.8 mg/kg
HSM320	6/16	Sediment	4, 4-DDE	103 µg/kg	31.3 µg/kg
HSM330	6/16	Sediment	Total PAH	26.916 mg/kg	22.8 mg/kg
HSM340[12]	6/16	Sediment	4, 4-DDE	31.5 µg/kg[13]	31.3 µg/kg
HSM340	6/16	Sediment	Lead	260 mg/kg	128 mg/kg
HSM240 Lead	3/16	Stormwater	DEHP	9.88 J mg/L	6.0 µg/L

[1] Site located north of Comal River Tube Chute near the western bank of the Comal River.
[2] bis(2-Ethylhexyl) phthalate
[3] Detection is above the method detection limit, but below the reporting limit.
[4] Micrograms per liter
[5] Site located on Elizabeth Street Bridge, east of the bridge, and on the northern bank of the Comal River.
[6] Site located south of Union Avenue and West Lincoln Street near the eastern bank of the Comal River adjacent to the Last Tubers Exit, west of the confluence of Guadalupe and Comal Rivers.
[7] Site located at the southwest corner of Spring Lake, near the bank adjacent to the Saltgrass Steakhouse parking lot on 221 Sessoms Drive.
[8] Sessoms Creek segment running past the Texas State FAB parking lot.
[9] Site located on Cape Street Bridge, north of bridge, and on the western bank of the San Marcos River.
[10] Polycyclic aromatic hydrocarbons
[11] Milligrams per kilogram
[12] Site located north of the E. Hopkins St. Bridge, south of the footbridge, close to the western bank of the San Marcos River.
[13] Micrograms per kilogram

bis(2-Ethylhexyl) phthalate in Water

DEHP was detected in the majority of water quality samples from the Comal and San Marcos springs complexes in 2013. However, DEHP results were noted in the laboratory blank samples for October 2013 surface water (base flow) sampling event and were considered likely post-collection contaminants or false positive detections. In general, DEHP is quite problematic in that it is common in plastics and other materials. Therefore, the EAA considered DEHP as a likely laboratory or sampling equipment artifact. DEHP was not detected in water quality samples from both springs complexes in 2014 and 2015. In 2016, DEHP was detected in multiple surface water (base flow) and stormwater samples collected from both spring complexes. Nonetheless, DEHP detections were "J" flagged indicating that the detection was above the method detection limit, but below the reporting limit. DEHP was positively detected, however, the concentration was estimated. The data will be stored in the database with the "J" flag associated with data.

PAHs in Sediment

PAHs are a group of semi-volatile organic compounds common in urban runoff (Mahler et al. 2005) that can have adverse effects on aquatic life including plants, invertebrates, and fish. The effects of exposure vary but can include organ damage, reproductive harm, or immune system weakening (Mahler et al. 2005). Coal-tar parking lot sealants have been identified as a significant source of PAHs in urban waterways and were banned from use in areas surrounding the Recharge Zone of the Edwards Aquifer within Comal and Hays counties by the EAA in 2012. In each year thus far, levels of total PAH in sediment samples have exceeded threshold effect concentrations (TECs) and PECs at two sites in the San Marcos Springs complex.

Lead in Sediment

Lead has been detected at concentrations of 56.0 mg/kg, 235 mg/kg, 63.5 mg/kg, and 260 mg/kg in years 2013, 2014, 2015, and 2016, respectively, at sample location HSM340. The TEC and PEC for lead are 35.8 milligrams per kilogram (mg/kg) and 128 mg/kg, respectively.

4, 4-DDE in Sediment

4,4-DDE has been detected at concentrations of 1.21 J µg/kg, <0.111 µg/kg, 17 J µg/kg, and 103 µg/kg in years 2013, 2014, 2015, and 2016, respectively, at sample location HSM320. 4,4-DDE has been detected at concentrations of <0.111 µg/kg, 21 µg/kg, 9.2 µg/kg, and 31.5 µg/kg in years 2013, 2014, 2015, and 2016, respectively, at sample location HSM340. The detections "J" flagged indicates that the detection was above the method detection limit, but below the reporting limit. The TEC and PEC for 4, 4-DDE are 3.16 µg/kg and 31.3 µg/kg, respectively.

The final 2016 Expanded Water Quality Monitoring Report, including water quality analysis reports, is included in **Appendix C1**.

Real Time Instrumentation

The objective for implementing the use of Real Time Instrumentation (RTI) was to measure changes in basic water quality parameters in near real time. The RTIs record data at 15-minute intervals, or nearly continuous basis, depending on the parameters. As such, the instrumentation provides a mechanism for recording water quality changes related to season, time of day, weather, and various other influences. The instrumentation measures the following parameters:

1) DO in milligram(s) per liter (mg/L);
2) pH (no units);
3) Conductivity in micro-Siemens per centimeter (µS/cm);
4) Turbidity in nephelometric turbidity units (NTU);
5) Temperature in degrees Celsius (°C).

The resulting data are included in **Appendix C2** of this Annual Report.

Proposed Activities for 2017:

In 2015, the EAHCP received the NAS *Report 1* containing recommendations for EAHCP's Monitoring, Modeling and Applied Research programs, including the WQP. From NAS *Report 1*, a list of water quality monitoring recommendations was presented to the NAS RRWG. Based on the NAS RRWG assessment, at its February 18, 2016, meeting, the IC appointed the WQWG to carry out a holistic review of the WQP, taking into account the recommendations of SRP/NAS, the NAS RRWG, the input of the SC, the Permittees, and subject matter experts. The purpose of the WQWG was to produce a final report for review by the IC, developed through a consensus-based decision-making process. The WQWG held meetings from March to May 2016. An overview of the approved WQP 2017 Scope of Work can be seen in **Table 3.1-10** below.

Table 3.1-10. Overview of Approved 2017 Scope of Work

Sampling Method	Frequency
Sediment	Biennially in even years
Real-time monitoring	Add one monitoring station per system
Stormwater	• Reduced to one sampling event per year • Test only for Integrated Pest Management Plan chemicals in odd years • Test full suite in even years as currently done • Add two samples to the rising limb of the hydrograph for a total of five samples per location ○ Priority given to locations at tributary outflows
Passive Diffusion Samplers	• Currently done • Add pharmaceuticals and personal care products membrane only at the bottom of the channel in both systems
Tissue sampling	One sample in odd years from both systems

EAA will continue the WQP consistent with the requirements outlined in the EAHCP and the final report of the WQWG **(Appendix I3)**.

3.1.7 Biological Monitoring (EAHCP §6.3.1, §6.4.3, and §6.4.4)

EAHCP Obligations:

The BioMP represents the continuation of the EAA's Variable Flow Study, initiated in 2000, amended to include CPMP and other EAHCP-specific monitoring to monitor changes to habitat availability and population abundance of the Covered Species that may result from the Covered Activities included in the EAHCP and natural events.

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

The BioMP also includes routine and flow-triggered sampling as required by the EAHCP to monitor natural changes occurring in the system as determined to be appropriate through the AMP as outlined in Sections 6.4.3 and 6.4.4 of the EAHCP.

2016 Compliance Actions:

It is important to recognize that many different sampling components are included in the EAHCP BioMP, and that several sampling location strategies are employed. The sampling locations selected are designed to cover a representative extent of Covered Species habitats in both systems, and are a subset that is used for ecological interpretation of the systems, while maximizing resources where practical, and when applicable. As such, the current design employed the following six basic sampling location strategies for the Comal and/or San Marcos systems, with associated sampling components:

1) System-wide sampling
   - Texas wild-rice full-system mapping—annually (San Marcos only)
   - Full system aquatic vegetation mapping—once every five years (will not be performed until 2018);
2) Select longitudinal locations
   - Temperature monitoring—thermistors
   - Water quality sampling—during CPMP sampling
   - Fixed-station photography
   - Discharge measurements (Comal system only);
3) Reach Sampling (four reaches)
   - Aquatic vegetation mapping
   - Fountain darter drop netting
   - Fountain darter presence/absence dip netting
   - Macroinvertebrate community sampling (San Marcos);
4) Springs Sampling
   - Endangered Comal invertebrate sampling
   - Comal Springs salamander sampling
   - San Marcos salamander sampling;
5) River Section/Segment Sampling
   - Fountain darter timed dip net surveys
   - Macroinvertebrate community sampling (Comal system)
   - Fish community sampling;
6) Critical Period (High-flow) Sampling
   - Both systems.

The 2016 Biological Monitoring Reports for both the Comal and San Marcos systems are included in **Appendix F** and **Appendix G**, respectively.

Proposed Activities for 2017:

In 2015, the EAHCP received the NAS *Report 1*, containing recommendations for all EAHCP programs, including the BioMP. From NAS *Report 1*, a list of biological monitoring-related recommendations was presented to the NAS RRWG. Based on the NAS RRWG assessment in 2015, on February 18, 2016, the IC created the BioWG whose charge was to carry out a holistic review of the BioMP, taking into account the recommendations of SRP/NAS and the NAS RRWG, and the input of the SC, the Permittees, and subject matter experts. The purpose of the BioWG was to produce a final report for review by the IC, developed through a consensus-based decision-making process. The BioWG held meetings from March to May 2016.

In 2017, the EAA will continue the amended BioMP pursuant to Section 6.3.1 of the EAHCP, with the following modifications per BioWG recommendations:

1) replace the macroinvertebrate food source monitoring with the TCEQ/TPWD Rapid Bio-Assessment protocols in five reaches in the Comal system and four reaches in the San Marcos system;
2) EAA to assume the responsibility of conducting the flow-partitioning within Landa Lake;
3) during "Water Quality Grab Sampling," the method detection limit for soluble reactive phosphorus will be reduced from 50 µg/L to at least 5 µg/L.

The final report of the BioWG is included here in **Appendix I4**.

3.1.8 Groundwater Modeling (EAHCP §6.3.2)

EAHCP Obligations:

By December 31, 2014, the EAA will: take appropriate steps to reduce the level of uncertainty in the MODFLOW model by filling in data gaps to the extent practicable and by reducing the number of structural limitations in the model, and create a new finite-element model to reduce uncertainty in the model results for use during the AMP and to provide assurance/confirmation that modeling results for the Edwards Aquifer and springflows are more reliable and defensible.

2016 Compliance Actions:

MODFLOW Model

During 2016 the EAA modeling team prepared several alternative model versions to evaluate uncertainty in the "bottom-up" approach used by the EARIP (2011) to evaluate the effectiveness of the EAHCP Conservation Measures to maintain springflows during a hypothetical repeat "drought-of-record." The different model versions are basically alternative model calibrations after making some conceptual change to the underlying model. Such conceptual changes included: an increased number of aquifer storage zones; modifications to the drain cells used to represent major springs by making the drain conductance variable with time (higher conductance at higher aquifer levels to reflect more spring orifices becoming active); adjustments to the amounts and spatial distribution of recharge; and changes to a hydrologic flow barrier

between the Uvalde and San Antonio pools of the Aquifer. These alternative model versions were then used to repeat the EARIP bottom-up analysis. Review and documentation of the results of this uncertainty analysis are in progress. Preliminary results indicate that, when an alternative model is able to match the observed minimum springflows during the "drought-of-record" in 1956, then the application of the combined EAHCP Conservation Measures is generally effective in maintaining average monthly springflows near 30 cfs at Comal Springs and 45 cfs at San Marcos springs under a scenario of modern pumping rates with "drought-of-record" recharge input.

Finite-Element Model

Use of the finite-element model in 2016 was limited to the EAA modeling team obtaining training on how run and make modifications to the model using the FEFLOW Finite Element Model groundwater modeling software. Because this model includes explicit representation of three hydrogeologic layers (Edwards, Upper Glen Rose, and Lower Glen Rose formations) and the Contributing Zone to the north of the Edwards Aquifer, it can be useful as a tool to evaluate conceptual models for inter-formational movement of water between the Glen Rose and Edwards formations. To the extent that conceptual changes may result from EAA's ongoing Inter-Formational Flow Study, this model may be used to investigate how best to represent such conceptual changes in any future model revisions or major updates.

Proposed Activities for 2017:

A main focus of 2017 groundwater modeling activities will be to complete the review and documentation of the set of alternative MODFLOW models used to repeat the bottom-up approach used to evaluate the effectiveness of EAHCP Conservation Measures and potentially other scenarios recommended by NAS. A peer-review panel is planned to provide feedback on these model results prior to finalization and release, and to advise on the planning of potential future model updates. NAS interim Phase 2 report, expected in December 2016, will contain scenarios for the groundwater model, which will be vetted through a NAS Review Work Group and the IC.

3.1.9 Ecological Modeling (EAHCP §6.3.3)

EAHCP Obligations:

The EAA will oversee and retain a contractor to develop a predictive ecological model to evaluate potential adverse ecological effects from Covered Activities and to the extent that such effects are determined to occur, to quantify their magnitude. The model results will help the Applicants (now Permittees) develop alternative approaches or possible mitigation strategies, if necessary.

2016 Compliance Actions:

In 2016, the project team completed a time-advancing, spatially-explicit, individual-based model representing fountain darter population dynamics using EAHCP biological monitoring data collected since 2000 as the foundation. Inputs to the simulation model include hydrology/hydraulic data, daily mean and maximum water temperature and daily minimum DO, and SAV distribution and densities. For initial model

calibration work, a de-coupled version of the simulation model was created, in which the output from the SAV component into the fountain darter component is disabled, and the SAV distributions and densities are taken directly from field observations. This de-coupling allowed parameterization of the fountain darter model to proceed in early 2016 without the complexity of simultaneously calibrating the SAV model.

Over the latter course of 2016, the SAV component was completed, calibrated, and assessed. Both the SAV and the fountain darter models are implemented within the NetLogo agent-based modeling framework, a time-and-space dependent numerical simulation. The spatial increment is 1 meter (m), which is a compromise between the detail of habitat variation in the river, and what is sufficient for management decisions as well as computationally efficiency. The SAV component simulates vegetation growth, density, and colonization of several SAV species found in the Comal and San Marcos rivers. This is a hybrid model: while some of the physical processes are based upon deterministic processes, others, notably dispersal, rely upon statistical models based upon the observational data base for the two rivers. Upon completion and assessment, the SAV component was successfully linked to the fountain darter component to comprise the "coupled" simulation model.

Additionally, in 2016, as mentioned previously in this Annual Report, the project team responded to the NAS interim Phase 2 report **(Appendix O2)** that provided recommendations regarding the development of the model.

Major tasks accomplished in 2016 were:

1) development and calibration of a DO component within the existing Qual-2E water quality model for incorporation into the overall ecological simulation model;
2) development and calibration of SAV growth and dispersal model for incorporation into the overall ecological simulation model;
3) completion of calibration work on the de-coupled simulation model;
4) sensitivity studies of the individual Qual-2E, fountain darter, and SAV models to respective input parameters;
5) completion of calibration and verification studies on the coupled simulation model;
6) sensitivity studies on the coupled simulation model;
7) completion of a user-oriented operational interface for the model.

The project team ran one scenario per system to document model use and application. The scenario chosen following discussions with EAHCP staff was the modeled springflow with the Phase 1 package (EAHCP flow regime) as described in Section 5.8 of the EAHCP. The EAHCP flow regime scenario model run was completed within the constraints of the tool in late 2016 and will be used as the prime example for discussion in the user's manual currently under development. In summary, the technical components of the ecological simulation model per contractual requirements have been completed and analyzed by the project team this year.

Proposed Activities for 2017:

Though the developed, calibrated and operational fountain darter simulation model completed the technical portion of this contract effort at the end of 2016, draft and final documentation as well as training activities will be performed in early 2017. Subsequent to submitting the draft report for review, the project team will provide on-site training to EAHCP staff on the use of the Ecological Model. In addition to on-site training, the project team will develop a "User Guide" to assist EAHCP staff in becoming familiar with the user interface and to serve as a reference for conducting model runs. Training and user guide development will occur in early 2017, followed by the completion and submittal of the final report. Model runs will include fountain darter survival in the "drought of record" conditions and potentially other scenarios recommended by NAS.

3.1.10 Impervious Cover and Water Quality Protection (EAHCP §5.7.6)

EAHCP Obligations:

The EAA will put together materials regarding the value of a ban on the use of coal tar sealants and work with local governments to explore and encourage their consideration of such a ban.

2016 Compliance Actions:

The effort to place a ban upon coal tar sealants throughout the Aquifer's Recharge Zone was officially completed in 2015 by the EAA Board of Directors. For a complete discussion of the EAA's efforts to implement this Conservation Measure, please refer to the *Edwaards Aquifer Habitat Conservation Plan 2015 Annual Report*, Chapter 3.0 – PLAN IMPLEMENTATION IN 2015, subsection 3.1.11 – Impervious Cover and Water Quality Protection.

Proposed Activities for 2017:

The EAA is continues to be available to serve as a resource for any local government that concludes future regulatory action is necessary.

3.1.11 Program Management

EAHCP Obligations:

Pursuant to Section 2.2 of the FMA, the EAA is responsible for the general management and oversight of the program, including the duties and responsibilities of the other ITP Permittees, in accordance with the ITP, EAHCP, FMA, and other program documents. Section 5.6.5 of the FMA allows for use of EAHCP monies to fund EAA administrative costs and employee salaries, so long as all incurred costs, including salaries, are 100 percent related to "general management and oversight" of the EAHCP.

Part of the EAA's responsibility includes facilitating the employment of the Program Manager, who is responsible for managing the EAHCP program, and ensuring compliance with all relevant program

documents. Although referred in the FMA as the "Program Manager," the title for this position under the EAA organizational structure is also referred to "Executive Director – Habitat Conservation Plan."

2016 Compliance Actions:

In 2016, three positions were added to the EAHCP staff team – Chief Science Officer (an EAA-funded position), Senior HCP Program Coordinator, and a second HCP Program Coordinator. The Senior HCP and HCP Program Coordinator positions were intended to assist in program administration activities, committee and work group meeting coordination, and in the implementation of the RWCP activities. The Chief Science Officer position was added to manage EAA's required Salvage and Long-Term Refugia programs, as well as EAA's implementation of the Applied Research, Ecological Modeling, and the Biological and Water Quality Monitoring programs. See **Figure 3.1-3** for the 2016 EAHCP staff organizational chart.

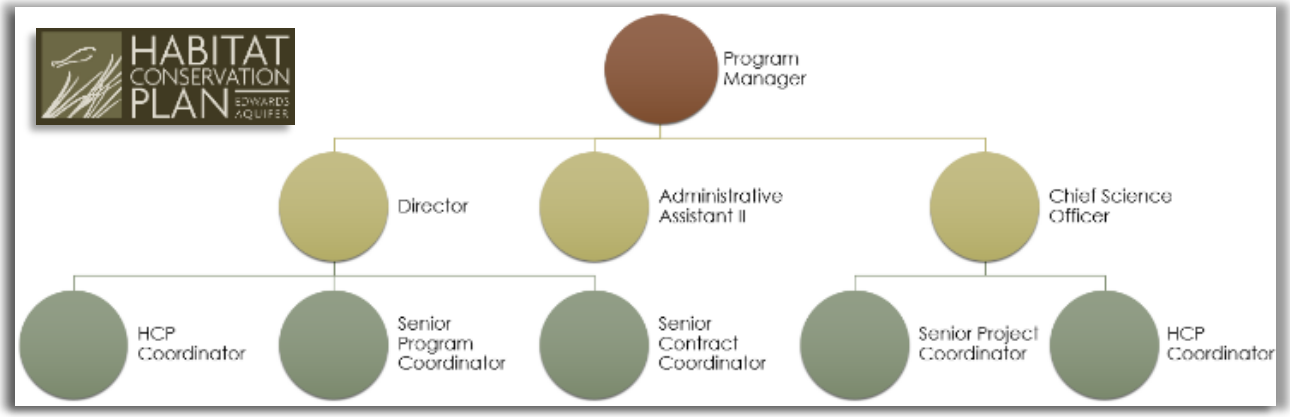

Figure 3.1-3. EAHCP 2016 staff organizational chart.

Selected Program Management activities completed in 2016 are listed below:

1) EAHCP staff facilitated the budgeting process and financial duties as assigned by the FMA. Staff tracked the budget throughout 2016, providing monthly updates to the IC and timely reimbursement to the Permittees. This process included managing and tracking more than 26 contracts.

2). EAHCP staff coordinated the 2016 budget process, including the timely approval of: 1) 2017 Work Plans from all Permittees; 2) Program Funding Applications from EAA, CONB, COSM, and Texas State; and 3) and implementation of the Interlocal Funding Contracts for reimbursement of CONB, COSM, and Texas State. Additionally, EAHCP staff assisted EAA staff with getting all necessary budget items approved by the EAA Board of Directors.

3) During 2016, EAHCP staff successfully facilitated eight IC meetings, five SC meetings, two SH meetings, one joint Committee meeting, and a two-day meeting for the SRP/NAS. Additionally, EAHCP staff facilitated and executed the development of three Work Groups, including:
   - The WQWG: This Work Group was commissioned by the IC in February 18, 2016 to carry out a holistic review of the current EAHCP program of water quality monitoring in the Comal and San Marcos springs and river systems, and to evaluate possible changes based on the recommendations contained in NAS *Report 1*, the NAS RRWG, the input of the SC, the

Permittees, and subject matter experts. The WQWG met five times (including two joint meetings with the BioWG) and produced a report with recommendations for modifications to the existing monitoring program. The IC adopted this report at its meeting on June 23, 2016. This report is included in **Appendix I3**.

- The BioWG: This Work Group was commissioned by the IC in February 18, 2016 to carry out a holistic review of the current EAHCP program of biological monitoring in the Comal and San Marcos springs and river systems, and to evaluate possible changes based on the recommendations contained in NAS *Report 1*, the NAS RRWG, the input of the SC, the Permittees, and subject matter experts. The BioWG met four times (including two joint meetings with the WQWG) and produced a report with recommendations for modifications to the existing monitoring program. The IC adopted this report at its meeting on June 23, 2016. This report is included in **Appendix I4**.
- The Cotton Lure WG: This Work Group was convened on March 25, 2016 by the Program Manager to discuss, develop, and adopt an SOP for the CSRB cotton lure methodology for entities that are routinely working with this species. This Work Group was comprised of representatives from EAA, EAHCP, Texas State, TPWD, USFWS, CONB, and BIO-WEST. This Work Group produced an SOP, which was presented to the SC on September 9, 2016, and finalized on September 12, 2016. This SOP is included in **Appendix I5**.

4) South Central Texas Regional Water Planning Group (Region L) EAHCP-led Tour of the San Marcos Springs and River System. On September 29, 2016, EAHCP staff hosted a tour of the San Marcos River in order to provide the Region L water planning group a better understanding of what is being done through the EAHCP to protect endangered species. The tour began with an "EAHCP 101" presentation, followed by a system tour of aquatic vegetation restoration, and riparian improvements for water quality protection. Following the tour, the Region L members participated in a glass-bottom boat tour of Spring Lake at the Meadows Center for Water and the Environment (MCWE).

5) In 2016, EAHCP staff continued to photograph the progress of the restoration activities in the San Marcos and Comal springs systems, including annual baseline photos for future years.

6) To facilitate communication and coordination among the Permittees in 2016, EAHCP staff and the IC members from the COSM and Texas State continued regular monthly meetings to discuss topics relevant to the San Marcos springs. The EAHCP Program Manager and Director held similar dialogues with the CONB on an as-needed basis. Also, the EAHCP staff held biweekly conference calls with the CONB, COSM, and Texas State staff to discuss any issues or problems with current projects. Also continued this year, the EAHCP Program Manager and the Chair of the IC, and the EAHCP Director and the Chair of the SC, held monthly meetings in preparation for upcoming committee meetings.

7) For better program transparency, the EAA maintained its contract from 2015 with a local public relations firm to design and publish a bi-monthly newsletter for the EAHCP, the *EAHCP Steward*. In 2016, the EAA published six regular *EAHCP Steward* newsletters. The newsletter articles covered a variety of subjects that included stories on the following topics: SAWS/EAA Regional Water Conservation Program Contract; the Old Channel Bank Stabilization Project; the City of San

Marcos/Texas State Texas Environmental Excellence Award (TEEA) by TCEQ; progress with CSRB research in Dr. Weston Nowlin's laboratory at Texas State; and the first Nonroutine AMP.

- The *EAHCP Steward* newsletter was distributed to about 400 committee members, partners, elected officials, and interested citizens. A sample issue of the *EAHCP Steward* newsletter is included in **Appendix K4**. Plans for 2017 are to continue current goals of six regular newsletters and one special edition newsletter to better engage members of the community concerning the work being done in the Edwards Aquifer Region to protect the Covered Species of the EAHCP.

8) Additionally, the EAA also continued to publish monthly newsletters for the ASR leasing program. The *ASR Forum* is a newsletter as part of the EAHCP Program for Edwards Aquifer permit holders. In 2016, articles included stories on several permit holder participating in the ASR program, as well as stories about upcoming ASR outreach events.

9) In October, through an online webinar, staff presented to more than 350 attendees a summary of how the EAA manages and uses water quality monitoring data for the protection the Edwards Aquifer endangered species. The title of the presentation was "Protecting Threatened and Endangered Species with Continuous Water Quality Data." An archive of this presentation can be found on the homepage of Aquatic Informatics at http://aquaticinformatics.com/.

10) For additional outreach efforts in 2016, EAHCP staff gave multiple presentations to describe in detail the current implementation of EAHCP measures, as well as to educate students, teachers and others on the fundamental background of the EAHCP. Presentations included the following organizations and events:
    - Texas State
    - Trinity University
    - Various high schools
    - Rotary Clubs
    - GBRA Clean Rivers Program
    - Texas Water Utilities Association
    - San Antonio Rodeo
    - The EAA's 20th Anniversary Reception
    - Water Forum VII – San Antonio Clean Technology Forum
    - National Habitat Conservation Plan Coalition USFWS
    - South Central Texas Water Research Interest Group

3.1.11.1 Permit Oversight

EAHCP staff is committed to maintain all regulatory permits necessary for the implementation of projects in the San Marcos and Comal systems to ensure compliance with the ITP. This does not include permits required for contractors to perform their specific tasks identified in the scope of work of a contract. The purpose of the permit oversight effort is to ensure current compliance with all Federal and State regulatory permits needed for current and future projects. A permit tracking matrix was developed from the information gathered to assist EAHCP staff and Permittees in identifying additional permits needed.

In 2016, EAHCP staff assisted COSM, Texas State, and CONB in completing and submitting all permit applications and coordination letters appropriate for full compliance. These projects include the permanent access point repair project in the San Marcos River, and bank stabilization and back-up culvert installation in the Comal River.

In 2016, EAHCP staff received technical assistance in developing permit applications for various State and Federal agencies that included the TPWD, TCEQ, and the U.S. Army Corps of Engineers (USACE). Additionally, a consultant firm was retained to provide archeological services and professional assistance regarding the EAHCP's Cultural Resources Permit with the Texas Historical Commission (THC). This permit is necessary to maintain compliance with the various Federal and State regulatory agencies, which exercise jurisdiction over the activities carried out in the San Marcos and Comal springs systems.

3.1.11.2 Amendments, Informational Memoranda, and Clarifications

Pursuant to Section 9.2 of the EAHCP, from time to time, it may be necessary to clarify or make amendments to the EAHCP, Implementing Agreement (IA) (EAA et al. 2013), FMA, or ITP to deal with issues that arise during implementation. In 2016, the Program Manager submitted five letters to the USFWS regarding the EAHCP. Three of these letters were requests for clarifications to the EAHCP, a fourth letter was a request for a clarification and an amendment to the EAHCP, and the fifth letter pertained to a request for an EAHCP amendment. The Program Manager did not submit any such requests to the IA, FMA, or ITP. A summary discussion of the five letters of clarification and/or amendment, as applicable, follows:

1) Clarification of ASR Regional Advisory Group Meeting Frequency
   This clarification sought to clarify the stated frequency of ASR Regional Advisory Group (EAHCP §5.5.1) meetings. The Permittees did not wish to change the substance of this chapter, but to provide clarification in order for the Permittees to conduct these meetings as needed, and no less than annually. This request was approved in writing by the USFWS in a letter dated June 13, 2016.

   Appendix A3 includes this clarification request letter, and **Appendix A4** includes the response letter from the USFWS.

2) Clarification to the specified vegetation in Table 4-21 of the EAHCP Biological Goals for fountain darter habitat and amendment regarding the estimated relative abundance of fountain darters within respective reaches in the San Marcos River for the ITP
   - *Clarification:* The clarification associated with this request proposed certain changes to Table 4-21, with the justification that said changes were warranted to properly maintain a diverse community of native aquatic vegetation to maximize fountain darter habitat. These changes included the complete removal of all non-native aquatic vegetation (East Indian hygrophila *[Hygrophila polysperma]*, Hydrilla *[Hydrilla verticillate]*, and Tapegrass [*Vallisneria spiralis]*) from the Biological Goals and replacing these goals with native vegetation such as pondweed (*Potamogeton illinoensis*), umbrella water-pennywort *(Hydrocotyle umbellate),* and Texas wild-rice (*Zizania texana*).
   - *Amendment*: The amendment associated with request was associated with the changes in fountain darter population counts resulting from adjusting the aforementioned Table 4-21.

Specifically, the original table (EAHCP Table 4-21) was calculated to provide habitat for 34,325 estimated fountain darters. Therefore, despite the proposed alterations being beneficial to the overall coverage of native vegetation throughout the system, the estimated densities associated with each vegetation type finds the revised table is calculated to provide habitat for 29,270 estimated fountain darters (a reduction of 5,055).

Appendix A5 includes the September 20, 2016 letter submitted to the USFWS for the above clarification and amendment, and **Appendix A9** includes the October 24, 2016 response letter from the USFWS.

3) Clarification to the specified vegetation in Table 4-1 of the EAHCP Biological Goals for fountain darter habitat in the Comal River for the ITP
This clarification involved EAHCP Table 4-1, which provides guidance to the permittees in square meter coverage of specified aquatic vegetation for designated Long-Term Biological Goal (LTBG) reaches for the Comal Springs ecosystem. The clarification proposed that certain changes to Table 4-1 were warranted to properly maintain a diverse community of native aquatic vegetation and maximize fountain darter habitat. These changes include the complete removal of all filamentous algae and non-native *Hygrophila polysperma* from the Biological Goals and to replace these goals with native *Potamogeton illinoensis*. In order to find the most adequate distribution of ideal habitat for the fountain darter, the proposed goals have additional native vegetation and an altered distribution for all vegetation types originally identified in EAHCP Table 4-1. As a result of this change, the estimated relative abundance of fountain darters within respective reaches will increase by 568.

   Appendix A6 includes the September 20, 2016 letter submitted to the USFWS for the above clarification, and **Appendix A9** is the October 24, 2016 response letter from the USFWS.

4) Clarification to the EAHCP Key Management Objective of "proportional expansion" and creation of "restoration reaches" for the Comal and San Marcos rivers for the ITP
This clarification involved a Key Management Objective for fountain darter protection, which calls for extending aquatic vegetation restoration "effort" in equal proportion beyond the established LTBG reaches. This management objective was not geographically or quantitatively defined in the EAHCP, therefore the Permittees provided this clarification to specifically establish a definition of "proportional expansion" found in Subsection 4.1.1.1 and Subsection 4.1.1.2 of the EAHCP for the Comal and San Marcos rivers respectively, including tables establishing estimated aquatic vegetation coverage for the proposed "restoration reaches." The establishment of the "restoration reaches" was identified to result in additional monitoring. Currently the EAHCP requires the EAA to maintain a comprehensive biological monitoring plan for the term of the ITP (EAHCP §6.3.1). The scope of the BioMP currently requires aquatic vegetation mapping of "select reaches." These reaches, as a result of this clarification, were expanded to include monitoring of the "restoration reaches" defining "proportional expansion" as well as the LTBG reaches.

   Appendix A7 includes the September 20, 2016 letter submitted to the USFWS for the above clarification, and **Appendix A9** includes the October 24, 2016 response letter from the USFWS.

5) Amendment to Table 5-3 of the EAHCP Flow-Split Management for the Old and New Channel of the Comal River for the ITP

   This amendment pertained to requested modifications to Table 5-3 of the EAHCP Flow-Split Management for the Old and New Channel of the Comal River. The Old Channel has been a particularly important, and successful, area for aquatic vegetation restoration. This amendment was designed to address the fact that when the EAHCP requires Table 5-3 prescribed flows measuring from 70 to 80 cfs be diverted into the Old Channel, destructive scour of previously restored areas has been observed. Additionally, during 2014, when total system flows dropped to as low as 60 cfs and the EAHCP required 40 cfs be diverted to the Old Channel, CSRB habitat around Spring Island became exposed and compromised.

   Appendix A8 includes the September 20, 2016 letter submitted to USFWS for the above amendment, and **Appendix A9** includes the October 24, 2016 response letter from USFWS.

3.1.12 Challenges Observed and Identified Solutions

Edwards Aquifer Authority

For the EAA, 2016 proved to be the most successful year yet with the ASR Program. The learned lessons through this successful experience have given the EAA cause to consider that fulfilling the obligations of the ASR leasing program, as envisioned in the EAHCP, could potentially be achieved in a more efficient and cost-effective manner. This could be done by considering the realities of the groundwater market and related considerations, such as improved weather conditions. With some possible tweaking of the existing tiered lease program, experience suggests that the ASR could be filled sooner than anticipated in the modeled repeat of the "drought of record," and the required water for forbearance secured in a simpler, more cost-efficient manner. Moreover, it is possible that doing this could result in an even more effective approach to managing groundwater through "drought of record" conditions, adding greater certainty to the assurance of maintaining continuous minimum springflows.

Securing Full Participation in the ASR Program

The goal of the ASR Program, as presently enacted, is to control 50,000 ac-ft through leasing of three equal Tiers of approximately 16,666 ac-ft each, as follows:

1) Tier I is always used as a lease to fill;
2) Tier II is somewhat like the VISPO as it incorporates two types of payments: a standby is provided at all times when the 10-year annual recharge average is greater than 572,000 ac-ft and, a higher option payment plus the standby payment is provided when the 10-year annual recharge average is less than 572,000 ac-ft. If a Tier II condition is in effect and the ASR is not full, the water will be injected. However, if the ASR is full and no further storage is required or drought conditions do not allow for additional injections, the contracted water will be forborne;
3) Tier III is exactly like Tier II; except the ten-year recharge threshold is 472,000 ac-ft. Also, Tier III water will be more likely forborne rather than injected into the ASR.

Lessons Learned and Potential Opportunities

The EAA believes there may be opportunity to further simplify the three-tiered approach and the associated recharge trigger mechanism in such a way that the program becomes more cost-efficient, and easier to explain and promote in the marketplace. For example, a transition to a simplified two-tiered program of leases for filling the ASR, and forbearance agreements that are activated off a more commonly recognized trigger mechanism could be more easily marketed and fully executed sooner than anticipated under the current regimen. Such changes could enhance the program's appeal to the regional water market, thus facilitating the ultimate success of the ASR leasing program as a Conservation Measure.

EAHCP Program Management

For 2016, the EAA observed the following challenges: implementing the Refugia Program; evaluating necessary changes to the SAV restoration activities and initiating the first AMP through the EAHCP Committees; establishing a robust database to house all EAHCP research and monitoring data; and evaluating the WQP and BioMP through a Work Groups of the IC to increase monitoring efficiencies.

Implementing the Refugia Program

In an effort toward ITP compliance regarding refugia, the EAA selected the USFWS to provide Long-Term Refugia Operations for the remainder of the ITP term. After several months of contract negotiation, the EAA Board of Directors approved the contract with USFWS at their November 8, 2016 meeting.

This project will provide a full refugia operation including Salvage and Long-Term Refugia programs, develop protocols for husbandry and propagation of the EAHCP Covered Species, help in understanding Covered Species' life cycles and reproduction, and develop understanding of genetic variation among the Covered Species.

Adaptive Management Process: SAV Restoration Activities

In 2016, the Permittees pursued an analysis of the current programs for SAV restoration in the San Marcos and Comal Springs systems. In this analysis, lessons learned as well as a Nonroutine Adaptive Management Proposal were brought forward and ultimately reviewed by the EAHCP Committee members. The proposal included a summary of the issues encountered with the SAV restoration programs, the recommendations from the study of these issues, and the stakeholder-driven process facilitated by the Program Manager.

The Nonroutine Adaptive Management Proposal included two sets of modifications to the EAHCP. Modifications to the SAV Conservation Measures and fountain darter LTBGs in the San Marcos and Comal River ecosystems that would, and a modification to the Flow-split Conservation Measure in the Comal system that would revise Table 5-3, Flow-Split Management for Old and New Channels to provide maximum benefit to sustaining fountain darter habitat in the Old Channel while keeping CSRB habitat around Spring Island wetted.

Implementing SRP/NAS Recommendations

Database Management: Per the recommendations of the 2015 ARWG and the SRP/NAS, in 2016 the EAHCP team initiated the development of a database to house and integrate all data collected through the program, specifically data collected through the Variable Flow, Biological Monitoring, and Expanded Water Quality Monitoring programs.

With the use of specialized software, the EAHCP team migrated 16 years of biological monitoring datasets, including all aquatic vegetation mapping, fountain darter, macroinvertebrate, salamander, fixed station photography and Texas Master Naturalist datasets, as well as three years of water quality datasets from both the San Marcos and Comal springs surveys, including stormwater, surface water, sediment, and passive diffusive sampling into the "Aquarius Samples" database.

Expanded Water Quality and Biological Monitoring Work Groups: In 2015, the EAHCP received the NAS *Report 1*. This review focused on the EAHCP's hydrologic and ecological models, water quality and biological monitoring, and applied research programs, and provided recommendations for all EAHCP programs. Those recommendations were subsequently presented to, and considered by, the NAS RRWG.

On February 18, 2016, based upon the NAS RRWG's assessment of those recommendations, the IC created the WQWG and BioWG to produce final reports for the IC with their assessments of the NAS *Report 1* and NAS RRWG's recommendations for those two EAHCP monitoring programs. The two Work Groups convened an initial joint meeting on March 15, 2016, and then continued separate Work Group efforts to fulfill the IC's charges to each of the Work Groups. They later re-convened in a joint meeting on May 20, 2016, to approve each of the Work Groups' reports for submittal to the IC, and to conclude their work. Copies of the joint Work Group meeting agendas and minutes can be found in **Appendix I2.**

3.2 City of New Braunfels

The CONB is responsible for implementation of the following measures under the EAHCP:

- Flow-Split Management in the Old and New Channels (EAHCP §5.2.1)
- Native Aquatic Vegetation Restoration and Maintenance (EAHCP §5.2.2)
- Management of Public Recreational Use of Comal Springs and River Ecosystems (EAHCP §5.2.3)
- Decaying Vegetation Removal and Dissolved Oxygen Management (EAHCP §5.2.4)
- Control of Harmful Non-Native Animal Species (EAHCP §5.2.5)
- Monitoring and Reduction of Gill Parasites (EAHCP §5.2.6 and §6.3.6)
- Prohibition of Hazardous Materials Transport Across the Comal River and its Tributaries (EAHCP §5.2.7)
- Native Riparian Habitat Restoration (Riffle Beetle) (EAHCP §5.2.8)
- Reduction of Non-Native Species Introduction and Live Bait Prohibition (EAHCP §5.2.9)
- Litter Collection and Floating Vegetation Management (EAHCP §5.2.10)
- Management of Golf Course Diversions and Operations (EAHCP §5.2.11)
- Native Riparian Habitat Restoration (Old Channel Improvements) (EAHCP §5.7.1)
- Management of Household Hazardous Wastes (EAHCP §5.7.5)

- Impervious Cover and Water Quality Protection (EAHCP §5.7.6)

3.2.1 Flow-Split Management in the Old and New Channels of the Comal River (EAHCP §5.2.1)

EAHCP Obligations:

The CONB will control flow entering the Old and New Channels of the Comal River from Landa Lake using the culverts and flow-control structure located between Landa Lake and the Old Channel of the Comal River. The purpose of this activity is to maintain optimal habitat conditions for the Covered Species under varying total flow conditions in the system per the Flow-Split Management Plan and Flow-Split Goals described in the EAHCP, and summarized in Table 5-3 of the EAHCP. Table 5-3 is re-stated in this Annual Report as **Table 3.2-1** below.

2016 Compliance Actions:

CONB staff routinely monitored stream flow conditions in the Comal River system based on the USGS streamflow gaging stations. Based on this routine monitoring, a deviation to the flow rates in the fall/winter of not to exceed 65 cfs was necessary to allow further analysis of whether sustained flows greater than 65 cfs would cause adverse impacts to aquatic restoration work already completed. This deviation from **Table 3.2-1** was communicated by the EAHCP to the USFWS in a memorandum dated November 30, 2015, and on January 15, 2016, the USFWS endorsed this deviation in writing. This effort was addressed in the *EAHCP 2015 Annual Report*.

From January 1, 2016 to May 9, 2016, the CONB continued to operate the flow-control gate with a target of maintaining 65 cfs in the Old Channel. Beginning on May 10, 2016, the CONB reduced flow in the Old Channel to 40 cfs and operated the control gate with a target of maintaining 40-50 cfs. This reduction in flow was due to water-filled bladder bags that were installed in the Old Channel to accommodate the EAHCP Bank Stabilization Project. The placement of the bladder bags restricted the width of the Old Channel, thereby warranting the need to reduce flow in order to prevent increased flow velocities and subsequent scouring of the streambed and aquatic vegetation. This deviation from **Table 3.2-1** and from previous correspondence with USFWS was communicated with USFWS on April 27, 2016. Upon removal of the water-filled bladder dams from the Old Channel in late September 2016, CONB began to operate the control gates to achieve a target flow of 60-65cfs.

Table 3.2-1. Flow-Split Management for Old and New Channels

Total Comal	Old Channel (cfs)			New Channel (cfs)		
Springflow (cfs)	Fall, Winter		Spring, Summer	Fall, Winter		Spring, Summer
350+	80		60	270+		290+
300	80		60	220		240
250	80		60	170		190
200	70		60	130		140
150		60			90	
100		60			40	
80		50			30	
70		50			20	
60		40			10	
50		40			10	
40		30			10	
30		20			10	

In order to provide a back-up to the existing 48-inch culvert and flow-control gate, CONB moved forward with engineering design of additional flow-control gates intended to be placed on existing 14-inch culverts located adjacent to the main 48-inch culvert. The 14-inch culverts are currently capped but are capable of transmitting water from Landa Lake to the Old Channel. Engineering design was completed in 2016 and includes specifications for the installation of flow-control gates and velocity dissipation structure. Permits for the project were acquired in 2016. The project is planned to be constructed in 2017.

As a result of the AMP in 2016, the EAHCP requested further amendments to Table 5-3 of the EAHCP (depicted as **Table 3.2-1** above) in September 2016, and those amendments were approved by the USFWS in October 2016. For more detailed discussion of the 2016 AMP, please refer to **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.1.11.2** – Amendments, Informational Memoranda, and Clarifications, and to **Chapter 4.0** – ADAPTIVE MANAGEMENT PROCESS ACTIVITIES FOR 2016, **Section 4.2** – Nonroutine Decisions.

Proposed Activities for 2017:

The CONB will continue to monitor flow rates in the Old and New Channels of the Comal River and will operate the flow-control gate to meet objectives specified in revised Table 5-3 of the EAHCP.

The CONB plans to install additional back-up flow control gates on the existing 14-inch culverts per the design plans completed in 2016. The CONB also intends to install floating vegetation booms that will minimize the collection of floating vegetation on the intake screens of the 48-inch and 14-inch culverts.

3.2.2 Native Aquatic Vegetation Restoration and Maintenance (EAHCP §5.2.2)

EAHCP Obligations:

The CONB will implement an Aquatic Vegetation Restoration Program within key, sustainable reaches of the Comal River system including Landa Lake, the Upper Spring Run area, and portions of the Old and New Channels. Restoration activities include the removal of non-native aquatic plant species, planting of target native aquatic plant species, and maintenance of restored areas. The overall goal of the Aquatic Vegetation

Restoration Program is to improve habitat conditions for the fountain darter by increasing the amount of usable habitat, and by improving the quality of existing habitat in the Comal River system.

2016 Compliance Actions:

Aquatic vegetation restoration activities in 2016 included removal of non-native aquatic vegetation and planting of target native aquatic plants as well as monitoring, mapping, and maintenance of restored areas within Landa Lake (including the Upper Spring Run area), the Old Channel of the Comal River and the "Mill Race" of the New Channel (**Figure 3.2-1**).

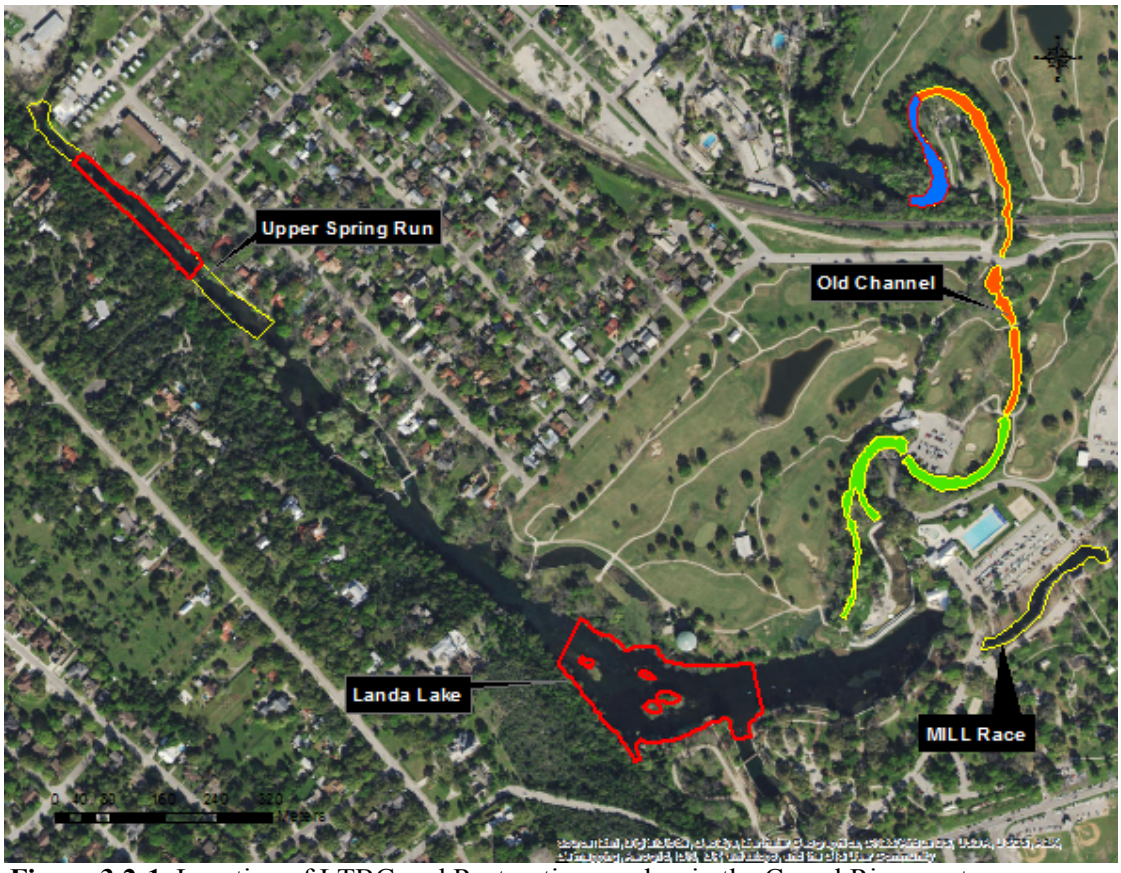

Figure 3.2-1. Location of LTBG and Restoration reaches in the Comal River system.

The Landa Lake, Upper Spring Run and Old Channel LTBG reaches outlined in red. The restoration reaches are outlined in yellow. Green indicates the extent of 2013 and 2014 Old Channel restoration activities. The area in orange represents extent for 2015 activities, and the area in blue indicates the location of 2016 activities. Aquatic vegetation and gardening occurred throughout these areas in 2016.

Non-Native Aquatic Vegetation Removal Results

Table 3.2-2 summarizes the amount of *Hygrophila* removed, by location, from the Comal River system in 2016. Approximately 764 square meters (m^2) of *Hygrophila* was removed from the Comal River system in 2016. In 2016 significant effort was put into removing and eliminating *Hygrophila* in the downstream portion of the Old Channel LTBG Reach as large-scale removal had yet to occur in this area. **Figure 3.2-2** illustrates

Hygrophila coverage in the Old Channel LTBG Reach prior to and following removal. *Hygrophila* patches observed throughout the Old Channel Restoration Reach between Landa Lake and the Old Channel LTBG were also removed in 2016. The Upper Spring Run and the spring-fed swimming pool have remained mostly clear of *Hygrophila* since large-scale removal occurred in these areas in 2015. Two small patches of *Hygrophila* were observed along the eastern shoreline of Landa Lake and were removed in early 2016.

Table 3.2-2. Amount of *Hygrophila* Removed from Comal River System in 2016

Location/ Section	Area of *Hygrophila* Removed (m^2)	Period of Work
Landa Lake Restoration Reach and LTBG Reach	16	2/16, 3/16
Old Channel Restoration Reach	36	2/16, 3/16, 5/16-7/16
Old Channel LTBG Reach	712	2/16, 3/16, 6/16-8/16
Spring-fed Pool	<1	Gardened as needed
Upper Spring Run LTBG Reach	<1	Gardened as needed
Upper Spring Run Restoration Reach	<1	Gardened as needed
APPROX. AREA REMOVED IN 2016	**~764**	

Figure 3.2-2. *Hygrophila* coverage in the Old Channel LTBG Reach prior (top photo) and following 2016 removal efforts (bottom photo).

New Channel Restoration Results

Below, **Table 3.2-3** shows vegetation coverage for the two portions of the New Channel LTBG Reach as mapped in fall 2016. No work was completed in the New Channel Restoration reaches in 2016, although they were mapped for vegetation coverage.

Table 3.2-3. Native Vegetation Coverage Within New Channel LTBG Reach, by Vegetation Type, in Fall 2016

Species	Fall Coverage (m^2)
Upper New Channel LTBG Reach (at RV Park)	
Cabomba	35
Ludwigia	23
Bryophytes	0
Hygrophila	171
Lower New Channel LTBG Reach (at Hinman Island Park)	
Cabomba	1,758
Ludwigia	0
Bryophyte	0
Hygrophila	414

Old Channel Restoration Results

In 2016, 705 m^2 of area was planted in eight restoration plots in the Old Channel (**Figure 3.2-3**), bringing the four-year total area planted in both the LTBG and Restoration reaches of the Old Channel to 3,378 m^2. A total of 2,812 plants were installed in 2016 within the Old Channel Restoration Reach and LTBG Reach combined (**Table 3.2-4**). All of these were planted within new plots. **Table 3.2-5** shows seasonal cover, in m^2, of the target species for the Restoration Reach as well as the LTBG Reach.

