Edwards Aquifer

Habitat Conservation Plan

2017 Annual Report

Prepared for

The U.S. Fish & Wildlife Service

On behalf of

The Edwards Aquifer Habitat Conservation Plan and Permittees

Prepared by

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EXECUTIVE SUMMARY

Edwards Aquifer Habitat Conservation Plan

The Edwards Aquifer Habitat Conservation Plan (EAHCP)[1] is the primary document that establishes the cooperative effort to protect the water of the Southern Segment of the Edwards Aquifer ("Edwards" or "Aquifer") both for people in the region and the threatened and 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 planning group led to the creation of the process known as the Edwards Aquifer Habitat Conservation Plan Program, which has now been fully transitioned from the EARIP. 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 in February 2013 by the USFWS to be effective 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. Because of EAHCP implementation efforts, there have been various amendments or clarifications made to the EAHCP, or its supporting documents, since the issuance of the ITP. **Appendix A2** is a table summarizing the amendments or clarifications from November 2012 through December 2017.

The Permittees under the ITP 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.

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

[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 xxvi - xxvii.

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]

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."

The Texas Cave Diving Beetle, Comal Springs Salamander, and Texas Troglobitic Water Slater are "petitioned" species and are not yet subject to the "take" prohibition in the ESA.

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 that are within the EAA's boundaries. 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 managed under the EAHCP by the CONB, and the COSM and Texas State, respectively. As shown in **Figure ES-1,** the Contributing Zone is part of the Edwards Aquifer *system* but is not technically a part of the Edwards Aquifer itself.

[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). Plants (e.g., Texas wild-rice) are treated differently under the ESA and are not subject to the take rules.

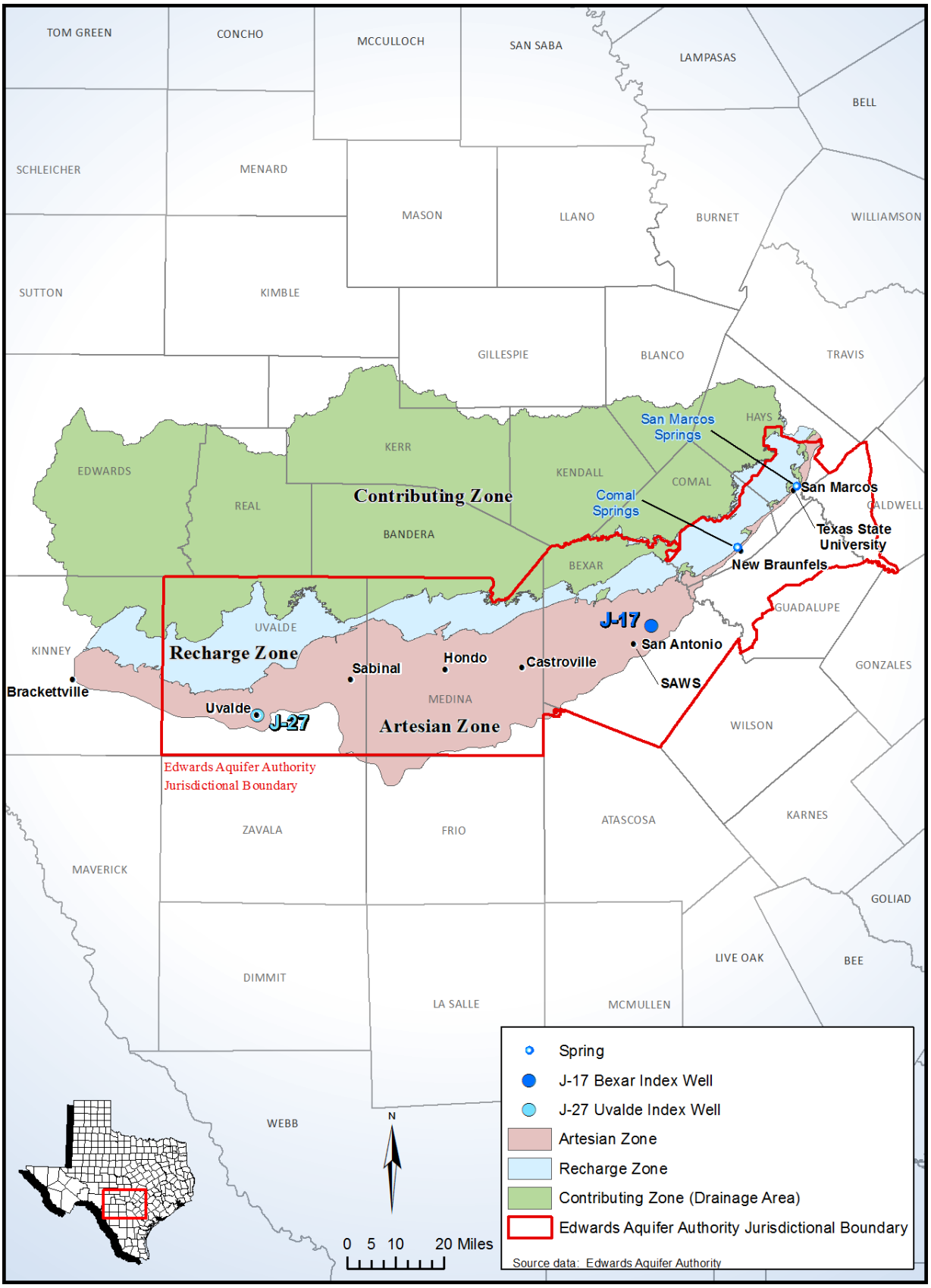

Figure ES-1. Incidental Take Coverage Area for ITP No. TE-63663A-1 (EAA Jurisdictional Boundary).

Effects on Covered Species in 2017

Chapter 5.0 – 2017 ANNUAL TAKE ESTIMATES, and **Appendix N,** of the Annual Report provide an overview of net disturbance percentages and a summary of incidental take for 2017 (**Table ES-2**). In the Comal system, the fountain darter and all three listed invertebrates had a net disturbance when considering the project footprint for EAHCP Conservation Measure activities overlaid on occupied habitat. The net disturbance was approximately 2 percent of the total occupied habitat for the fountain darter and less than 1 percent for each of the three federally-listed invertebrates in the Comal system. In the San Marcos system, only the fountain darter and San Marcos salamander had net disturbances calculated at approximately 3 percent and less than 1 percent, respectively, of their total occupied habitat. For the Texas blind salamander, CSRB, and Comal Spring dryopid beetle there were no Conservation Measure activities conducted in the San Marcos system in 2017 that directly impacted any documented occupied habitat or spring orifices where these species collections have been made over the years. In summary, the net disturbance in 2017 was under the 10 percent disturbance rule as outlined ITP Condition M.1.a and 2.a).

Table ES-2 shows the calculated incidental take on the Comal system with respect to the EAHCP Covered Species. The calculated value for the fountain darter was slightly less in 2017 than observed during 2016. The primary cause for the decrease for the fountain darter was stable flow conditions in 2017, which resulted in less spring to fall aquatic vegetation (habitat) reductions caused by scour. Unlike 2016, there was take associated with EAHCP Conservation Measure activities for the Comal invertebrates in Spring Run #3. In previous years, all invertebrate restoration activities have occurred on shore, whereas in 2017, native aquatic vegetation was planted in key areas within Spring Run #3 to support invertebrate habitat stability.

For the San Marcos system, incidental take for the fountain darter went down slightly in 2017 compared to 2016. Slight reductions were due to a reduced restoration footprint in 2017 relative to previous years. The return of Texas wild-rice exclusion zones in 2017 resulted in a minor amount of incidental take being calculated for the San Marcos salamander. When examining 2017 results, conditions are in line with those characterized in the Biological Opinion as an average year. As such, the incidental take numbers summarized in **Table ES-2** and documented in **Appendix N** continues to justify the data sets used and methodologies employed in 2017 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.

2017 Edwards Aquifer Conditions, Management, and Notable Conditions

After well above average rainfall in 2015 and 2016, the Edwards Aquifer region of south Central Texas returned to below average rainfall totals during the 2017 calendar year. With the exception of the far eastern portion of the Edwards Aquifer Contributing Zone affected by Hurricane Harvey, rainfall totals across the Contributing Zone were between 75 and 100 percent of normal totals. Springflow and index wells followed rainfall patterns with typical lag times. The J-17 Index Well fell over 34 feet (ft) between spring maximums and summer minimums. Comal springflow was well above the historical average during the first half of 2017, and was similar to slightly above averages over the latter half of 2017. Springflow in the San Marcos system remained just above average over the entirety of the 2017 calendar year. No major flooding occurred within the San Marcos or Comal rivers during 2017.

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 2017 TOTAL (m^2)	Incidental Take		2017 Incidental Take Total	ITP Maximum Permit Amount	ITP Permit Maximum Minus (Combined First Five Years)
	Impacted Habitat (m^2)	Net Disturbance % Of Total Occupied Habitat	Impacted Habitat (m^2)		EAHCP Mitigation/ Restoration	EAHCP Measures/ Drought			
COMAL SYSTEM									
Fountain Darter	2,126	2.2%	954	**3,080**	3,189	1,431	**4,620**	797,000	743,766
Comal Springs Riffle Beetle	7	< 1%	0	**7**	46	0	**46**	11,179	8,887
Comal Springs Dryopid Beetle	0.5	< 1%	0	**0.5**	1	0	**1**	1,543	1,527
Peck's Cave Amphipod	2.5	< 1%	0	**2.5**	3	0	**3**	18,224	18,057
SAN MARCOS SYSTEM									
Fountain Darter	2,754	2.9%	4,072	**6,826**	4,131	6,108	**10,239**	549,129	485,951
San Marcos Salamander	12	< 1%	0	**12**	36	0	**36**	263,857	261,228
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
Comal Springs Dryopid Beetle	0	0.0%	0	**0**	0	0	**0**	N/A	N/A

EAHCP 2017 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 2017 totaling $18,162,597, as compared to the EAA Board-approved 2017 Program Funding Applications totaling $22,332,476. Significant decreases in the ASR Leasing and VISPO budgets, and a significant increase is the Refugia budget largely account for the variation between these two amounts. Actual expenses for 2017 were $16,981,651, and unspent funds in the Refugia, ASR Leasing, and ASR Operations and Maintenance budgets mostly account for the difference between the total approved budget and actual expenses.

The EAHCP Expense Report also breaks down the adopted budget, Program Funding Applications budget and actual expenses. Approximately 24 percent of the approved 2017 Program Funding Applications budget and 29 percent of the adopted budget amounts remained at the end of the December 2017. These amounts were due primarily to balances resulting from unspent funds in the Program Administration, Science Panel Review, ASR Leasing, ASR Operations and Maintenance, LID/BMP Management, Applied Environment Research, and Refugia budgets. By the end of 2017, the reserve balance for the EAHCP was $36,105,205, which includes unspent funds accumulated since the inception of the EAHCP.

The EAHCP Expense Report also shows the actual revenue for 2017 of $16,081,152 compared to the budgeted revenue of $15,854,400, which is a variance of $226,752. Approximately 95 percent of the actual revenue comes from Aquifer Management Fees (AMFs). It is anticipated that revenue acquired in 2018 will be similar to the revenue acquired in previous years.

EAHCP Activities Completed in 2017

As stated above, the five Permittees under the ITP are the EAA, CONB, COSM, Texas State, and SAWS. Under the IA, the TPWD is an additional cooperating agency. These are the agencies 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 38 Conservation 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 2017, of this 2017 Annual Report describes actions by the Permittees and the TPWD, including subsections discussing their *EAHCP Obligations*, *2017 Compliance Actions*, and *Proposed Activities for 2018*.

In Year 2017, EAHCP completed an ambitious year, from securing a sound understanding of EAHCP data and modeling, to ensuring increased establishment of native aquatic habitat in both the Comal and San Marcos ecosystems. Overall, the EAHCP work falls into items that are more programmatic, while other functions deal mainly with field work associated with habitat and species protection. Both components of the program are building on work and research accomplished over the last four years, along with regional stakeholder guidance and recommendations from the National Academy of Sciences (NAS).

Highlights of major EAHCP accomplishments for 2017 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 SAWS Aquifer Storage and Recovery [ASR] 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 2017, EAHCP staff[4] 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 2017, SAWS continued its Leak Detection and Repair Program, including that portion of the program funded by the EAA through an agreement between the EAHCP and SAWS, which completes the RWCP goals of conserving 20,000 ac-ft of water. This five-year agreement with SAWS, along with work in the cities of Uvalde and Universal City, guarantees over 10,000 ac-ft of Edwards Aquifer water will 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 2012, and has been implemented as necessary. Due to decreased Aquifer levels and springflows, Stage I of the CPMP in the San Antonio Pool was triggered on July 13, 2017, for 47 days. Stage I in the San Antonio Pool was again triggered on September 16, 2017, for an additional 14 days.

d. *SAWS ASR Program* –This Conservation Measure supports the SAWS operation of the ASR for the EAHCP to ensure that the Comal Springs continue to flow during a repeat of the drought of record (DOR), and consists of three basic components: (1) the injection (recharge), storage and recovery of EAHCP Groundwater at the SAWS ASR; (2) the acquisition by lease and lease options of EAHCP Groundwater by the EAA; and (3) forbearance of Edwards pumping by SAWS under its EAA-issued groundwater withdrawal permit during certain drought conditions stated in the EAHCP and the SAWS-EAA ILC. From the effective date of the ITP in 2013 through 2017, SAWS has injected 82,708 ac-ft of EAHCP Groundwater. Additionally, because the drought triggers under the EAHCP and the SAWS-EAA ILC were not satisfied at any time during 2017, SAWS did not recover any EAHCP Groundwater in storage from the SAWS ASR. Once the program goal for the storage component of the SAWS ASR Program is achieved, there is intended to be as much as 126,000 ac-ft stored and available to ease the effects of a DOR. From the effective date of the ITP in 2013 through 2017, the EAA has acquired 32,583 ac-ft in Tier I leases, and no Tier II or III lease options. In light of this, the year 2017 also provided the EAHCP with an opportunity to reflect upon past successes and evaluate options to fulfill its obligations for the leasing component after the SAWS ASR Program more efficiently and cost-effectively in the future by considering the groundwater market and related considerations, such as improved weather conditions. Possible tweaks to the leasing component could result in the ASR being filled sooner and the required water for forbearance being secured in a simpler, more cost-efficient manner. In late 2017, the EAA utilized its revised

[4] As used in this Annual Report, "EAHCP staff" is used to refer to EAA employees who are assigned to the Threatened and Endangered Species Team.

groundwater model to run alternative scenarios to evaluate alterations to the original ASR leasing structure, and an ASR Optimization Program was presented at a joint meeting of the EAHCP committees after December 2017.

Habitat Restoration: Comal and San Marcos Spring Systems –

a. *Nonroutine Adaptive Management Processes* – The EAHCP completed two Nonroutine Adaptive Management Processes (AMPs) in 2017. One AMP Report and Proposal provided to the Implementing Committee (IC) outlined the EAHCP's changes to the locations of two water quality sedimentation ponds related to the Minimizing Impacts of Contaminated Runoff (EAHCP §5.7.4) Conservation Measure. The two new locations improved the effectiveness of this Conservation Measure by increasing the total drainage area and the overall total suspended solids (TSS) to be removed per year. The combined total drainage area for both ponds will treat up to two times the original area, thus increasing the estimated TSS removed per year by approximately 3,500 lbs. The second AMP Report and Proposal provided to the IC combined the funding of the Sediment Removal Conservation Measures (EAHCP §5.3.6 and §5.4.4) with the funding for the Impervious Cover and Water Quality Protection Conservation Measure (EAHCP §5.7.6) to fund the Middle Reach Restoration project. This project is intended to mitigate stream erosion that is generating high sediment loads, which impact critical habitat. A draft of the Preliminary Engineering Report (PER) was completed in 2017. Work on the 30 percent design plan also began in 2017. This project is being implemented as a proactive alternative to managing sediment as opposed to the previous reactive method of sediment removal (via hydrosuction) contemplated in the EAHCP.

b. *Comal Springs Systems* –
Dissolved Oxygen Management Plan – In 2017, the CONB developed a comprehensive dissolved oxygen (DO) management plan for Landa Lake. The *Landa Lake Dissolved Oxygen Management Plan 2017*, includes an analysis of previously collected DO and biological monitoring data, and sets forth a DO monitoring plan to help better characterize DO levels spatially throughout Landa Lake and the Upper Spring Run area during both normal and low-flow (<80cfs) conditions. The DO management plan also presents specific strategies for managing DO levels in Landa Lake, especially during low-flow conditions. The DO management plan includes a detailed description of proposed DO monitoring and mitigation activities, including monitoring DO spatially at strategic locations throughout Landa Lake and the Upper Spring Run in 2018 and during low-flow conditions when low DO conditions are more prone to occur. Mitigation activities included in the plan include monitoring and management of floating vegetation/algal mats to minimize oxygen consumption by decaying organic matter.

Vegetative Restoration in the Old Channel, Landa Lake, and Upper Spring Run – Aquatic vegetation restoration activities in 2017 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 2017 restoration results follows.

i. *Old Channel* – In 2017, a total of 1,433 m^2 was planted in ten restoration plots in the Old Channel Long-Term Biological Goal (LTBG) and Restoration reaches, bringing the five-year total area planted in the Old Channel to 4,814 m^2.

ii. *Landa Lake* – In 2017, 502 m^2 of area was planted in eight restoration plots in Landa Lake bringing the five-year total of area planted in the lake to 3,429 m^2.

iii. *Upper Spring Run* – Per the long-term restoration plan schedule, only limited effort was spent in 2017 to plant native plants to the Upper Spring Run LTBG and Restoration reaches. Only two restoration plots were planted in the Upper Spring Run LTBG Reach. Seasonal mapping did occur in the Upper Spring Run area.

Control of Harmful Non-Native Animal Species – CONB efforts in 2017 involved five removal sessions, each for three days, between February and September. In 2017, approximately 1,491 pounds (lbs) of invasive species biomass was removed from Landa Lake, that consisted of armored catfish, tilapia, nutria, and goldfish. Between 2013 and 2017, CONB staff reported that a total of 14,300 lbs (or 7.15 tons) of invasive biomass has been removed from the Comal River system.

c. *San Marcos Springs Systems* –
Texas wild-rice Enhancement and Restoration – Restoration activities in 2017 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 expanded an estimated 7,963 m^2 through planting and natural expansion. Since 2016, Texas wild-rice has expanded by an estimated 3,800 m^2.

Riparian Restoration – The COSM focused aquatic vegetation treatment (e.g., removal and planting) efforts from the following seven work sites throughout 2017: Ramon Lucio Park – Wildlife Annex; Dog Beach Park; Rio Vista Park; Crooks Park; Bicentennial Park; and Sessom Creek Park.

Control of Harmful Non-Native and Predator Species – COSM hosted two spearfishing tournaments in 2017 to remove non-native invasive species. In 2017, 526.17 lbs of invasive species biomass was removed in the San Marcos system, that consisted of Plecostomus, Tilapia, and Nutria. From 2015 – 2017, COSM staff reported that 1,253.63 lbs of invasive species biomass has been removed through spearfishing tournaments to date.

d. *Refugia* **–** In 2017, the EAA contracted with the USFWS to operate off-site refugia operations at the San Marcos Aquatic Resource Center (SMARC) and the Uvalde National Fish Hatchery (UNFH). The primary activities in 2017 consisted of species collection, species research, and facility construction. The Covered Species were collected throughout the year by both USFWS facilities, in accordance with their 2017 Work Plan, and held at these two facilities.

Two multi-year research projects were initiated (Larval Development of the Comal Springs Dryopid Beetle, and Juvenile Development and Maturation of the Peck's Cave Amphipod) in the second half of 2017 (see **Appendix K5** and **Appendix K6**, respectively, for work plans/proposals for these two projects).

To accommodate the Covered Species moving forward, construction began at the SMARC facility in late 2017, and is anticipated to be completed in 2018. Engineering design was completed and the procurement process was initiated for the UNFH project, which is anticipated to be completed in 2018.

The 2017 Refugia Annual Report (*Implementation of the Refugia Program under the Edwards Aquifer Habitat Conservation Plan Annual Report 2017*) can be found in **Appendix K7** that contains the details of all the activities described above, monthly progress reports, and species propagation plans for the Comal Springs riffle beetle, Peck's cave amphipod, and Texas blind salamander.

e. *Ecological Model* **–** While the project team developed, and calibrated an operational fountain darter model at the end of 2016, the draft and final documentation, as well as on-site training activities, were performed in early 2017, completing this effort. The final report can be found in **Appendix K9.**

f. *Hydrological Model: MODFLOW Model* **–** Considerable progress was made with the MODFLOW model in 2017. A model verification test was conducted by running the model using pumping and recharge inputs for the years 2012 through 2015, and comparing the computed water levels and spring flows to observations. The model performed reasonably well at matching observations for the period for which it was not calibrated.

After completing several parameter sensitivity and uncertainty analyses with the MODFLOW model, an updated DOR scenario was developed and used to repeat the "bottom-up" analysis cited in the EAHCP to demonstrate the effectiveness of the Conservation Measures. Repeating this analysis with the updated and recalibrated MODFLOW model showed results very similar to the original analysis and indicated that the EAHCP Conservation Measures as modeled, appear likely to be successful in maintaining the desired minimum spring flows at Comal and San Marcos springs of 30 cfs and 45 cfs daily average not to exceed six months in duration, respectively, during a repeat of the DOR. The updated model resulted in a minimum daily average flow at Comal Springs of 29.7 cfs, compared to 27 cfs computed with the original model, and 48 cfs at San Marcos Springs compared to 51 cfs computed with the original model.

g. *Applied Research* **–** The Applied Research Program in 2017 primarily focused on three statistical analyses of existing long-term EAHCP data sets to date to provide a time integrated statistical analyses of EAHCP data generated by the EAA and its contractors, and to develop biological and hydrological statistical questions related to achieving compliance with the EAHCP's LTBGs. The first study analyzed the San Marcos and Comal Springs aquatic ecosystems datasets to provide exploratory, time-integrated statistical analysis of water quantity and quality, submerged aquatic vegetation and Covered Species data (**Appendix K2**) The second study was a temporal and spatial analysis of the San Marcos and Comal springs aquatic ecosystems biomonitoring datasets examining data for fountain darters, vegetation, salamanders, macroinvertebrates, and water quality (**Appendix K3**). The third study completed was a statistical analysis of the San Marcos and Comal springs aquatic macrophytes and discharge datasets to provide data summarization, evaluate aquatic

vegetation coverage, determine long-term discharge patterns, and provide statistical analysis of the macrophyte and discharge datasets (**Appendix K4**).

EAHCP Program Activities –

The EAHCP completed another active year. As discussed above, EAHCP staff managed and facilitated two Nonroutine AMPs resulting in amendments to the EAHCP. EAHCP program staff also facilitated more than 20 public meetings. These meetings included regular meetings of the IC, Adaptive Management Science Committee (SC), and the Adaptive Management Stakeholder Committee (SH), topical based Work Groups to inform program decisions, and a meeting of the National Academy of Sciences/Science Review Panel (NAS/SRP).

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LIST OF ACRONYMS AND ABBREVIATIONS

ac-ft	acre-foot/acre-feet
AMF	Aquifer Management Fee(s)
AMP	Adaptive Management Process
Aquifer	Edwards Aquifer
ASR	Aquifer Storage and Recovery
BioMP	Biological Monitoring Program
BIO-WEST	BIO-WEST, Inc.
BMP(s)	best management practice(s)
BTEX	benzene, toluene, ethylbenzene and xylene
CC	Conservation Crew
cfs	cubic feet per second
COI	Certificate of Inclusion
CONB	City of New Braunfels
COSM	City of San Marcos
CPMP	Critical Period Management Program
CPS Energy	City Public Service Energy
CSRB	Comal Springs riffle beetle
yd^3	cubic yards
°C	degrees Celsius
DAC	Dive Authorization Course
DC	Discovery Center
DEET	Diethyl-meta-toluamide
D4S	Diving for Science
DO	dissolved oxygen
DOR	drought of record
EAA	Edwards Aquifer Authority
EAHCP	Edwards Aquifer Habitat Conservation Plan
EARDC	Edwards Aquifer Research and Data Center
EARIP	Edwards Aquifer Recovery Implementation Program
EcoModel	Ecological Model
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^2	square foot/feet
ft^3	cubic feet
GBRA	Guadalupe-Blanco River Authority
GMAP	Groundwater Model Advisory Panel
HAZMAT	Hazardous Material
HCP	Habitat Conservation Plan
HHCB	galaxolide
HHW	Household Hazardous Waste
IA	Implementing Agreement
IC	Implementing Committee
IH	Interstate Highway
ILA	Interlocal Agreement

List of Acronyms and Abbreviations (Continued)

ILC	Interlocal Contract
IPMP	Integrated Pest Management Plan
ITP	Incidental Take Permit
lbs	pounds
LID	Low Impact Development
LTBG	Long-Term Biological Goals
m	meter(s)
m^2	square meters
m^3	cubic meters
MCWE	Meadows Center for Water and the Environment
mg/L	milligram(s) per liter
msl	mean sea level
MTBE	methyl *tert*-butyl ether
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*
NASWG2	Report 2 National Academy of Sciences 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
PER	Preliminary Engineering Report
POCIS	polar organic chemical integrative samples
PPCP(s)	pharmaceutical and personal care product(s)
RCMC	Regional Conservation Monitoring Committee
RECON	RECON Environmental, Inc.
Report 2 Implementation Plan	*Edwards Aquifer Habitat Conservation Plan Report 2 Implementation Plan*
RFP(s)	Request for proposal(s)
RTI	Real Time Instrumentation
RWCP	Regional Water Conservation Program
SARA	San Antonio River Authority
SAV	submerged aquatic vegetation
SAV Report	Submerged Aquatic Vegetation Analysis and Recommendations Report
SAWS	San Antonio Water System
SC	Adaptive Management Science Committee
SCUBA	Self contained underwater breathing apparatus
SCTWAC	South Central Texas Water Advisory Committee
SER	Scientific Evaluation Report
Service	U.S. Fish & Wildlife Service
SH	Adaptive Management Stakeholder Committee
SMARC	San Marcos Aquatic Research Center
SMCISD	San Marcos Consolidated Independent School District

List of Acronyms and Abbreviations (Continued)

SMRF	San Marcos River Foundation
SOT	Statement of Tasks
SOW	Scopes of Work
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
TCEP	tris(2-carboxyethyl)phosphine
TCEQ	Texas Commission on Environmental Quality
TCPP	tris(chloroisopropyl) phosphate
TDA	Texas Department of Agriculture
TDCPP	tris(1,3-dichloroisopropyl) phosphate
Texas State	Texas State University
TP	total phosphorus
TPH	total petroleum hydrocarbons
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
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
WQP	Water Quality Monitoring Program
WQPP	Water Quality Protection Plan
WRIP	Water Resources Integration Program

LIST OF ALL SPECIES OF MANAGEMENT INTEREST REFERENCED[5]

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*

[5] 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 INCLUDED IN THE EAHCP 2017 ANNUAL REPORT

Term or Phrase	Term or Phrase Definition and Source
Conservation Measure	Specified projects to be implemented by the Permittees in order to minimize and mitigate to the maximum extent practicable and will not appreciably reduce the likelihood of the survival and recovery of the Covered Species due to the performance of the Covered Activities by the Permittees during the term of the ITP.
Covered Activity	Those activities identified in the ITP and the EAHCP and performed by the Permittees within the boundaries of the EAA, including recreation and pumping from the portion of the Southern Segment of the Edwards Aquifer within the EAA's boundaries, for which incidental take coverage has been provided during the term of the ITP.
Critical period	A period characterized by certain defined lower aquifer levels, which are primarily managed by the triggering of increasing withdrawal restrictions from the Aquifer.
Critical period sampling	High flow and low flow specific sampling to evaluate disturbance and recovery, 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, the "springflow protection" Conservation Measures are based off of the specific drought triggers that are tailored for each measure, except for the RWCP, which has no drought triggers. These measures are designed to prevent springflows at Comal Springs and San Marcos springs from being reduced below certain levels stated in the EAHCP during a repeat of the “Drought of Record,” which refers to the six-year drought that occurred from 1951 through 1956, and specifically to a drought characterized by an average recharge for any seven-year period of less than 168,700 ac-ft as derived from the period 1950 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

List of Defined Terms Included in the EAHCP 2017 Annual Report (continued)

	hold quantitative goals associated with specific plants regarded as fountain darter habitat.
Low flow(s) Low flow conditions Extreme low flow	A period of springflow that decreases below the long-term average and the minimum averages identified in Tables 4-2 and 4-13 of the EAHCP significantly. Low-flow may also be specified in the Comal system as 130 cfs or lower, and in the San Marcos system as 120 cfs or lower based on Condition M in the ITP.
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.
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.
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.

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1.0 BACKGROUND AND 2017 EDWARDS AQUIFER CONDITIONS, MANAGEMENT, AND NOTABLE CHALLENGES, EAHCP OVERSIGHT, AND COORDINATION

The Edwards Aquifer Habitat Conservation Plan (EAHCP)[6] was approved by the U.S. Fish & Wildlife Service (Service or USFWS) as a regional plan to protect the federally-listed species[7] associated with the Edwards Aquifer while helping to ensure stability of the Edwards Aquifer as a water supply for the region (RECON Environmental, Inc. [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 21, 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. Because of EAHCP implementation efforts, there have been various amendments or clarifications made to the EAHCP, or its supporting documents, since the issuance of the ITP. **Appendix A2** is a table summarizing the amendments or clarifications from November 2012 through December 2017.

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**). As shown in **Figure 1.0-1,** the Contributing Zone is part of the Edwards Aquifer system but is not technically a part of the Edwards Aquifer itself.

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

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

[7] 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 xxvi - xxvii.

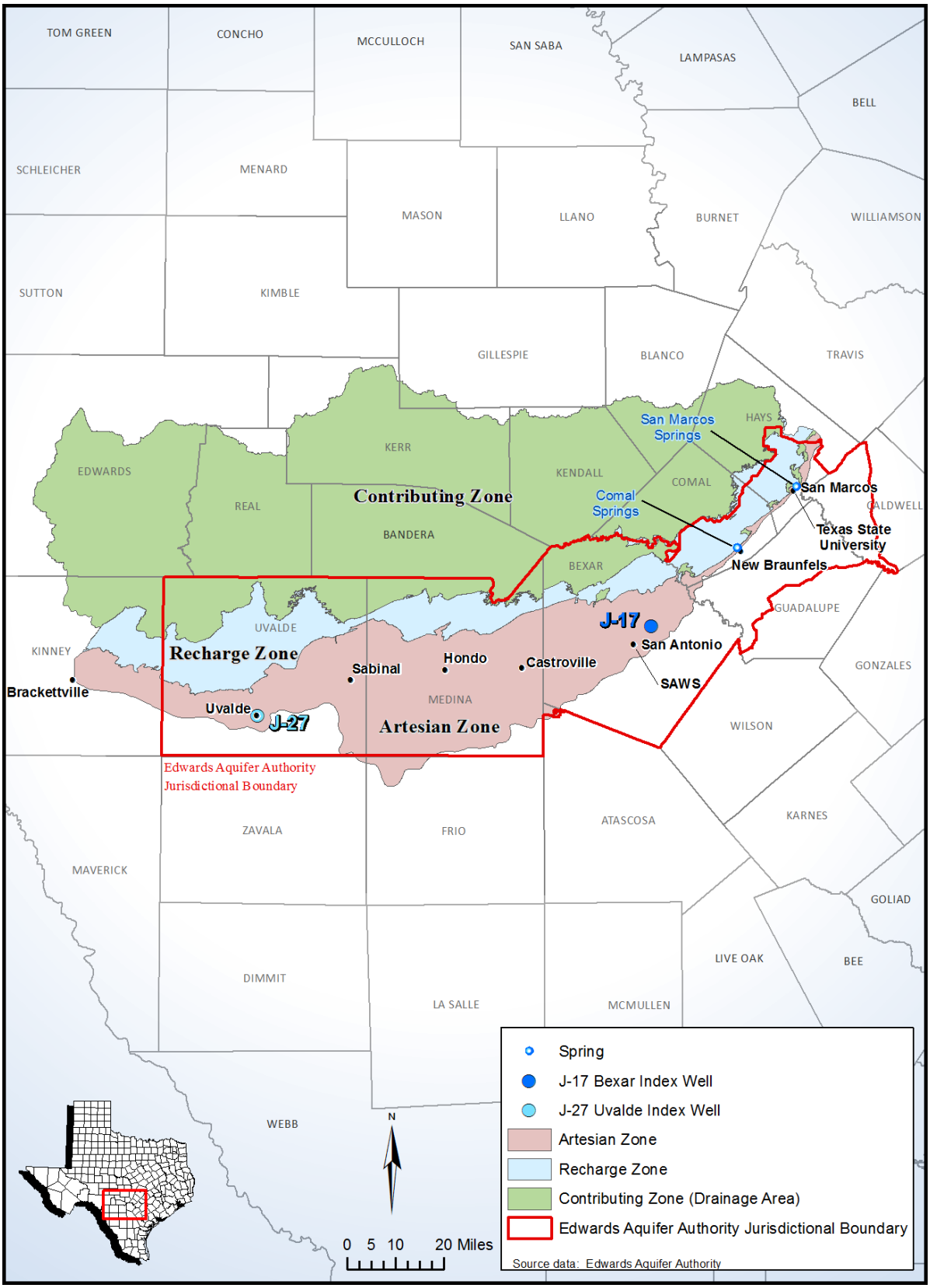

Figure 1.0-1. Incidental Take Coverage Area for ITP No. TE-63663A-1 (EAA Jurisdictional Boundary).

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."

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 EAHCP 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 2017 as documented in this Annual Report to comply with these conditions.

This document serves as the Annual Report for the calendar year 2017. The comments received on earlier drafts of the 2017 Annual Report are included in **Appendix B**.

Table 1.1-1. ITP Conditions and EAHCP 2017 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**)

Table 1.1-1. ITP Conditions and EAHCP 2017 Annual Report References Documenting Permittee Compliance Efforts

ITP Condition	ITP Condition Subsection	ITP Condition Title	Annual Report Chapter, Section, Subsection, or Appendix Reference
	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.
	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**)

Table 1.1-1. ITP Conditions and EAHCP 2017 Annual Report References Documenting Permittee Compliance Efforts

ITP Condition	ITP Condition Subsection	ITP Condition Title	Annual Report Chapter, Section, Subsection, or Appendix Reference
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	**1.0**
	1.	Edwards Aquifer Authority (EAA)	**3.1**
	2.	City of New Braunfels (CONB)	**3.2**
	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 2017.

Table 1.1-1. ITP Conditions and EAHCP 2017 Annual Report References Documenting Permittee Compliance Efforts

ITP Condition	ITP Condition Subsection	ITP Condition Title	Annual Report Chapter, Section, Subsection, or Appendix Reference
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.
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 2017.
R.		CHANGED CIRCUMSTANCES	**4.0,** and **Appendices A4** through **A13**
T.		MONITORING REQUIREMENTS	**1.0**
	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

Table 1.1-1. ITP Conditions and EAHCP 2017 Annual Report References Documenting Permittee Compliance Efforts

ITP Condition	ITP Condition Subsection	ITP Condition Title	Annual Report Chapter, Section, Subsection, or Appendix Reference
	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**
	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 J2**
	d.	Report on the status of implementation of minimization and mitigation measures and their effectiveness	**1.0**
	e.	Interim updates and final copies of any research, thesis or dissertation, or published studies accomplished in association with the EARIP or HCP	**3.3.3, 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**, **3.1.12**, **3.3.6**, **3.3.12**, **3.3.14**, **4.2**, and **Appendices A4** through **A13**

Table 1.1-1. ITP Conditions and EAHCP 2017 Annual Report References Documenting Permittee Compliance Efforts

ITP Condition	ITP Condition Subsection	ITP Condition Title	Annual Report Chapter, Section, Subsection, or Appendix Reference
	g.	Any changes to the Biological Goals and Key Management and Flow-related Objectives of the HCP and the reasons for such changes	No changes during report period.
	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.
	j.	Evaluation of progress toward achieving the Biological Goals and Objectives.	**1.4.4, 2.0**, **3.1.1**, **3.1.11.2**, **3.1.12**, **3.2.1**, **3.2.2**, **3.3.3**, **3.3.6**, **3.3.8**, **3.3.12**, **3.3.14**, **4.2**, and **Appendices A4** 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 2017 Edwards Aquifer Conditions, Management and Notable Conditions – Springflows

Well discharge and recharge data are included in the 2016 Hydrological Reports (**Appendices D1** through **D4**). **Appendix E** contains a listing of all EAA groundwater withdrawal permits.

After well above average rainfall in 2015 and 2016, the Edwards Aquifer region of south Central Texas returned to below average rainfall totals during the 2017 calendar year. With the exception of the far eastern portion of the Edwards Aquifer Contributing Zone affected by Hurricane Harvey, rainfall totals across the Contributing Zone were between 75 and 100 percent of normal totals. Springflow and index wells followed rainfall patterns with typical lag times. The J-17 Index Well fell over 34 feet (ft) between spring maximums and summer minimums. Comal springflow was well above the historical average during the first half of 2017, and was similar to slightly above averages over the latter half of 2017. Springflow in the San Marcos system remained just above average over the entirety of the 2017 calendar year. No major flooding occurred within the San Marcos or Comal rivers during 2017.

1.3 2017 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 2017 Program Funding Applications budgets for each of the Permittees during at their meeting on November 8, 2016.

Throughout the course of 2017, the EAA Board of Directors approved two amendments to the EAHCP budget to meet the needs of the program. Specifically, the items amended and adjusted were the Refugia Conservation and Adaptive Management Measure, the Ecological Modeling Adaptive Management Measure, and the VISPO and ASR Conservation Measures for the EAA, and the LID/BMP Conservation Measure for the COSM. 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 amendments 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 2017 totaling $18,162,597. These amounts can be compared to the EAA Board-approved 2017 Program Funding Applications totaling $22,332,476. **Figure 1.3-1** reflects the 2017 EAA Board-approved 2017 Program Fund Applications, by budget and EAHCP activity.

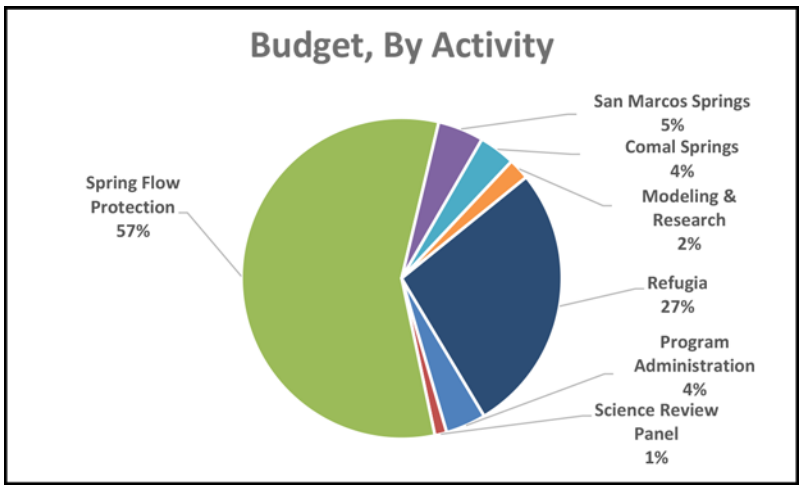

Figure 1.3-1. 2017 EAA Board-approved 2017 Program Fund Applications, by budget and EAHCP activity.

The 2017 actual expenses were $16,981,651. Unspent funds in the Program Administration, Science Panel Review, ASR Leasing, ASR Operations and Maintenance, LID/BMP Management, Applied Environment Research, and Refugia budgets account for most of the difference between total approved budget and actual expenses. **Figure 1.3-2** shows the 2017 actual expenses by each EAHCP activity.

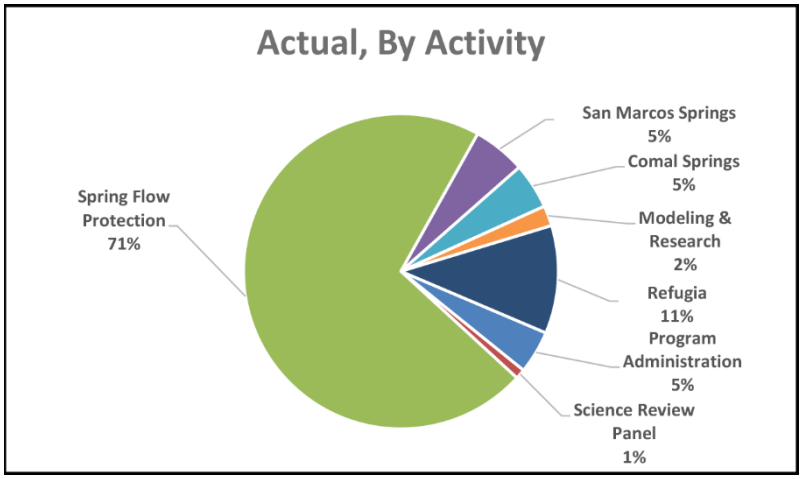

Figure 1.3-2. 2017 actual expenses by EAHCP activity.

The report also breaks down the adopted budget, Program Funding Applications budget, and actual expenses. By the end of 2017, the reserve balance for the EAHCP was $36,105,205, which includes unspent funds accumulated since the inception of the EAHCP (**Figure 1.3-3**).

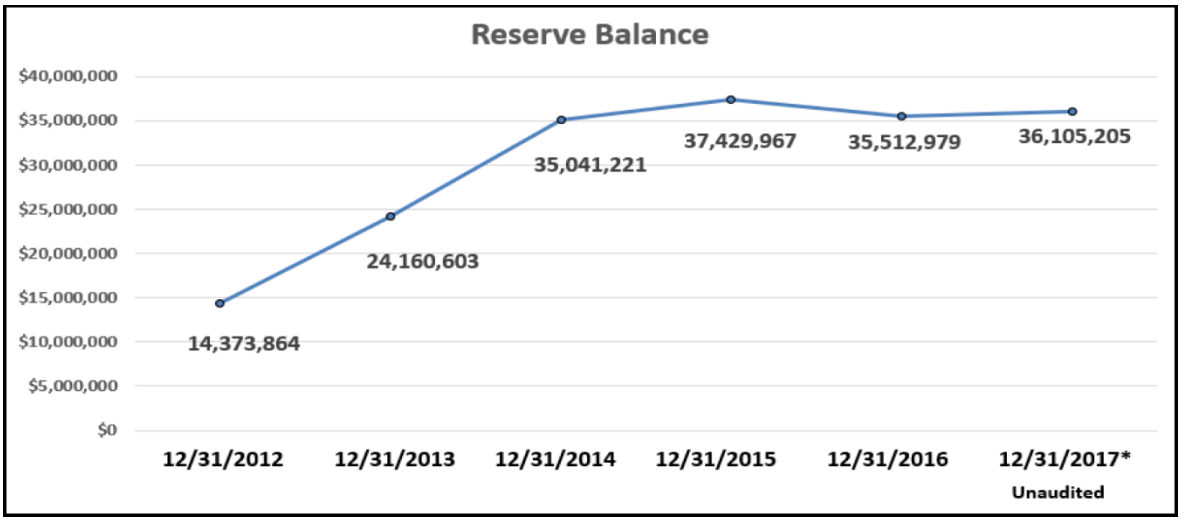

Figure 1.3-3. Reserve balances for EAHCP since program inception.

The EAHCP Expense Report also shows the actual revenue for 2017 of $16,081,152 compared to the budgeted revenue of $15,854,400, which is a variance of $226,752. Approximately 95 percent of the actual revenue comes from Aquifer Management Fees (AMFs).

1.4 2017 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 2017 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 et al. 2012). The activities of this committee are not covered in this Annual Report as the RCMC authorized the EAHCP Program Manager to submit a "Statement of Program Finalization" to the IC as the obligations of the Regional Water Conservation Program (RWCP) and the RCMC under the EAHCP were fulfilled in 2016.

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 2017. The IC met eight times in 2017. The IC also met jointly with the SH and SC two times during 2017. The agendas and minutes for those meetings are provided in **Appendix I1**.