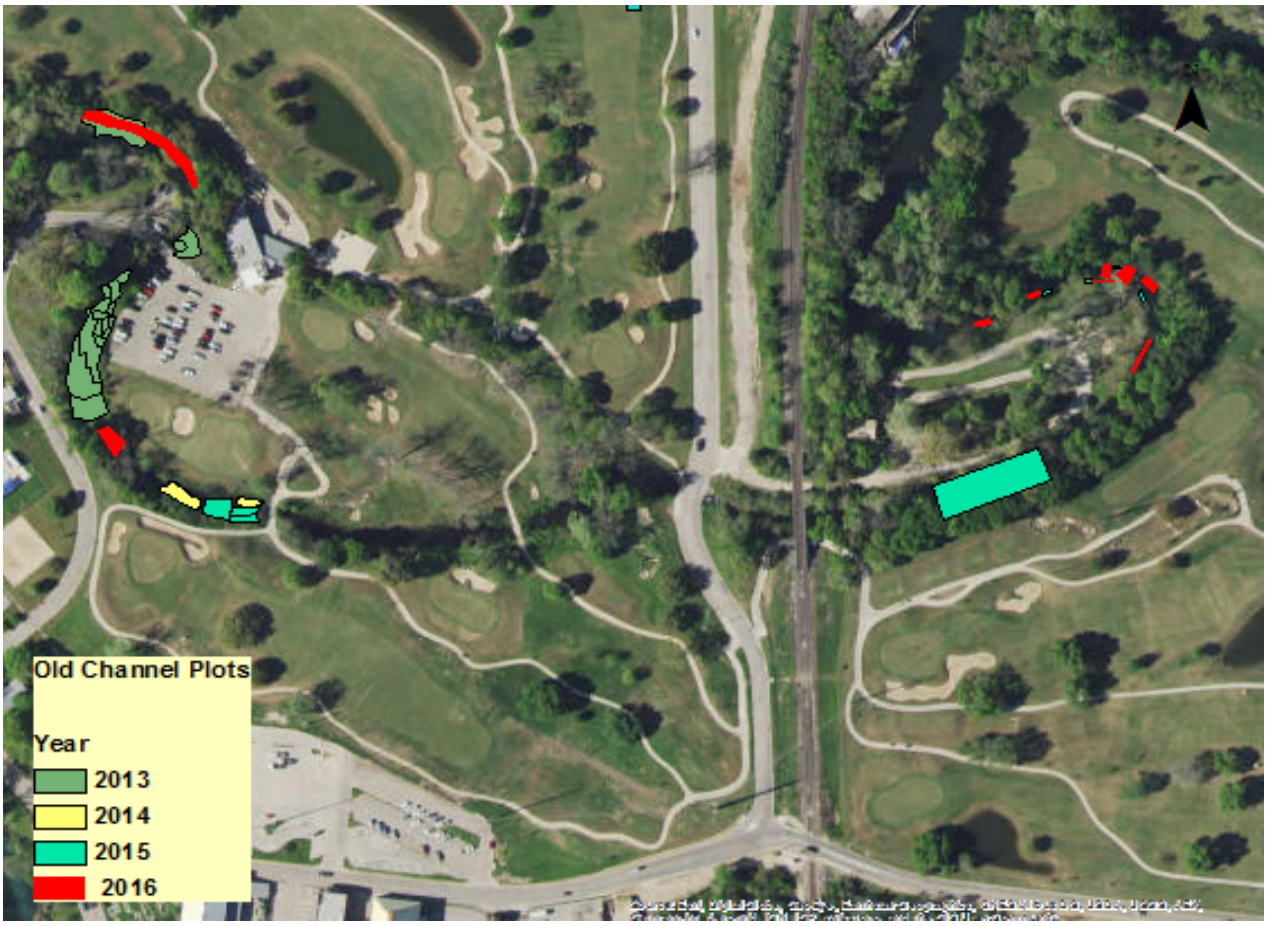

Figure 3.2-3. Aquatic vegetation restoration plots in the Old Channel Restoration and LTBG reaches.

Table 3.2-4. Number of Native Plants Planted Within Each Old Channel Restoration Reach, by Plot, in 2016

2016 Old Channel Restoration Plantings					
Old Channel LTBG Reach					
Date Planted	**Plot***	***Ludwigia***	***Sagittaria***	***Cabomba***	***Vallisneria***
3/1/16	2016A	300			
3/3/16	2016C		160		
3/3/16	2016D		400	50	
3/3/16	2016E		400		
10/5/16	2016G			150	
11/ 16	2016H	482		0	
TOTALS		**782**	**960**	**200**	
Old Channel Restoration Reach					
3/1/16	2016B	150			
3/15/16	2016F	720			
TOTALS		**870**	**0**	**0**	

* Planting data is tracked by individual plot.

Table 3.2-5. Seasonal Cover (m^2) per Vegetation Type in 2016 in Old Channel

Species	January	April	August	October
Old Channel LTBG Reach				
Ludwigia	10	31	7	35
Sagittaria	0	7	0	0
Cabomba	0	0	0	0
Bryophytes	122	116	296	250
Hygrophila	801	726	89	503
Old Channel Restoration Reach				
Ludwigia	607	652	480	594
Sagittaria	591	535	285	284
Cabomba	118	56	100	186
Bryophytes	389	500	467	478
Hygrophila	79	84	11	204

The Bank Stabilization Project that occurred in 2016 along the Old Channel between Landa Lake and the Golf Course Road Bridge crossing had an impact on aquatic vegetation in the immediate area due to the placement of water-filled bladder dams in the channel. The bladder dams were installed in order to provide a stabilized work area and to minimize sediment and debris from entering the main portion of the channel during construction. Prior to placement of the bladder dams, aquatic vegetation (especially *Ludwigia, Sagittaria,* and *Potamogeton*) in the footprint of the dams was removed in order to decrease the likelihood of fountain darters being harmed by the placement of the dams. Remaining *Ludwigia* and *Potamogeton* in the vicinity of the bank project faired relatively well. A stand of *Sagittaria* was situated in a portion of the channel where the placement of the bladder dams had constricted the channel, thereby increasing channel velocity. The higher velocities in this portion of the channel caused some channel scouring and unintended removal of *Sagittaria*. *Ludwigia* sprigs were planted in the disturbed areas following the removal of the bladder dams and completion of the project.

Landa Lake Restoration Results

In 2016, 236 m² of area was planted in six restoration plots in Landa Lake (**Figure 3.2-4**) bringing the four-year total of area planted in the lake to 2,927 m². In 2016, a total of 1,636 plants were planted into the Landa Lake LTBG Reach, which largely overlaps the Landa Lake Restoration Reach (**Table 3.2-6**). Plantings in Landa Lake included *Ludwigia*, *Cabomba* and *Potamogeton*. Plantings were also planted within the upper portion of the Mill Race on the New Channel of the Comal River (a.k.a. Lower Landa Lake Reach). Plantings in the Mill Race included *Ludwigia* and *Sagittaria*. **Table 3.2-7** presents the number and types of native aquatic plants that were planted in the Landa Lake LTBG Reach and the Mill Race Restoration Reach.

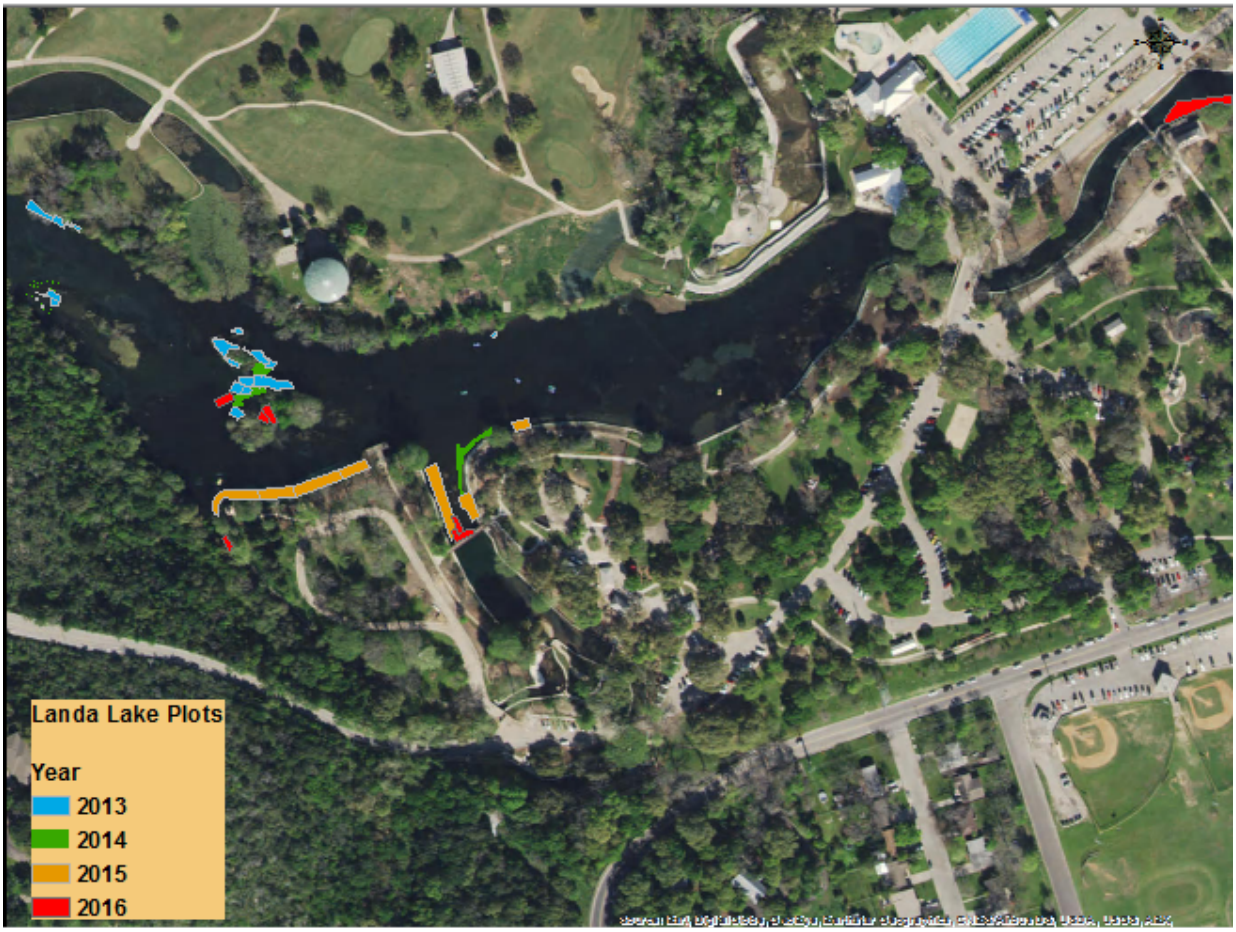

Figure 3.2-4. Map of restoration plots in the Landa Lake LTBG and Mill Race restoration reaches.

Table 3.2-6 provides seasonal cover of target aquatic plant species in the Landa Lake Restoration Reach in 2016. Seasonal cover of target species in this reach remained somewhat variable over the course of the year. *Ludwigia* and *Cabomba* cover was lower in October compared to January while *Sagittaria*, *Vallisneria* and bryophyte cover increased each season. Approximately 100 m^2 of *Sagittaria* was removed from around existing *Ludwigia* stands at the three islands area of Landa Lake. The removal of *Sagittaria* in this area was accomplished in order to prevent the encroachment of *Sagittaria* into the *Ludwigia* stand and to allow natural expansion of the *Ludwigia*.

Table 3.2-6. Number of Native Plants Planted Within Each Landa Lake Restoration Reach in 2016

Landa Lake Restoration Plantings					
Date Planted	***Ludwigia***	***Sagittaria***	***Cabomba***	***Vallisneria***	***Potamogeton***
3/1/16	150				
4/11/16	328				
4/11/16	328				
4/28/16	150				150
7/12/16			75		
7/13-14/16			355		
7/25/16	100*				
TOTALS	**1,056**		**430**		**150**
Mill Race Restoration Reach					
5/4/16	500	250			
5/4/16	15	100			
TOTALS	**515**	**350**			

*Planted as supplemental plantings.

In 2016, *Ludwigia* and *Sagittaria* were introduced into the Mill Race below Landa Lake to test the suitability of this area for these target plant species. Previously, the Mill Race has been a monoculture of *Vallisneria* with no other habitat type or aquatic plant species, including bryophytes, present. The establishment of different aquatic plants in this area will produce a more diverse environment which, even under low flow conditions, should receive enough continuous flow to maintain a healthy habitat for fountain darters.

Table 3.2-7. Seasonal Cover (m^2) per Vegetation Type in 2016 in Landa Lake LTBG and Mill Race Reaches

Species	January	April	August	October
Landa Lake LTBG Reach				
Ludwigia	607	591	616	532
Sagittaria	2,991	2,906	3,240	3,130
Cabomba	204	179	157	171
Bryophytes	1,121	1,765	2,067	2,772
Hygrophila	2	0	0	0
Vallisneria	13,668	14,992	14,060	14,589
Mill Race/Lower Landa Lake Restoration Reach				
Ludwigia	0	0	12	10
Sagittaria	0	0	4	7

Upper Spring Run Restoration Results

By the spring of 2016 all *Hygrophila* had been effectively eliminated from the Upper Spring Run area. Thus, in 2016 the introduction of *Ludwigia* began. *Ludwigia* was planted in five restoration plots in the Upper Spring Run LTBG Reach as well as three restoration plots in the Upper Spring Run Restoration Reach (**Figure 3.2-5**). The eight Upper Spring Run plots are collectively 620 m^2. A total of 622 *Ludwigia* plants were planted in the Upper Spring Run LTBG Reach and 530 planted in the Upper Spring Run Restoration Reach (**Table 3.2-8)**. **Table 3.2-9** shows the seasonal cover of *Ludwigia* and other vegetation types in the Upper Spring Run LTBG and Restoration reaches over the course of 2016.

In 2016, *Ludwigia* and *Cabomba* were the primary vegetation types utilized for restoration efforts in the Upper Spring Run since *Sagittaria* is well established and widespread in the Upper Spring Run. *Ludwigia*

and *Cabomba* have both been present in this stretch intermittently over the last several years. However, based on annual vegetation mapping, *Cabomba* has rarely been observed within the LTBG Reach while baseline mapping in 2013 and January of 2016 shows *Cabomba* present in several locations within the Upper Spring Run Restoration Reach.

Figure 3.2-5. Map of the Upper Spring Run LTBG Reach and three restoration reach plots.

Table 3.2-8. Number of Native Plants Planted Within Upper Spring Run Restoration Reach, by Plot, in 2016

2016 Upper Spring Run Plantings		
Upper Spring Reach LTBG Reach		
Date Planted	**Plot***	***Ludwigia***
4/11/16	2016E	328
6/3/16	2016J	150
7/26/16	2016M 1-3	144
TOTALS		**622**
Upper Spring Run Restoration Reach		
3/17/16		192
6/3/16		150
3/15/16		188
TOTALS		**530**

* Planting data is tracked by individual plot.

Table 3.2-9. Seasonal Cover (m^2) per Vegetation Type in 2016 in Upper Spring Run LTBG and Restoration Reaches

Species	January	April	July	October
Upper Spring Run LTBG Reach				
Ludwigia	11	10	35	53
Sagittaria	825	1,072	1,109	936
Cabomba	1	2	4	9
Bryophytes	155	754	570	1,540
Hygrophila	0	0	0	0
Upper Spring Run Restoration Reach				
Ludwigia	5	N/A	72	59
Sagittaria	277	N/A	204	287
Cabomba	12	N/A	26	57
Bryophytes	495	N/A	655	987
Hygrophila	2	N/A	0	0

Aquatic Vegetation Maintenance and Monitoring

Maintenance and gardening of the restoration reaches occurred throughout 2016. In January 2016, a total system gardening event took place to remove any *Hygrophila* sprigs that had established over winter. In general, gardening occurred once a month during the growing season (April to September) in order to remove any *Hygrophila* re-growth.

Monitoring of aquatic vegetation also continued in 2016. The vegetation monitoring program involves mapping of aquatic vegetation utilizing GPS and GIS technology. In 2016, four mapping events were conducted to evaluate the restoration projects and to assess coverage of individual native plant species. Restoration reaches were also photographed in 2016 using a drone or unmanned aerial vehicle.

Compliance for this measure is based on total coverage of fountain darter habitat in m^2 specified in Table 4-1 of the EAHCP. 2016 status is determined by the October monitoring event shown in **Table 3.2-10**.

Table 3.2-10. Status of Fountain Darter Habitat Within LTBG Reaches in Comal Springs Ecosystem (October 2016)

Fountain darter habitat (aquatic vegetation) status in m^2							
LTGB Reach	*Bryophytes*	*Hygrophila*	*Ludwigia*	*Cabomba*	Filamentous Algae	*Sagittaria*	*Vallisneria*
Upper Spring Run Reach	1,540	0	53	9	0	936	0
Landa Lake	2,772	0	532	171	0	3,130	14,589
Old Channel	250	503	35	0	0	0	0
New Channel	0	585	23	1,793	0	0	0
TOTALS	**4,562**	**1,088**	**643**	**1,973**	**0**	**4,066**	**14,589**

As discussed previously, and to be discussed in more detail later in this Annual Report, the original EAHCP LTBGs were amended through the AMP in 2016. As a result of the AMP in 2016, the EAHCP requested further amendments to Table 4-1 of the EAHCP in September 2016. In addition, the EAHCP requested further clarification to the EAHCP Key Management Objectives of "proportional expansion" and creation of "restoration reaches" for the Comal and San Marcos rivers at that same time. Those amendments and clarifications were approved by the USFWS in October 2016. For more detailed discussion of the 2016 AMP, please refer to **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.1.11.2** –

Amendments, Informational Memoranda, and Clarifications, and to **Chapter 4.0** – ADAPTIVE MANAGEMENT PROCESS ACTIVITIES FOR 2016, **Section 4.2** – Nonroutine Decisions.

Compliance reporting for 2016 maintained the original EAHCP LTBGs, while the new LTBGs will be reflected in the 2017 Annual Report.

Proposed Activities for 2017:

In 2017, the CONB will continue a program to increase the amount of aquatic vegetation preferred by fountain darters for habitat. Aquatic vegetation restoration efforts will be focused in the Landa Lake and Old Channel LTBG reaches, as well as within the Old Channel Restoration Reach. Aquatic vegetation restoration efforts in the Landa Lake LTBG Reach will include planting of *Ludwigia*, *Cabomba*, *Vallisneria*, and *Potamogeton* to move towards achieving the revised LTBGs. Efforts in the Old Channel will focus on the planting of *Ludwigia, Cabomba, Sagittaria,* and *Potamogeton*. Efforts in 2017 will also include continued maintenance and gardening in Landa Lake, the Upper Spring Run and the Old Channel to support existing native aquatic vegetation and suppression of non-native vegetation species (i.e. *Hygrophila*).

3.2.3 Management of Public Recreational Use of Comal Springs and River Ecosystems (EAHCP §5.2.3)

EAHCP Obligations:

The CONB will continue to enforce recreation restrictions on the Comal River that were in place at the time of EAHCP development through the duration of the ITP. This restriction specifically applies to regulations limiting recreation on Landa Lake, the spring runs in Landa Park, and the Old Channel of the Comal River. The CONB will additionally extend its take protection to commercial outfitting businesses willing to meet the conditions of such protection through a Certificate of Inclusion (COI) Program to be developed by the CONB.

2016 Compliance Actions:

The CONB continued to enforce City Ordinance Section 142-5, which restricts access to Landa Lake, the Spring Runs (with the exception of the wading pool on Spring Run #2), and portions of the Comal River, including the Old Channel. The CONB Parks Department continued to utilize trained park rangers to routinely patrol Landa Park to prevent access to these water bodies. In 2016, four signs were installed along the shoreline of Landa Lake and along the banks of the spring runs to inform park visitors of access restrictions and sensitive areas (**Figure 3.2-6**).

The CONB worked with EAA's EAHCP staff to discuss strategies for implementation of the COI Program.

Figure 3.2-6. New signage installed in Landa Park to inform visitors of access restrictions.

Proposed Activities for 2017:

The CONB will continue to educate and inform river recreation outfitters on the benefits of the EAHCP COI program. The CONB will recruit outfitters who conduct their operations in the Comal River system and wish to participate in the COI program. They will monitor the status of participating outfitters to comply with the minimum outfitter standards and requirements set forth in the EAHCP, and continue to uphold and enforce existing restrictions limiting recreational access to Landa Lake, spring runs, and portions of the Old and New Channels of the Comal River.

3.2.4 Decaying Vegetation Removal and Dissolved Oxygen Management (EAHCP §5.2.4)

EAHCP Obligations:

The CONB will continue to implement a DO management program in Landa Lake as required by the EAHCP. The program will be focused on monitoring DO concentrations and related water quality parameters in Landa Lake and mitigating for depressed DO levels (<4 mg/L), regardless of the initiating circumstances. Specific program elements include water quality data collection in Landa Lake, maintenance of water quality equipment, and operation and maintenance of the existing aeration system. The CONB will also explore options for optimizing the DO management program.

2016 Compliance Actions:

In 2016, the CONB continued to operate and maintain the existing water quality sonde and aeration system in Landa Lake (**Figure 3.2-7**). Water quality data including water temperature, DO, pH, conductivity, and turbidity was collected at the water quality sonde at 30-minute intervals throughout 2016.

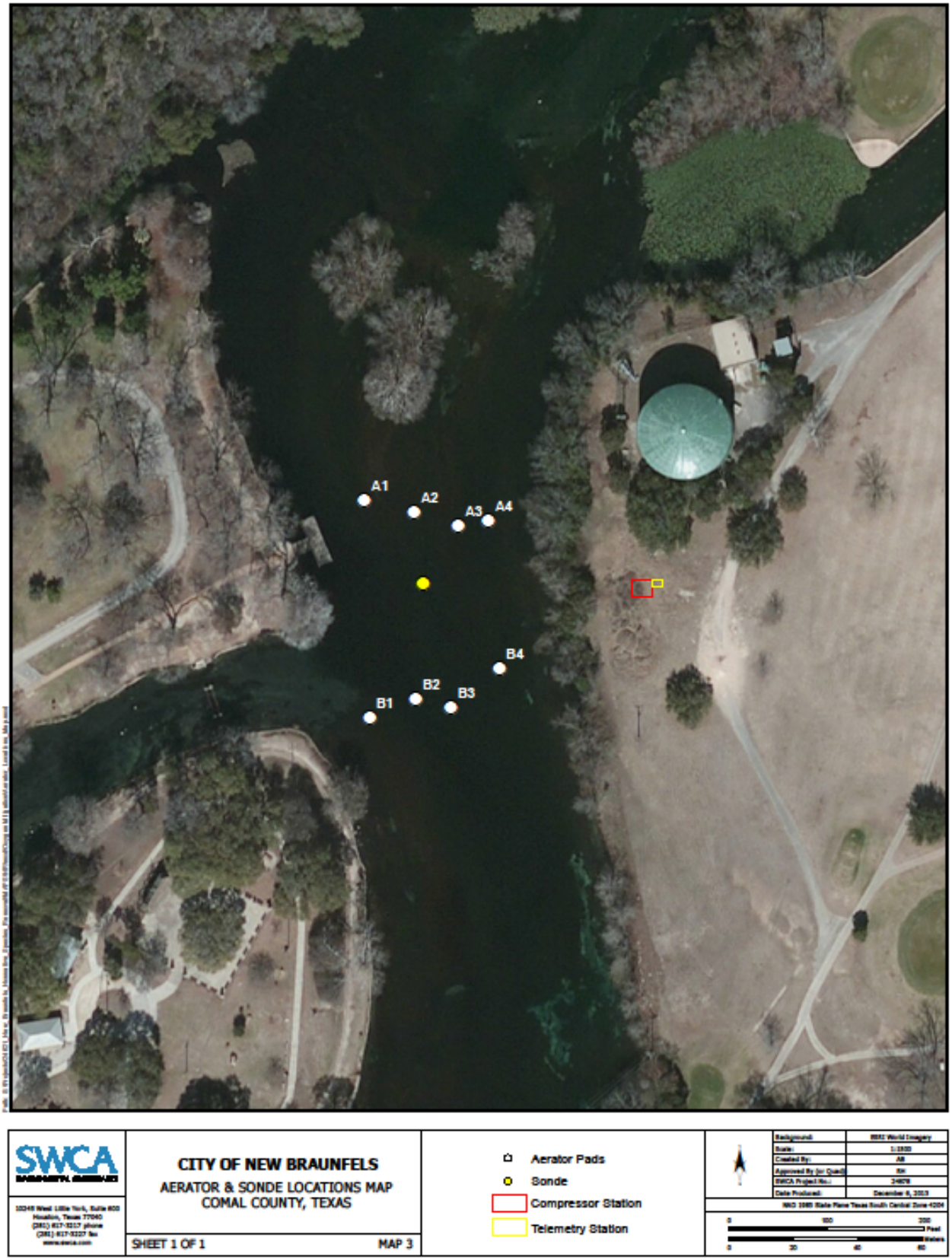

Figure 3.2-7. Location of existing water quality monitoring sonde and aeration system in Landa Lake.

Water quality data, including DO, was recorded throughout 2016 except during a period extending from late May to September 2016 when the monitoring equipment was offline due to a series of equipment malfunctions and repairs. A detailed report including the 2016 water quality monitoring results is included as **Appendix L1**. The existing aeration system in Landa Lake was inspected and maintained throughout 2016 to ensure continued operation. The aeration system was operated during the overnight hours throughout 2016 to supplement DO in Landa Lake.

Proposed Activities for 2017:

CONB will develop a comprehensive DO management plan for Landa Lake. The management plan will include an evaluation of DO data collected and DO-related research conducted to date. The management plan will identify feasible mitigation strategies that can be implemented in Landa Lake during periods of depressed DO. The CONB will continue to operate existing aerators when DO concentrations, as measured in Landa Lake, fall below 4 mg/l. The efficiency and suitability of the existing aerators to increase DO concentrations during periods of low springflow will also continue to be evaluated in 2017.

3.2.5 Control of Harmful Non-Native Animal Species (EAHCP §5.2.5)

EAHCP Obligations:

The CONB will implement a non-native species control program that targets armored catfish (Loricariidae), tilapia (*Oreochromis* sp.), nutria (*Myocastor coypus*), and giant ramshorn snail (*Marisa cornuarietis*). The CONB will conduct annual monitoring and maintenance activities to ensure continued control of invasive species populations within the Comal system.

2016 Compliance Actions:

In 2016, the CONB continued to implement a non-native species removal program focused on the targeted species. Efforts in 2016 involved six removal sessions, each three days in length, in April, May, June, July, August, and September. Gill nets, fyke nets, and hand-spears were utilized to capture fish species. Baited box traps were utilized to trap nutria. Over the course of 2016, approximately 1,855 pounds (lbs.) of invasive species biomass was removed from Landa Lake. This volume includes 93 armored catfish, 714 tilapia, and 11 nutria. **Table 3.2-11** presents the results of invasive species removal efforts that took place from April 2016 to September 2016. The total number removed, biomass, and average biomass per individual are reported for each species.

Table 3.2-11. Non-Native Animal Species Removal (April – September 2016)

Species	Number Removed	Biomass (lbs.)	Average biomass (lbs./individual)
Armored Catfish	93	218.4	2.35
Tilapia	714	1,588.0	2.22
Nutria	11	48.8	4.44
TOTALS	**818**	**1,855.2**	**N/A**

Comparing the three years of removal efforts, there were several key shifts in the data. During 2016, 11 nutria were captured and removed while observations indicated that additional nutria were unable to be

trapped. This data indicates that new breeding individuals have moved into the system from a source population and started to reestablish a breeding population. Eight of the eleven nutria removed were juvenile individuals while the other three were breeding adults.

In 2016, tilapia and armored catfish were caught in far fewer numbers as compared to 2013 and 2014. This is likely due to the smaller overall population of these species residing in Landa Lake. A significant shift in fish size was again documented in 2016. Each fish species showed a significant decrease in average length and weight as compared to previous years. This continued decrease in the size of captured fish strongly implies that removal efforts are suppressing the population's ability to breed and to gain adult mass.

A full report including additional information regarding characteristics of the removed species (i.e., length, weight, and sex ratios) is included as **Appendix L2** of this report.

Proposed Activities for 2017:

Continue existing program to remove non-native species, including tilapia, nutria, and armored catfish from the Comal River system utilizing removal methods proven successful in previous years.

3.2.6 Monitoring and Reduction of Gill Parasites (EAHCP §5.2.6 and §6.3.6)

EAHCP Obligations:

The CONB will retain a contractor to establish a monitoring and reduction program associated with the gill parasite, *Centrocestus formosanus* and its intermediate host snail, *Melanoides tuberculatus*. Obligated work activities in 2016 include the continuation of gill parasite cercaria water column density monitoring and host snail distribution and density monitoring. Additional research will be conducted through the AMP to determine the most appropriate strategy for gill parasite control in the system.

2016 Compliance Actions:

In 2016, the CONB continued a program to monitor the distribution, abundance, and density of both the gill parasite host snail (*M. tuberculatus*) and the free-swimming cercaria of the gill parasite. Data collection in 2016 was accomplished by using monitoring techniques established in previous years.

Sampling results in 2016 showed that 29 percent of sites sampled were occupied by red-rimmed melania (*Melanoides tuberculatus*), an intermediate host species for the gill species *Centrocestus formosanus* (**Table 3.2-12).** The frequency of *red-rimmed melania* remains high in Landa Lake and the New Channel above the old hydroelectric dam, but is still relatively low in the Old Channel of the Comal River and lower portions of the New Channel.

Table 3.2-12. Capture Results for *Melanoides tuberculatus* (MT) and *Marisa cornuarietis* (MC) from All Sites Sampled During 2013-2016 System-Wide Surveys for Comal River Study Area.

Year	Number of Sites	Number of MT	Number of Sites w/ MT	Number of Sites w/ >15 MT/ Dip	Number of MC
2013	245	1,480	88	11	37
2014	222	1,628	79	12	16
2015	197	1,198	82	4	6
2016	330	>1,953	97	40	4

Overall, host snail density estimates were much lower in 2016 (**Table 3.2-13**) and could be due to previous construction activities from 2015 as well as higher flows not allowing for settling of adult forms. Changes in size-class structure within sampling reaches were observed in 2016 (**Table 3.2-13**). Changes were observed to be decreasing; although mean snail length has remained relatively similar across years. Previously the increased frequency of larger snails was presumed to indicate an equilibrium state consequent of biological processes. In 2016, an increased frequency of larger snails (able to shed greater numbers of parasite cercaria) was observed in the New Channel Reach. Whereas, the other reaches (Old Channel Reach, Landa Lake, and Upper Spring Run) had lower frequencies of larger snails (**Table 3.2-13**).

Table 3.2-13. Mean Annual Snail Density Estimates and Mean Snail Lengths Averaged Over Samples Within Each Reach

Year	Sampling Reach							
	Upper Spring Run		Landa Lake		New Channel Reach		Old Channel Reach	
	Density (per m^2)	Length (mm)	Density (per m^2)	Length (mm)	Density (per m^2)	Length (mm)	Density (per m^2)	Length (mm)
2013	371.7 (±115.6)	26	399.3 (±70.9)	27	607.1 (±221.2)	25	---	---
2014	426.9 (±114)	23	350 (±103.3)	23	343.7 (±37.8)	29	146.2 (±32.6)	16
2015	480.2 (±127.7)	24	185.3 (±55.8)	26	147.1 (±55.9)	27	62 (±6)	15
2016	256 (±102.1)	25	155.7 (±49.5)	21	37.3 (±24)	34	35.6 (±20.9)	13

Estimates of density of drifting parasite cercaria in the water column at all three sampling sites were lower in 2016 relative to all other sample years (**Table 3.2-14**). All sampled reaches saw a decrease in densities for all seasons in 2016, except in the Old Channel Reach. The Old Channel Reach is historically a reach with the lowest densities, and is unique in that flow to this reach is controlled providing a much more stable flow regime relative to the other reaches. Thus, we would not expect to see large changes in parasite concentrations in this reach unless significant changes occurred in snail host populations.

Table 3.2-14. Mean Seasonal and Annual Cercaria Densities (cercaria/Liter)

Transect	Year	Season			
		Winter	Spring	Summer	OVERALL
Landa Lake Outflow	2014	4.4 (±0.4)	6.1 (±0.5)	13.3 (±0.6)	**7.9 (±1.0)**
	2015	2.6 (±0.3)	2.6 (±0.3)	3.4 (±0.3)	**2.9 (±0.2)**
	2016	0.8 (±0.9)	2.3 (±0.8)	1.9 (±0.8)	**1.6 (±2.2)**
Old Channel at Elizabeth Ave	2014	0.4 (±0.1)	1.0 (±0.2)	2.0 (±0.3)	**1.1 (±0.2)**
	2015	1.4 (±0.2)	1.9 (±0.2)	2.4 (±0.2)	**1.9 (±0.1)**
	2016	2.0 (±1.1)	1.2 (±0.9)	1.8 (±1.2)	**1.7 (±1.1)**
New Channel at Landa RV Park	2014	3.8 (±0.3)	7.8 (±0.9)	4.8 (±0.4)	**5.6 (±0.2)**
	2015	4.5 (±0.7)	3.1 (±0.3)	3.6 (±0.3)	**3.7 (±0.2)**
	2016	2.1 (±1.1)	2.5 (±0.8)	2.3 (±0.8)	**2.3 (±0.6)**

A full report regarding gill parasite monitoring activities in the Comal River system is included as **Appendix L3** of this report.

Proposed Activities for 2017:

The CONB will continue the gill parasite monitoring program that includes snail distribution and density monitoring, and cercaria water column concentration monitoring.

3.2.7 Prohibition of Hazardous Materials Transport Across the Comal River and Tributaries (EAHCP §5.2.7)

EAHCP Obligations:

The CONB will continue efforts to prohibit the transport of hazardous material (HAZMAT) on routes crossing the Comal River and its tributaries. This effort may include legislation, CONB ordinances, and additional signage.

2016 Compliance Actions:

Section 126-185 of CONB City Code designates Interstate Highway (IH)-35 and Loop 337 as thru hazardous cargo routes through the city limits, effectively prohibiting the transport of hazardous cargo over the Comal River and a majority of its key tributaries (**Figure 3.2-8**). Signs notifying drivers of the designated routes are located along IH-35 and State Highway 46. In 2016, CONB installed HAZMAT cargo prohibition signs at key locations. These locations include Rock Street near Loop 337, Gruene Road near Loop 337, River Road near Loop 337, Oakwood Blvd near Loop 337, and California Ave near Loop 337 (**Figure 3.2-8** and **Figure 3.2-9**).

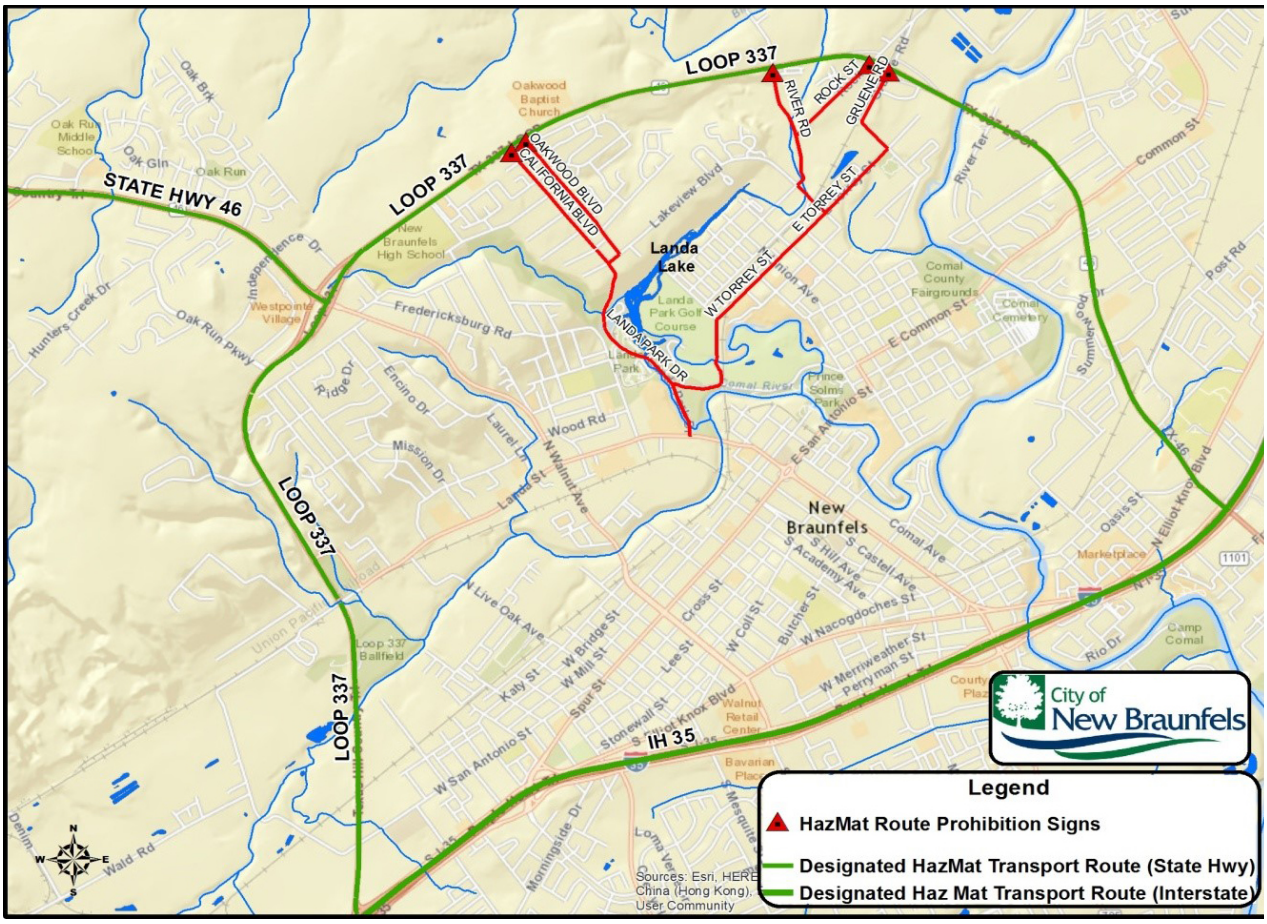

Figure 3.2-8. Map of designated HAZMAT transport routes and locations of HAZMAT route prohibition signs.

Figure 3.2-9. HAZMAT cargo prohibition signage.

Proposed Activities for 2017:

The CONB will maintain HAZMAT signage installed in 2016 and monitor for the presence of trucks carrying hazardous cargo on routes crossing the Comal River and its tributaries.

3.2.8 Native Riparian Habitat Restoration (Riffle Beetle) (EAHCP §5.2.8)

EAHCP Obligations:

In order to improve CSRB habitat, the CONB will implement a restoration program to improve the riparian zone along Spring Run #3 and the western shoreline of Landa Lake, and to minimize sedimentation impacts. The program will involve removal of non-native vegetation and revegetation with native species.

2016 Compliance Actions:

In 2016, CONB continued a program to plant and maintain riparian restoration along the northwestern bank of Spring Run #3 and along approximately 600 feet (ft) of the western shoreline of Landa Lake. The total length of the project area is approximately 1,105 ft, extending from the head of Spring Run #3 to a private property fence line on the western shoreline of Landa Lake. Restoration planting and erosion control activities extended from the shoreline to approximately 15 yards up the hillside. A summary of 2016 riparian restoration activities is presented below.

Restoration and maintenance activities in 2016 included:

1) planting of native riparian vegetation;
2) removal and/or treatment of exotic vegetation including Japanese ligustrum (*Ligustrum japonicum*) and elephant ear (*Colocasia* sp.);
3) maintenance of erosion control structures;
4) sediment and vegetation monitoring.

Planting of riparian vegetation was completed during two site visits that occurred on April 5, 2016 and May 24, 2016. Inland sea-oats (*Chasmanthium latifolium*) and indiangrass (*Sorghastrum nutans*) plugs have been successful in the past and were therefore used for restoration efforts in 2016. In 2016, 250 inland sea-oat and 150 indiangrass plugs were planted within the project area. Mexican buckeye (*Ungnadia speciosa*) seedlings (10) and cut grass plugs (10) were also planted in 2016 within the project area. All plantings were sprayed throughout the year with an egg and cayenne solution (one dozen eggs, three teaspoons cayenne to one gallon of water) to discourage deer, squirrels, and rodents, and to allow establishment of plant roots. Planted areas were monitored throughout the year for plant survival. Monitoring results, by plot, were compiled and are included in the full report in **Appendix L4**.

Re-emergent non-native plant species were continued to be removed from the project area in 2016. The areal extent of elephant ears in 2016 was very small, therefore, mechanical removal methods (hand pulling of plant and roots) were employed in lieu of herbicide application. By the end of 2016, elephant ears had nearly been eradicated from the project area. In 2016, Additional Ligustrum trees ranging between two inches and

six inches in diameter were cut six inches to twelve inches from the ground in order to keep the root structure intact, and to provide an anchor for installed erosion control structures. Limited re-growth was also observed from stumps left from the 2014 and 2015 removals, which were also re-treated.

Previously installed sediment capture devices were maintained and monitored for structural integrity and sediment capture throughout 2016. To monitor depth of captured sediment, a steel pin was driven just inside the erosion control structure approximately at the midway point along the structure length. Change in exposed height of the steel pin was used to calculate deposited material. To quantify captured sediment runoff, a series of measurements were taken by dividing the selected control structures into equal segments. Cross-sectional area was calculated for each segment by assuming measured cross sections were parallel to each other, and the control structure was roughly triangular in shape. This assumption is conservative and likely under-estimates sediment accumulation behind the erosion control structures. Captured sediment was estimated for the sampling period from April 5, 2016 to September 15, 2016. Total estimated sediment retained over this time period is estimated to be 19.44 cubic feet (ft^3).

Proposed Activities for 2017:

The CONB will continue to maintain previously restored areas along Spring Run #3 and the Western shoreline of Landa Lake. The CONB will also continue removal of non-native vegetation and planting of native riparian vegetation, and continue to monitor recently restored areas for stability and established vegetative growth.

3.2.9 Reduction of Non-Native Species Introduction and Live Bait Prohibition (EAHCP §5.2.9)

EAHCP Obligations:

The CONB will take action to prohibit the introduction of domestic and non-native aquatic organisms, targeting specifically bait species and aquarium trade species into the Comal River system. In addition, the CONB will continue to educate and promote awareness on the adverse impacts of aquarium dumping and use of non-native bait species to the Comal River ecosystem.

2016 Compliance Actions:

The CONB developed educational materials designed to inform the public of invasive species issues and the negative impacts of aquarium dumping. A non-native species introduction educational piece was included in the CONB's *Making the Most of Our Resources* newsletter that was distributed as an insert in 10,000 copies of the Sunday, July 3, 2016 edition of the local *New Braunfels Herald-Zeitung* newspaper.

Proposed Activities for 2017:

The CONB will continue developing and implementing a program to educate residents and visitors on the negative impacts of aquarium dumping and usage of specific live bait species. Education and outreach will

be achieved by distributing educational information and installing signage at key locations at Landa Lake and the Comal River. TPWD education materials and programs will be consulted and utilized.

3.2.10 Litter Collection and Floating Vegetation Management (EAHCP §5.2.10)

EAHCP Obligations:

The CONB will perform activities to manage floating vegetation and litter removal to enhance habitat for Covered Species. Management activities will include dislodging of vegetation mats that form on top of the water surface, particularly during low flows, to allow continued movement downstream, and removal of litter from the littoral zone and stream bottom. The CONB will manage floating vegetation mats in Landa Lake by removing floating materials entrained on the flow control structures, fishing piers, Three Island area, Landa Park Drive Bridge and other areas where mats collect. Litter removal in Landa Lake and the Comal River will continue under the existing CONB program.

2016 Compliance Actions:

The CONB continued to implement a program to remove litter and dislodge floating vegetation mats from Landa Lake and portions of the Comal River system where Covered Species habitat is present. Management of floating vegetation mats in key areas in Landa Lake and portions of the Comal River (**Figure 3.2-10**) prevents shading of restored aquatic vegetation areas, minimizes entrainment of material in the 48-inch culvert screen and control gate to the Old Channel, and reduces oxygen consumption in Landa Lake associated with decaying vegetation.

Litter collection efforts in 2016 consisted of litter removal from the surface of Landa Lake and the spring runs. Litter collection efforts also included removal of litter from select portions of the Old Channel and from the bottom of Landa Lake utilizing Self-Contained Underwater Breathing Apparatus (SCUBA) equipment. In 2016, approximately 236 lbs., or 109 7.5-gallon bags, of litter was collected.

Figure 3.2-10. Location of target floating vegetation mat management areas.

Proposed Activities for 2017:

Continue efforts to remove litter and dislodge floating vegetation mats from applicable portions of the Comal River system to prevent negative impacts to flow control structures, aquatic restoration reaches, and Covered 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 may be initiated to prevent oxygen consumption by decaying vegetative material as per Decaying Vegetation Removal and Dissolved Oxygen Management (EAHCP §5.2.4)

3.2.11 Management of Golf Course Diversions and Operations (EAHCP §5.2.11)

EAHCP Obligations:

The CONB will develop and implement a Golf Course Management Plan that will include an IPMP designed to target techniques to protect water quality and minimize potential negative effects to Covered Species.

2016 Compliance Actions:

The CONB continued to update the existing IPMP, as needed, and maintain a vegetative buffer between the golf course and Landa Lake and the Old Channel of the Comal River in order to provide increased water quality protection. This *2016 Landa Lake Golf Course Integrated Pest Management Plan* is located in **Appendix L5** of this Annual Report.

Proposed Activities for 2017:

The CONB will continue to update the IPMP and maintain a vegetative buffer between the golf course and Landa Lake and the Old Channel of the Comal River. The IPMP will be revised, as needed; to address any operational changes associated with the management of the golf course grounds.

3.2.12 Native Riparian Habitat Restoration (Old Channel Improvements) (EAHCP §5.7.1)

EAHCP Obligations:

The CONB will initiate a riparian restoration program to enhance the riparian zone along the Old Channel, the golf course, and in the vicinity of Clemens Dam. The CONB will implement bank stabilization and riparian restoration activities in the Old Channel adjacent to where the sediment island was removed.

2016 Compliance Actions:

The CONB underwent efforts in 2016 to stabilize and restore approximately 1,000 ft of previously eroding streambank area along the Old Channel of the Comal River. The Bank Stabilization Project was completed according to design specifications set forth in the plans titled "Comal River Bank Reclamation and Riparian Zone Restoration."

The Bank Stabilization Project began in May 2016. Bladder dams were installed within the Old Channel prior to the commencement of construction activities to create a stabilized work area and to minimize sediment and debris from entering the main portion of the channel (**Figure 3.2-11**).

Figure 3.2-11. Water-filled bladder dams installed prior to project construction.

The project involved the re-contouring of the existing slope and installation of toe-of-slope support system, mid-slope waler walls, run-on control berms, and drainage swales. Effort was made to preserve existing native trees located on the project site. Photos of the completed slope stabilization elements are illustrated in **Figure 3.2-12**.

Figure 3.2-12. Photos of the bank stabilization work.

The photos in **Figure 3.2-12**, from top-left and clockwise, illustrate the toe wall, mid-slope waler wall, run-on control berm, and grouted rock swales.

The project also included riparian restoration activities that were completed within and around the main Bank Stabilization Project area (**Figure 3.2-13**). Riparian restoration work associated with the project included treatment of non-native invasive vegetation, seeding with a native seed mixture, and planting of native plants and trees.

The CONB project engineer completed as-built drawings for the Bank Stabilization Project. These as-built drawings document the structural elements installed as part of the project (**Appendix L6**).

Figure 3.2-13. Riparian restoration work area, outlined in red, and site location of Bank Stabilization Project.

Treatment of large, woody invasive species such as Japanese ligustrum (*Ligustrum japonicum*), Chinese tallow (*Triadica sebifera*) and chinaberry (*Melia azedarach*) was accomplished by injecting herbicide directly into the tree trunk. A total of 75 Ligustrum, 60 Chinese tallow and five chinaberry trees were treated using this method. Tree saplings less than two inches in diameter were treated with a foliar application of aquatic-approved Glyphosate mixture ranging from two percent to five percent depending on conditions. Trees that had succumbed to herbicide treatment were removed and utilized to create 300-linear ft of erosion control berms along the Old Channel between Landa Lake and the main portion of the bank project. Elephant ears within the restoration reach were treated by applying Aquaneat, a glyphosate-based herbicide, to the foliage. Approximately 2,150 ft^2 of elephant ear coverage was treated with the foliar herbicide application. Elephant ears were also removed using mechanically. Photos illustrating the initial effectiveness of the elephant ear treatments are included in **Figure 3.2-14**.

Figure 3.2-14. Elephant ear stands within restoration reach.

The top photo in **Figure 3.2-14** depicts the restoration reach prior to treatment, the middle photo shows the restoration area two weeks after treatment, and the bottom photo shows the same area seven weeks following treatment.

Following the completion of construction activities, erosion control matting was installed over the disturbed areas of the re-graded slope. Approximately one inch of top soil was spread on top of the erosion control matting. The prepared areas were hydro-seeded on October 10, 2016 using a native plant seed mix (**Table 3.2-15**) applied at twice the recommended seeding rate. Photos of the prepared slopes and the hydro-seeding process are illustrated in **Figure 3.2-15**.

Table 3.2-15. Seed Types Utilized in Hydro-seed Mixture

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 (*Chamaecrista fasciculate)*
Prairie Wildrye (*Elymus canadensis)*	Texas Yellow Star (*Lindheimeri 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)*	
Hall's Panicum (*Panicum hallii)*	
Bushy Bluestem (*Andropogon glomeratus)*	
Cereal Rye (*Secale cereale*)	

Figure 3.2-15. The completed bank stabilization work (top) and hydro-seeding process (bottom).

Native plants and trees were planted intermittently throughout the stabilized bank area and restoration area. More than 200 trees and shrubs were planted within the restoration reach. The species of trees, shrubs, and herbaceous plants that were planted within the restoration reach are included in **Table 3.2-16**. Many of the plantings were enclosed with wire cages to prevent deer browsing. An additional 300 Turk's caps (*Malvaviscus arboreus var. drummondii*) were planted within the restoration reach, primarily behind the newly constructed erosion control berms. Volunteer work days were organized to encourage public participation and to get assistance with planting efforts (**Figure 3.2-16**).

Table 3.2-16. Riparian Plantings

Trees and Shrubs	Herbaceous
American Beautyberry (*Callicarpa americana)*	Bushy Bluestem (*Andropogon glomeratus*)
Bald Cypress (*Taxodium distichum)*	Coral Honeysuckle (*Lonicera sempervirens*)
Bee Brush (*Eysenhardtia texana)*	Creeping Spotflower (*Acmella oppositifolia* var. *repens*)
Black Walnut (*Juglans nigra)*	Emory Sedge (*Carex emoryi*)
Burr Oak (*Quercus macrocarpa)*	Frog Fruit (*Phyla nodiflora*)
Buttonbush (*Cephalanthus occidentalis)*	Frostweed (*Helianthemum canadense*)
Elderberry (*Sambucus canadensis)*	Strangler daisy (*Calyptocarpus vialis*)
Eve's Necklace (*Styphnolobium affine)*	Inland Sea Oats (*Chasmanthium latifolium*)
Fragrant Sumac (*Rhus aromatica*)	Switchgrass (*Panicum virgatum*)
Green Ash (*Fraxinus pennsylvanica)*	Texas Lantana (*Lantana urticoides*)
Mexican Buckeye (*Ungnadia speciosa)*	Turks Cap (*Malvaviscus arboreus var. drummondii*)
Mexican Plum (*Prunus mexicana)*	Water Willow (*Decodon verticillatus*)
Pecan (*Carrya illinoinenesis)*	White Boneset (*Eupatorium serotinum*)
Possum Haw Holly (Ilex decidua)	Woodland Fern
Red Buckeye (*Aesculus pavia)*	Woodland Sedge (*Carex blanda*)
Red Mulberry (*Morus rubra)*	Yellow Bidens (*Bidens sp.*)
Dwarf Palmetto (*Sabal minor*)	Orange wedelia (*Wedelia acapulcensis var hispida*)
Soapberry (*Sapindus drummondii)*	
Sycamore (*Platanus occidentalis)*	
Texas Red Oak (*Quercus buckleyi)*	

Figure 3.2-16. Volunteers helping to plant native riparian plants within the restoration reach.

A brief summary of the riparian restoration efforts associated with the Bank Stabilization Project is included in **Appendix L7**.

Proposed Activities for 2017:

The CONB will continue to monitor and maintain previously restored riparian areas along the Old Channel of the Comal River between Landa Lake and the Golf Course Road Bridge crossing (i.e. maintenance of riparian restoration that occurred as part of the Bank Stabilization and Riparian Restoration project in 2016). Monitoring and maintenance activities will include follow-up treatment of non-native, invasive plant species (as needed), re-seeding (as needed), and irrigation (as needed). The CONB will also remove non-native

riparian vegetation along the Old Channel of the Comal River between Golf Course Road and the Old Channel LTBG Reach. Removal of non-native vegetation and select native vegetation will first be targeted to locations that will increase solar penetration and complement aquatic vegetation restoration efforts. The CONB will install erosion control structures along channel utilizing removed non-native vegetation.

3.2.13 Management of Household Hazardous Wastes (EAHCP §5.7.5)

EAHCP Obligations:

The CONB will continue to implement a Household Hazardous Waste (HHW) program. The CONB will continue to enhance its HHW program to generate additional participation by the general public.

2016 Compliance Actions:

The CONB held three HHW collection events in 2016. The HHW collection events were held in February, May and October. Overall, 802 cars/participants were recorded, and a total of 81,346 lbs. of hazardous waste collected (**Figure 3.2-17**). The CONB produced educational materials to increase awareness of the HHW program and the EAHCP (e.g., including web links to the CONB's EAHCP and HHW website).

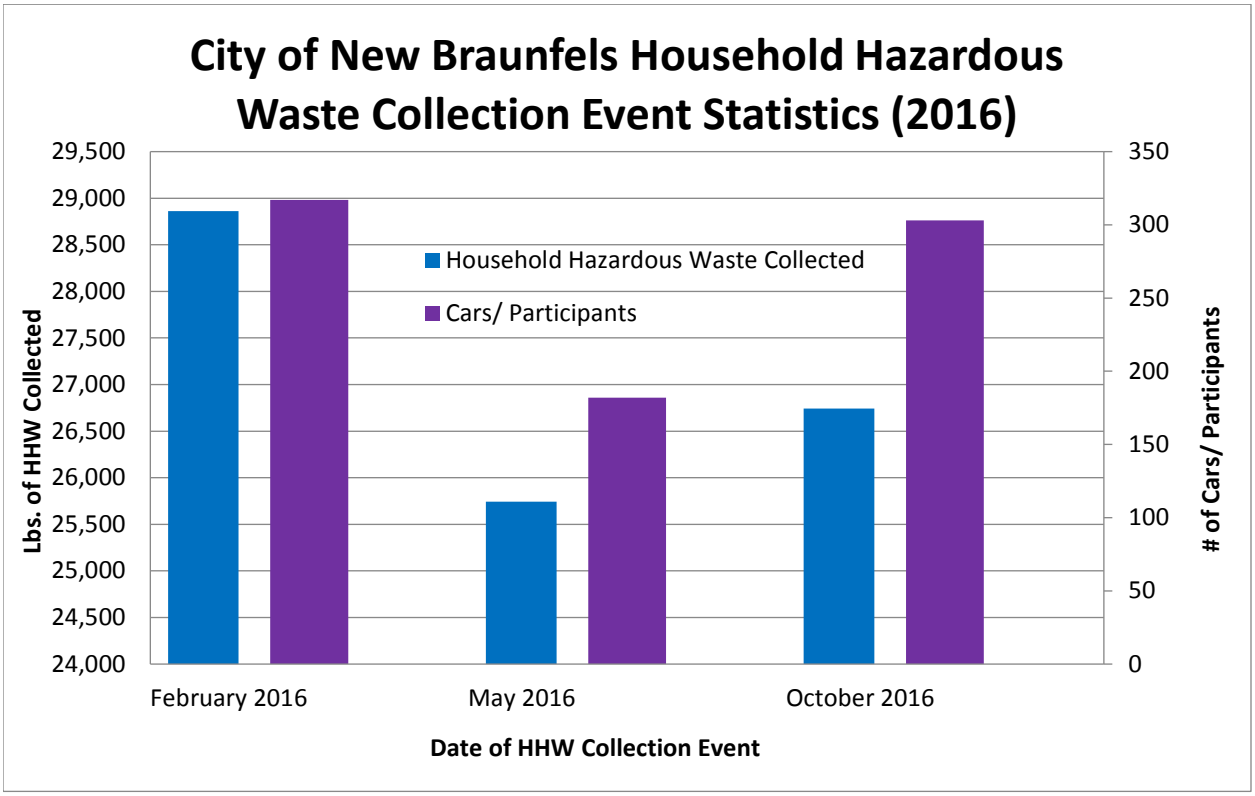

Figure 3.2-17. 2016 Household Hazardous Waste collection event statistics.

Proposed Activities for 2017:

The CONB will continue the HHW program in 2017, which will include three HHW collection events. The CONB will tentatively hold a fourth HHW collection event in 2017 pending available budget.

3.2.14 Impervious Cover and Water Quality Protection (EAHCP §5.7.6)

EAHCP Obligations:

The CONB will expand criteria related to desired impervious cover, provide incentives to reduce existing impervious cover on public and private property in New Braunfels, and implement BMPs associated with stormwater runoff in the area of Landa Lake and the spring runs.

2016 Compliance Actions:

The CONB provided financial incentives to support the removal of existing impervious cover associated with the Headwaters at the Comal (a.k.a. Comal Springs Conservation Center) project. The project is located near the confluence of Blieders Creek and the Upper Spring Run area of Landa Lake (**Figure 3.2-18**). The project is being led by NBU and includes the removal of 85 percent of the existing impervious cover, native plant restoration, restoration of Spring Run #4, and construction of LID features, such as bioswales and rain gardens, designed to treat stormwater runoff prior to entering Landa Lake. The project will provide direct water quality benefits to Landa Lake and the Comal River system by increasing infiltration and treating stormwater runoff.

Figure 3.2-18. Location of the Headwaters of the Comal Project that includes impervious cover removal and native plant restoration.

Proposed Activities for 2017:

The City will continue to examine the LID Rebate Program, as it has been developed to date, and will evaluate potential water quality management strategies, methods, and funding for implementation of a water quality protection program.

3.2.15 Challenges Observed and Identified Solutions

Overall, the EAHCP measures completed in 2016 went well. With respect to the Native Aquatic Vegetation Restoration Program, *Cabomba* has been difficult to establish in Landa Lake. A reduction in natural-growing *Cabomba* in Landa Lake has been observed based on annual and seasonal vegetation mapping. It is thought that this decrease is attributable to the natural expansion of *Sagittaria* in the lake, which consumes available habitat for *Cabomba*. Future efforts may include more extensive gardening of *Sagittaria* to prevent growth into existing or planned *Cabomba* areas. Vegetation along the eastern shoreline of Landa Lake may also be blocking solar exposure to *Cabomba* plants, which may be negatively impacting growth. CONB will explore options to increase solar exposure to the eastern portion of Landa Lake to promote *Cabomba* growth.

The growth of native grasses within the Bank Stabilization Project area has been marginal. While grass growth is evident, browsing deer and squirrels have negatively impacted establishment of much of the riparian plantings. The growth of native grass within the project area will be monitored. Riparian restoration efforts in 2017 will include continued monitoring and maintenance of this area in order to ensure optimal vegetative growth and stabilization. This effort may include re-seeding, installation of deer fencing and/ or the installation of additional plants and shrubs to offset the marginal grass growth.

3.3 City of San Marcos

The COSM is responsible for the following measures under the EAHCP:

- Texas wild-rice Enhancement and Restoration (EAHCP §5.3.1 and §6.3.5)
- Management of Recreation in Key Areas (EAHCP §5.3.2)
- Management of Aquatic Vegetation and Litter Below Sewell Park (EAHCP §5.3.3)
- Prohibition of Hazardous Materials Transport Across the San Marcos River and Its Tributaries (EAHCP §5.3.4)
- Reduction of Non-Native Species Introduction (EAHCP §5.3.5)
- Sediment Removal Below Sewell Park (EAHCP §5.3.6)
- Designation of Permanent Access Points and Bank Stabilization (EAHCP §5.3.7)
- Control of Non-Native Plant Species (EAHCP §5.3.8)
- Control of Harmful Non-Native and Predator Species (EAHCP §5.3.9)
- Native Riparian Habitat Restoration (EAHCP §5.7.1)
- Septic System Registration and Permitting Program (EAHCP §5.7.3)
- Minimizing Impacts of Contaminated Runoff (EAHCP §5.7.4)
- Management of Household Hazardous Wastes (EAHCP §5.7.5)
- Impervious Cover and Water Quality Protection (EAHCP §5.7.6)

Implementation of these measures has been accomplished in partnership with Texas State, as specified in the EAHCP. The COSM extended its EAHCP obligations in partnership with Texas State to maintain consistency in implementation of EAHCP measures that jointly affect the Covered Species and their habitats in the San Marcos River.

3.3.1 Texas wild-rice Enhancement and Restoration (EAHCP §5.3.1 and §6.3.5)

EAHCP Obligations:

The COSM, in partnership with Texas State, will identify optimal habitat areas for Texas wild-rice (*Zizania texana*) and target those areas for restoration. Restoration will involve the removal of non-native plant species, propagation of new Texas wild-rice plants, and continued monitoring of the new stands. The COSM will use modeling results from Texas State to determine appropriate sites for restoration to ensure the highest possible success rate.

2016 Compliance Actions:

Non-native aquatic vegetation was removed in areas suggested as optimal Texas wild-rice habitat based on modeling results from Hardy et al. 2010. Non-native vegetation was also removed in mixed stands of Texas wild-rice, and original Texas wild-rice stands were monitored for expansion. Similarly, for Texas wild-rice stands occupying optimal areas with adjacent non-native vegetation, the non-native vegetation was removed and Texas wild-rice monitored for expansion. Non-native vegetation was fanned to displace fountain darters (*Etheostoma fonticola*) prior to uprooting the vegetation. After removal, all non-native vegetation was sorted, and any fountain darters that remained in the piles were salvaged and returned to the river. The non-native vegetation was disposed at the COSM composting facility or the Spring Lake composting facility. Portions of the denuded areas were planted with Texas wild-rice obtained from the SMARC (seed-derived) or from raceways (tiller-derived) located at the FAB. Polygons of areas planted with Texas wild-rice were developed in ArcMap with number of individual plants recorded. Areal coverage of Texas wild-rice for 2016 was assessed using geo-referenced areal imagery collected with a quadcopter in conjunction with ground-truthed data collected using Trimble GPS units.

Table 3.3-1 illustrates an estimated 7,469 Texas wild-rice individuals planted between November 2015 – November 2016 in Spring Lake and the San Marcos River. These individuals covered 20 to 50 percent of the denuded area. Estimated area planted for Texas wild-rice was 285 m^2. **Figure 3.3-1** and **Figure 3.3-2** illustrate planting locations of Texas wild-rice in Spring Lake and the San Marcos River.

Table 3.3-1. Estimated Number of Texas wild-rice Individuals Planted, Estimated Area of Texas wild-rice Planted, and Number of Days Worked Planting Texas wild-rice per Reach in Spring Lake and the San Marcos River, 2015-2016 Comparison

Recreation Reach	Work Site	No. Individuals Planted		Estimated Area Planted (m^2)		Effort (Days Worked)	
		2015	2016	2015	2016	2015	2016
Spring Lake	Spring Lake	0	3,512	0	85	0	6
Spring Lake Dam – Rio Vista Dam	Headwaters	0	0	0	0	0	0
	Sewell Park	0	250	0	7	0	1
	Below Sewell	95	0	9	0	1	0
	City Park	8,752	348	616	16	18	0
	Hopkins St. – Purgatory	0	869	0	14	0	3
	Cypress Island	7,752	1,115	337	58	26	8
	Reach Total	16,599	2,582	962	95	45	12
Rio Vista Dam – IH-35	Above IH-35	0	1,375	0	105	0	8
TOTAL RIVER		**16,599**	**7,469**	**962**	**285**	**45**	**26**

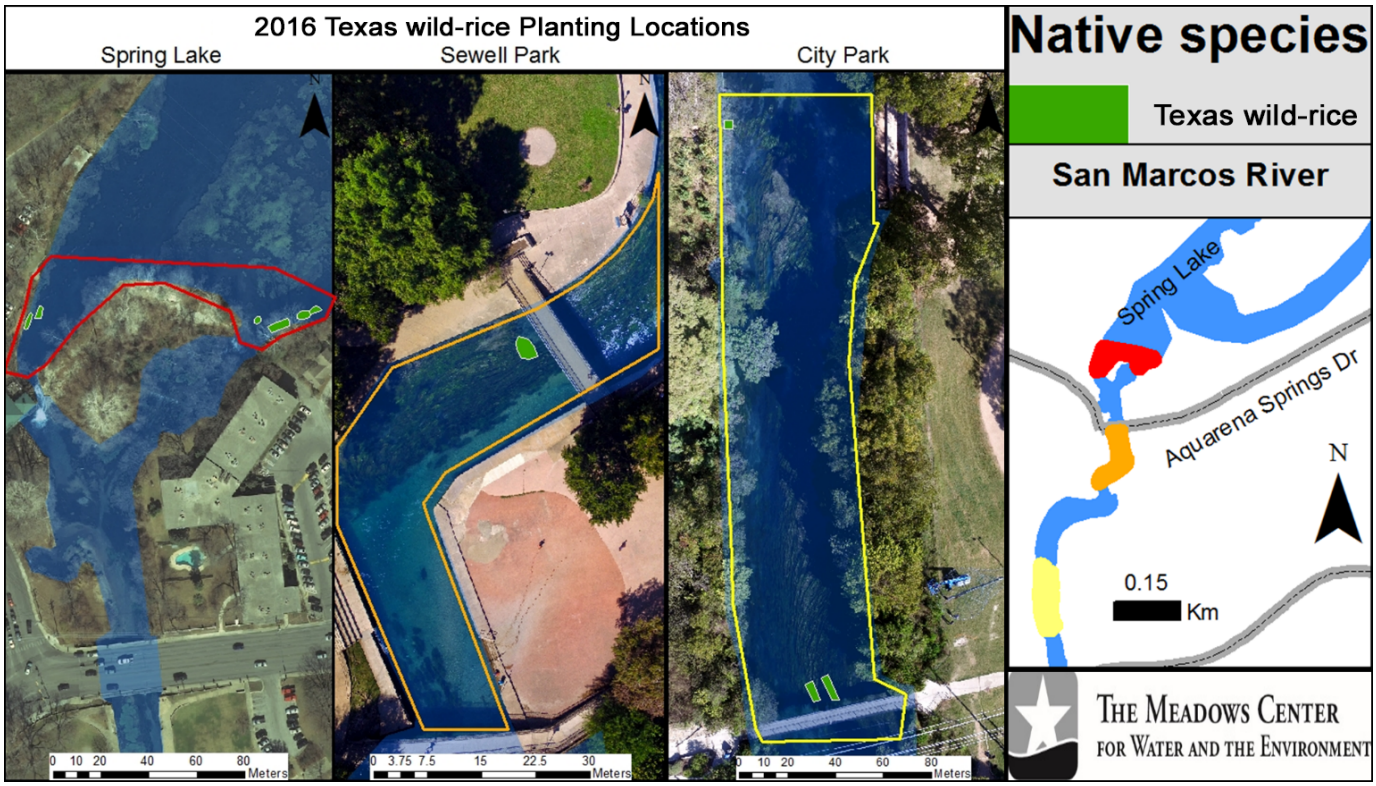

Figure 3.3-1. Planting locations of Texas wild-rice in Spring Lake, Sewell Park, and City Park in 2016.

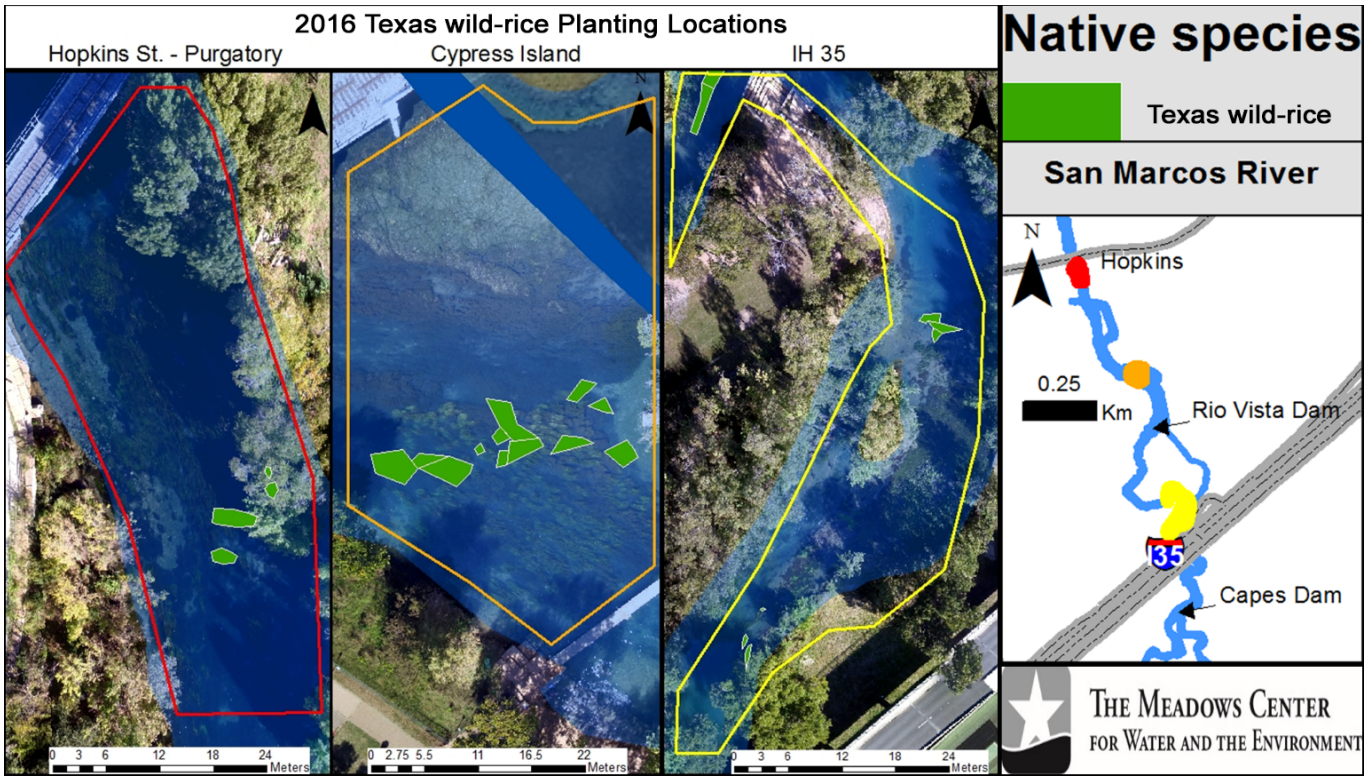

Figure 3.3-2. Planting locations of Texas wild-rice at Hopkins St. bridge – Purgatory, Cypress Island, and IH-35 in 2016.

Table 3.3-2 quantifies changes in Texas wild-rice coverage from 2013 to 2016. Since 2013, Texas wild-rice has increased through plantings and natural expansion an estimated 3,338.8 m^2 within work sites (i.e., Spring Lake to IH-35). Since 2015, Texas wild-rice has expanded by an estimated 798.6 m^2. **Figure 3.3-3** through **Figure 3.3-10** illustrate changes in areal coverage of Texas wild-rice among work sites.

Table 3.3-2. Texas wild-rice 2016 Areal Coverage, Change in Areal Coverage 2013-2016, and Change in Areal Coverage 2015-2016, per LTBG Reach (m^2)

Restoration Reach	Work Site	Total Area (m^2)					
						Change	
		2013	2014	2015	2016	2013-2016	2015-2016
Spring Lake	Spring Lake	0.0	0.0	0.0	47.1	47.1	47.1
Spring Lake Dam – Rio Vista Dam	Headwaters	198.5	360.2	572.8	887.3	688.8	314.5
	Sewell Park	666.3	838.7	1,201.5	1,185.8	519.5	-15.7
	Below Sewell	1,212.0	1,963.0	2,253.0	2,429.0	1,217.0	176.0
	City Park	384.0	603.0	1,348.0	1,545.0	1,161.0	197.0
	Hopkins St. – Purgatory	6.2	0.0	0.0	84.9	78.7	84.9
	Cypress Island	0.0	0.0	123.0	238.0	238.0	115.0
	Reach Total	**2,467.0**	**3,764.9**	**5,498.3**	**6,370.0**	**3,903.0**	**871.7**
Rio Vista Dam – IH-35	Above IH-35	0.0	0.0	81.7	276.0	276.0	194.3
TOTAL RIVER		**2,467.0**	**3,764.9**	**5,580.0**	**6,693.1**	**4,226.1**	**1,113.1**

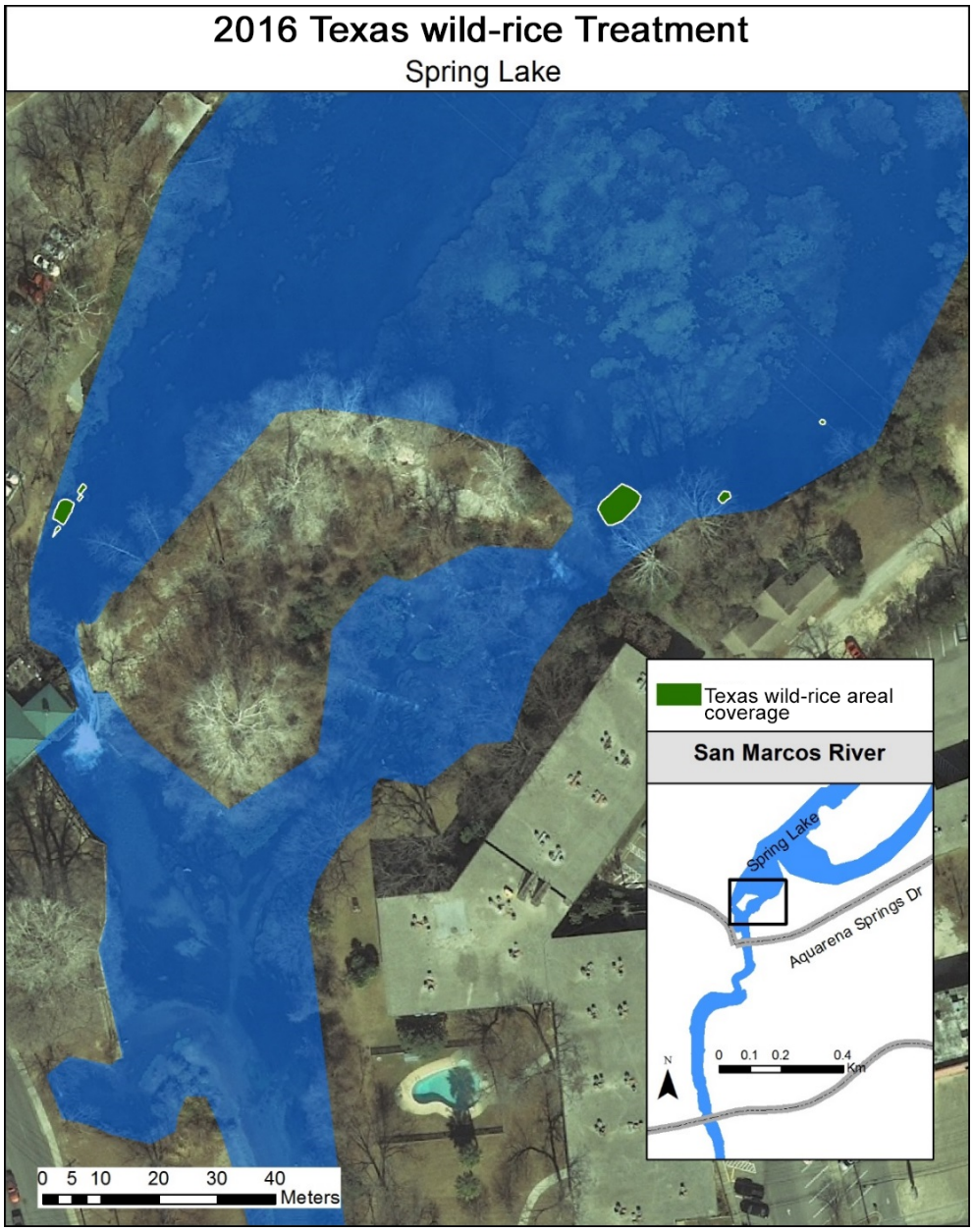

Figure 3.3-3. Texas wild-rice areal coverage in Spring Lake 2016.

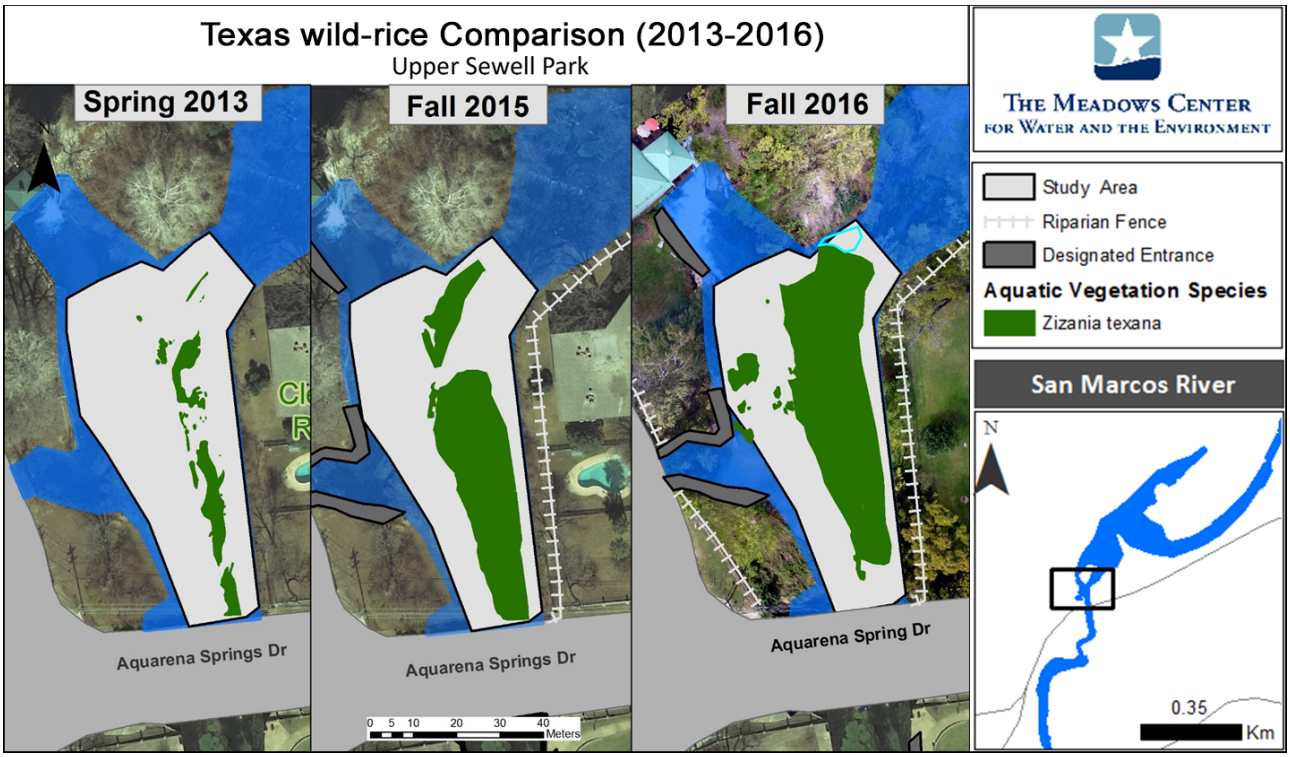

Figure 3.3-4. Texas wild-rice areal coverage in upper Sewell Park (headwaters near Saltgrass) prior to vegetation treatment (spring 2013), one year ago fall 2015), and this year (fall 2016).

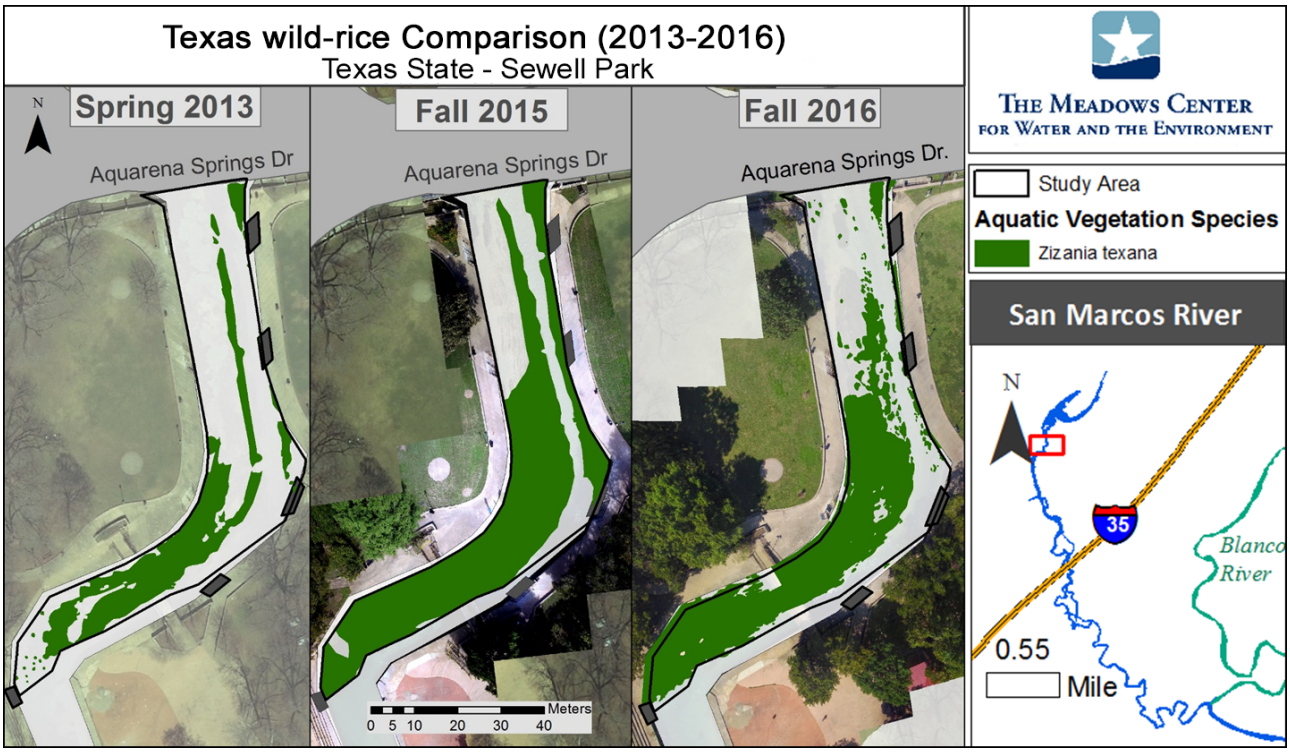

Figure 3.3-5. Texas wild-rice areal coverage in Sewell Park prior to vegetation treatment (spring 2013), one year ago (fall 2015), and this year (fall 2016).

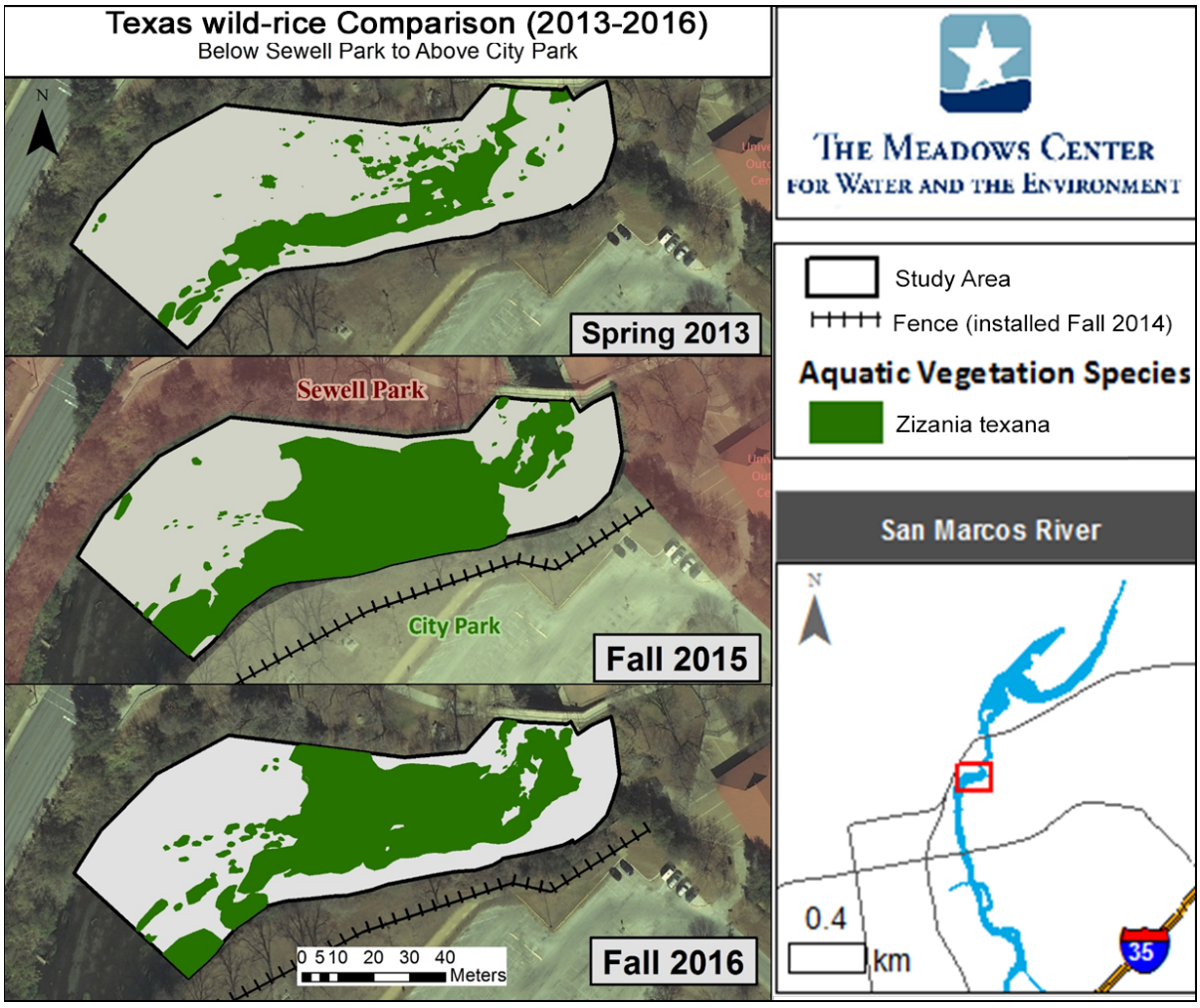

Figure 3.3-6. Texas wild-rice areal coverage below Sewell Park to above City Park prior to vegetation treatment (spring 2013), one year ago (fall 2015), and this year (fall 2016).

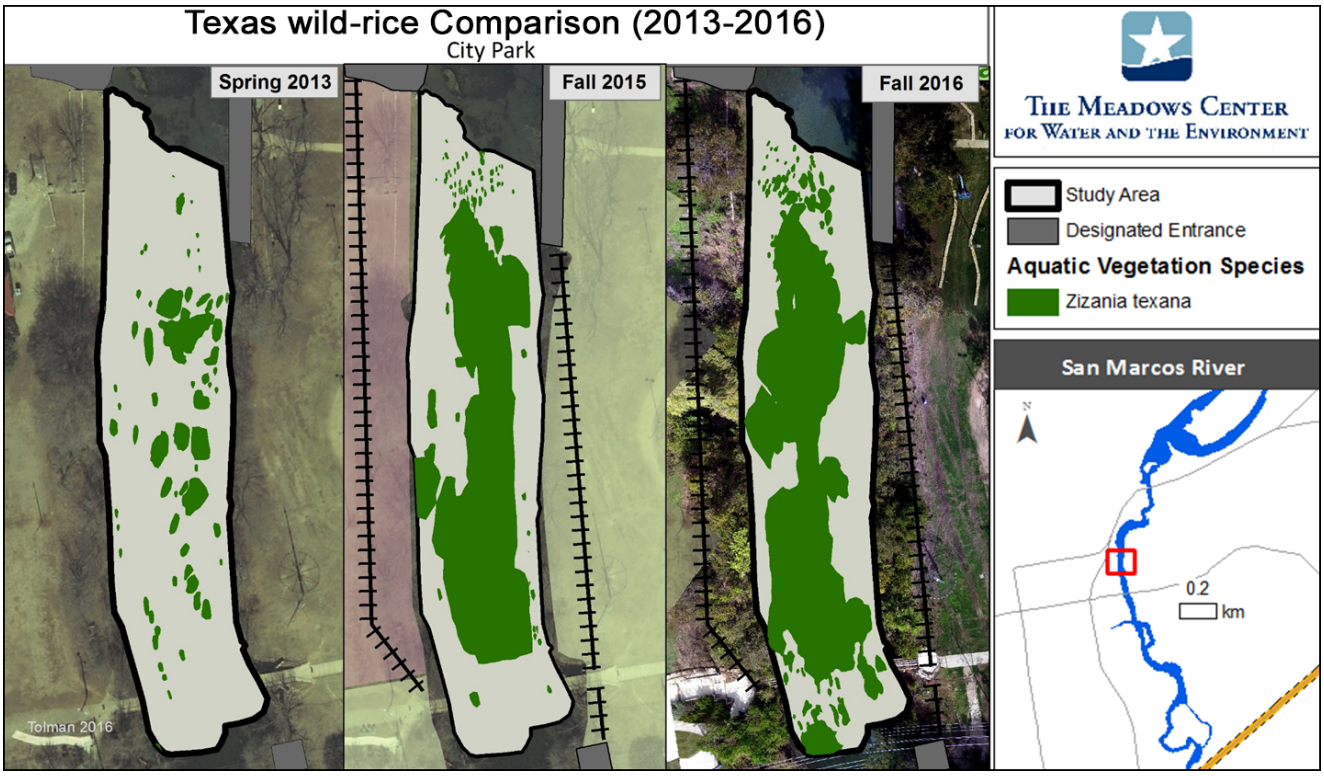

Figure 3.3-7. Texas wild-rice areal coverage at City Park prior to vegetation treatment (spring 2013), one year ago (fall 2015), and fall 2016.

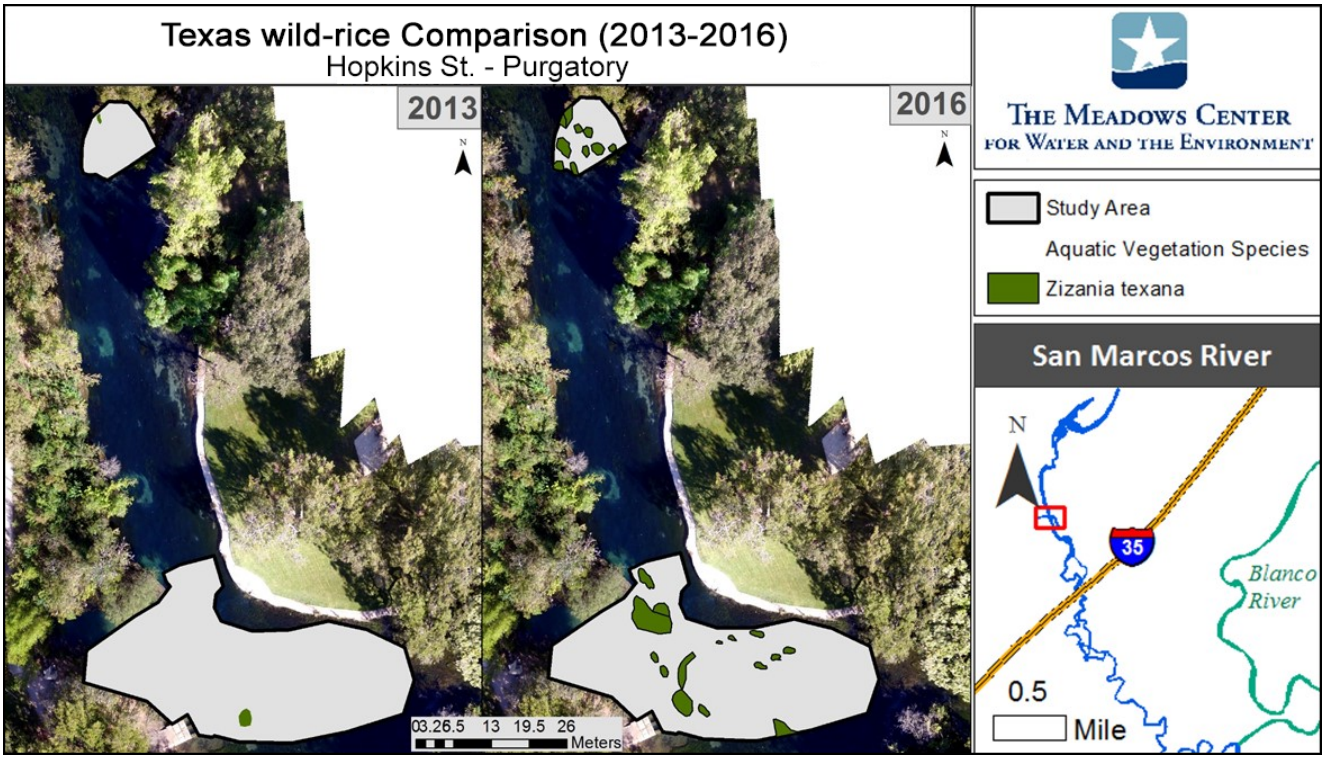

Figure 3.3-8. Texas wild-rice areal coverage at Hopkins Street – Purgatory Creek prior to vegetation treatment (spring 2013) and fall 2016.

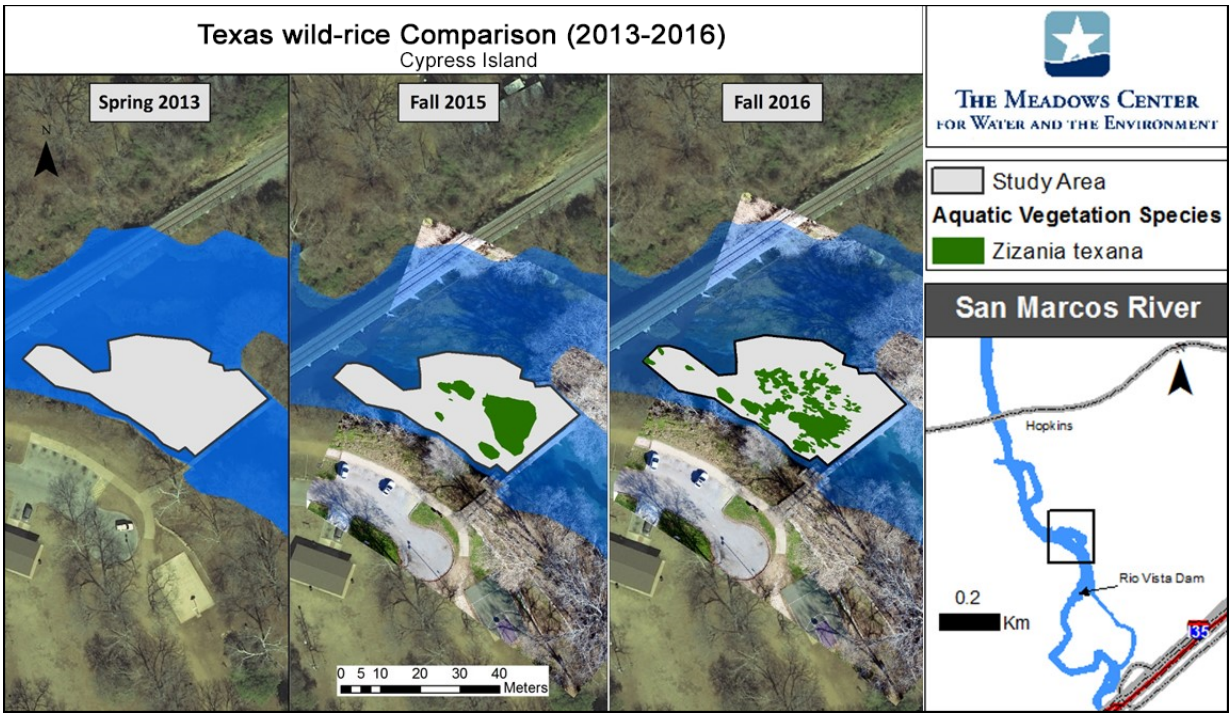

Figure 3.3-9. Texas wild-rice areal coverage at Cypress Island prior to vegetation treatment (spring 2013), one year ago (fall 2015), and this year (fall 2016).

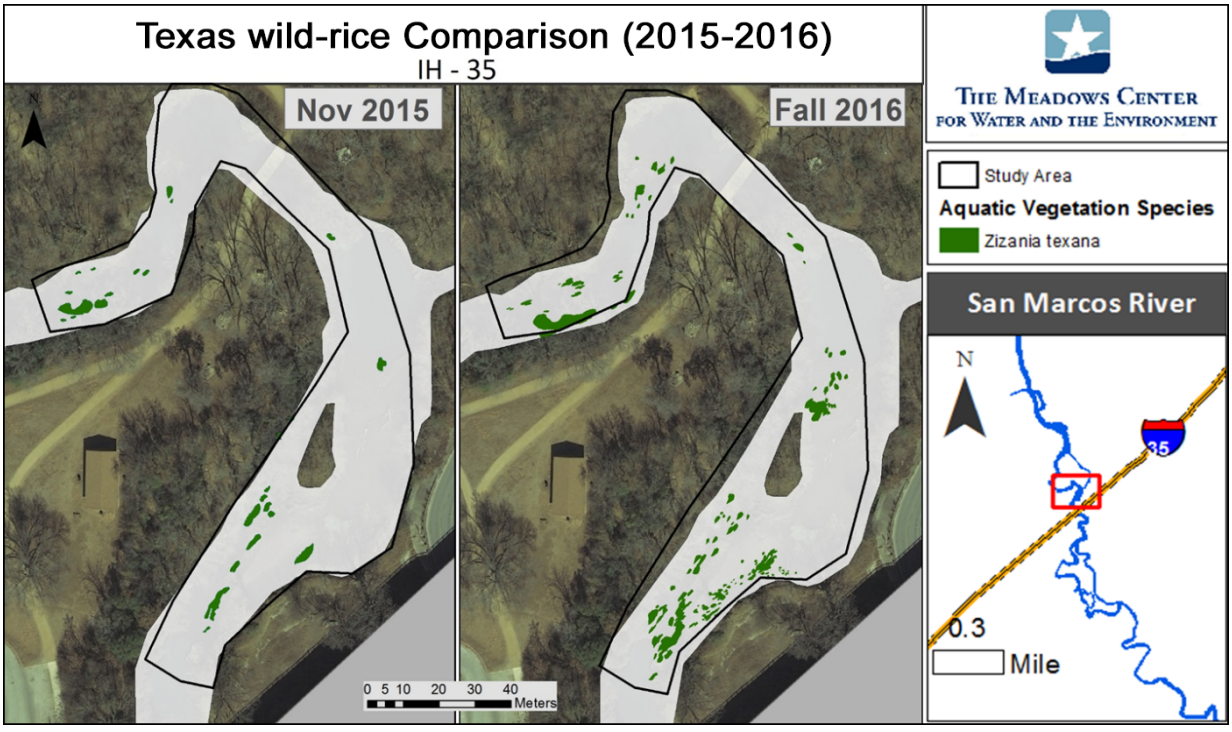

Figure 3.3-10. Texas wild-rice areal coverage at Cypress Island prior to vegetation treatment (spring 2013), one year ago (fall 2015), and this year (fall 2016).

Proposed Activities for 2017:

Texas wild-rice is now being considered as a plant that provides fountain darter habitat and will therefore be counted toward meeting EAHCP Biological Goals. As a result of the AMP in 2016, the EAHCP requested further amendments to Table 4-21 of the EAHCP in September 2016, and those amendments were approved by the USFWS in October 2016. For more detailed discussion of the 2016 AMP, please refer to **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.1.11.2** – Amendments, Informational Memoranda, and Clarifications, and to **Chapter 4.0** – ADAPTIVE MANAGEMENT PROCESS ACTIVITIES FOR 2016, **Section 4.2** – Nonroutine Decisions.

Therefore, in accordance with the revisions to Table 4-21 of the EAHCP, 25 m^2 will be planted in the Spring Lake Dam Reach, 75m^2 in the City Park Reach and 75m^2 in the IH-35 Reach in 2017.

3.3.2 Management of Recreation in Key Areas (EAHCP §5.3.2)

EAHCP Obligations:

The COSM will continue to implement recreation mitigation measures approved by the San Marcos City Council on February 1, 2011 (Resolution 2011-21). These include, but are not limited to, buffer zones around designated recreation areas, implementing a robust river education program, addressing the accumulation of silt in the river through watershed controls, reducing recreational impacts that harm the river (such as litter), and issuing COI to river outfitters to extend the protections of the ITP to those entities.

2016 Compliance Actions:

Several strategies were used by the COSM to manage recreation in key areas:

1) Access control: In 2016, temporary repairs were made to a number of access points with the addition of concrete bags and rebar under the limestone blocks at Dogbeach, Hopkins, Veramendi, Bicentennial, upper Rio Vista, and lower Ramon Lucio access points to address the damage caused by undermining. Undermining was regularly monitored to assure public safety and target repairs as necessary.
2) Public awareness: In 2016, the COSM HCP team partnered with Keep San Marcos Beautiful to create a public awareness video that explains the ecological sensitivity of the San Marcos River, while helping both visitors and residents get a better understanding of how their actions affect the aquatic life. This video will be installed at Lions Club tube rental for river users to view while in line.
3) Conservation Crew (CC): This work team was developed to educate the public about the EAHCP and to monitor and protect Texas wild-rice stands in high recreation areas. In 2016, the CC was composed of 15 university students. These students were paid by both EAHCP and COSM funding. They began work on May 18, 2016, working Wednesday through Sunday, and through the Labor Day weekend. Four to six crew members worked in teams of two to three each day from 11:00 a.m. – 7:00 p.m., with one group kayaking the river and the other group walking the banks in an effort to maximize river user contact (**Figure 3.3-11**).

Figure 3.3-11. Picture of Conservation Crew participating in public education event.

The CC accomplished many tasks under the EAHCP, such as education and protection of endangered species and their habitats (primarily Texas wild-rice, monitoring, volunteer planting events, project maintenance, and litter removal), specifically including the following:

- Education was accomplished in speaking with river users about the importance of EAHCP projects and Covered Species habitat protection. The CC participated in a ten public events to discuss the EAHCP and educate the public with brochures, signage, and a watershed model. The involvement of university students is an added benefit. These students provide the CC Program with a deep understanding of endangered species and the unique nature of the San Marcos River. Additionally, the EAHCP is advertised through these students and the COSM's intern program.
- The CC removed floating vegetation mats (consisting of mostly *Hydrilla verticillata* and *Hygrophila polysperma*) from Texas wild-rice stands to ensure their health. They also installed and maintained educational buoys that inform river users about Texas wild-rice and the importance of its protection.
- The CC assisted with other projects, including the Texas wild-rice survey with USFWS, invasive plant removal, tiller collection, and native plantings. Areas with an abundance of people such as Rio Vista, City Park and upper Sewell Park were frequently monitored in an effort to reduce negative impacts to the river and to ensure park and university rules were observed. Riparian fences and signs were inspected for damage or graffiti, and any problem areas along the river were reported.

4) Over 7,095 ft^3 of litter and mixed recyclables were removed from the river substrate, litter boats, and parks along the river by the CC. They also emptied three litter boats in the river by kayak four times a day, helping to prevent litter from entering the river. For a complete list of accomplished tasks and public outreach by the CC, see **Appendix M1.**

5) Texas wild-rice Protection Zones: In support of the Texas wild-rice Protection Zones, the CC provided buoys with messages, signage, and informational kiosks.

6) Buffer Zones: Rio Vista Falls has a 100-ft buffer zone on the east side of the river that excludes picnic tables, pop-up tents, shelters, and portable grills. Riparian restoration efforts continue to increase the amount of riverside buffers like this from upper Sewell Park to IH-35.

7) Signage: The October 2015 flood destroyed all signs that were mounted along the riparian fence line. In 2016, new native riparian restoration and litter informational signage was installed along fences.

8) Stencil on rented tubes: Applied stencils rubbed off over time, so this action was eliminated. The video loop at City Park and signage while tube renters are queuing will replace this action and has been completed.

9) Reduce recreation turbidity: Management actions aimed at this objective, accomplished via watershed management strategies, was covered in 2016 as discussed in Section 1.2.17 of the COSM and Texas State WQPP.

10) Partnership between the COSM and Texas State: The CC monitors both the COSM and Texas State properties and is supported by COSM Park Rangers and Texas State Police. A pre-recreation season meeting is held with Texas State and COSM law enforcement to ensure a cohesive approach to recreation management. Additionally, the COSM Habitat Conservation Plan Manager is funded equally by Texas State and COSM to ensure a unified approach.

Proposed Activities for 2017:

In 2017, continue the implementation of recreational management goals as outlined above. The COSM will educate the public engaged in water-based recreation on sustainable river use that protects Covered Species and their habitats. The CC will also conduct cleanup and EAHCP project maintenance while walking/kayaking. Introduce the COI program to qualified third parties conducting recreational activities in and along the San Marcos River.

3.3.3 Management of Aquatic Vegetation and Litter Below Sewell Park (EAHCP §5.3.3)

EAHCP Obligations:

The COSM will dislodge floating vegetation mats on the river's surface to facilitate their movement downstream. The COSM will also remove inorganic litter regularly during the recreation season.

2016 Compliance Actions:

Monthly, the COSM's contractor removed inorganic litter from Clear Springs Natural Area to IH-35. The contractor used SCUBA equipment to remove underwater litter from the substrate and river surface (**Figure 3.3-12** through **Figure 3.3-15**).