Table 1.4-1. Members of the Implementing Committee for 2017

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

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

Highlights of the IC meetings in 2017 are listed below.

- January 19, 2017:
  - Confirmation of 2017 IC officers through ratification of an adopted officer succession plan;
  - Presentation of the *2016 Net Disturbance and Take Estimate Report*;
  - Approval of the *National Academy of Sciences – Review of the Edwards Aquifer Habitat Conservation Plan: Report 2 (*NAS *Report 2*) review process, and creation of the Report 2 National Academy of Sciences Work Group (NASWG2);
  - Discussion of possible Adaptive Management Process (AMP) for Aquifer Storage and Recovery (ASR) in 2017;
  - Approval of the amended EAA 2017 Work Plan and related 2017 Funding Application.
- February 16, 2017:
  - Approval to create the EAHCP Budget Work Group, including the Work Group Work Group's charge and membership;
  - Discussion of possible San Marcos Water Quality Conservation Measures[8] AMPs for 2017;
  - Approval of the amended EAA Refugia 2017 Work Plan and related 2017 Funding Application.
- March 16, 2017:
  - Approval of the Nonroutine AMP Proposal related to the "Minimizing Impacts of Contaminated Runoff" Conservation Measure for the COSM;
  - Approval to direct the Program Manager to submit the necessary documentation to the USFWS based on the approved AMP Proposal on behalf of the IC;
  - Approval of the amended 2017 COSM and Texas State Work Plans, and related 2017 Funding Applications;
  - Approval of the *EAHCP 2016 Annual Report* for submittal to the USFWS.
- May 18, 2017:
  - Presentation of the 2016 recharge estimate and 10-year rolling recharge average;
  - Presentation on the 2016 EAA Pumping Report;
  - Presentation summarizing the NAS *Report 2* SH and SC Public Workshop;
  - Discussion regarding the National Academy of Sciences (NAS) Phase 3 Statement of Tasks (SOT);

[8] EAHCP staff developed a **LIST OF DEFINED TERMS FOR DISCUSSIONS INCLUDED IN THE EAHCP 2017 ANNUAL REPORT**, located on pages xxviii - xxix of this Annual Report, for words or phrases that have specific meaning within 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.

- Presentation of the EAA 2018 Work Plans;
- Presentation of the COSM and Texas State 2018 Work Plans;
- Presentation of the CONB 2018 Work Plans.

- June 15, 2017:
  - Approval of the EAA 2017 Work Plan and related Funding Application Amendments;
  - Approval of the COSM 2017 Work Plan and Funding Application Amendments;
  - Approval of the 2018 Work Plans for the EAA, CONB, and COSM and Texas State.
- July 28, 2017:
  - Joint workshop of the IC, SH and SC regarding the Ecological Model (EcoModel) and Strategic Adaptive Management model runs and future EcoModel use.
- August 17, 2017:
  - Adoption of the *2017 Budget Work Group Report*;
  - Approval to amend the 2017 COSM and Texas State Work Plans;
  - Presentation on the EcoModel workshop and EAHCP Strategic Adaptive Management considerations;
  - Presentation on the RWCP and SAWS Leak Repair Update;
  - Adoption of the *NAS Report 2 Implementation Plan*;
  - Presentation on the NAS *Report 2* Recommendations Issues List.
- September 21, 2017:
  - Approval of the Sediment Removal and Impervious Cover/Water Quality Protection Nonroutine AMP Proposal submitted to the IC in the SH Report.
- October 19, 2017:
  - Approval for the Program Manager to submit the necessary documentation to USFWS based on the approved Sediment Removal and Impervious Cover/Water Quality Protection AMP Proposal on behalf of the IC;
  - Approval of the amended 2018 COSM and Texas State Work Plans and related Funding Applications;
  - Approval of the amended 2017 EAA Work Plan.
- December 14, 2017:
  - Joint meeting of the IC, SH and SC.

1.4.1.1 EAHCP Budget Work Group

On February 16, 2017, the IC approved the creation of the EAHCP Budget Work Group, and approved the Work Group's charge and membership. Pursuant to the Budget Work Group's charge, they were to "collaborate with and inform the EAA Budget Process, as it relates to the EAHCP, EAHCP reserve and EAHCP aquifer management fee, and address fiscal issues as they arise and are referred by the IC." Also, as approved by the IC, the Budget Work Group will be in existence for the duration of the ITP.

The members of the Budget Work Group were Tom Taggart (IC Member) – Budget Work Group Chair, Brock Curry (EAA Designee), Steve Raabe (SH Member), Myron Hess (SH Member), Mary Bailey (SAWS Designee), and Adam Yablonski (Member-at-Large). The Work Group met in April and May of 2017. The Budget Work Group by consensus approved the *Report of the 2017 Budget Work Group* to submit to the

IC. Copies of the Budget Work Group's charge, meeting agendas and minutes, and final report can be found in **Appendix I2.**

1.4.1.2 Report 2 National Academy of Sciences Work Group

As with *National Academy of Sciences – Review of the Edwards Aquifer Habitat Conservation Plan: Report 1* (NAS *Report 1*), the IC undertook a contemplative process to review and consider the recommendations contained in the NAS *Report 2* as it related to all EAHCP programs. That process began when the IC created the Report 2 National Academy of Sciences Work Group (NASWG2) on January 19, 2017. At this meeting, the IC also appointed the following representatives to serve on the NASWG2: Cindy Loeffler (Texas Parks & Wildlife Department [TPWD]) – NASWG2 Chair, Mark Enders (CONB), Kerim Jacaman (Bexar County), Patrick Shriver (SAWS), and Julia Carrillo (EAA). The IC charged the NASWG2 with, while operating on a consensus-basis, providing the EAHCP Program Manager with advice concerning the development of an implementation plan for NAS *Report 2* (*Report 2 Implementation Plan*), and providing representation for the SH and IC over the course of the implementation planning process. On April 18, 2017, the SH and SC held a joint workshop on NAS *Report 2*. As mentioned previously, a report on the joint committee workshop was presented to the IC on May 18, 2017.

The NASWG2 met twice during May 2017. At their meeting on May 26, 2017, the NASWG2, by consensus, approved the process and timeline for final approval of the *Edwards Aquifer Habitat Conservation Plan Report 2 Implementation Plan* (*Report 2 Implementation Plan*). On August 17, 2017, the IC adopted the *Report 2 Implementation Plan* recommended by the NASWG2. Copies of the NASWG2's meeting agendas and minutes, and final report can be found in **Appendix I3**. A copy of the report on the April 18th joint SH and SC workshop can also be found in **Appendix I4** and **Appendix I5**, respectively.

For additional discussion related to the NAS *Report 2*, please refer to subsection 1.4.4, Activities of the Science Review Panel/National Academy of Sciences, below.

1.4.2 Activities of the Adaptive Management Stakeholder Committee

Table 1.4-2 lists the 27 SH representatives, their affiliations, the interests they represented, and their alternates for 2017.

Table 1.4-2. Members of the Adaptive Management Stakeholder Committee in 2017

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	Annie Kellough
Dianne Wassenich***	San Marcos River Foundation (SMRF)	Conservation organization	Annalisa Peace
Carl Adkins	Texas BASS Federation Nation	Recreational interest in the Guadalupe River Basin	Tim Cook
Chuck Ahrens	EAA	EAA	Elizabeth Woody****
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	Tim Kelly, Mayor – City of Castroville

Table 1.4-2. Members of the Adaptive Management Stakeholder Committee in 2017

Member	Affiliation	Representing	Alternate
Buck Benson	Alamo Cement/Pulman Law	Holder of an initial regular permit issued by the EAA for industrial purposes	Shanna Castro/Paul Hunt
Roger Biggers	New Braunfels Utilities (NBU)	Retail public utility in whose service area the Comal Springs or San Marcos Springs is located	Trino Pedraza
Jim Bower	City of Garden Ridge	Holder of an EAA initial regular permit issued to a small municipality (population under 50,000) located east of San Antonio	No alternate named
Doris Cooksey	City Public Service (CPS) Energy	CPS Energy	Louisa Eclarinal
James Dodson	City of Victoria	Holder of a municipal surface water right in the Guadalupe River Basin	No alternate named
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
Cindy Hooper	Texas Commission on Environmental Quality (TCEQ)	TCEQ	Cary Betz
Melani Howard	COSM	COSM	Laurie Moyer
Dan Hunter	Texas Department of Agriculture (TDA)	TDA	David Villarreal
Cindy Loeffler	TPWD	TPWD	Colette Barron
Glenn Lord	DOW Chemical	Holder of an industrial surface water right in the Guadalupe River Basin	Dwaine Schoppe
Greg Malatek	CONB	CONB	Robert Camareno
Kimberly Meitzen	Texas State	Texas State	Andy Sansom
Gary Middleton	South Central Texas Water Advisory Committee (SCTWAC)	SCTWAC	No alternate named
Con Mims	Nueces River Authority (NRA)	NRA	Sky Lewey
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
Patrick Shriver	SAWS	SAWS	John Waugh
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
**** Javier Hernandez was named as the EAA alternate in late 2017.

The SH met three times in 2017. The SH also met jointly with the SC on April 18, 2017, for a workshop on the NAS Report 2, and jointly with the IC and SC on July 28th and December 14th. The agendas and minutes for the SH meetings and joint meetings are included in **Appendix I4**. A copy of the agenda for the April 18th joint workshop and the report to the IC resulting from that workshop can also be found in **Appendix I4**.

Highlights of the SH meetings are noted below.

- March 16, 2017:
  - Presentation on NAS *Report 2*, and review process adopted by the IC to implement NAS *Report 2*;
  - Update regarding the EAHCP Hydrologic Modeling effort;
  - Presentation on 2017 EAHCP Nonroutine AMPs;
  - Approval to recommend the Nonroutine AMP Proposal related to the "Minimizing Impact of Contaminated Runoff" Conservation Measure for the COSM to the IC;
  - Approval of an expedited process to prepare and submit the Nonroutine AMP SH Report, with SH Chair and Vice-chair approval, to the IC.
- April 18, 2017:
  - Joint workshop of the SH and SC regarding NAS Report 2.
- June 15, 2017:
  - Update on the 2017 AMP Processes: ASR, COSM Sessom Creek, and COSM Sedimentation Ponds;
  - Update on the 2017 Refugia operations;
  - Update on the Hydrologic Model and EcoModel and their use in Phase II of the ITP.
- July 28, 2017:
  - Joint workshop of the IC, SH and SC regarding the EcoModel and Strategic Adaptive Management model runs and future EcoModel use.
- September 21, 2017:
  - Approval to recommend the Sediment Removal and Impervious Cover/Water Quality Protection Nonroutine AMP Proposal to the IC;
  - Approval to expedite the process to develop and submit the Nonroutine AMP SH Report to the IC;
  - Presentation on the ASR Nonroutine AMP Proposal and timeline;
  - Presentation on the EcoModel workshop and EAHCP Strategic Adaptive Management considerations;
  - Presentation regarding the *Report 2 Implementation Plan*;
  - Presentation on the NAS *Report 2* Recommendations Issues List;
  - Presentation on the 2017 Budget Work Group Report.
- December 14, 2017:
  - 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 1.4-3**).

The SC met four times in 2017. The SC also met jointly with the SH on April 18, 2017, for a workshop on the NAS Report 2, and jointly with the IC and SH on July 28th and December 14th. The agendas and minutes

for the SC meetings and joint meetings are included in **Appendix I5**. A copy of the agenda for the April 18th joint workshop and the report to the IC resulting from that workshop can also be found in **Appendix I5**.

Table 1.4-3. Members of the Adaptive Management Science Committee in 2017

Member	Affiliation	Expertise	Nominating Entity
Tom Arsuffi, Ph.D.*	Texas Tech University (TTU)	Aquatic Biology Stream Ecology	IC
Floyd Weckerly, Ph.D.**	Texas State	Population Ecology Experimental Design	SH
Doyle Mosier, M.S.	TPWD (Retired)	Instream Flows Aquatic Habitats	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
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

* Committee Chair
** Committee Vice Chair

Highlights of the 2017 SC meetings are listed below.

- March 8, 2017:
  - Presentation Summarizing NAS *Report 2*;
  - Presentation of proposed methodology for the 2017 Applied Research study: *Statistical analysis of the San Marcos & Comal Springs aquatic ecosystems biomonitoring dataset (BIO-WEST, Inc. (BIO-WEST])*;
  - Presentation of proposed methodology for the 2017 Applied Research study: *Statistical analysis of the San Marcos & Comal Springs aquatic ecosystems biomonitoring dataset (Beaver Creek)*;
  - Presentation and discussion of the proposed methodology for the 2017 Applied Research study: *Statistical analysis of the San Marcos & Comal Springs aquatic ecosystems biomonitoring dataset (UTSA)*;
  - Approval to create the SC's Research Work Group to review Refugia research projects and 2018/2019 Applied Research projects, and approve the Work Group's charge and membership;

- Presentation on the first of two possible AMPs for 2017 related to COSM and Texas State Water Quality Measures;
- Approval to recommend the Nonroutine AMP Proposal related to the "Minimizing Impacts of Contaminated Runoff" Conservation Measure for the COSM to the SH;
- Presentation on ecological considerations, relevant to the Covered Species, associated with proposed designs for sedimentation ponds to fulfill the "Minimizing Impacts of Contaminated Runoff" Conservation Measure for the COSM;
- Approval to expedite the process to prepare and submit the Scientific Evaluation Report (SER) on the proposed Nonroutine AMP action, with SC Chair and Vice-Chair approval, to the SH;
- Presentation on the second of two possible AMPs for 2017 related to COSM and Texas State Water Quality Measures;
- Approval to create the SC's San Marcos Water Quality Protection Work Group to review the COSM/Texas State proposed water quality protection projects, and approve the Work Group's charge and membership.

- April 18, 2017:
  - Joint workshop of the SC and SH regarding NAS Report 2.
- May 10, 2017:
  - Presentation on the 2016 Applied Research results: *Evaluation of the long-term elevated temperature and low dissolved oxygen tolerances of larvae and adult Comal Springs riffle beetle (CSRB)*;
  - Update on Applied Research project: *Evaluation of the life history of the CSRB from egg to adult*;
  - Approval of recommendation regarding the COSM and Texas State 2018 Work Plans;
  - Approval of recommendation regarding the CONB 2018 Work Plan;
  - Presentation on the *Report of the Research Work Group: 2018 Refugia Research and 2018 – 2019 Applied Research*;
  - Presentation on the 2018 Applied Research Projects strategy and process for soliciting comments;
  - Approval of recommendation regarding the EAA 2018 Work Plan.
- July 28, 2017:
  - Joint workshop of the IC, SH and SC regarding the EcoModel and Strategic Adaptive Management model runs and future EcoModel use.
- August 7, 2017:
  - Presentation on 2016 Applied Research results: *Evaluation of the trophic level status and functional feeding group categorization of larvae and adult CSRB*;
  - Presentation on 2018 Applied Research Projects Scopes of Work (SOW);
  - Presentation of the EcoModel workshop and EAHCP Phase 2 considerations;
  - Approval to recommend the Nonroutine AMP Proposal related to the COSM and Texas State Sediment Removal Conservation Measures (EAHCP §§5.3.6 and 5.4.4) and Impervious Cover/Water Quality Protection Conservation Measure (EAHCP §5.7.6), to the SH;
  - Approval of an expedited process to prepare and submit the Nonroutine AMP SER, with SC Chair and Vice-Chair approval, to the SH.

- November 8, 2017:
  - Presentation on 2016 – 2017 Applied Research results: *Evaluation of the life history of the CSRB from egg to adult*;
  - Discussion of changes to CSRB biomonitoring program;
  - Presentation on the procedure for the SC to review proposals received for the 2018 Applied Research Project Request for Proposals (RFPs);
  - Election of a new SC Chair and Vice Chair for 2018.
- December 14, 2017:
  - Joint meeting of the IC, SH, and SC.

1.4.3.1 Research Work Group

On, March 8, 2017, the SC created the Research Work Group, and approved the Work Group's charge and membership. The SC charged the Work Group with, while operating on a consensus-basis, suggesting specific Applied Research projects to be conducted during 2018 and 2019 as part of the Applied Research Program, and suggesting refinements to the methodology proposed for Refugia research projects. The Work Group is to meet on an as-needed basis, and is expected to be in existence for the duration of the ITP. The Work Group members are derived from the SC membership. The Work Group members are Chad Norris (TPWD), Tom Arsuffi (TTU), Floyd Weckerly (Texas State), and Conrad Lamon (Statistical Ecology Associates LLC).

The Research Work Group met on March 22, 2017, and developed a final report that was approved and endorsed by the SC on May 10, 2017. Copies of the Research Work Group's charge, meeting agenda and minutes, and final report can be found in **Appendix I6**.

1.4.3.2 San Marcos Water Quality Protection Work Group

On, March 8, 2017, the SC created the San Marcos Water Quality Protection Work Group, and approved the Work Group's charge and membership. The SC charged the Work Group with, while operating on a consensus-basis, considering the EAHCP staff recommendation of the Sessom Creek watershed as the top priority for implementing projects, and reviewing and prioritizing the proposed list of water quality protection projects identified in the Water Quality Protection Plan (WQPP) for the chosen watershed. The Work Group was only expected to meet once.

The Work Group met on July 18, 2017. Copies of the Work Group's charge, meeting agenda, and minutes can be found in **Appendix I7**.

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.[9]

Table 1.4-4 lists the eleven SRP/NAS members for 2017. In 2017, the SRP/NAS met once from October 2 – October 4, 2017, at the EAA's offices in San Antonio, Texas. The agenda for that meeting is provided in **Appendix I8**.

Table 1.4-4. Science Review Panel/National Academy of Sciences Members for 2017

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
Stuart E.G. Findlay, Ph.D.**	Carey Institute of Ecosystems Studies	Freshwater Ecosystems
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
Steve A Johnson, Ph.D.**	University of Florida	Wildlife Ecology and Conservation
James A. Rice**	North Carolina State University	Aquatic Ecology
Kenneth A. Rose, Ph.D.	Louisiana State University	Population Modeling
J. Court Stevenson, Ph.D.**	University of Maryland (Retired)	Botany
Laura Toran, Ph.D.	Temple University	Groundwater Monitoring and Modeling

* Committee Chair
** New SRP/NAS member for Phase 3 and Report 3

Table 1.4-5 lists former members of the SRP/NAS that served during Phases 1 and 2 of the SRP/NAS' work to support the EAHCP.

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

Member	Affiliation	Area of Expertise
Robin K. Craig, Ph.D., J.D.	University of Utah	Water Law
Timothy K. Kratz, Ph.D.	University of Wisconsin—Madison	Aquatic Ecology
Andrew J. Long, Ph.D.	U.S. Geological Survey (USGS)	Hydrology
Laura Murray, Ph.D.	University of Maryland	Wetlands Ecology
Jayanthan Obeysekera, Ph.D.	South Florida Water Management District	Hydrologic Modeling
Greg D. Woodside, P.G., C.HG.	Orange County Water District	Watershed Management and Planning

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.

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

The second phase of the SRP/NAS process was completed on December 30, 2016 with the publication of NAS *Report 2* (NAS 2016). A copy of that report is provided in **Appendix O1**. For this second report, the SRP/NAS focused its evaluation and recommendations concerning NAS *Report 1* implementation, the EAHCP's monitoring programs, scenarios for ecological and hydrological modeling, and Conservation Measure implementation. NAS *Report 2* determined that satisfactory progress has been achieved in several different EAHCP programs, and identified areas for continued improvement.

The third phase of the SRP/NAS process was initiated in the fall of 2017, with the NAS' issuance of the *Study Announcement – Review of the Edwards Aquifer Habitat Conservation Program – Phase 3* (see **Appendix O2**). For this third and final report, the SRP/NAS is focusing on the relationships among proposed EAHCP Conservation Measures (including flow protection and habitat restoration), Biological Objectives (such as water quality criteria, habitat condition, and specified spring flow rates), and Biological Goals (such as maintaining populations of the Covered Species). Phase 3 is scheduled to be completed in late 2018 with the delivery of the third report.

1.4.5 Committee and Work Group Support

During 2017, EAHCP staff successfully facilitated eight IC meetings, four SC meetings, three SH meetings, two joint SH and SC workshops, two Joint Committee meeting (IC, SH, and SC) and organized the meetings of four 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 2017. Thus, 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. 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.

Facilitating meetings by EAHCP staff 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 2017, SC meetings were held at the San Marcos Activity Center, IC meetings were held at the EAA, GBRA, San Marcos Activity Center, San Marcos Recreation Hall, and the New Braunfels City Hall, and SH meetings were held at GBRA, San Marcos Activity Center and the New Braunfels City Hall.

In addition to their work involving standing EAHCP committees, in 2017 staff facilitated and executed the development of four *ad hoc* work groups – the NASWG2, Budget Work Group, Research Work Group and the San Marcos Water Quality Protection Work Group. Between these four Work Groups, staff organized and facilitated six 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 A3**. The EAHCP Biological Goals and Objectives summarized in **Appendix A3** reflect the clarifications of, and/or amendments made to, the EAHCP in 2017 through the AMP. This process is discussed in further detail in **Chapter 3.0** – PLAN IMPLEMENTATION IN 2017, **subsection 3.1.11.2** – Amendments, Informational Memoranda, and Clarifications, and in **Chapter 4.0** – ADAPTIVE MANAGEMENT PROCESS ACTIVITIES FOR 2017, 4.2 – Nonroutine Decisions, of this Annual Report.

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3.0 PLAN IMPLEMENTATION IN 2017

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, the cooperating agency, stakeholders and the USFWS. Also, equally meaningful is the on-going collaboration that takes place between the Permittees, the cooperating agency, 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 two Nonroutine AMPs in 2017, 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 2017 towards meeting the measures outlined in the EAHCP, and the efforts to comply with the ITP requirements.

Chapter 3.0 – PLAN IMPLEMENTATION IN 2017, of this Annual Report describes actions by each of the Permittees and the TPWD, including subsections discussing their *EAHCP Obligations*, *2017 Compliance Actions*, and *Proposed Activities for 2018*.

The following sections describe the activities implemented in 2017 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 2017 Work Plans. The 2017 Work Plans approved by the IC on June 23, 2016, and as amended in 2017, are included in this Annual Report in **Appendix J1**. The 2018 Work Plans approved by the IC on June 15, 2017, are included in this Annual Report as **Appendix J2**.

3.1 Edwards Aquifer Authority

The EAA is a political subdivision 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 on a four-year alternative basis, 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:

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 EcoModel, 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.

2017 Compliance Actions:

The initial stage of the Applied Research Program conducted studies prescribed in the EAHCP to fill critical gaps in data regarding the species and their habitat. As the new data were 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 conducted in 2017 are listed below.

Applied Research Program Activities for 2017

1) *Evaluation of the life history of the Comal Springs riffle beetle from egg to adult: Phase 2*
   Rationale and role of this study in the EAHCP process: Phase 1 of this study developed the methods to identify CSRB adult gender (without harming the beetle), which allowed for successful breeding and the determination of number of eggs laid and time to hatch. In 2017, the study collected CSRB data on number of instars, pupation and the length of time to emerge as an adult. The study gathered and evaluated data required for management decisions regarding species husbandry. These data were necessary for successful refugia operations and will be used in development of a CSRB component of the EcoModel.

   The *Comal Springs Riffle Beetle (Heterelmis comalensis): Life History and Captive Propagation Techniques* can be found in **Appendix K1**.

2) *Statistical analysis of the EAHCP San Marcos and Comal springs aquatic ecosystems datasets*
   Rationale and role of this study in the EAHCP process: Biological and water quality data have been collected on the species and their habitats through the EAA since 2000, and no statistical analyses

have been performed on the cumulative dataset since 2007. The purpose of this applied research project is twofold: (1) provide a time integrated statistical analysis of data generated by the EAA and its contractors, and (2) develop biological and hydrological statistical questions related to achieving compliance with the EAHCP's Long-Term Biological Goals (LTBGs). Three different contractors were selected to conduct studies.

a. The *Analysis of the Comal Springs and San Marcos Springs Long-Term Monitoring Dataset* report can be found in **Appendix K2**.

   The goals of this study were to:
   Provide exploratory, time-integrated statistical analysis of three categories of data:
   i. Water Quantity and Quality
   ii. Submerged Aquatic Vegetation
   iii. Covered Species

b. The *Statistical Analysis of the San Marcos and Comal Springs Aquatic Macrophytes and Discharge Datasets* report can be found in **Appendix K3**.

   The goals of this study were to examine the following items:
   i. Fountain darter – continue to track association between plant density and darter abundance. Statistics could focus on the impacts of invasive species/floating plants.
   ii. Vegetation – why does the plant community within the New Channel varying so greatly? Measure stressors (if not already monitored).
   iii. Salamanders – solidify analysis showing correlations with water quality and results could imply additional understand of sites that vary most
   iv. Macroinvertebrates – explore temperature gradient further as a source of site-level variance.
   v. Water Quality – use analysis results to propose further study related to NO_3 variance.

c. The *Distributional Patterns of Aquatic Macrophytes in the San Marcos and Comal Rivers from 2000 to 2015* report can be found in **Appendix K4**.

   The goals of this study were to:
   i. Provide data summarization
   ii. Evaluate aquatic vegetation coverage
   iii. Determine long-term discharge patterns
   iv. Provide statistical analysis of the macrophyte and discharge datasets.

Proposed Activities for 2018:

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. Studies continue to be conducted as deemed necessary and appropriate. 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 2018, the SC will be creating two separate Work Groups designed to target

various research issues for the EAHCP. The first will be to reconvene the previous Research Work Group to begin discussing topics of future and current applied research. The second one will be a Work Group designed to discuss research pertaining specifically to the CSRB.

Ongoing research in the San Marcos River system has noted that sediment deposition on Texas wild-rice is a recurring issue (RECON et al. 2012, Earl and Wood 2002). Sandbar and sediment removal from the San Marcos River have thus far not proven to be long-lasting or cost effective, and are currently considered unsuccessful. Therefore, sediment removal Conservation Measures were recently rewritten to enhance sediment prevention, placing the emphasis on keeping sediments out of the system.

For 2018, a study of the sediment export from the Sessom Creek watershed to the upper San Marcos River will be conducted. The goals of this study are to:

1) Collect data on sediment/constituent loading
2) Calculate sediment/constituent loading curves
3) Examine the physical factors that contribute to sediment transport

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 supports and coordinates with the USFWS on the work relating to the SMARC operation and maintenance of two 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."

2017 Compliance Actions:

Refugia Operations

Refugia operations were established to provide protection for the Covered Species included in the ITP in accordance with the EAHCP, and to allow research on those species. Establishing off-site refugia for the Covered Species is necessary to provide back-up populations that can be used to re-establish endemic populations in case of extirpation from the wild. In 2017, the EAA contracted with the USFWS to operate off-site refugia operations at the San Marcos Aquatic Resource Center (SMARC) and the Uvalde National Fish Hatchery (UNFH).

The primary activities occurring in 2017 were related to species collection, species research, and facility construction.

The Covered Species were planned for collection throughout the year by both USFWS facilities, in accordance with their 2017 Work Plan. The species census for December 2017 is shown in **Table 3.1-1**.

Table 3.1-1. Number of Organisms Incorporated in Refugia, and Total Census as of December 2017, of Edwards Aquifer Organisms Taken to Facilities (by Species and Facility)

Species	Incorporated into Refugia SMARC	Incorporated into Refugia UNFH	SMARC Dec 31 census	UNFH Dec 31 census	SMARC Survival Rate	UNFH Survival Rate
Fountain darter-San Marcos *Etheostoma fonticola*	624[1]	435[1]	610	246	73% (83%)*	57%
Fountain darter-Comal *Etheostoma fonticola*	497[1]	72[1]	408	66	82%	92%
Comal Springs riffle beetle *Heterelmis comalensis*	412	169	191	51	32%	30%
Comal Springs dryopid beetle *Stygoparnus comalensis*	38	12	13	2	30%	17%
Peck's Cave amphipod *Stygobromus pecki*	220	154	173	45	54%	29%
Edwards Aquifer diving beetle *Haideoporus texanus*	6	0	0	0	0%	-
Texas troglobitic water slater *Lirceolus smithii*	440	0	25	0	6%	-
Texas blind salamander *Eurycea rathbuni*	50	0	47	0	78%	-
San Marcos salamander *Eurycea nana*	214	201	267	180	77%	90%
Comal Springs salamander *Eurycea* sp.	54	9	47	4	87%	44%
Texas wild rice plants *Zizania texana*	116	66	240	67	93%	100%

[1]The number incorporated into the refugia is counted after the 30-day quarantine period. During this period fish are evaluated for health and suitability for inclusion into the refugia.
*Survival rate not including supersaturation event.

Table 3.1-1 shows the number of organisms incorporated in the Refugia and total census at the end of December of Edwards Aquifer organisms taken to facilities for refugia by species and facility housed. Further details of these numbers can be found in supporting documents.

Given the limited knowledge surrounding many of the Covered Species, a successful research program is paramount to building a successful refugia. In 2017, two research projects were initiated:

1) Larval Development of the Comal Springs Dryopid Beetle
2) Juvenile Development and Maturation of the Peck's Cave Amphipod

Both projects did not begin until the second half of 2017, and are intended to be multi-year efforts. The work plans/proposals for these two projects can be found in **Appendix K5** and **Appendix K6**, respectively.

During the entirety of 2017, refugia populations were held in existing facilities at the SMARC and UNFH. To accommodate the Covered Species moving forward, construction projects at each of the facilities are underway. Construction began in late 2017 at the SMARC facility and is anticipated to be completed in 2018. The engineering design was completed and procurement process initiated for the UNFH project. It is anticipated to be completed in 2018.

The *Implementation of the Refugia Program under the Edwards Aquifer Habitat Conservation Plan Annual Report 2017* can be found in **Appendix K7**. The report contains the details of all the activities described above, the monthly progress reports, and the species propagation plans for the Comal Springs riffle beetle, Peck's cave amphipod, and Texas blind salamander.

Proposed Activities for 2018:

The USFWS will continue to operate off-site refugia facilities in 2018, in accordance with its contractual agreement with the EAA and the 2018 work plan. Main activities include completion of construction projects at SMARC and UNFH, species collections in accordance with their workplan, and research activities. The proposed 2018 Refugia research projects include:

1) Peck's Cave amphipod life stage development and sex determination (in progress)
2) Comal Springs riffle beetle life history (in progress)
3) Comal Springs dryopid beetle life stage development (in progress)
4) San Marcos salamander propagation
5) Assess invertebrate collection techniques

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 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 acre-feet (ac-ft) of enrolled EAA-issued irrigation permits. 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 as to place and purpose of use for irrigation use.

2017 Compliance Actions:

On October 1, 2016, the Aquifer level at the J-17 Index Well was recorded at 678.1 ft msl and therefore did not trigger VISPO forbearance by permit holders in 2017. All VISPO participants were paid only the standby amount in 2017, with combined total VISPO payments amounting to $2,208,722 as presented by county in **Table 3.1-2**. Throughout the year, several ownership changes of permits occurred requiring amendments to existing VISPO forbearance agreements including one amendment of a 5-year term to a 10-year term; however, the total combined enrollment of 40,921 ac-ft. as shown in **Table 3.1-2** remains the same as 2016. No new enrollments occurred in 2017 due to the VISPO program enrollment goal being met in 2014.

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	764	0	67	2,908	14,532	18,625
5-Year Unrestricted	0	120	0	56	575	5,925	6,676
Subtotal	354	884	0	123	3,483	20,457	25,301
10-Year Base	0	1,451	0	0	6,152	4,183	11,786
10-Year Unrestricted	0	122	0	0	1,801	1,911	3,834
Subtotal	0	1,573	0	0	7,953	6,094	15,620
TOTALS	**354**	**2,457**	**0**	**123**	**11,436**	**26,551**	**40,921**
PAYMENTS	**$18,255**	**$136,054**	**$0**	**$6,441**	**$638,016**	**$1,409,956**	**$2,208,722**

Proposed Activities for 2018:

On October 1, 2017, the Aquifer level recorded at the J-17 Index Well was 665.5 ft msl and as a result, forbearance is not required by permit holders in 2018. Since 2018 is not a trigger year, standby payments will be made by March 2018 to all participants. All VISPO participants were notified by mail of the October 1, 2017, Aquifer level reading and that no forbearance from withdrawals will be required in 2018. No new program enrollment will occur as the 40,000 ac-ft goal has been met; however, staff will begin

contacting VISPO participants with five-year VISPO agreements expiring at the end of 2018, to explore possible extension of their participation in the program. The total amount of groundwater rights enrolled under VISPO forbearance agreements expiring at the end of year 2018 is 9,489 ac-ft.

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 included 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.

2017 Compliance Actions:

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 the 2016 Annual Report. For 2017, SAWS reported a total of 4,494 ac-ft of water saved. This information can be found in more detail in **Appendix K8**.

Proposed Activities for 2018:

In 2018, 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 2018. Final data will be included in an official report, which will be provided to the EAA in February of 2019.

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 of Directors regarding conserved water determinations, make specific recommendations regarding program implementation, and develop periodic updates tracking the program's progress.

In 2016 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. **Table 3.1-4** below shows the results of the RWCP conservation programs and groundwater committed to the Groundwater Trust.

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 the authorized groundwater withdrawal amount of EAA-issued groundwater withdrawal permits, 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 cubic feet per second (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.

2017 Compliance Actions:

Due to decreased Aquifer levels and springflows, Stage I of the CPMP in the San Antonio Pool was the only stage that was triggered in 2017. It was first triggered on July 13, 2017, for 47 days. Stage I in the San Antonio Pool was again triggered on September 16, 2017, for an additional 14 days in 2017, resulting in a total reduction of 3.4 percent to all permits. **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 2018:

In 2018, 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.

2017 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 2017 and a matrix of analytical parameters by sample type are provided in **Table 3.1-7** and **Table 3.1-8**, respectively.

Table 3.1-7. Summary of Data Types and Water Quality Sampling Events for 2017

San Marcos River	Sample Dates
Tissue Sampling (Tissue, Plasma, and Surface Water)	N/A
Passive Diffusion Samplers	Feb., Apr., Jun., Aug., Oct., Dec.
Polar Organic Chemical Integrative Sampler (only at HSM 470*)	Feb.
Comal River	**Sample Dates**
Stormwater – Integrated Pest Management Plan (only at HCS 210 and 260)	Feb. 14
Tissue Sampling (Tissue, Plasma, and Surface Water)	N/A
Passive Diffusion Samplers	Feb., Apr., Jun., Aug., Oct., Dec.
Polar Organic Chemical Integrative Sampler (only at HCS 460)	Feb., Apr.

* For an explanation of the sampling location codes referenced in this table (e.g. HSM 470), please refer to the following:

- HSM = San Marcos; and HCS = Comal
- The number following the abbreviation is either 1, 2 or 3 to indicate whether location is:
  - 1 = surface water sampling
  - 2 = stormwater sampling
  - 3 = sediment sampling
  - 4 = passive diffusion sampling
- The last two digits correspond to a specific sample location

Table 3.1-8. Analytical Parameters by Sample Type

Analytical Parameter	Tissue Sampling (Tissue, Plasma, and Water)	Passive Diffusion Sampling	Polar Organic Chemical Integrative Sampler	Stormwater Samples
Total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylene (BTEX), 1,3,5- and 1,2,4-trimethylbenzene, methyl *tert*-butyl ether (MTBE), phenanthrene, naphthalene,1-methylnaphthalene, 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	Yes	No	No
Caffeine, carbamazepine, diltiazem, diphenhydramine, propranolol, sertraline, trimethoprim, acetaminophen, amitriptyline, amlodipine, aripiprazole,	Yes	No	No	No

Table 3.1-8. Analytical Parameters by Sample Type

Analytical Parameter	Tissue Sampling (Tissue, Plasma, and Water)	Passive Diffusion Sampling	Polar Organic Chemical Integrative Sampler	Stormwater Samples
benzoylecgonine, buprenorphine, desmethylsertraline, diclofenac, duloxetine, erythromycin, fluoxetine, ketamine, methylphenidate, norfluoxetine, promethazine, sucralose, sulfamethoxazole				
Atrazine, diclofop-methyl, azoxystrobin, indoxacarb, thiophanate-methyl, bifenthrin, chlorothalonil, iprodione, oxadiazon, prodiamine, mancozeb, forasmsulfuron, trifloxysulfuron	No	No	No	Yes
17-a-estradiol, 17-a-ethynylestradiol, 17-b-estradiol, diethylstilbestrol, epitestosterone, estriol, estrone, progesterone, testosterone, bisphenol A, diclofenac, gemfibrozil, ibuprofen, ioperamide, naproxen, salicylic acid, triclosan, acetaminophen, amoxicillin, atenolol, atorvastatin, azithromycin, caffeine, carbamazepine, ciprofloxacin, cotinine, diethyl-*meta*-toluamide (DEET), diazepam, fluoxetine, galaxolide (HHCB), meprobamate, methadone, oxybenzone, phenytoin (Dilantin), praziquantel, primidone, quinoline, sucralose, sulfamethoxazole, tris(2-carboxyethyl)phosphine (TCEP), tris (chloroisopropyl) phosphate (TCPP), tris(1,3-dichloroisopropyl) phosphate (TDCPP), trimethoprim	No	No	Yes	No

Sampling activities were minimally affected by weather conditions in the area. Significant rainfall occurred during the first half of 2017. On February 14, 2017, the New Braunfels area received approximately 1.11 inches of rain, and the EAA was able to safely obtain stormwater samples from the Comal River. Rainfall was sparse from July 2017 through the middle of August 2017. On August 25, 2017, Hurricane Harvey made landfall along the Texas Coast as a Category 4 storm. Rain and wind from Harvey impacted both the New Braunfels and San Marcos areas. From August 26, 2017, through August 28, 2017, the New Braunfels area received approximately 6.86 inches of rain and the San Marcos area received approximately 8.93 inches of rain.

Summary of 2017 Results

EAA collected passive diffusion samples, polar organic chemical integrative samples (POCIS), and tissue samples from the Comal and San Marcos spring systems. EAA also collected stormwater samples from the Comal system. In odd numbered years, stormwater samples are not collected for San Marcos Springs.

Stormwater samples were analyzed for Integrated Pest Management Plan (IPMP) compounds. 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.

Stormwater Samples

Stormwater samples from the Comal Spring system included one upstream of Landa Park Golf Course (HCS 210) and one adjacent to and downstream of most of the golf course (HCS 260). EAA collected five samples from each sample location during a storm event. Three samples were collected on the rising limb of the storm hydrograph, one sample collected at the peak, and one sample collected at the tail end. Oxadiazon, an herbicide, was detected in three samples collected from the downstream sample location during the rising limb of the storm hydrograph. The measured concentrations of oxadiazon were below the chronic drinking water level of comparison of 0.49 µg/L (Environmental Protection Agency [EPA] 2004). The oxadiazon concentrations were also below the toxicological endpoints for freshwater fish, freshwater invertebrates, estuarine fish, estuarine invertebrates, birds, and mammals (EPA 2004).

Passive Diffusion Samples

Passive diffusion samples detected tetrachloroethene in all samples analyzed, except for samples from HSM 410. TPH were detected in approximately half of the samples analyzed. A few other constituents such as 1,2,4,-timethylbenzene, 1,3,5-trimethylbenzene, BTEX, chloroform, o-xylene, p/m-xylene, and undecane were also detected in some samples. TCEQ has established acute and chronic surface water benchmarks for freshwater aquatic life and for human consumption of water and fish (30 Texas Administrative Code (TAC) § 307.6). None of the concentrations of detected constituents exceeded TCEQ surface water benchmarks for aquatic life or standards for human consumption.

Polar Organic Chemical Integrative Samplers

POCIS were deployed at HCS 460 and HSM 470 six times throughout 2017. Of the 43 pharmaceuticals and personal care products (PPCPs) compounds analyzed, 14 were detected. No suitable regulatory standards are available to compare to POCIS results. However, the data are used as a qualitative tool for evaluating the presence of trace concentrations of PPCPs.

Tissue Sampling

The tissue sampling effort is done as a part of the Biological Monitoring Program (BioMP). No suitable regulatory standards are available for comparison to tissue, plasma, and surface water PPCP results. However, the data are used as a qualitative tool for evaluating the presence of trace concentrations of PPCPs.

The final *2017 Expanded Water Quality Monitoring Report*, including water quality analysis reports, is included in **Appendix C1**.

The GBRA's Clean Rivers Program (CRP) monitor water quality in both the Comal and San Marcos systems based on TCEQ parameter requirements. Prior to 2017 the EAHCP collected this data as well. As an outcome of the Water Quality Monitoring Work Group the Water Quality Monitoring Program dropped this monitoring in order to minimize duplicated efforts. Collaboration between GBRA and EAHCP has

continued making this data available for analysis. The data collected by the CRP can be found in **Appendix C2**.

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 standard units (SU);
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 C3** of this Annual Report.

Proposed Activities for 2018:

In 2018, the EAA will continue the expanded Water Quality Monitoring Program (WQP) consistent with the requirements outlined in the EAHCP. An overview of the WQP 2018 Scope of Work is provided in **Table 3.1-9**.

Table 3.1-9. Overview of 2018 Water Quality Monitoring Program Scope of Work

Sampling Method	Frequency
Sediment	• Biennially in even years for both systems • Analyze full suite of compounds, as done in years 2013 – 2016
Real-time Monitoring	Add one monitoring station in Comal system
Stormwater	• Reduced to one sampling event per year • Test only for IPMP chemicals at Comal Springs in odd years, as done in 2017 o Only at sites HCS 210* and 260 • Test full suite of analytes in even years from both systems as done in years 2013 – 2016 • Add two samples to the rising limb of the hydrograph for a total of five samples per location o Priority given to locations at tributary outflows
Passive Diffusion Samplers	Currently conducted in both systems
Polar Organic Chemical Integrative Sampler	• PPCP membrane o Only at sites HCS 460 and HSM 470 o Left in place for 30-day periods, six times during the year
Tissue Sampling	One sample in odd years from both systems, as done in 2017

* For an explanation of the sampling location codes referenced in this table (e.g. HSM 470), please refer to the following:

- HSM = San Marcos; and HCS = Comal
- The number following the abbreviation is either 1, 2 or 3 to indicate whether location is:
  - 1 = surface water sampling
  - 2 = stormwater sampling
  - 3 = sediment sampling
  - 4 = passive diffusion sampling

The last two digits correspond to a specific sample location

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 EcoModel development (EAHCP §6.3.3). The BioMP includes: (1) comprehensive sampling, (2) any triggered CPMP sampling, (3) any high flow triggered monitoring, (4) any EAHCP-specific sampling required by Section 6.4 of the EAHCP.

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.

2017 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
    a) Texas wild-rice full-system mapping—annually (San Marcos only)
    b) Full system aquatic vegetation mapping—once every five years (will not be performed until 2018);
2) Select longitudinal locations
    a) Temperature monitoring—thermistors
    b) Water quality sampling—during CPMP sampling
    c) Fixed-station photography
    d) Discharge measurements (Comal system only);
3) Reach Sampling (four reaches)
    a) Aquatic vegetation mapping
    b) Fountain darter drop netting
    c) Fountain darter presence/absence dip netting
    d) Macroinvertebrate community sampling (San Marcos);
4) Springs Sampling
    a) Endangered Comal invertebrate sampling
    b) Comal Springs salamander sampling
    c) San Marcos salamander sampling;
5) River Section/Segment Sampling
    a) Fountain darter timed dip net surveys
    b) Macroinvertebrate community sampling (Comal system)
    c) Fish community sampling;
6) Critical Period (High-flow) Sampling
    a) Both systems.

In 2017, the EAA continued BioMP sampling pursuant to Section 6.3.1 of the EAHCP, with the following modifications:

1) Replacement of 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 assumed the responsibility of conducting the flow-partitioning within Landa Lake;

3) During “Water Quality Grab Sampling,” the method detection limit for soluble reactive phosphorus was reduced from 50 µg/L to at least 5 µg/L.

The 2017 Biological Monitoring Reports for both the Comal and San Marcos systems are included in **Appendix F** and **Appendix G**, respectively.

Proposed Activities for 2018:

In 2018, the BioMP will continue as in 2017 with the exception of full system vegetation mapping, which occurs every five years. The last full system vegetation mapping occurred in 2013. Additionally, as stated in the text, fish tissue analysis was an effort of the BioMP and will not be occurring in 2018.

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. As discussed below, the EAHCP obligations to reduce uncertainty in the MODFLOW model and develop a new finite-element model by December 31, 2014 have been met.

2017 Compliance Actions:

MODFLOW Model

Significant additional progress was made with the MODFLOW model in 2017. After completing the updates and recalibrating the model for the period of 2001 – 2011 in the preceding years, a model verification test was conducted by running the model forward using pumping and recharge inputs for the years 2012 through 2015, and comparing the computed water levels and spring flows to observations. The model performed reasonably well at matching observations for the period for which it was not calibrated. This verification test addresses one of the recommendations made by the SRP/NAS.

After completing several parameter sensitivity and uncertainty analyses with the MODFLOW model, an updated drought-of-record (DOR) scenario was developed. This DOR scenario was used to repeat the “bottom-up” analysis cited in the EAHCP to demonstrate the effectiveness of the four "springflow protection” Conservation Measures. Repeating this analysis with the updated and recalibrated MODFLOW model showed results that were very similar to the original analysis and indicated that the EAHCP Conservation Measures as modeled, appear likely to be successful in maintaining the desired minimum spring flows at Comal and San Marcos springs of 30 cfs and 45 cfs daily average not to exceed six months in duration, respectively, during a repeat of the DOR. The updated model resulted in a minimum daily

average flow at Comal Springs of 29.7 cfs, compared to 27 cfs computed with the original model, and 48 cfs at San Marcos Springs compared to 51 cfs computed with the original model.

A final model report titled, "Updates to the MODFLOW Groundwater Model of the San Antonio Segment of the Edwards Aquifer" was published in November 2017. Prior to publication of the final report, a Groundwater Model Advisory Panel (GMAP) was convened to provide peer review of the methods and results of the updated model. This final report documents all the updates made to the original 2004 version of the model, the recalibration process, the verification analysis, development of the DOR scenario, and the GMAP peer review process.

Finite-Element Model

The EAA contracted with Southwest Research Institute in 2017 to use the finite-element model to evaluate different conceptualizations of hydrogeologic structure in the Uvalde Pool and Knippa Gap area. This work was ongoing at the time this report was prepared, so the results are not yet available. The model was also updated with pumping and precipitation inputs for years 2012 through 2015.

Proposed Activities for 2018:

A main focus of 2018 groundwater modeling activities will be use of the MODFLOW model to support any proposed changes to Conservation Measures under the AMP. The EAA has also contracted with the U.S. Geological Survey (USGS) to conduct a comprehensive uncertainty analysis with the MODFLOW model. This analysis will address a recommendation by the SRP/NAS. The EAA modeling team will continue to make updates and refinements to the model as appropriate when new data or conceptual interpretations become available.

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 Permittees develop alternative approaches or possible mitigation strategies, if necessary.

2017 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. 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 submerged aquatic vegetation (SAV) component was successfully linked to the fountain darter component to comprise the "coupled" model.

The developed, calibrated and operational fountain darter model completed the technical portion of this contract effort at the end of 2016. The draft and final documentation, as well as on-site training activities were performed in early 2017, completing the contract. The final report can be found in **Appendix K9.**

Proposed Activities for 2018:

In 2017, the EcoModel requirements in the EAHCP have been satisfied. EAHCP staff will maintain the EcoModel and use as needed in 2018 and beyond but no additional development is necessary.

3.1.10 Impervious Cover and Water Quality Protection (EAHCP §6.3.3)

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.

2017 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 Edwards 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 2018:

The EAA is continues to be available to serve as a resource for any local government that concludes future regulatory action is necessary. Additionally, the EAA will continue to enforce its coal tar rules in Section 713.703 of the EAA Rules.

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 EAHCP, including the duties and responsibilities of the other ITP Permittees, in accordance with the ITP, IA, 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 – Threatened and Endangered Species."

2017 Compliance Actions:

In 2017, the EAHCP staff team included the Program Manager (or Executive Director), Director, Chief Science Officer (an EAA-funded position), Senior HCP Program Coordinator, Senior Contract Coordinator, Senior Project Coordinator (an EAA-funded position), two HCP Program Coordinators, and Administrative Assistant II positions. No changes were made to team structure in 2017. See **Figure 3.1-1** for the 2017 EAHCP staff organizational chart.

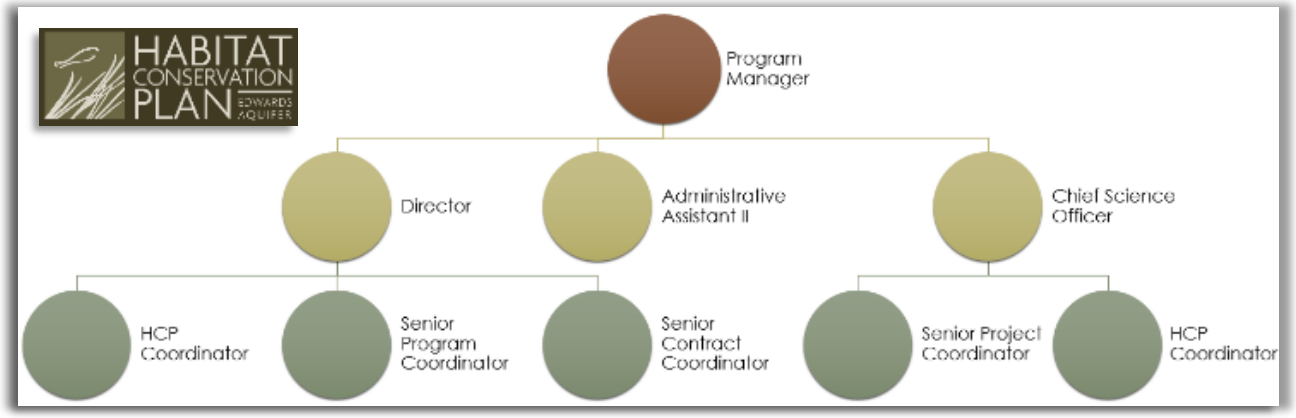

Figure 3.1-1. EAHCP 2017 staff organizational chart.

Selected Program Management activities completed in 2017 are listed below:

1) EAHCP staff facilitated the budgeting process and financial duties as assigned by the FMA. Staff tracked the budget throughout 2017, providing monthly updates to the IC and as needed to the EAA Board of Directors and the Finance Committee. EAHCP staff implemented the Interlocal Funding Contracts for timely reimbursements of CONB, COSM, and Texas State invoices and included procuring, managing, and tracking more than twelve contracts.

2) EAHCP staff coordinated the 2018 budget preparation process, including the timely approval of: 1) 2018 Work Plans from all Permittees; 2) 2018 Program Funding Applications from EAA, CONB, COSM, and Texas State; and 3) additionally, EAHCP staff assisted other EAA staff with processing the 2018 Funding Applications and all other necessary budget items with the EAA Board of Directors.

3) During 2017, EAHCP staff successfully facilitated eight IC meetings, four SC meetings, three SH meetings, one joint Committee meeting, two joint Stakeholder and Science Committees workshops, and a three-day meeting for the SRP/NAS. Additionally, EAHCP staff facilitated and executed the development of four Work Groups, including:

    a) The Research Work Group: The Program Manager and the IC jointly determined to create an SC Work Group (Research Work Group) comprised of members from the SC to suggest specific Applied Research projects to be conducted during 2018 and 2019 as part of the Applied Research Program, and to suggest refinements to the methodology proposed for Refugia research projects. The Work Group met once on March 22, 2017 and produced a report with

recommendations for potential future research topics for the Refugia and Applied Research programs that serve as guidelines for these programs. This report is included in **Appendix I6**.

b) The Budget Work Group: At its meeting on February 16, 2017, the IC created the Budget Work Group to collaborate with and inform the EAA budget process and to address fiscal issues as they arise and are referred by the Implementing Committee. This Work Group shall exist for the duration of the ITP. In its report, the Work Group found that the EAHCP budget picture is positive and its trend looks good, supported a general goal of a stable AMF with reasonable flexibility, and a reserve that does not fall below $26.4 million. The IC adopted this report at its meeting on August 17, 2017. This report is included in **Appendix I2**.

c) The NASWG2: At its meeting on January 19, 2017, the IC created the NASWG2 to provide the Program Manager with advice concerning the development of an implementation plan for the NAS *Report 2*. The IC adopted the *Report 2 Implementation Plan* at its meeting on August 17, 2017. The *Report 2 Implementation Plan* and Implementation Plan Matrix are included in **Appendix I3**.

d) The San Marcos Water Quality Protection Work Group: At its meeting on March 8, 2017, the SC created the San Marcos Water Quality Protection Work Group to provide input on the selection of water quality protection projects identified in the *Water Quality Protection Plan for the City of San Marcos and Texas State University* for implementation to fulfill both the objectives of the COSM's "Impervious Cover/Water Quality Protection" Conservation Measure and the COSM's and Texas State's "Sediment Removal" Conservation Measures. The SC endorsed the recommendations of the Work Group through the AMP for the Sediment Removal and Impervious Cover/Water Quality Protection AMP proposal.

4) In 2017, EAHCP staff continued to photograph the progress of the restoration activities in the San Marcos and Comal springs systems.

5) To facilitate communication and coordination among the Permittees in 2017, 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 continued to hold similar dialogues with the CONB on an as-needed basis. Also, the EAHCP staff had regular communications 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 Chief Science Officer and the Chair and Vice-chair of the SC, held routine meetings in preparation for upcoming committee meetings.

6) For better program transparency, the EAA maintained its contract with a local public relations firm to design and publish a bi-monthly newsletter for the EAHCP, the *EAHCP Steward*. In 2017, the EAA published six regular *EAHCP Steward* newsletters. The newsletter articles covered a variety of subjects that included stories on the following topics: "Promoting Progress – Data Shows Programs Paying Dividends for the Edwards System", "Annual Report – Ready for Release", "NAS Report 2 – National Academy of Sciences Seeing Progress in EAHCP", "Slowing Sediment – EAHCP Adapting to New Ways to Protect the San Marcos River from Sediment Overload", and

"Gone Fishin'- Removing Non-native Animal Species from Landa Lake helps EAHCP Meet Its Goals".

The *EAHCP Steward* newsletter was distributed to about 400 committee members, partners, elected officials, and interested citizens. An issue of the 2017 *EAHCP Steward* newsletter is included in **Appendix K10**. Plans are to continue with six bi-monthly newsletters for 2018.

7) Additionally, the EAA also continued to publish monthly newsletters for the SAWS ASR leasing program. The *ASR Forum* is a newsletter as part of the EAHCP Program for Edwards Aquifer permit holders. In 2017, articles included stories on public outreach events, ASR benefits to SAWS and the EAHCP, and potential changes to the program through the AMP.
8) For additional outreach efforts in 2017, EAHCP staff gave multiple presentations to describe in detail the current implementation of EAHCP Conservation Measures, as well as to educate students, teachers and others on the fundamental background of the EAHCP. Presentations included the following organizations and events:
   a) Texas State
   b) University of Texas at Austin
   c) UTSA
   d) University of the Incarnate Word
   e) Texas A&M AgriLife
   f) Baylor University
   g) Various middle and high schools
   h) GBRA Clean Rivers Program
   i) Leadership Organization of Professionals with Recreational Equipment Inc.
   j) SAWS Planning Department
   k) Dos Rios Watershed Clean-up
   l) National Habitat Conservation Plan Coalition USFWS
   m) 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 maintained to assist EAHCP staff and Permittees in identifying additional permits needed.

Staff received technical assistance from two consulting firms in developing permit applications for various State and Federal agencies that included the TPWD, TCEQ, Texas Historical Commission (THC) and the U.S. Army Corps of Engineers (USACE). In 2017, EAHCP staff assisted COSM, Texas State, and CONB

in completing and submitting all permit applications and coordination letters appropriate for full compliance. Projects in 2017 included the permanent access point repair work in the San Marcos River and installing back-up culverts for Flow-split management of the Comal River's Old Channel. Additionally, following AMP changes to the COSM Sediment Removal and Impervious Cover/Water Quality Protection requirements, a planning process was begun to review all permitting needs for natural streambed work in Sessom Creek. This preliminary stage will continue throughout 2018.

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 2017, the Program Manager submitted two amendment requests following the approval of Adaptive Management Proposals from the IC, SH, and SC. The Program Manager did not submit any such requests to the IA, FMA, or ITP. A summary discussion of the amendments is as follows:

1) Amendment to Minimizing Impacts of Contaminated Runoff Conservation Measure
   This amendment pertained to the requirements for two specific sedimentation ponds to be constructed along the San Marcos River to reduce contaminated runoff from being deposited into the river, and to slow the velocity of stormwater to reduce bank erosion. The first pond required by the EAHCP was to have been located in Veramendi Park, beside Hopkins Street bridge ("Veramendi Pond"); and the second was to have been located alongside Hopkins Street to consist of widened extant drainage ditches running parallel to either side of Hopkins ("Hopkins Pond"). Through the COSM/Texas State WQPP, which evaluated and prioritized several best management practices (BMP) including two alternative ponds that would provide increased water quality protection benefits relative to the Veramendi and Hopkins Ponds. The first of these is a pre-existing, non-functioning, sedimentation pond ("Downtown Pond") drainage system upgrade, located on COSM property at the corner of N. C.M. Allen Parkway and E. Hutchison Street. The second is to design and construct a currently inoperable sedimentation pond ("City Park Pond") located on COSM property in City Park, adjacent to the San Marcos Recreation Hall parking lot.

   Appendix A4 includes this amendment request letter, and **Appendix A5** includes the response letter from the USFWS.

2) Amendment to the COSM and Texas State Sediment Removal Conservation Measures as well as the Impervious Cover/Water Quality Protection Measure
   These amendments pertained to requested modifications to focus Sediment Removal in the San Marcos system to be preventative, rather than reactive. Hydro-suction and mechanical removal of sediment will be the methods to target specific stands of Texas wild-rice or other fountain darter habitat. Additionally, the original intent of the Impervious Cover/Water Quality Protection measure was to develop an incentive program for private landowners to develop low-impact development (LID) BMPs. This method of implementing BMPs has proven ineffective, thus both the COSM and CONB have invested in developing WQPPs. In each WQPP, possible non-point source pollutant issues have been identified throughout both watersheds and plans were developed to identify public

property that could benefit from the development of stormwater BMPs. The amendment provides explicit direction to develop plans and prioritize BMPs proposed in both WQPPs to protect water quality in both systems and to prevent sediment runoff.

Appendix A6 includes this amendment request letter, and **Appendix A7** includes the response letter from the USFWS.

3.1.12 Challenges Observed and Identified Solutions

Edwards Aquifer Authority

For the EAA, 2017 was a year to reflect upon past successes and consider ways to fulfill its obligations for the SAWS ASR leasing program 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 SAWS ASR could be filled sooner than anticipated in the modeled repeat of the DOR and the required water to offset SAWS forbearance could be 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 DOR conditions, adding greater certainty to the assurance of maintaining continuous minimum springflows.

Securing Full Participation in the ASR Program

As of late 2017, the EAA utilized its revised groundwater model to run alternative scenarios that attempted to make alterations to the original SAWS ASR leasing structure. At the December 2017 joint IC, SC and SH committee meeting, EAA staff presented the ASR Optimization Program. Through the early part of 2018, the EAHCP committees will discuss and comment on the proposed changes to the ASR program through the AMP.

EAHCP Program Management

For 2017, the EAHCP Program Management staff observed the following challenges: evaluating necessary changes to the Sediment Removal, Impervious Cover/Water Quality Protection, and Minimizing Impacts of Contaminated Runoff and initiating an AMP through the EAHCP Committees; reviewing and processing recommendations provided by NAS *Report 2*; and establishing a comprehensive annual Work Plan approach to minimize the uncertainty of established annual goals for each of the partners' designated Conservation Measures.

Adaptive Management Process

Minimizing impacts of contaminated runoff in San Marcos is an important aspect of maintaining water quality in the springs ecosystems. The EAHCP required two specific sedimentation ponds to be constructed along the river to reduce contaminated runoff from being deposited into the river, and to slow the velocity of stormwater to reduce bank erosion. During the implementation of the COSM Impervious Cover/Water Quality Protection measure, COSM developed a WQPP that evaluated and prioritized several BMPs. It was

during this time staff determined that two alternative ponds would provide increased water quality protection benefits relative to the current provisions in the EAHCP. Considerable research and technical analysis was completed that EAHCP staff coordinated throughout the first part of 2017. In March, the EAHCP committees completed their review of the AMP Proposal and approved the submission of an official amendment letter to USFWS.

Sediment Removal & Impervious Cover/Water Quality Protection are two complementary measures required by the EAHCP. The COSM and Texas State are required to not only implement specific water quality protection measures, like the CONB, but are required to also remove sediment that had been deposited from the watershed to assist in the establishment of Texas wild-rice stands. Both the COSM and CONB had developed a WQPP to identify BMPs that would most effectively limit contamination into the San Marcos and Comal rivers. It was identified by staff that the specific requirements for Impervious Cover/Water Quality Protection for both the COSM and CONB in the EAHCP stated working towards an incentive program with private landowners. This strategy was proving to be less successful than originally anticipated, thus both partners pursued development of a WQPP. For both the COSM and CONB making the appropriate amendments regarding this focus shift seemed prudent.

Furthermore, the WQPP for San Marcos identified Sessom Creek as a priority watershed for its erosive streambed, as well as its confluence's proximity to critical habitat in the San Marcos River. In 2016, the COSM and Texas State provided staff information regarding their sediment removal efforts, communicating that mitigation of sediment deposition through retroactive approaches proved expensive and ineffective. In 2017, EAHCP staff, in partnership with the COSM and Texas State, developed a strategy to redirect efforts from a reactive to a proactive sediment management strategy.

In preparation for the AMP Proposal, EAHCP staff and COSM representatives called upon the SC to identify a subcommittee that consisted of individuals experienced in watershed improvement projects and the local variables found in Sessom Creek and the Upper San Marcos River Watershed. Thus, the San Marcos Water Quality Protection Work Group was called upon to provide input concerning the selection of a subset of projects identified in the WQPP for the COSM and Texas State for implementation. This provided the rationale for replacing the requirements for sediment removal while simultaneously satisfying the intent of the Impervious Cover/Water Quality Protection measure.

Implementing SRP/NAS Recommendations

As was done in 2016 for the first report from the NAS, EAHCP staff received NAS *Report 2* outlining a series of recommendations that could help in the EAHCP's implementations success. The second report focused primarily on the methodologies used in implementing various Conservation Measures in the springs ecosystems. NAS *Report 2* was first analyzed in a public workshop for comprehensive feedback from the public and all EAHCP Stakeholders, then staff compiled the information to provide a robust Implementation Plan. A draft *Report 2 Implementation Plan* was presented to the NASWG2. This Work Group was made up of representatives from the various Partners' respective entities or affiliates and met twice specifically to provide feedback regarding the Implementation Plan. The final *Report 2 Implementation Plan* from the NASWG2 was presented and approved by the IC in August.

EAHCP Annual Work Plan Process

Due, in part, to the complexity of implementation of many of the EAHCP's Conservation Measures, the Partners responsible for producing the annual Work Plans and Funding Applications often describe their projected work in generic terms. This result is expected because of how early in the year such planning documents are submitted for approval. Unfortunately, vague planning documents provide EAHCP staff with little comprehensive information regarding priorities, methodologies, and process for any given year's implementation strategy. Not all Conservation Measures require significant detail due to their maintenance approach, but some measures consist of complex methodological aspects and require a systematic approach to successful implementation. In addition, EAHCP staff must substantiate work completed through an internal accounting process, which requires performance to be adequately communicated in the entities' work plans, or else would require formal amendments through the EAHCP committees.

The staff worked in partnership with the COSM, Texas State, CONB and EAA to include additional details associated with work expected to be performed in 2018. It is expected that such detail may require revisions in the future, yet such a process improves overall transparency and provides staff the adequate details to substantiate reimbursements to its Partners.

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 structures 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 revised in 2016 as part of the EAHCP AMP that was approved by USFWS in October 2016. The revised Table 5-3 is re-stated in this Annual Report as **Table 3.2-1.** below.

2017 Compliance Actions:

CONB staff routinely monitored streamflow conditions in the Comal River system based on local USGS streamflow gaging stations. Based on this routine monitoring, CONB staff adjusted the flow-control gate between Landa Lake and the Old Channel of the Comal River to meet streamflow targets specified in **Table 3.2-1.**

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+	65		60	280+		290+
300	65		60	235		240
250	60		55	190		195
200	60		55	140		145
150		55			95	
100		50			50	
80		45			35	
70		40			30	
60		35-40			25	
50		35-40			15	
40		30			10	
30		20			10	

The CONB installed two flow-control gates on the existing 14-inch culverts per design plans completed in 2016. The new flow control gates will serve as a back-up to the primary flow control gate on the adjacent 48-inch culvert. The CONB also installed floating vegetation booms in front of the 48-inch and 14-inch culverts that minimize the collection of floating vegetation and prevent restrictions in flow caused by the accumulation of vegetative material and debris on the culvert intake screens (**Figure 3.2-1**).

Figure 3.2-1. Back-up flow control gates and booms (left photo), and flow issuing into Old Channel from Landa Lake via new back-up flow controls gates and 14" culverts (right photo).

Proposed Activities for 2018:

The CONB will continue to monitor flow rates in the Old and New Channels of the Comal River and will operate the flow-control gates conjunctively to meet objectives specified in **Table 3.2-1**.

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.

2017 Compliance Actions:

Aquatic vegetation restoration activities in 2017 occurred within Landa Lake (including the Upper Spring Run area) and the Old Channel of the Comal River (**Figure 3.2-2**). Aquatic vegetation restoration activities conducted in 2017 include 1) removal of non-native aquatic vegetation (i.e. *Hygrophila*), 2) planting of native aquatic plants, and 3) monitoring, mapping, and gardening of restored areas.

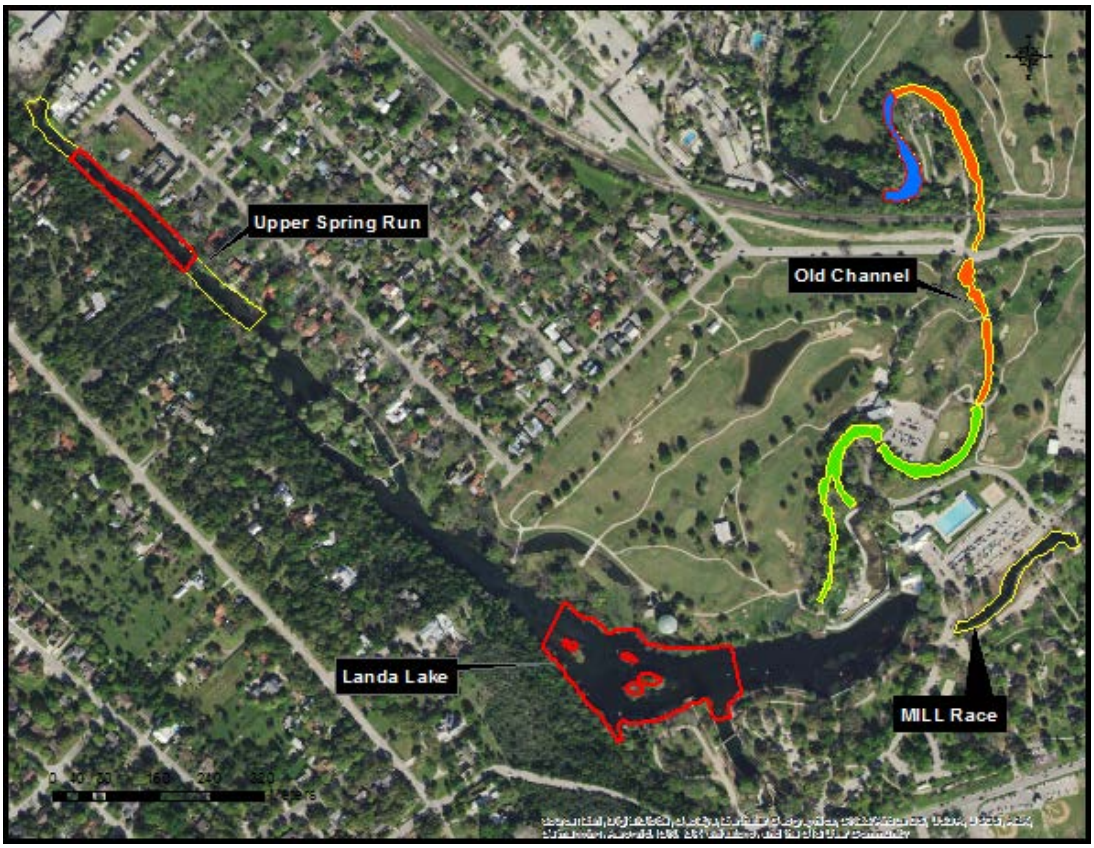

Figure 3.2-2. LTBG reaches and restoration reaches within the Comal River system.

Figure 3.2-2 indicates the location of the Landa Lake, Upper Spring Run and Old Channel LTBG Reaches (outlined in red). Yellow outlines the established restoration reaches.

The EAHCP Nonroutine AMP related to the SAV that occurred in 2016 resulted in the development of a timeline that includes specific annual coverage goals for individual restoration reaches to be met annually through 2027. This year (2017) was the first year of enactment of efforts to meet the annual aquatic vegetation coverage goals**.**

In the following Results and Discussion sections for the Old Channel and Landa Lake, tables are included that compare the 2017 restoration goals to actual increases in target aquatic vegetation coverage. Annual restoration goals were not scheduled in 2017 for the New Channel LTBG Reach, Upper Spring Run LTGB Reach, Landa Lake Upper Restoration Reach, and Landa Lake Lower Restoration Reach. Thus, no work was performed in these reaches.

Old Channel Restoration Results & Discussion

In 2017, 1,433 square meters (m^2) of native vegetation was planted in ten restoration plots in the Old Channel LTBG and Restoration reaches (**Figure 3.2-3**), bringing the cumulative, five-year total area planted in the Old Channel to 4,814 m^2. A total of 6,073 plants were installed in 2017 within the Old Channel Restoration Reach and LTBG Reach combined (**Table 3.2-2**). **Figure 3.2-4** illustrates *Ludwigia*

that was planted in plot 2017A in early 2017. Most of these were planted within new plots except for 650 *Cabomba* plants that were planted in the previously established Plots C and D, which are located immediately downstream of the Golf Course Road bridge, as supplemental plantings.

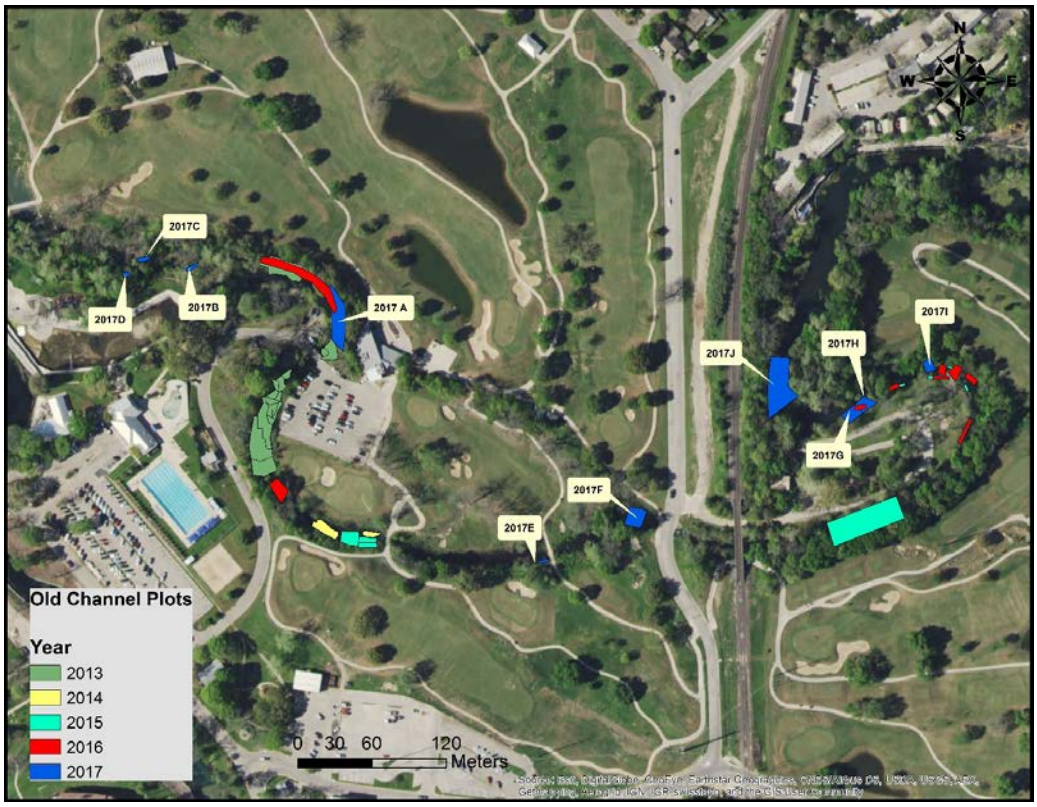

Figure 3.2-3. Aquatic vegetation restoration plots in the Old Channel Restoration and LTBG reaches.

Table 3.2-2. Number of Native Plants Planted Within the Old Channel LTBG Reach and Restoration Reach, by Plot, in 2017

2017 Old Channel Restoration Plantings					
Old Channel LTBG Reach					
Date Planted	**Plot**	**Plot size (m^2)**	***Ludwigia***	***Sagittaria***	***Cabomba***
7/18/17	2017G	99			700
7/18/17	2017H	93	510		
7/19/17	2017I	59	120		
8/9 – 8/11/17	2017J	579		1,200	
8/15/17	2017G	-			300
10/13/17	2017J	-		163	
TOTALS		**830**	**630**	**1,363**	**1,000**
Old Channel Restoration Reach					
1/12/17	2017A	370	50		
2/9/17	C&D	-			650
2/15 – 2/23/17	2017A	-	675		700
2/17/17	2017B	23	25		
3/27/17	2017A	-	600		
4/10/17	2017E	14	40		

Table 3.2-2. Number of Native Plants Planted Within the Old Channel LTBG Reach and Restoration Reach, by Plot, in 2017

2017 Old Channel Restoration Plantings					
4/10/17	2017C	26	20		
4/10/17	2017D	14	20		
5/25/17	2017F	156	100		
5/28/17	2017F	-	200		
TOTALS		**603**	**1,730**		**1,350**

Figure 3.2-4. Photo taken in April 2017 of *Ludwigia* planted in Plot 2017A within the Old Channel Restoration Reach in early 2017.

Table 3.2-3 shows seasonal cover, in m^2, of the target species for this Restoration Reach as well as the LTBG Reach. Most all native species showed an increase in aerial coverage in both the LTBG and Restoration reaches with this result being a combination of restorative plantings and natural expansion. In the LTBG Reach, most of the increase in native plant cover is a direct result of this year's plantings, which were able to be carried out after thorough and successful removal of *Hygrophila*.

Table 3.2-3. Seasonal Cover (m^2) per Vegetation Type in Old Channel, October 2016 – October 2017

Species	October 2016	January 2017	April 2017	October 2017
Old Channel LTBG Reach				
Ludwigia	35	14	10	106
Sagittaria	0	0	0	45
Cabomba	0	0	0	72

Table 3.2-3. Seasonal Cover (m^2) per Vegetation Type in Old Channel, October 2016 – October 2017

Species	October 2016	January 2017	April 2017	October 2017
Hygrophila	503	818	962	589
Bryophyte	250	114	58	107
Old Channel Restoration Reach				
Ludwigia	594	574	713	772
Sagittaria	284	362	355	401
Cabomba	186	60	94	118
Potamogeton	N/A	267	354	474
Vallisneria	715	770	800	938
Hygrophila	204	481	464	0
Bryophyte	478	503	456	561

Following preparations for planting in the Old Channel LTBG Reach (i.e. *Hygrophila* removal), four new restoration plots were established, and three target species were planted; *Ludwigia*, which had been planted previously in the reach; and *Sagittaria* and *Cabomba*, which had not been previously planted at this locale (**Figure 3.2-5**). For the Old Channel LTBG Reach, the increase in vegetative cover achieved for each target plant species as of October 2017, as well as the 2017 annual goal for that species, is summarized in **Table 3.2-4**.

Figure 3.2-5. Location of new restoration plots in the Old Channel LTBG Reach in 2017.

Table 3.2-4. 2017 Annual Restoration Goals and Increases in Target Aquatic Species Vegetation, Old Channel LTBG

2017 Old Channel LTBG Reach Results				
Plot	Plot Area (m^2)	Ludwigia (m^2)	Cabomba (m^2)	Sagittaria (m^2)
2017G	99		72	
2017H	93	20		
2017I	59	26		
2017J	579			45
2017 – TOTALS	**-**	**46**	**72**	**45**
2017 – GOALS	**-**	**75**	**50**	**150**

Cabomba was the only species to achieve or exceed the specific 2017 coverage goal in the Old Channel LTBG Reach. Conversely, although a total of 152 m^2 of *Ludwigia* was planted, which is well over the 75 m^2 target goal, only 46 m^2 remained as of October mapping. As previously discussed, the Old Channel LTBG Reach is highly variable in growing conditions. Due to the finicky nature of *Cabomba*, this species was given priority over *Ludwigia* planting in 2017 to investigate the level of success possible in the Old Channel LTBG Reach. As such, the prime planting areas with ample sun exposure and silty substrate were planted with *Cabomba*, which ultimately limited *Ludwigia* plantings to the more shaded and rocky, less suitable, portions of the reach. Expectedly, this greatly influenced the expansion rate of *Ludwigia*. While *Sagittaria* fell short of the specific 2017 goal for this reach; it was planted rather late in the season and the coverage number indicated in **Table 3.2-4.** is a result of thin density not the complete absence of plants. Due to its robust and aggressive nature in other locations, it is highly anticipated that *Sagittaria* will vastly expand in this area over the next several months.

Six new restoration plots were planted in the Old Channel Restoration Reach in 2017 (**Figure 3.2-6**). For the Old Channel Restoration Reach, the increase in vegetative cover achieved for each target plant species as of October 2017, as well as the 2017 annual goal for that species, is summarized in **Table 3.2-5.**

Figure 3.2-6. Location of new restoration plots in the Old Channel Restoration Reach, 2017.

Table 3.2-5. 2017 Restoration Goals and Increases in Target Aquatic Vegetation, Old Channel Restoration Reach

2017 Old Channel LTBG Reach Results					
Plot	Plot Area (m^2)	Ludwigia (m^2)	Cabomba (m^2)	Sagittaria (m^2)	Potamogeton (m^2)
2017A	370	156	7		
2017B	23	11			
2017E	14	20			
2017F	156	55			
2017 – TOTALS	**-**	**242**	**7**	**0***	**0****
2017 – GOALS	**-**	**100**	**25**	**75**	**10**

*Based on previous experience, the focus in 2017 was on extensive removal of nonnative *Hygrophila* to prepare locations for *Sagittaria* plantings in 2018.
**Existing *Potamogeton* coverage (474 m^2 as of Oct '17) exceeds the EAHCP Total Goal of 100 m^2.

The majority of *Ludwigia* planted in 2017 within the Old Channel Restoration Reach was planted adjacent to the Old Channel Streambank Stabilization Project, which was completed in late 2016. The removal of dense, overlying invasive riparian vegetation and stabilization of the bank in this area created ample area of suitable planting space to plant target native aquatic plants. Priority plantings of both *Ludwigia* and *Cabomba* were planted into this area (Plot 2017A). *Ludwigia* succeeded in providing the greatest extent of cover, while *Cabomba* expansion was minimal. Based on experience with what it takes for long-term vegetation establishment, the focus during 2017 was to comprehensively remove large amounts of *Hygrophila* regrowth in the lower sections of the Old Channel Restoration Reach. This strategic decision resulted in additional *Sagittaria* not being planted in this reach during 2017. However, with *Hygrophila* permanently removed, specific areas below Elizabeth Street will be dedicated to future *Sagittaria* plantings only. This plan of action will segregate the more aggressive *Sagittaria* from less aggressive *Ludwigia* and *Cabomba* upstream in an effort to isolate and limit competition between these species. *Potamogeton* was also not planted in this reach in 2017. *Potamogeton* has aggressively expanded on its own in the Old Channel Restoration Reach over the course of 2017 more than doubling its cover from 267 m^2 to 474 m^2, which far exceeds the total EAHCP goal of 100 m^2 cover for this species in this reach. *Potamogeton* will not be planted as part of future restoration activities as long as its coverage remains at or above the EAHCP total coverage goal.

Landa Lake Restoration Results

In 2017, 502 m² of area was planted in eight restoration plots in Landa Lake (**Figure 3.2-7**) bringing the five-year total of area planted in the lake to 3,429 m². Additional *Ludwigia* plants were also planted as supplemental plantings in pre-existing plots along the wall near the Landa Park Gazebo. In 2017, a total of 2,860 plants were planted into the Landa Lake LTBG Reach (**Table 3.2-6**). Plantings in Landa Lake included *Ludwigia*, *Cabomba*, *Sagittaria* and *Potamogeton*.

Figure 3.2-7. Map of restoration plots in the Landa Lake LTBG Reach.

Table 3.2-6. Number of Native Plants Planted Within Each Landa Lake Restoration Plot in 2017

2017 Landa Lake Restoration Plantings						
Date Planted	**Plot**	**Plot size (m^2)**	***Ludwigia***	***Sagittaria***	***Cabomba***	***Potamogeton***
2/6/17	C*	-	40			
3/8/17	2017C	207			200	
3/20/17	2017C	-			300	
3/23/17	2017A	73	50			
3/23/17	2017B	30	100			
3/23/17	2017C	-	100			
5/18/17	2017D	107	160			
6/13/17	T*	-	20			
6/14/17	H*	-	100			
6/14/17	Q*	-	100			
6/27/17	2017D	-	50			
6/27/17	2017F	51		100		
6/28/17	2017C	-			200	
6/28/17	2017E		100			
6/29/17	U2*		70			
6/29/17	H*		30			
6/29/17	F*		30			
6/30/17	2017C	-			360	
7/21/17	U3		150			

Table 3.2-6. Number of Native Plants Planted Within Each Landa Lake Restoration Plot in 2017

2017 Landa Lake Restoration Plantings						
Date Planted	**Plot**	**Plot size (m^2)**	***Ludwigia***	***Sagittaria***	***Cabomba***	***Potamogeton***
7/22/17	Q*		50			
8/18/17	2017H	34				250
8/23/17	2017C	-			150	
8/27/17	2017F	-		150		
TOTALS			**1,150**	**250**	**1,210**	**250**

*Planted as supplemental plantings in existing plots.

Table 3.2-7 provides seasonal cover of target aquatic plant species in the Landa Lake Restoration Reach between October 2016 and October 2017. Seasonal cover of target species in this reach remained somewhat variable over the course of the year. Seasonal cover of target species in this reach tended to increase over the course of the year, except for *Ludwigia*, which experienced the highest amount of cover in April and decreased thereafter despite additional 2017 restoration plantings. This is largely due to a natural senescence that has been observed as the top growth of *Ludwigia* plants becomes too dense to be supported by the roots and stem and breaks away leaving smaller individual patches rather than a large continuous stand. *Vallisneria* also decreased from January to October mostly as natural loss in some areas and partly due to removal by the project team to create more planting areas for other native species.

Table 3.2-7. Seasonal Cover (m^2) per Target Vegetation in Landa Lake, October 2016 – October 2017

Species	October 2016	January 2017	April 2017	October 2017
Landa Lake Restoration Reach				
Ludwigia	532	479	512	498
*Sagittaria**	3,130	2,990	3,302	3,227
*Cabomba**	171	115	117	206
Potamogeton	0	0	0	21
*Vallisneria**	14,589	15,592	15,053	15,160
Hygrophila	0	0	0	0
Bryophyte	2,772	2,524	2,459	2,939

*Coverages are a total of naturally occurring and planted *Sagittaria*, *Cabomba,* and *Vallisneria* in Landa Lake.

A total of eight restoration plots were planted in Landa Lake in 2017 (**Figure 3.2-8**). Four restoration plots were planted with *Ludwigia*, two with *Cabomba*, one with *Potamogeton* and one with *Sagittaria*. One *Ludwigia* plot failed to establish while the others established well, but failed to expand significantly or expanded and retracted due to the senescence of the summer foliage. Specific 2017 annual coverage goals for *Potamogeton* and *Cabomba* were achieved while *Ludwigia* coverage fell just short of the annual target despite planting over 200 m^2 of area (**Table 3.2-8**). A large plot of *Cabomba* (2017C) was planted after suitable space was created by removing *Sagittaria* and transplanting it elsewhere. *Cabomba* did exceedingly well at this planting location that boosted *Cabomba* coverage in the Landa Lake LTBG Reach significantly. As expected, *Potamogeton* established well and quickly exceeded its coverage goal for the year.

Although considered target species, *Sagittaria* and *Vallisneria* are dominant species in Landa Lake and current coverages exceed the EAHCP total goals. Therefore, no prioritized plantings of these two species will occur in the future unless coverages dip below the total EAHCP coverage goals. It should be noted that in 2017 one area of *Vallisneria* below the three islands area was replaced with *Sagittaria* translocated from upper sections of Landa Lake. The specific reason for this activity was an aquatic gardening strategy to

improve water flow and limit the formation of summer floating vegetation mats which have been observed to be problematic at this same location for several years as a result of tall and dense *Vallisneria* growth. By replacing taller growing *Vallisneria* with shorter growing *Sagittaria*, the water flow below the three islands area has improved and floating vegetation mats should be less likely to occur in the future.

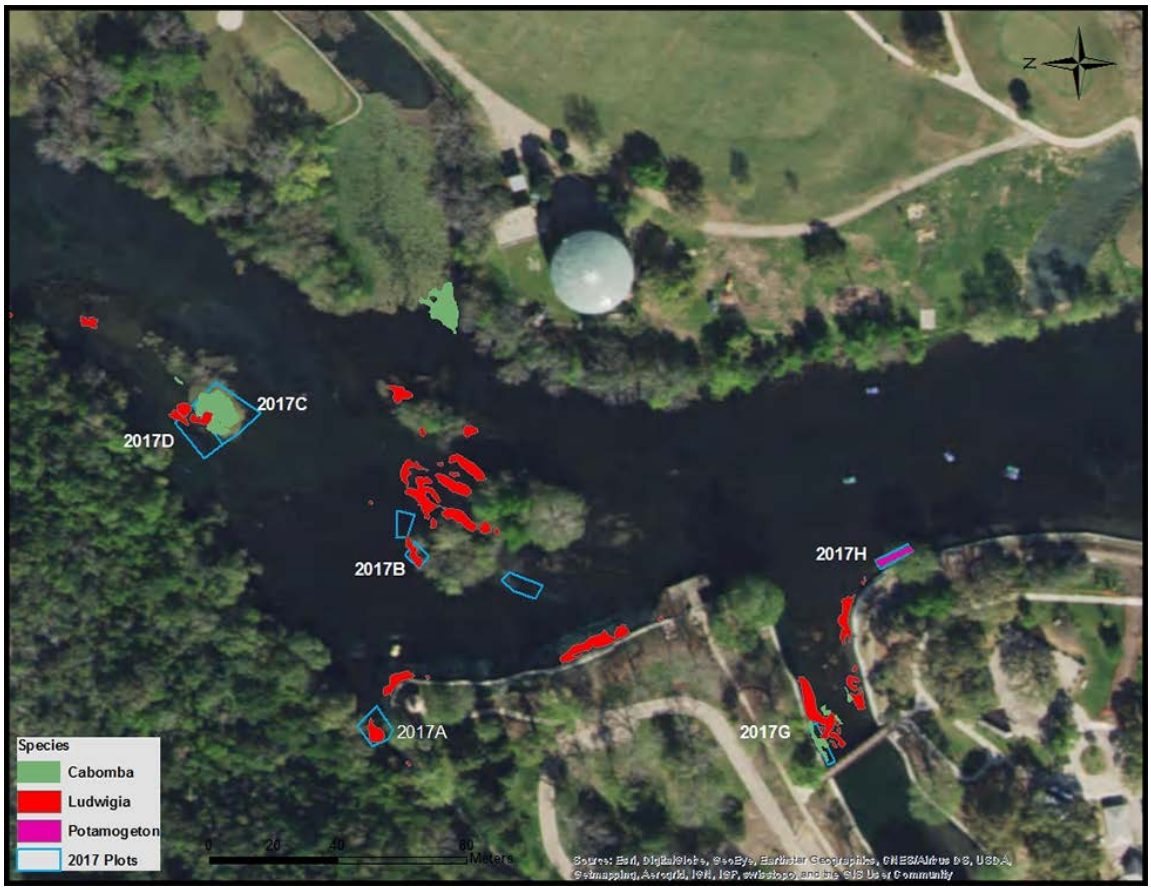

Figure 3.2-8. Location of new restoration plots in the Landa Lake LTBG Reach, 2017.