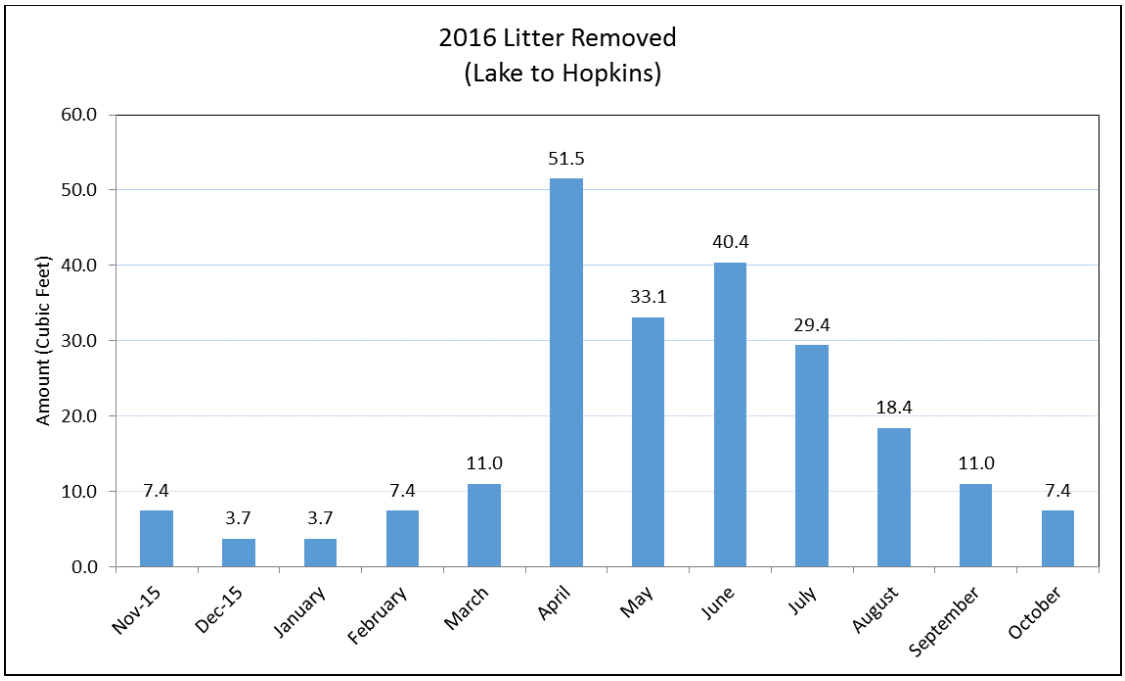

Figure 3.3-12. Cubic feet of litter removed from Clear Springs Natural Area to Hopkins Street (2015 included as projected 2016 data).

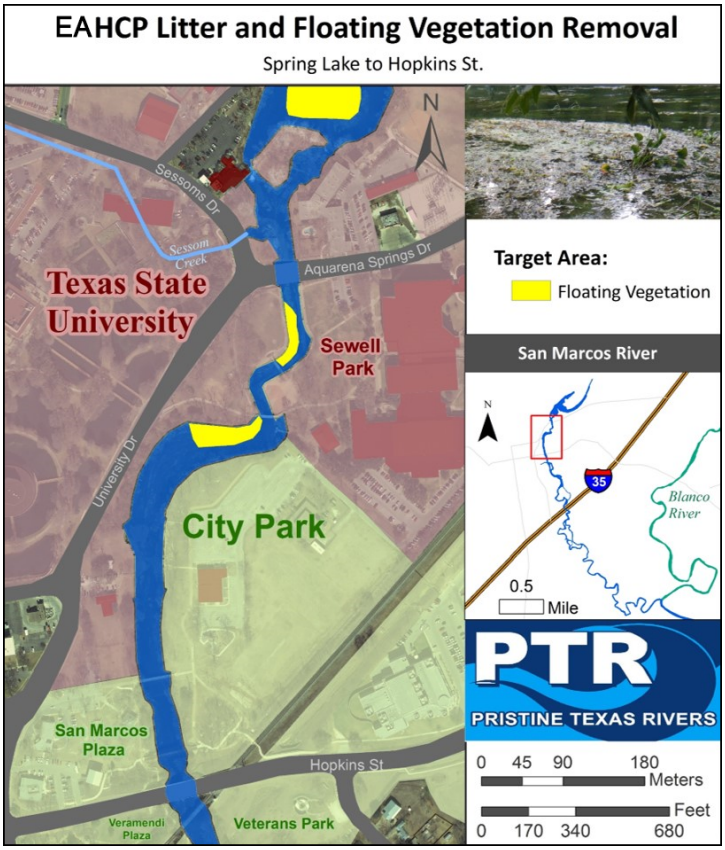

Figure 3.3-13. Area treated from Clear Springs Natural Area to Hopkins Street.

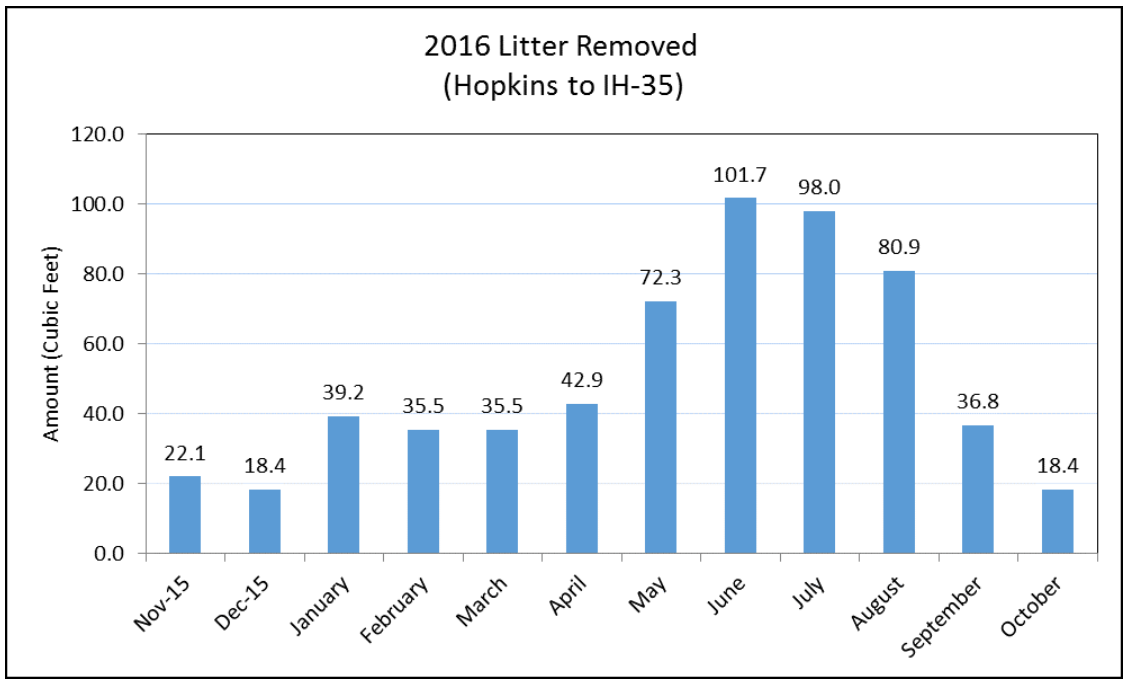

Figure 3.3-14. Cubic feet of litter removed from Hopkins Street to IH-35 (2015 data included as 2016 projected data).

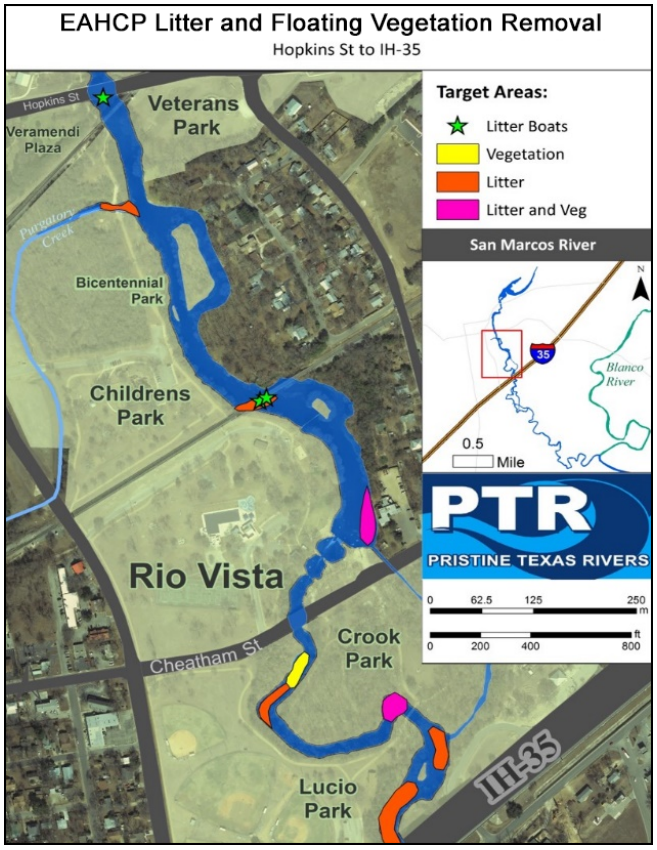

Figure 3.3-15. Area treated from Hopkins Street to IH-35.

The contractor walked the four San Marcos River tributaries—Purgatory Creek, Sessom Creek, Sink Creek, and Willow Creek **Figure 3.3-16** and **Figure 3.3-17**)—and collected litter in mesh bags. The monthly totals of litter removed exhibits the importance of focusing the tributaries, which includes areas downstream of IH-35. Due to the low amounts of litter collected in Spring Lake during the first year of implementation (2013), this location will be accomplished by Texas State as needed under the Spring Lake Management Plan.

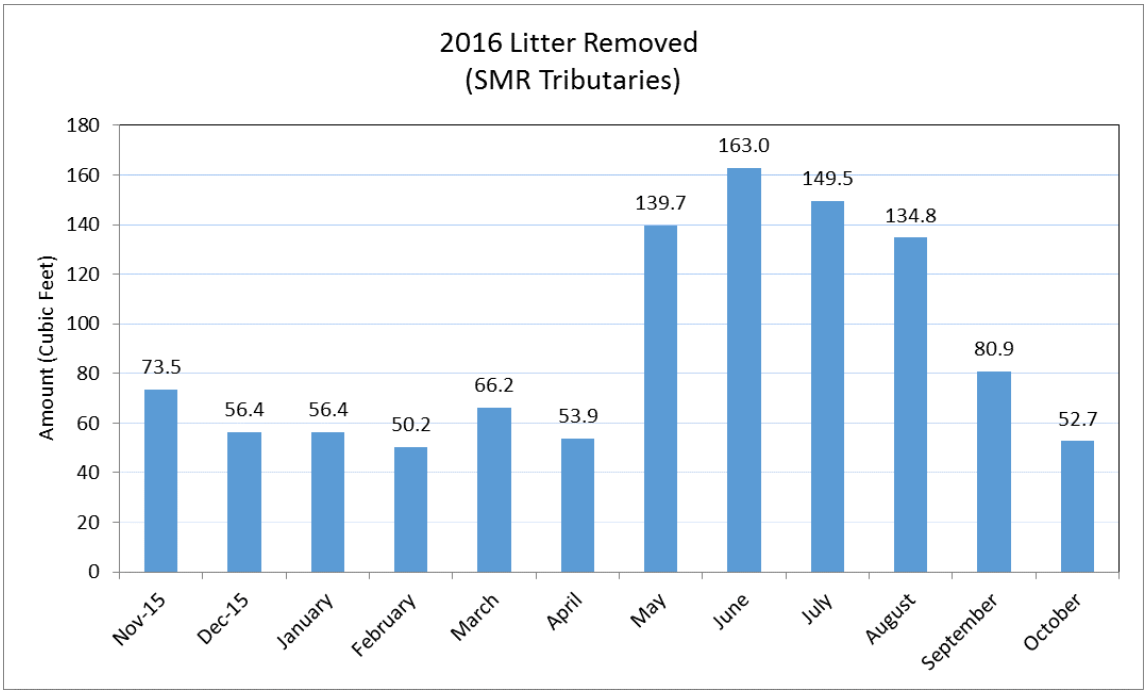

Figure 3.3-16. Cubic feet of litter found in San Marcos River tributaries by month (2015 included as 2016 projected data).

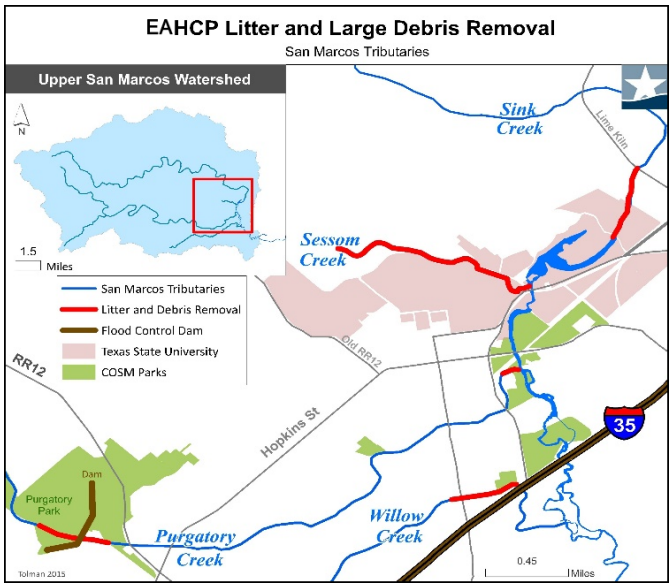

Figure 3.3-17. San Marcos River tributaries treated for litter removal.

Proposed Activities for 2017:

In 2017, the COSM will continue to implement litter removal consistent with protocols established in the EAHCP and the 2017 Work Plan.

3.3.4 Prohibition of Hazardous Materials Transport Across the San Marcos River and its Tributaries (EAHCP §5.3.4)

EAHCP Obligations:

The COSM will coordinate with Texas Department of Transportation (TxDOT) to designate routes for the transportation of hazardous materials that will minimize the potential for impacts to the San Marcos River and its tributaries.

2016 Compliance Actions:

The COSM contacted TxDOT and was informed that the city must pass an ordinance designating a hazardous route before TxDOT can confer state approval. A route was mapped and submitted to the Transportation Division for comment.

Proposed Activities for 2017:

The COSM will adopt a city ordinance and work with TxDOT to receive state approval.

3.3.5 Reduction of Non-Native Species Introduction (EAHCP §5.3.5)

EAHCP Obligations:

The COSM will partner with Texas State and other groups to establish and implement an education campaign targeted at reducing the introduction of non-native species into the river system. The COSM will also provide opportunities for people to dispose of unwanted aquatic animals and plants to deter aquarium dumps into the river system.

2016 Compliance Actions:

Flyers advertising the negative impacts of releasing non-native fish into the San Marcos River were distributed through:

1) Local pet stores except Walmart and PetsMart, which maintain a policy against such public education;
2) Local schools – distribute flyer to teachers for posting in classrooms;
3) Texas State campus – accomplished in April;
4) On social media websites – working with COSM Parks and Communications departments, SMRF and local Facebook sites;

5) Included in EAHCP presentations, and public events.

Additionally, there are currently two donation centers in San Marcos. The Discovery Center, and educational booth at special events.

Proposed Activities for 2017:

The COSM, in partnership with Texas State and contractors, will continue to implement the plan described above.

3.3.6 Sediment Removal Below Sewell Park (EAHCP §5.3.6)

EAHCP Obligations:

The COSM will remove sediment from areas along the river between City Park and IH-35. Sediment removal efforts will specifically target potential Texas wild-rice habitat.

2016 Compliance Actions:

A 3-inch hydrosuction hose was used to remove accumulations of fine sediment from the bed of the San Marcos River. Divers were trained on equipment operations, diving safety protocols, and recognition of all stages of listed species from larval to adult forms prior to any sediment removal. Before dredging, vegetation was removed and the area was fanned to encourage fountain darters and other biota to move out of the area. Additional details regarding fountain darters and the potential for "take" are discussed in **Chapter 5.0** – 2016 ANNUAL TAKE ESTIMATES of this Annual Report.

Dredging efforts started in October 2016 once the City of San Marcos and Texas State received a TCEQ permit for temporary water use and diversion at the Rio Vista Dam location. A requirement of the TCEQ water diversion permit includes installing a non-resettable totalizer water meter before diversions can begin. Texas State encountered issues finding a water meter that could withstand operating on a dredge since water and debris are suctioned though the meter instead of only water. Consequently, dredging was delayed until TCEQ and the COSM developed an agreement to monitor water diversion by multiplying the number of hours worked by pumping rate (gallons per minute).

Approximately 679 m^2 of non-native aquatic vegetation was removed prior to dredging near Rio Vista Dam (**Table 3.3-3**). Once most of the aquatic vegetation was removed, dredging was completed to remove fine sediment in the San Marcos River just upstream of Rio Vista Dam (**Figure 3.3-18**).

Table 3.3-3. Date, Vegetation Species, and Estimated Area Removed (m^2) in the San Marcos River Near Rio Vista Dam to Prepare for Sediment Removal

Date	Vegetation Species	Area removed (m^2)
6/22/16	*Hydrilla/Hygrophila*	82
6/23/16	*Hydrilla/Hygrophila*	145
6/29/16	*Hydrilla/Hygrophila*	41
6/30/16	*Hydrilla/Hygrophila*	71
7/28/16	*Hydrilla verticillata*	174
10/3/16	*Hydrilla verticillata*	47
10/10/16	*Hydrilla verticillata*	24
10/17/16	*Hydrilla verticillata*	95
	TOTAL	**679**

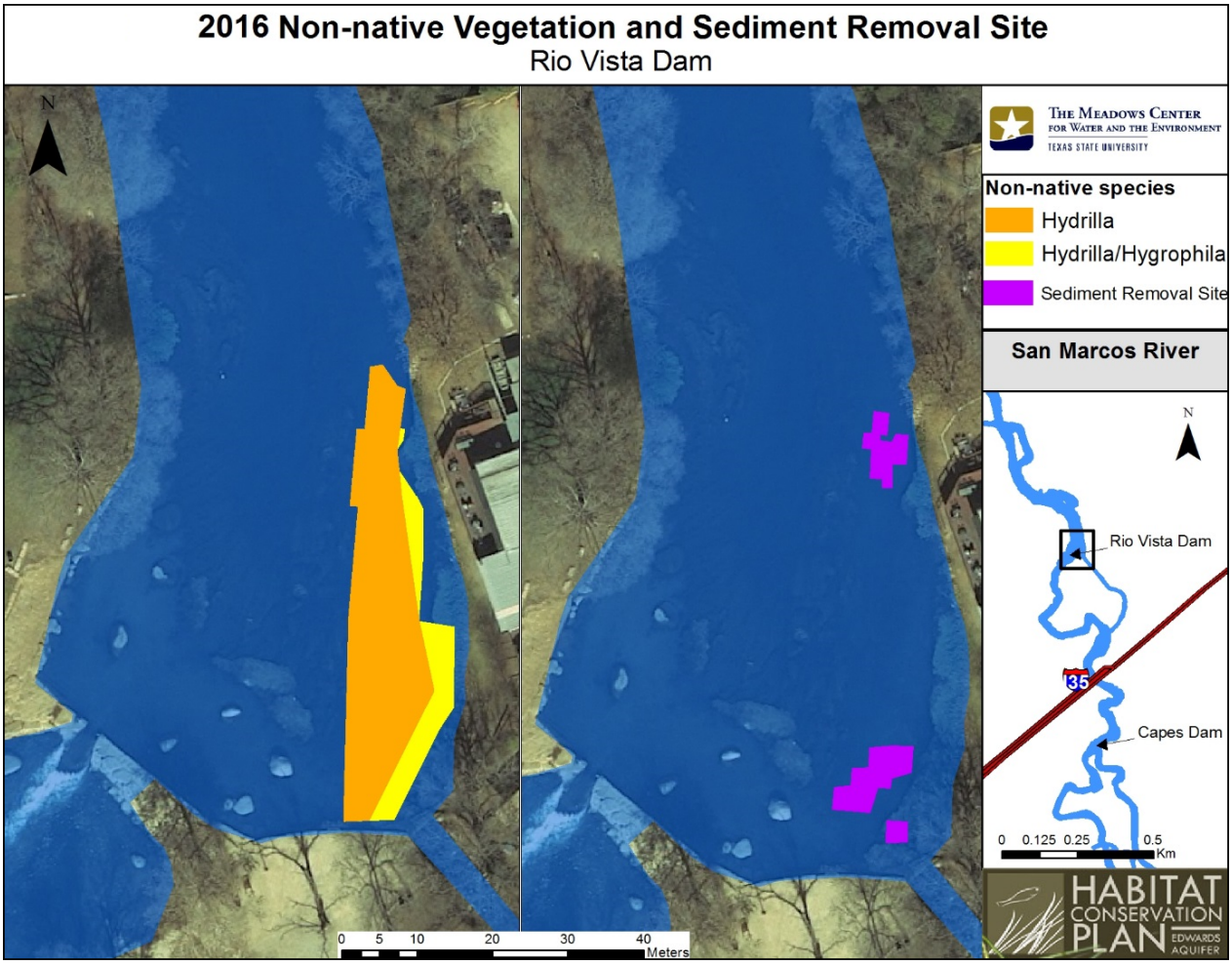

Figure 3.3-18. Non-native vegetation and sediment removal site just upstream of Rio Vista Dam 2016.

The dredging crew for removing fine sediment at Rio Vista Dam consisted of one person diving while another monitored the dredge equipment in case the rig needed to be shut down (**Figure 3.3-19**). Typically, one additional person monitored the dewatering bag and mitigated any erosion from water run-off seeping from the bag.

Figure 3.3-19. Arrangement for dredging at Rio Vista Dam (above) and placement of dewatering bag to minimize erosion and prevent turbid run-off back into river (below).

Approximately 92 m^2 (i.e., 28 cubic meters) of fine sediment was removed from the San Marcos River near Rio Vista Dam in October 2016 (**Table 3.3-4**). **Figure 3.3-20** shows the amount (6 inches in a 7-ft by 50-ft bag) and type of sediment already accumulated inside the dewatering bag at Rio Vista. Contractors will continue to dredge fine sediment in the area of Rio Vista Dam through December 2016. Once dredging is complete, Texas wild-rice and other native vegetation species will be planted in the area.

Figure 3.3-20. Accumulation of fine sediment in the dewatering bag (left) and type of sediment dredged (right) just upstream of Rio Vista Dam.

Table 3.3-4. Date and Estimates for Fine Sediment Removed (m^2) in San Marcos River

Date	Area (m^2)
10/6/16	6
10/11/16	32
10/13/16	9
10/18/16	26
10/20/16	9
10/21/16	10
TOTAL	**92**

Proposed Activities for 2017:

There will be no dredging activities in 2017. It has been identified by the COSM and the EAHCP SC that the Sediment Removal Conservation Measure should be reexamined for effectiveness. In 2017, EAHCP staff will work through the Adaptive Management process for this measure.

3.3.7 Designation of Permanent Access Points and Bank Stabilization (EAHCP §5.3.7)

EAHCP Obligations:

The COSM will stabilize banks in City Park, at the Hopkins Street underpass, Bicentennial Park, Rio Vista Park, Ramon Lucio Park, and at the Cheatham Street underpass. Bank stabilization will be conducted using stone terraces and native vegetation along the riparian zone. The COSM will incorporate permanent access points to facilitate river entrance by recreationists that is more protective to the Covered Species and their

habitats. The COSM will maintain all access points in perpetuity. All preexisting bank stabilization/access points were heavily eroded areas that experienced intense use by the public through river access. This strategy of providing access points and enhancing riparian zones provides a balance between recreation and maintaining a healthy riparian buffer and river bank.

2016 Compliance Actions:

Six of the seven access points were repaired as shown in **Table 3.3-5**. Installation of concrete bags constitutes a temporary repair to maintain the integrity of the access points until permanent repairs can be accomplished (**Figure 3.3-21**). The permanent repairs are currently scheduled for early 2017.

Table 3.3-5. Concrete Bags Installed in 2016

Date	No. of Bags	Access Point
6/29/16	6	Bicentennial
7/6/16	10	Rio Vista
7/7/16	13	Ramon Lucio (lower)
7/8/16	6	Hopkins/Veramendi
7/14/16	8	Dogbeach apron
7/14/16	9	City Park (between pedestrian bridges)
10/28/16	2	Bicentennial
10/28/16	10	Rio Vista
10/28/16	14	Ramon Lucio (lower)
11/2/16	4	Hopkins/Veramendi
11/2/16	4	Dogbeach apron
11/2/16	2	City Park (between pedestrian bridges)

Figure 3.3-21. Pictures of temporary access point repairs at Bicentennial and Ramon Lucio. Map shows all repair locations.

Proposed Activities for 2017:

The COSM will begin repairing the existing access points in accordance with the approved design specifications reviewed by the USACE, TPWD, and THC. Access points will be monitored quarterly to ensure ongoing structural stability.

3.3.8 Control of Non-Native Plant Species (EAHCP §5.3.8)

EAHCP Obligations:

The COSM will partner with Texas State to develop and implement a non-native plant removal program reaching from Spring Lake downstream to the city boundary. Aquatic, littoral, and riparian non-native plant species will be removed and replaced with native species. The riparian zone will be re-planted to cover 15 meters in width where possible. The COSM will install fencing to protect the new plantings while they mature. Divers conducting sediment control will first remove non-native aquatic plant species from the area. All removed non-native plants will be bagged and disposed of in accordance with state laws.

2016 Compliance Actions:

Non-Native Aquatic Plant Removal

Non-native aquatic vegetation removal focused on *Hydrilla verticillata* and *Hygrophila polysperma,* as these species were the most actively invasive. Prior to non-native vegetation removal, the area was fanned to minimize incidental take of fountain darters and other native species. The non-native aquatic vegetation was removed, shaken, and bagged for disposal at the COSM or Spring Lake composting facility. There were a variety of native animals inadvertently collected and returned during non-native aquatic vegetation removal including one fountain darter (January 2016 – October 2016). Progress for non-native vegetation removal was tracked with polygons containing the date, 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 was also generated using weekly polygons. The maps illustrating the degree of effort was created by overlaying all the weekly polygons (**Figure 3.3-22** through **Figure 3.3-28**). As a result, the layers capture the degree of overlap between 82 work sites (64 work days) and identify areas that required repeated removal efforts.

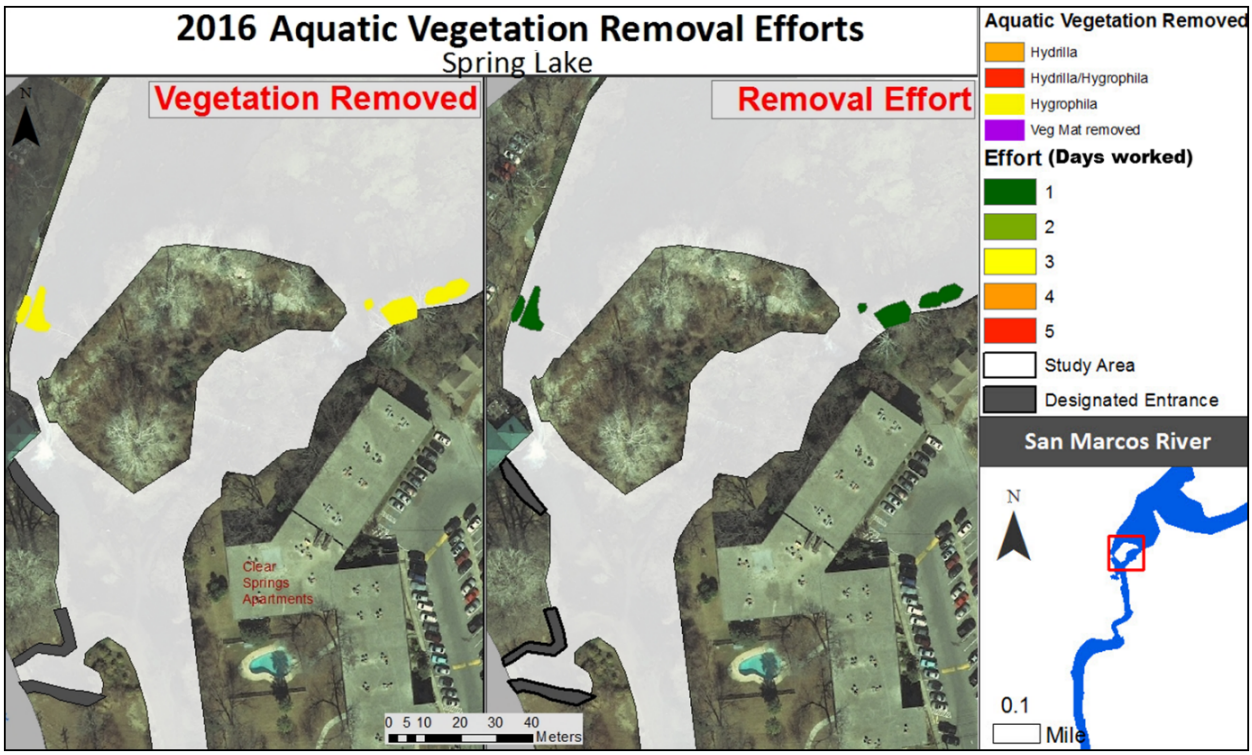

Figure 3.3-22. Non-native aquatic vegetation removal locations and degree of effort in Spring Lake in the San Marcos River (2016).

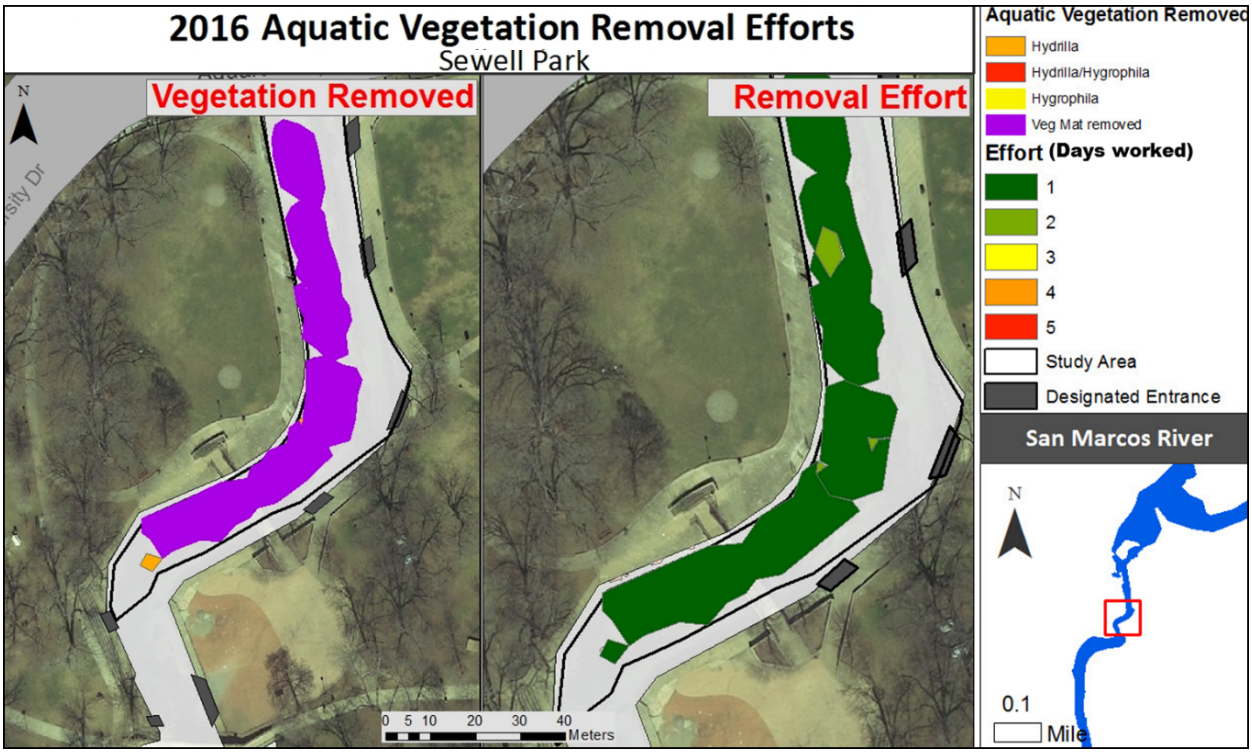

Figure 3.3-23. Non-native aquatic vegetation removal locations and degree of effort at Sewell Park in the San Marcos River (2016).

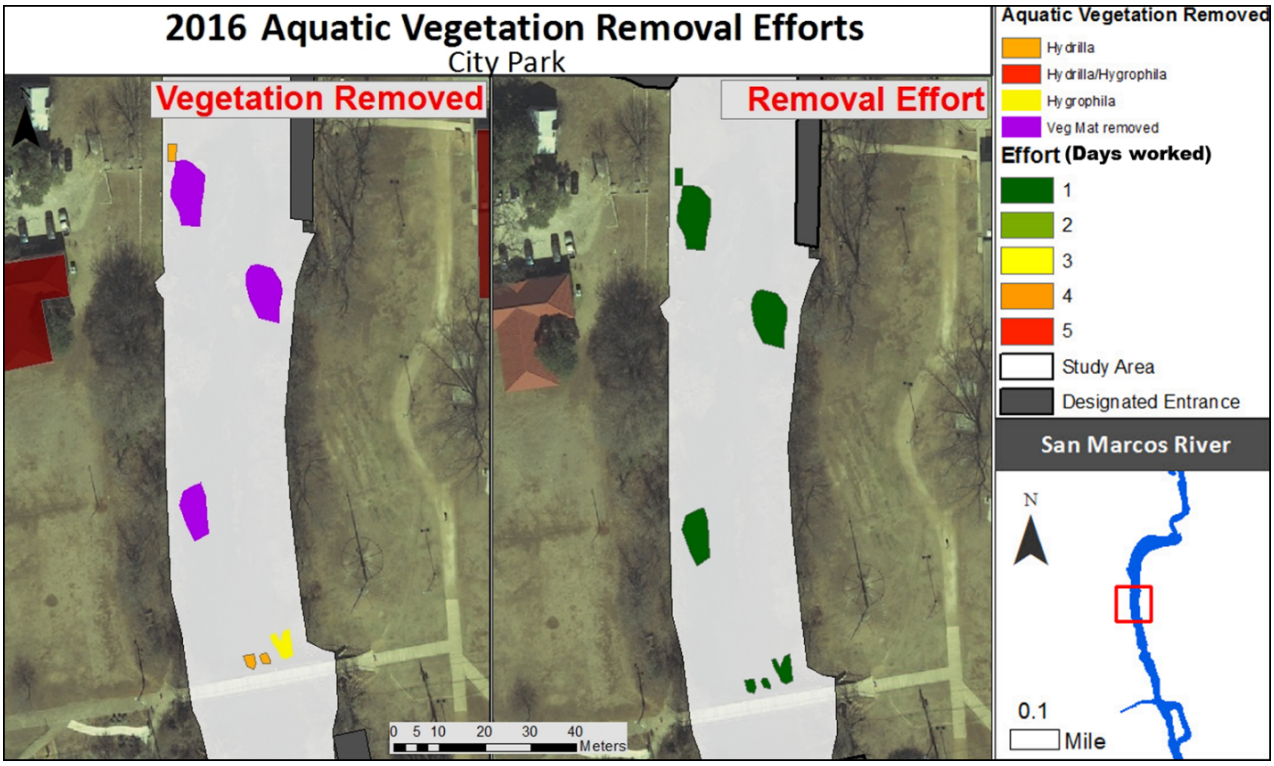

Figure 3.3-24. Non-native aquatic vegetation removal locations and degree of effort at City Park in the San Marcos River (2016).

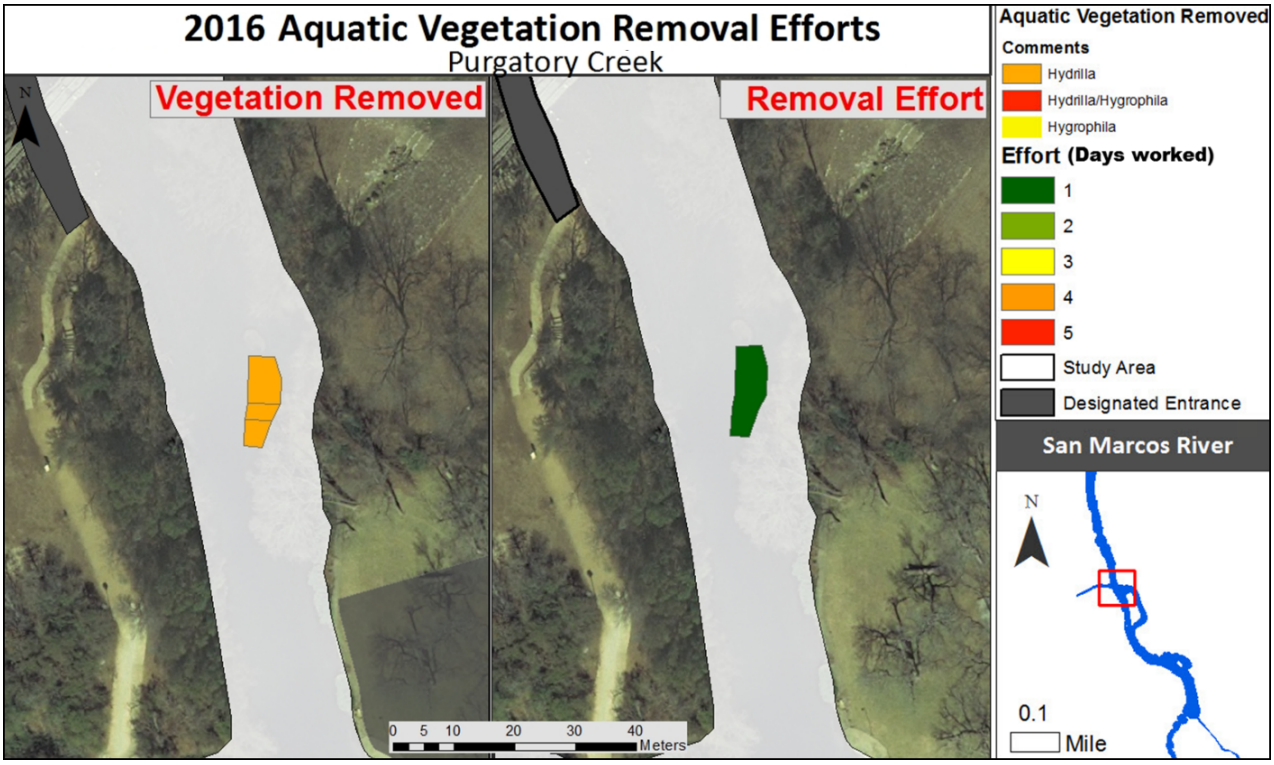

Figure 3.3-25. Non-native aquatic vegetation removal locations and degree of effort just upstream of Purgatory Creek confluence in the San Marcos River (2016).

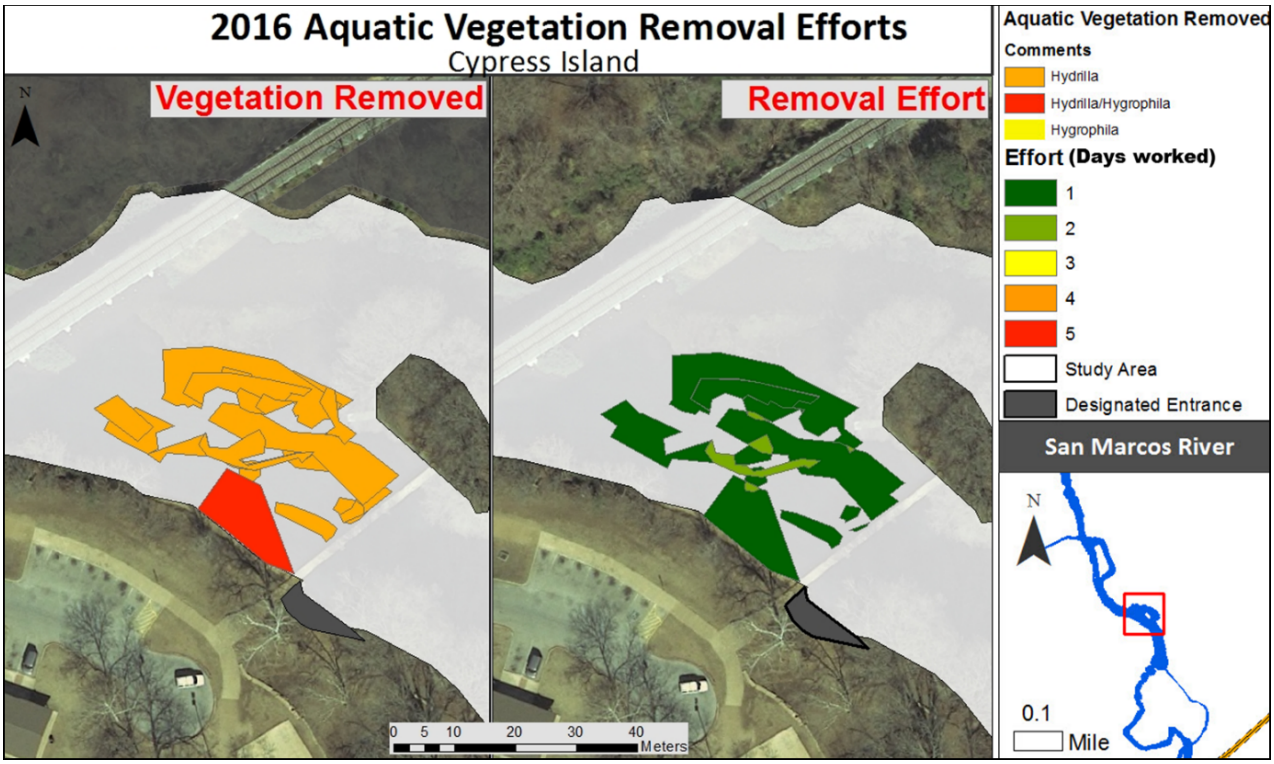

Figure 3.3-26. Non-native aquatic vegetation removal locations and degree of effort at Cypress Island in the San Marcos River (2016).

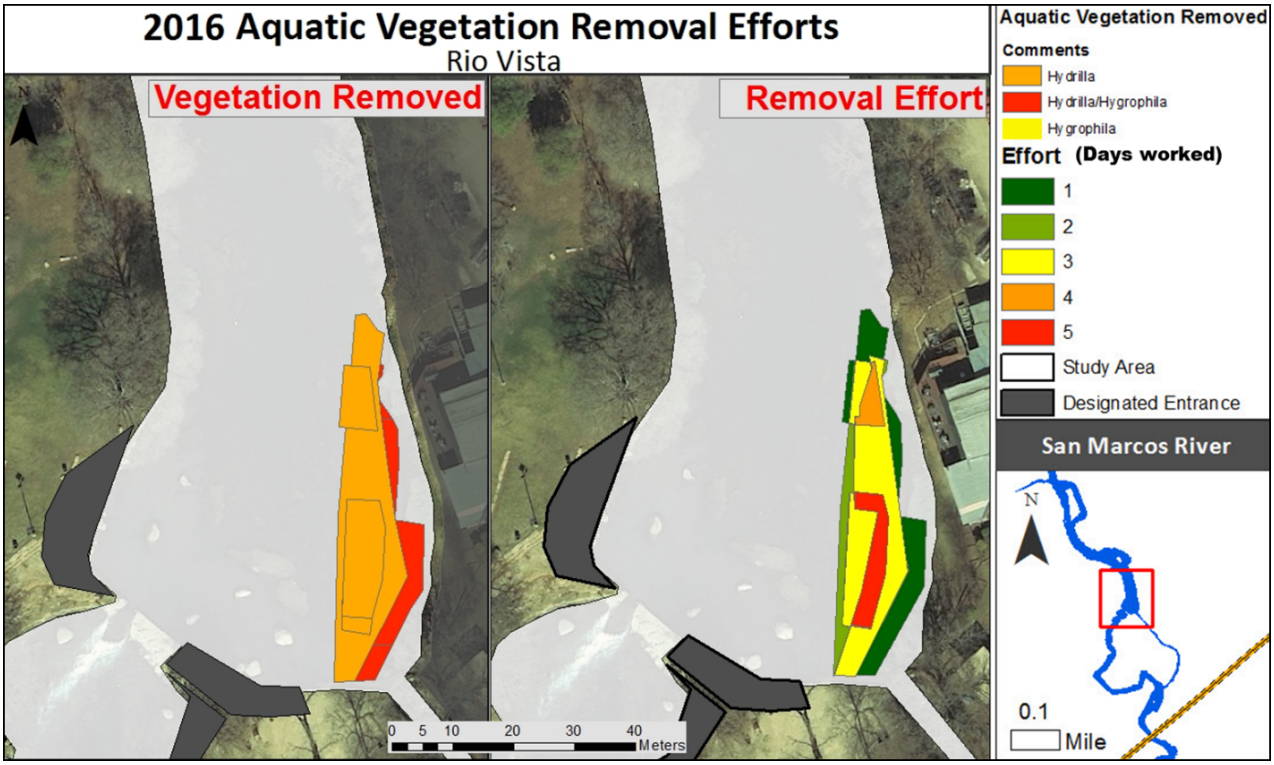

Figure 3.3-27. Non-native aquatic vegetation removal locations and degree of effort just upstream of Rio Vista Dam in the San Marcos River (2016).

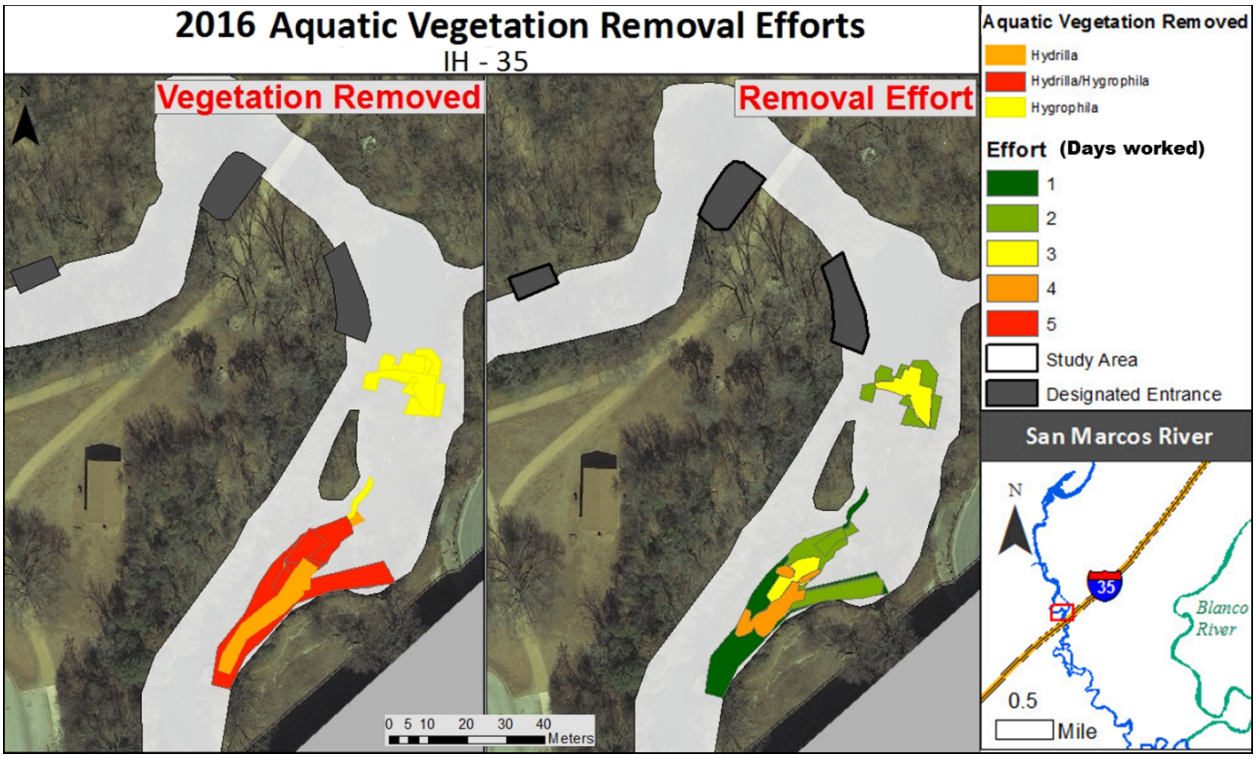

Figure 3.3-28. Non-native aquatic vegetation removal locations and degree of effort in IH-35 Reach of the San Marcos River (2016).

Denuded areas were targeted for Texas wild-rice or other selected native aquatic species plantings based on habitat preferences for each native species. Texas wild-rice and other native species were obtained from the SMARC or from raceways located at the FAB. **Table 3.3-6** denotes the number of individuals per species propagated in the raceways on Texas State campus. Propagation of *Heteranthera dubia* was discontinued in July after the SC discouraged further planting of this species. *Hydrocotyle umbellata* was proposed for a replacement species and planting of the species was suspended until its use was approved by the USFWS. Permission was granted by the USFWS to start planting *H. umbellata* in December 2016. Initial efforts for restoration of Texas wild-rice and other native vegetation were targeted at planting approximately 20-50 percent of the surface area restored. Planting efforts were tracked with polygons containing the date, number of individuals and estimated area (m^2). A map illustrating planting locations was generated using weekly polygons. Aquatic vegetation in work sites was mapped using geo-referenced imagery collected using a quadcopter in conjunction with Trimble GPS units prior to and post non-native vegetation removal and native planting to assess changes in the vegetation community through time. Work sites were separated into reaches to assess changes among and within reaches of the San Marcos River. **Figure 3.3-29** through **Figure 3.3-38** shows changes in native aquatic vegetation from 2013 to 2016 among restoration reaches (work sites) of the San Marcos River. Changes in native vegetation outside of the areas worked were not included, since differences observed could not be attributed to work by the team.

Table 3.3-6. Total Number of Individuals per Species Propagated Each Month at the Raceways on Texas State University Campus (Freeman Aquatic Building) in 2016

Month	Species							
	Zizania	*Potamogeton*	*Ludwigia*	*Heteranthera*	*Cabomba*	*Sagittaria*	*Hydrocotyle*	Total
January	165	-	-	-	-	-	-	165
February	633	130	150	240	105	60	430	1,748
March	1,396	775	315	455	445	105	800	4,600
April	354	1,991	0	820	151	73	250	4,317
May	873	404	0	600	437	0	0	2,970
June	574	80	1,146	150	300	40	210	3,461
July	762	6	1,455	0	1,250	54	755	4,897
August	563	600	640	0	24	4	0	3,038
September	420	2	860	0	0	0	0	1,282
October	0	0	0	0	0	0	0	0
YEAR-TO-DATE TOTALS	**5,740**	**3,988**	**4,566**	**2,265**	**2,712**	**336**	**2,445**	**26,478**

2016 Restoration Reaches

In 2016, aquatic vegetation treatment (i.e., removal and planting) efforts were focused in seven work sites including Spring Lake, Sewell Park, City Park, Hopkins Street-Bicentennial Park, Cypress Island, Rio Vista Dam, and IH-35 (**Figure 3.3-29**). Spring Lake, Rio Vista Dam, and IH-35 are new work sites for 2016. Although no aquatic vegetation treatment effort was completed in upper Sewell Park (Headwaters at Saltgrass) and above City Park, aquatic vegetation was monitored and changes in aquatic vegetation in these areas were assessed for 2015 to 2016.