Table 3.2-8. 2017 Annual Restoration Goals and Increases in Target Aquatic Vegetation Coverage in Landa Lake LTBG Reach, 2017

2017 Landa Lake LTBG Reach Results				
Plot	**Plot Area (m^2)**	**Ludwigia (m^2)**	**Cabomba (m^2)**	**Potamogeton (m^2)**
2017A	73	21		
2017B	30	16		
2017C	207		109	
2017D	107	30		
2017G	36		20	
2017H	33			21
2017 – TOTALS	**-**	**67**	**129**	**21**
2017 – GOALS	**-**	**75**	**50**	**5**

Upper Spring Run Restoration Results

Per the long-term restoration plan schedule, only limited effort was spent in 2017 to plant native plants to the Upper Spring Run LTBG and Restoration reaches. In fact, only two restoration plots were planted in the Upper Spring Run LTBG Reach adding 250 *Cabomba* plants (**Figure 3.2-9**). *Ludwigia* was sprigged into Plot 2016 C as a supplemental planting (**Table 3.2-9**). Although the Upper Spring Run LTBG Reach was not a target reach for 2017, several "test" plantings of *Cabomba* were conducted to get a sense of what to expect for future targeted plantings of this species. Although extensive restoration did not occur in the Upper Spring Run area, seasonal mapping did occur. **Table 3.2-10** provides seasonal cover of target aquatic plant species in the Upper Spring Run LTBG and Restoration reaches between October 2016 and October 2017.

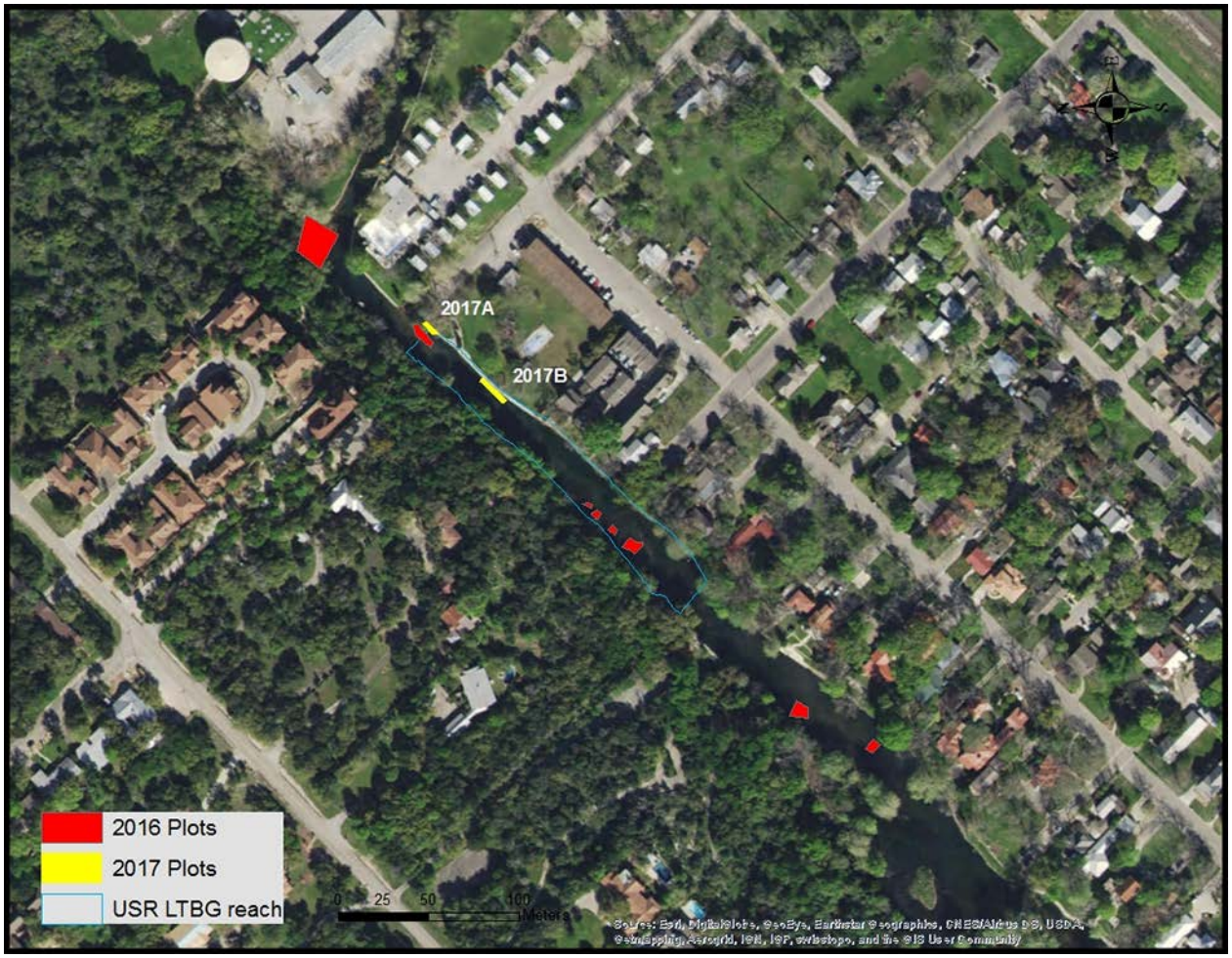

Figure 3.2-9. Map of the Upper Spring Run LTBG Reach and Restoration Reach plots.

Table 3.2-9. Number of Native Plants Planted Within Upper Spring Run LTBG Reach, by Plot, in 2017

2017 Upper Spring Run Plantings			
Upper Spring Run LTBG Reach			
Date Planted	**Plot**	***Ludwigia***	***Cabomba***
3/21/17	2017A		50
3/21/17	2017B		200
5/17/17	2016C	50	
TOTALS		**50**	**250**

Table 3.2-10. Seasonal Cover (m^2) per Target Vegetation Type in Upper Spring Run LTBG and Restoration Reaches, October 2016 – October 2017

Species	October 2017	January 2017	April 2017	October 2017
Upper Spring Run LTBG Reach				
Ludwigia	53	72	45	21
Sagittaria	936	761	982	961
Cabomba	9	5	7	7
Hygrophila	0	0	0	0
Bryophyte	1,536	1,687	1,944	1,070
Upper Spring Run Restoration Reach				
Ludwigia	59	82	110	13
Sagittaria	287	887	1,372	533
Cabomba	57	75	146	214
Hygrophila	0	0	0	0
Bryophyte	987	2,227	2,311	977

Significant decreases in *Ludwigia* coverage in the Upper Spring Run were observed over the course of 2017. Throughout 2017 and in previous years there has been an observance of senescence in *Ludwigia* that tends to occur from summer to fall. A typical growth pattern has been observed where planted *Ludwigia* increases its biomass and expands coverage between spring and summer and then begins to senesce between summer and fall, resulting in patchy *Ludwigia* stands as opposed to robust, continuous stands.

Non-Native Aquatic Vegetation Removal Results (Miscellaneous Reaches)

Table 3.2-11 summarizes the amount of *Hygrophila* removed, by location, from the Comal River system in 2017. Approximately 886 m^2 of *Hygrophila* was removed from the Comal River system in 2017. In 2017, significant effort was put into removing and eliminating *Hygrophila* throughout the Old Channel, especially below the Elizabeth Street bridge through the downstream end of the Old Channel LTBG Reach. Baseline mapping in January 2017 showed that *Hygrophila* had reestablished in the Old Channel immediately above Elizabeth Street and below Elizabeth Street since October 2016. Both areas were previously cleared of *Hygrophila* during the summer of 2016. The Upper Spring Run and the spring-fed swimming pool have remained clear of *Hygrophila* patches since multiple removal events in 2015 and consistent gardening in 2016. Only one small patch of *Hygrophila* appeared in the Upper Spring Run in 2017 and no fragments or patches were found in the spring-fed swimming pool. In Landa Lake, two small patches of *Hygrophila* were noted near the dam, outside of the LTBG Reach. These were quickly eliminated and that area was continually monitored for reemergence.

Table 3.2-11. Amount of *Hygrophila* Removed from Comal River System in 2017

Location/Section	Area of *Hygrophila* Removed (m^2)	Period of Work
Landa Lake (outside of the LL LTBG reach)	7	Feb, Mar
Old Channel Restoration Reach	481	May-July
Old Channel LTBG Reach	373	Feb, March, June-Oct
Spring-fed Pool	0	Gardened as needed
Upper Spring Run LTBG Reach	0	Gardened as needed
Upper Spring Run Restoration Reach	<1	Gardened as needed
Landa Lake Spillway	~25	Monitored continuously
APPROX. AREA REMOVED IN 2017	**~886**	

The area that posed the greatest challenge for *Hygrophila* removal was the Landa Lake spillway, which allows overflow from Landa Lake to pass into the Old Channel uncontrolled. Unfortunately, erosion control matting placed after spillway construction in 2015 has captured the few *Hygrophila* fragments flowing out of Landa Lake. Since the spillway has been flowing continually since 2015, it has provided optimal growing conditions for *Hygrophila*, with several large patches developing in late 2016. This growth is problematic, since fragments from these patches can break off and flow downstream directly into the Old Channel.

A full report regarding aquatic plant restoration activities in the Comal River system is included as **Appendix L1** of this report.

Compliance for this measure is based on total coverage of fountain darter habitat in m^2 specified in Table 4-1 of the EAHCP. 2017 status is shown in **Table 3.2-12**.

Table 3.2-12. Comal LTBG Fountain Darter Habitat (Aquatic Vegetation) Status in m^2

LTGB Reach		Bryophytes	Potamogeton	Ludwigia	Cabomba	Sagittaria	Vallisneria
Upper Spring Run Reach		1,066	0	21	4	956	0
Landa Lake		2,348	18	495	194	3,033	12,597
Old Channel		134	0	84	73	39	0
New Channel	Upper	15	0	33	9	0	0
	Lower	0	0	0	1,665	1	0
TOTALS		**3,563**	**18**	**633**	**1,945**	**4,029**	**12,597**

Proposed Activities for 2018:

In 2018, the CONB will continue a program to increase the coverage of target aquatic vegetation preferred by fountain darters for habitat. Aquatic vegetation restoration efforts in 2018 will occur in the Landa Lake LTBG Reach, the Old Channel LTBG Reach and the Old Channel Restoration Reach. Restoration work in these areas will be conducted to meet the established annual coverage goals for 2018. Aquatic restoration efforts in 2018 will also be completed in the Upper Spring Run and New Channel LTBG reaches in order to increase target aquatic vegetation coverage required to meet established annual restoration goals for these reaches.

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 throughout 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, COSM, EAHCP program staff, and stakeholders.

2017 Compliance Actions:

The CONB continued to enforce City Ordinance Section 142-5, which restricts access to Landa Lake, the Spring Runs (except for the wading pool on Spring Run #2), and portions of the Comal River, including the Old Channel and the "Mill Race" of the New Channel. The CONB Parks and Recreation Department continued to utilize trained park rangers to routinely patrol Landa Park and adjacent areas to prevent access to these water bodies.

Proposed Activities for 2018:

CONB will 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. The CONB will work with EAHCP program staff and stakeholders to develop a plan to inform river recreation outfitters on the benefits of the EAHCP COI program. The CONB will recruit outfitters who operate on the Comal River and wish to conduct their operations in accordance with the COI program.

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

EAHCP Obligations:

The CONB will continue to implement a dissolved oxygen (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.

2017 Compliance Actions:

In 2017, the CONB developed a comprehensive DO management plan for Landa Lake. The DO management plan, entitled *Landa Lake Dissolved Oxygen Management Plan 2017*, includes an analysis of previously collected DO and biological monitoring data and sets forth a DO monitoring plan to help better characterize DO levels spatially throughout Landa Lake and the Upper Spring Run area during both normal and low-flow (<80cfs) conditions. The DO management plan also presents specific strategies for managing DO levels in Landa Lake, especially during low-flow conditions.

A detailed description of proposed DO monitoring and mitigation activities are included in the *Landa Lake Dissolved Oxygen Management Plan 2017* that is included in **Appendix L2**. Monitoring activities included in the DO management plan include monitoring DO spatially at strategic locations throughout Landa Lake and the Upper Spring Run in 2018 and during low-flow conditions when low DO conditions are more prone to occur. Mitigation activities included in the plan include monitoring and management of floating vegetation/algal mats to minimize oxygen consumption by decaying organic matter.

In January 2017, EAA staff took over operation and maintenance of the near-continuous water quality data sonde located in the middle of Landa Lake. The sonde collects DO data that is available for access in real-time via a web-based site. CONB staff routinely monitored the real-time DO data throughout 2017. No DO concerns were noted in 2017 that warranted further action.

Proposed Activities for 2018:

The CONB will implement monitoring and mitigation activities outlined in the *Landa Lake Dissolved Oxygen Management Plan 2017.* Specifically, CONB will implement the following activities in 2018:

1) Remove floating vegetation mats, as needed, that form on Landa Lake to prevent oxygen consumption by decaying vegetation (Management of floating/decaying vegetation to be accomplished through Task 5.2.10: Litter and Floating Vegetation Management);
2) Deploy DO monitoring sensors in summer time (July through September) to collect baseline DO data in select fountain darter habitat areas within Landa Lake;
3) Implement expanded DO monitoring at select locations if low-flow conditions (<80cfs total Comal system discharge) occur;
4) Refine and update the DO management plan with field observations and pertinent data collected through the various EAHCP monitoring programs.

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 River system.

2017 Compliance Actions:

In 2017, the CONB continued to implement a non-native species removal program focused on the targeted species. Efforts in 2017 involved five removal sessions, each three days in length, between February 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 2017, approximately 1,491 pounds (lbs) of invasive species biomass was removed from Landa Lake. This volume includes 46 armored catfish, 616 tilapia, five nutria,

and one goldfish. **Table 3.2-13** presents the results of invasive species removal efforts that took place from February 2017 to September 2017. The total number removed, biomass, and average biomass per individual are reported for each species.

Table 3.2-13. Non-Native Animal Species Removal (February – September 2017)

Species	Number Removed	Biomass (lbs)	Average Biomass (lbs/individual)
Armored Catfish	46	93.5	2.03
Tilapia	616	1,344.8	2.18
Nutria	5	51.2	10.24
Goldfish	1	2.0	2.0
TOTALS	**668**	**1,491.5**	**N/A**

A full report including additional information regarding characteristics of the removed species (i.e., length, weight, and sex ratios) is included as **Appendix L3** of this report. Between 2013 and 2017, a total of 14,300 lbs (or 7.15 tons) of invasive biomass has been removed from the Comal River system.

Proposed Activities for 2018:

The CONB will continue the existing program to remove target 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*. Work activities in 2017 include the continuation of gill parasite cercaria water column density monitoring and host snail distribution and density monitoring.

2017 Compliance Actions:

In 2017, the CONB continued a program to monitor the spatial 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 2017 was accomplished by using monitoring techniques established in previous years.

Host snail distribution and density sampling was conducted in the study reaches that were established in previous study years. The study reaches include Landa Lake, New Channel Reach, Old Channel Reach, and the Upper Spring Run, and are depicted in **Figure 3.2-10**.

Figure 3.2-10. Gill Parasite study reaches within the Comal River system.

Overall capture results from the snail distribution surveys conducted annually between 2013 and 2017 are presented in **Table 3.2-14**. Host snail distribution sampling in 2017 showed that 38 percent of sites sampled were occupied by *M. tuberculatus*, an intermediate host species for the gill species *Centrocestus formosanus.* Unlike previous surveys, where the New Channel Reach had the highest captures of *M. tuberculatus*, 2017 results revealed that Landa Lake had the highest rate of captures (n=1,295) with the Upper Spring Run having the second highest captures (n=1,152). Similar to previous annual surveys, the Old Channel Reach had the fewest amount of captures (n=173). 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 3.2-14. Capture Results for *Melanoides tuberculatus* (MT) and *Marisa cornuarietis* (MC) from All Sites Sampled During 2013 – 2017 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
2017	299	2,882	114	29	46

Average 2013 densities of *M. tuberculatus* in high density areas ranged from 179/m^2 to over 1,000/m^2, 2014 densities observed ranged from 50/m^2 to 850/m^2, in 2015 the observations ranged from 33.3/m^2 to 936/m^2, 2016 densities ranged from 1.3/m^2 to 744/m^2, and in 2017 densities ranged from 36/m^2 to 1,283/m^2. Contrary to the data from 2014 – 2016, the highest observed densities in 2017 were found in Landa Lake (**Table 3.2-15**).

Table 3.2-15. 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
2017	384(±112.5)	26	431.7 (±287.4)	21	253 (±74.4)	19	76.9 (±52.3)	12

Mean lengths of snails captured within each reach from 2013 to 2017 do not appear to differ greatly among sample years (**Table 3.2-16**). An exception to this occurs in the New Channel Reach where the mean length decreased considerably from 2016 to 2017. This decrease comes after observation of the highest mean lengths in 2016 reported from all previous sampling events. Additionally, the Upper Spring Run was the only reach to show an increase in mean length amongst the four reaches, with all other reaches showing the lowest means recorded over the five years (**Table 3.2-16**). The Old Channel Reach has consistently had the lowest overall mean lengths among all reaches.

The departure from the bimodal distribution in snail size structure present in the New Channel Reach data from last year illustrates a change in size structure within this population. This possibly represents increased reproduction or recruitment in this reach, and an apparent reduction in the abundance of large snails. However, the exact mechanisms behind this unique distribution are unknown at this time.

Drifting gill parasite (*C. formosanus*) cercariae monitoring was also conducted in 2017 as in previous years using established monitoring methods. Drifting cercariae monitoring was conducted at three established monitoring sites with the Comal River system (**Figure 3.2-11**). These include a site at the outflow area of Landa Lake (LL), the RV Park along the New Channel (RVP), and the Old Channel Reach (OCR). The results of the drifting cercariae monitoring conducted annual between 2014 and 2017 are shown in **Table 3.2-16**. Density estimates of drifting parasite cercariae in the water column at all three sampling sites were lower in 2017 relative to all other sample years.

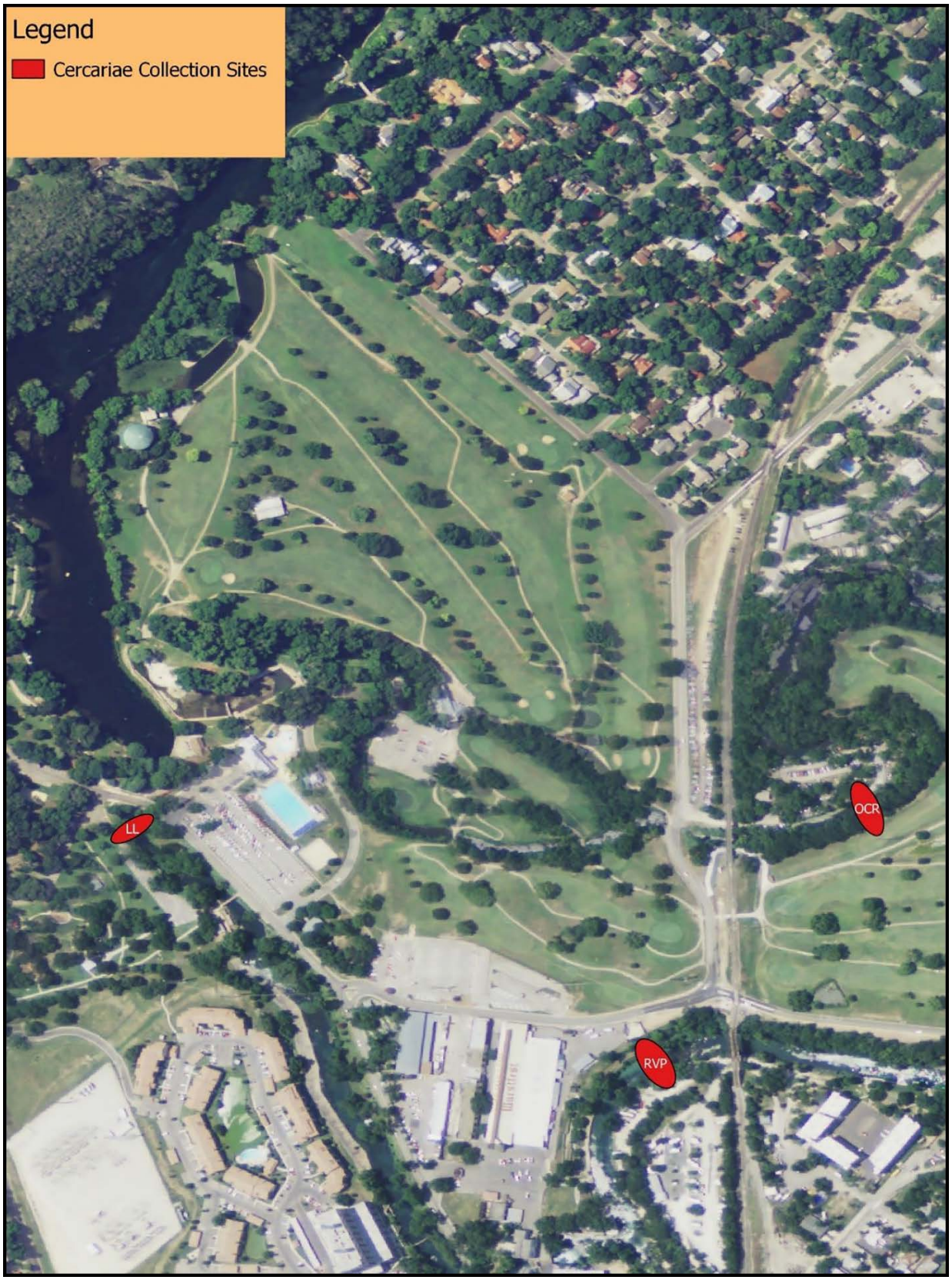

Figure 3.2-11. Drifting cercariae monitoring locations at Landa Lake (LL), RV Park along New Channel (RVP), and the Old Channel Reach (OCR).

Table 3.2-16. Mean Seasonal and Annual Cercaria Densities (Cercariae/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)**
	2017	1.3 (±0.1)	1.4 (±0.3)	1.0 (±0.2)	**1.2 (±0.1)**
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)**
	2017	0.7 (±0.1)	0.6 (±0.2)	0.5 (±0.1)	**0.6 (±0.1)**
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)**
	2017	2.0 (±0.6)	2.3 (±0.2)	1.5 (±0.2)	**1.9 (±0.2)**

A full report regarding gill parasite monitoring activities in the Comal River system is included as **Appendix L4** of this report.

Proposed Activities for 2018:

The CONB's 2018 EAHCP Work Plan includes the continuation of the existing gill parasite monitoring program that includes snail distribution and density monitoring, and cercaria water column concentration monitoring. With that said, the results and conclusions of 2017 and previous years' monitoring suggest that existing conditions do not present any know concern specific to fountain darter in the Comal System, particularly during average and above average streamflow conditions. As such, CONB will pursue discussions with EAHCP program staff and standing EAHCP committees to evaluate the need for continued gill parasite monitoring.

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

EAHCP Obligations:

The CONB was tasked with prohibiting the transport of hazardous material (HAZMAT) on routes crossing the Comal River and its tributaries. This effort was to include legislation, CONB ordinances, and additional signage.

2017 Compliance Actions:

Section 126-185 of CONB City Code designates Interstate Highway (IH)-35 and Loop 337 as through truck routes and 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 3.2-12**). 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 3.2-12)**. No further action was taken in 2017.

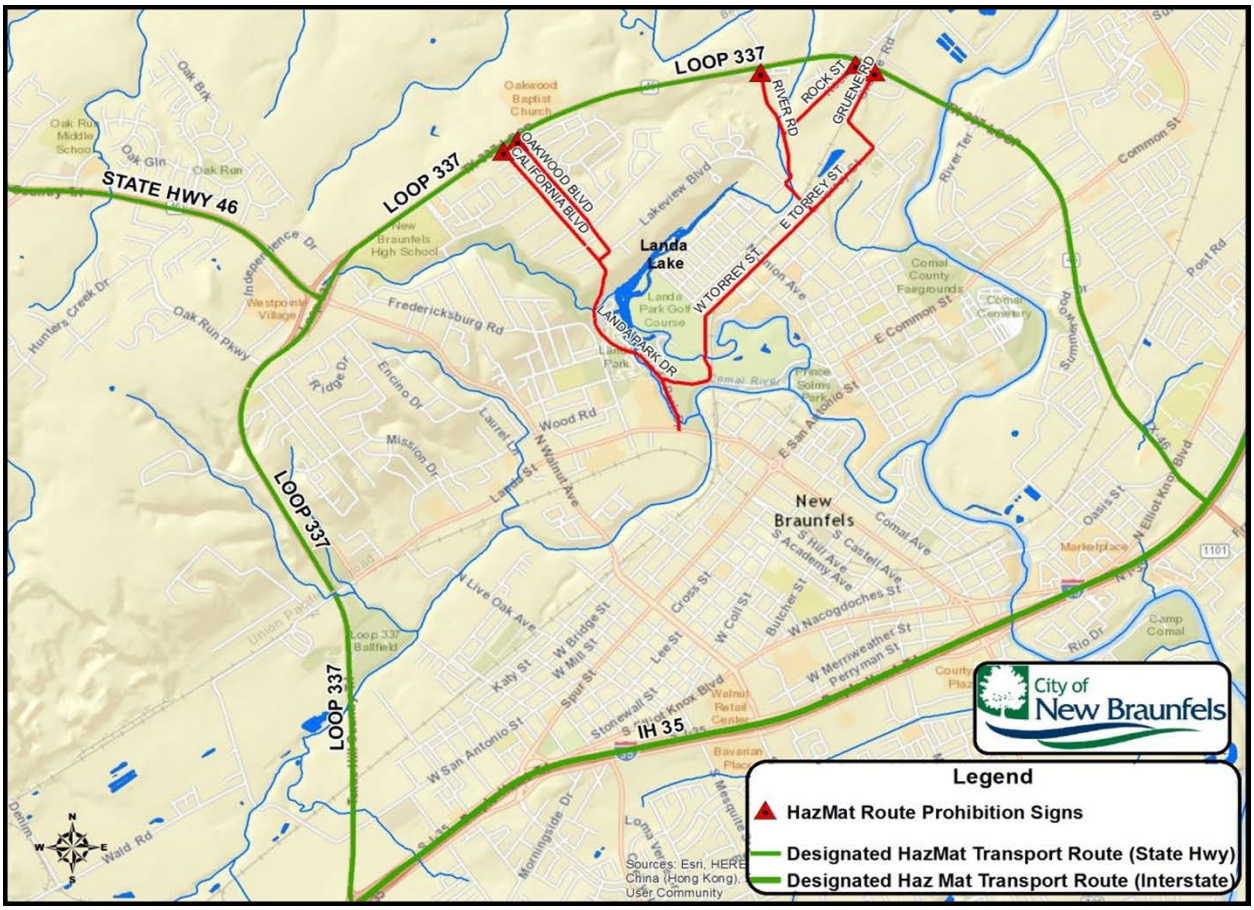

Figure 3.2-12. Map of designated HAZMAT transport routes and locations of HAZMAT route prohibition signs.

Proposed Activities for 2018:

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.

2017 Compliance Actions:

In 2017, the CONB continued to take action to increase the density of riparian vegetation along the northwestern bank of Spring Run #3 and along 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 2017 riparian restoration activities is presented below.

Riparian restoration and maintenance activities in 2017 included:

1) Removal and/or treatment of exotic vegetation including Japanese ligustrum (*Ligustrum japonicum*) and elephant ear (*Colocasia*);
2) Selective pruning and removal of anacua trees (*Ehretia anacua*) to increase light penetration to underlying vegetation;
3) Planting of native riparian vegetation;
4) Maintenance of erosion control structures and installation of brush berms;
5) Sediment and vegetation monitoring.

Additional non-native vegetation was removed in 2017 to prevent further expansion and to decrease competition with native vegetation. 19 ligustrum trees were treated within the project area in 2017 using aquatic-safe herbicide injections. Re-emergent elephant ears, which had been treated in previous work years, were re-treated in 2017 using an aquatic-safe herbicide. Approximately 10 square feet (ft^2) of elephant ear re-growth were treated in 2017.

Efforts were undertaken in 2017 to promote conditions for the growth and proliferation of riparian vegetation within the project area. These efforts included the treatment of ligustrum (as mentioned previously) and anacua trees within the project area. Ligustrum trees and several anacua trees were treated and/or selectively pruned to increase light penetration through the dense tree canopy. Approximately 500 linear ft of brush berms were constructed along the shoreline (**Figure 3.2-13**) to reduce trampling and foraging by white-tailed deer, capture sediment, and promote the recruitment of understory vegetation. Fenced enclosures were also constructed along the water's edge immediately upgradient of sensitive spring openings that provide habitat for the CSRB (**Figure 3.2-13**). The fenced enclosures prevent disturbance and browsing by deer and promote vegetative growth in the areas surrounding spring orifices.

Various species of native riparian plants were planted along within the project area to increase the density of vegetation within the riparian zone and to promote further stabilization of the banks through establishment of root structures. Many plants were planted immediately adjacent to spring openings to help protect prime CRSB habitat areas (**Figure 3.2-14**). A total of 385 native plants were planted within the project area in 2017. The type and quantity of native plants planted within the project area in 2017 are listed in **Table 3.2-17**.

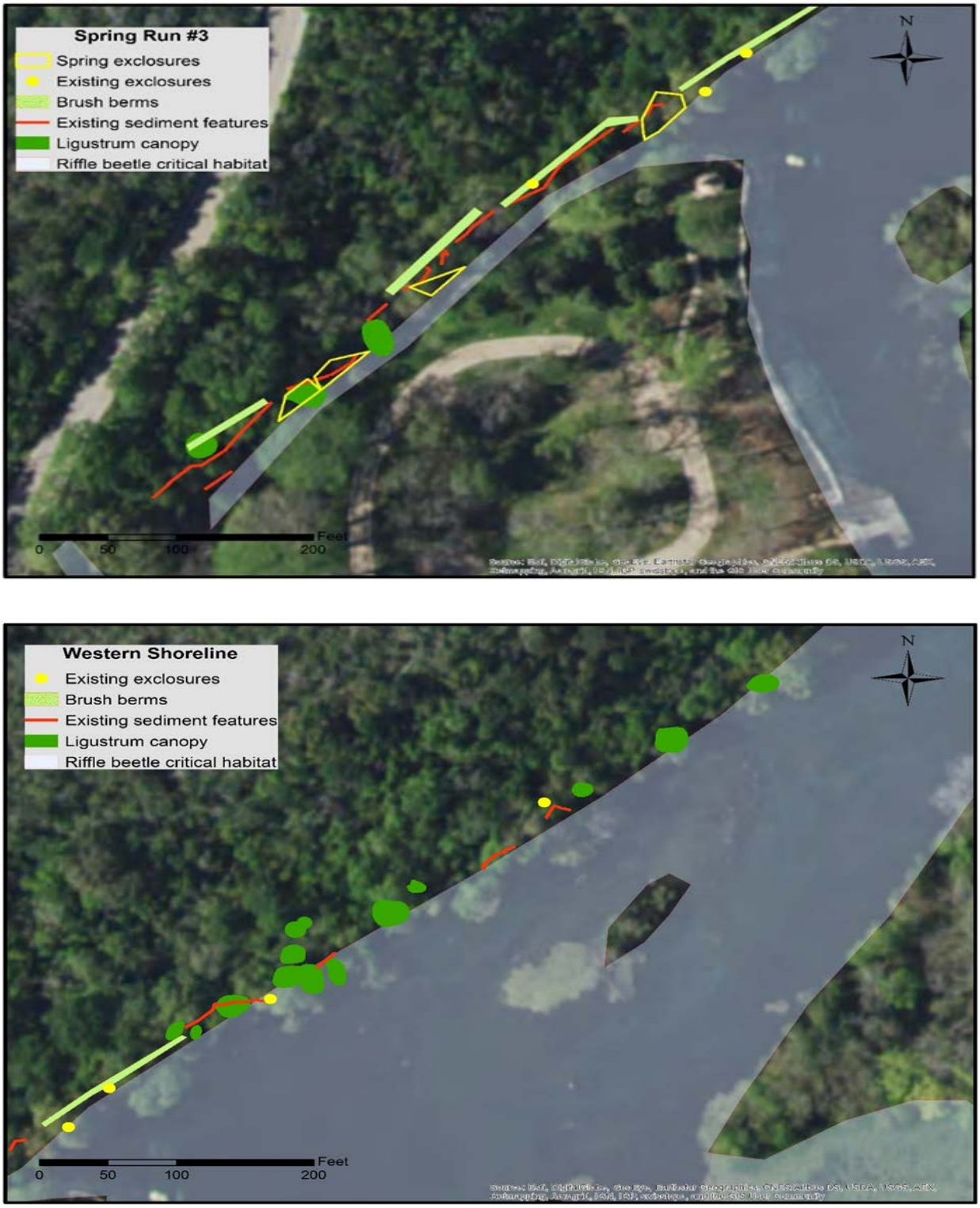

Figure 3.2-13. Maps of Spring Run #3 (above) and Western Shoreline (below) work areas.

Figure 3.2-14. Photos depicting efforts to establish vegetation along spring openings located along Spring Run #3 and the Western shoreline of Landa Lake.

Table 3.2-17. Species and Quantities of Native Plants Planted Within the Project Area in 2017

Common Name	Scientific Name	Quantity Planted
Frostweed	*Verbisina virginica*	60
Giant spiderwort	*Tradescantia gigantea*	40
Swamp sweetscent	*Pluchea odorata*	8
Elderberry	*Sambucus nigra*	12
Water pennywort	*Hydrocotyle verticillata*	20
Water hyssop	*Bacopa monnieri*	40
Emory sedge	*Carex emoryi*	50
Smooth beggar ticks	*Bidens laevis*	40
Obedient plant	*Physostegia intermedia*	12
Bushy bluestem	*Andropogon glomeratus*	4
Cut rice grass	*Zizaniopsis milacea*	15
Mexican plum	*Prunus mexicana*	2
Red Buckeye	*Aesculus pavia*	1
Whitetopped sedge	*Rynchospora colorata*	3
Frogfruit	*Lippia nodiflora*	3
Turkscap	*Malvoviscus drummondii*	12

Table 3.2-17. Species and Quantities of Native Plants Planted Within the Project Area in 2017

Common Name	Scientific Name	Quantity Planted
Needle spikerush	*Eleocharis acicularis*	25
Inland seaoats	*Chasmanthium latifolium*	12
Creeping spotflower	*Acmella repens*	20
Maidenhair fern	*Adiantum capllus-veneris*	6
TOTAL PLANTED		**385**

Previously installed sediment capture devices were monitored for structural integrity and effectiveness throughout 2017 and maintained, as needed, to promote the capture of sediment.

Proposed Activities for 2018:

The CONB will take action to establish a functioning riparian zone along the southeastern side of Spring Run #3. CONB will continue to monitor and maintain previously restored areas along the northwest site of Spring Run #3 and the Western shoreline of Landa Lake.

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.

2017 Compliance Actions:

The CONB developed educational materials designed to inform the public of invasive species issues and the negative impacts of aquarium dumping. Throughout 2017, CONB staff presented to school groups and local organizations on general watershed management. These presentations included information on the negative impacts of introducing non-native aquarium and bait species into the Comal River system.

Proposed Activities for 2018:

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. CONB staff will work with TPWD to draft an ordinance prohibiting aquarium dumping and usage of certain live bait species. City staff will present the proposed ordinance to its City Council for consideration.

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 the 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.

2017 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 3.2-15**) 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 2017 consisted of litter removal from the surface of Landa Lake, along the banks of the Old Channel and around 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 2017, approximately 136 lbs, or 67 7-gallon bags, of litter was collected.

Proposed Activities for 2018:

CONB will 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 DO 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) and the *Landa Lake Dissolved Oxygen Management Plan 2017*.

Figure 3.2-15. Location of target floating vegetation mat management areas.

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 the Covered Species.

2017 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 in **Appendix L5** of this Annual Report.

Proposed Activities for 2018:

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.

2017 Compliance Actions:

The primary riparian restoration activity that took place in 2017 was to remove and control non-native riparian vegetation along the Old Channel of the Comal River. Non-native species that were targeted in 2017 include elephant ear (*Colocasia*), ligustrum (*Ligustrum* sp.), Chinese tallow (*Triadica sebifera*) and chinaberry (*Melia azedarach*). There were three segments of the Old Channel that received varying levels of non-native vegetation treatment in 2017. These segments are described below and shown in **Figure 3.2-16**:

1) **Old Channel Restoration Area A – Old Channel between Landa Lake and the Golf Course Bridge Crossing:** Non-native vegetation in this reach was initially treated in 2016 as part of the Bank Stabilization and Riparian Restoration Project. In 2017, re-emergent non-native vegetation was re-treated and removed.
2) **Old Channel Restoration Area B – Old Channel between Golf Course Bridge Crossing and Elizabeth Street:** Non-native vegetation in this reach was treated for the first time in 2017. Abundant non-native vegetation was present in this area prior to the initiation of non-native

removal work described in this section. Non-native control work in this area was focused primarily on treatment and removal of elephant ear, ligustrum, and chinaberry.

3) **Old Channel Restoration Area C – Old Channel from Elizabeth Street through the Old Channel LTBG Reach:** Only selective non-native vegetation removal occurred in this reach in 2017 in an effort to increase sunlight penetration through the tree canopy to support EAHCP aquatic vegetation restoration efforts.

Figure 3.2-16. 2017 Old Channel riparian restoration areas.

Non-native vegetation was treated using chemical and mechanical treatment methods. Elephant ears were treated with foliar applications of Aquaneat, a Glyphosate-based aquatic herbicide. Elephant ears were treated throughout Areas A & B beginning in February 2017. Follow-up treatment was conducted throughout the year to control re-emergent elephant ears. Woody non-native vegetation, including ligustrum, Chinese tallow, and chinaberry, was treated by scarring the base of the tree to the cambium layer and applying Relegate, a Triclopyr-based herbicide. Approximately 616 ligustrum, 319 Chinese tallow and 123 chinaberry were treated and removed in 2017. The removed woody vegetation was utilized to construct erosion control berms to promote sediment capture.

Planting of native riparian vegetation occurred in Area A in 2017 to expand the riparian zone along the Old Channel. Planting of native vegetation included planting of potted native plants and hand-distribution of native seed and was conducted primarily in the spring and fall of 2017 (**Figure 3.2-17**). Planting was focused on the south side of the Old Channel in Area A but also occurred in bare areas on the north side of the channel where native plant restoration had previously occurred as part of the Bank Stabilization project. Volunteers were utilized throughout the year to assist with planting efforts (**Figure 3.2-17**). Volunteer assistance helped to reduce project costs and to educate residents on the importance of riparian zones and the EAHCP in general. A list and quantities of the species planted within Area A is presented in **Table 3.2-18**. Limited planting, using solely plants provided by local organizations and volunteer effort, was conducted in Area B along the Golf Course side of the Old Channel. CONB installed sections temporary fencing along the south side of the channel in Area A to establish an approximately 10-foot riparian buffer area and to delineate a no-mow zone. Fencing was also installed in areas adjacent to the Golf Course parking lot and in select areas along the Old Channel to delineate the riparian zone, create a no-mow zone, discourage pedestrian traffic and to prevent vehicles from parking and negatively impacting riparian vegetation (**Figure 3.2-18**). The riparian restoration that occurred in 2016 as part of the Old Channel Bank Stabilization Project continued to fill in with vegetation creating a functioning riparian buffer (**Figure 3.2-19**).

Figure 3.2-17. Old Channel riparian planting area and volunteers assisting with planting effort.

Table 3.2-18. Species and Quantities of Native Plants Planted Within Area A in 2017

Common Name	Scientific Name	Quantity Planted (primarily 1- and 5-gallon sizes)
Turkscap	*Malvoviscus drummondii*	169
Lindheimer Muhly	*Muhlenbergia lindheimeri*	31
Retama	*Parkinsonia aculeata*	6
Mesquite	*Prosopis glandulosa*	6
American Beauty Berry	*Callicarpa americana*	6
Texas Mountain Laurel	*Sophora secundiflora*	19
Gum Bumelia	*Sideroxylon lanuginosum*	1
Kidneywood	*Eysenhardtia texana*	2
Fragrant Mimosa	*Mimosa borealis*	2
Chili Pequin	*Capsicum annuum var. aviculare*	11
Mexican Plum	*Prunus mexicana*	1
Little Bluestem	*Schizachyrium scoparium*	2
Side Oats Grama	*Bouteloua curtipendula*	4
Horsetail Reed	*Equisetum hyemale*	1
Texas Lantana	*Lantana horrida*	15
Mexican Buckeye	*Ungnadia speciosa*	9
Meahly Blue Sage	*Salvia farinacea*	40
Inland Sea Oats	*Chasmanthium latifolium*	6
Palmetto	*Sabal minor*	2
Texas Persimmon	*Diospyros texana*	1
Cutleaf Daisy (seed)	*Engelmannia peristenia*	¼ lb.
Little Bluestem (seed)	*Schizachyrium scoparium*	1 lb.
Prairie Verbena (seed)	*Glandularia bipinnatifida*	10 grams
Sideoats Grama (seed)	*Bouteloua curtipendula*	1 lb.
Texas Native Wildflower Mix (seed)	*Misc-Black-eyed Susan, Coneflower, Blanketflower, Mexican Hat, Lemon Mint, etc.*	5 lbs.
Total Number of Plants Planted		**334**
Amount of Seed Distributed		**Approx. 7 ½ lbs**

Figure 3.2-18. Riparian zone fencing and exclosures along Old Channel.

Figure 3.2-19. Riparian establishment in Bank Stabilization Project area.

Proposed Activities for 2018:

The CONB will implement a systematic program to treat and remove non-native riparian vegetation along the golf course side of the Old Channel between Elizabeth Street and to the downstream end of the Old

Channel LTBG Reach (Area C). Removed material will be used to create sediment control structures along the streambanks to control erosion in areas where non-native vegetation is being removed. CONB will plant suitable native vegetation along the Old Channel between the Golf Course Road Bridge and Elizabeth Street where invasive plants were removed in 2017 (Area B) to increase the coverage and density of native vegetation in this area. CONB will maintain previously restored areas to prevent re-establishment of non-native vegetation and promote native vegetation growth.

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.

2017 Compliance Actions:

The CONB held three HHW collection events in 2017. The HHW collection events were held in February, May and October. Overall, 856 cars/participants were recorded, and a total of 86,075 lbs of hazardous waste collected (**Figure 3.2-20**). 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). As compared to 2016 data, there was an increase in the number of participants and the total amount of HHW collected in 2017.

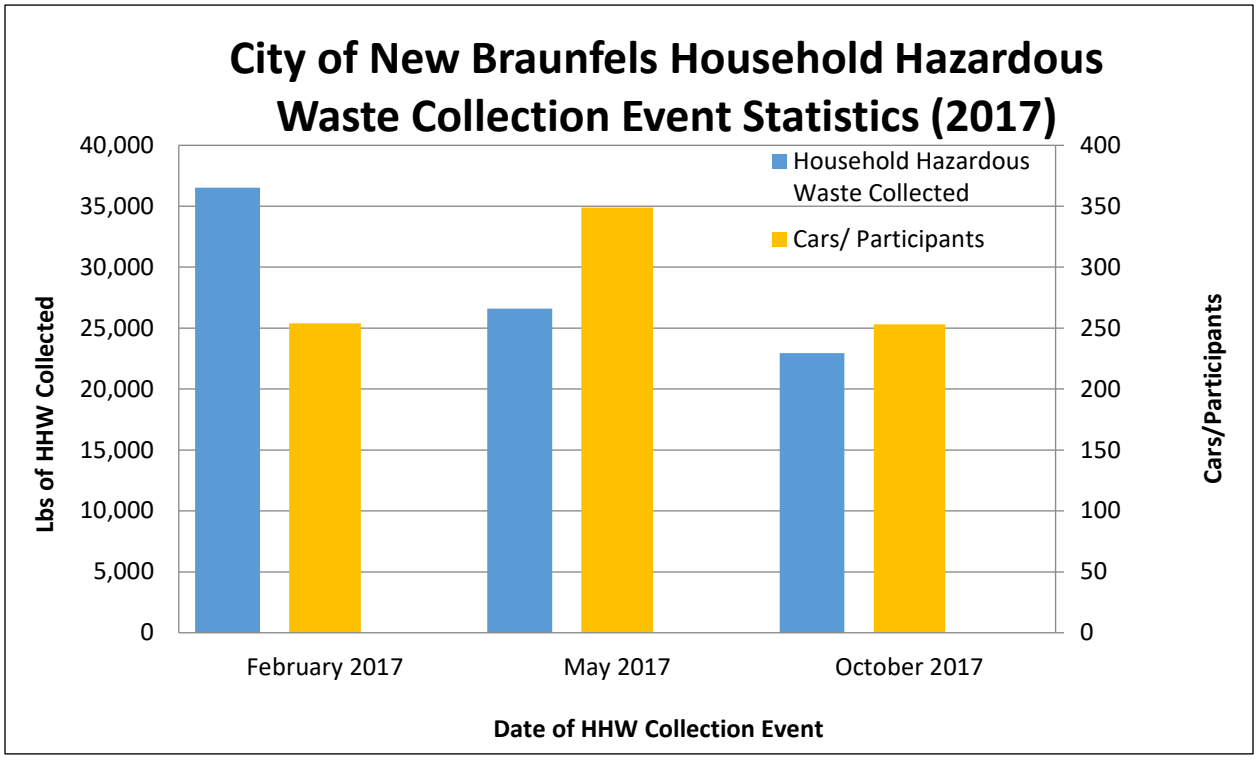

Figure 3.2-20. 2017 Household Hazardous Waste collection event statistics.

Proposed Activities for 2018:

The CONB will continue the HHW program in 2017, which will include three HHW collection events. CONB will continue to partner with NBU on the Operation MedSafe drug recovery and collection program.

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.

2017 Compliance Actions:

The CONB developed a WQPP that identifies stormwater controls and management measures that can be implemented within the Comal River watershed to help protect water quality and reduce pollutant loading. The WQPP proposes and evaluates seven water quality retrofit projects that can be constructed in the upper portion of Comal River watershed to filter pollutants from and/or promote infiltration of stormwater runoff. The proposed water quality retrofits include rain gardens, permeable parking surfaces and underground stormwater treatment systems. The proposed water quality retrofits along with estimated costs and treatment efficiency are included in **Table 3.2-19** below. The locations of proposed water quality retrofits are shown in **Figure 3.2-21**. The full WQPP is included in **Appendix L6**.

Table 3.2-19. Evaluation of Proposed Water Quality Retrofit Projects

Location	Site 1 Elizabeth Ave @ Landa Lake	Site 2 North Union Street	Site 3 North Houston Ave @ Landa Lake	Site 4 Golf Course Parking Lot	Site 5 Overflow Parking Area along Elizabeth Ave	Site 6 Fredericksburg Rd Storm Drain Outfall	Site 7 Landa Park Aquatic Center Parking Lot
Proposed Measure	**Rain Garden**	**Linear Roadside Rain Garden**	**Rain Garden**	**Permeable Parking Surface**	**Permeable Pavers**	**Stormwater Treatment Vault**	**Permeable Parking surface**
Approx. Drainage Area (acres)	5.0	4.0	4.3	0.26	1.2	5.4	1.5
Approx. Impervious Cover (acres)	1.9	1.2	1.3	0.24	0	5	1.4
Approx. % Impervious Cover	38%	30%	30%	92%	0%	93%	93%
Measure Width (ft)	30	8	30	20	20	N/A	100
Measure Length (ft)	50	300	70	150	800		160
Measure Footprint (ft^2)	1,900	2,400	2,100	3,000	16,000	N/A	16,000
Measure Depth (ft)	1.5	1	1	N/A	N/A	N/A	N/A
Measure Volume (cubic feet [ft^3])	2,250	2,400	2,100	N/A	N/A	N/A	N/A
Runoff Depth Treated (inches)	0.34	0.52	0.44	N/A	N/A	N/A	N/A

Table 3.2-19. Evaluation of Proposed Water Quality Retrofit Projects

Location	Site 1 Elizabeth Ave @ Landa Lake	Site 2 North Union Street	Site 3 North Houston Ave @ Landa Lake	Site 4 Golf Course Parking Lot	Site 5 Overflow Parking Area along Elizabeth Ave	Site 6 Fredericksburg Rd Storm Drain Outfall	Site 7 Landa Park Aquatic Center Parking Lot
Total Suspended Solids (TSS) Managed/ Year (lbs)	875	720	700	170	15	2200	170
Estimated Measure Cost/ft^2	$33	$40	$33	$8	$6	N/A	$15
Cost per Unit						$60,000	
Total Measure Cost	$71,156	$138,000	$99,619	$34,500	$138,000	$86,250	$345,000
Cost/TSS (lbs) Managed/ Year	$81	$192	$142	$203	$9,200	$39	$2,029
Maintenance Requirements	Minimal-Moderate	Minimal-Moderate	Minimal-Moderate	Moderate	Moderate	Moderate	Moderate

Figure 3.2-21. Locations of proposed water quality retrofit projects.

Proposed Activities for 2018:

The EAHCP AMP was implemented in 2017 to place emphasis on the CONB's WQPP to meet the requirements set forth in Section §5.7.6 of the EAHCP. As such, CONB will implement select water quality protection measures identified in the WQPP in 2018. Specifically, the CONB will design and construct a stormwater treatment system (i.e. rain garden/ bioretention basin) at the end of North Houston Ave (Site 3)

to treat stormwater runoff prior to entering the Upper Spring Run of Landa Lake. The CONB will also design a measure to treat stormwater runoff from the Landa Park Golf Course parking lot (Site 4). The proposed measure is to replace the existing impermeable asphalt surface with a permeable parking surface that will allow reduce runoff volume and provide for the filtration of stormwater runoff.

3.2.15 Challenges Observed and Identified Solutions

Overall, the EAHCP project efforts of the CONB in 2017 were successful. With respect to aquatic vegetation restoration, it was difficult meeting the annual aquatic vegetation coverage goals, despite significant planting efforts. This was due to a variety of reasons that include: 1) competition of the target native plant species given the aggressive nature of *Vallisneria* and *Sagittaria* that tends to outcompete *Ludwigia*, *Cabomba*, and *Potamogeton*; and 2) limited amount of suitable planting space. In order to address both of these challenges, it may be necessary to perform removal of *Vallisneria* and *Sagittaria* in certain locations that provide the optimal conditions for *Cabomba*, *Ludwigia*, and *Potamogeton*. In turn, *Vallisneria* and *Sagittaria* can be planted in locations less suitable for *Cabomba*, *Ludwigia*, and *Potamogeton.* In addition, effort will be taken in future years to segregate the more aggressive *Sagittaria* from less aggressive *Ludwigia* and *Cabomba* upstream in an effort to isolate and limit competition between these species.

The additional effort needed to control and remove *Hygrophila* in portions of the Old Channel, primarily below Elizabeth Street, also limited the resources needed to increase target native plant coverage in this area in 2017. That said, the efforts to remove *Hygrophila* in 2017 will allow native plantings to be installed earlier in 2018 in this area.

Also noted over the course of 2017 and in previous years is the senescence of *Ludwigia* that tends to occur from summer to fall. A typical growth pattern has been observed where planted *Ludwigia* increases its biomass and expands coverage between spring and summer and then begins to senesce between summer and fall, resulting in patchy *Ludwigia* stands as opposed to robust, continuous stands. This senescence has resulted in the inability to meet the annual coverage goals for *Ludwigia* in certain areas. A solution may be to plant supplemental plantings within previously restored reaches to maintain vegetation coverage in these areas.

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. Any measures specified above that were modified in response to drought conditions or any other changes are noted under each EAHCP measure. 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 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, implementation of buffer zones around designated recreation areas, 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 the issuance of COI to river outfitters to extend the protections of the ITP to those entities.

2017 Compliance Actions:

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

1) Access control: In 2017, permanent repairs were made to a number of access points with the installation of anchor rock at the Dogbeach apron, City Park, Hopkins, Bicentennial, upper Rio Vista, and lower Ramon Lucio access points to address the damage caused by undermining. Undermining is regularly measured to assure public safety and guide maintenance actions.

2) Signage: In 2017, EAHCP partnered with Keep San Marcos Beautiful to create a public outreach booth that was stationed at City Park and Rio Vista Park during peak recreation times. This booth educated river users about how their actions affect the environment and wildlife habitat, primarily focusing on litter. The 'San Marcos River: Life at 72 Degrees' video was installed at Lions Club tube rental for river users to view while in line as well as posted on social media. Additional riparian fence signage was added to further educate river users about the purpose of restoration area fences. Conservation Crew and interns participate in science fairs at the San Marcos Consolidated Independent School District (**Figure 3.3-1**). Maps were posted at the Discovery Center (DC) showing trails, access points, and other amenities and the city website was updated with this

information. The DC also provides interpretive signage covering Aquifer, river habitats, and listed species.

Figure 3.3-1. Educational booths for San Marcos Consolidated Independent School District students.

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 2017, the CC was composed of 14 university students and alumni. These individuals were paid by both EAHCP and COSM funding and included volunteer interns. They began work on May 17, 2017, working Wednesday through Sunday, and worked through the Labor Day weekend. Four crew members worked in teams of four to six 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.

    a) The CC accomplished many tasks under the EAHCP, such as education, protection of endangered species and their habitats (primarily Texas wild-rice, monitoring, project maintenance, and litter removal).
    b) The CC spoke with river users about the importance of EAHCP projects and listed species habitat protection. The CC participated in ten public events to discuss the EAHCP and educate the public with brochures, signage, interactive river habitat card deck game, and a watershed model. The involvement of university students is an added benefit. These students leave 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.
    c) The CC also separated 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 stands and the importance of its protection.
    d) The CC assisted with other projects, including the Texas wild-rice survey with USFWS, invasive plant removal, tiller collection, and native plantings. These opportunities provide a "conversation-starters" between the CC and the public. Areas with an abundance of people such as Rio Vista, City Park and upper Sewell Park are frequently monitored in an effort to reduce negative impacts to the river and to ensure park and university rules are observed.

Riparian fences and signs are inspected for damage or graffiti, and any problem areas along the river are reported and addressed.

4) During the recreation season, 3,729.5 ft^3 of litter and mixed recyclables were removed from the river substrate, litter boats, and parks along the river by the CC. The three litter boats are emptied 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 in 2017, see **Appendix M1**.

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

6) Rio Vista Falls has a 100-ft buffer zone on the west side of the river that excludes picnic tables, pop-up tents, shelters, and portable grills. The riparian restoration efforts continue to increase the number of riverside buffers from upper Sewell Park to IH-35.

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

8) The reduction of turbidity through watershed management strategies is addressed through the COSM and Texas State WQPP.

9) The CC monitors both COSM and Texas State property and the program is supported by COSM Park Rangers and University 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 HCP Manager is funded equally by Texas State and COSM to ensure a unified approach.

10) Administered public survey to assess the level of understanding of Covered Species, ongoing EAHCP measures, effectiveness of the public outreach and education program, and the impacts of recreational activities on species and habitat.

Proposed Activities for 2018:

In 2018, COSM will continue the implementation of recreational management goals as outlined above and continue to educate the public engaged in water-based recreation on sustainable river use that protects listed species and their habitats. The seasonal workers will also conduct miscellaneous cleanup and EAHCP project maintenance while walking/kayaking. Introduce the COI program as directed by the EAHCP Program Manager to qualified third parties conducting recreational activities in and along the San Marcos River.

3.3.2 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.

2017 Compliance Actions:

The COSM's contractor removed inorganic litter from Hopkins Street (City Park) to River Road (Stokes Park). The contractor used SCUBA equipment to remove underwater litter from the substrate and river surface (**Figure 3.3-2** and **Figure 3.3-3**).

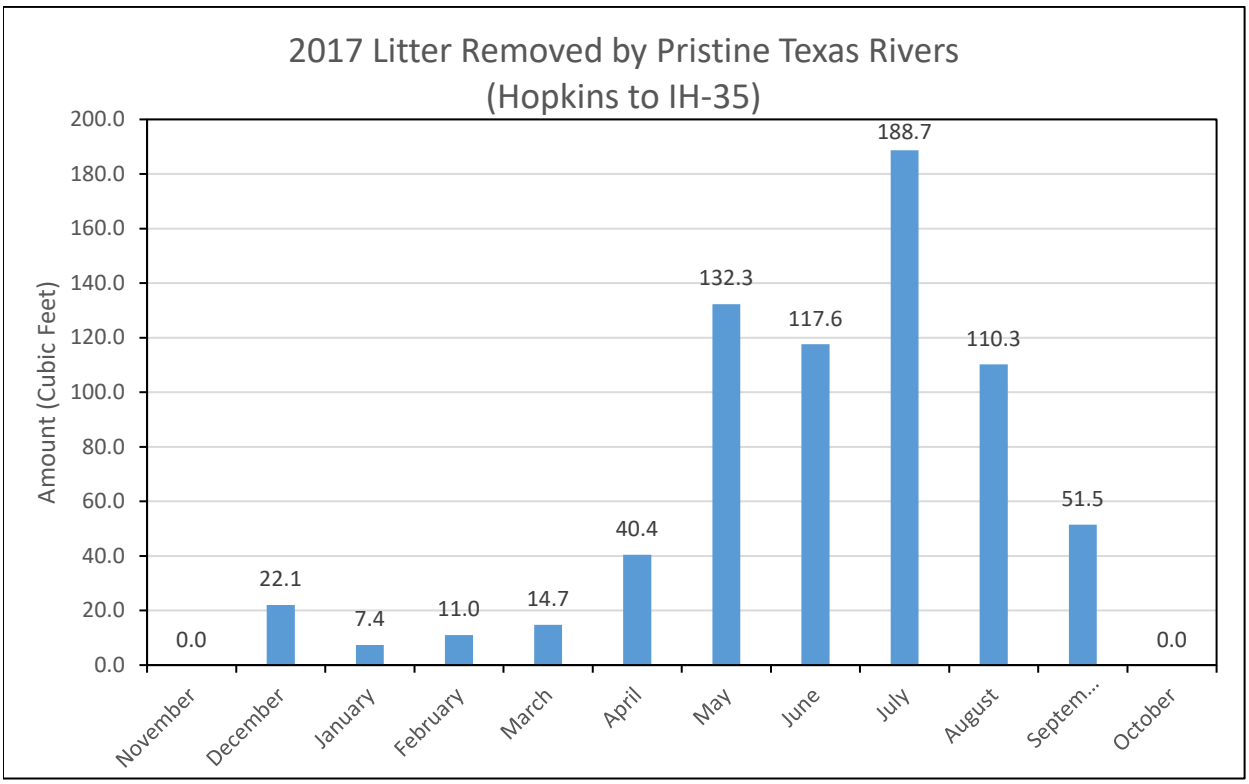

Figure 3.3-2. Cubic feet of litter removed from Hopkins Street to IH-35 (2016 included as projected 2017 data).

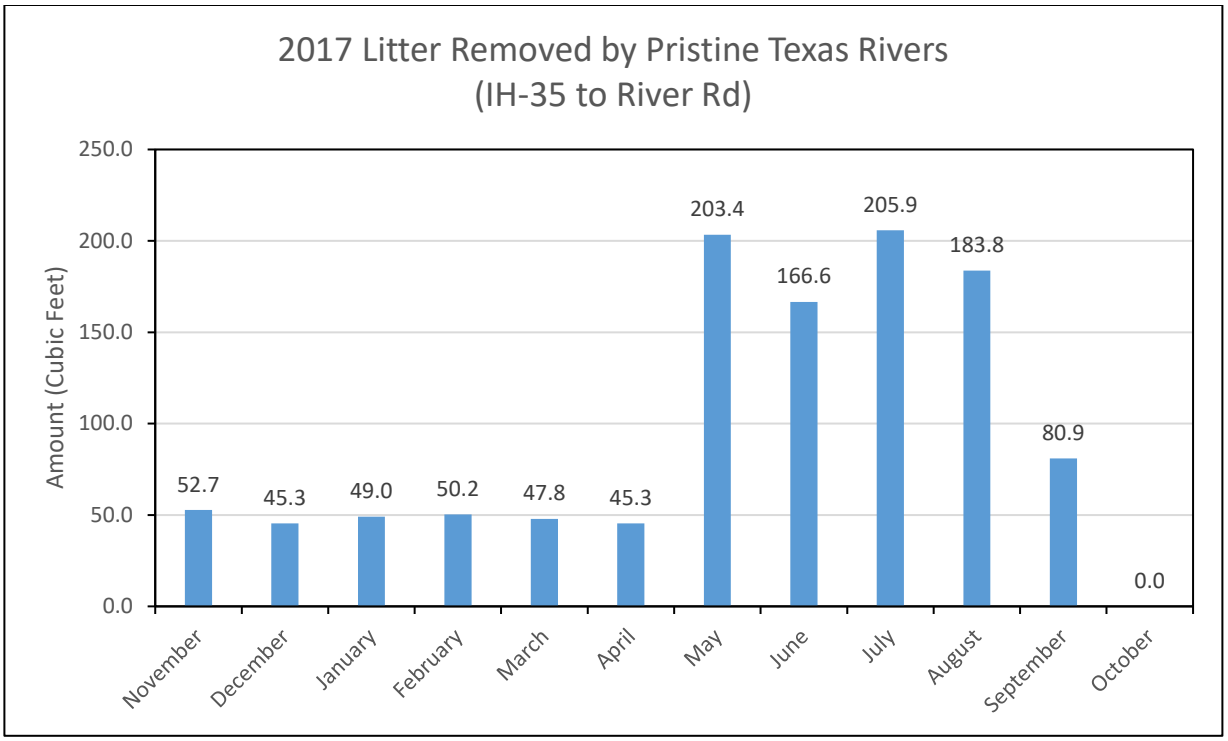

Figure 3.3-3. Cubic feet of litter removed from IH-35 to Stokes Park (2016 data included as 2017 projected data).

The COSM contractor walked the four San Marcos River tributaries (**Figure 3.3-2**) and collected litter in mesh bags. The monthly totals of litter removed exhibits the importance of focusing on areas downstream of IH-35 and the tributaries (**Figure 3.3-2**, **Figure 3.3-3**, and **Figure 3.3-4**). 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.

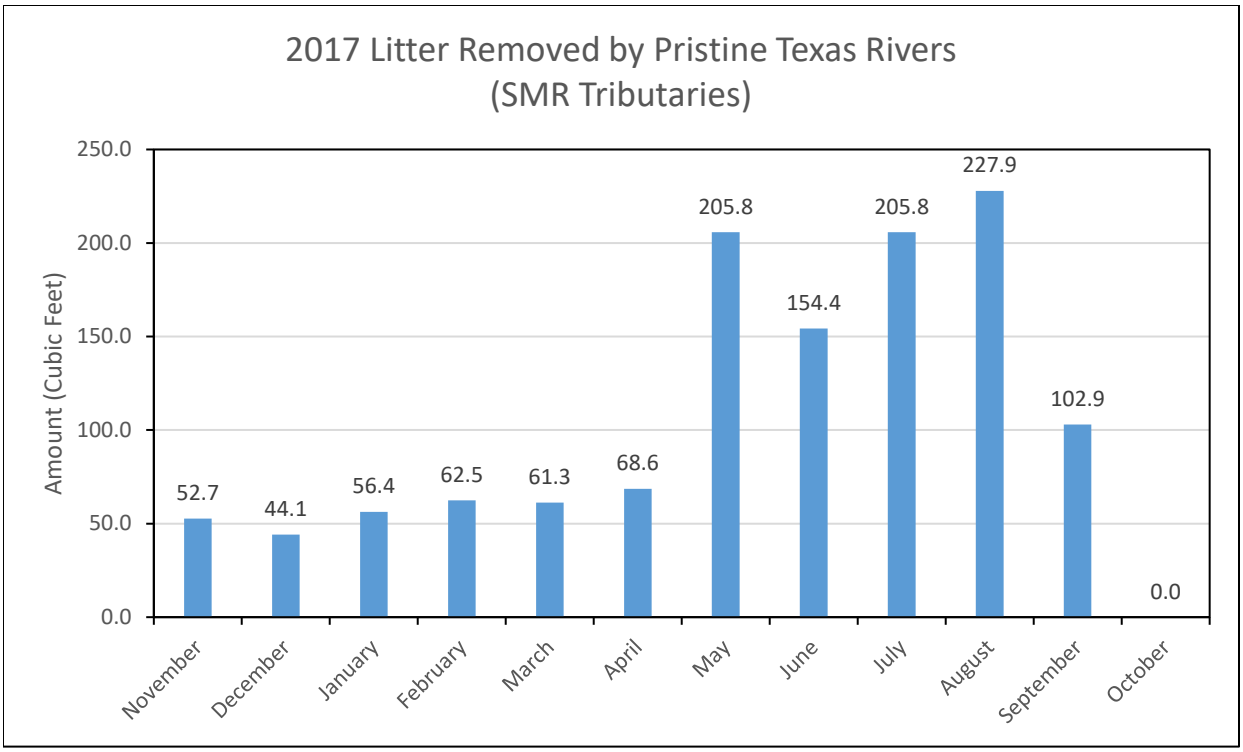

Figure 3.3-4. Cubic feet of litter removed from San Marcos River tributaries by month (2016 included as 2017 projected data).

Proposed Activities for 2018:

In 2018, the COSM will continue to implement litter removal consistent with protocols established in the EAHCP and in the 2018 Work Plan.

3.3.3 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 and target those areas for restoration. Restoration will involve the removal of non-native plant species, propagation and planting of new Texas wild-rice plants, and continued monitoring of the new stands. The COSM uses the Submerged Aquatic Vegetation Analysis and Recommendation Report (SAV Report) as the guide for removal and planting areas each year.

2017 Compliance Actions:

Non-native vegetation is removed from mixed stands of Texas wild-rice. 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. Before removal, non-native vegetation was fanned to displace fountain darters (*Etheostoma fonticola*). After removal, all non-native vegetation was sorted, and any fountain darters and other biota 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 Freeman Aquatic Building (FAB). Polygons of areas planted with Texas wild-rice were developed in ArcMap with number of individual plants recorded. Aerial coverage of Texas wild-rice for 2016 was assessed using geo-referenced aerial imagery collected with a quadcopter in conjunction with ground-truthed data collected using Trimble GPS units.

Table 3.3-1 illustrates an estimated 12,786 Texas wild-rice individuals planted November 2016 – November 2017 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 620 m^2. **Figure 3.3-5** illustrate planting locations of Texas wild-rice in Spring Lake and the San Marcos River in 2017.

Table 3.3-1. Estimated Number of Texas wild-rice Individuals Planted, Estimated Area of Texas wild-rice Planted (Cumulative), and Number of Days Worked Planting Texas wild-rice per Reach in Spring Lake and the San Marcos River in 2016 and 2017

Reach	No. Individuals Planted		Estimated Area		Effort (Days Worked)	
	2016	2017	2016	2017	2016	2017
Spring Lake	3,512	4,412	85	279	6	8
Spring Lake Dam	0	0	0	0	0	0
Sewell Park	250	0	7	0	1	0
Below Sewell-City Park	0	0	0	0	0	0
City Park	348	0	16	0	0	0
Hopkins St.-Snake Island	869	0	14	0	3	0
Cypress Island-Rio Vista Dam	1,115	0	58	0	8	9
IH-35 (Upper and Lower)	1,375	8,374	105	341	8	9
TOTAL RIVER	**7,469**	**12,786**	**285**	**620**	**26**	**17**

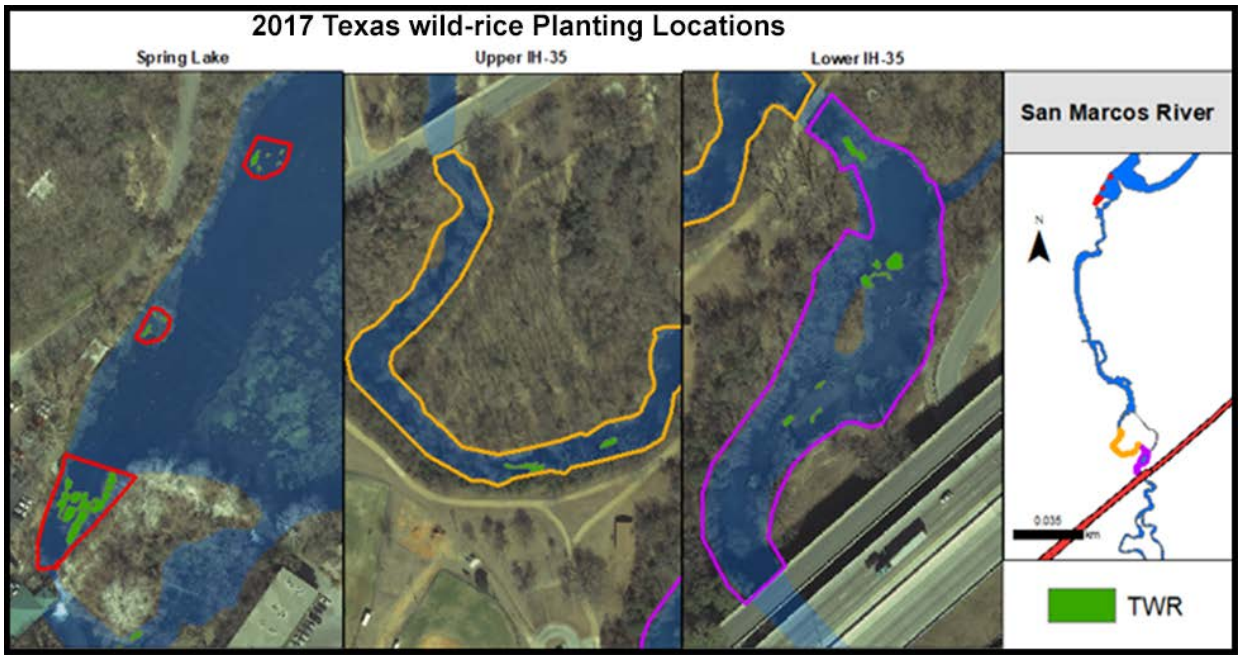

Figure 3.3-5. Planting locations of Texas wild-rice in Spring Lake, IH-35 LTBG Reach and IH-35 expanded Restoration Reach.

Table 3.3-2 quantifies changes in Texas wild-rice coverage from 2013 to 2017. Since 2013 Texas wild-rice has expanded an estimated 7,963 m^2 through planting and natural expansion. Since 2016, Texas wild-rice has expanded by an estimated 3,800 m^2. **Figure 3.3-6** through **Figure 3.3-10** illustrate changes in aerial coverage of Texas wild-rice among active work sites.

Table 3.3-2. Texas wild-rice 2017 Aerial Coverage, Change in Aerial Coverage 2013 – 2017, and Change in Aerial Coverage 2016 – 2017, per LTBG and Restoration Reaches (m^2)

Reach	Total Area (m^2)			
			Change	
	2016	2017	2013 – 2017	2016 – 2017
Spring Lake	47.1	184.1	184.1	137.0
Spring Lake Dam	887.3	1,389.3	1,190.8	502.0
Sewell Park	1,185.8	1,811*	1,144.7	625.2
Below Sewell-City Park	2,429.0	2,810*	1,598.0	381.0
City Park	1,561.5	2,247.0	1,863.0	685.5
Hopkins St- Snake Island	-	1,168.57*	-	-
Cypress Island-Rio Vista Dam	238.0	246.9	246.9	8.9
IH-35 (Upper and Lower)	276.0	512.1	512.1	236.1
Below IH-35	-	55.61*	-	-

*BIO-WEST data mapped July 2017.

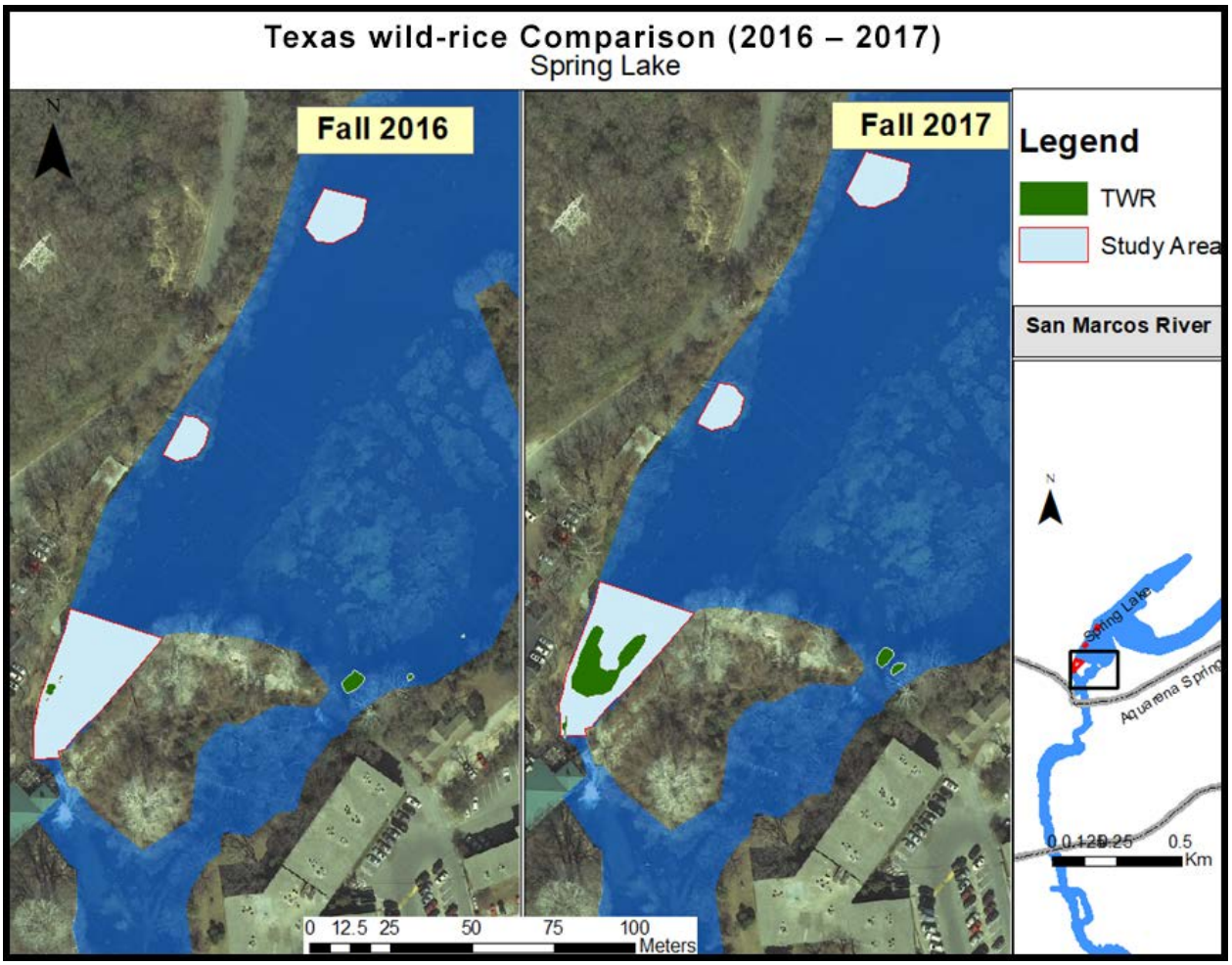

Figure 3.3-6. Texas wild-rice aerial coverage in the Spring Lake Restoration Reach one year ago (fall 2016) and fall 2017.

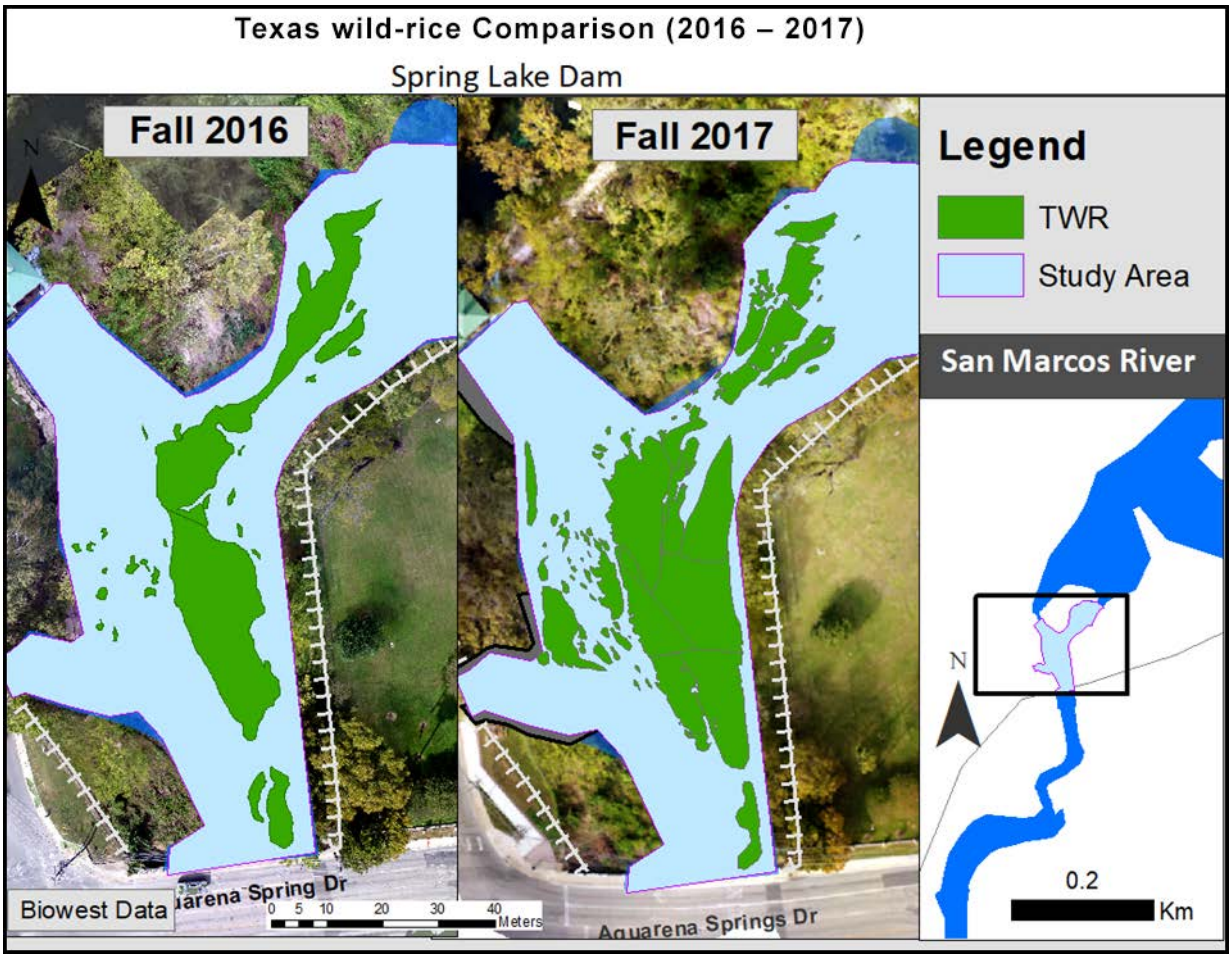

Figure 3.3-7. Texas wild-rice aerial coverage in Spring Lake Dam LTBG Reach one year ago (fall 2016) and fall 2017.

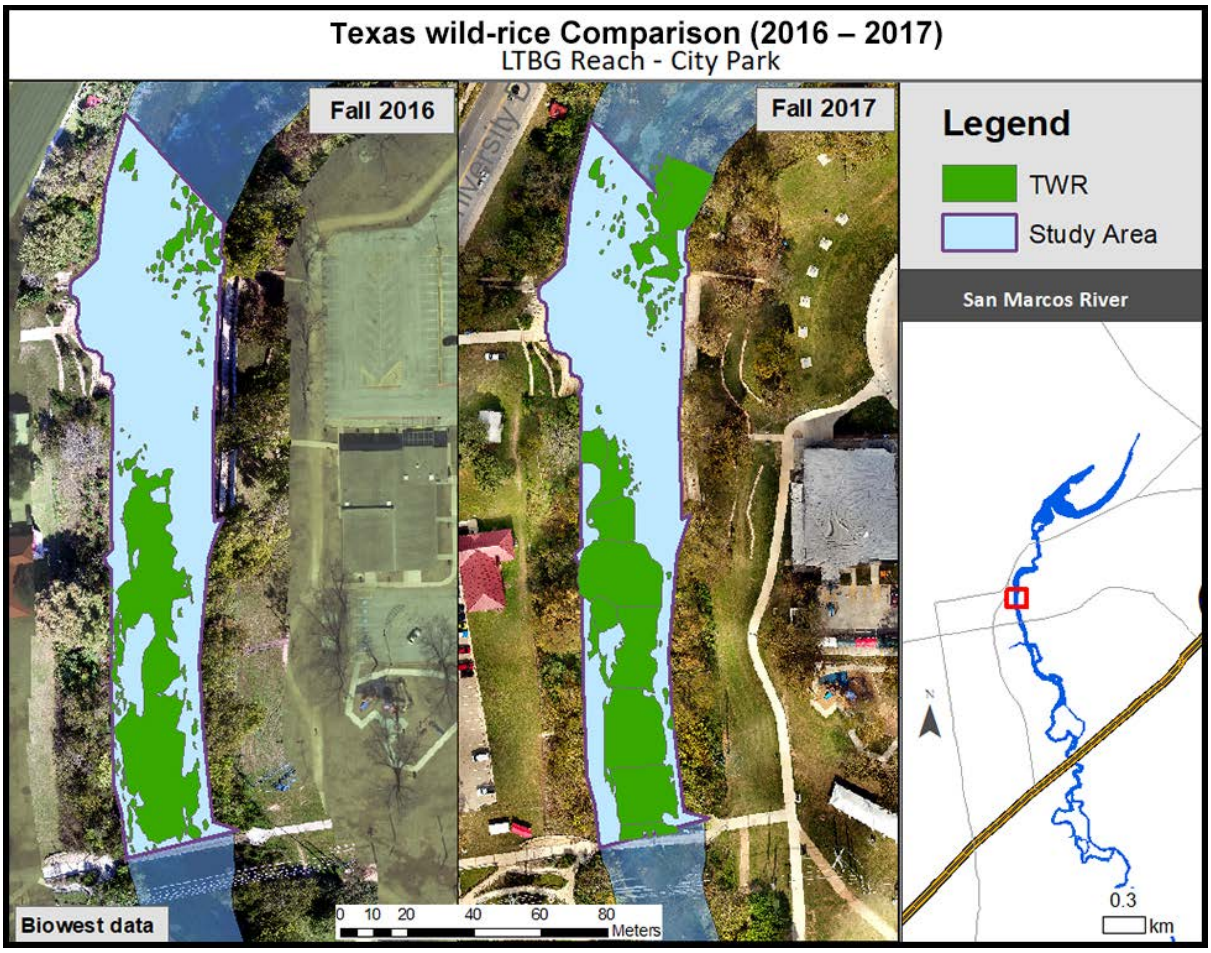

Figure 3.3-8. Texas wild-rice aerial coverage in City Park LTBG Reach one year ago (fall 2016) and fall 2017.

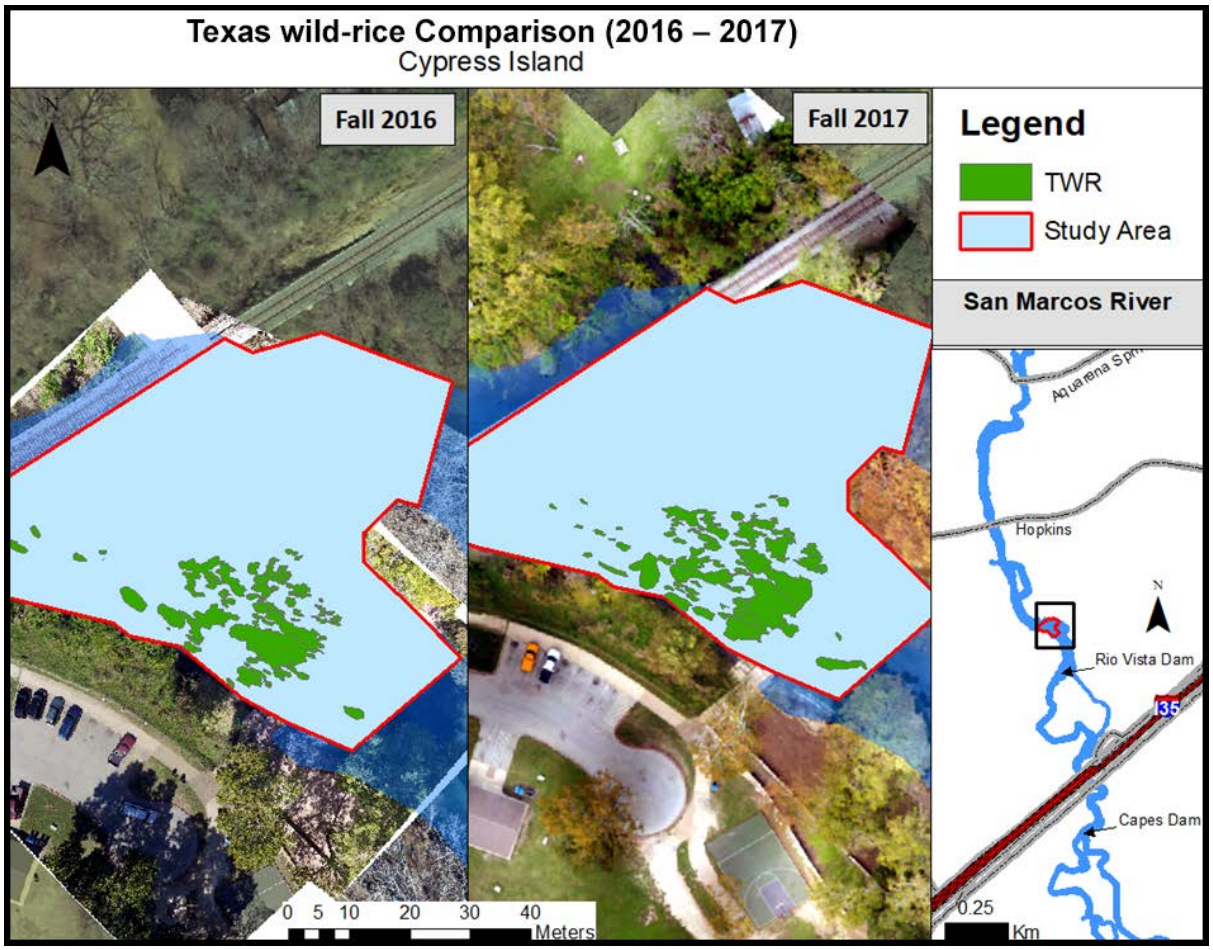

Figure 3.3-9. Texas wild-rice aerial coverage in Cypress Island Restoration Reach one year ago (fall 2016) and fall 2017.