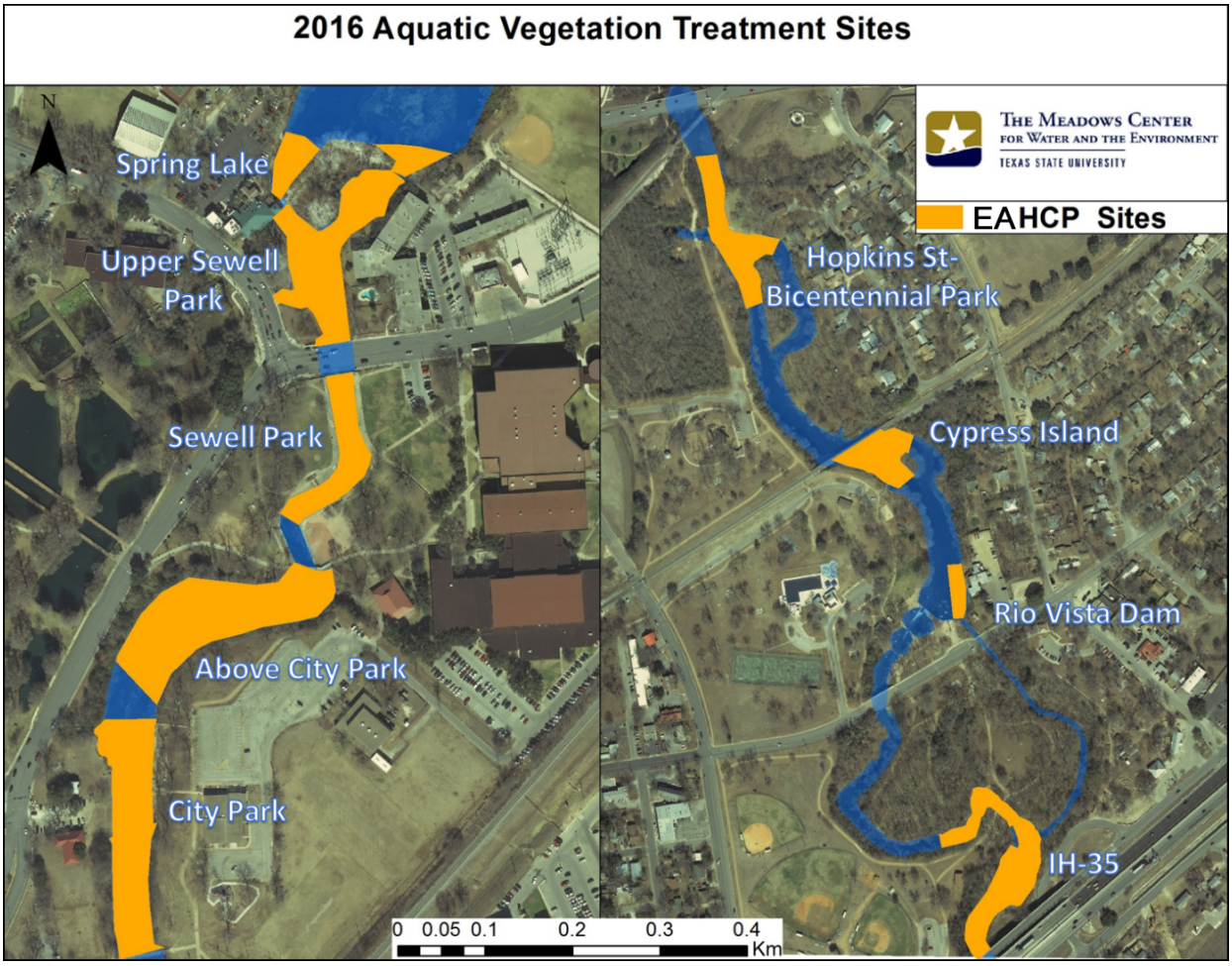

Figure 3.3-29. Site Map of Aquatic Vegetation Treatment Sites in the San Marcos River (2016).

Spring Lake

In 2016, the COSM contractor initiated non-native aquatic removal and planting of Texas wild-rice in Spring Lake. Before any work could be started in Spring Lake, the contractor had to receive concurrence from the THC that their efforts would not have any major impacts to Spring Lake's archaeological resources. On June 13, 2016, the THC granted permission to work in Spring Lake.

The contractor focused efforts adjacent to previously established Texas wild-rice stands in Spring Lake, which occur just upstream of both spillways. Non-native removal efforts in Spring Lake occurred between June 28, 2016 – September 1, 2016, for a total of six days, and resulted in the removal of approximately 108 m^2 of *Hygrophila*. Once the area was denuded of non-native aquatic vegetation, the COSM contractor planted Texas wild-rice grown at FAB or SMARC. Texas wild-rice planting efforts occurred between June 28, 2016 – September 1, 2016, for a total of six days, and resulted in the planting of approximately 3,512 Texas wild-rice individuals, covering an estimated area of 85 m^2 (**Figure 3.3-30**).

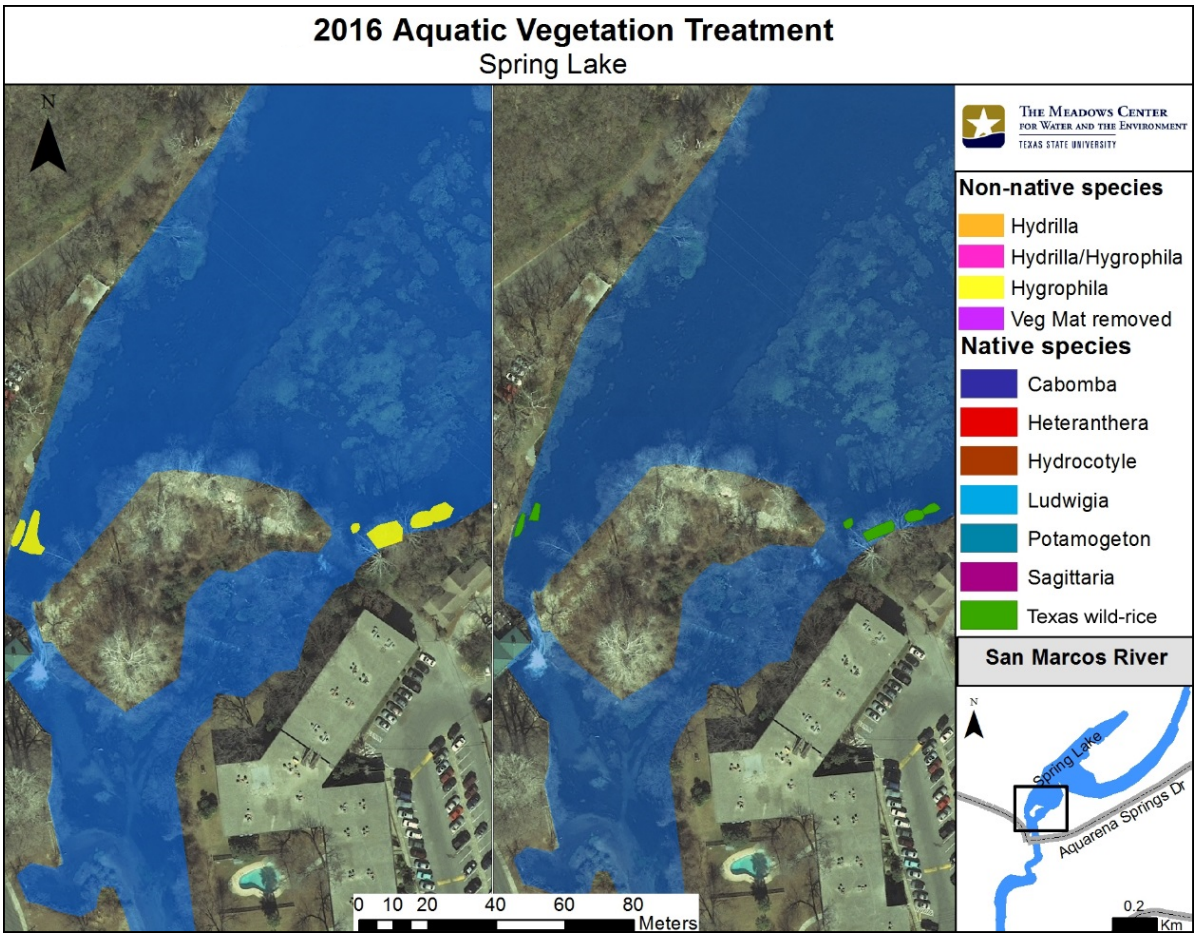

Figure 3.3-30. Locations of aquatic vegetation removal (left) and planting (right) efforts in Spring Lake (2016).

Figure 3.3-31 illustrates Texas wild-rice planting locations in Spring Lake during 2016 and the resulting areal coverage of Texas wild-rice in the planting locations. Of the approximately 85 m^2 planted, the COSM's contractor estimates roughly 47 m^2 of established Texas wild-rice areal coverage. The contractor observed unsuccessful establishment of Texas wild-rice in areas upstream of Spring Lake's eastern spillway. The area planted was in silt substrate and had riparian shading during part of the day. Therefore, the contractor will shift Texas wild-rice plantings in Spring Lake into more open areas with coarser substrate in 2017.

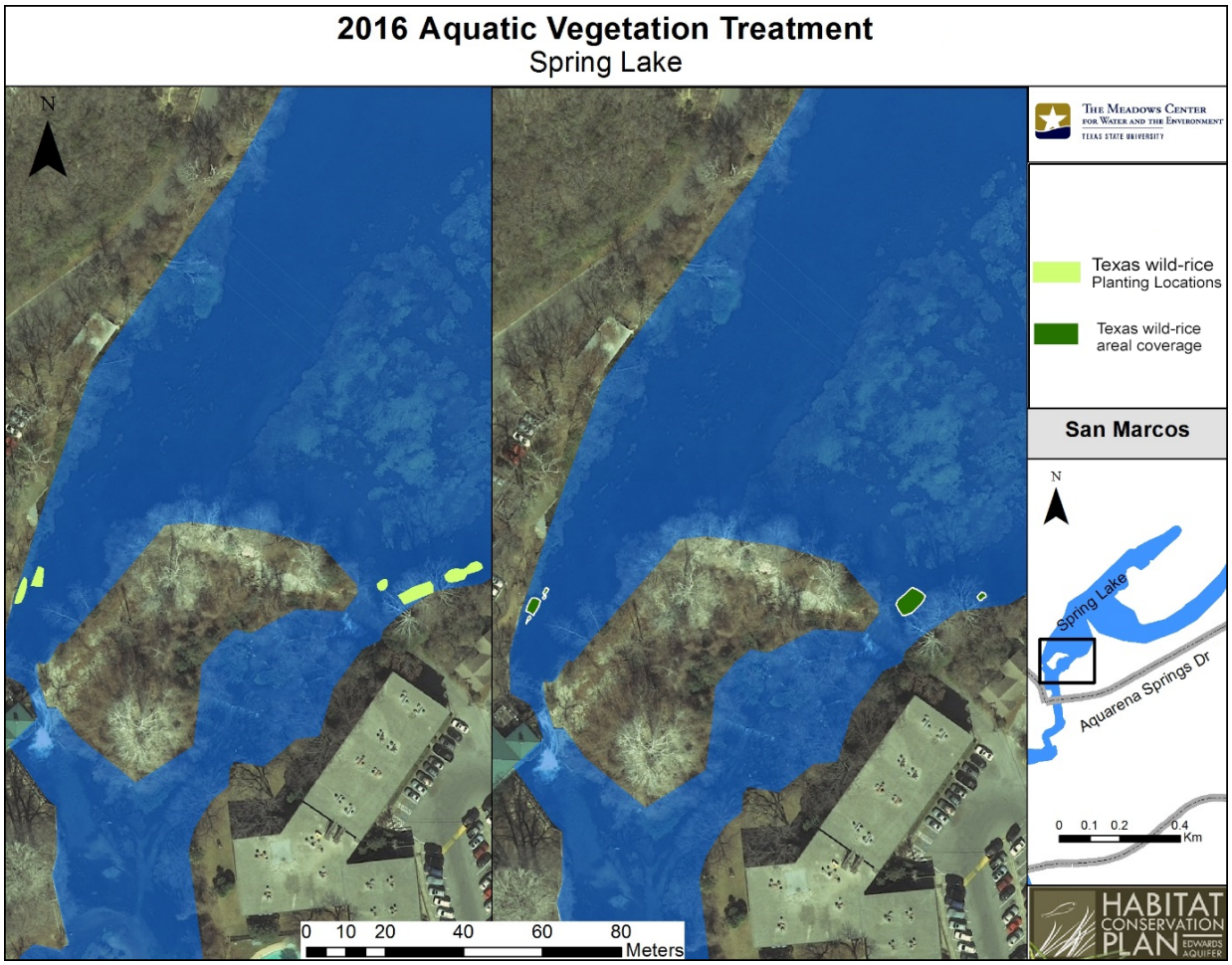

Figure 3.3-31. Texas wild-rice planting locations in Spring Lake during 2016 and the resulting areal coverage of Texas wild-rice in the planting locations.

Upper Sewell Park (Headwaters near Saltgrass) Reach

In, 2016, the COSM contractor did not perform any aquatic vegetation treatment in the upper Sewell Park section of the San Marcos River. However, in January 2016, a perimeter fence surrounding upper Sewell Park was placed to prevent access during bank stabilization efforts. Consequently, recreation in this section of the river in 2016 was significantly less compared to previous years. **Table 3.3-7** denotes areas (m^2) of aquatic vegetation species from 2013-2016 and changes in area (m^2) of aquatic vegetation from 2013-2016 and 2015-2016 within upper Sewell Park Reach of the San Marcos River. Changes in vegetation outside of the areas worked were not included, since differences observed could not be attributed to work by the COSM contractor team. **Figure 3.3-32** illustrates the changes in areal coverage of aquatic vegetation within upper Sewell Park prior to EAHCP activities (spring 2013), one year ago (fall 2015), and current (fall 2016). Since 2013, areal coverage of non-native aquatic vegetation decreased in upper Sewell Park by approximately 233 m^2. In 2016, *Hydrilla* continued to decrease from 2015 (~35 m^2), but *Hygrophila* expanded (~78 m^2). Since 2013, Texas wild-rice expanded ~689 m^2 in areal coverage in the upper Sewell Park Reach of the San Marcos River. In 2016, Texas wild-rice continued to increase from 2015 by ~315 m^2. In 2016, areal coverage of *Potamogeton* expanded considerably since 2015 (~132 m^2). Other native aquatic vegetation with slight increases since 2015 include *Sagittaria (*49 m^2*)* and *Hydrocotyle (*29 m^2*)*. The contractor attributes the expansion of native aquatic vegetation in the upper Sewell Park Reach in part to the perimeter fence surrounding the area that reduced the level of recreation in this reach during 2016. Expansion from 2015 to 2016 might also be attributable to the reestablishment of aquatic vegetation after the large scour event in October 2015.

Table 3.3-7. Area (m^2) of Aquatic Vegetation within Upper Sewell Park of San Marcos River 2013-2016, and Changes Detected 2013-2016 and 2015-2016

Species	2013	2014	2015	2016	Changes 2013-2016	Changes 2015-2016
Hydrocotyle	55.1	97.8	10.3	39.2	-15.9	28.9
*Hydrilla**	257.7	115.5	36.5	1.7	-256.0	-34.8
*Hygrophila**	63.9	38.1	8.9	86.5	22.6	77.6
Potamogeton	164.4	127.2	0.0	132.1	-32.3	132.1
Sagittaria	2.7	7.0	9.9	58.5	55.8	48.6
*Vallisneria**	0.0	10.1	0.0	0.0	0.0	0.0
Zizania texana	198.5	360.2	572.8	887.3	688.8	314.5

*Non-native vegetation species highlighted in red.

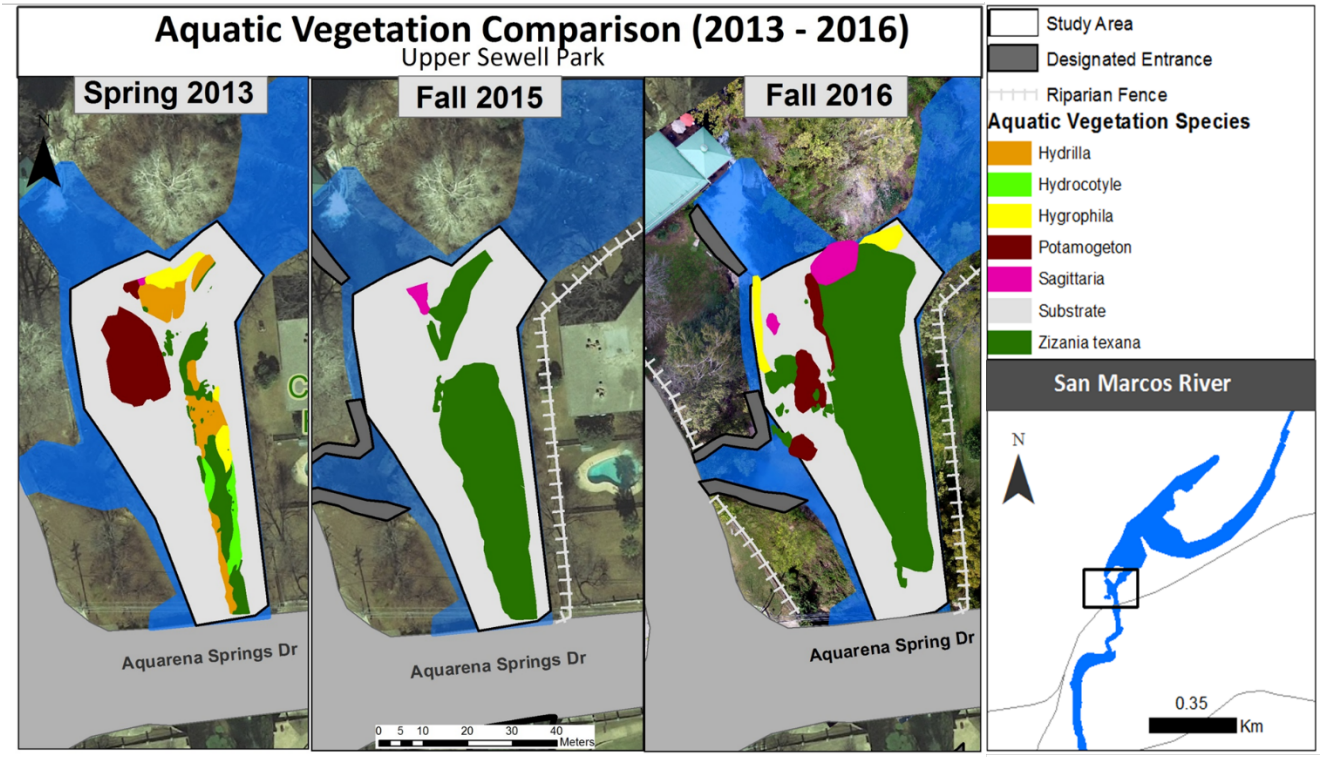

Figure 3.3-32. Changes in aquatic vegetation prior to treatment (spring 2013), after treatment year three (fall 2015), and treatment year four (fall 2016) within the upper Sewell Park Reach (Headwaters near Saltgrass) of the San Marcos River.

Sewell Park Reach

Extensive aquatic vegetation treatment work was not prioritized in the lower Sewell Park Reach of the San Marcos River in 2016. The large rain event on October 30, 2015 scoured a good portion of this reach and very little non-native aquatic vegetation remained at the end of 2015. In February 2016, the COSM contractor replanted an area with Texas wild-rice (~250 individuals, 6.6 m^2) that had been scoured during the October 2015 rain event. On August 28, 2016, approximately 28 m^2 of *Hydrilla* and *Hygrophila* was removed in Sewell Park among Texas wild-rice stands, and on September 16, 2016, close to 1,000 m^2 of vegetation mat was removed (**Figure 3.3-33**). Vegetation mats block sunlight to underlying aquatic vegetation and can eventually lead to vegetation die-off. Therefore, removing mats covering Texas wild-rice stands and other native aquatic vegetation can be an important component in the success of planting native aquatic vegetation.

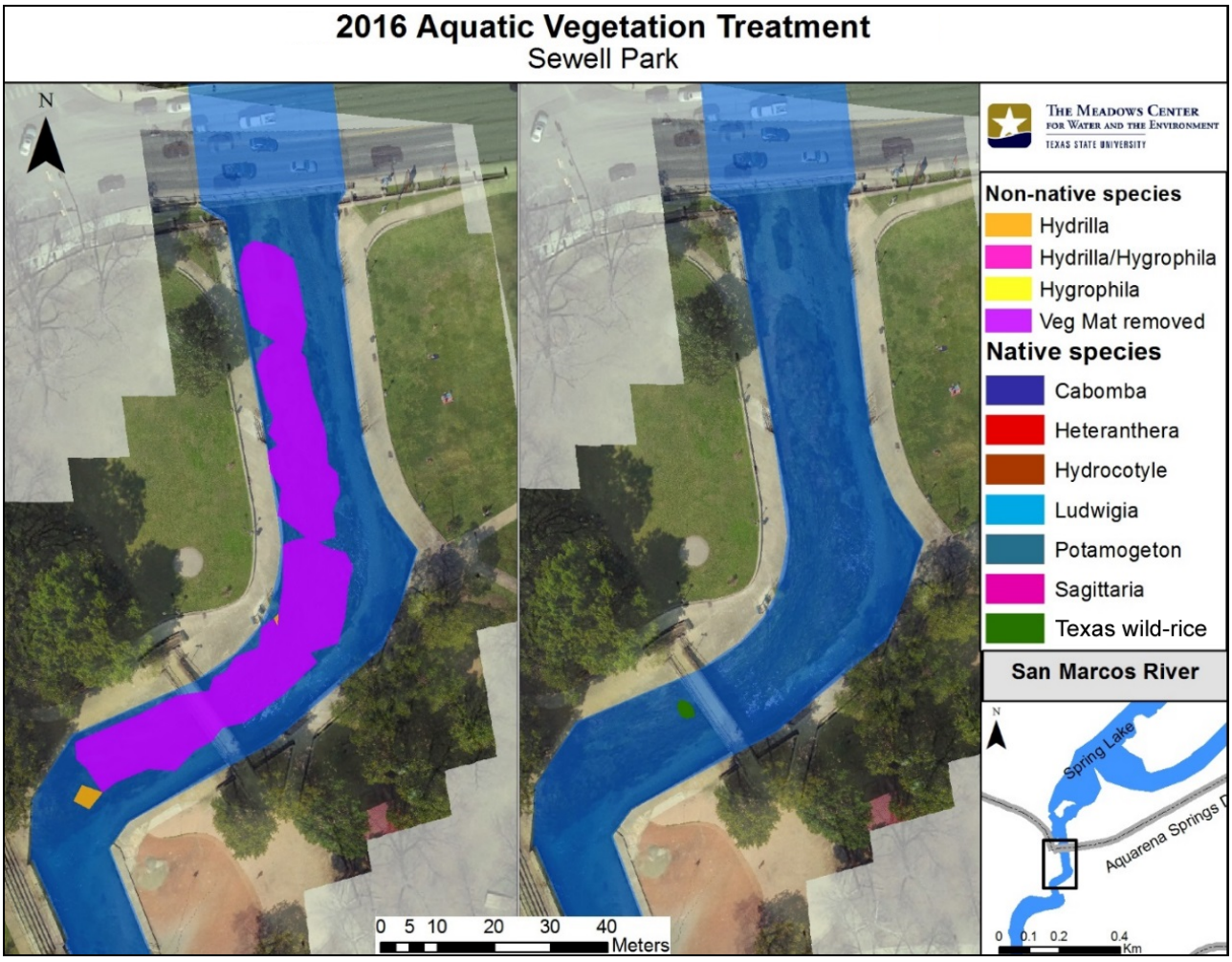

Figure 3.3-33. Locations of aquatic vegetation removal (left) and planting (right) efforts in Sewell Park (2016).

Table 3.3-8 denotes areas (m^2) of aquatic vegetation species 2013-2016 and changes in area (m^2) of aquatic vegetation from 2013-2016 and 2015-2016 within Sewell Park of the San Marcos River. Changes in

vegetation outside of the areas worked were not included since differences observed could not be attributed to work by the COSM contractor's team. **Figure 3.3-34** illustrates the changes in areal coverage of aquatic vegetation in Sewell Park prior to EAHCP activities (spring 2013), one year ago (fall 2015), and current (fall 2016). Since 2013, areal coverage of non-native aquatic vegetation decreased in Sewell Park by approximately 346 m^2. In 2016, *Hydrilla* continued to decrease from 2015 (~42 m^2) but *Hygrophila* expanded (~44 m^2). Since 2013, Texas wild-rice expanded ~519 m^2 in areal coverage in the Sewell Park Reach of the San Marcos River. However, a loss of Texas wild-rice (~16 m^2) was observed since 2015. In 2016, areal coverage of *Potamogeton* expanded considerably compared to 2015 (~117 m^2). Other native aquatic vegetation with slight increases compared to 2015 included *Sagittaria*, *Heteranthera*, and *Hydrocotyle*. No increase in areal coverage for *Ludwigia* was observed and areal coverage of *Cabomba* continued to decrease. The contractor attributes the observed loss of native vegetation in Sewell Park, particularly Texas wild-rice, to recreation impacts. **Figure 3.3-35** illustrates changes in aquatic vegetation near access points in Sewell Park in fall 2015, February 2016, and fall 2016. After the scouring event in fall 2015, aquatic vegetation was observed expanding in February 2016. However, by fall 2016, areas near access points were scoured down to bare substrate.

Table 3.3-8. Area (m^2) of Aquatic Vegetation within Sewell Park of San Marcos River 2013-2016 and Changes Detected from 2013-2016 and 2015-2016

Species	2013	2014	2015	2016	Changes 2013-2016	Changes 2015-2016
Cabomba	44.8	21.4	13.8	N/A	N/A	N/A
Heteranthera	0.0	71.5	0.0	2.3	2.3	2.3
Hydrocotyle	0.0	0.0	0.0	0.2	0.2	0.2
*Hydrilla**	133.5	72.8	55.4	13.7	-119.8	-41.7
*Hygrophila**	242.1	201.3	6.4	49.9	-192.2	43.5
Ludwigia	0.0	31.4	0.0	0.0	0.0	0.0
*Nasturtium**	31.8	0.0	0.0	0.0	-31.8	0.0
Potamogeton	208.0	193.4	88.0	204.9	-3.1	116.9
Sagittaria	21.4	37.6	1.6	2.3	-19.1	0.7
*Vallisneria**	2.4	3.0	0.0	0.0	-2.4	0.0
Zizania texana	666.3	838.7	1,201.5	1,185.8	519.5	-15.7
Zizaniopsis	154.3	0.0	0.0	0.5	-153.8	0.5

* Non-native vegetation species highlighted in red.
N/A – Not applicable as data not recordered.

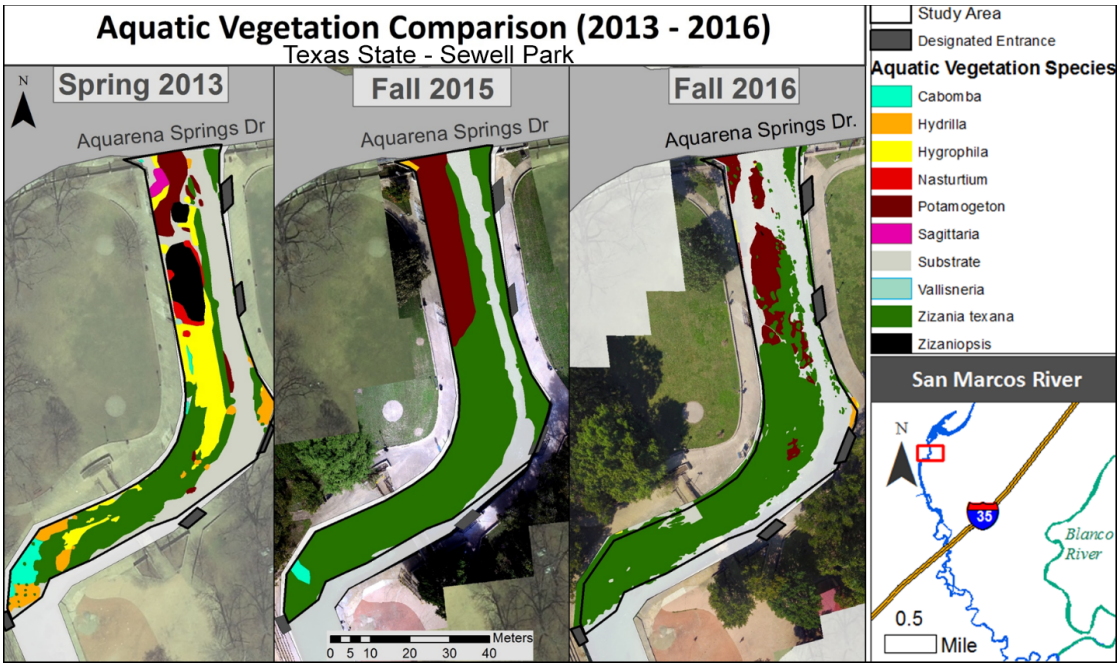

Figure 3.3-34. Changes in aquatic vegetation prior to treatment (spring 2013), after treatment year three (fall 2015), and after treatment year four (fall 2016) within Sewell Park of the San Marcos River.

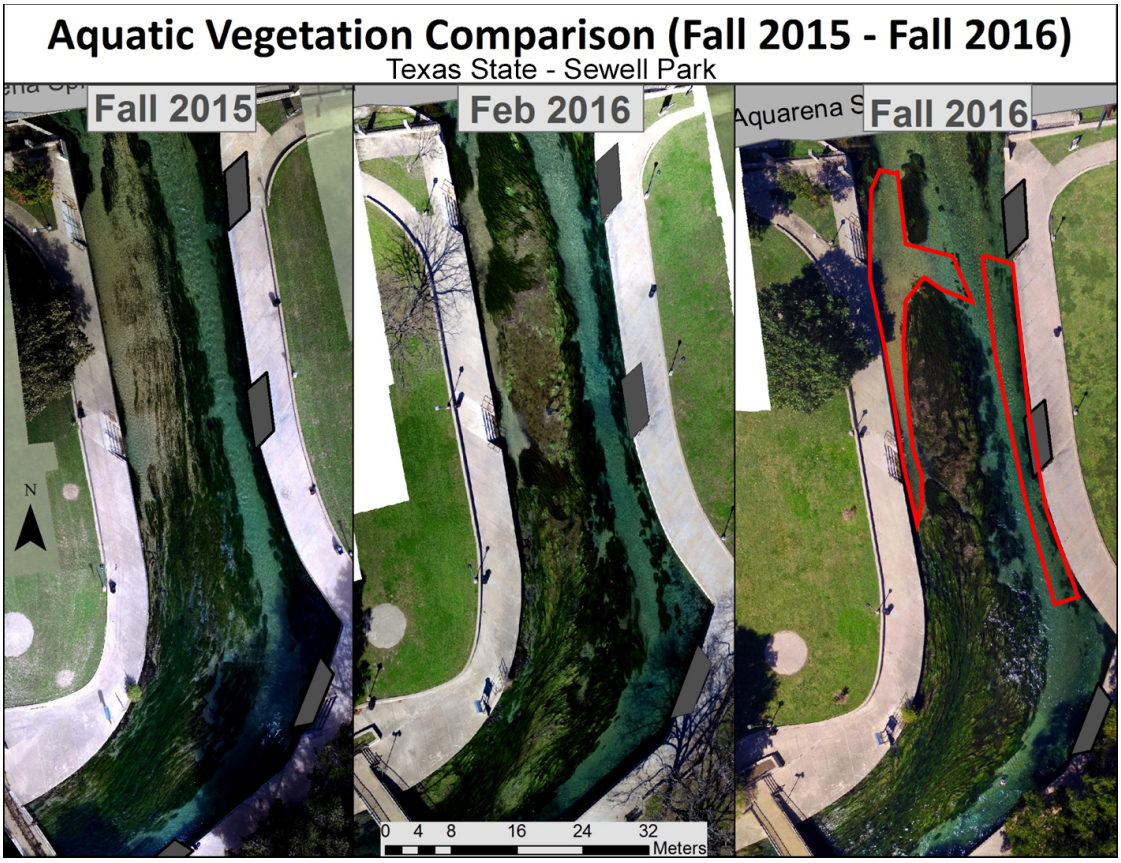

Figure 3.3-35. Changes in vegetation coverage near recreation access points in Sewell Park from fall 2015, February 2016, and fall 2016.

The red lines in **Figure 3.3-35** are showing loss of vegetation from river access creating pathways at Sewell Park.

Above City Park Reach

In, 2016, the COSM contractor did not perform any aquatic vegetation treatment in the above City Park section of the San Marcos River. **Table 3.2-9** denotes areas (m^2) of aquatic vegetation species by year from 2013-2016 and changes in area (m^2) of aquatic vegetation from 2013-2016 and 2015-2016 in the above City Park Reach of the San Marcos River. Changes in vegetation outside of the areas worked were not included since differences observed could not be attributed to work by the contractor's team. **Figure 3.3-36** illustrates the changes in areal coverage of aquatic vegetation above City Park prior to EAHCP activities (spring 2013), one year ago (fall 2015), and current (fall 2016). Since 2013, areal coverage of non-native aquatic vegetation decreased above City Park by approximately 1,643 m^2. In 2016, *Hydrilla* continued to decrease from 2015 (~140 m^2) but *Hygrophila* expanded (~71 m^2). Since 2013, Texas wild-rice expanded ~1,217 m^2 in areal coverage in the above City Park Reach of the San Marcos River. In 2016, Texas wild-rice continued to expand from 2015 by ~176 m^2. In 2016, areal coverage of *Hydrocotyle* and *Potamogeton* expanded considerably since 2015 (~97 m^2 and 313 m^2, respectively). A native aquatic vegetation with a slight increase since 2015 was *Cabomba* (7.3 m^2). No increase in areal coverage for *Heteranthera* was observed and areal coverage of *Sagittaria* slightly decreased.

Table 3.3-9. Area (m^2) of Aquatic Vegetation in Above City Park Reach of San Marcos River 2013-2016, and Changes Detected 2013-2016 and 2015-2016

Species	2013	2014	2015	2016	2013-2016 Change	2015-2016 Change
Cabomba	11.0	5.9	0.0	7.3	-3.7	7.3
Heteranthera	0.0	18.8	0.0	0.0	0.0	0.0
Hydrocotyle	23.1	33.6	14.9	112.1	89.0	97.2
*Hydrilla**	857.3	1,034.5	236.9	96.5	-760.8	-140.4
*Hygrophila**	1,483.7	795.2	530.7	601.6	-882.1	70.9
Potamogeton	769.8	336.1	169.7	482.9	-286.9	313.2
Sagittaria	22.4	375.6	684.9	642.1	619.7	-42.8
Zizania texana	1,212.3	1,963.4	2,253.0	2,429.3	1,217.0	176.3
Zizaniopsis	16.0	0.0	0.0	0.0	-16.0	0.0

*Non-native vegetation species highlighted in red.

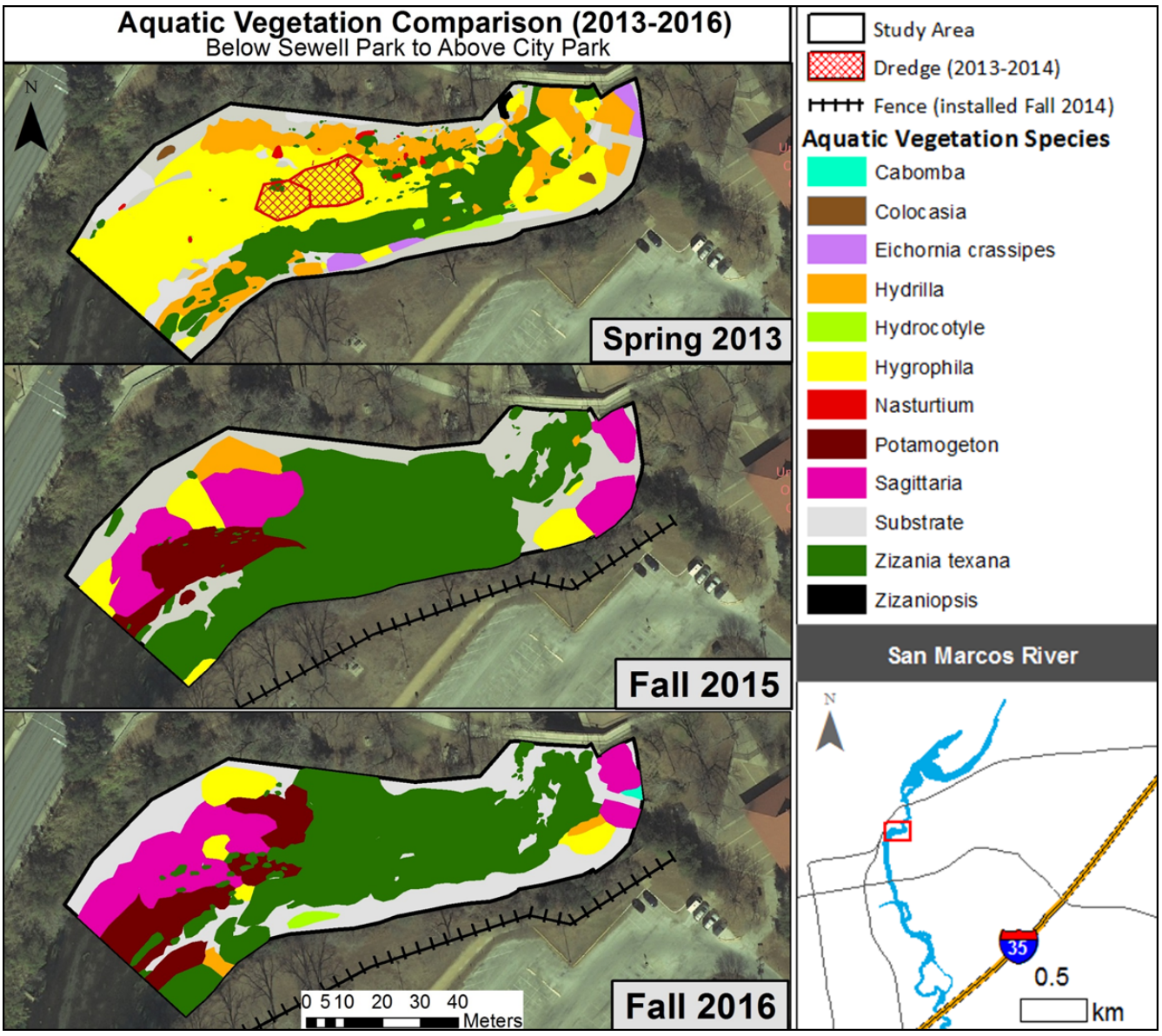

Figure 3.3-36. Changes in aquatic vegetation prior to treatment (spring 2013), fall 2015, and fall 2016 below Sewell Park to above City Park in San Marcos River.

City Park Reach

Minimal aquatic vegetation treatment work was completed in the City Park Reach of the San Marcos River in 2016. Non-native removal efforts in City Park consisted of two days (April 13, 2016 and September 29, 2016) and removed approximately 25 m^2 of *Hydrilla* and *Hygrophila*. One day of effort (September 15, 2015) consisted of removing approximately 188 m^2 of vegetation mat occurring over Texas wild-rice stands. Once an area was denuded of non-native aquatic vegetation, the COSM contractor planted Texas wild-rice and other native species grown at FAB or SMARC. Texas wild-rice and other native species plantings occurred on two days (April 13, 2016 and September 29, 2016) and planted approximately 802 native species individuals, covering an estimated area of 33 m^2 (**Figure 3.3-37**). Native species planted in City Park included: *Heteranthera* (24 individuals), *Hydrocotyle* (6 individuals), *Ludwigia* (100 individuals), *Potamogeton* (324 individuals), and Texas wild-rice (348 individuals).

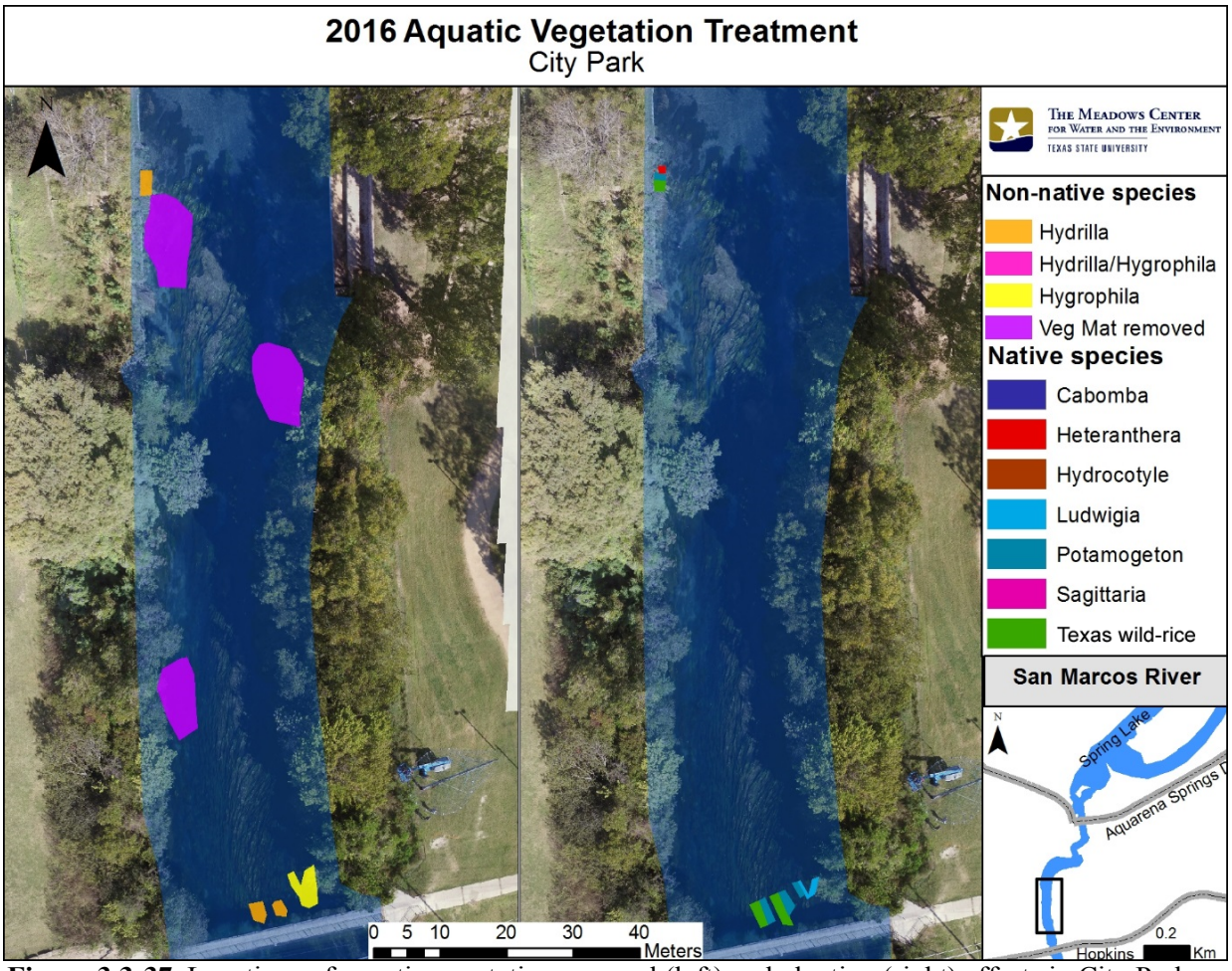

Figure 3.3-37. Locations of aquatic vegetation removal (left) and planting (right) efforts in City Park (2016).

Table 3.3-10 denotes areas (m^2) of aquatic vegetation species 2013-2016, and changes in area (m^2) of aquatic vegetation from 2013-2016 and 2015-2016 along the City Park Reach of the San Marcos River. Changes in vegetation outside of the areas worked were not included since differences observed could not be attributed to work by the contractor's team. **Figure 3.3-38** illustrates the changes in areal coverage of

aquatic vegetation in City Park prior to EAHCP activities (spring 2013), one year ago (fall 2015), and current (fall 2016). Since 2013, areal coverage of non-native aquatic vegetation decreased in City Park by approximately 1,699 m^2. In 2016, *Hydrilla* and *Hygrophila* continued to decrease from 2015 (~145 m^2). Since 2013, Texas wild-rice expanded ~1,160 m^2 in areal coverage at City Park and continued to expand ~196 m^2 since Fall 2015. Other native aquatic vegetation species with notable increases since 2015 include *Sagittaria* (~19 m^2) and *Ludwigia* (~9.0 m^2). In 2016, areal coverage of *Potamogeton* decreased since 2015 (~68 m^2).

Table 3.3-10. Area (m^2) of Aquatic Vegetation at City Park of San Marcos River 2013-2016 and Changes Detected 2013-2016 and 2015-2016

Species	2013	2015	2016	Changes 2013-2016	Changes 2015-2016
Heteranthera	0.0	0.3	0.8	0.8	0.5
Hydrocotyle	0.0	0.0	0.1	0.1	0.1
*Hydrilla**	1,466.3	308.3	301.1	-1,165.2	-7.2
*Hygrophila**	585.6	191.8	53.8	-531.8	-138.0
Ludwigia	0.0	0.0	9.0	9.0	9.0
*Nasturtium**	1.6	0.0	0.0	-1.6	0.0
Potamogeton	254.0	180.2	112.1	-141.9	-68.1
Sagittaria	17.8	0.0	19.1	1.3	19.1
*Vallisneria**	1.7	0.0	0.0	-1.7	0.0
Zizania texana	384.3	1,348.3	1,544.6	1,160.3	196.3

* Non-native vegetation species highlighted in red.

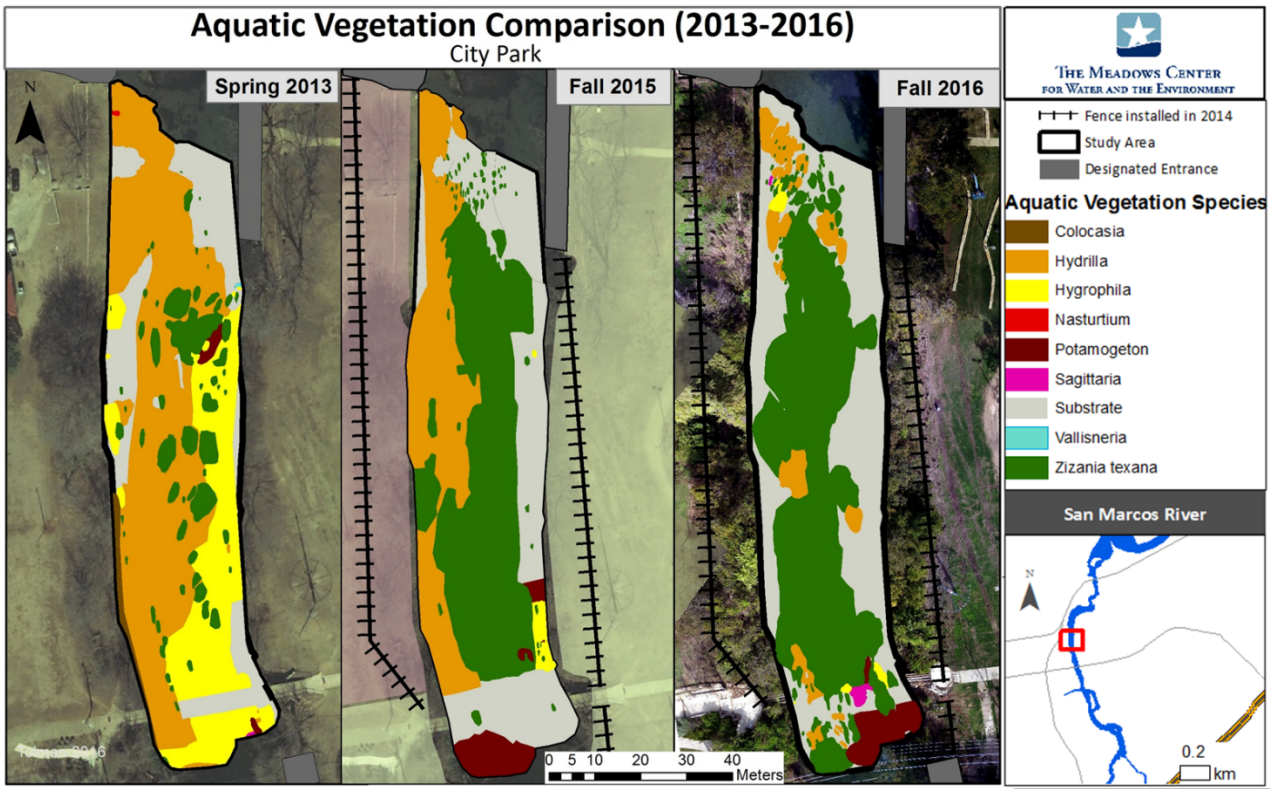

Figure 3.3-38. Changes in aquatic vegetation prior to treatment (spring 2013), fall 2015, and fall 2016 just below City Park in San Marcos River.

Hopkins Street – Purgatory Creek Reach

In 2016, the COSM contractor concentrated aquatic vegetation treatment work in the Hopkins Street – Purgatory Creek Reach of the San Marcos River just downstream of Hopkins Street Bridge. The contractor chose this location because access to the area was through City Park property, and because the water depth was sufficient to reduce recreation impacts.

Texas wild-rice and other native species plantings occurred on three days (February 4, 2016 – February 11, 2016) and approximately 1,733 native species individuals were planted, covering an estimated area of 25 m^2. Native species planted in Hopkins Street – Purgatory Creek Reach included: *Heteranthera* (108 individuals), *Potamogeton* (450 individuals), *Sagittaria* (306 individuals), and Texas wild-rice (869 individuals). The contractor revisited the site in April 2016 and noticed *Hydrilla* reestablishing. Therefore, non-native removal efforts in the Hopkins Street – Purgatory Creek Reach consisted of three days (March 29, 2016 – April 5, 2016) and removed approximately 66 m^2 of *Hydrilla*. **Figure 3.3-39** shows the locations of aquatic vegetation removal and planting efforts in the Hopkins Street – Purgatory Creek Reach of the San Marcos River in 2016.

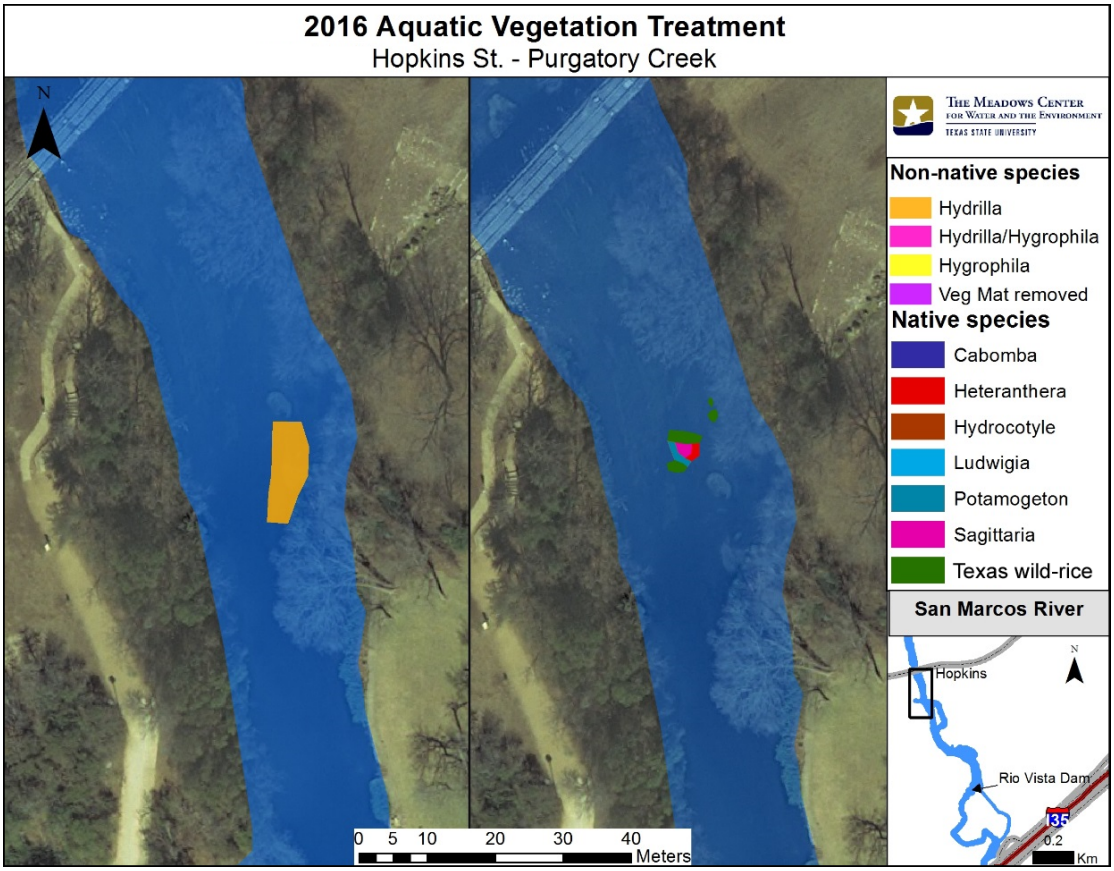

Figure 3.3-39. Locations of aquatic vegetation removal (left) and planting (right) efforts in Hopkins Street – Purgatory Creek Reach of the San Marcos River (2016).

Table 3.3-11 denotes areas (m^2) of aquatic vegetation species 2013-2016, and changes in area (m^2) of aquatic vegetation from 2013-2016 and 2015-2016 in the Hopkins Street - Purgatory Reach of the San Marcos River. Changes in vegetation outside of the areas worked were not included since differences observed could not be attributed to work by the COSM's contractor team. **Figure 3.3-40** illustrates the changes in areal coverage of aquatic vegetation at Hopkins St. - Purgatory prior to EAHCP activities (2013) and current (Fall 2016). Since 2013, areal coverage of non-native aquatic vegetation decreased at Hopkins Street - Purgatory by approximately 94.7 m^2. Since 2013, Texas wild-rice expanded by approximately 78.65 m^2 in areal coverage at Hopkins Street – Purgatory.