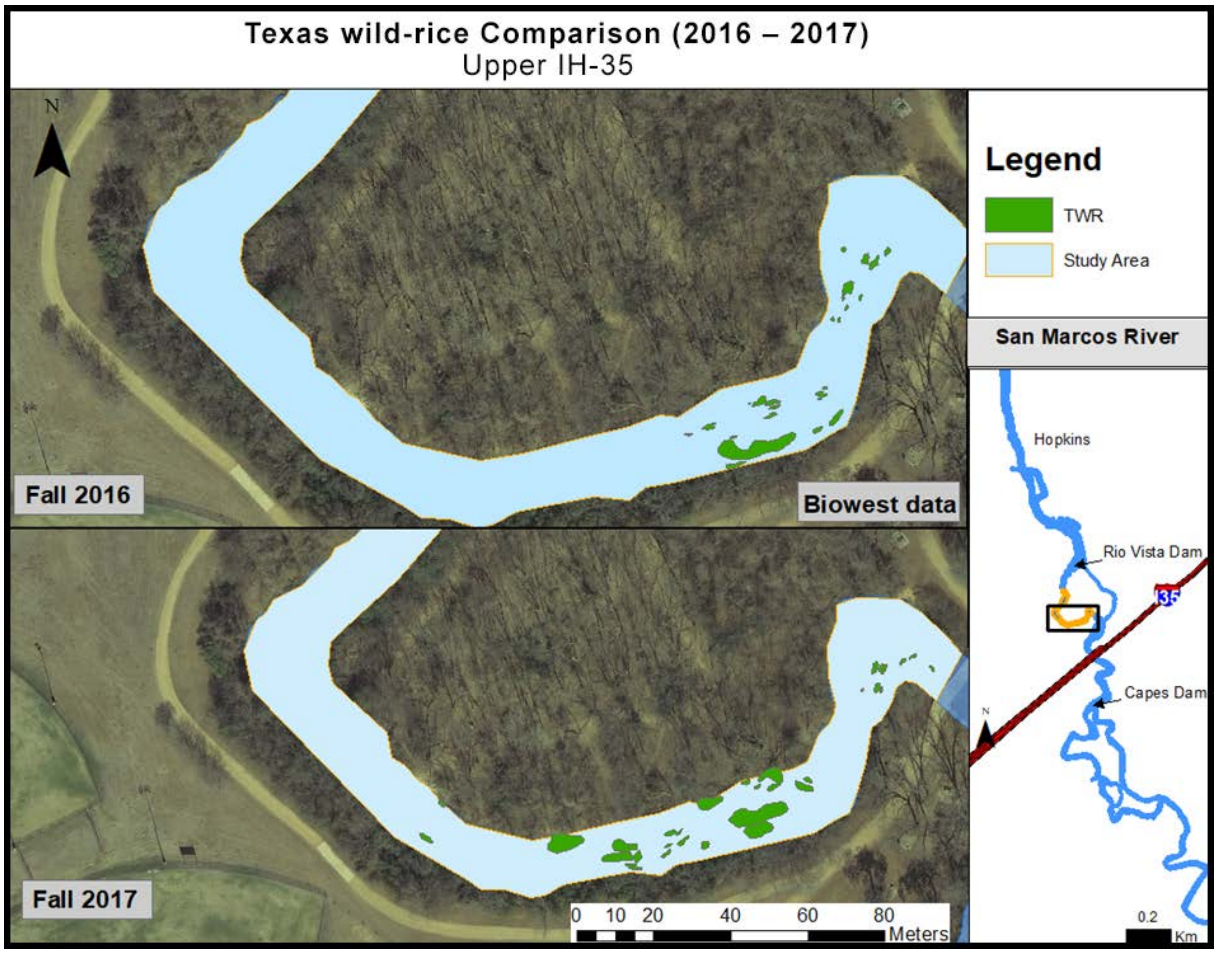

Figure 3.3-10. Texas wild-rice aerial coverage in IH-35 LTBG Reach one year ago (fall 2016) and fall 2017.

Proposed Activities for 2018:

In order to meet Texas wild-rice coverage goals for 2018 as defined by Table 34 of the SAV Report (Section 3.1.2.2), work plans include planting 100 m^2 in the Spring Lake reach, 25 m^2 in the Cypress Island reach and 75 m^2 in the IH-35 LTBG Reach. Cumulative Texas wild-rice coverage goals for 2017 have been met or exceeded in all reaches except the IH-35 LTBG Reach (approximately 10 m^2 below goal). Texas wild-rice planting in 2018 for the IH-35 LTBG Reach will be adjusted to rectify the difference. All planted areas will be maintained.

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.

2017 Compliance Actions:

The COSM successfully 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 COSM Transportation Division for comment. COSM staff states that an ordinance is already in place, but TxDOT is requesting that penalties be added. Also, TxDOT is requesting changes to the hazardous route map.

Proposed Activities for 2018:

The COSM will meet with TxDOT to clarify its requirements and determine if a route can be set.

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 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.

2017 Compliance Actions:

1) Flyer(s):
   a) Posted in Texas State dorms near the end of the spring semester (April)
   b) Distribute to pet stores that will accept flyers. Currently, the city only has PetSmart and Walmart who will not post fliers.

2) State the harms of releasing non-native fish into our river:
   a) Included in EAHCP signage, presentations, and public events

3) Advertise through:
   a) Local pet stores (not allowed by Walmart and PetSmart)
   b) Local festivals and parades (Veterans & Mermaid)
   c) Semiannual volunteer polespear tournament public outreach
   d) Texas State campus – accomplished in April
   e) On social media websites – working with Parks and Communications Departments, SMRF and local Facebook sites
   f) Video posted on city channel about pet fish drop-off location

4) Donation Centers:
   a) Discovery Center – received 16 unwanted fish; two carp, three betas, three suckermouth catfish, eight mollies and one sunfish (**Figure 3.3-11**).
   b) Educational Booth for Events – flyers advertising that the DC provides a home to unwanted fish were present at each event.

Figure 3.3-11. Fish drop-off pond at the Discovery Center.

Proposed Activities for 2018:

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.

2017 Compliance Actions:

The removal of sediment in support of native aquatic planting activities has proven to be both unnecessary and overly expensive. For example, to remove 158 cubic meters (m^3), the cost was $555,000 (2013 – 2015). Additionally, the crew has successfully accomplished multiple plantings in silted areas without first removing silt. Therefore, the funds allocated for sediment removal will be used primarily to prevent influx of sediment into Sessom Creek. In 2017, no funds were expended for sediment removal. Instead, the AMP was implemented to change the actions taken under the Sediment Removal measure for upcoming years. The fund reallocation was approved by both the IC and the USFWS. Funds will be available for the Texas wild-rice plantings in Spring Lake as needed.

Proposed Activities for 2018:

Sediment will be removed only as needed to support aquatic planting.

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 species and their habitats. The COSM will maintain all access points in perpetuity. All 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.

2017 Compliance Actions:

Six existing access points were stabilized by adding one or two rows of anchor rock along the front of each access (**Figure 3.3-12**). Construction began on October 16, 2017 and was completed and inspected by the engineer on November 3, 2017. **Figure 3.3-13** and **Figure 3.3-14** show the excavator moving onto the Ramon Lucio access point and the newly installed anchor rock at Hopkins Railroad Bridge access point.

Figure 3.3-12. Locations of stabilized access points along the San Marcos River.

Figure 3.3-13. Excavator and trackhoe at Ramon Lucio access point.

Figure 3.3-14. Portion of the installed anchor rocks at Hopkins Railroad Bridge access point.

Proposed Activities for 2018:

All access points will be monitored semiannually through measurements of undermining and gaps between rocks.

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 a minimum of 15 meters in width where possible. The COSM will install fencing to protect the new plantings while they mature. Appropriate permits will be obtained for the removal of non-native plants.

2017 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. **Table 3.3-3** denotes the species collected and returned to the San Marcos River during non-native aquatic vegetation removal (January 2017 through early November 2017). 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 3.3-15** through **Figure 3.3-21**). As a result, the layers capture the degree of overlap between 125 work sites (57 work days) and identify areas that required repeated removal efforts.

Table 3.3-3. Animal Species Collected and Returned to the San Marcos River During Non-Native Vegetation Removal (January 2017 – October 2017)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	TOTALS
Lepomis sp. (sunfishes)	1						2	4	2	3	12
Etheostoma fonticola (fountain darter)											0
Ameiurus sp. (bullhead catfish)							3				3
Dionda nigrotaeniata (roundnose minnow)								1			1
Cambaridae (crayfish)	25	20	10	20	3	25	15	15	50	50	233

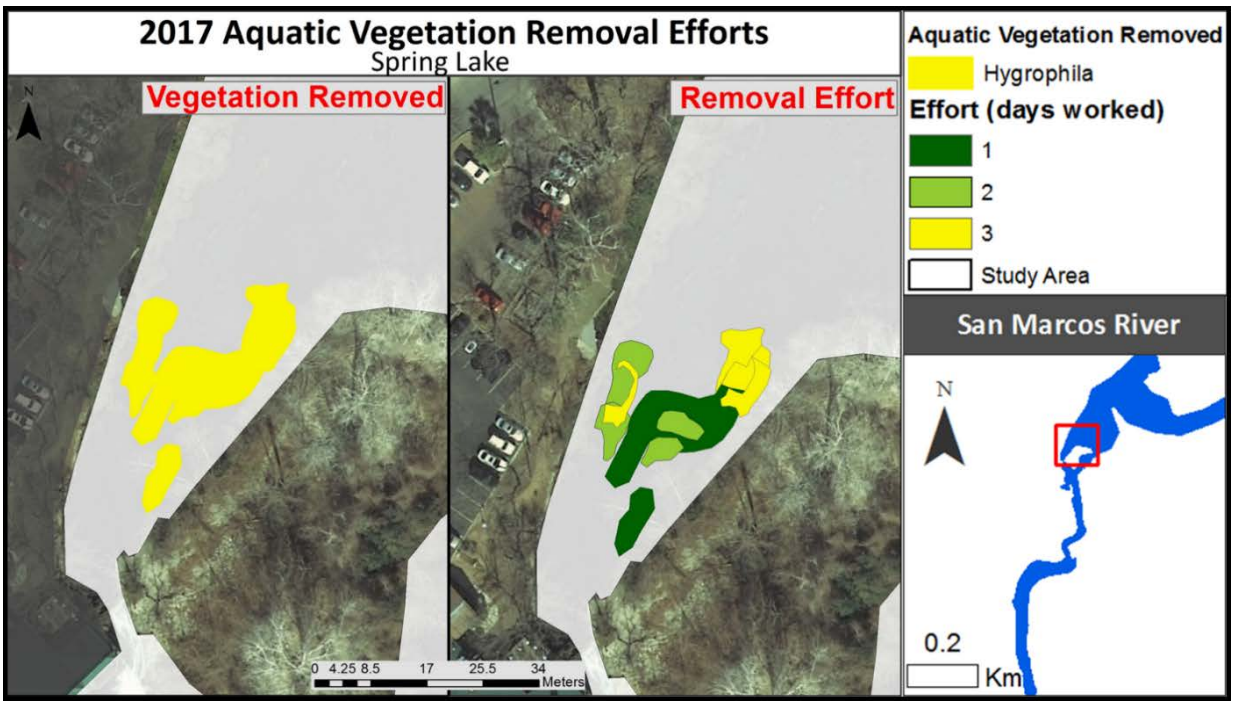

Figure 3.3-15. Non-native aquatic vegetation removal locations and degree of effort in Spring Lake in the San Marcos River (2017).

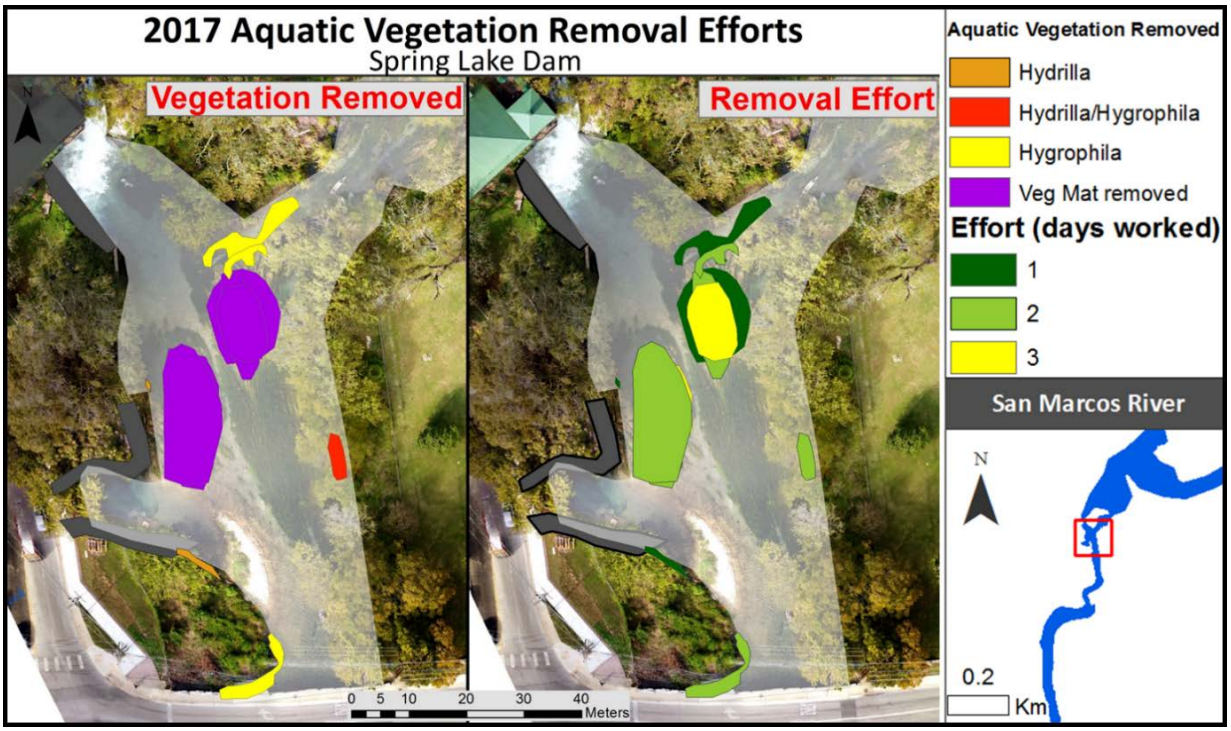

Figure 3.3-16. Non-native aquatic vegetation removal locations and degree of effort at Spring Lake Dam LTBG Reach in the San Marcos River (2017).

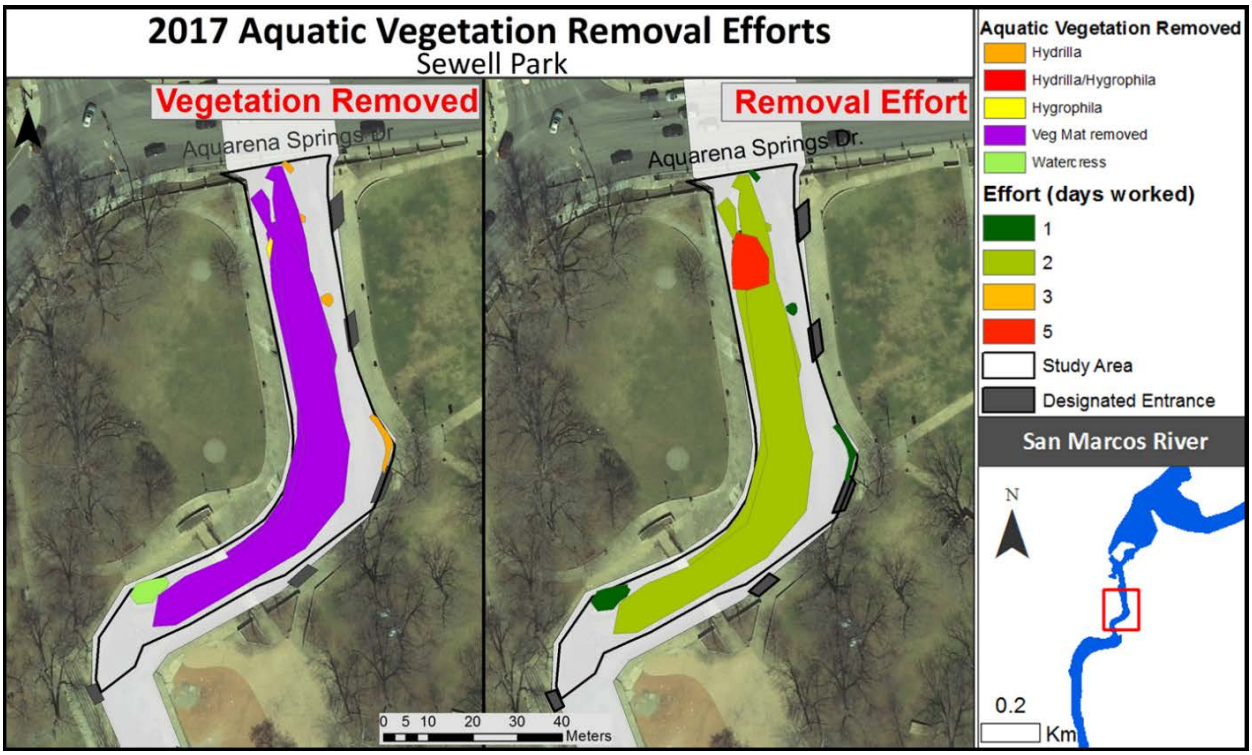

Figure 3.3-17. Non-native aquatic vegetation removal locations and degree of effort at Sewell Park in the San Marcos River (2017).

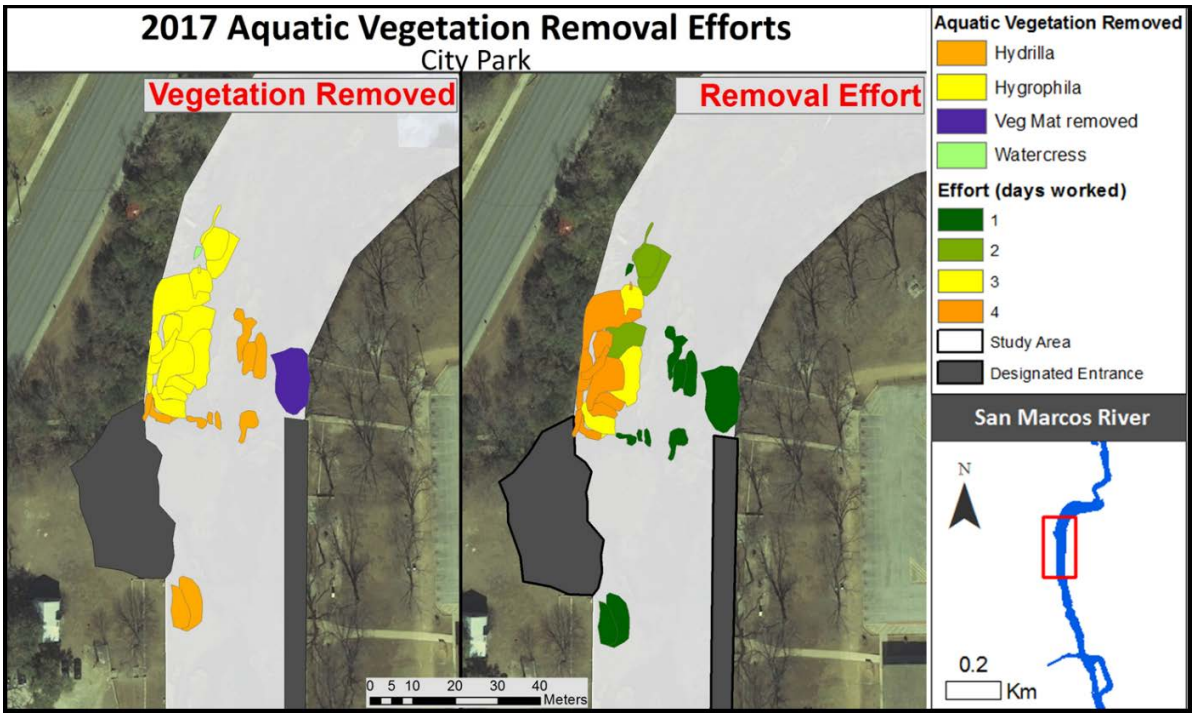

Figure 3.3-18. Non-native aquatic vegetation removal locations and degree of effort in the reach below Sewell Park to City Park reach in the San Marcos River (2017).

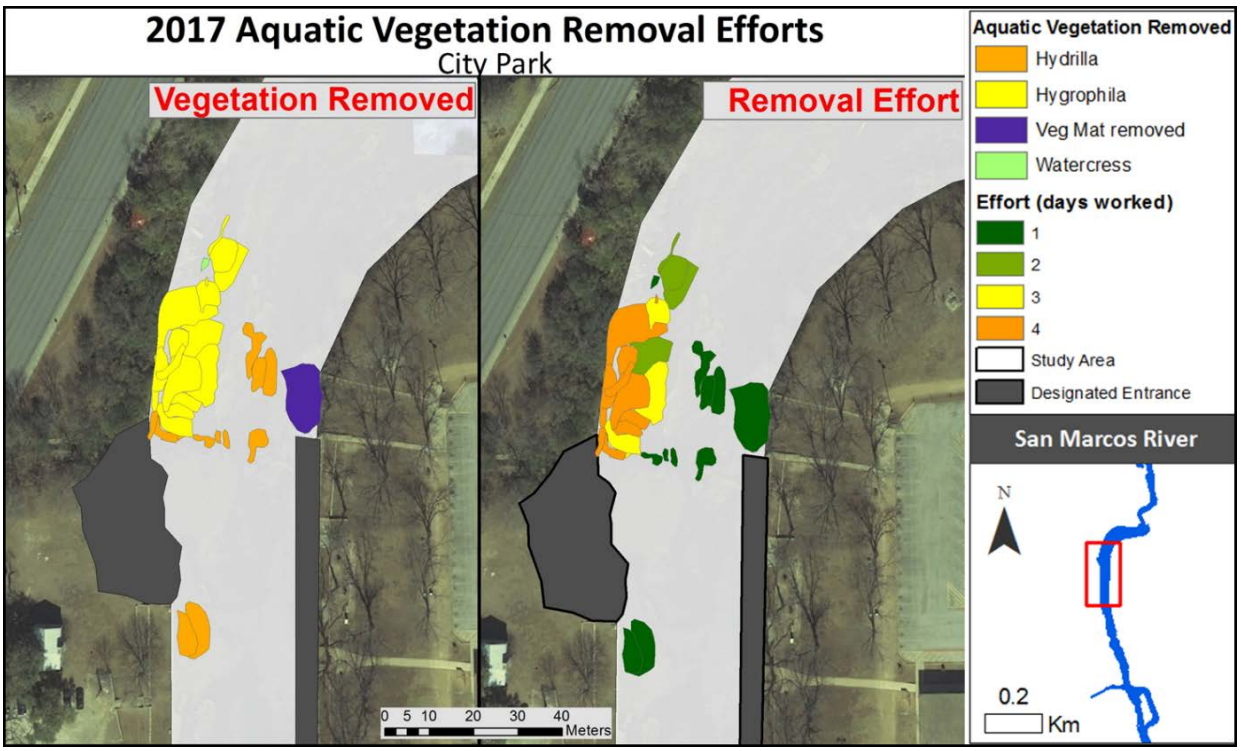

Figure 3.3-19. Non-native aquatic vegetation removal locations and degree of effort at City Park in the San Marcos River (2017).

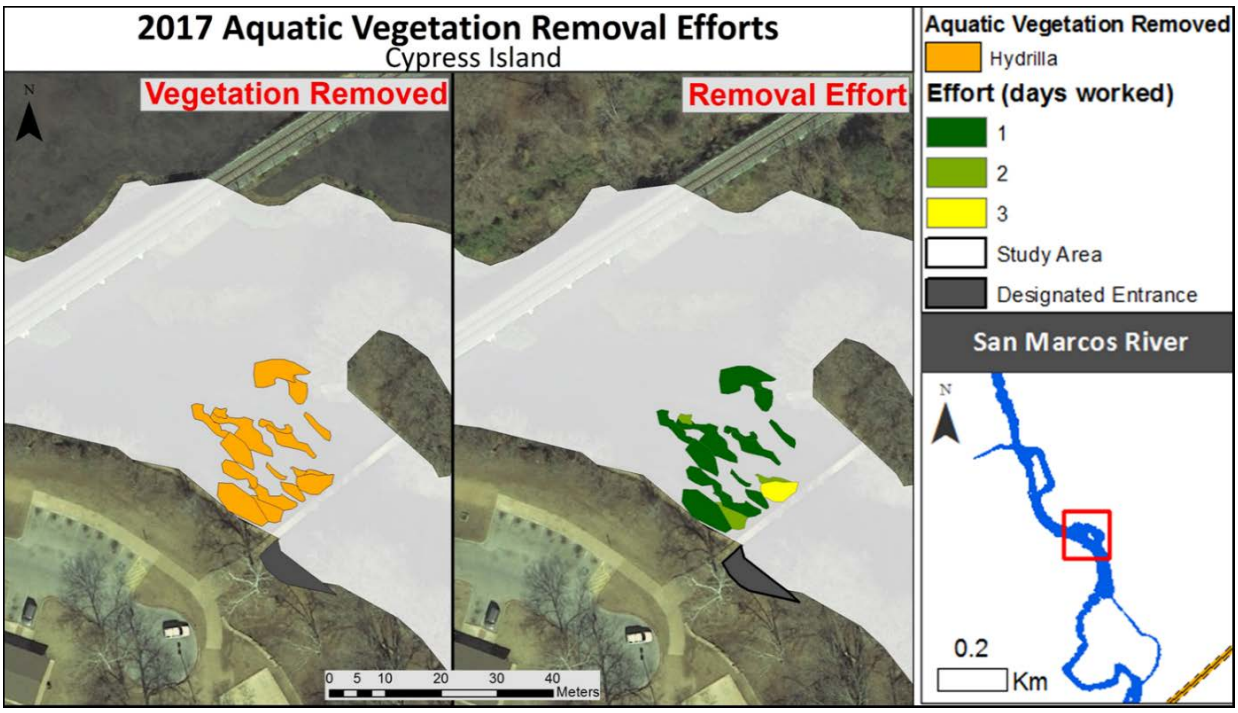

Figure 3.3-20. Non-native aquatic vegetation removal locations and degree of effort at Cypress Island in the San Marcos River (2017).

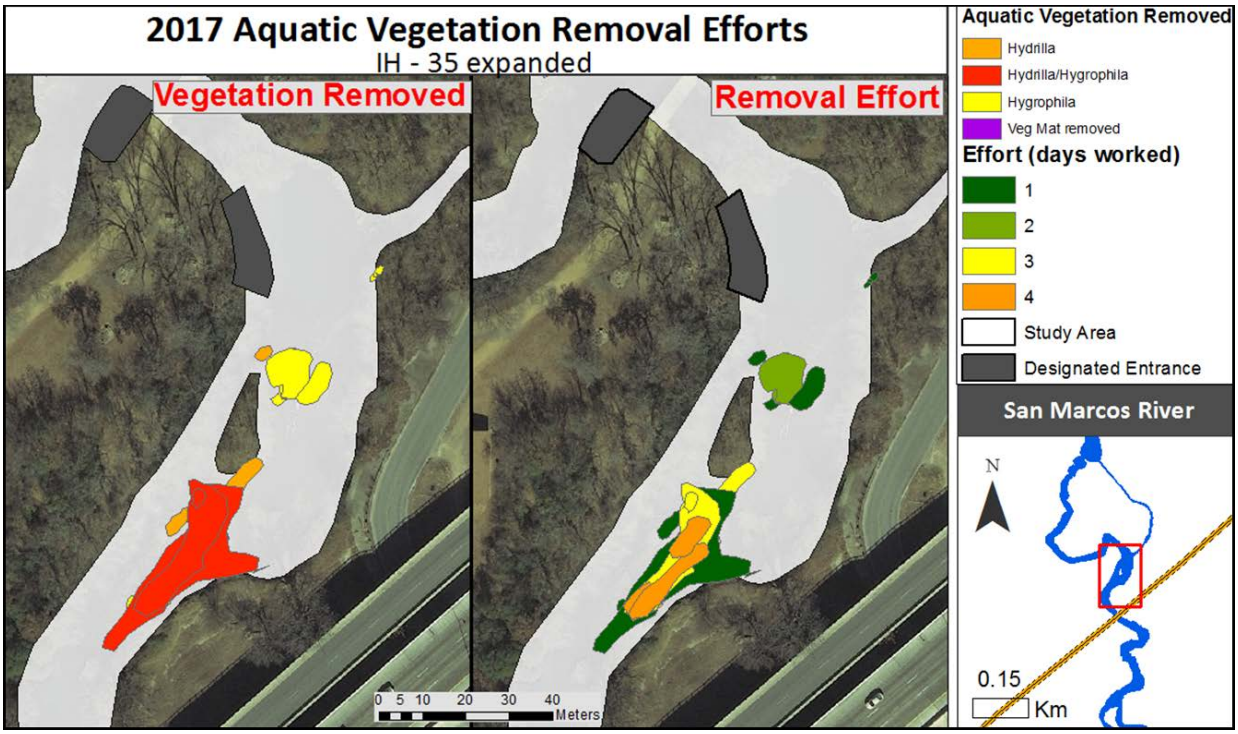

Figure 3.3-21. Non-native aquatic vegetation removal locations and degree of effort in the IH-35 expanded reach of the San Marcos River (2017).

Denuded areas were targeted for Texas wild-rice or selected native aquatic species planting based on habitat preferences for each native species. Texas wild-rice and native species were obtained from the USFWS SMARC or from raceways located at the FAB at Texas State Campus. **Table 3.3-4** denotes the number of plants per species maintained in the raceways on Texas State University campus each month. Initial efforts for restoration of Texas wild-rice or native vegetation were targeted at planting approximately 20 to 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 treatment 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. Vegetation work sites were separated into LTBG or restoration reaches to assess changes among and within reaches of the San Marcos River.

Table 3.3-4. Total Number of Plants per Species Maintained Each Month in the Raceways at the Freeman Aquatic Building in 2017

Month	Species				
	Zizania	*Potamogeton*	*Ludwigia*	*Sagittaria*	*Cabomba*
January	760	930	285	45	1,035
February	275	380	840	105	1,470
March	665	1,300	510	63	1,470
April	800	810	1,200	0	1,275
May	1,030	518	1,419	0	935
June	955	952	1,364	0	715
July	1,1176	786	640	0	288

Table 3.3-4. Total Number of Plants per Species Maintained Each Month in the Raceways at the Freeman Aquatic Building in 2017

Month	Species				
	Zizania	*Potamogeton*	*Ludwigia*	*Sagittaria*	*Cabomba*
August	534	906	1,116	16	236
September	1,225	1,560	1,566	6	1,026
October	648	1,484	1,525	170	672

2017 Restoration Reaches (Aquatic Vegetation Non-Native Removal and Native Planting Sites)

In 2017, aquatic vegetation treatment efforts were focused in works sites listed on Table 34 of the SAV Report. This included non-native removal and native planting efforts within Spring Lake, Spring Lake Dam LTBG Reach, City Park LTBG Reach, Cypress Island Restoration Reach, IH-35 LTBG Reach, and expanded IH-35 Restoration Reach (**Figure 3.3-22**). Aquatic vegetation maintenance (i.e., non-native removal) was performed in other reaches when necessary.

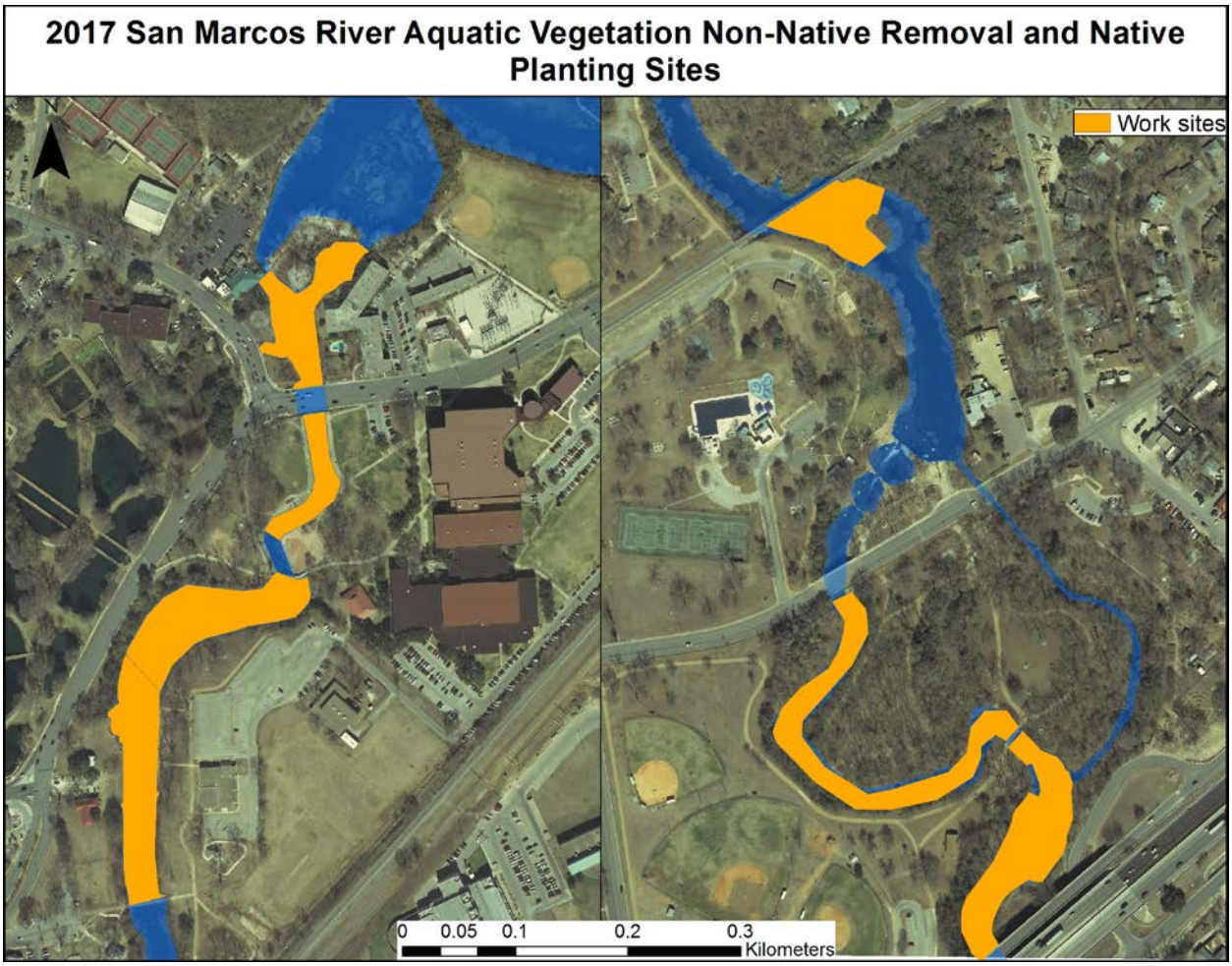

Figure 3.3-22. Map of non-native removal and native planting sites in the LTBG and Restoration reaches in the San Marcos River.

Spring Lake

Aquatic vegetation work efforts in Spring Lake occurred adjacent to previously established Texas wild-rice stands from 2016 and in new additional areas upstream within the lake. Non-native removal efforts in Spring Lake occurred between January 11, 2017 through October 3, 2017, for a total of five days and removed approximately 329 m^2 of *Hygrophila*. Once the area was denuded of non-native aquatic vegetation, Texas wild-rice plants grown at FAB or SMARC were planted. Texas wild-rice planting efforts occurred between January 12, 2017 through October 3, 2017, for a total of eight days and planted approximately 4,412 Texas wild-rice individuals, covering an estimated area of 279 m^2 (**Figure 3.3-23**).

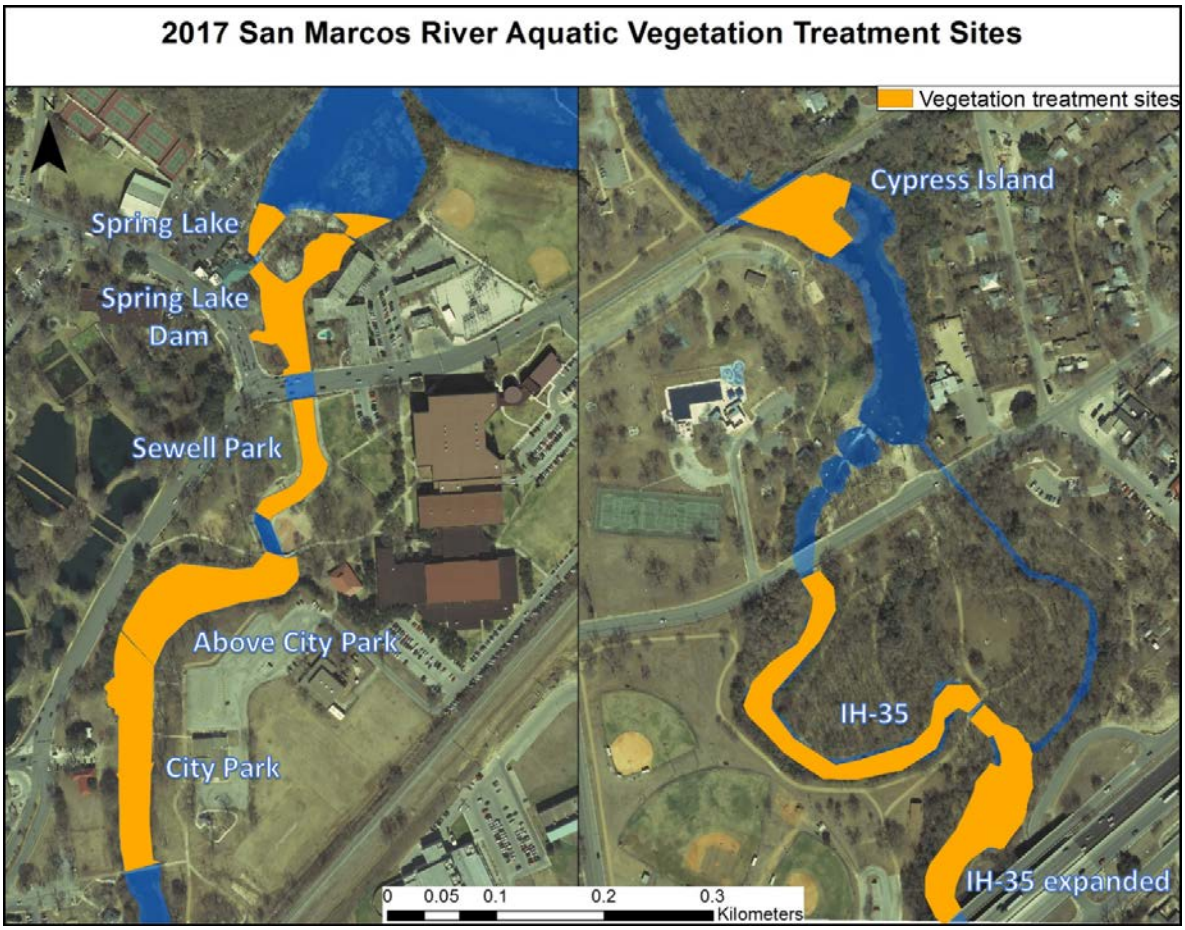

Figure 3.3-23. Locations of aquatic vegetation removal (left) and planting (right) efforts in Spring Lake (2017).

Figure 3.3-24 illustrates Texas wild-rice aerial coverage in fall 2016 and fall 2017. Approximate aerial coverage of Texas wild-rice in Spring Lake in fall 2016 was 47 m^2. After additional plantings in 2017, approximate aerial coverage in fall 2017 increased to 184 m^2. Unsuccessful establishment of Texas wild-rice plantings was observed in areas upstream of the western spillway in Spring Lake. The area planted was not in riparian shading and had flowing water but was in silt substrate. Continued assessment of successful Texas wild-rice establishment locations in Spring Lake will continue into 2018.

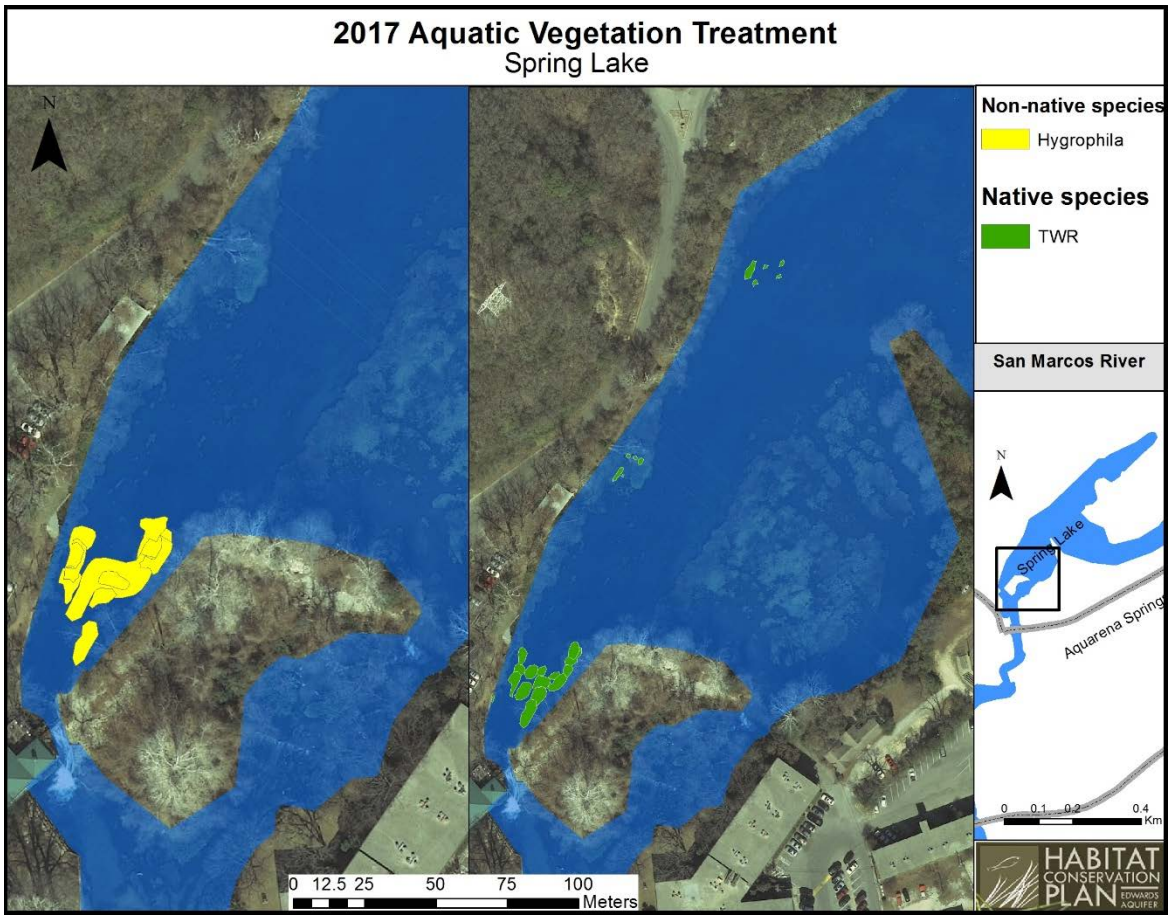

Figure 3.3-24. Texas wild-rice aerial coverage in Spring Lake in fall 2016 and fall 2017.

Spring Lake Dam LTBG Reach

Non-native removal efforts in the Spring Lake Dam LTBG Reach consisted of six days (between February 7, 2017 and November 2, 2017) and removed approximately 498 m^2 of *Hydrilla*, *Hygrophila*, and vegetation mats. Once the area was denuded of non-native aquatic vegetation, native species were planted that were grown at FAB raceways at Texas State or at the SMARC. Native species plantings occurred on five days (between February 19, 2017 and November 2, 2017) and planted approximately 934 native species individuals, covering an estimated 30 m^2 (**Figure 3.3-25**). Native species planted in the Spring Lake Dam LTBG Reach included: *Cabomba* (120 individuals), *Ludwigia* (804 individuals), and *Sagittaria* (10 individuals).