Table 3.3-11. Area (m^2) of Aquatic Vegetation at City Park of San Marcos River 2013-2016 and Changes Detected 2013-2016 and 2015-2016

Species	2013	2015	2016	Changes 2013-2016	Changes 2015-2016
Heteranthera	0.0	0.3	0.8	0.8	0.5
Hydrocotyle	0.0	0.0	0.1	0.1	0.1
*Hydrilla**	1,466.3	308.3	301.1	-1,165.2	-7.2
*Hygrophila**	585.6	191.8	53.8	-531.8	-138.0
Ludwigia	0.0	0.0	9.0	9.0	9.0
*Nasturtium**	1.6	0.0	0.0	-1.6	0.0
Potamogeton	254.0	180.2	112.1	-141.9	-68.1
Sagittaria	17.8	0.0	19.1	1.3	19.1
*Vallisneria**	1.7	0.0	0.0	-1.7	0.0
Zizania texana	384.3	1,348.3	1,544.6	1,160.3	196.3

* Non-native vegetation species highlighted in red.

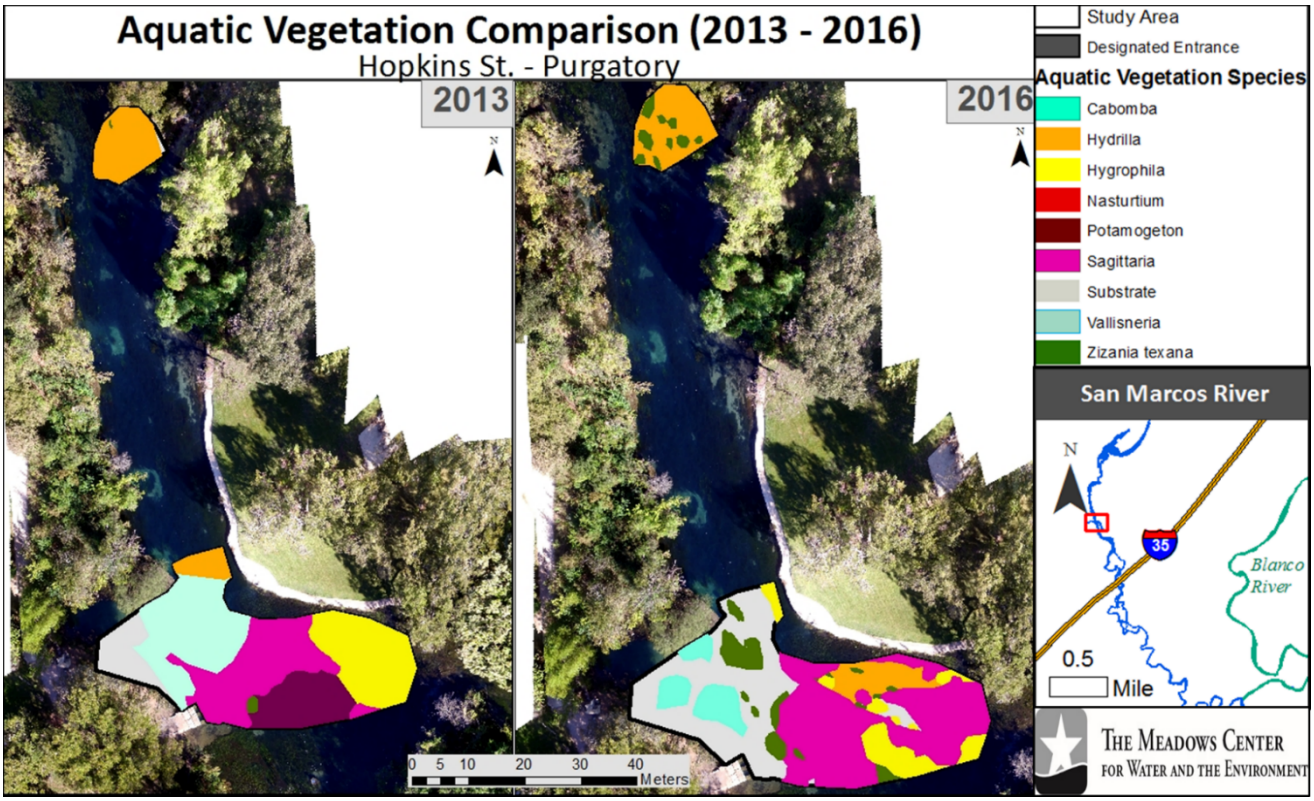

Figure 3.3-40. Changes in aquatic vegetation prior to treatment (2013) and after treatment (2016) in Hopkins Street – Purgatory Reach of San Marcos River.

Cypress Island Reach

The COSM contractor noted successful establishment of Texas wild-rice and other native species in the Cypress Island Reach of the San Marcos River during 2015, so the contractor continued aquatic vegetation treatment effort into 2016. Non-native removal efforts in the Cypress Island Reach consisted of twelve days (March 3, 2016 – August 3, 2016) and removed approximately 613 m^2 of *Hydrilla* and *Hygrophila*. Once the area was denuded of non-native aquatic vegetation, the contractor planted Texas wild-rice plants and other native species grown at FAB or SMARC. Texas wild-rice and other native species plantings occurred on ten days (November 19, 2016 – August 11, 2016) and planted approximately 5,911 native species individuals, covering an estimated area of 223 m^2 (**Figure 3.3-41**). Native species planted in the Cypress Island included: *Cabomba* (968 individuals), *Heteranthera* (2,108 individuals), *Ludwigia* (153 individuals), *Potamogeton* (1,438 individuals), *Sagittaria* (129 individuals) and Texas wild-rice (1,115 individuals).

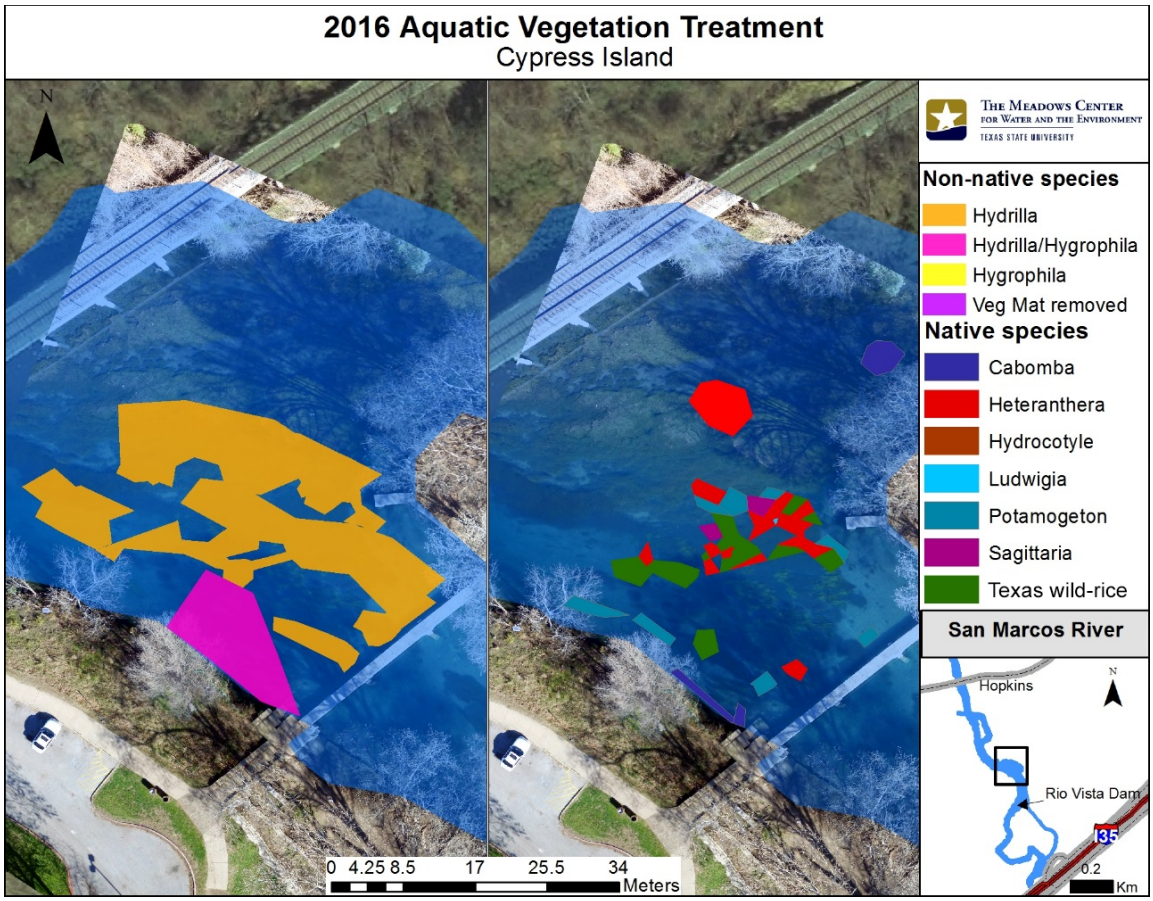

Figure 3.3-41. Locations of aquatic vegetation removal (left) and planting (right) efforts in Cypress Island Reach of San Marcos River (November 2015 – October 2016).

Table 3.3-12 denotes areas (m^2) of aquatic vegetation species 2013-2016, and changes in area (m^2) of aquatic vegetation from 2013-2016 and 2015-2016 in the Cypress Island Reach of the San Marcos River. Changes in vegetation outside of the areas worked were not included since differences observed could not be attributed to work by the COSM contractor's team. **Figure 3.3-42** illustrates the changes in areal coverage of aquatic vegetation at Cypress Island prior to EAHCP activities (spring 2013), one year ago (fall 2015), and current (fall 2016). Since 2013, areal coverage of non-native aquatic vegetation decreased at Cypress Island by approximately 623 m^2. In 2016, *Hydrilla* and *Hygrophila* increased from 2015 by ~228 m^2. Since 2013, Texas wild-rice expanded ~ 238m^2 in areal coverage at Cypress Island and continued to expand ~115 m^2 since Fall 2015. Another native aquatic vegetation species with a notable increase at Cypress Island since 2015 was *Heteranthera* (~19 m^2). The COSM contractor's effort of planting *Cabomba* and *Potamogeton* at Cypress Island only resulted in minimal expansion of the two species (**Table 3.3-12**).

Table 3.3-12. Area (m^2) of Aquatic Vegetation at Cypress Island Reach of San Marcos River 2013-2016, and Changes Detected 2013-2016 and 2015-2016

Species	2013	2015	2016	Changes 2013-2016	Changes 2015-2016
Cabomba	-	-	1.5	1.5	1.5
Heteranthera	-	63.4	82.3	82.3	18.9
*Hydrilla**	1,006.1	156.0	382.3	-623.8	226.3
*Hygrophila**	2.5	-	1.8	-0.7	1.8
Potamogeton	-	-	0.4	0.4	0.4
Sagittaria	-	4.9	0.7	0.7	-4.2
Zizania texana	-	123.0	238.2	238.2	115.2

* Non-native vegetation species highlighted in red.

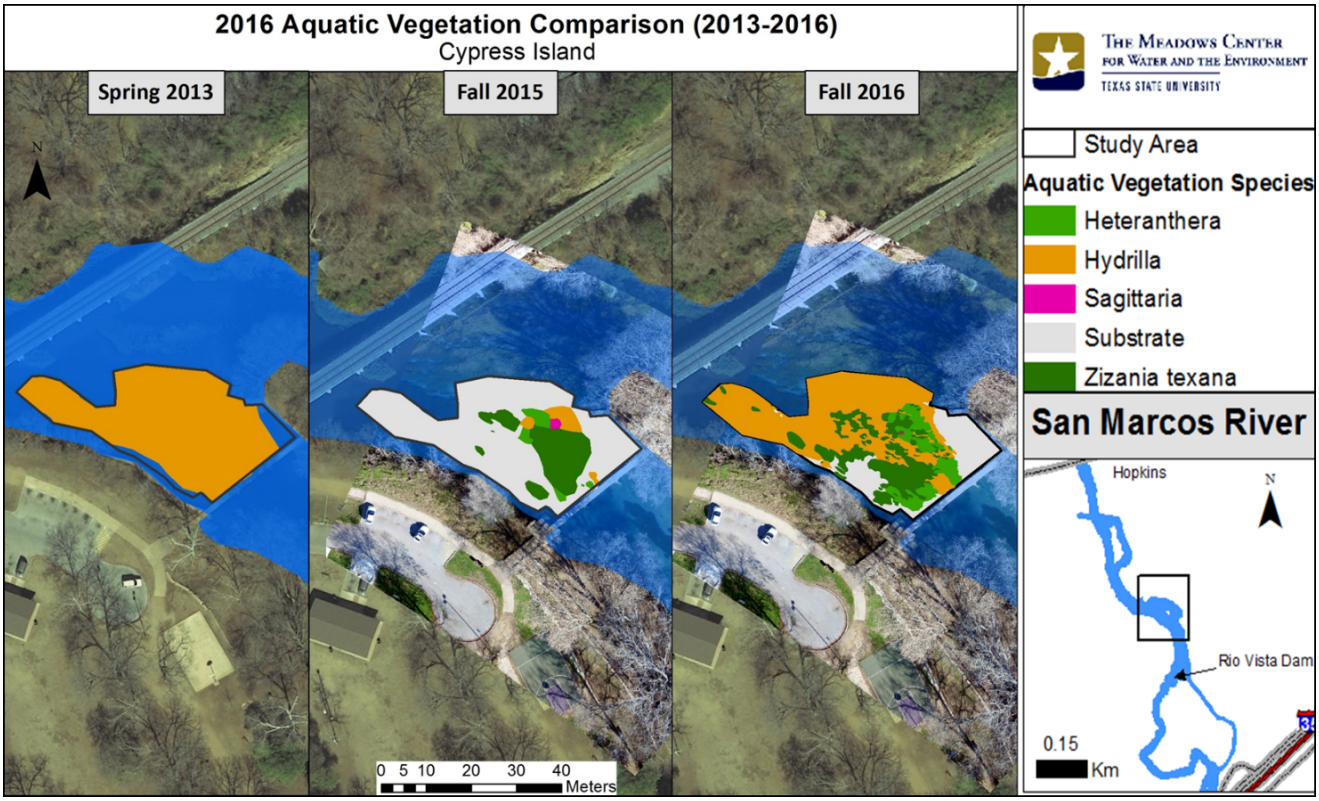

Figure 3.3-42. Changes in aquatic vegetation prior to treatment (spring 2013), fall 2015, and fall 2016 in the Cypress Island Reach of the San Marcos River.

Rio Vista Falls Reach

In 2016, the COSM contractor initiated aquatic vegetation treatment efforts near Rio Vista Dam in the San Marcos River (**Figure 3.3-43**). The contractor selected this reach to dredge after removing non-native vegetation before replanting with native aquatic vegetation due to the large accumulation of fine sediment. Non-native removal efforts in the Rio Vista Dam Reach occurred between June 22, 2016 – October 17, 2016 for a total of eight days, and removed approximately 679 m^2 of *Hydrilla*. As part of the separate Conservation Measure for Sediment Removal Below Sewell Park (EAHCP §5.3.6, p. 17), the contractor initiated dredging sediment in this area in October and will continue dredging through December before replanting the area with Texas wild-rice and other native aquatic vegetation. Therefore, the contractor did not compare changes in the Rio Vista Dam area for 2016, but will conduct this comparison in 2017.

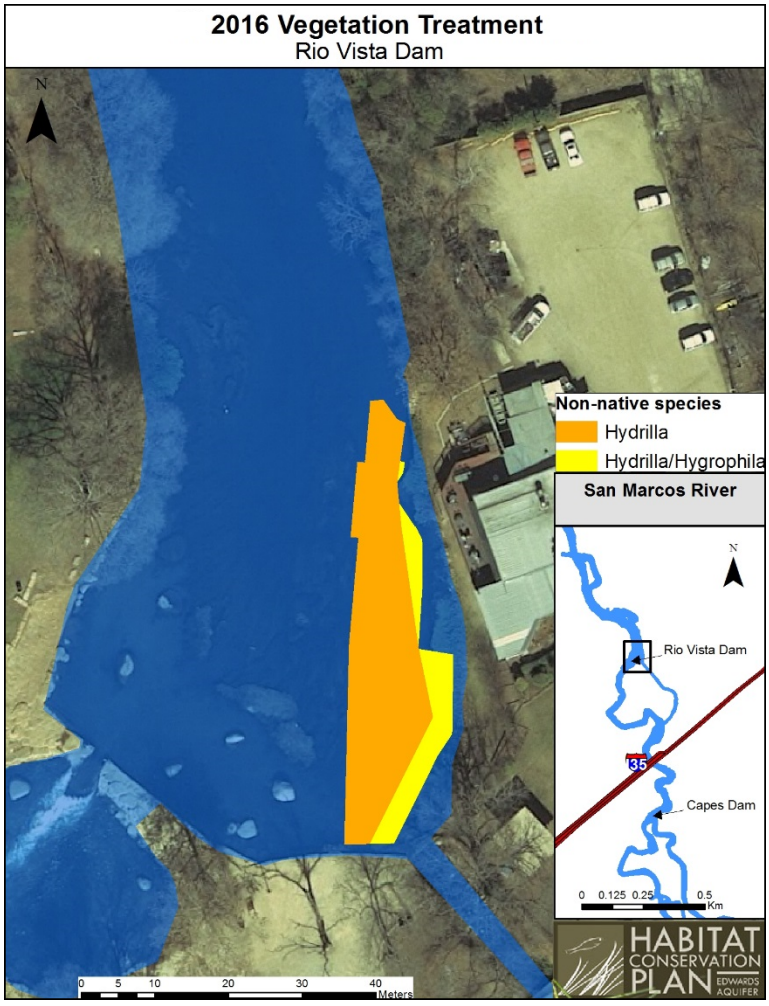

Figure 3.3-43. Locations of aquatic vegetation removal efforts in Rio Vista Dam Reach of San Marcos River (2016).

IH-35 Reach

In 2016, the COSM contractor initiated aquatic vegetation treatment efforts in the IH-35 Reach in the San Marcos River (**Figure 3.3-44**). Non-native removal efforts in the IH-35 Reach occurred between February 17, 2016 – October 4, 2016 for a total of 24 days, and removed approximately 694 m^2 of *Hydrilla* and *Hygrophila*. Once the area was denuded of non-native aquatic vegetation, the contractor planted Texas wild-rice plants and other native species grown at FAB or SMARC. Texas wild-rice and other native species plantings occurred on 23 days (January 19, 2016 – September 22, 2016) and planted approximately 12,384 native species individuals, covering an estimated area of 573 m^2 (**Figure 3.3-44**). Native species planted in the IH-35 Reach included: *Cabomba* (975 individuals), *Hydroctoyle* (3,505 individuals), *Ludwigia* (3,847 individuals), *Potamogeton* (2,070 individuals), *Sagittaria* (612 individuals) and Texas wild-rice (1,375 individuals).

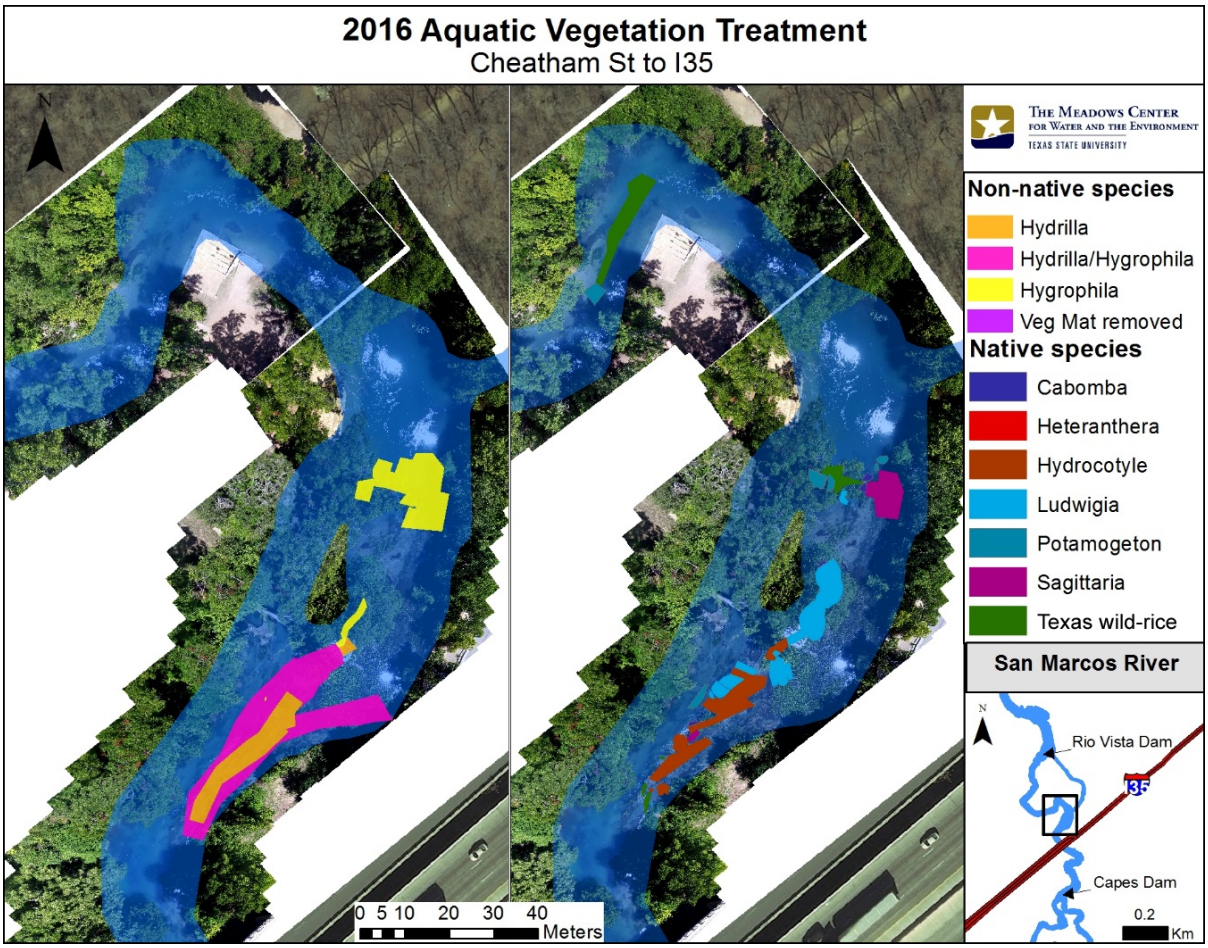

Figure 3.3-44. Locations of aquatic vegetation removal (left) and planting (right) efforts in IH-35 Reach of the San Marcos River (2016).

Table 3.3-13 denotes areas (m^2) of aquatic vegetation species 2015-2016, and changes in area (m^2) of aquatic vegetation from 2015-2016 within the IH-35 Reach of the San Marcos River. Changes in vegetation outside of the areas worked were not included since differences observed could not be attributed to work by the COSM contractor's team. **Figure 3.3-45** illustrates the changes in areal coverage of aquatic

vegetation in IH-35 one year ago (fall 2015), and current (fall 2016). Since November 2015, areal coverage of non-native aquatic vegetation increased by in the IH-35 Reach of the San Marcos River, mainly *Hygrophila* (~107 m^2). However, the COSM contractor noted areal coverage of native aquatic vegetation species increased notably more than nonnative species (~600 m^2). Since November 2015, Texas wild-rice expanded in areal coverage by 194 m^2, followed by *Sagittaria* (176 m^2), *Ludwigia* (163 m^2), *Hydrocotyle* (19 m^2), and *Potamogeton* (18 m^2).

Table 3.3-13. Area (m^2) of Aquatic Vegetation Within IH-35 Reach of San Marcos River Fall 2015, Fall 2016, and Changes Detected 2015-2016

Species	November 2015*	October 2016	Changes 2015-2016
Cabomba	8.9	45.0	36.1
Heteranthera	0.0	0.3	0.3
Hydrocotyle	0.0	19.2	19.2
*Hydrilla***	123.5	125.0	1.5
*Hygrophila***	130.6	237.8	107.2
Ludwigia	8.1	170.7	162.6
Potamogeton	0.0	18.2	18.2
Sagittaria	376.6	552.2	175.6
Zizania texana	81.7	275.5	193.8
Zizaniopsis	3.2	0.0	-3.2

* EAHCP data mapped in November 2015.
** Non-native vegetation species highlighted in red.

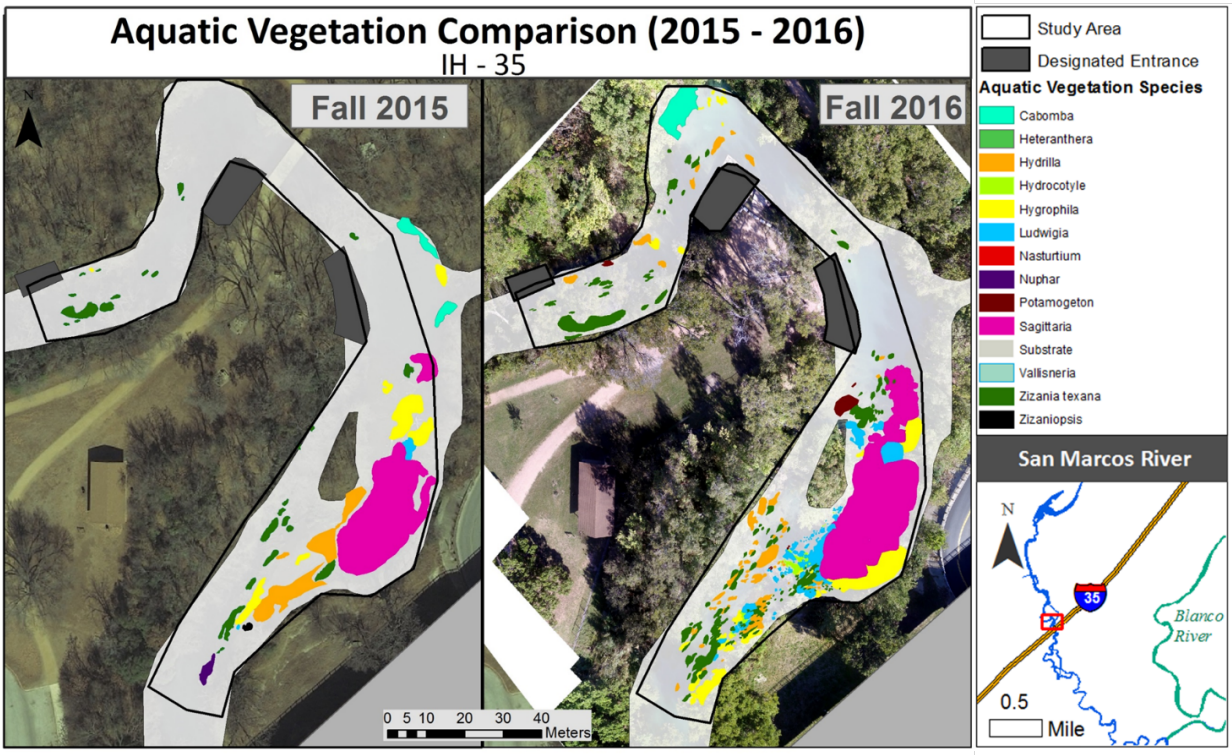

Figure 3.3-45. Changes in aquatic vegetation from fall 2015 (November 2015) to fall 2016 within the IH-35 Reach of San Marcos River.

Summary of All Non-Native Plant Species Control Aquatic Reaches

Table 3.3-14 denotes the amount of non-native aquatic vegetation removed in the San Marcos River in 2016 and **Table 3.3-15** denotes the total areal coverage of species within work sites from 2013-2016. Estimated area reduction per non-native vegetation species since 2013 was *Hygrophila polysperma* 1,749 m^2, *Hydrilla verticillata* (3,116 m^2), *Nasturtium officinale* (31 m^2). Estimated area reduction per non-native vegetation species from 2015-2016 includes *Hygrophila polysperma* (27.13 m^2), and *Hydrilla verticillata* (168.39 m^2).

Table 3.3-14. Amount of Non-Native Vegetation Species Removed in San Marcos

River Reach	Species/Type	Estimated Area Removed (m^2)	Effort in Days
Spring Lake	Hygrophila	108	6
Sewell Park	Hydrilla/Hygrophila	28	1
	Vegetation mat	948	1
City Park	Hydrilla	15	2
	Hygrophila	10	1
	Vegetation mat	188	1
Hopkins St-Purgatory Creek	Hydrilla	66	3
Cypress Island	Hydrilla	631	12
Rio Vista Dam	Hydrilla	679	8
IH-35	Hydrilla	171	8
	Hydrilla/Hygrophila	306	9
	Hygrophila	217	12
TOTAL RIVER	Hydrilla	1,590	34
	Hydrilla/Hygrophila	306	9
	Hygrophila	335	19
	Vegetation mat	1,136	2
TOTALS – AREA REMOVED AND DAYS		**3,367**	**64**

Table 3.3-15. Area (m^2) of Aquatic Vegetation at Work Sites 2013-2016 and Changes Detected 2013-2016 and 2015-2016

Species	2013	2014	2015	2016	2013-2016	2015-2016
Cabomba	163.0	36.6	13.8	11.5	-151.5	-2.3
Heteranthera	0.0	152.8	63.8	165.5	165.5	101.7
Hydrilla	3,980.2	1,804.1	1,032.5	864.1	-3,116.1	-168.4
Hydrocotyle	78.2	131.4	25.3	112.4	34.2	87.1
Hygrophila	2,610.6	1,382.6	888.8	861.6	-1,749.0	-27.2
Ludwigia repens	0.0	73.3	0.0	9.0	9.0	9.0
Nasturtium	31.4	111.7	0.0	0.0	-31.4	0.0
Potamogeton	1,530.4	762.7	437.8	800.9	-729.5	363.1
Sagittaria	457.3	452.5	709.2	1,014.3	557.0	305.1
Zizania texana	2,467.6	3,765.0	5,511.1	5,482.8	3,015.2	-28.3

As indicated in **Table 3.3-16**, the estimated number of native species planted in the San Marcos River downstream of Sewell Park was 24,592 individuals from December 2015 – October 2016. The greatest number of individuals planted was Texas wild-rice (7,469), followed by *Potamogeton illinoensis* (4,282), *Ludwigia repens* (4,100), *Hydrocotyle* (3,511), *Heteranthera dubia* (2,240), *Cabomba* (1,943), and

Sagittaria platyphylla (1,047). Estimated area planted with native species was 946 m^2 in the San Marcos River downstream of Sewell Park within areas removed of non-native vegetation (**Table 3.3-16**).

Table 3.3-16. Number of Individuals Planted, Estimated Areas Planted (m^2), and Effort (Days Worked) Planting for Each Native Species per Reach in the San Marcos River (2016)

River Reach	Species	Individuals Planted	Estimated Area (m^2)	Effort in days
Spring Lake	*Zizania*	3,512	85	6
Sewell Park	*Zizania*	250	6.6	1
City Park	*Heteranthera*	24	1.2	1
	Hydrocotyle	6	<1	1
	Ludwigia	100	3.7	1
	Potamogeton	324	12	2
	Zizania	348	16	2
Hopkins St	*Heteranthera*	108	2.9	1
	Potamogeton	450	4.3	1
	Sagittaria	306	3.8	1
	Zizania	869	14	3
Cypress Island	*Cabomba*	968	25	3
	Heteranthera	2,108	80	8
	Ludwigia	153	8.9	2
	Potamogeton	1,438	42	6
	Sagittaria	129	9.1	2
	Zizania	1,115	58	8
IH-35	*Cabomba*	975	17	5
	Hydrocotyle	3,505	146	9
	Ludwigia	3,847	153	10
	Potamogeton	2,070	51	8
	Sagittaria	612	101	5
	Zizania	1,375	105	8
TOTAL RIVER	*Cabomba*	1,943	42	8
	Heteranthera	2,240	84	10
	Hydrocotyle	3,511	146	10
	Ludwigia	4,100	166	13
	Potamogeton	4,282	109	17
	Sagittaria	1,047	114	8
	Zizania	7,469	285	28
TOTALS - INDIVIDUALS PLANTED, AREA, AND DAYS		**24,592**	**946**	**94**

Table 3.3-16 lists areas where planting occurred in 2016. No plantings were accomplished in the Upper Sewell Park, above City Park, or Rio Vista in 2016.

Non-Native Littoral and Riparian Plant Removal

In 2016, removal efforts consisted primarily of removal of regrowth and invasive plants from Spring Lake to Cheatham Street (**Figure 3.3-46, Figure 3.3-47,** and **Figure 3.3-48**. New effort was placed into volunteer

removal in the remaining area to Stokes Park **(Figure 3.3-49**). Effort was greater in fall and winter before the elephant ears began their spring growth.

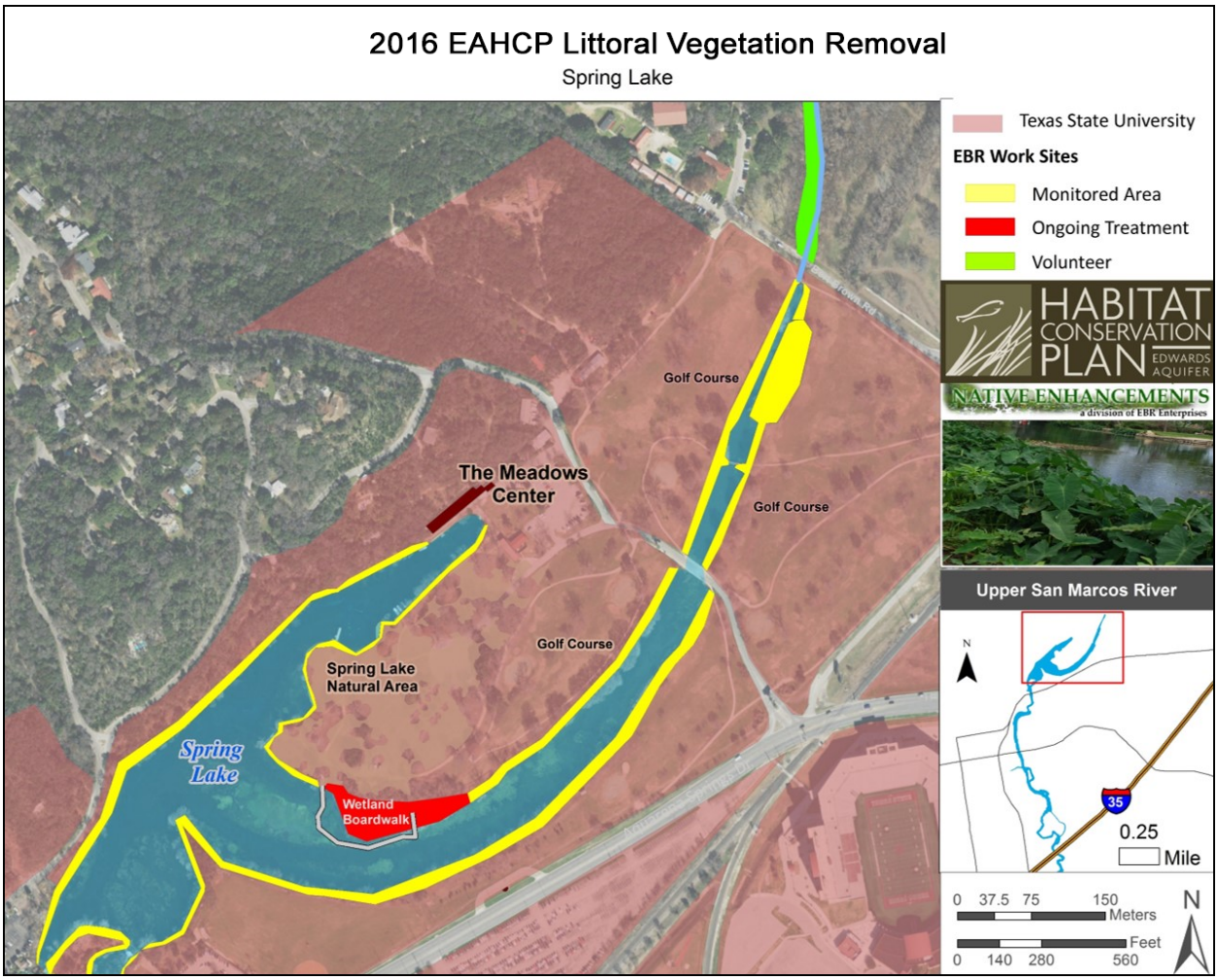

Figure 3.3-46. Maintenance and hot spot treatment in Spring Lake and Sink Creek.

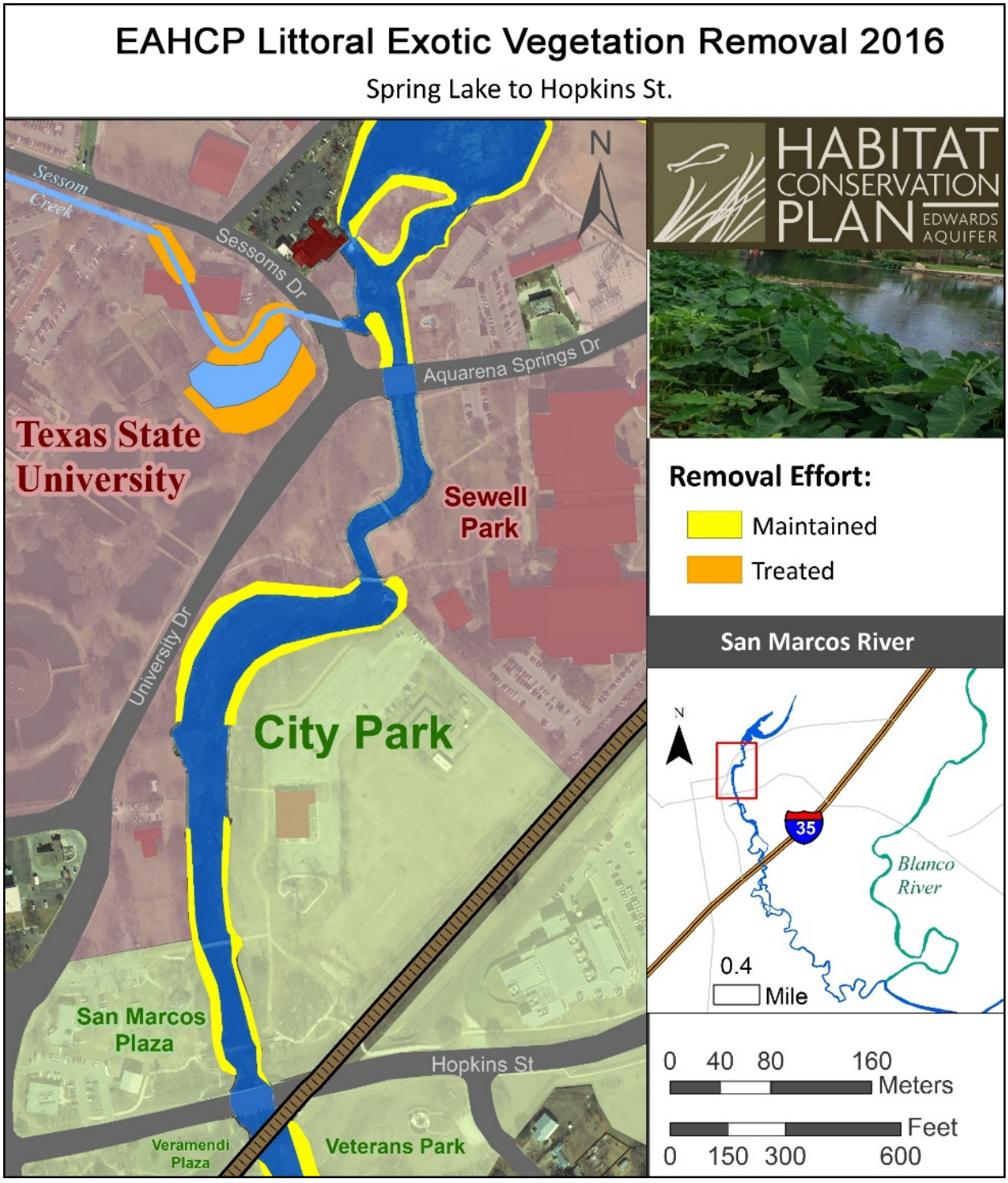

Figure 3.3-47. Maintained and treated areas from Spring Lake to Veramendi Plaza.

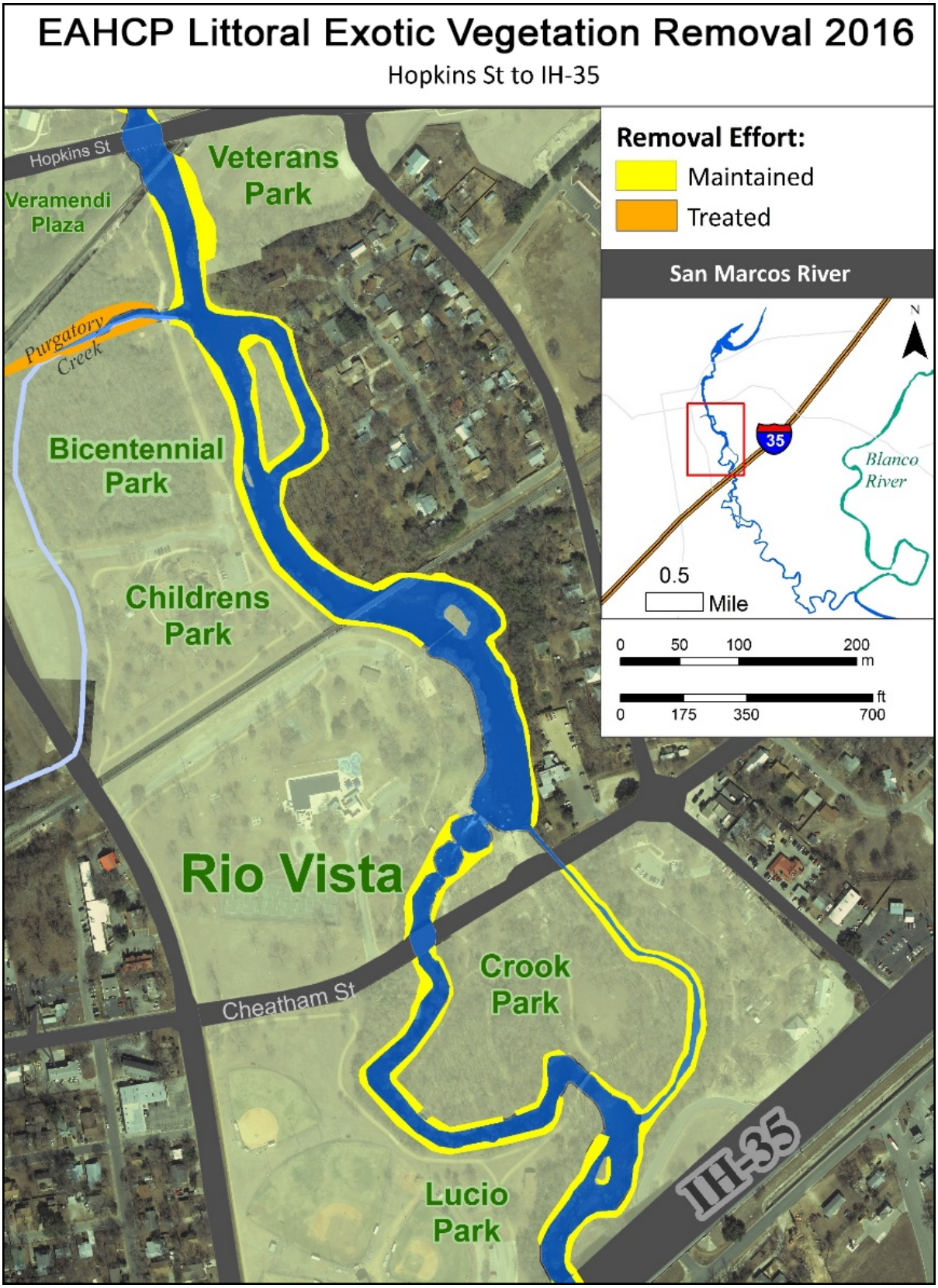

Figure 3.3-48. Maintained and treated areas from Veramendi to IH-35.

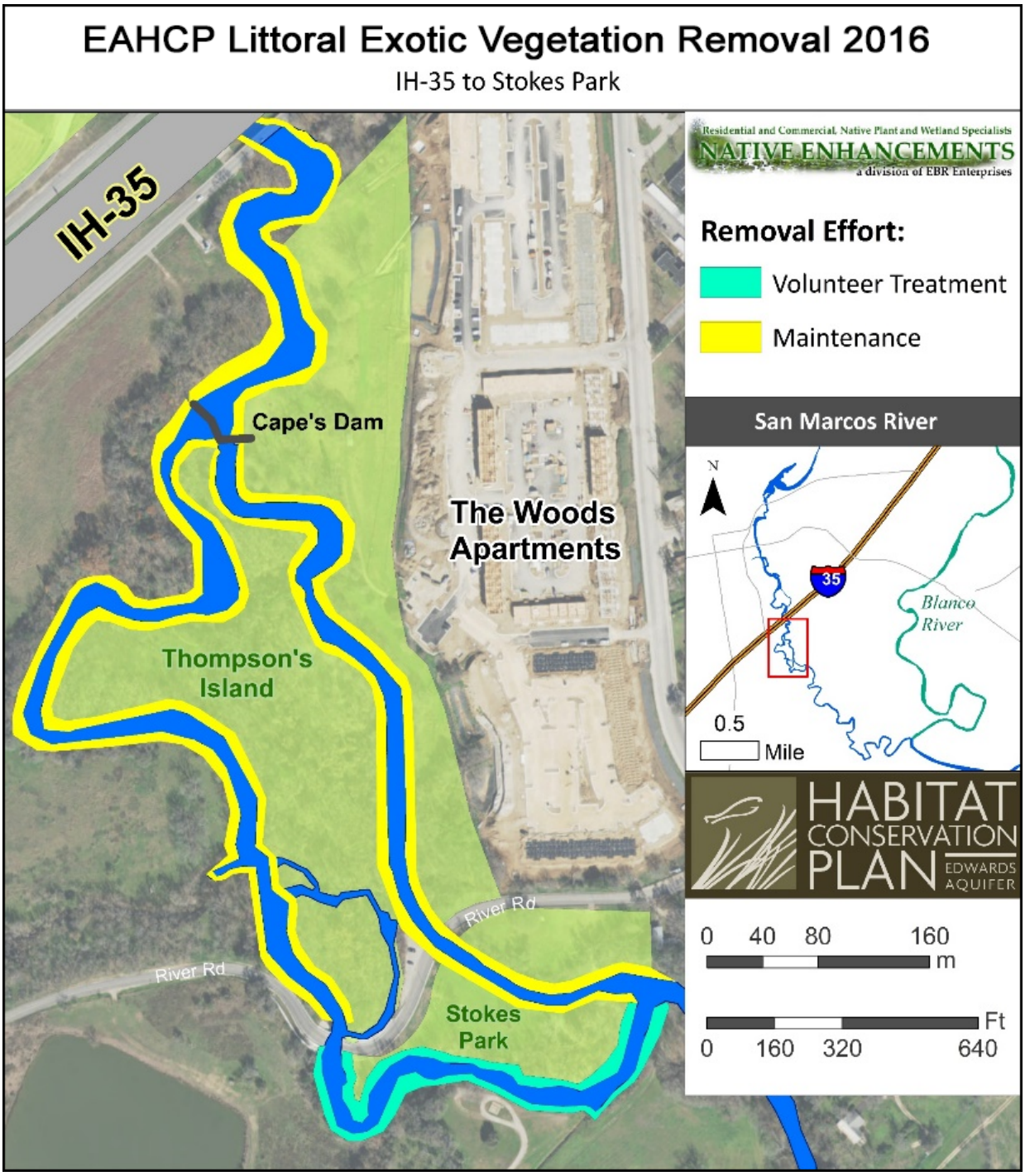

Figure 3.3-49. Maintained area below IH-35 and new removal efforts at Stokes Island.

The COSM's contractor targeted several hot spots in 2016 including areas along Sink Creek (**Figure 3.3-46**), in Sessom Creek adjacent to the FAB (**Figure 3.3-47**), and around detention ponds, and another large stand of elephant ears on lower Purgatory Creek was also treated (**Figure 3.3-48**). All of the remaining large Chinese tallow, chinaberry, and Ligustrum close to the FAB were documented with pictures, paint

marks, and GPS readings. This information was given to the COSM and Texas State to help maintain native restoration activities that have been previously implemented.

The COSM contractor has the entire area from Sewell Park to IH-35 under control and is continuing to do maintenance runs (**Figure 3.3-47** and **Figure 3.3-48**). Spring Lake is under a tight maintenance schedule as this is a more difficult area to gain control.

The contractor used Aquaneat (glyphosate-based herbicide) for elephant ears and other non-native plants encountered in the littoral zone (10.25 ounces (oz.) per gallon maximum). This herbicide was mixed with Aqua King Plus Surfactant (1 oz. per gallon) and Turf Mark Blue, Blue Dye. On the upland tree, shrub stumps and root buttresses, a COSM contractor used Relegate **(**Triclopyr-based herbicide) at 10 oz. per gallon. The Relegate was mixed with glyphosate (10.25 oz. per gallon maximum), Drexel Surf Ac 820 Surfactant (1 oz. per gallon) and Turf Mark Blue, a blue dye. Chemicals were applied with a one-gallon pump-up sprayer set on a steady stream for a more precise target hit to minimize leaching and non-target plant damage. Roots of woody plants were scarred up with a machete to expose the cambium layer and treated with an herbicide mix.

Compliance for this measure is based on total coverage of fountain darter habitat in m^2 specified in Table 4-21 of the EAHCP. 2016 status is determined by the October monitoring event shown in **Table 3.3-17**.

Table 3.3-17. Status of Fountain Darter Habitat Within LTBG Reaches in San Marcos Ecosystem (October 2016)

LTBG Reach	*Hygrophila*	*Ludwigia*	*Cabomba*	*Hydrilla*	*Potamogeton*	*Sagittaria*	*Vallisneria*
Spring Lake Dam	47.42		2.27		109.73	7.79	2.53
City Park	264.17	1.27		503.23	132.94	112.68	
IH-35	252.94	103.22	27.93	28.29		429.73	

As discussed previously, and to be discussed in more detail later in this Annual Report, the original EAHCP LTBGs were amended through the AMP in 2016. As a result of the AMP in 2016, the EAHCP requested further amendments to Table 4-21 of the EAHCP in September 2016. In addition, the EAHCP requested further clarification to the EAHCP Key Management Objectives of "proportional expansion" and creation of "restoration reaches" for the Comal and San Marcos rivers at that same time. Those amendments and clarifications were approved by the USFWS in October 2016. For more detailed discussion of the 2016 AMP, please refer to **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.1.11.2** – Amendments, Informational Memoranda, and Clarifications, and to **Chapter 4.0** – ADAPTIVE MANAGEMENT PROCESS ACTIVITIES FOR 2016, **Section 4.2** – Nonroutine Decisions, of this Annual Report.

Compliance reporting for 2016 maintained the original EAHCP LTBGs, while the new LTBGs will be reflected in the 2017 Annual Report.

Proposed Activities for 2017:

The entire river from Spring Lake to just below IH-35 has undergone initial removal of elephant ears, so in 2017 all treated areas will be monitored for regrowth and planted with natives. Importantly, efforts will continue to be extended to remove hot spots that contribute to regrowth**.**

3.3.9 Control of Harmful Non-Native and Predator Species (EAHCP §5.3.9)

EAHCP Obligations:

The COSM, in partnership with Texas State, will implement a non-native species control program that targets armored catfish (Loricariidae), tilapia (*Oreochromis* spp.), red-rimmed melania (*Melanoides tuberculata*), and the giant ramshorn snail *(Marisa cornuarietis)*. The COSM will conduct annual monitoring and maintenance activities to ensure continued control of the invasive population within the San Marcos system.

2016 Compliance Actions:

Tilapia

The tilapia in Spring Lake spawn from March through June. During this time the COSM contractor focused all efforts on tilapia removal by bowfishing, spearfishing, and using gill nets. A speargun was used for removal in Spring Lake only. Tilapia were also captured throughout the river along with armored catfish by polespear and seine net. Bowfishing was the most successful method during spawning season. Outside of spawning season, a speargun was the most successful method for removing tilapia. Two-thirds of the removed tilapia were from Spring Lake.