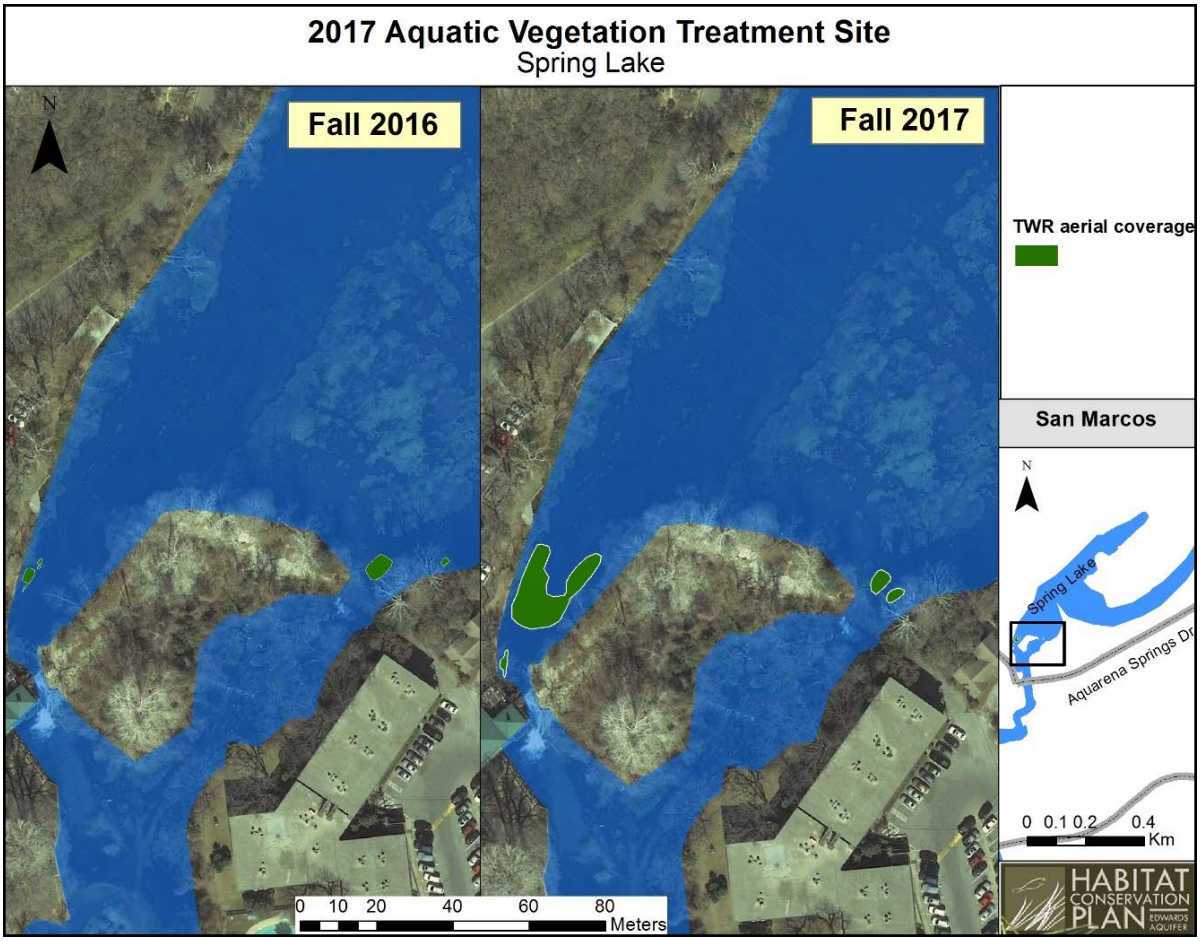

Figure 3.3-25. Locations of aquatic vegetation removal (left) and planting (right) efforts in Spring Lake Dam LTBG Reach (2017).

Table 3.3-5 denotes areas (m^2) of aquatic vegetation species for fall 2016, fall 2017, and aquatic vegetation species area changes (m^2) between 2016 and 2017 within the Spring Lake Dam LTBG Reach of the San Marcos River. Continued expansion of Texas wild-rice and *Potamogeton* was observed in 2017 (572.37 m^2, and 128.64 m^2, respectively) and establishment of 17 m^2 of *Ludwigia* also occurred in this reach. Minimal aerial coverage of non-native aquatic vegetation (~33 m^2) was observed for fall 2017 in the Spring Lake Dam LTBG Reach. Continued expansion of native aquatic vegetation in the Spring Lake Dam LTBG Reach was likely attributed in part to the perimeter fence constructed in 2016 that reduced the level of recreation in the area (**Figure 3.3-26**).

Table 3.3-5. Area (m^2) of Aquatic Vegetation Within Spring Lake Dam LTBG Reach of the San Marcos River 2016 – 2017, and Changes Detected 2016 – 2017

Species	2016 *	2017	Change 2016 – 2017
Cabomba	2.3	0.92	-1.38
Heteranthera	-	0.25	0.25
Hydrilla	-	4.92	4.92
Hygrophila	47.4	28.2	-19.2
Hydrocotyle	21.8	72.53	50.73
Ludwigia	-	17.34	17.34
Nasturtium	-	-	-
Pistia	7.5	-	-7.5
Potamogeton	109.7	238.34	128.64
Sagittaria	7.80	25.55	17.75
Vallisneria	2.50	0.68	-1.82
Zizania	816.90	1,389.27	572.37

*Non-native vegetation species highlighted in red.

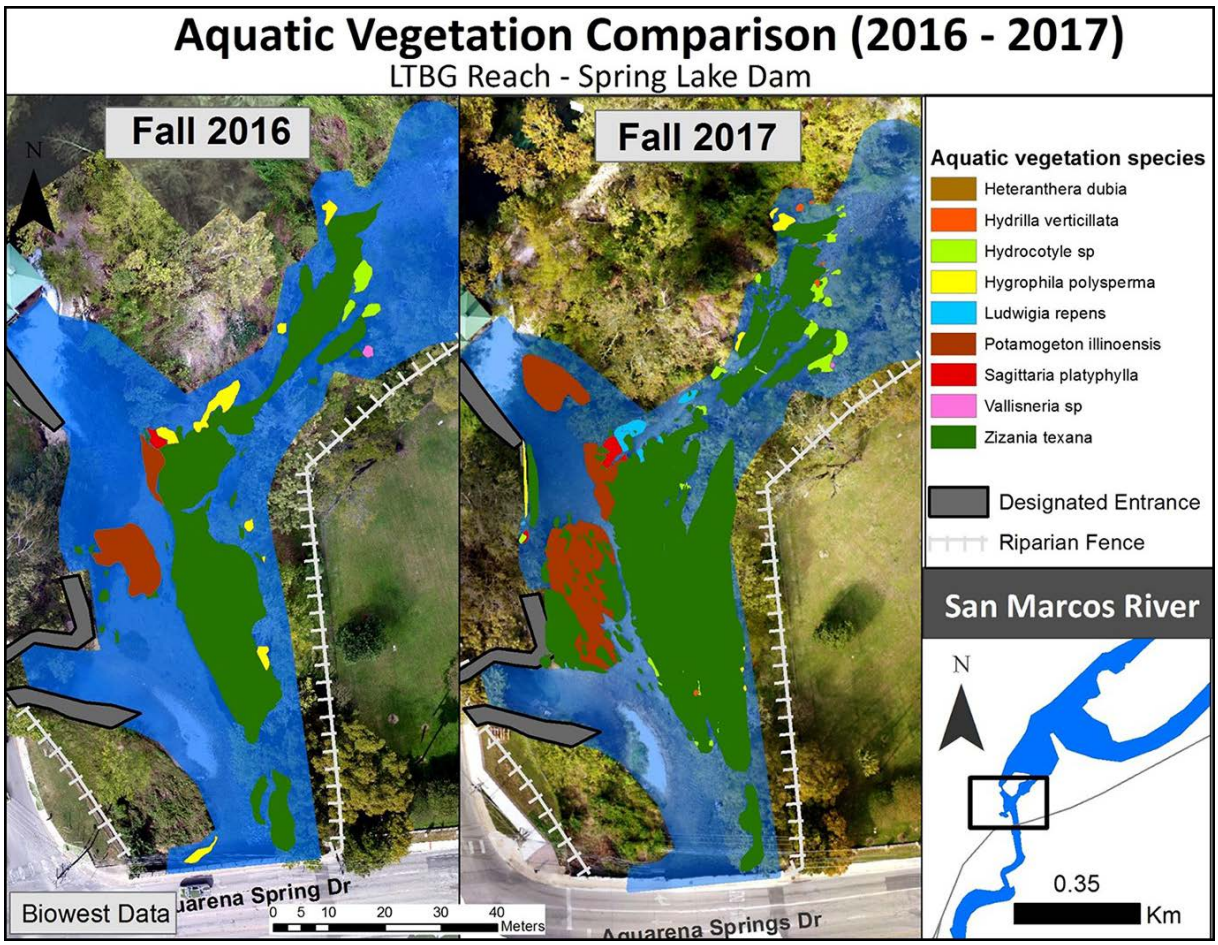

Figure 3.3-26. Changes in aquatic vegetation within the Spring Lake Dam LTBG Reach of the San Marcos River from fall 2016 to fall 2017.

Sewell Park Restoration Reach

Only aquatic vegetation maintenance was performed in the Sewell Park Restoration Reach during 2017 since the reach was not listed as a designated work area in Table 34 of the SAV Report that denotes the restoration timeline to meet proposed EAHCP goals. Aquatic vegetation maintenance was performed for a total of six days (between June 14, 2017 and November 3, 2017) and removed approximately 698 m^2 of *Hydrilla*, *Hygrophila*, watercress, and vegetation mats. 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. Since no native species expansion was listed in Table 34 of the SAV Report for the Sewell Park reach this year, aerial coverage of native aquatic vegetation was monitored but not mapped. Aerial imagery of aquatic vegetation in Sewell Park captured between fall 2016 and fall 2017 showed no loss in native aquatic vegetation coverage. Gaps in aquatic vegetation observed in fall 2016 were repopulated during 2017 with expansion observed in the native species, Texas wild-rice and *Potamogeton*.

Below Sewell Park to City Park Restoration Reach

Only aquatic vegetation maintenance was performed in the below Sewell Park to City Park reach during 2017 since the reach was not listed as a designated work area in Table 34 of the SAV Report denoting the restoration timeline to meet proposed EAHCP goals. Aquatic vegetation maintenance was performed for a total of four days (between February 10, 2017 and November 3, 2017) and removed approximately 841 m^2 of watercress (**Figure 3.3-27**). Watercress can block sunlight to underlying aquatic vegetation and can eventually lead to vegetation die off. Therefore, removing watercress covering Texas wild-rice stands and other native aquatic vegetation can be an important component in the success of planting native aquatic vegetation. Since no native species expansion was listed in Table 34 of the SAV Report for the below Sewell Park to City Park reach this year, aerial coverage of native aquatic vegetation was monitored but not mapped. Aerial imagery of aquatic vegetation in the below Sewell Park to City Park reach captured between fall 2016 and fall 2017 showed no loss in native aquatic vegetation coverage (**Figure 3.3-27**).

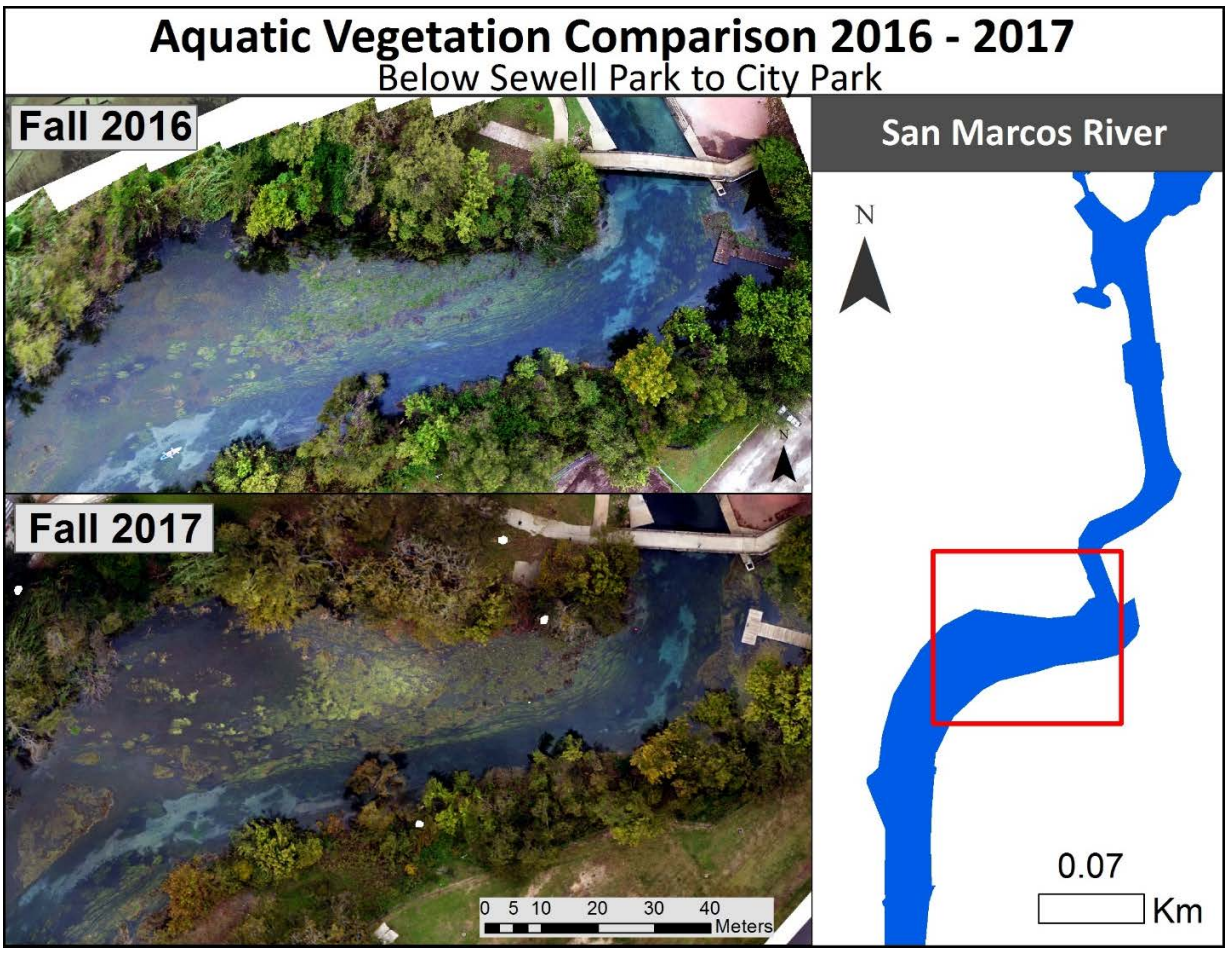

Figure 3.3-27. Aerial imagery of aquatic vegetation coverage in fall 2016 and fall 2017 within the below Sewell Park to City Park reach of the San Marcos River.

City Park

Non-native removal efforts in the City Park LTBG Reach consisted of 16 days (between February 10, 2017 and September 14, 2017) and removed approximately 691 m^2 of *Hydrilla*, *Hygrophila*, and vegetation mats. Once the area was denuded of non-native aquatic vegetation, native species were planted that were grown at FAB or SMARC. Native species plantings occurred on 15 days (between February 24, 2017 and September 6, 2017) and planted approximately 7,408 native species individuals, covering an estimated area of 287 m^2 (**Figure 3.3-28**). Native species planted in the City Park LTBG Reach included: *Potamogeton* (2,588 individuals) *Cabomba* (983 individuals), *Ludwigia* (2,733 individuals), and *Sagittaria* (1,104 individuals).

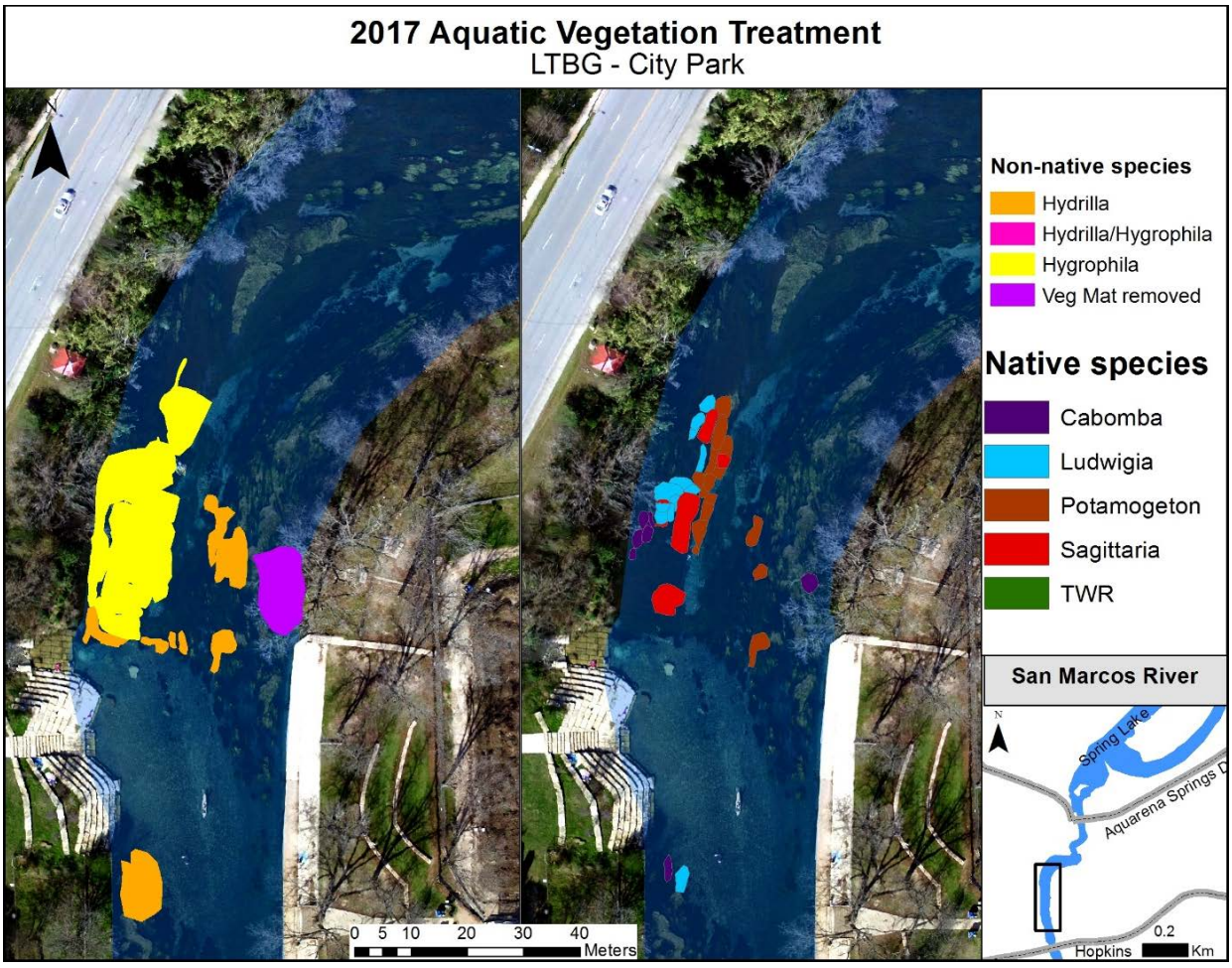

Figure 3.3-28. Locations of aquatic vegetation removal (left) and planting (right) efforts in City Park LTBG Reach (2017).

Table 3.3-6 denotes areas (m^2) of aquatic vegetation species for fall 2016, fall 2017, and aquatic vegetation species area changes (m^2) between 2016 and 2017 within the City Park LTBG Reach of the San Marcos River. **Figure 3.3-29** illustrates the changes in aerial coverage of aquatic vegetation between fall 2016 and fall 2017.

Table 3.3-6. Area (m^2) of Aquatic Vegetation Within City Park LTBG Reach of the San Marcos River for Fall 2016 and Fall 2017, and Changes Detected 2016 through 2017

Species	2016 *	2017	Change 2016 – 2017
Cabomba	-	32.92	32.92
Heteranthera	2.55	0.35	-2.2
Hydrilla	503.2	491.03	-12.17
Hygrophila	264.2	595.08	330.88
Hydrocotyle	-	5.46	5.46
Ludwigia	1.3	47.31	46.01
Nasturtium	-	1.84	1.84
Potamogeton	133	250.23	117.23
Sagittaria	112.70	145	32.30

Table 3.3-6. Area (m^2) of Aquatic Vegetation Within City Park LTBG Reach of the San Marcos River for Fall 2016 and Fall 2017, and Changes Detected 2016 through 2017

Species	2016 *	2017	Change 2016 – 2017
Vallisneria	-	1.61	1.61
Zizania	1,561.50	2,247.23	685.73

*Non-native vegetation species highlighted in red.

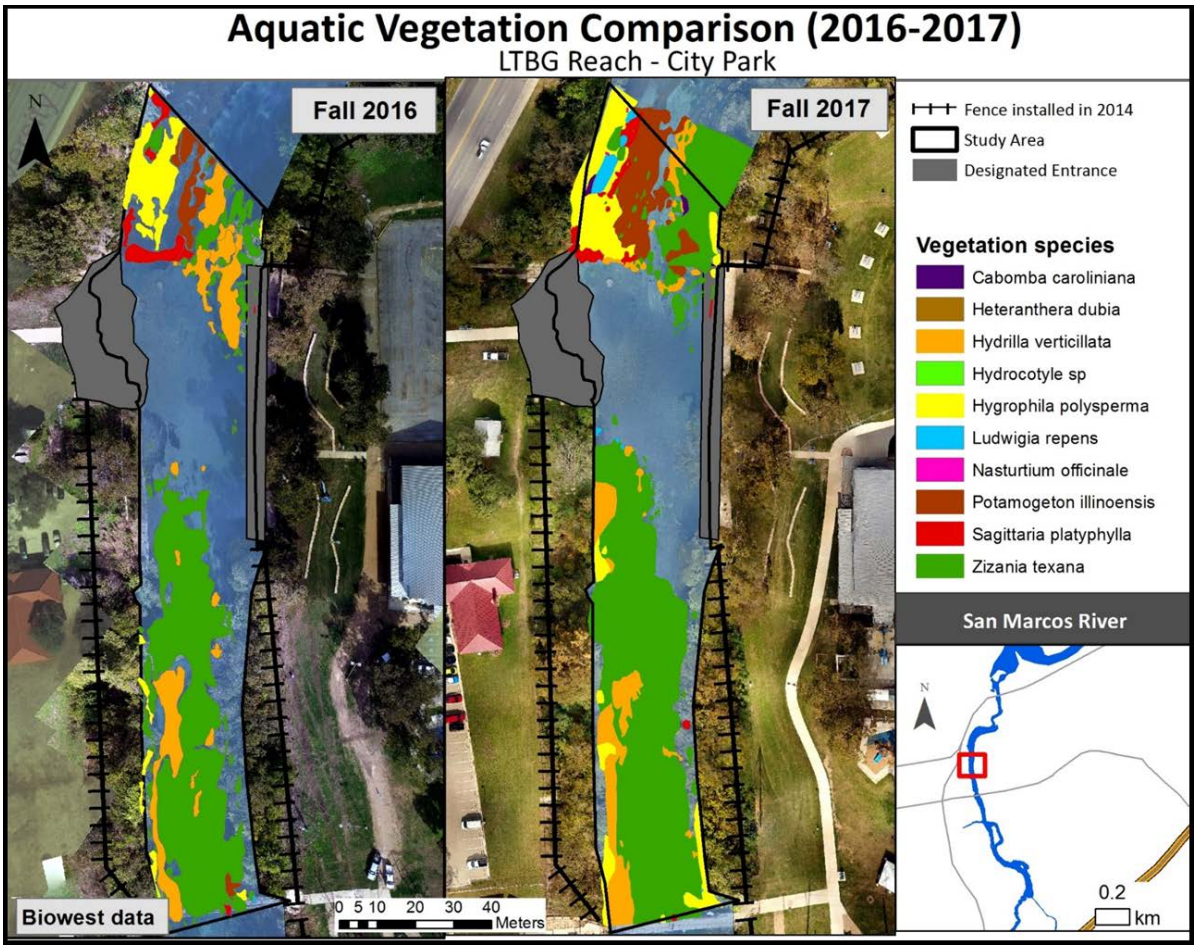

Figure 3.3-29. Changes in aquatic vegetation within the City Park LTBG Reach of the San Marcos River from fall 2016 to fall 2017.

Hopkins Street – Purgatory Creek Restoration Reach

No work was performed in the Hopkins St – Purgatory Creek restoration reach during 2017 since the reach was not listed as a designation work area in Table 34 of the SAV Report denoting the proposed restoration timeline to meet proposed EAHCP goals. Since no native species expansion was listed in Table 34 of the SAV Report for 2107 in this reach, aerial coverage of native aquatic vegetation was monitored but not

mapped. Aerial imagery of aquatic vegetation in the Hopkins Street – Purgatory Creek reach captured between fall 2016 and fall 2017 showed no loss in native aquatic vegetation coverage (**Figure 3.3-30**).

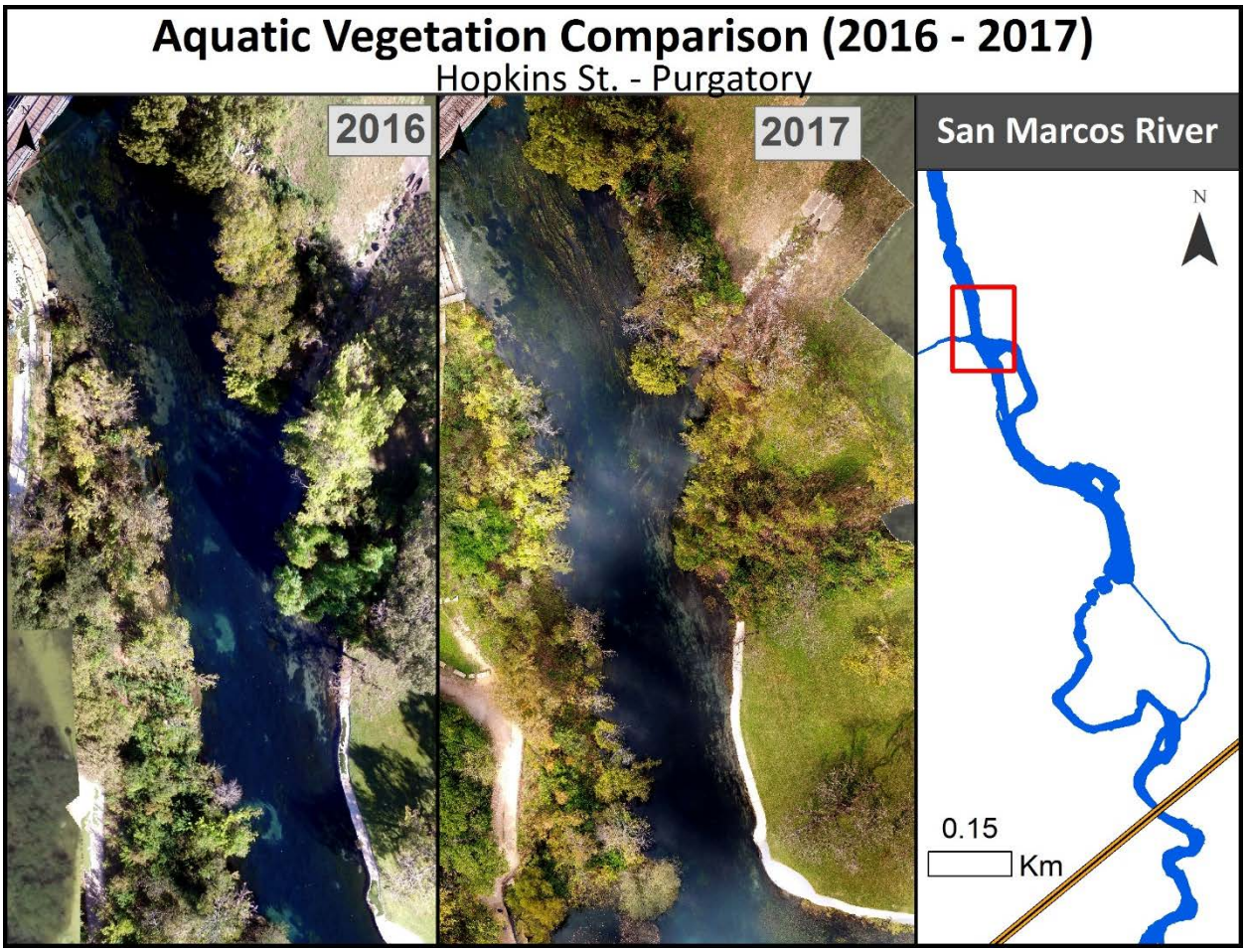

Figure 3.3-30. Aerial imagery of aquatic vegetation coverage in fall 2016 and fall 2017 within the Hopkins St – Purgatory Creek reach of the San Marcos River.

Cypress Island

Non-native removal efforts in the Cypress Island reach consisted of nine days (between September 12, 2017 and October 27, 2017) and removed approximately 191 m^2 of *Hydrilla*. Once the area was denuded of non-native aquatic vegetation, native species were planted that were grown at FAB or SMARC. Native species plantings occurred on six days (between September 15, 2017 and October 27, 2017) and planted approximately 1,592 native species individuals, covering an estimated area of 39 m^2 (**Figure 3.3-31**). Native species planted in the Cypress Island included: *Cabomba* (152 individuals), *Ludwigia* (937 individuals), *Potamogeton* (396 individuals), and *Sagittaria* (107 individuals).

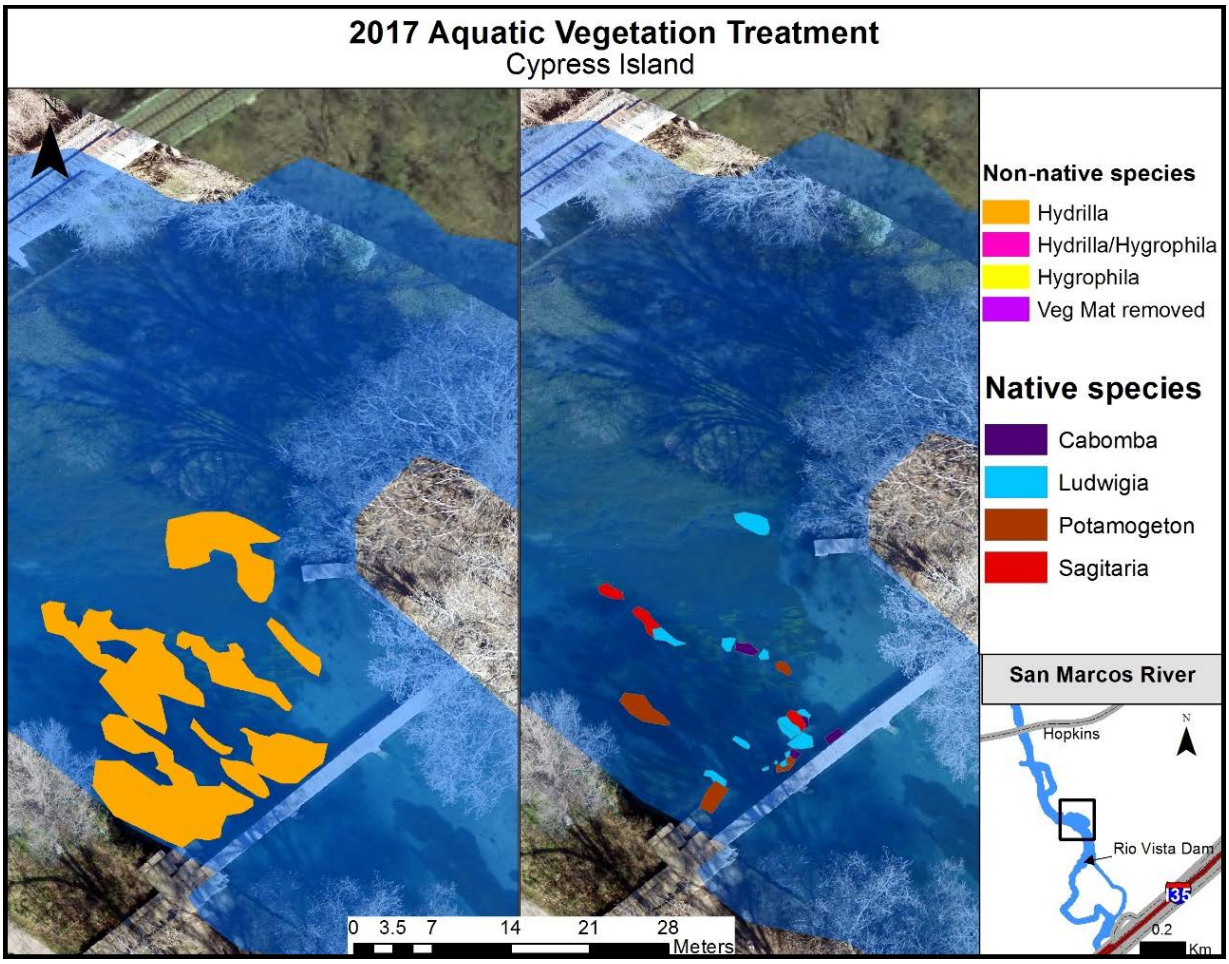

Figure 3.3-31. Locations of aquatic vegetation removal (left) and planting (right) efforts in Cypress Island reach of the San Marcos River (2017).

Table 3.3-7 denotes areas (m^2) of aquatic vegetation species for fall 2016, fall 2017, and area changes in aquatic vegetation species (m^2) between 2016 and 2017 within the Cypress Island Restoration Reach of the San Marcos River. Establishment of close to 15 m^2 of *Ludwigia* was observed and small aerial increases of other native species including *Cabomba*, *Sagittaria*, and *Potamogeton*, and Texas wild-rice occurred in 2017. Aerial coverage estimates of the non-native species, *Hydrilla verticillata*, increased during 2017 in the Cypress Island Restoration Reach, but this is mostly due to higher densities of *Hydrilla* in existing stands rather than the further expansion of the species in the reach (e.g., a *Hydrilla* stand was estimated at 70 percent coverage in fall 2016 and was observed to be 90 percent coverage in fall 2017). **Figure 3.3-32** illustrates the changes in aerial coverage of aquatic vegetation in the Cypress Island Restoration Reach from fall 2016 to fall 2017.

Table 3.3-7. Area (m^2) of Aquatic Vegetation at Cypress Island Restoration Reach of the San Marcos River 2016 – 2017, and Changes Detected 2016 through 2017

Species	2016*	2017	Change 2016 – 2017
Cabomba	1.97	4.78	2.81
Heteranthera	82.36	100.48	18.12
Hydrilla	1,284.71	1,562.82	278.11
Hygrophila	3.07	38.31	35.24
Ludwigia	-	14.89	14.89
Potamogeton	-	1.56	1.56
Sagittaria	0.65	3.81	3.16
Vallisneria	-	3.13	3.13
Zizania	246.91	247.71	0.8

*Non-native vegetation species highlighted in red.

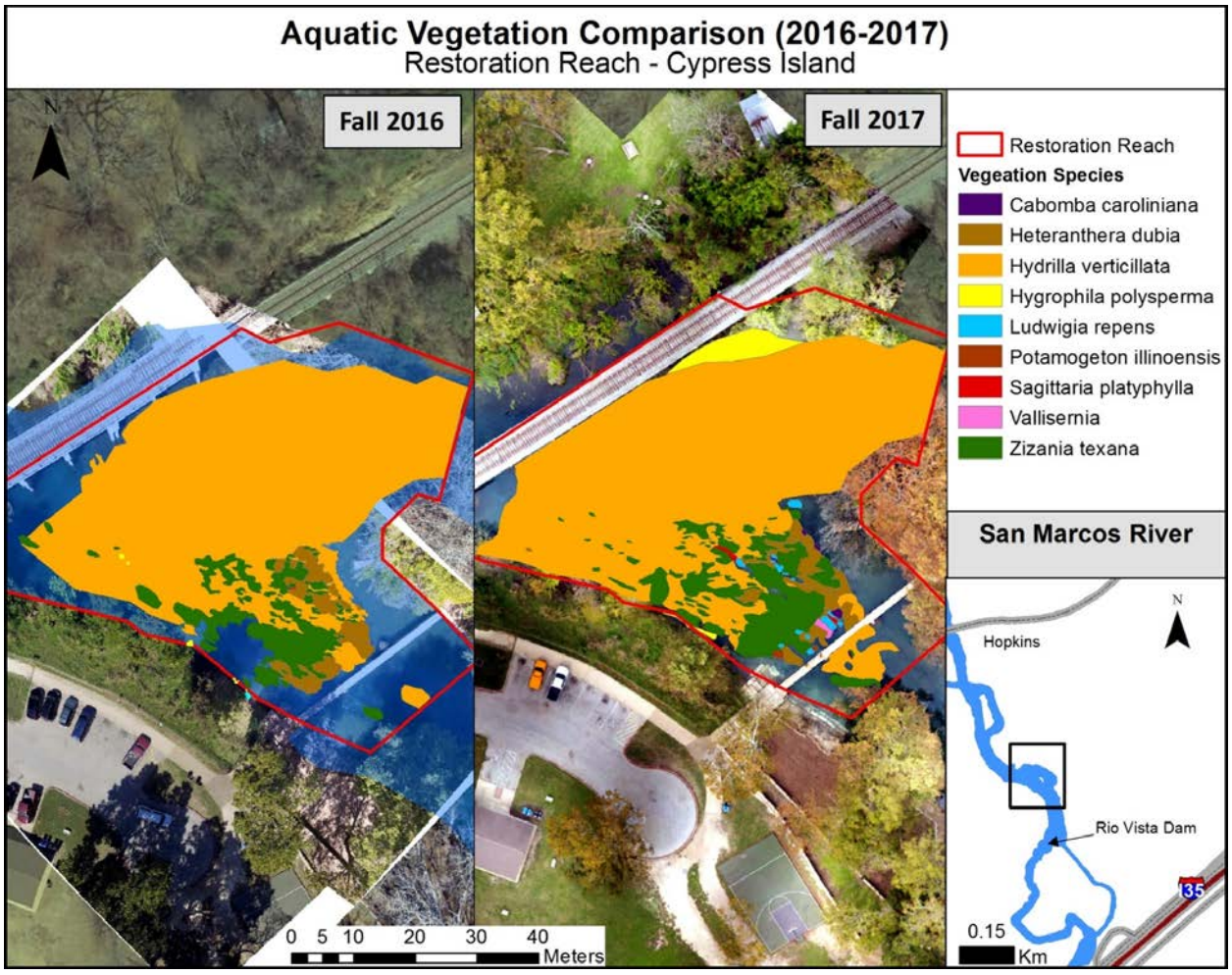

Figure 3.3-32. Changes in aquatic vegetation fall 2016 and fall 2017 in the Cypress Island Restoration Reach of the San Marcos River.

IH-35 LTBG Reach

Non-native removal efforts in the IH-35 LTBG Reach occurred on two days (October 9, 2017 and October 23, 2017) and removed approximately 11 m^2 of *Hydrilla* and *Hygrophila*. Once the area was denuded of non-native aquatic vegetation, Texas wild-rice plants and other native species were planted that were grown at FAB or SMARC. Texas wild-rice and other native species plantings occurred on seven days (between August 2, 2017 and October 30, 2017) and planted approximately 2,811 native species individuals, covering an estimated area of 144 m^2 (**Figure 3.3-33**). Native species planted in the IH-35 LTBG Reach included: *Cabomba* (268 individuals), *Ludwigia* (620 individuals), *Potamogeton* (1,056 individuals), *Sagittaria* (155 individuals) and Texas wild-rice (712 individuals).

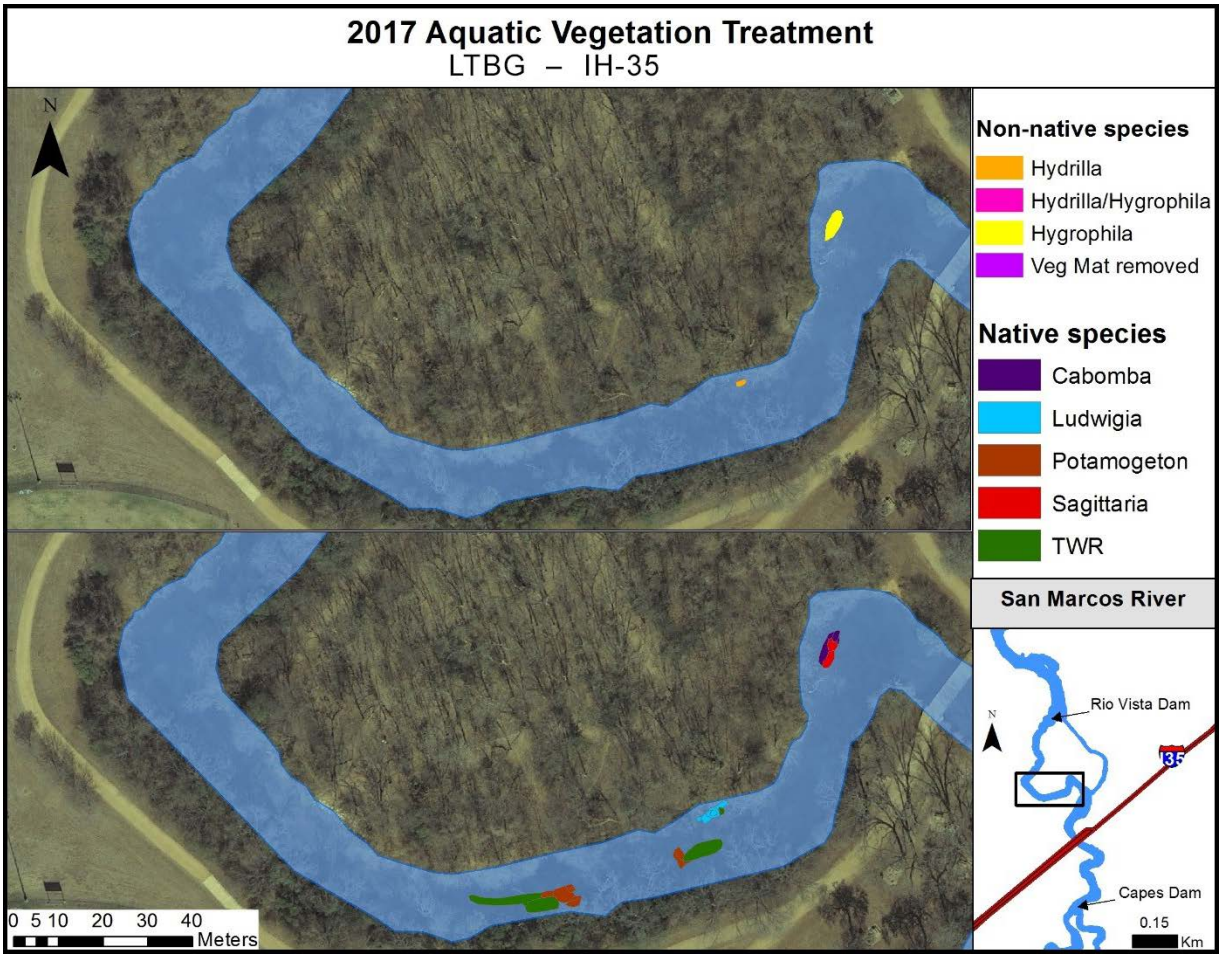

Figure 3.3-33. Locations of aquatic vegetation removal (top) and planting (bottom) efforts in IH-35 LTBG Reach of the San Marcos River (2017).

Table 3.3-8 denotes areas (m^2) of aquatic vegetation species for fall 2016, fall 2017, and area changes in aquatic vegetation species (m^2) between 2016 and 2017 within the IH-35 LTBG Reach of the San Marcos River. Expansion of Texas wild-rice and *Cabomba* was observed in 2017 (86.44 m^2, and 19.38 m^2, respectively) and establishment of 7 m^2 of *Ludwigia*, 15 m^2 of *Potamogeton*, and ~5 m^2 of *Sagittaria* also occurred in this reach. Minimal aerial coverage of non-native aquatic vegetation (~39 m^2) was observed for

fall 2017 in the IH-35 LTBG Reach. **Figure 3.3-34** illustrates the changes in aerial coverage of aquatic vegetation in the IH-35 LTBG Reach from fall 2016 to fall 2017.