Armored Catfish

All of the catfish captured from Spring Lake to this date have been identified as the sailfin catfish. The suckermouth catfish species and the sailfin catfish have both been captured from other parts of the San Marcos River. The suckermouth catfish has not been found in Spring Lake. Both catfish species were removed using pole spears and hand collection while snorkeling. Catfish were speared at both night and day, but during the recreation season contractor dives were only conducted at night due to the constant turbidity of the water during the day. The highest captures of sailfin catfish from Spring Lake occur during the coldest time of the winter (December – February). Observational counts over time show that the number of sailfin catfish are reducing in Spring Lake, i.e. four sailfin catfish were removed from Spring Lake in January – February 2016.

The COSM contractor has observed that since the contract began in 2013, painted river prawn (*Macrobrachium carcinus*) have been making a huge comeback. Places that normally hid suckermouth catfish (caves, under ledges, etc.) are now occupied by prawn.

Snails

The COSM contractor works areas of large concentrations of the red-rimmed melania, and the giant ramshorn snail by hand-collection, and primarily in Spring Lake and in Clear Springs Natural Area. Snails are also included in the biannual spearfishing tournament, with an award given for greatest weight in snails removed.

Tournaments

With permission from the San Marcos Park Rangers, the COSM contractor programs two week-long pole spear tournaments twice each year to give the community the opportunity to take part in the EAHCP by removing non-native invasive fish. The contractor hosts spring and winter spearfishing tournaments that increase the capture of tilapia, armored catfish, and exotic snails. Results of the 2016 spring tournament: 26 participants removed 319 catfish (161.32 lbs.) and 5 tilapia (7.56 lbs.). The winter tournament took place from November 1-21, 2016 and approximately 31 participants registered. The winter tournament participants removed 311 suckermouth catfish (121.8 lbs.) and 3.23 ounces (or 0.20 lbs.) of red rimmed melania snails. No giant ramshorn snails, tilapia, or sailfin catfish were removed.

Monitoring Program

In order to provide details associated with invasive animals' general abundance in the San Marcos River, biomass data was collected in order to more adequately determine the health of the populations. **Table 3.3-18** shows the total biomass collected in relation to numbers collected to better determine how much impact is being made towards controlling this species.

Table 3.3-18. Annual Non-Native Species Removal Totals for 2016 Through October 2016

Species	Total Biomass (lbs.)	Total No.	Average biomass/individual (lbs.)
Tilapia	2,732.24	839	3.27
Catfish (Suckermouth & Sailfin)	2,715.81	4,460	0.61
Nutria	120.74	14	8.62
Red-rimmed snail	3.42	N/A	N/A
Giant ramshorn snail	3.08	N/A	N/A

N/A – Not applicable as data not recorded.

Proposed Activities for 2017:

In 2017, the COSM will continue regular removal of the tilapia, armored catfish, and exotic snails. Monthly monitoring will continue starting in January 2017. Semiannual tournaments will continue to increase removal.

3.3.10 Native Riparian Habitat Restoration (EAHCP §5.7.1)

EAHCP Obligations:

The COSM will restore riparian habitats with native species on City property from City Park to Stokes Island. The COSM will establish a program for private landowners to implement riparian restoration on their properties with the opportunity for reimbursement of plant acquisition costs if program criteria are met.

2016 Compliance Actions:

The COSM contractor, staff, and volunteers continued non-native tree and vine removal in City Park, Riverhouse, Bicentennial (**Figure 3.3-50**), Rio Vista, Wildlife Annex, Crooks, and Ramon Lucio parks throughout 2016. Invasive plant removal was performed with chainsaws and hand tools. All cut stumps were chemically treated by the contractor and licensed staff. Erosion control measures placed all the straight branches and trunks on contour and used mulch produced on-site to fill between the contour logs (**Figure 3.3-51**). In Ramon Lucio Park, the logs from the site were not sufficient, so the contractor supplemented erosion control with mulch logs. In 2016, the invasive species removed were Japanese and Chinese privet (*Ligustrum japonicum* and *L. sinense*), chinaberry (*Melia azedarach*), white mulberry (*Morus alba*), Chinese tallow (*Triadica sebifera*), and Japanese honeysuckle (*Lonicera japonica*). New invasive seedlings were removed in August and September, mostly by hand-digging or pulling.

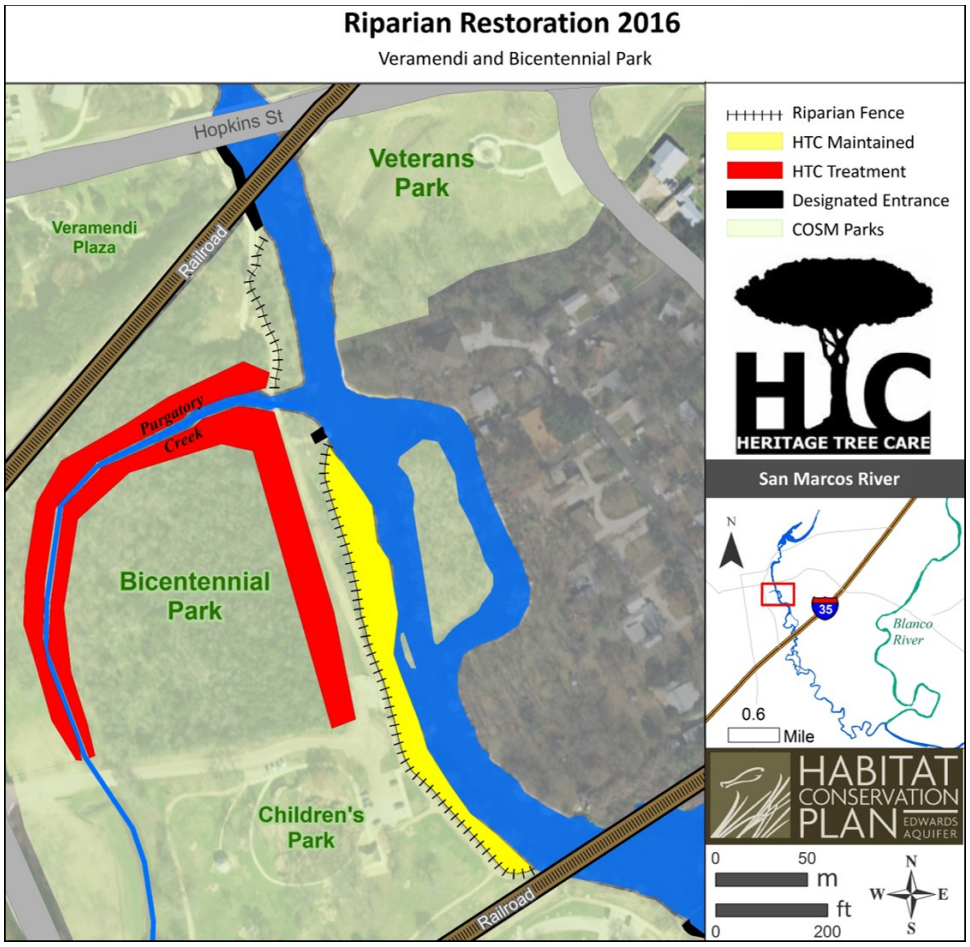

Figure 3.3-50. Maintenance and new removal areas accomplished in 2016.

Figure 3.3-51. Erosion control and soil protection practices.

Most plantings occurred in March – April 2016 and October – November 2016 to take advantage of spring and fall rains and temperatures. Sites planted included Clear Springs, City, Rio Vista, Crooks and Ramon Lucio parks. To reduce costs and involve the community, all plantings were performed by volunteer Plant Work Days (**Figure 3.3-52**). Plants were sourced from SMARC and other donation sources. The COSM continues to plant drought-tolerant species and littoral species, and broadcast native seed stock to revegetate riparian buffer zones (**Figure 3.3-53**). Hand-watering was performed in areas without irrigation until plant roots were established.

Figure 3.3-52. Volunteer native riparian improvement planting.

Figure 3.3-53. COSM use of drought tolerant prohibitive species, littoral species, and native seed stock.

New plant species are selected as recommended by local plant experts, the U.S. Department of Agriculture (USDA), USFWS, TPWD and TCEQ for riparian restoration projects. The existing plant species composition is very diverse, which will assist the riparian restoration.

Also in 2016, the COSM and Texas State received high honors for riparian buffer accomplishments. The signatories were awarded the TEEA from TCEQ for the Civic and Community category highlighting the volunteerism and success of the Riparian Habitat Restoration measure of the EAHCP.

Proposed Activities for 2017:

In 2017, the COSM contractor will remove invasive species from the last portion of Ramon Lucio Park (Wildlife Annex). Volunteers will replant with natives, and contractor/volunteers will maintain all treated areas from Spring Lake to IH-35. Giant Reed *(Arundo donax)* removal will be researched for possible extraction. The program will focus on private landowners to participate.

3.3.11 Septic System Registration and Permitting Program (EAHCP §5.7.3)

EAHCP Obligations:

The COSM will establish a registration, evaluation, and permitting program for aerobic and anaerobic septic systems.

2016 Compliance Actions:

As of January 1, 2016, the San Marcos Environmental Health Department had registration records for 602 septic systems within the COSM jurisdiction. Five new septic systems were added into service in 2016, yielding a total, as of December 31, 2016, of 607 septic systems in the City. All systems have been permitted and evaluated to prevent subsurface pollutant loadings into the Edwards Aquifer or the San Marcos River.

Proposed Activities for 2017:

The COSM will continue to implement their septic system registration and permitting program. This program includes the required connection to municipal sewer lines according to COSM Ordinance, Section 86.152.

3.3.12 Minimizing Impacts of Contaminated Runoff (EAHCP §5.7.4)

EAHCP Obligations:

The COSM will excavate and stabilize two areas for the construction of two sedimentation ponds in the vicinity of the San Marcos River. Once funded, construction of these BMPs will be closely monitored for potential impacts to the river system. Upon completion, the COSM will regularly monitor these ponds to remove and properly dispose of accumulated sediments off-site.

2016 Compliance Actions:

The EAHCP calls for the design and construction of two water quality BMPs. The first will be located on the west side of the river at Veramendi Park beside Hopkins Street bridge (Pond 1) and the other on the east side of the San Marcos River capturing stormwater runoff carried in the Union Pacific Railroad (UPRR) drainage channel that runs along Hopkins Street (Pond 2). **Figure 3.3-54** and **Figure 3.3-55** below show the proposed locations of Pond 1 and Pond 2.

The concept design for Pond 1 has been submitted for funding through the U.S. Environmental Protection Agency (EPA) 319 grant process. This grant request includes multiple projects for both the WQPP and the EPA/TCEQ Watershed Protection Plan (WPP) for the San Marcos River watershed. Awards will be announced in early 2017.

Pond 2 is proposed for a modified location than what has been proposed in previous reports, but captures the same stormwater runoff targeted in this Conservation Measure. The EAHCP is taking advantage of an opportunity to partner with the COSM in a project that includes the demolition of an existing, degrading asphalt parking lot that sends untreated runoff directly to the San Marcos River. Phase One includes the construction of a new parking lot and a biofiltration system that will treat runoff from onsite. It is estimated that the biofiltration pond will remove 1,449 lbs. of TSS and 3.6 lbs. of total phosphorus (TP) on an annual basis. Phase One is currently under construction. Phase Two will include the construction of an inlet that allows treatment of offsite runoff from approximately 12 acres of offsite runoff from the Strahan parking lot owned by Texas State. Phase Two will remove an additional 5,229 lbs. of TSS and 13.2 lbs. of TP annually. The COSM is currently working with UPRR for approval of constructing an inlet into their right-of-way.

Figure 3.3-54. Design Concept Plan for Hopkins Pond 1 at Veramendi Park.

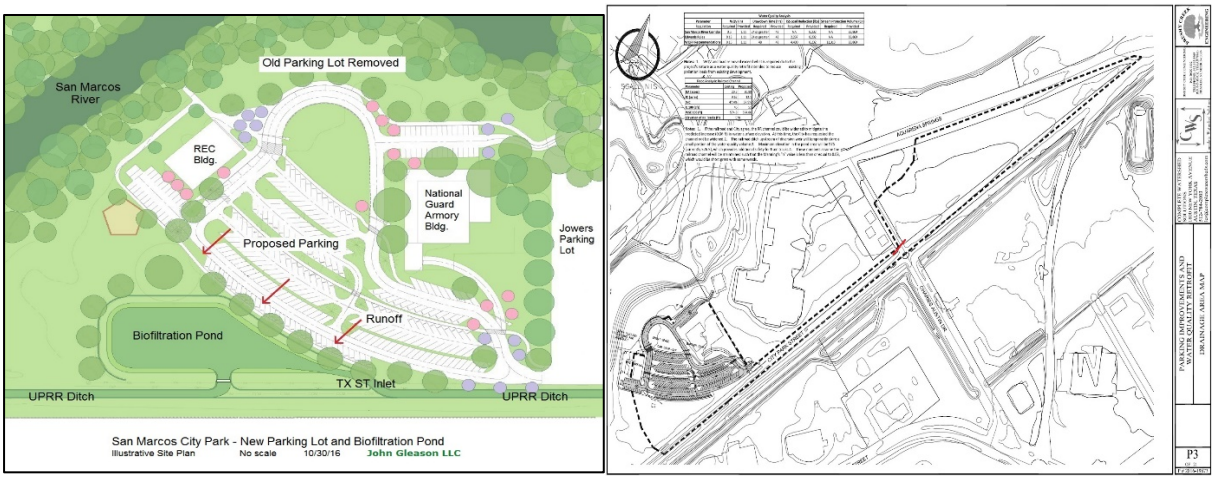

Figure 3.3-55. Design Concept Plan for UPRR channel Pond 2 at San Marcos Plaza.

Proposed Activities for 2017:

If negotiations with UPRR are successful, the inlet will be constructed to treat water, thus meeting the intent for Pond 2 as described in the EAHCP. If Pond 1 is funded through the EPA 319 grant, construction will begin in 2017. If not, then grants will be sought to match EAHCP funding for its construction.

3.3.13 Management of Household Hazardous Wastes (EAHCP §5.7.5)

EAHCP Obligations:

The COSM will continue to expand its existing HHW program. This program will include opportunities for collection locations available to the general public.

2016 Compliance Actions:

As a member of the EAHCP, the COSM operates an HHW collection program. This program is available free of charge for all Hays County residents. Visitors are able to drop off household chemicals and paint that are hazardous for the environment. This facility also operates a reuse program for items that are in good condition. Labor for the facility is contracted to Green Guy Recycling. HHW is open to the public every Tuesday and Friday from 12:00 p.m. to 3:30 p.m. It is located at 630 E. Hopkins, San Marcos, TX 78666.

The majority of participants come from the cities of San Marcos, Kyle, and Wimberley, and areas outside of the city limits. These areas are home to environmentally-sensitive watersheds and the Edwards Aquifer Contributing and Recharge zones. Offering a safe alternative to improper or illegal dumping of hazardous household chemicals is paramount to improving water quality and regional sustainability.

Drop-Off Center Participation

The primary function of the HHW program is the drop-off center. Residents drive into the unloading area, where they are met by an HHW worker. The participants remain in their vehicle as the worker unloads the containers onto a cart. Each participant fills out a survey and provides their address. From these surveys,

monthly participation rates are tracked for each community. The average number of participants for 2016 was 155 per month, compared to 2015 at 150 per month.

The HHW facility is open to all residents of Hays County. The majority of the residents come from the COSM and areas outside of municipal jurisdictions. The San Marcos region is an environmentally-sensitive area for the San Marcos River. Preventing illegal dumping and pollution in this region makes great strides towards improving water quality.

Reuse Program Participation

The reuse program supports the drop-off center by attracting residents and diverting reusable items from the disposal stream. When chemicals are unloaded, the worker segregates new and slightly used containers that are ready for use. Many visitors with items eligible for reuse are in the moving process. Rather than moving all of their cleaning supplies, they have the option to deliver them to the HHW. These items are taken to the reuse building and are sorted on shelves. This building is open to the public during regular operating hours. Reuse participants fill out a form documenting the materials they pick up. This form explains that unused items are to be returned to HHW and not to be thrown into the regular waste stream. Participation for the reuse program has grown over time. The program also serves to educate the public about safe disposal and alternatives to harmful chemicals.

The monthly average participation is 72 participants. For 2015, the average was 71 participants. This program received many compliments from visitors. Participants save money by collecting reuse items at no cost and the HHW program saves money by reducing disposal expenses.

The average participants from drop-offs and reuse for 2016 was 227 participants per month, the average for 2015 was 221 participants per month. The drop-off center surveys indicate that the COSM website and word of mouth contributed to the steady program participation.

The annual outreach goal for HHW is 1,400 total participants. In 2016, this goal was exceeded by 95 percent with an annual total of 2,725 participants. The popularity of the reuse program and increased exposure through public outreach contributed to the program's success.

Chemicals

Household hazardous materials accepted by HHW include a wide-range of common chemicals and waste products. After the household waste is unloaded from the vehicle, the material is sorted and weighed. Each item is sorted based on chemical type. HHW facility workers collaborate with the chemical disposal company to evaluate the waste stream and finding storage and shipping options that reduce the expense. For example, oil based and latex paint, liquid flammables, used motor oil, cooking oil, and anti-freeze are bulked into 55-gallon drums. The remaining chemicals are sorted into either 55-gallon drums or lined Gaylord boxes. Each container is stored in a chemical building or under cover until they are shipped to recycling facilities and a chemical landfill.

The HHW Program disposed of approximately 145,074 lbs. of HHW. Without this program, much of this waste would have been improperly disposed of in the municipal waste stream or illegally dumped. Drop-off disposal weights for 2016 averaged 12,090 lbs. per month.

The amount of household hazardous waste diverted from the waste stream and distributed by the Reuse Program totaled 12,469 lbs. Not only does this save on costs, it also decreases the demand for new products. The program helps with both material reuse and waste reduction.

Proposed Activities for 2017:

Moving forward, the COSM's goal for 2017 is to increase participation rates and continue to enhance awareness of the impact of HHW on the environment, particularly Covered Species habitat. An additional off-site event in Driftwood will be held in the fall of 2017.

3.3.14 Impervious Cover and Water Quality Protection (EAHCP §5.7.6)

EAHCP Obligations:

The COSM will establish a program to protect water quality and reduce the impact of impervious cover. Target programs will be identified consistent with the recommendations of the LID/Water Quality Work Group Report developed during the EARIP and included as Appendix Q to the EAHCP.

The San Marcos WQPP is a locally-developed approach for compliance with the ITP in San Marcos, Texas. The intent of the WQPP is to provide a holistic, integrated approach for Texas State and the COSM in regards to water quality concerns associated with impervious cover and urban development. While the primary intent of the WQPP is protecting habitat for the Covered Species, off-shoot benefits include helping entities serve the needs of their growing populations and promote responsible economic development, good public infrastructure, and preserve open space.

2016 Compliance Actions:

The WQPP was modified slightly to ensure that it provided a higher level approach to water quality protection that clearly defined the outcome, but allowed the technical details to be provided by the COSM and Texas State. The WQPP is now included under the umbrella of the WPP, which was developed by a stakeholder group representing the COSM, Texas State and Hays County. So as the WPP is adopted and implemented, so also is the WQPP. This development was presented to the COSM City Council in September and upon approval from TCEQ, the WPP/WQPP will be brought back to council for a resolution. A COSM contractor actively implements WQPP recommendations through on-the-ground projects as described below and participates in planning and site meetings with COSM and Texas State staff regularly as well as attending and presenting to quarterly WPP/WQPP stakeholder meetings. **Table 3.3-19** includes the list of Upper San Marcos WPP Stakeholder Committee Members.

Table 3.3-19. Members of the Upper San Marcos WPP Stakeholder Committee for 2016

Name	Affilation
Bill Adams	Department of Geography
Elizabeth Arceneaux	Texas State - EHSRM Department
Justin Bates	National Park Services
Denise Blanchard	Department of Geography
William Butler	Texas State
Margo Case	Community Member
Cliff Caskey	Agriculture/Rancher/Rural Land Owner
Gustavo Cantu	Texas State - EHSRM Department
John David Carson	Developer, Real Estate, Construction
Jesse Dalton	Anthropology
Vincent Debrock	Local Business Owner
Gail Dickinson	
Gena Fleming	Community Member
Mario Garza	Indigenous Cultures Institute
John Gleason	John Gleason LLC
Steve Goodson	San Marcos Greenbelt Alliance
Juan Guerra	Texas State
Daniel Gurrero	COSM
Glenn Hanley	
Tom Hegemier	Espy Consultants/City Water Quality Protection Planning
Melani Howard	COSM - Water Quality
Jane Hughson	Riparian Land Owner
Ted Ingwersen	
Bell Kendall	Barton Springs/Edwards Aquifer Conservation District
Brian Koch	Texas State Soil and Water Conservation Board
Nathan Lawrence	Texas State - Facilities
Derrick Lee	Heritage Tree Care
Brooke Leftwich	Hays County
Jon Lohse	Texas State - Archaeology Dept
Debbie Magin	GBRA
Ryan McGillicuddy	TPWD
Sam Meacham	MCWE
Don Meador	Ranching and Agriculture
Meredith Miller	MCWE
Bob Millican	Ranching and Agriculture
Paul Murray	Sessom Creek Neighborhood Association
Kyle Mylius	Chamber of Commerce
Ben Nelson	St. Mark's Episcopal Church
Weston Hugh Nowlin	Science/Research
MIke Olendorf	Landowner
Melissa Parker	TPWD
Shaun Payne	Texas State - Student
Cresencio Perez	USDA
Annick Prevost	Habitat Conservation Plan
Lisa Prewitt	Gardens by Lisa
Brian Reis	Espy Consultants/City Water Quality Protection Planning
Maria Rocha	Indigenous Cultures Institute
Thomas Ryan	MCWE
Benjamin Schwartz	Texas State - Biology Department
Sheri Lara	Texas State - Utilities Operations
Stella Silva	Texas State - Multicultural Student Affairs

Table 3.3-19. Members of the Upper San Marcos WPP Stakeholder Committee for 2016

Name	Affilation
Dan Stauffer	McCoy Corporation
Pat Stroka	EAA
Arthur Talley	TCEQ
Chad Thomas	Texas State - EHSRM Department
Cinde Thomas-Jimenez	GBRA
Travis Tidwell	MCWE
Kristina Tolman	MCWE
Katie Tritsch	Community Member
Mary Van Zant	MCWE
Nikkye Vargas	MCWE
Ellena Waller	Gardenville
Tiankai Wang	Texas State - HIM Department
Emily Warren	MCWE
Dianne Wassenich	SMRF
Chris Wood	Wood and Thomas Construction

The following services were performed in support of the EAHCP/WQPP and are prefaced by an associated 2016 Performance Measure:

1) Staff integration. Prepared a Land Conservation Plan for the COSM including priorities, a rank-based methodology, and strategies to protect critical habitat. The COSM is partnering with Texas State for the implementation of this plan. Acquisition of conservation easements on strategic sites are the most efficient and long-lasting BMP that offsets the impacts of impervious cover thus acting to "reduce" impervious cover for the protection of endangered species.

2) Potential changes to City's Land Development Code (LDC). Submitted recommendations for COSM LDC environmental regulations (currently under CodeSMTX review). The LDC is currently going through last stages of editing and review before going to city council for adoption.

3) Preparation for retrofit water quality project designs and integration of existing designs. Prepared a comprehensive Sessom Creek Watershed Restoration Plan with numerous individual BMPs to address erosion control, water quality treatment, stream restoration and riparian restoration. As a plan for retrofit BMPs to offset the impacts of overdevelopment, this fits exactly within the intent of this Conservation Measure.

4) Design for retrofit water quality projects. Prepared a HEC-RAS flood model and a Design Concept Plan for proposed water quality retrofit ponds at the Glade on the Texas State campus. As a plan for retrofit BMPs to offset the impacts of overdevelopment, this fits exactly within the intent of this Conservation Measure.

5) Design for retrofit water quality projects. Prepared designs for three rain gardens in the Victory Gardens Subdivision; the COSM will fund the construction of these rain gardens. This will be a continuing relationship for future city development. As a plan for retrofit BMPs to offset the impacts of overdevelopment, this fits exactly within the intent of this Conservation Measure.

6) Staff education and integration. Assessed proposed drainage modifications to the decommissioned golf course on the Texas State campus in an effort to avoid the flow of pollutants to Spring Lake as a result of erosion and chemical use on the athletic fields, which protects the water quality of the river's headwaters.

Proposed Activities for 2017:

In 2017, the COSM and Texas State will continue implementation of the WQPP, including participation from all jurisdictional watershed areas that directly or indirectly impact the Covered Species. Funding opportunities for water quality retrofits in San Marcos are being pursued. Notably, a TCEQ 319 grant application was submitted in late 2016. The application demonstrates the need for several million dollars which, if awarded, will be combined with matching funds from the EAHCP, COSM, and Texas State.

The following information describes several high-priority stormwater management opportunities that are being pursued next year. However, any opportunity that presents itself for the protection of water quality in the San Marcos River will be pursued. Thus, the following notes reflect this emphasis.

1) City Hall Rain Garden: Design concepts have been prepared for a rain garden at the COSM City Hall. The 1.2 acres that drain to the proposed stormwater retrofit is approximately 77 percent impervious cover and includes the parking lot. The project is anticipated to cost around $80,000, and to remove 1.7 lbs. of TP annually.

2) Dunbar Park Regional Stormwater Retrofit Pond: Concept Plans have been prepared for a regional water quality BMP in this municipal park where three major drainage outfalls exist. The stormwater facility is designed to treat runoff from 160 acres at 28.5 percent impervious cover. It is anticipated to cost around $200,000 and remove approximately 14.7 lbs. of TP annually.

3) Sessom Creek Wet Pond: This pond is located at the intersection of University Drive and Aquarena Springs Drive, and drains to Sessom Creek near its confluence with the San Marcos River. This pond was constructed as an in-line wet pond accepting flow from Sessom Creek. The pond is substantially under-sized in relation to the watershed. Maintenance is necessary since sediment is building up in the pond. The maintenance project will provide an opportunity to redesign and expand the pond, improving the pond performance and better protecting critical habitat.

4) Fish Ponds: This project would achieve multiple objectives in adding stormwater treatment functionality to the existing fish ponds while maintaining their aesthetic appeal. In addition, it would replace river water as the source needed to maintain permanent pools in these ponds, serve as a highly visible stormwater management site, and thus provide an excellent opportunity for community education. One advantage to this project is that there is no need for a change in land use as these are pre-existing ponds. The modeling predicts this project would remove 182 lbs. of TP at an estimated capital cost of $6 million.

5) The Gulch: The Gulch is an existing extended detention pond located on the northern edge of campus and adjacent to the Cogen Plant near West Sessom Drive and Tomas Rivera Drive. The drainage area to this facility is approximately 57.3 acres with 41.5 percent impervious cover and drains to Sessom Creek. Maintenance is needed to address erosion and pond elements that are

functioning poorly. The maintenance project will provide an opportunity to add water quality treatment functions to the pond. The Gulch provides an opportunity to remove approximately 13.9 lbs. of TP annually at an estimated capital cost of $300,000 without the need for clearing or re-purposing land and with the added benefit of addressing existing erosion and safety issues.

6) The Glade: The Glade refers to a corridor on the southwestern edge of campus that drains to Purgatory Creek. The existing Glade Outdoor Theatre has been abandoned and will be demolished in 2017. A recycling facility is located at the downstream end of this area, which floods occasionally. The site is under evaluation to determine opportunities for flood management and water quality protection. Discussions are underway and a Design Concept will be presented early next year. Approximately 8.9 lbs. of TP are anticipated to be removed annually with this project at an estimated capital cost of $400,000.

3.3.15 Challenges Observed and Identified Solutions

Management of Key Recreation Areas

- Challenge: Number of people in river parks increases each summer; increased river recreation means increased litter, bank erosion, infrastructure damage, pollutants, illegal parking close to the river, bank compaction, etc.
- Solution: Propose control of crowds in the river parks through parking limitations, designated spots for pop up tents and grills, and ordinance enforcement.

Riparian Restoration

- Challenge: Fences along riparian buffers, particular Rio Vista, are damaged by river users during the summer.
- Solution: See above. Controlling the number of people in the river parks will allow park rangers and the CC to keep people away from fences.

Removal of Non-native Species

- Challenge: Reduced numbers and/or behavior change, has made tilapia more difficult to remove.
- Solution: Talk with ichthyologists to refine search based on fish behavior.
- Challenge: Had a tough time during tilapia spawning season because the boardwalks were closed off (due to flood) and could not bowfish.
- Solution: Boardwalk is now open providing increased access to spawning areas.
- Challenge: It is a challenge to market the tournaments.
- Solution: City interns will help market in 2017.

Household Hazardous Waste

- Challenge: Seeing an increase in HHW drop offs (people and material) but Capital Area Council of Governments funding is decreasing so no funding is available.
- Solution: Use EAHCP funding to garner matching grant funds.

Removal of Non-native Plants

- Challenge: Population of elephant ears "exploding" and repopulating some downstream areas after the April 2016 floods. Most areas stayed under control, but lost ground along Sink Creek.
- Solution: Just keep after elephant ears until they run out of energy for regrowth.

- Challenge: Determining a way to remove non-native aquatic vegetation in large, deep water areas. Previously, large bag seines were used to collect removed non-native aquatic vegetation. However, in deeper water, the seines became ineffective and difficult to use.
- Solution: Built large nets out of light weight plastic garden mesh (2-inch by 2-inch mesh size) and added floats and weights. At a site, nets were strategically placed in a way to funnel removed vegetation to a suitable extraction area. **Figure 3.3-56** illustrates the arrangement using the nets with divers pulling non-native aquatic vegetation and workers on the bank removing the pulled vegetation and placing into a trailer to be transported to a compost facility. Using the nets was particularly useful when removing non-native aquatic vegetation from Spring Lake and near Rio Vista Dam where water depths reached up to 10 ft.

Figure 3.3-56. Arrangement of using nets to remove non-native aquatic vegetation from areas with greater water depth.

3.4 Texas State University

Texas State is responsible for the following measures under the EAHCP:

- Texas wild-rice Enhancement and Restoration (§5.4.1 and §6.3.5)
- Management of Recreation in Key Areas (§5.4.2)
- Management of Vegetation (§5.4.3)
- Sediment Removal in Spring Lake and Sewell Park (§5.4.4)
- Diversion of Surface Water (§5.4.5)
- Restoration of Native Riparian Vegetation (§5.7.1)
- Sessom Creek Sand Bar Removal (§5.4.6)
- Diving Classes in Spring Lake (§5.4.7)
- Research Programs in Spring Lake (§5.4.8)
- Management of Golf Course and Grounds (§5.4.9)
- Boating in Spring Lake and Sewell Park (§5.4.10)
- Reduction of Non-Native Species Introduction (§5.4.11)
- Control of Non-Native Plant Species (§5.4.12)
- Control of Harmful Non-Native and Predator Species (§5.4.13)

Implementation of these measures has been accomplished in partnership with the COSM, as specified in the EAHCP. Texas State extended its EAHCP obligations in partnership with the COSM to maintain consistency in implementation of EAHCP measures that jointly affect the Covered Species and their habitats in the San Marcos River.

3.4.1 Texas wild-rice Enhancement and Restoration (EAHCP §5.4.1 and §6.3.5)

For discussion related to Texas State's *EAHCP Obligations*, *2016 Compliance Actions*, and *Proposed Activities for 2017* related to this Conservation Measure, please refer to the discussion under **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.3.1 –** Texas wild-rice Enhancement and Restoration (EAHCP §5.3.1 and §6.3.5), in this Annual Report.

3.4.2 Management of Recreation in Key Areas (EAHCP §5.4.2)

For discussion related to Texas State's *EAHCP Obligations*, *2016 Compliance Actions*, and *Proposed Activities for 2017* related to this Conservation Measure, please refer to the discussion under **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.3.2** – Management of Recreation in Key Areas (EAHCP §5.3.2), in this Annual Report.

3.4.3 Management of Vegetation (EAHCP §5.4.3)

EAHCP Obligations:

Texas State will utilize hand-cutting and a harvester boat to manage aquatic vegetation in Spring Lake and will push floating vegetation downstream of any Texas wild-rice stands. Inorganic litter will be picked up weekly from the San Marcos River from Sewell Park to City Park during the recreational season (Memorial

Day to Labor Day) and monthly during offseason. Texas State will also monitor downstream Texas wild-rice stands to keep the stands clear of drifting vegetation. Divers will not pick up litter in or around Texas wild-rice stands.

2016 Compliance Actions:

Management of Submerged and Floating Aquatic Vegetation in Spring Lake

1) Spring Orifice Maintenance: Texas State personnel in conjunction with qualified Diving for Science (D4S) volunteers removed accumulated sediment where necessary from target springs in Spring Lake by finning the substrate away. In addition, aquatic vegetation was removed from an approximately 1.5-m radius of each target spring with a machete. The aquatic vegetation within the next 1.5-m radius area around each target spring was cut to a height of 30 centimeters and the cut material allowed to flow downstream with the current. Aquatic vegetation within the next three-m radius of target springs was sheared to height of one-m and cut vegetation allowed to drift downstream.
2) Harvester Boat: Management of submerged and floating aquatic vegetation followed the protocols outlined in the EAHCP (EAHCP §5.4.3.1) and the approved Spring Lake Management Plan. The harvesting schedule targets three cuts per week, typically on Monday, Wednesday, and Friday mornings. Scheduled harvesting of each zone rotates in order to allow each zone adequate recovery time and ensure that a specific zone is not over cut. This results in each zone being cut two or three times a month. The estimated aquatic vegetation harvest is approximately 10 to 12 cubic yards (yd^3) per cutting. The total estimated harvest is approximately 1,200 yd^3 for the year.

Management of Aquatic Vegetation below Spring Lake Dam to City Park

Texas State collaborated with the COSM to control aquatic vegetation mats entrained on Texas wild-rice stands below Spring Lake Dam to the end of Sewell Park. Aquatic vegetation removal was conducted by a COSM contractor by pushing floating mats downstream, as specified in the EAHCP. In addition, personnel at the COSM's CC supplemented vegetation removal during low flows.

Proposed Activities for 2017:

In 2017, Texas State will continue to implement floating vegetation mat and litter removal consistent with protocols established in the EAHCP and in the 2017 Work Plan.

3.4.4 Sediment Removal in Spring Lake and Sewell Park (EAHCP §5.4.4)

For discussion related to Texas State's *EAHCP Obligations*, *2016 Compliance Actions*, and *Proposed Activities for 2017* related to this Conservation Measure, please refer to the discussion under **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.3.6 –** Sediment Removal Below Sewell Park (EAHCP §5.3.6), in this Annual Report.

3.4.5 Diversion of Surface Water (EAHCP §5.4.5)

EAHCP Obligations:

Texas State will reduce the amount of surface water diverted from the San Marcos River in accordance with the following conditions:

1) Reduce diversion by two cfs when the USGS gauge at University Bridge reads 80 cfs (reduction made below Spring Lake Dam).
2) Reduce diversion by an additional two cfs (total four cfs) when the USGS gauge at University Bridge reads 60 cfs (reduction made in Spring Lake).
3) Reduce diversion by all but one cfs when the USGS gauge at University Bridge reads 49 cfs (reduction made in the Sewell Park reach).
4) Cease all surface water diversions when the USGS gauge at University Bridge reads 45 cfs.

2016 Compliance Actions:

Texas State did not reduce permitted pumping in 2016 to meet EAHCP requirements, since total San Marcos River flows did not reach trigger points (i.e. < 80 cfs). Texas State partially suspended use of Certificate 18-3866; they did not use permit 18-3866-400, but used 18-3866-401 to fill campus ponds. The total volume of surface water diversions from Spring Lake (Certificate 18-3865) was 21.67 ac-ft/year for 2016; well below the permitted 100 ac-ft/year. Maximum instantaneous diversion rates are not available.

Proposed Activities for 2017:

In 2017, Texas State will reduce or cease the diversion of surface water as required by flow conditions and described in the EAHCP Obligations above.

3.4.6 Restoration of Native Riparian Vegetation (EAHCP §5.7.1)

For discussion related to Texas State's *EAHCP Obligations*, *2016 Compliance Actions*, and *Proposed Activities for 2017* related to this Conservation Measure, please refer to the discussion under **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.3.10 –** Native Riparian Habitat Restoration (EAHCP §5.7.1), in this Annual Report.

3.4.7 Sessom Creek Sand Bar Removal (EAHCP §5.4.6)

EAHCP Obligations:

Texas State, in partnership with the COSM, completed a study to determine the most appropriate technique for removal of the Sessom Creek Sand Bar. The sediment bar has been monitored over several major rain events to validate study results. The best sediment removal options will be determined to minimize impacts to listed species. Texas State will submit the study for review though the AMP and implement the actions coming out of that process.

2016 Compliance Actions:

Monitoring in 2015 showed that the majority of rain events deposited fine sediment at the confluence of Sessom Creek and San Marcos River. The October flood scoured out the sediment bar and redeposited new material including rock from the bank opposite the Spring Lake western spillway as well as dislodging the limestone blocks stabilizing the banks of Sessom Creek. In 2016, the majority of rain events including the heavy rainfall in October resulted in sediment laden runoff from Sessom Creek, which further increased the deposition at the sediment bar.

Proposed Activities for 2017:

Texas State will coordinate with the COSM to accomplish removal of rock deposition during the repair of the bank stabilization project at Sessom Creek confluence.

The bank stabilization infrastructure will be repaired by Texas State. Following this, removal of the accumulation of fine sediment as discussed in the Sessom Sand Bar Removal Report will be targeted (**Appendix M2**).

3.4.8 Diving Classes in Spring Lake (EAHCP §5.4.7)

EAHCP Obligations:

Every diver participating in Texas State's D4S Program will need to show an understanding of the Covered Species found in Spring Lake and their habitats, as well as the laws and regulations relevant to those species. Divers must exhibit good buoyancy control, have the ability to avoid contact with listed species and critical habitat, and maintain a distance from the lake bottom. No more than 16 trained divers may be present in Spring Lake at any time. Texas State will conduct training for check-out dives and SCUBA classes no more than three times per day, and classes will include a maximum of twelve students per class.

2016 Compliance Actions:

Texas State followed requirements in the EAHCP and Spring Lake Management Plan in implementing the diving program in Spring Lake. The program continues to host Texas State SCUBA Classes – twelve students, no more than three classes per day, and are restricted to the Dive Training Area.

Proposed Activities for 2017:

In 2017, Texas State will continue to implement their diving class program consistent with the protocols identified in the EAHCP.

3.4.9 Research Programs in Spring Lake (EAHCP §5.4.8)

EAHCP Obligations:

No research will be conducted in Spring Lake without prior review and approval by Texas State to assess impacts to the Covered Species. Where take cannot be avoided, Texas State will provide education to researchers regarding the species and their habitats. Independent researchers may need to obtain individual permits from the USFWS.

2016 Compliance Actions:

The Chief Science Officer at Texas State chairs the Spring Lake Environmental Committee, which oversees all access to Spring Lake. To this end, Texas State developed an online access request form (http://www.aquarena.txstate.edu/Diving-for-Science/Access.html). Each request is reviewed by an eight-member committee, and if a vertebrate animal is the target of research, the Institutional Animal Care and Use Committee is also consulted for approval. In the event that the proposed research involves diving, the application and methods are reviewed by the Spring Lake Diving Control Board and, if necessary, Scientific Diving training is required prior to access. **Table 3.4-1** is a summary of the research and activities in Spring Lake.

Table 3.4-1. Summary of Research and Access Activities in Spring Lake.

Approved Research and Access Activities			
Description	**Duration**		**Impact**
2016 Salvage Refugia Plan	1/2/16	12/31/16	N/A
Stress and male mate choice in sailfin mollies	4/9/16	5/6/217	Minimal
Set/check Diversion trap	12/5/14	Still Active	Minimal
Trapping/monitoring turtle community	9/1/12	Still Active	Minimal
EARDAC salamander survey	10/28/12	Still Active	Minimal
Collecting wild San Marcos Salamanders	9/1/14	Still Active	Minimal
Assess Burleson's Dam	9/1/14	Still Active	Minimal
Gastrotrich collecting	2/16/15	Still Active	Moderate
Testing camera/go pro grid photographic tech	3/16/16	3/3/16	Minimal
Composting Tea study	4/7/16	7/31/16	Minimal
Submersible probe experiment	6/3/16	7/22/16	Minimal
Lab instruction for Bio course	4/28/16	4/28/16	Minimal
Filming predatory reaction triggers of bass	6/16/16	6/17/16	Minimal
Identifying effect methods/strategies for removal of invasive plants with hand tools	7/23/16	Still Active	Minimal
Fish specimen collections for instructional disections	6/6/16	6/07/16	Minimal
Independent Film	10/8/15	10/8/17	Minimal
Triathlon	4/16/16	4/17/17	Minimal
Trail Race	10/15/16	10/15/16	Minimal
Underwater Photography	5/17/16	5/18/16	Minimal
Photography on Hillside	4/29/16	4/29/16	Minimal
Triathlon	7/23/16	7/23/16	Minimal
Triathlon	9/17/16	9/17/16	Minimal
Demonstration of a student built remote operated underwater robotic vehicle to Engineering program	6/24/16	6/24/16	Minimal
Flint knappers experimental study	8/4/16	8/7/16	Minimal

Proposed Activities for 2017:

In 2017, Texas State will implement their research program consistent with the protocols identified in the EAHCP.

3.4.10 Management of Golf Course and Grounds (EAHCP §5.4.9)

EAHCP Obligations:

Texas State will develop and implement a Grounds Management Plan, including an IPMP. These plans will consider the appropriate application of environmentally-sensitive chemicals to reduce negative impacts to neighboring ecosystems. Any significant changes in the management protocol will be addressed through the AMP.

2016 Compliance Actions:

The Texas State golf course has closed and the area is being converted to accommodate other campus sports. Land management will continue to follow a Grounds Management Plan and IPMP guidelines based on both the EAHCP (EAHCP §5.4.9) and the Spring Lake Management Plan (**Appendix M3**).

Proposed Activities for 2017:

In 2017, Texas State will continue to implement its Grounds Management Plan and IPMP.

3.4.11 Boating in Spring Lake and Sewell Park (EAHCP §5.4.10)

EAHCP Obligations:

Boating at Spring Lake will be restricted to areas treated with the harvester, operators will enter and exit boats at designated access points, and all boats will follow USFWS standards for proper cleaning.

2016 Compliance Actions:

The canoe/kayak classes are limited to no more than two classes per day with a maximum duration of one hour and limited to 20 students in ten canoes. In addition, the glass-bottom boats are restricted to areas in Spring Lake that are mowed for aquatic vegetation control. Boat access into Spring Lake must follow the USFWS de-contamination process as outlined in the Spring Lake Management Plan and only enter at specific controlled locations that minimize potential impacts to listed species or their habitats. A total of 7,077 glass-bottom boat tours were conducted in 2016. Glass-bottom kayaks no longer operate in Spring Lake.

Canoeing/kayak classes in Sewell Park were limited to the region between Sewell Park and Rio Vista Dam as specified in the EAHCP. Access to the river was confined to the floating boat dock adjacent to the recreation center downstream of the walking bridge in Sewell Park. No more than three classes/day with a maximum of 20 students in ten canoes are permitted and not to exceed two hours in duration.

Proposed Activities for 2017:

In 2017, Texas State will continue to implement the boating program in Spring Lake and Sewell Park consistent with the protocols identified in the EAHCP.

3.4.12 Reduction of Non-Native Species Introduction (EAHCP §5.4.11)

For discussion related to Texas State's *EAHCP Obligations*, *2016 Compliance Actions*, and *Proposed Activities for 2017* related to this Conservation Measure, please refer to the discussion under **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.3.5** – Reduction of Non-Native Species Introduction (EAHCP §5.3.5), in this Annual Report.

3.4.13 Control of Non-Native Plant Species (EAHCP §5.4.12)

For discussion related to Texas State's *EAHCP Obligations*, *2016 Compliance Actions*, and *Proposed Activities for 2017* related to this Conservation Measure, please refer to the discussion under **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.3.9** – Control of Harmful Non-Native and Predator Species (EAHCP §5.3.9), in this Annual Report.

3.4.14 Control of Harmful Non-Native and Predator Species (EAHCP §5.4.13)

For discussion related to Texas State's *EAHCP Obligations*, *2016 Compliance Actions*, and *Proposed Activities for 2017* related to this Conservation Measure, please refer to the discussion under **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.3.9** – Control of Harmful Non-Native and Predator Species (EAHCP §5.3.9), in this Annual Report.

3.4.15 Challenges Observed and Identified Solutions

For discussion of challenges observed and identified solutions by Texas State, please refer to the discussion under **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.3.12** – Minimizing Impacts of Contaminated Runoff (EAHCP §5.7.4).

3.5 San Antonio Water System (SAWS)

SAWS is one of the largest water and wastewater systems in the United States and serves most of Bexar County, as well as portions of three adjacent counties. The municipally-owned utility serves a customer base of over 1.7 million customers. San Antonio is one of the fastest growing cities in the country, growing at an annual rate of approximately two percent per year. SAWS' Twin Oaks ASR Project in southern Bexar County is a key Conservation Measure for the EAHCP. This Conservation Measure involves the storage of Edwards Aquifer water produced under EAA-issued groundwater withdrawal permits leased by the EAA. Under certain conditions — more fully described in the EAHCP and the Interlocal Contract (ILC) between the EAA and SAWS for use of the Twin Oaks ASR Project for Contribution to Springflow Protection ILC —this water may be recovered from storage to serve SAWS customers during certain drought conditions as specified in the ILC. The day-to-day operation of the ASR is managed by SAWS. A twelve-person

Regional Advisory Group composed of diverse stakeholders advises SAWS on the implementation of this Conservation Measure.

The EAHCP broadly outlines how SAWS, with the advice of the Regional Advisory Group, will describe in the Annual Report the storage and recovery activities (EAHCP §5.5.1, page 5-38).

SAWS is responsible for the following measure under the EAHCP:

- Use of the San Antonio Water System Aquifer Storage and Recovery for Springflow Protection (EAHCP §5.5.1 and §5.5.2)

3.5.1 Use of the San Antonio Water System Aquifer Storage and Recovery for Springflow Protection (EAHCP §5.5.1 and §5.5.2)

EAHCP Obligations:

SAWS will utilize the Twin Oaks ASR Facility as a contributing springflow protection measure during defined times of extreme drought. When the level of the Edwards Aquifer index well J-17 is less than 630 ft-msl and the ten-year rolling recharge to the Aquifer is less than or equal to 500,000 ac-ft/year, SAWS may recover water from the ASR facility and return it to its distribution system. Additionally, when these conditions are met, SAWS will forbear making withdrawals from the Aquifer from designated wells on the northeast side of its service area equivalent to certain forbearance schedules prescribed in the ILC, or an alternative schedule prescribed by processes detailed in the ILC.

SAWS will make every effort to meet the forbearance schedule identified in the ILC; however, the EAHCP recognizes that future droughts may not exactly mimic the drought of record, so flexibility will be afforded to SAWS through processes outlined in the ILC to provide for alternative forbearance schedules.

Section 5.5.2 of the EAHCP includes a discussion on the use of the SAWS Water Resources Integration Program (WRIP) as the Phase II presumptive action for the EAHCP. To date, Phase II is not yet in effect and has not yet been discussed by the committees of the EAHCP, so it is not discussed at length in this report. The WRIP has been constructed and is operational between the Twin Oaks ASR facility and the newly-commissioned Old Pearsall Road pump-station. Further interconnects will be constructed in the first quarter of 2017, enhancing the water distribution capacity of the WRIP.

2016 Compliance Actions:

In 2013, the ILC was developed between the EAA and SAWS over a seven-month period. The ILC translates the conceptual elements of SAWS ASR commitment in Section 5.5.1 of the EAHCP into measurable activities related to both parties' responsibilities. Summaries of SAWS actions related to fulfilling these responsibilities in 2016 are provided below (see **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.5.1.1** – San Antonio Water System Aquifer Storage and Recovery Regional Advisory Committee, **subsection 3.5.1.2** – Status of San Antonio Water System Aquifer Storage and Recovery Lease Acquisition, **subsection 3.5.1.3 –** Edwards Aquifer Authority Notices of Availability to San Antonio Water System, and **subsection 3.5.1.4** – Groundwater Rights Pooling Program for Aquifer Storage and Recovery, below).

SAWS is responsible for organizing and facilitating an ASR Advisory Group. The ILC also required formation of a Staff Work Group. This subject will also be discussed further in this section of the Annual Report.

Under the ILC, SAWS is required to credit to the EAA as being in storage any permitted Edwards Aquifer water for which it receives a Notice of Availability (NOA) from the EAA by certain dates.

3.5.1.1 San Antonio Water System Aquifer Storage and Recovery Regional Advisory Committee

Per the requirement on page 5-39 of the EAHCP, a twelve-person Regional Advisory Group consisting of four representatives of SAWS, the EAHCP Program Manager, and one representative each from the EAA, an EAA permit holder for irrigation purposes, a representative of small municipal aquifer users, a representative of the COSM and CONB, an environmental representative (including TPWD), a representative of industrial aquifer users, and downstream interests provides advice to SAWS regarding the implementation of the program.

The EAHCP and the ILC provide for continued dialog and interaction. Under the ILC, SAWS has the responsibility to facilitate two groups. The first group is the SAWS ASR Regional Advisory Group as described in the EAHCP, as amended. The second group is a Staff Work Group whose membership and general descriptions are described in the ILC. **Table 3.5-1** lists the members of the SAWS ASR Regional Advisory Group for 2016.

Table 3.5-1. Members of the SAWS Aquifer Storage and Recovery Advisory Group in 2016

Entity	Appointee	Alternate
SAWS	Darren Thompson	No alternate named
SAWS	Robert Macias	No alternate named
SAWS	Karen Guz	No alternate named
SAWS	Parviz Chavol	No alternate named
EAA	Roland Ruiz	No alternate named
Irrigator	Rader Gilliland	Adam Yablonski
Small Municipal	Bruce Alexander	No alternate named
Springs Communities	Roger Biggers	Steve Ramsey
Environmental Interest	Tyson Broad	Cindy Loeffler
Industry	Buck Benson	Louisa Eclarinal
Downstream Interest	Todd Votteler	Jerry James
EAHCP Program Manager	Nathan Pence	No alternate named

In 2016, these groups each met in compliance with EAHCP, as amended, and the ILC. The SAWS ASR Regional Advisory Group met on March 21, 2016 and agreed to submit a request to the USFWS for a clarification to the EAHCP. The clarification that would adjust the Group's meeting frequency to an as-needed, but no less than annual, basis. The clarification request was approved by the USFWS. For more detailed discussion, please refer to **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.1.11.2** – Amendments, Informational Memoranda, and Clarifications, of this Annual Report.

3.5.1.2 Status of San Antonio Water System Aquifer Storage and Recovery Lease Acquisition

The EAA will acquire a total of 50,000 ac-ft annually of Edwards Aquifer permitted water through leases and options for use in the SAWS ASR Program. Acquisition will be accomplished in three tiers (**Table 3.5-2**). Through 2016, SAWS has stored 51,233 ac-ft of EAHCP water as shown in **Figure 3.5-1** below furnished by SAWS. The EAA will have 33,334 ac-ft of ASR leases under contract for 2017 for storage, bringing the total amount of EAHCP water in storage in the ASR to 84,567 ac-ft.

Table 3.5-2. SAWS Aquifer Storage and Recovery Lease and Structure Option as Identified in the EAHCP

Tier	Ac-ft	Description
I	16,667	Leased for immediate storage in the ASR
II	16,667	Acquired as options; exercised when the 10-year rolling recharge for the previous year falls below 572,000 ac-ft/year
III	16,667	Acquired as options; exercised when the 10-year rolling recharge for the previous year falls below 472,000 ac-ft/year

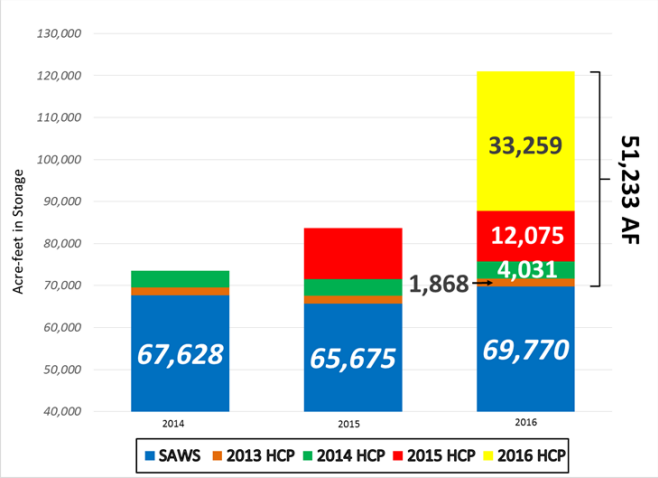

Figure 3.5-1. Total EAHCP water stored at the SAWS ASR facility (2014-2016).

The ASR leasing program has oversubscribed its enrollment goal for Tier 1 in 2016 by 16,667 ac-ft. Tier 2 and 3 options have yet to implemented and are under current review by the EAA as appropriate management options for the SAWS ASR. For additional related discussion, please refer to **CHAPTER 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.1.12** – Challenges Observed and Identified Solutions, of this Annual Report.

Enrollment is ongoing, and the program will continue to be adjusted to respond to the dynamics of the market.

3.5.1.3 Edwards Aquifer Authority Notices of Availability to San Antonio Water System

Of the total 33,258.630 ac-ft available to the EAA in 2016, EAA made available to SAWS 33,258.630 ac-ft since no critical period conditions were present in 2016 (**Table 3.5-3**). The EAA issued six NOAs to SAWS during the months ASR leases were accepted by the EAA Board of Directors.

Table 3.5-3. SAWS Aquifer Storage and Recovery Notices of Availability in 2016

NOA #	Date Effective (through December 31, 2016)	Total Ac-ft Acquired	Total Ac-ft Authorized
2016 NOA #1	1/5/16	9,849.221	9,849.221
2016 NOA #2	2/10/16	2,486.050	2,486.050
2016 NOA #3	3/8/16	4,018.003	4,018.003
2016 NOA #4	4/13/16	4,919.545	4,919.545
2016 NOA #5	5/11/16	5,273.600	5,273.600
2016 NOA #6	6/28/16	6,712.211	6,712.211
TOTALS		**33,258.630**	**33,258.630**

3.5.1.4 Groundwater Rights Pooling Program for Aquifer Storage and Recovery

No groundwater withdrawal rights were made available to SAWS under this program in 2016.

No modifications to the use of SAWS' ASR due to drought conditions occurred in 2016. Trigger levels were not reached during this time period, so SAWS ASR use for EAHCP springflow protection was not implemented. However, beneficial rainfall in 2016 enabled storage of EAHCP groundwater for nearly the entire year, with only minor pauses related to WRIP construction and commissioning.

Proposed Activities for 2017:

In 2017, SAWS will continue to manage this Conservation Measure as described in the EAHCP and consistent with the terms of the ILC. The EAA will devote resources to finding the most appropriate means of obtaining the 50,000 ac-ft of water rights required for the ASR program.

3.5.2 Challenges Observed and Identified Solutions

The SAWS Twin Oaks ASR facility is gated, fenced, and patrolled, and SAWS is unaware of any unauthorized activities by the public at the ASR.

3.6 Texas Parks & Wildlife Department

The TPWD serves as the state agency with primary responsibility for conserving, protecting and enhancing the state's fish and wildlife resources. In this role, TPWD has the authority to establish a state "scientific area" (SSA) for the purposes of education, scientific research, and preservation of flora and fauna of scientific or educational value (Texas Parks & Wildlife Code §81.501). To minimize the impacts of recreation, TPWD has created a two-mile segment of the public waters of the San Marcos River as an SSA in the San Marcos Springs ecosystem (31 Texas Administrative Code (TAC) 57.910).

In order to protect existing and restored fountain darter habitat, TPWD, in coordination with the CONB, will also pursue creation of state scientific areas in the Comal Springs ecosystem. The goal of these regulations will be to minimize impacts to habitat from recreation activities.

3.6.1 State Scientific Areas (EAHCP §5.6.1)

EAHCP Obligations:

The TPWD will pursue the establishment of an SSA in the San Marcos Springs ecosystem for expanded protection of Texas wild-rice within a two-mile segment. TPWD will pursue an Interlocal Agreement (ILA) with the COSM and Texas State regarding enforcement of the SSA.

To protect extensive aquatic and riparian restoration, TPWD, in coordination with the CONB, will also pursue an SSA within the Old Channel of the Comal River. Once an SSA is established, TPWD will pursue an ILA with the CONB regarding enforcement of the area.

2016 Compliance Actions:

The EAHCP requires that TPWD pursue creation of SSAs in the San Marcos and Comal River. To preserve Texas wild-rice during low flows and to minimize the impacts of recreation, TPWD created and maintains a two-mile segment of the public waters of the San Marcos River as an SSA in the San Marcos Springs ecosystem (31 TAC 57.910). This SSA is designed to protect Texas wild-rice by restricting recreation in these areas during flow conditions below 120 cfs. The rule makes it unlawful for any person to: (1) move, deface, alter, or destroy any sign, buoy, boom, or other such marking delineating the boundaries of the area; (2) uproot Texas wild-rice within the area; and (3) enter an area that is marked. The regulations are intended to preserve at least 1,000 m^2 of Texas wild-rice (**Appendix M4**).

In cooperation with the COSM and Texas State, signs and information kiosks were designed, produced, and installed during the summer of 2013. The purpose of the signs and information kiosks is to educate the public about protecting the San Marcos River and its endangered biota, especially during prime recreational season. The COSM produced new signs in 2016, in cooperation with TPWD.

When the flows within the San Marcos River SSA are 120 cfs or less, physical barriers may be placed within the SSA to help recreational users avoid vulnerable stands of Texas wild-rice while enjoying the river and to protect areas where habitat has been restored. Flows in the San Marcos River were above 120 cfs throughout 2016.

Proposed Activities for 2017:

In 2017, TPWD will work to expand their public education efforts to include signage in Spanish. In addition, TPWD will pursue an ILA with the COSM and Texas State regarding enforcement of the SSA. TPWD will also initiate discussion with CONB regarding creation of a SSA for the Comal River.

3.6.2 Challenges Observed and Identified Solutions

Efforts to expand education outreach by translating SSA signage into Spanish were initiated but not completed due to staff resource limitations. A formal ILA between TPWD, the COSM, and Texas State regarding enforcement of the SSA was not completed but the three entities communicated as needed.

4.0 ADAPTIVE MANAGEMENT PROCESS ACTIVITIES FOR 2016

Article 7 of the FMA outlines the procedural steps and responsibilities of the Permittees for making AMP decisions. It also identifies three different AMP decisions the Permittees may make – Routine, Nonroutine, and Strategic AMP decisions.

Routine decisions are decisions involving ongoing, day-to-day matters related to the management and administration of existing Conservation Measures and Phase II Conservation Measures implemented through the Strategic AMP that do not require an amendment to the ITP. Nonroutine AMP decisions are decisions relating to existing Conservation Measures, which are not Routine or Strategic AMP decisions. Strategic AMP decisions are decisions that relate to the selection of Phase II Conservation Measures that are to be implemented by the Permittees in Phase II.

Strategic AMP decisions will not be made until 2018, but in 2016, the Permittees continued to implement monitoring, research and modeling activities to provide information that will be necessary to support later Strategic AMP decisions. These activities are summarized in **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **Section 3.1 –** Edwards Aquifer Authority, of this Annual Report.

4.1 Routine Decisions

In 2016, the Permittees made a variety of Routine AMP decisions, as improvements to methodologies came to light and other circumstances presented themselves requiring minor adjustments to the implementation of Conservation Measures. An example of these decisions include the following:

1) Modifications to the New Braunfels Bank Stabilization Project. Following receipt of bids by the CONB, and coordination with a contractor, it was proposed that a minor change in materials would be made from those previously shown (May 2014). Instead of a concrete block at the toe of slope (at the channel bottom edge), the CONB proposed to use gabions (i.e., coated wire mesh baskets filled with rock). There was no noticeable change above the water line, and the bank above the toe will be primarily vegetated soil slopes covered with a turf reinforcement mat. The revised material is also similar in concept to what is used in other portions of Landa Park, and provides crevices and spaces for aquatic fauna that improve habitat conditions. This change was coordinated with all appropriate regulatory agencies for permitting coordination. Any changes to the EAHCP regarding stormwater protection will be compared to COSM and Texas State MS4 permit requriements to ensure no EAHCP funds will be spent to complete required work.

2) Meeting frequency of the SAWS ASR Regional Advisory Committee. According to the EAHCP, the 12-person ASR Regional Advisory Committee was to meet no less than quarterly. The Permittees did not wish to change the substance of the chapter, but rather provided a clarification in order for the Permittees to conduct the meetings as needed, but no less than annually.

   On May 23, 2016, the EAHCP submitted a letter to the USFWS to clarify the stated frequency of ASR Regional Advisory Group (EAHCP §5.5.1) meetings. This request was approved in writing by the USFWS in a letter dated June 13, 2016. **Appendix A3** includes this clarification request letter, and **Appendix A4** includes the response letter from USFWS.

For additional discussion regarding this process, please refer to **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.1.11.2** – Amendments, Informational Memoranda, and Clarifications, of this Annual Report.

4.2 Nonroutine Decisions

In 2016, the Permittees conducted an analysis of the current programs for the SAV restoration in the San Marcos and Comal Springs systems. In this analysis, lessons learned as well as a Nonroutine Adaptive Management Proposal were brought forward and ultimately reviewed by the EAHCP Committee members. The proposal included a summary of the issues encountered with the SAV restoration programs, the recommendations from the study of these issues, and the stakeholder-driven process facilitated by the Program Manager that resulted in a more thorough approach to the final proposal for this Nonroutine decision.

The Nonroutine Adaptive Management Proposal included two sets of modifications to the EAHCP:

1) Modifications to the SAV Conservation Measures and fountain darter LTBGs in the San Marcos and Comal River ecosystems that would:
   - Remove non-native plant species from the LTBGs for the fountain darter habitat and replacing them with native plant species;
   - Adjust areal coverage targets for SAV per the study recommendations;
   - Recognize Texas wild-rice as fountain darter habitat;
   - Have the COSM and Texas State field test two other native SAV species;
   - Clarify "proportional expansion" as required by Section 4.1.1.1 and Section 4.1.1.2 of the EAHCP with quantifiable and measurable metrics;
   - Follow successful suggested field methodologies for implementation;
   - Use the fall Comprehensive Vegetation Mapping Event from the Bio MP to quantify vegetation amounts;
   - Adopt the number of estimated fountain darter that the recommended SAV habitat can support, specifically the decrease of 5,055 fountain darters in the San Marcos LTBG reaches and an increase of an estimate 568 fountain darters in the Comal LTBG reaches.
2) A modification to the Flow-split Conservation Measure in the Comal system that would revise Table 5-3, Flow-Split Management for Old and New Channels, to provide maximum benefit to sustaining fountain darter habitat in the Old Channel while keeping CSRB habitat around Spring Island wetted.

On September 1, 2016, after receiving the input from the chairs and vice-chairs of the EAHCP Committees, the Program Manager officially submitted this Nonroutine Adaptive Management Proposal to all members of the SC, SH and IC. In accordance to the procedural steps outlined in Article 7 of the FMA, the EAHCP Committees were convened to evaluate, review, and approve the proposal. On September 9, 2016, the SC convened in a meeting, and evaluated and recommended the proposal to the SH as presented with five specific recommendations, including the following:

1) That species names in EAHCP documents and processes be identified whenever possible;

2) That consideration of community assembly rules is incorporated in the future, where appropriate, in activities involving ecological issues within the Comal and San Marcos systems (e.g., the selection of SAV species);

3) That the dynamic nature of the Comal and San Marcos rivers as natural systems is considered in the future, such as by considering expressing goals as +/- ranges, or some other means;

4) That establishing an experimental reach as a control, in which EAHCP restoration activities would be suspended, is investigated as a possible project;

5) That the relatively resilient nature of the fountain darter in the face of habitat fluctuations be recognized.

On September 15, the SH was convened and by consensus, recommended the proposal to the IC for approval and adoption, with the following points regarding their decision:

1) Acknowledge that this proposal is realistic;

2) Acknowledge that the loss of fountain darter habitat is minimal in the systems;

3) Acknowledge and document the impacts of rains, flooding, and droughts to the systems and to the SAV restoration programs.

Finally, in accordance with Article 7 of the FMA, also on September 15, 2016, the IC met and unanimously approved the SH recommendation for the Nonroutine Adaptive Management Proposal. **Appendix A10** is the *Submerged Aquatic Vegetation Analysis and Recommendations Report* and addendum, **Appendix A11** is the EAHCP Nonroutine Adaptive Management Proposal, **Appendix A12** is the SC's Scientific Evaluation Report (SER), and **Appendix A13** is the SH's report.

On September 20, 2016, this Nonroutine Adaptive Management decision was submitted to the USFWS through the following four letters regarding clarifications and/or amendments to the EAHCP:

1) Clarification to the specified vegetation in Table 4-21 of the EAHCP Biological Goals for fountain darter habitat and amendment regarding the estimated relative abundance of fountain darters within respective reaches in the San Marcos River;

2) Clarification to the specified vegetation in Table 4-1 of the EAHCP Biological Goals for fountain darter habitat in the Comal River;

3) Clarification to the EAHCP Key Management Objective of "proportional expansion" and creation of "restoration reaches" for the Comal and San Marcos rivers;

4) Amendment to Table 5-3 of the EAHCP Flow-Split Management for the Old and New Channel of the Comal River.

On October 24, 2016, the USFWS approved these clarifications and/or amendments. For additional discussion regarding this Nonroutine AMP, please refer to discussion earlier in this Annual Report in **Chapter 3.0** – PLAN IMPLEMENTATION IN 2016, **subsection 3.1.11.2** – Amendments, Informational Memoranda, and Clarifications.

SAV Conservation Measures and fountain darter Long-term Biological Goals in the San Marcos and Comal River ecosystems

In the San Marcos River ecosystems, Section 4.1.1 of the EAHCP discusses the Biological Goals and Objectives associated with the Covered Species. Table 4-21 provides guidance to the Permittees in square meter coverage of specified aquatic vegetation for the designated LTBG reaches in the San Marcos springs ecosystems. The Nonroutine Adaptive Management Proposal recommended revisions to Table 4-21 of the EAHCP (**Table 4.2-1** below) to properly maintain a diverse community of native aquatic vegetation to maximize fountain darter habitat. These changes include the complete removal of all non-native aquatic vegetation (*Hygrophila polysperma*, *Hydrilla verticillata* and *Vallisneria spiralis*) from the Biological Goals and replacing these goals with native vegetation (*Hydrocotyle umbellate* and *Zizania texana*).

As a result of this change, the overall vegetation coverage, and the estimated relative abundance of fountain darters within respective reaches was altered. The original Table 4-21 of the EAHCP was calculated to provide habitat for 34,325 estimated fountain darters. Therefore, despite the alterations being beneficial to the overall coverage of native vegetation throughout the system, the estimated densities associated with each vegetation type finds the revised table is calculated to provide habitat for 29,270 estimated fountain darters (a reduction of 5,055 or approximately 15 percent of the original EAHCP Goal for the San Marcos River).

Table 4.2-1. Revised Table 4-21 for Fountain Darter Habitat in the San Marcos River

Fountain darter habitat (aquatic vegetation) goal in m^2								
LTBG Reach	~~***Hygrophila***~~	***Ludwigia***	***Cabomba***	~~***Hydrilla***~~	***Potamogeton***	***Sagittaria***	~~***Vallisneria***~~ ***Hydrocotyle***	***Zizania***
Spring Lake Dam	~~50~~	~~200~~ 100	~~25~~ 50	~~100~~	~~1,000~~ 200	~~100~~ 200	~~125~~ 50	700
City Park	~~200~~	~~1,000~~ 150	~~50~~ 90	~~500~~	~~2,000~~ 1,450	300	~~50~~ 10	1,750
IH-35	~~50~~	~~200~~ 50	~~300~~ 50	~~100~~	~~300~~ 250	~~100~~ 150	~~25~~ 50	600
TOTALS	~~300~~	~~1,400~~ 300	~~375~~ 190	~~700~~	~~3,300~~ 1,900	~~500~~ 650	~~200~~ 110	3,050
Fountain darter median density number/m^2								
	~~***Hygrophila***~~	***Ludwigia***	***Cabomba***	~~***Hydrilla***~~	***Potamogeton***	***Sagittaria***	~~***Vallisneria***~~ ***Hydrocotyle***	***Zizania***
	~~4~~	7	7	~~5~~	5	1	1 4	5

In the Comal Springs ecosystem, Table 4-1 of the EAHCP provides guidance to the permittees in square meter coverage of specified aquatic vegetation for designated LTBG reaches for the Comal Springs ecosystem. The Nonroutine Adaptive Management Proposal recommended revisions to Table 4-1 (**Table 4.2-2** below) to properly maintain a diverse community of native aquatic vegetation and maximize fountain darter habitat. These changes include the complete removal of all filamentous algae and non-native *Hygrophila polysperma* from the Biological Goals and replace these goals with native *Potamogeton illinoensis*.

In order to find the most adequate distribution of ideal habitat for the fountain darter, the recommended goals have additional native vegetation and an altered distribution for all vegetation types originally

identified in Table 4-1 of the EAHCP (or **Table 4.2-2** below). As a result of this change, the estimated relative abundance of fountain darters within respective reaches will increase by 568.

Table 4.2-2. Revised Table 4-1 for Fountain Darter Habitat in the Comal River

Fountain darter habitat (aquatic vegetation) goal in m^2							
LTBG Reach	***Bryophytes***	***~~Hygrophila~~ Potamogeton***	***Ludwigia***	***Cabomba***	***~~Fil. Algae~~***	***Sagittaria***	***Vallisneria***
Upper Spring Run Reach	~~1,850~~ 1,750	~~650~~ 0	~~150~~ 25	~~0~~ 25	~~0~~	~~600~~ 850	0
Landa Lake	~~4,000~~ 3,950	~~250~~ 25	900	500	~~0~~	~~1250~~ 2,250	~~13,500~~ 12,500
Old Channel	~~150~~ 550	~~200~~ 0	~~1,500~~ 425	~~0~~ 180	~~300~~	~~0~~ 450	0
New Channel	150	~~1,350~~ 0	~~0~~ 100	~~350~~ 2,500	~~0~~	0	0
TOTALS	~~6,150~~ 6,400	~~2,450~~ 25	~~2,550~~ 1,450	~~850~~ 3,205	~~300~~	~~1850~~ 3,550	~~13,500~~ 12,500
Fountain darter median density number/m^2							
	Bryophytes	***~~Hygrophila~~ Potamogeton***	***Ludwigia***	***Cabomba***	***~~Fil. Algae~~***	***Sagittaria***	***Vallisneria***
	20	~~4~~ 3.3	7	7	~~14~~	1	1

Additionally, the Nonroutine Adaptive Management Proposal resulted in a clarification of the "proportional expansion" as required by Subsection 4.1.1.1 and Subsection 4.1.1.2 of the EAHCP by including quantifiable and measurable metrics. The proportional expansion is a key management objective for fountain darter protection by extending aquatic vegetation restoration "effort" in equal proportion beyond the established LTBG reaches. **Table 4.2-3** and **Table 4.2-4** below summarize the recommendations from the Nonroutine Adaptive Management Proposal establish for the measurable estimated aquatic vegetation coverage for the "restoration reaches." Additionally, it is important to note, the aquatic vegetation considered for the "restoration reaches" correspond to the vegetation covered in **Table 4.2-1** and **Table 4.2-2**.

It has been determined that the establishment of the "restoration reaches" will result in additional monitoring. Currently the EAHCP requires the EAA to maintain a comprehensive biological monitoring plan for the term of the ITP (EAHCP §6.3.1). The scope of the BioMP currently requires aquatic vegetation mapping of "select reaches." These reaches will include monitoring of the "restoration reaches" defining "proportional expansion" as well as the LTBG reaches.

Table 4.2-3. Restoration Reaches for the Comal River

Fountain darter habitat (aquatic vegetation) in m^2							
Restoration Reach	***Bryophytes***	***Potamogeton***	***Ludwigia***	***Cabomba***	***Sagittaria***	***Vallisneria***	**TOTALS**
Landa Lake UP[A]	5,500		25	250	250		**6,025**
Landa Lake DOWN[B]	500		50	125	100	22,500	**23,275**
Old Channel UP[C]	1,250	100	850	200	750	750	**3,900**
TOTALS	**7,250**	**100**	**925**	**575**	**1,100**	**23,250**	**33,200**
Fountain darter median density (number/m^2)							
	Bryophytes **20**	***Potamogeton*** **3.3**	***Ludwigia*** **7**	***Cabomba*** **7**	***Sagittaria*** **1**	***Vallisneria*** **1**	**TOTAL**
# darters *veg total	145,000	330	6,475	4,025	1,100	23,250	**180,180**

[A] Landa Lake LTBG Reach to downstream boundary of Spring Island.
[B] Landa Lake LTBG Reach to weir across from City of New Braunfels Park Office.
[C] Old Channel from LTBG Reach upstream to Landa Lake Dam.

Table 4.2-4. Restoration Reaches for the San Marcos River

Fountain darter habitat (aquatic vegetation) in m^2							
Restoration Reach	***Ludwigia***	***Cabomba***	***Potamogeton***	***Sagittaria***	***Hydrocotyle***	***Zizania***	**TOTALS**
Sewell Park	25	25	150	25	10	1,100	**1,335**
Below Sewell to City Park[A]	50	50	500	700	20	2,300	**3,620**
Hopkins Street – Snake Island	50	50	475	750	10	950	**2,285**
Cypress Island – Rio Vista	50	50	150	50	0	350	**650**
IH-35 Expanded[B]	50	100	250	450	50	450	**1,350**
TOTALS	**225**	**275**	**1,525**	**1,975**	**90**	**5,150**	**9,240**
Fountain darter median density (number/m^2)							
	Ludwigia **7**	***Cabomba*** **7**	***Potamogeton*** **5**	***Sagittaria*** **1**	***Hydrocotyle*** **4**	***Zizania*** **5**	**TOTAL**
# darters *veg total	1,575	1,925	7,625	1,975	360	25,750	**39,210**

[A] Sewell Park to the upstream boundary of the City Park LTBG Reach.
[B] Immediately downstream of the established IH-35 LTBG Reach to IH-35.

Flow-Split Management in the Old and New Channels of the Comal River

The Nonroutine Adaptive Management Proposal recommended revisions to EAHCP Table 5-3, *Flow Split Management for the Old and New Channels,* to provide maximum benefit to sustaining fountain darter habitat in the Old Channel while keeping CSRB habitat around Spring Island wetted. **Table 4.2-5** below summarizes these revisions EAHCP Table 5-3.

Table 4.2-5. Revised Table 5-3 for Flow-Split Management

Total Comal	Old Channel (cfs)			New Channel (cfs)		
Springflow (cfs)	Fall, Winter		Spring, Summer	Fall, Winter		Spring, Summer
350+	~~80~~ 65		60	~~270+~~ 280+		290+
300	~~80~~ 65		60	~~220~~ 235		240
250	~~80~~ 60		~~60~~ 55	~~170~~ 190		~~190~~ 195
200	~~70~~ 60		~~60~~ 55	~~130~~ 140		~~140~~ 145
150		~~60~~ 55			~~90~~ 95	
100		~~60~~ 50			~~40~~ 50	
80		~~50~~ 45			~~30~~ 35	
70		~~50~~ 40			~~20~~ 30	
60		~~40~~ 35-40			~~10~~ 25	
50		~~40~~ 35-40			~~10~~ 15	
40		30			10	
30		20			10	

4.3 Strategic Adaptive Management Process Decisions

As stated above, Strategic AMP decisions are not planned until 2018.

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5.0 2016 ANNUAL TAKE ESTIMATES

The ITP requires a Net Disturbance and Incidental Take Assessment to be conducted at the conclusion of each year for incorporation into the EAHCP Annual Report. Condition M (1a and 2a) of the ITP specifically addresses Conservation Measure activities associated with the EAHCP. This Condition stipulates that over the course of any given year no more than 10 percent of a Covered Species occupied habitat can be affected by EAHCP Conservation Measure activities. Following quantification of net disturbance specific to these activities, incidental take was calculated for the disturbed areas. However, that is only part of the overall incidental take assessment. Incidental take associated with implementation of all other applicable EAHCP Covered Activities was then characterized and quantified to the degree practical. For a more detailed description of methodologies and species specific results, please refer to the "Item M Net Disturbance and Incidental Take Assessment for 2016 EAHCP ITP Annual Report" Memorandum dated December 29, 2016, located in **Appendix N**. As in previous years, all 2016 assessments were performed in accordance with ITP requirements.

Table 5.0-1 provides an overview of net disturbance percentages and a summary of incidental take for 2016. As shown in **Table 5.0-1**, only the fountain darter in the Comal system had a net disturbance when considering the project footprint for EAHCP Conservation Measure activities overlaid on occupied habitat. The net disturbance was 3.3 percent of the total occupied habitat for the fountain darter in the Comal system. As shown in **Table 5.0-1**, there were no project footprints that overlapped with any of the occupied habitat for the endangered Comal invertebrates. In the San Marcos system, only the fountain darter had a net disturbance, which was calculated at 4.1 percent of its total occupied habitat. For the San Marcos salamander, Texas blind salamander and CSRB, there were no EAHCP Conservation Measure activities conducted in 2016 that directly impacted any documented occupied habitat or spring orifices where Texas blind salamander collections have been made over the years. In summary, the net disturbance in 2016 was under the 10 percent disturbance rule as outlined in ITP Condition M[a].

Table 5.0-1 shows the calculated incidental take on the Comal and San Marcos systems with respect to the EAHCP Covered Species. For the Comal system, there was no incidental take for the Comal invertebrates in 2016. The calculated value for the fountain darter was less in 2016 than observed during the drought conditions experienced in both 2013 and 2014. The primary cause for no calculated take for the invertebrates and decrease for the fountain darter relative to drought years was the above average discharge conditions throughout most of 2016, which resulted in full inundation of surface habitats within CSRB occupied habitat and inundated habitat and constant water temperatures for the fountain darter. The 2016 incidental take for the fountain darter in the Comal system was slightly higher than reported in 2015 most notably because of aquatic vegetation disturbance in the New Channel. For the San Marcos system, incidental take for the fountain darter went down slightly in 2016 compared to 2015. This decrease relative to the fountain darter was influenced by slightly reduced spring to fall aquatic vegetation impacts in all three study reaches. Additionally, higher than average flow conditions experienced the entire year eliminated the need for recreational exclusion structures in designated SSAs in 2016. This modification eliminated any project footprint over San Marcos salamander habitat and thus the reason no impacts were noted for this species in 2016 compared to previous years.

When examining 2016 impacts, conditions are in line with those characterized in the Biological Opinion as an average year. As such, the incidental take numbers summarized in **Table 5.0-1** and documented in **Appendix N** continue to justify the data sets used and methodologies employed in 2016 relative to performing an incidental take assessment within the context of the Biological Opinion. It is understood that adjustments to data sets and/or methodologies may be employed based on feedback from the USFWS, SC, EAHCP participants, or others as deemed appropriate by the EAHCP.

Table 5.0-1. Summary of Impacted Habitat (m2) and Net Disturbance and Incidental Take for EAHCP Covered Species Compared Against ITP Maximum Permit Amounts

Covered Species Per System	EAHCP Mitigation/Restoration		EAHCP Measures/ Drought	Combined Impacted Habitat 2016 TOTAL (m2)	Incidental Take		2016 Incidental Take Total	ITP Maximum Permit Amount	ITP Permit Maximum Minus (Combined First Four Years)
	Impacted Habitat (m2)	Net Disturbance % Of Total Occupied Habitat	Impacted Habitat (m2)		EAHCP Mitigation/ Restoration	EAHCP Measures/ Drought			
COMAL SYSTEM									
Fountain Darter	3,002	3.3%	3,637	**6,639**	4,503	5,456	**9,959**	797,000	748,386
Comal Springs Riffle Beetle	0	0.0%	0	**0**	0	0	**0**	11,179	8,933
Comal Springs Dryopid Beetle	0	0.0%	0	**0**	0	0	**0**	1,543	1,528
Peck's Cave Amphipod	0	0.0%	0	**0**	0	0	**0**	18,224	18,060
SAN MARCOS SYSTEM									
Fountain Darter	3,652	4.1%	3,697	**7,349**	5,478	5,545	**11,023**	549,129	496,190
San Marcos Salamander	0	0.0%	0	**0**	0	0	**0**	263,857	261,264
Texas Blind Salamander	0	0.0%	0	**0**	0	0	**0**	10	10
Comal Springs Riffle Beetle	0	0.0%	0	**0**	0	0	**0**	N/A	N/A

Table 5.0-2 provides a tracking of the running take totals so far in the implementation of the EAHCP. Flow levels and habitat conditions in both the Comal and San Marcos springs systems benefitted the species in 2016. The fountain darter was the only species that required "take" calculations for the ITP. In the Comal system in 2016, incidental take for fountain darters (9,959) was almost double that in 2015 (5,115) due to a pulse-flow from the Dry Comal Creek that removed some of the SAV in the New Channel about one month before the system was mapped. In the San Marcos system in 2016, incidental take for fountain darters (11,023) was about 2,000 less than that in 2015 (13,295) due to a decrease in impacted habitat. Overall, the incidental take that has occurred since the implementation of the EAHCP is within a proportional level to assume compliance for the remainder of the ITP.

Table 5.0-2. Incidental Take Summary (2013-2016)

Spring System	Species (Common Name)	ITP Take Limit	2013 Take	2014 Take	2015 Take	2016 Take	TOTAL Take	Remaining ITP Take
Comal	Fountain Darter	797,000	10,482	23,060	5,115	9,959	**48,616**	748,384
	Comal Springs Riffle Beetle	11,179	681	1,564	0	0	**2,245**	8,934
	Comal Springs Dryopid Beetle	1,543	13	2	0	0	**15**	1,528
	Peck's Cave Amphipod	18,224	81	82	0	0	**163**	18,061
San Marcos	Fountain Darter	549,129	16,698	11,909	13,295	11,023	**52,925**	496,204
	San Marcos Salamander	263,857	1,053	482	1,059	0	**2,594**	261,263
	Texas Blind Salamander	10	0	0	0	0	**0**	10
	Comal Springs Riffle Beetle	N/A	0	0	0	0	**0**	N/A

6.0 RECOMMENDATIONS MOVING FORWARD

The Permittees are now in their fifth year of implementing the EAHCP. With the benefit of experience—including during wide-ranging weather conditions—and time, the Permittees continue to gain perspective and practical insights into implementation of the EAHCP. Based upon this knowledge and experience, the Permittees recommend the following as priorities for 2017.

6.1 Edwards Aquifer Authority

Aquifer Storage and Recovery

After four years of implementation, the ASR leasing program has been very successful. This success has allowed the EAA to assess the requirements detailed in the EAHCP and propose possible modifications to improve the operational and financial efficiency, while still providing the same benefit to springflow protection.

As stated in Section 5 of the FMA, the AMP requires SH recommendations and IC approval. In addition, the ASR Regional Advisory Group will be given the opportunity to advise and direct the proposed changes prior to when the official AMP begins.

As stated in the EAHCP, the ASR leasing program establishes a goal to control 50,000 ac-ft of Edwards Aquifer groundwater withdrawal permits through acquisition of three tiers of leasing structure and have stored 80,000 acre-feet in the SAWS Twin Oaks Facility. The proposed plan for 2017 and 2018 is to continue an aggressive leasing program to accumulate a storage volume of 95,000 ac-ft. This amount is predicted to be sufficient in recovering from the potential drought of record conditions. Once this volume has been obtained, staff will propose to consolidate the current three-tiered leasing approach into a simplified two-pronged program.

In 2017, the EAA will be committed to the review and process of proposed changes through the AMP.

Refugia

Beginning January 1, 2017, the USFWS SMARC/UNFH and BIO-WEST will provide refugia, salvage, reintroduction, and monitoring services in fulfillment of the contract to provide for Long-Term Refugia Operations.

Per the terms of the contract approved in November 2016, USFWS will preserve the capacity for the EAHCP Covered Species to be re-established at the Comal and San Marcos rivers if extirpation were to occur. This effort will be achieved through duplicated off-site refugia populations of the EAHCP Covered Species. The primary off-site refugia is located at the SMARC with the second being located at the UNFH.

During the 2017 calendar year, USFWS will hire the necessary staff to perform refugia operations (husbandry, propagation, research), collect contractually required amounts of EAHCP Covered Species, and commence the design and build of EAA physical infrastructure used to house the EAHCP Covered

Species. While construction is set to begin in late 2017 and finish in 2018, salvage refugia populations are already intact at the facilities. Long-term refugia populations should come on line by late 2017 or 2018.

6.2 New Braunfels Springs System

In 2017, the CONB will continue efforts to maintain and enhance endangered species habitat in the Comal River system. The CONB will continue existing programs to increase native aquatic vegetation coverage and remove non-native animal species. The CONB will also begin a riparian restoration program in 2017 that will include efforts to systematically remove non-native vegetation along the banks of the Old Channel of the Comal River. Non-native riparian vegetation to be removed in 2017 includes elephant ear, Ligustrum, chinaberry, and Chinese tallow. Methods to remove non-native riparian vegetation will include herbicide application as well as mechanical removal. Removal of large non-native trees will allow light penetration to the Old Channel, which will increase the area in which native aquatic vegetation can be planted. Riparian restoration efforts in 2017 will also include maintenance of riparian plantings that were installed as part of the Bank Stabilization Project that was completed in 2016.

Habitat protection efforts in 2017 will also include the development of a Dissolved Oxygen Management Plan for Landa Lake and an evaluation of potential water quality management strategies that can be implemented in future years to minimize potential stormwater-related contaminants from entering Landa Lake and the Comal River.

6.3 San Marcos Springs System

Water Quality Protection

The intent of the WQPP is to provide a holistic, integrated approach in regard to water quality concerns associated with impervious cover and urban development. The WQPP has mapped and prioritized sources of pollution in the San Marcos River watershed within city limits and developed conceptual solutions in partnership with the Upper San Marcos River WPP. In 2017, the COSM/Texas State will construct two stormwater controls to minimize the impacts from stormwater runoff. Also, in 2017 through the AMP, the COSM/Texas State will prioritize several stormwater controls for design to capture and treat stormwater runoff from the Sessom Creek and/or downtown watersheds. This work is a partnership between the EAHCP, the COSM, and the MCWE.

Riparian Restoration

The riparian buffer of the San Marcos River has undergone non-native invasive plant removal, followed by plantings of native trees, shrubs and vines from the headwaters almost to IH-35. This buffer has also been expanded wherever possible to increase infiltration and treatment of stormwater runoff. Two sections immediately upstream of IH-35 will be treated in 2017, almost completing the water quality buffer from the headwaters to IH-35. The work will then continue downstream to Stokes Island at Cape's Road.

7.0 LITERATURE REVIEW

The following list of articles and reports represent a review of literature related to the protected species, aquatic features, and management actions associated with the EAHCP and the EARIP. This review includes journal articles, study reports, and theses and dissertations published or approved during late 2015 and 2016. The literature search was accomplished by conducting online searches of academic databases (such as BioOne, EBSCO, and JSTOR), Google Scholar, Texas State University Dissertations and Theses, and the EAA document library.

7.1 Literature from 2015

Barr, C. B., J. R. Gibson, and P. H. Diaz. 2015. *Typhloelmis* Barr (Coleoptera: Elmidae: Elminae), a new stygobiontic riffle beetle genus with three new species from Texas, USA. The Coleopterists Bulletin 69: 531-558.

This journal article reported on Typhloelmis, a new genus of eyeless, subterranean aquatic riffle beetles from spring habitats in west-central Texas. The adults of three new species in this taxon were described and illustrated. In addition, taxonomic keys and detailed descriptions of habitats for each new species were provided.

Clark, M. K. 2015. Testing of trophic cascade within a headwater spring community: implications for water quantity management. Thesis, Texas State University, San Marcos, Texas, USA.

This thesis tested for cascading effects of benthic fish predation by examining consumption of fountain darters by crayfish, largemouth bass, and a combination of both within vegetated and non-vegetated experimental settings. Water temperature was varied to mimic low-flow and average seasonal conditions. Though trophic cascading effects were not conclusive during the study, the results supported the recommended management strategy of removing piscine carnivores to protect fountain darters during low-flow conditions, as the crayfish-only experiments had less observed fountain darter mortality.

Nichols, H. T. 2015. Spring flow and habitat-mediated effects on reproductive effort of the fountain darter. Thesis, Texas State University, San Marcos, Texas, USA.

This thesis examined the effects of reduced surface flow and changes in aquatic vegetation on reproduction in the fountain darter in the Comal and San Marcos rivers by quantifying annual reproductive effort across a gradient of flows and aquatic habitats. The study found that while several measures of reproductive potential did not vary based on flow or habitat, gonadosomatic index and batch fecundity were greater at higher flows during the optimum reproductive season (January through April) and lower at lower flows during the leading reproductive season (October through December).

Wilson, W. D., J.T. Hutchison, and K. G. Ostrand. 2015. Genetic diversity assessment of *in situ* and *ex situ* Texas wild rice (*Zizania texana*) populations, an endangered plant. Aquatic Biology. doi:10.1016/j.aquabot.2015.12.005.

This journal article described genetic comparisons of in situ Texas wild rice populations in the San Marcos River with ex situ populations maintained by the USFWS. The results showed that ex situ populations had lower genetic diversity compared to the in situ population. The wild population, which had historically been dynamic both in time and space, showed three unique genetic clusters in the San Marcos River. The study indicated that Texas wild rice has a plastic reproductive system, as it utilizes both asexual and sexual reproduction.

7.2 Literature from 2016

Becker, L. J. S., E. M. Brooks, C. R. Gabor, and K. G. Ostrand. 2016. Effects of turbidity on foraging behavior in the endangered fountain darter (*Etheostoma fonticola*). American Midland Naturalist 175: 55-63.

This journal article examined the effects of high, moderate, and minimal turbidity on foraging and predatory behaviors in the fountain darter. Results of experimental trials with hatchery-reared fountain darters indicated that elevated turbidity affected the number of prey consumed and the amount of time needed to forage, but did not appear to affect prey capture success.

Committee to Review the Edwards Aquifer Habitat Conservation Plan, Water Science and Technology Board, Division on Earth and Life Studies, National Research Council of the National Academies. 2016. Evaluation of the Predictive Ecological Model for the Edwards Aquifer Habitat Conservation Plan: An Interim Report as Part of Phase 2. Washington, D.C.: The National Academies Press. 32 pages. doi:10.17226/23557.

This interim report provided a review of the ecological modeling efforts associated with efforts by the EAA and its partners to implement the HCP. The introduction indicated that this report would eventually be included as an appendix in the second of three reports on the EAHCP. The report reviewed the current status of the ecological models under development for fountain darters and submerged aquatic vegetation. Four topics were discussed: (1) modeling objectives and usage, (2) model configuration, (3) model calibration and testing, and (4) model coupling.

Craig, C. A., K. A. Kollaus, K. P. K. Behen, and T. H Bonner. 2016. Relationships among spring flow, habitats, and fishes within evolutionary refugia of the Edwards Plateau. Ecosphere 7: 1-13. doi:10.1002/ecs2.1205.

This journal article examined how distributional patterns, such as species richness, relative abundance, and density, of fish species in spring complexes and spring-river systems varied based on spring flow magnitude and habitat type. Using previously published studies and reports, the authors statistically analyzed data to compare patterns of endemic spring fishes and river fishes from six spring-river systems of the Edwards Plateau, including the Upper San Marcos-San Marcos

system. The study found that while spring-associated fishes did not exclusively use spring complexes, these fish were generally more abundant in spring complexes than in river habitats. Species richness, relative abundance, and density of spring fishes were directly related to spring flow magnitude, as spring complexes with higher spring output also had higher relative abundances and densities of spring fishes compared to the system's river habitat. However, river fishes did not show clear affinity patterns in the spring-river systems studied.

Crow, J. C., M. R. J. Forstner, K. G. Ostrand, and J. R. Tomasso. 2016. The role of temperature on survival and growth of the Barton Springs salamander (*Eurycea sosorum*). Herpetological Conservation and Biology 11: 328-334.

This journal article examined the physiological responses of the Barton Springs salamander to thermal manipulations. The study found that an optimal growth temperature of 18.3°C resulted in an approximately 60 percent increase in total length in tested salamanders, while an optimal temperature of 18.7°C resulted in an approximately 287 percent increase in weight. The temperature that showed loss of righting response effects for 50 percent of the experimental population was approximately 32.5°C.

Gabor, C. R., K. C. Zabierek, D. S. Kim, L. Alberici da Barbiano, M. J. Mondelli, N. F. Bendick, and D. R. Davis. 2016. A non-invasive water-borne assay of stress hormones in aquatic salamanders. Copeia 104: 172-181.

This journal article reported on the use of a water-borne hormone assay to measure corticosterone (CORT), in order to assess the health and chronic stress levels in three species of aquatic salamanders in central Texas, including the San Marcos salamander. The study tested the amount of time taken to mount a CORT response and performed further tests when the salamanders were exposed to additional stressors. Hormone responses in wild-caught and captive populations were also compared, though no consistent pattern was observed among all species.

Hardy, T., and N. Raphelt. 2016. Application of adaptive hydraulics for estimation of river bed evolution after dam removal on the habitat quantity and quality of aquatic resources and river recreation. Extended Abstract. In: *Proceedings of the 11th International Symposium on Ecohydraulics*. Melbourne, Australia, 7-12 February 2016. The University of Melbourne.

This extended symposium abstract described modeling simulations developed to predict river bed changes in the San Marcos River in response to removal alternatives at Cape's Dam, using river topography data and sediment characteristics. Modeling predicted that both half-height replacement and full removal of the lowhead dam would result in a shallower river bed compared to existing conditions. The shallower conditions would increase the area for Texas wild rice habitat and increase habitat quality, due to better light penetration. Habitat for fountain darter would be improved by better hydraulic conditions, dependent on availability of aquatic vegetation. Dam removal would also maintain human recreational opportunities along the river corridor by canoes, kayaks, and inner tubes.

Hutchins, B. T., A. S. Engel, W. H. Nowlin, and B. F. Schwartz. 2016. Chemolithoautotrophy supports macroinvertebrate food webs and affects diversity and stability in groundwater communities. Ecology 97: 1530-1542. doi:10.1890/15-1129.1.

This journal article examined the role of chemolithoautotrophy as a basal food resource in subterranean food webs in the Edwards Aquifer, including study sites at San Marcos and Comal Springs. Isotopic composition of stygobiont communities were measured along a geochemical gradient between photosynthetic organic matter sources near the aquifer recharge zone and chemolithoautotrophic organic matter sources near the freshwater-saline water interface (FWSWI). The study found that stygobiont community species richness declined with increasing distance from the FWSWI and the food web identified as adjacent to the FWSWI had greater trophic diversity compared to other sites along the gradient. According to the authors, the observed spatial variation in chromophoric dissolved organic matter (CDOM) results were consistent with the conclusion that organic matter near the FWSWI was likely produced through chemolithoautotrophy.

Jiménez-Mena, B., K. Schad, N. Hanna, and R. C. Lacy. 2016. Pedigree analysis for the genetic management of group-living species. Ecology and Evolution 6: 3067-3078. doi:10.1002/ec3.1831.

This journal article described the use of pedigree analysis methods for population management of group-living species in ex situ breeding programs, using the studbook of the Texas blind cave salamander as an example. According to the article, the studbook of the ex situ population of the Texas blind cave salamander included the records of nonliving and living populations between 1988 and 2011 that were held in seven U.S. institutions, and the current captive breeding population of the species included two distinct lines of descent.

Kanda, K., R. A. Gomez, R. Van Driesche, K. B. Miller, and D. R. Maddison. 2016. Phylogenetic placement of the Pacific Northwest subterranean endemic diving beetle *Stygoporus oregonensis* Larson & LaBonte (Dytiscidae, Hydroporinae). ZooKeys 632: 75-91. doi:10.3897/zookeys/632.9866.

This journal article discussed taxonomy and phylogenetic analysis of a stygobitic diving beetle from Oregon. This species was unusual because all other stygobitic beetles in the U.S. were known only from the Edwards-Trinity aquifer system in Texas.

Loney, L. A. 2016. Nutrient recycling and stoichiometry of stygobionts in the Edwards Aquifer, central Texas. Thesis, Texas State University, San Marcos, Texas, USA.

This thesis studied adaptations and life-history traits of obligate subterranean organisms by examining nutrient excretion and body chemistry in stygobiont taxa. As part of the study, stygobionts were collected from the Artesian Well at Texas State University over the course of a year. The author found that stygobiont mass-specific nitrogen and phosphorus excretion rates declined with body size, though when mass-corrected, the excretion rates were not substantially different from those of analogous surface taxa. In addition, stygobiont stoichiometry (as measured

by percentage of nitrogen and phosphorus body content) did not differ significantly from surface counterparts.

Lucas, L. K., Z. Gompert, J. R. Gibson, K. L. Bell, C. A. Buerkle, C. C. Nice. 2016. Pervasive gene flow across critical habitat for four narrowly endemic, sympatric taxa. Freshwater Biology 61: 933-946. doi:10.1111/fwb.12758.

This journal article presented results of a comparative phylogeographic analysis of genetic variation in four endemic taxa from Comal Springs: Eurycea salamanders, Heterelmis riffle beetles, Stygobromus amphipods and Stygoparnus dryopid beetles. Analysis of genetic markers across the taxa indicated that an island model of gene flow was most probable of the five models tested, with equal or constant gene flow among all subpopulations studied. The four taxa studied, across eleven subpopulations, had high migration rates, meaning that gene flow between subpopulations was influenced by new migrants each generation. The study also found small numbers of single nucleotide polymorphisms (SNPs) in each taxon could be associated with environmental variables, indicating the potential for local adaptation.

Maleki, S. 2016. An insight into groundwater management and policy in Texas. Thesis, Texas State University, San Marcos, Texas, USA.

This thesis examined groundwater management in Texas, summarizing the history and current management practices. The author also presented the case study of the Electro Purification project in Hays County, which is a groundwater project located outside of existing groundwater conservation districts. Interviews were conducted with seven professionals and stakeholders in south-central Texas to gather opinions on groundwater law, rule of capture, and management strategies for sustainable use of groundwater in Texas.

Miller, K. B. and J. Bergsten. 2016. Diving Beetles of the World: Systematics and Biology of the Dytiscidae. John Hopkins University Press, Baltimore, MD. 336 pp.

This book provided information about the diving beetles of the world (Coleoptera: Dytiscidae), including taxonomic keys and species descriptions. The book included a description and photo for the Texas cave diving beetle, Haideoporus texanus.

Moore, A. A., M. C. Green, D G. Huffman, and T. S. Simpson. 2016. Green herons (*Butorides virescens*) in an urbanized landscape: Does recreational disturbance affect behavior? American Midland Naturalist 176: 222-333.

This journal article presents the results of a study to assess the effects of human recreational disturbance on Green Herons along the headwaters of the San Marcos River, including two sites at Spring Lake. Habitat parameters, observed foraging behaviors, and foraging efficiency were measured at urbanized sites with varying levels of human recreational disturbance. The study found that foraging behavior in Green Herons was influenced more by habitat than human disturbance

events. Since the highest foraging efficiency was associated with the least disturbed study site, the authors speculated that birds may have become habituated to disturbance.

Musgrove, M., S. P. Opsahl, B. J. Mahler, C. Herrington, T. L. Sample, and J. R. Barta. 2016. Source, variability, and transformation of nitrate in a regional karst aquifer: Edwards Aquifer, central Texas. Science of the Total Environment 568: 457-469. doi:10.1016/j.scitotenv.2016.05.201.

This journal article described the results of nitrate analysis of water samples collected over time from recharge streams, groundwater wells, and springs from the Barton Springs and San Antonio Segments of the Edwards Aquifer. The data were also augmented with historical data from the USGS. The study found that groundwater nitrate levels were generally increasing, likely from anthropogenic sources. In addition, nitrification processes within the aquifer were a potential source of nitrate in groundwater.

Nowlin, W. H., B. F. Schwartz, M. Worsham, and R. Gibson. 2016. Refugia research: Development of husbandry and captive propagation techniques for invertebrates covered under the Edwards Aquifer Habitat Conservation Plan. Final Report. February 17, 2016. Prepared for the Edwards Aquifer Authority. 37 pp.

This research report presents preliminary results from studies on captive populations of endangered aquatic invertebrates conducted during 2015. These studies focused on methods for anesthesia of invertebrates in captivity, light response of subterranean and subsurface invertebrates, mating behavior and reproduction in captive Peck's cave amphipods, and housing systems for Peck's cave amphipods in captivity.

Olsen, J. B., A. P. Kinzinger, J. K. Wenburg, C. J. Lewis, C. T. Phillips, and K. G. Ostrand. 2016. Genetic diversity and divergence in the fountain darter (*Etheostoma fonticola*): Implications for conservation of an endangered species. Conservation Genetics 17: 1393-1404. Published online 20 July 2016. doi:10.1007/s10592-016-0869-7.

This journal article examined genetic diversity, population structure, and estimated effective population size of fountain darters in the San Marcos and Comal rivers. Given that fountain darters were reintroduced to the Comal River in the 1970s by transferring darters from the San Marcos River, the authors were interested in the genetic drift between two populations and the influence of low-head dams on dispersal in both rivers. Genetic variation estimated from fin tissue samples and analysis of 23 microsatellite loci indicated little evidence of genetic divergence between the two populations or genetic drift between dams. Based on the study data, effective population sizes of fountain darters in the Comal and San Marcos systems were estimated at 899 and 9,234, respectively, which were smaller (<10 percent) than census-estimated population sizes.

Oxley, F. M., T. M. Waliczek, and P. S. Williamson. 2016. Stakeholder opinion on invasive species and their management in the San Marcos River. HortTechnology 26: 514-521.

This journal article presented the results of a survey to stakeholders to assess their opinions on non-native invasive species. While the 335 respondents had a wide range of affiliations and knowledge, the majority believed that invasive species should be controlled or managed, especially when these species threaten rare Texas native species like those found in the San Marcos River.

U.S. Fish & Wildlife Service, Austin Environmental Services Field Office. 2016. Biological Opinion for USACE activities as part of the development of New Braunfels Utilities Comal Springs Conservation Center. *https://www.fws.gov/southwest/es/Documents/R2ES/BO_USACE_NBU_15Aug2016_02ETAU00-2016-F-0216.pdf.* Accessed 3 December 2016.

This biological opinion letter from the USFWS to USACE described the potential impacts to endangered species by the proposed New Braunfels Utilities Comal Springs Conservation Center project. The project may affect, and is likely to adversely affect, the Peck's cave amphipod, the Comal Springs dryopid beetle, the Comal Springs riffle beetle, and the fountain darter, as well as federally designated critical habitat for Peck's cave amphipod, Comal Springs dryopid beetle, and Comal Springs riffle beetle. The biological opinion indicated that the project is not anticipated to jeopardize the continued existence of these species or adversely modify designated critical habitat. Incidental take limits, terms and conditions for reasonable and prudent measures, and conservation recommendations were also detailed for the project.

Worsham, M. L. D., R. Gibson, and D. G. Huffman. 2016. The aquatic annelid fauna of the San Marcos River headsprings, Hays County, Texas. Zookeys 618: 1-14. doi:10.3897/zookeys.618.8560.

This journal article described the annelid fauna and some other soft-bodied invertebrates found during surveys of the San Marcos River headsprings. Collected species included four epigean Hirundinia, two Aphanoneura, one Branchiobdellida, and up to thirteen oligochaetous clitellates, as well as three free-living Platyhelminthes and one Nemertea. The Nemertea species was the first record of the phylum from the San Marcos River. The article included a dichotomous key, with photos and line drawings of diagnostic characteristics.

Zabierek, K. and K. Epp. 2016. Antipredator response of *Eurycea nana* to a nocturnal and a diurnal predator: avoidance is not affected by circadian cycles of predators. Amphibia-Reptila 37: 397-403. doi:10.1163/15685381-0003070.

This journal article examined the antipredator response of the San Marcos salamander to chemical cues associated with green sunfish, a diurnal predator, and red swamp crayfish, a nocturnal predator. Though the authors hypothesized that the salamander's response, characterized by reduced activity, would be more intense during the time of day corresponding to the predator's activity period, there was no detectable difference in response. The study suggested that the San Marcos salamander may not exhibit circadian patterns when avoiding circadian-influenced predators.

Zabierek, K. C. and C. R. Gabor. 2016. Multimodal communication, mismatched messages and the effects of turbidity on the antipredator behavior of the Barton Springs salamander, *Eurycea sosorum*. Behavioural Processes 130: 4-10.

This journal article described studies of the response of the Barton Springs salamander to sensory cues (visual and chemical) that trigger antipredatory behaviors, under different environmental conditions, such a turbidity. The results indicated that Barton Springs salamanders in the study preferentially relied on chemical cues over visual cues. Salamanders also showed decreased activity and increased latency to first move in clear conditions than in turbid conditions.

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