Table 3.3-8. Area (m^2) of Aquatic Vegetation in the IH-35 LTBG Reach of the San Marcos River 2016 – 2017, and Changes Detected 2016 – 2017

Species	2016 *	2017	Change 2016 – 2017
Cabomba	13.93	33.31	19.38
Heteranthera	1.98	5.42	3.44
Hydrilla	0.67	30.54	29.87
Hygrophila	7.62	16.98	9.36
Ludwigia	-	7.01	7.01
Potamogeton	-	15.12	15.12
Sagittaria	-	4.93	4.93
Zizania	69.75	156.19	86.44

*Non-native vegetation species highlighted in red.

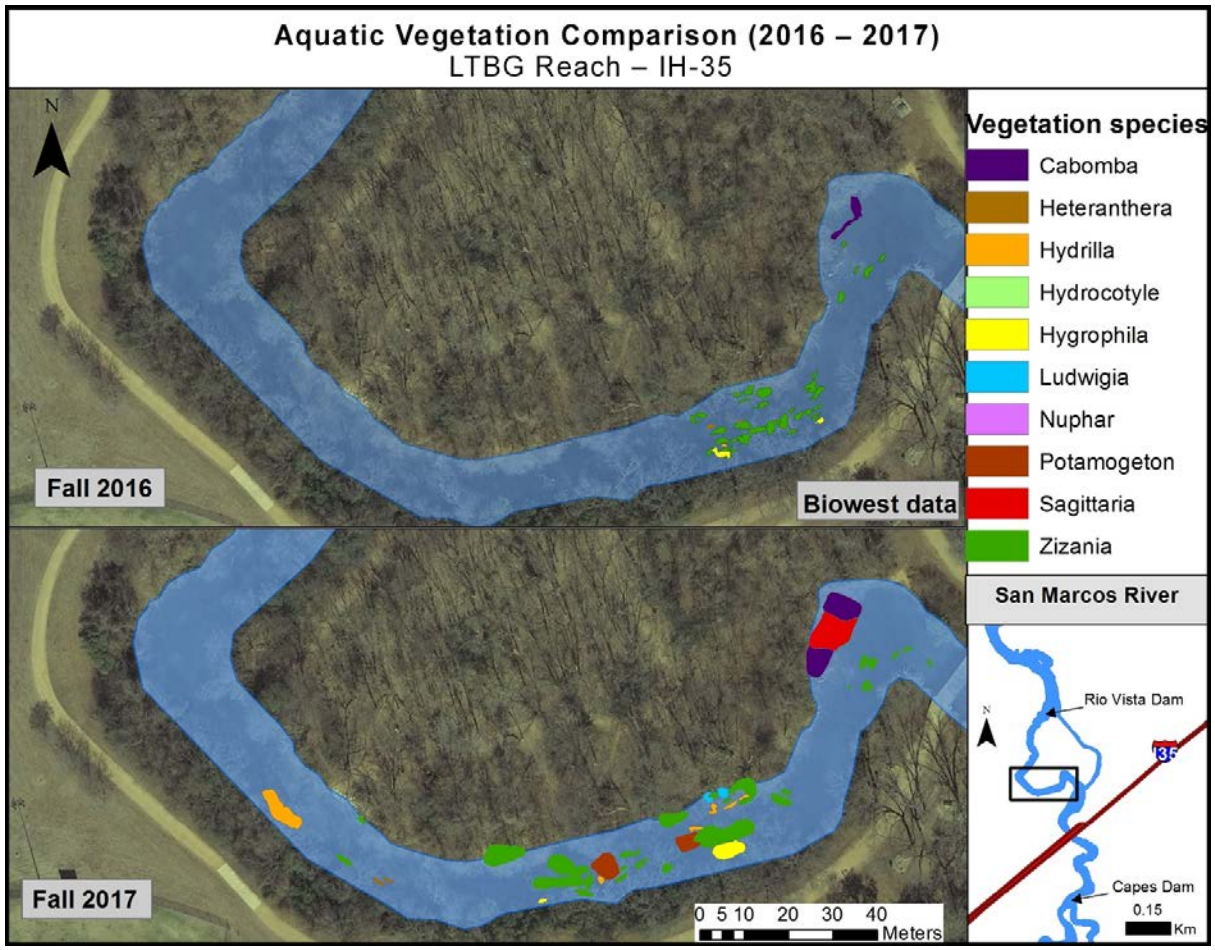

Figure 3.3-34. Aquatic vegetation coverage in the IH-35 LTBG Reach of the San Marcos River (fall 2016 and fall 2017).

IH-35 Expanded Restoration Reach

Non-native removal efforts in the IH-35 expanded Restoration Reach occurred on 14 days (between January 3, 2017 and November 1, 2017) and removed approximately 361 m^2 of *Hydrilla* and *Hygrophila*. Once the area was denuded of non-native aquatic vegetation, Texas wild-rice plants and other native species were planted that were grown at FAB or SMARC. Texas wild-rice and other native species plantings occurred on 14 days (between October 19, 2017 and November 1, 2017) and planted approximately 5,607 native species individuals, covering an estimated area of 205 m^2 (**Figure 3.3-35**). Native species planted in the IH-35 expanded reach included: *Cabomba* (630 individuals), *Ludwigia* (2,240 individuals), *Potamogeton* (961 individuals), *Sagittaria* (122 individuals), and Texas wild-rice (1,654 individuals).

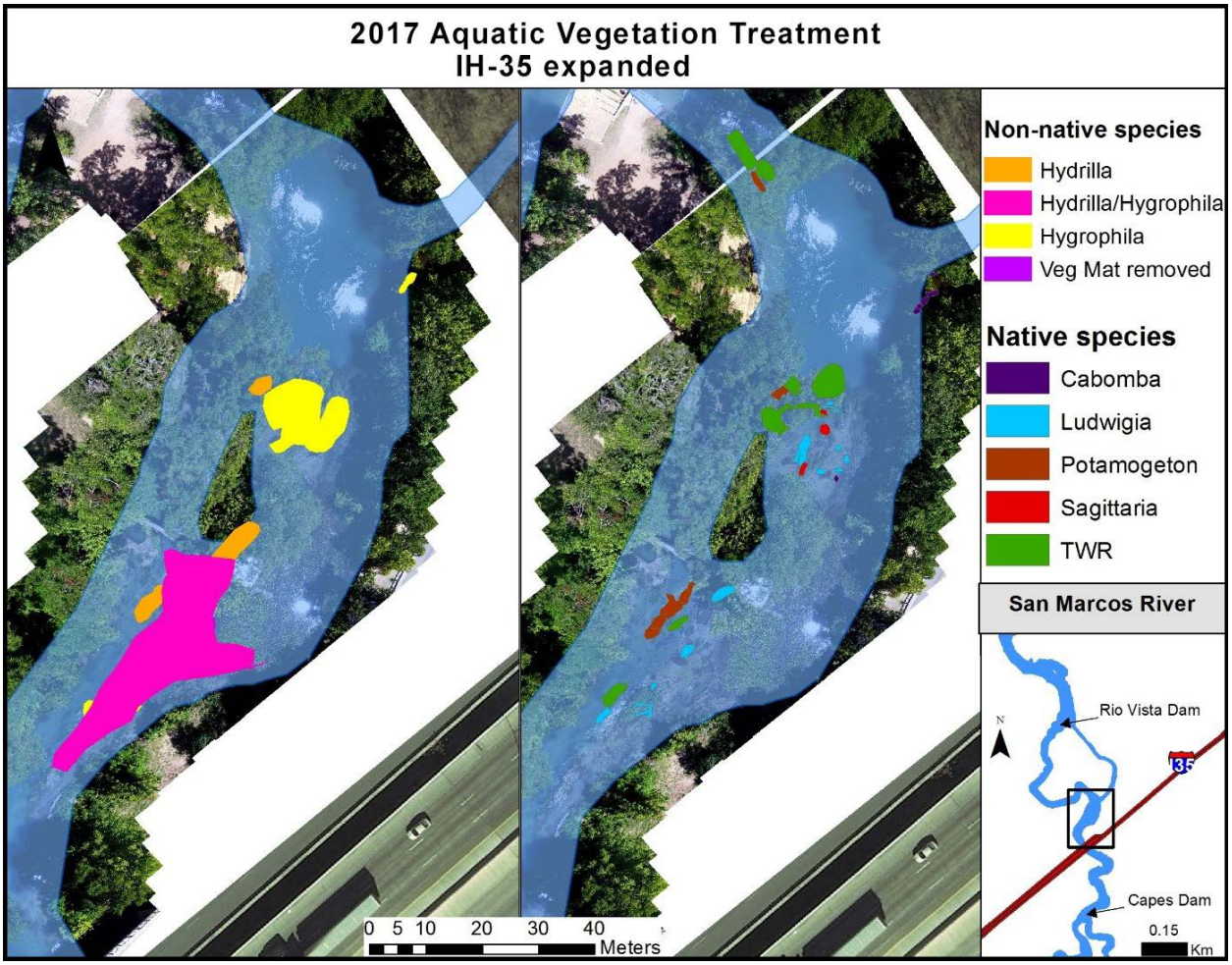

Figure 3.3-35. Locations of aquatic vegetation removal (left) and planting (right) efforts in IH-35 expanded Restoration Reach of the San Marcos River (2017).

Table 3.3-9 denotes areas (m^2) of aquatic vegetation species for fall 2016, fall 2017, and area changes in aquatic vegetation species (m^2) between 2016 and 2017 within the IH-35 expanded Restoration Reach of the San Marcos River. Expansion of Texas wild-rice and *Ludwigia* was observed in 2017 (156.08 m^2, and 86.19 m^2, respectively). Other native species with aerial coverage increases in 2017 include: *Sagittaria* (80.21 m^2), *Cabomba* (27.12 m^2), and *Heteranthera* (27.12 m^2). Despite several planting events in 2017,

no establishment of *Potamogeton* occurred in the IH-35 expanded reach in 2017. Aerial coverage of non-native species, *Hydrilla verticillata*, decreased during 2017 (-81.11 m^2); however, an increase in *Hygrophila polysperma* was observed (37.26 m^2). **Figure 3.3-36** illustrates the changes in aerial coverage of aquatic vegetation in the IH-35 expanded Restoration Reach from fall 2016 to fall 2017.

Table 3.3-9. Area (m^2) of Aquatic Vegetation in the IH-35 Expanded Restoration Reach of the San Marcos River 2016 – 2017, and Changes Detected 2016 – 2017

Species	2016*	2017	Change 2016 – 2017
Cabomba	11.23	38.35	27.12
Heteranthera	0.23	12.67	12.44
Hydrilla	99.62	18.51	-81.11
Hygrophila	200.25	237.51	37.26
Hydrocotyle	18.64	6.79	-11.85
Ludwigia	170.71	256.9	86.19
Nuphar	32.22	22.38	-9.84
Potamogeton	13.81	-	-13.81
Sagittaria	552.16	632.37	80.21
Zizania	188.50	344.58	156.08

*Non-native vegetation species highlighted in red.

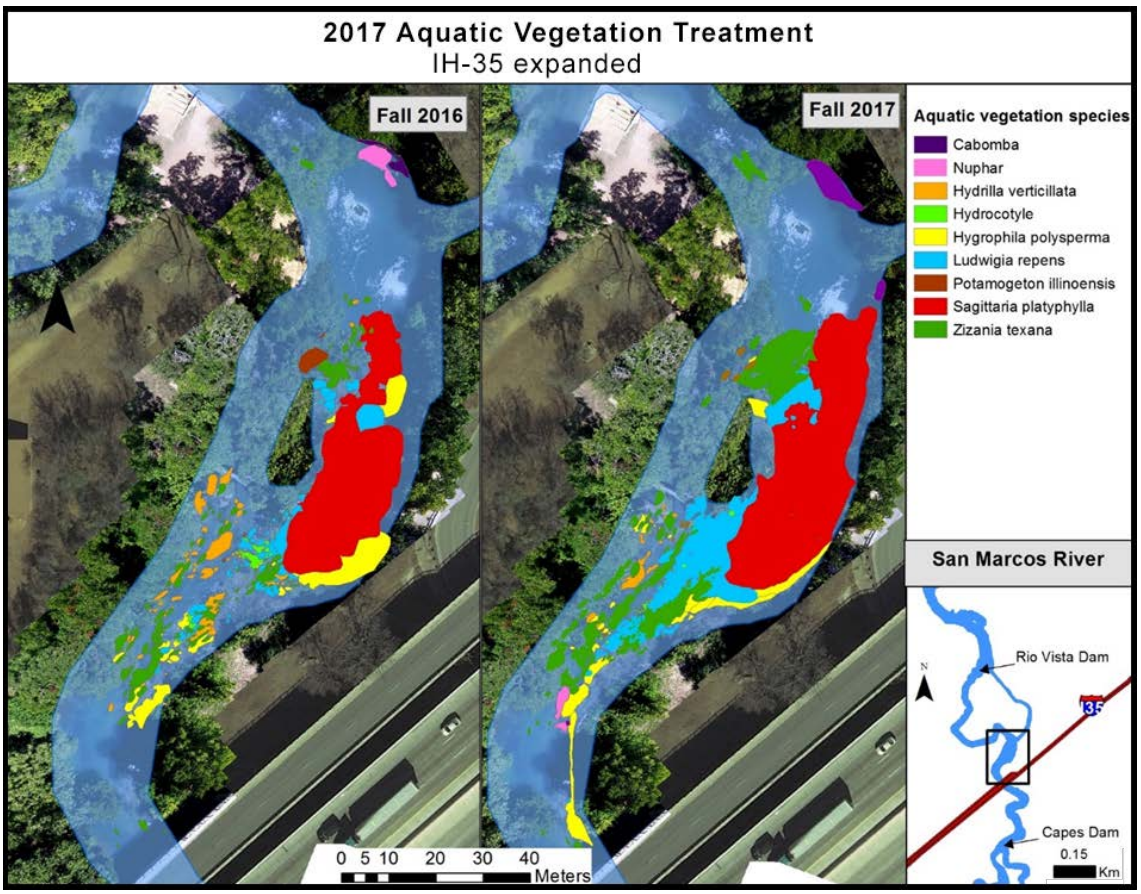

Figure 3.3-36. Aquatic vegetation coverage in the IH-35 expanded Restoration Reach of the San Marcos River (fall 2016 and fall 2017).

Summary of 2017 Aquatic Vegetation LTBG and Restoration Reaches

Table 3.3-10 denotes the amount of non-native aquatic vegetation removed in the San Marcos River in 2017. Approximately 3,595 m^2 of non-native aquatic vegetation was removed from Spring Lake and the San Marcos River in 2017. Large amounts of watercress and vegetation mats were removed to prevent native vegetation die-off from lack of sunlight availability.

Table 3.3-10. Amount of Non-Native Vegetation Species Removed in San Marcos River (2017)

River Reach	Species	Estimated Area (m^2)	Effort (days worked)
Spring Lake	*Hygrophila polysperma*	328	5
Spring Lake Dam LTBG	*Hydrilla verticillata*	19	4
	Hygrophila polysperma	74	5
	Vegetation mat	405	3
Sewell Park	*Hydrilla verticillata*	45	4
	Hygrophila polysperma	21	3
	Vegetation mat	609	3
	Watercress	23	1
Below Sewell to City Park	*Watercress*	841	4
City Park LTBG	*Hydrilla verticillata*	164	9
	Hygrophila polysperma	492	13
	Vegetation mat	33	1
	Watercress	3	1
Cypress Island	*Hydrilla verticillata*	191	9
IH-35 LTBG	*Hydrilla verticillata*	2	1
	Hygrophila polysperma	9	1
IH-35 Expanded	*Hydrilla verticillata*	147	5
	Hygrophila polysperma	131	11
	Vegetation Mat	83	1
TOTAL RIVER	*Hydrilla verticillata*	567	32
	Hygrophila polysperma	1,055	38
	Vegetation mat	1,130	8
	Watercress	843	5

The estimated number of native species planted in the San Marcos River vegetation LTBG and Restoration reaches was 22,964 individuals in 2017. The greatest number of individuals planted was *Ludwigia repens* (7,534), followed by Texas wild-rice (6,778), *Potamogeton illinoensis* (5,001), *Cabomba* (2,153), and S*agittaria platyphylla* (1,498).

Table 3.3-11 denotes the number of individuals planted and the planting efforts in terms of days worked were necessary for San Marcos River reach and species.

Table 3.3-11. Number of Individuals Planted and Planting Effort (Days Worked) for Each Native Species per Reach in the San Marcos River (2017)

River Reach	Species	Individuals Planted	Effort (days worked)
Spring Lake	*Zizania*	4,412	8
Spring Lake Dam LTBG	*Cabomba*	120	1
	Ludwigia	1,004	5
	Sagittaria	10	1
City Park LTBG	*Cabomba*	983	8
	Ludwigia	2,733	11
	Potamogeton	2,588	11
	Sagittaria	1,104	7
Cypress Island	*Cabomba*	152	4
	Ludwigia	937	6
	Potamogeton	396	4
	Sagittaria	107	2
IH-35 LTBG	*Cabomba*	268	4
	Ludwigia	620	5
	Potamogeton	1,056	5
	Sagittaria	155	2
	Zizania	712	3
IH-35 Expanded	*Cabomba*	630	4
	Ludwigia	2,240	7
	Potamogeton	961	5
	Sagittaria	122	2
	Zizania	1,654	5
TOTAL RIVER	*Cabomba*	2,153	21
	Ludwigia	7,534	34
	Potamogeton	5,001	25
	Sagittaria	1,498	14
	Zizania	6,778	16
TOTALS – INDIVDUALS PLANTED AND DAYS WORKED		**45,928**	**220**

Establishment of *Ludwigia* in multiple aquatic vegetation treatment sites was observed in 2017. Increases in *Ludwigia* were observed within the Spring Lake Dam LTBG, City Park LTBG, Cypress Island, and IH-35 reaches. Therefore, 2017 has been the most successful year so far in expanding *Ludwigia* within the San Marcos River. Further expansion of Texas wild-rice among vegetation treatment sites occurred in 2017 with notable increases in aerial coverage within the Spring Lake, Spring Lake Dam LTBG, and IH-35 reaches. Continued expansion of Texas wild-rice in the Spring Lake and IH-35 reaches will occur in 2018. Small increases in the species, *Cabomba*, were observed in 2017, but additional knowledge on optimal planting locations will be evaluated in 2018. Mixed results occurred for *Potamogeton* in 2017. Successful establishment and expansion occurred for plantings adjacent to existing *Potamogeton* stands (City Park LTBG and IH-35 LTBG reaches). However, unsuccessful establishment of *Potamogeton* was observed in the IH-35 expanded reach. *Potamogeton* was planted in areas that appeared as suitable habitat (i.e., fast flowing water and coarser substrates), but plantings failed within these areas after a few weeks after

planting. In 2018, refinement of successful planting locations of *Potamogeton* will occur by planting small stands of *Potamogeton* in multiple habitats and determining which stand persists.

Compliance for this measure is based on total coverage of fountain darter habitat in m^2 specified in Table 4-21 of the EAHCP. 2017 status is shown in **Table 3.3-12**.

Table 3.3-12. Status of Fountain Darter Habitat Within LTBG Reaches within San Marcos Springs Ecosystem in 2017

San Marcos LTBG Fountain darter habitat (aquatic vegetation) status in m^2						
LTBG Reach	***Ludwigia***	***Cabomba***	***Potamogeton***	***Sagittaria***	***Hydrocotyle***	***Zizania***
Spring Lake Dam	6	0	208	11	53	1,033
City Park	29	3	256	116	0	1,783
IH-35	2	72	5	3	0	83
TOTALS	**37**	**75**	**469**	**130**	**53**	**2,899**

Proposed Activities for 2018

The native aquatic plant coverage goals for 2018 will be met as defined by Table 34 of the SAV Report (Section 3.1.2.3). All planted areas will be maintained.

Non-Native Littoral Plant Removal

In 2017, removal efforts consisted of treating invasive, exotic plants from Bert Brown Road to IH-35. The majority of the work was removal of upstream sources of elephant ears and other invasive, exotic plants. The Wetland Boardwalk area at Spring Lake was brought back up to a maintenance state.

Two heavy labor weekends were performed along areas of Sink Creek to also bring them back into a maintenance state. One area was along the west bank of Sink Creek leading to the Wetland Boardwalk area, and the other was both banks of Sink Creek leading up to Bert Brown Road. Small Chinese Tallow trees were also removed.

Almost all of the littoral areas from Sewell Park to IH-35 are still under control as far as aquatic invasive, exotic plants. The exceptions are a stand of elephant ears on private property just upstream of Rio Vista Park. The other is a stand of Water Hyacinth in a detention pond close to the Freeman Aquatic Center.

The contractor used Aquaneat (glyphosate-based herbicide) for elephant ears and other non-native plants encountered in the littoral zone (10 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, the COSM contractor used Relegate (Triclopyr-based herbicide) at 10 oz. per gallon. The Relegate was mixed with glyphosate (10 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. Root flares of woody plants were scarred up with a heavy blade to expose more of the cambium layer and treated with an herbicide mix.

Figure 3.3-37 is a summary map depicting the status of removal of non-native littoral plant removal (November 2017), and **Figure 3.3-38** shows the status of invasive tree (small caliper) eradication (November 2017).

Figure 3.3-37. Status of *C. esculenta* removal (November 2017).

Figure 3.3-38. Status of small caliper littoral invasive plant removal (November 2017).

Proposed Activities for 2018:

The COSM plans to extend invasive, exotic removal efforts to Stokes Park in 2018. Any remaining stands of elephant ears along Sink Creek will be treated. When the rest of the elephant ears are treated and under

control, efforts will be focused on removal of invasive, exotic, smaller woody plants. This will be primarily on areas of Spring Lake and in areas of the river that were restored and replanted.

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 the 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.

2017 Compliance Actions:

Tilapia

The tilapia in Spring Lake seek thermal refuge and follow the warmest water throughout the year.

From March to June, the tilapia spawn near the boardwalks and the shallow waters of the slough arm. During this time, the contractor focused all efforts on tilapia removal by bowfishing, spearfishing with a speargun, and using gill nets. The combined effort of all three methods has been the most successful: setting the gill net, then bowfishing and spearfishing around it while scaring the tilapia into the net.

After spawning season and throughout summer, from July to September, the tilapia in Spring Lake are too far up the slough arm to have enough visibility to remove, so efforts are focused on the river. Tilapia in the river are targeted by the contractor each week of the summer. The tilapia in the river are most active on clear hot days in the early to late afternoon. The contractor's biannual polespear tournaments are also successful in removing tilapia in the river.

During the months of October to February, the contractor spearfishes tilapia with a speargun and has the most success during the coldest mornings and afternoons. At this time, the tilapia are coming to the tip of the slough arm into spring fed water seeking thermal refuge.

Suckermouth catfish (*Hypostomus plecostomus*)

All of the catfish captured from Spring Lake to this date have been identified as the sailfin catfish species, with twelve spines along the dorsal fin. Only one small sailfin catfish was removed from Spring Lake this year. The suckermouth catfish species with seven spines along the dorsal fin and the sailfin catfish are both found in the San Marcos River. Only one sailfin catfish was removed from the river this year. In the river, both catfish species were removed using pole spears and hand collection, while in Spring Lake a speargun is used. Catfish were speared at both night and day, but during the recreation season the contractor dives were only conducted in early morning or at night due to the constant turbidity of the water during the day.

Red-Rimmed Melania and Giant Ramshorn Snail Removal

The contractor works areas of large concentrations by hand-collection primarily in Spring Lake and in Clear Springs Natural Area. Snails are also included in the biannual spearfishing tournament, with an award given for most weight in snails removed. The contractor did not find a live giant ramshorn snail in 2017.

The contractor participated in the EAHCP's public outreach efforts using brochures and posters to inform the public on the impacts of dumping aquaria into rivers. These have been distributed at local schools, San Marcos Discovery Center and the University. The contractor also set up an educational booth to increase public awareness of non-native invasive fish and promote the polespear tournaments at the annual Mermaid Festival. The contractor created a giant suckermouth catfish sculpture out of trash removed from the San Marcos River; this sculpture was in the Mermaid Parade and is on display at the contractor's local residence off Riverside Drive to promote environmental stewardship and upcoming tournaments. With permission from the San Marcos Park Rangers, the contractor programs three week-long pole spear tournaments twice each year to give the community the opportunity to legally spearfish and take part in the EAHCP.

Tournaments

The contractor hosts spring and winter spearfishing tournaments that increase the capture of tilapia and catfish, as well as exotic snails. The results of the 2017 tournaments are shown in **Table 3.3-13**.

Table 3.3-13. Results of 2017 Spring and Winter Spearfishing Tournaments

	Spring Tournament Results		Winter Tournament Results		2017 COMBINED TOURNAMENT TOTALS	
Species	Total Number	Total Biomass (lbs)	Total Number	Total Biomass (lbs)	Total Number	Total Biomass (lbs)
Plecostomus	212	99.99	400	207.60	612	307.59
Tilapia	43	182.06	14	28.50	57	210.56
Nutria	1	8.02	N/A	N/A	1	8.02
TOTALS	**256**	**290.07**	**414**	**236.10**	**670**	**526.17**

The total number of invasive species and biomass removed to date through these tournaments are shown in **Table 3.3-14.**

Table 3.3-14. Total Number of Species and Biomass Removed Through All Spearfishing Tournaments to Date (2015 – 2017)

Species	Total Number	Total Biomass (lbs)
Plecostomus	2,145	1,080.48
Tilapia	94	173.15
TOTALS	**2,239**	**1,253.63**

Monitoring Program

In order to provide details associated with invasive fishes' general abundance in the San Marcos River biomass data was collected in order to more adequately determine the health of the species. **Table 3.3-15**

shows the total biomass collected, including the biomass collected through tournaments, as a relation to the numbers to measure impact of this Conservation Measure on controlling targeted species.

Table 3.3-15. Non-Native Species Removal Totals through November 2017

Species	Total Biomass (lbs)	Total Number	Average biomass/individual (lbs)
Tilapia	3,547.72	1,047	3.39
Catfish (Suckermouth & Sailfin)	3,228.11	5,642	.57
Nutria	335.82	30	11.19
Red-rimmed snail	18.63	-	-
Giant Ramshorn snail	15.36	-	-

Proposed Activities for 2018:

In 2018, the COSM will continue regular removal of the tilapia, suckermouth catfish, and snails. Monthly monitoring will continue and include tilapia starting in January 2018. Biannual tournaments will continue to increase the removal quantities.

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.

2017 Compliance Actions:

The contractor, staff and volunteers continued non-native tree and vine removal in Ramon Lucio Park - Wildlife Annex (**Figure 3.3-39**) throughout 2017. Invasive plant removal was performed with chainsaws and hand tools. All cut stumps were chemically treated by 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. In 2017, 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*).

Figure 3.3-39. Areas of large invasive removal in Ramon Lucio Park (Wildlife Annex).

Native plantings occurred in January and February 2017 and October 2017, to take advantage of spring and fall rains and temperatures. Sites planted included Dog Beach, Rio Vista, Crooks and Bicentennial parks. To reduce costs and involve the community, all plantings were performed by volunteers (**Figure 3.3-40** and **Figure 3.3-41**). The COSM continues to plant drought tolerant species, littoral species, and broadcast native seed stock to re-populate riparian buffer zones (**Figure 3.3-42**). Hand-watering was performed in areas without irrigation until plant roots were established. Invasive removal and native planting was pursued in Sessom Creek Park from January to June; October to December.

Figure 3.3-40. Volunteer native riparian improvement planting.

Figure 3.3-41. Educating volunteers during planting work day.

Figure 3.3-42. Bank erosion control through native plantings.

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 diverse, which will assist the riparian restoration. **Table 3.3-16** contains a list of the plants supplied by the COSM in 2017 made possible by a reimbursable agreement between the COSM and the USFWS.

Table 3.3-16. Summary of Plants Supplied by the COSM in 2017

Species*	No. Containers**				
	Qtr. 1: Jan – Mar	Qtr. 2: Apr – Jun	Qtr. 3: Jul – Sep	Qtr. 4: Oct – Dec	Total – all sizes
ACERACEAE					
Acer negundo, box elder[T]	3[b]	0	0	0	3
APIACEAE					
Hydrocotyle umbellata, water pennywort[Aq]	77[a], 17[b]	19[a]	0	0	113
AQUIFOLIACEAE					
Ilex vomitoria, yaupon holly[T]	1[b]	1[b]	0	0	2
CABOMBACEAE					
Cabomba caroliniana, cabomba[Aq]	24[b]	27[b]	0	32[b]	83
CORNACEAE					
Cornus drummondii, dogwood[T]	11[b]	4[b]	0	3[d]	18
FABACEAE					
Mimosa aculeaticarpa var. biuncifera, mimosa[T]	1[b]	0	0	4[b]	5
Parkinsonia aculeata, retama[T]	0	0	0	1[c]	1
Styphnolobium affine, Eve's necklace[T]	0	2[b]	0	5[e]	7
FAGACEAE					
Quercus fusiformis, live oak[T]	1[b]	0	0	0	1

Table 3.3-16. Summary of Plants Supplied by the COSM in 2017

Species*	No. Containers**				
	Qtr. 1: Jan – Mar	Qtr. 2: Apr – Jun	Qtr. 3: Jul – Sep	Qtr. 4: Oct – Dec	Total – all sizes
Quercus laceyi, Lacey oak[T]	0	0	0	1[e]	1
Quercus macrocarpa, bur oak[T]	0	1[b]	0	0	1
JUGLANDACEAE					
Juglans nigra, black walnut[T]	1[b]	2[b]	0	0	3
MORACEAE					
Maclura pomifera, Osage orange[T]	2[b]	3[b]	0	0	5
OLEACEAE					
Fraxinus albicans, Texas ash[T]	0	1[b]	0	0	1
ONAGRACEAE					
Ludwigia repens, creeping primrose willow[Aq]	42[a], 17[b]	27[a]	24[a]	0	110
PLATANACEAE					
Platanus occidentalis, sycamore[T]	5[b]	0	0	1[e]	6
POACEAE					
Chasmanthium latifolium, inland sea oats[T]	1[b]	41[b]	0	0	42
Panicum virgatum, switchgrass[T]	0	56[f]	0	13[c]	69
Schizachyrium scoparium, little bluestem[T]	1[b]	0	0	0	1
Zizania texana, Texas wild rice[Aq]	105[b]	55[b]	118[b]	113[b]	391
PONTEDERIACEAE					
Potamogeton illinoensis, pondweed[Aq]	55[b]	31[b]	36[a]	48[b]	170
ROSACEAE					
Prunus mexicana, Mexican plum[T]	0	1[b]	0	1[e]	2
RUBIACEAE					
Cephalanthus occidentalis, buttonbush[T]	0	14[b]	0	1[e]	15
SALICACEAE					
Populus deltoides, cottonwood[T]	6[b]	2[b]	0	2[d]	10
Salix nigra, black willow[T]	0	1[b]	0	0	1
SAPINDACEAE					
Sapindus saponaria, western soapberry[T]	0	4[b]	0	3[e]	7
Ungnadia speciosa, Mexican buckeye[T]	0	0	0	1[e]	1
SMILACACEAE					
Smilax bona-nox, cat brier[T]	5[b]	0	0	0	5
ULMACEAE					
Celtis laevigata, sugar hackberry[T]	2[b]	0	0	0	2
VERBENACEAE					
Callicarpa americana, beautyberry[T]	0	3[b]	0	0	3
TOTALS	**389**	**301**	**191**	**277**	**1,158**

*Type: Aq = aquatic; T = terrestrial

**Containers: a = 1-quart pot, b = 1-gallon pot, c = 2- to 4- gallon pot, d = 5-gallon pot, e = > 5-gallon pot, f = 25-cubic-inch tube; all Z. texana grown from seed to ≥ 50-cm stem lengths, 3-5 seedlings/container; all aquatic species other than Z. texana grown from cuttings to 1-8 rooted stems/container; all terrestrial species grown from seed to 1 plant/container

Proposed Activities for 2018:

In 2018, this measure will revert to primarily maintenance of the areas of invasive removal along the San Marcos River. Removal of invasive species, followed by native plantings, will continue down to Stokes Park in a largely volunteer effort.

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.

2017 Compliance Actions:

As of January 1, 2017, the San Marcos Environmental Health Department had registration records for 608 septic systems within COSM jurisdiction. Three new septic systems were added into service in 2017 yielding a total as of December 31, 2017, of 611 septic systems in the COSM. All systems have been permitted and evaluated to prevent subsurface pollutant loadings into the Edwards Aquifer or San Marcos River.

Proposed Activities for 2018:

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.

2017 Compliance Actions:

The AMP was implemented to change the location of the two waterquality BMPs called for in the EAHCP. This change was approved by both the IC and the USFWS. The new locations are two water quality pond sites that were partially constructed by the COSM: the City Park pond; and the Downtown pond. The Downtown pond was not functional upon construction completion, so the EAHCP funded a redesign in 2017 to achieve a properly functioning drainage and landscape feature. The construction phase for this project will begin in early 2018. The City Park pond needs final excavation, construction, and landscaping to become operational. The project has been bid and awarded, with construction to begin in January 2018. More detail is presented on these two projects **Chapter 3.0** – PLAN IMPLEMENTATION IN 2017, **subsection 3.3.14** – Impervious Cover and Water Quality Protection (EAHCP §5.7.6), in this Annual Report.

Proposed Activities for 2018:

The COSM will pursue construction of the Downtown and City Park ponds.

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.

2017 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 can drop off household chemicals and paint that are hazardous to 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, 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 2017 was 180 per month compared to 2016 at 155 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 65 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 annual outreach goal for HHW is 1,400 total participants. In 2017, this goal was exceeded by 109 percent with an annual total of 2,930 participants. The popularity of the reuse program and increased exposure through public outreach contributed to the program's success.

The average participants from drop-offs and reuse for 2017 was 244 participants per month. The drop-off center surveys indicate that the COSM website and word of mouth contributed to the steady program participation.

The Chemicals

The 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.

HHW disposed of approximately 171,840 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 2017 averaged 14,320 lbs per month.

The amount of household hazardous waste diverted from the waste stream and distributed by the Reuse Program totaled 8,992 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 2018:

Moving forward, the COSM’s goal for 2018 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 fall 2018.

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 ESA in San Marcos, Texas. The intent of the WQPP is to provide a holistic, integrated approach for Texas State and the COSM in regard to water quality concerns associated with impervious cover and urban development. In addition to protecting habitat for endangered species, the WQPP will help the entities serve the needs of their growing populations and promote responsible economic development, good public infrastructure, and preserve open space.

2017 Compliance Actions:

Contract documents and the bid process for a biofiltration pond were completed for City Park, a facility owned by the COSM. This project includes the demolition of an existing, degraded asphalt parking lot that sent untreated runoff directly to the San Marcos River. Phase One of the project was completed, and Phase Two has begun. Phase One included the demolition of the old parking lot, construction of a new one, and rough grading for a biofiltration system that will treat runoff from both onsite and offsite areas. Phase Two will finish construction of the pond, including an inlet that will allow treatment of about twelve acres of off-site runoff from the Strahan parking lot owned by Texas State. It is estimated that the pond system will remove about 6,700 lbs of TSS and 17 lbs of total phosphorus (TP) on an annual basis.

Contract documents for the Downtown Biofiltration Pond rehabilitation project on C.M. Allen Parkway were completed. This project will remediate an existing water quality pond that is not performing. Once installation is complete, it will treat runoff from 32 acres at 80 percent impervious cover. The pond project will be bid and built in 2018, and is estimated to remove about 24 lbs of TP on an annual basis.

Following through on the Sessom Creek Watershed Restoration Plan envisioned in 2016, the Middle Reach Restoration project is intended to mitigate stream erosion that is generating high sediment loads, which impact critical habitat (**Figure 3.3-43**). Using the AMP, the project will combine the funding of EAHCP Sediment Removal (EAHCP §5.3.6 and §5.4.4) with that of Impervious Cover and Water Quality Protection (EAHCP §5.7.6) into one Conservation Measure. A draft of the Preliminary Engineering Report (PER) was completed in 2017 for the Sessom Creek water quality improvement project. The PER uses a natural channel design approach, with plans to bring the creek back into equilibrium as it responds to urban development in the watershed. Specific recommendations include the use of grade controls, bank stabilization, and water quality features within a reach length of 2,300 linear ft. This project is moving forward in tandem with a COSM effort to remove exposed wastewater lines from the creek and protect municipal infrastructure in the channel. Together, they will support the goal of reducing instream erosion by 50 percent. Work on the 30 percent design plan began in 2017.

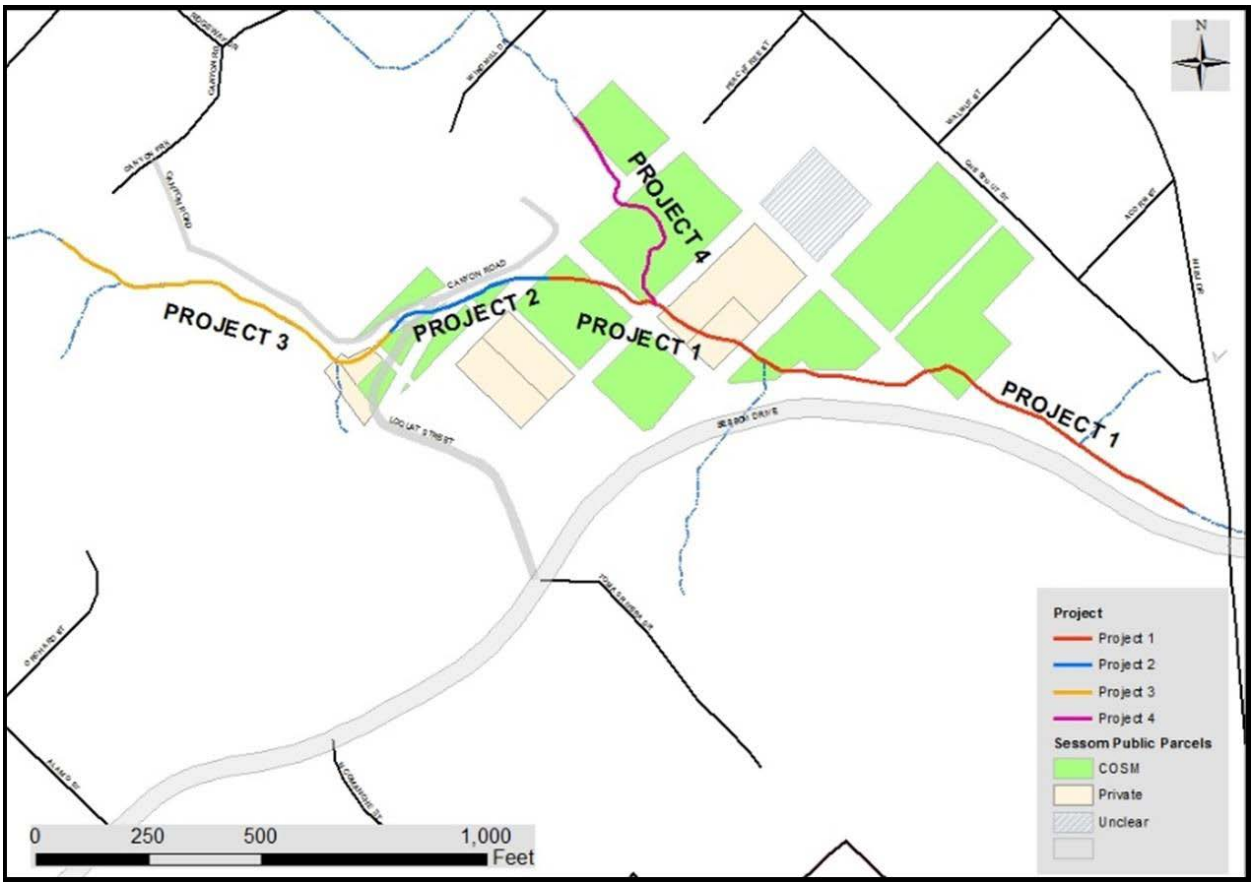

Figure 3.3-43. Project areas 1 & 2 proposed for Phase One implementation; Project areas 3 & 4 for Phase Two pending approval.

Proposed Activities for 2018:

The COSM will complete construction of two biofiltration ponds: the City Park pond and the Downtown pond and will manage the system post-construction to ensure vegetative establishment and long-term success. The COSM will also implement the next phase of the Sessom Creek – Middle Reach Restoration project and complete the final PER as well as 100 percent designs and contract documents by the end of the year. Meetings with Texas State are planned to discuss their involvement in protecting water quality in Sessom Creek.

3.3.15 Challenges Observed and Identified Solutions

Non-native plant removal

Challenge: Many of the seed sources for the woody invasive, exotic plants that were identified last year have not been treated. Part of the old golf course has been allowed to go wild, and a number of smaller Chinese Tallow trees are coming in. Unfortunately, some of these are too far from the COSM's areas of responsibility for the COSM to address them, but they could become seed sources.
Solution: It will take more coordination with all interested parties to get these removed. The COSM is working with the Texas State grounds crew to address this problem.

Removal of non-native species

Challenge: Scheduling with Spring Lake management during business hours in tilapia spawning season and closing off the boardwalks.
Solution: The COSM will continue coordination and discussion will be on-going.

Challenge: Finding the best time to dive the river in terms of visibility.
Solution: The COSM will coordinate with others to create a master calendar with all river projects and spring lake projects, to get all contractors on the same page of what is happening in the river/spring lake that particular day/time. COSM staff can then follow this calendar for scheduling dives with volunteers. Spring Lake Management will need to follow the schedule of only harvesting on Monday, Wednesday, and Friday, to avoid running the harvester off schedule.

Challenge: The COSM contractor would like to try new methods of trapping suckermouth catfish in the river and netting tilapia in Spring Lake.
Solution: The contractor will build and test suckermouth catfish traps in specific crevices, ledges, and caves throughout the river, and will purchase a new net to try netting tilapia during cold winter days.

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: The COSM will recommend using EAHCP funding to garner matching grant funds.

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*, *2017 Compliance Actions,* and *Proposed Activities for 2018* related to this Conservation Measure, please refer to the discussion under **Chapter 3.0** – PLAN IMPLEMENTATION IN 2017, **subsection 3.3.3** – 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*, *2017 Compliance Actions,* and *Proposed Activities for 2018* related to this Conservation Measure, please refer to the discussion under **Chapter 3.0** – PLAN IMPLEMENTATION IN 2017, **subsection 3.3.1** – 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. Related activities include:

1) Weekly, floating vegetation mats will be dislodged in five springs; each spring will be addressed every two to three weeks.
2) Floating vegetation mats will be dislodged more frequently in the summer.
3) Floating vegetation mats will be dislodged from Texas wild-rice stands weekly.
4) Algae will be removed regularly in the summer.
5) Accumulated sediments around spring orifices will be removed within a 1.5-meter buffer radius.
6) From 1.5 to 3.0 m from spring orifices, vegetation will be sheared to a height of 30 centimeters (cm) and from 3.0 to 6.0 m from the orifice, vegetation will be sheared to a height of one m.
7) Fifteen to 20 boatloads of plant material will be removed by the harvester boat monthly; including weekly removal from designated zones one, two, and three (EAHCP Figure 5.2).
8) Removed vegetation will be inspected for aquatic species that will be returned to the river system immediately.
9) Vegetation mats will be removed from zones four and five (EAHCP Figure 5.2) on an as-needed basis.
10) Texas State employees or others working with and around Texas wild-rice will be trained by TPWD to recognize and protect the plant while doing work in the San Marcos system.
11) All vegetation removal activities on Texas State property will be managed by a full-time staff person responsible for operating the harvester boat, manually removing floating vegetation mats,

and ensuring all staff and volunteers involved in vegetation removal are familiar with the aquatic ecosystem and able to recognize Covered Species.

2017 Compliance Actions:

Management of Submerged and Floating Aquatic Vegetation in Spring Lake

Spring Orifice Maintenance: Texas State personnel at the Meadows Center for Water and the Environment (MCWE) in conjunction with qualified Dive Authorization Course (DAC) 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 cm and the cut material allowed to flow downstream with the current. Aquatic vegetation within the next three-meter radius of target springs was sheared to height of one-meter and cut vegetation allowed to drift downstream. **Table 3.4-1** provides a summary of work conducted for this EAHCP measure.

Table 3.4-1. Aquatic Vegetation Maintenance Activities within Spring Lake in 2017

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	TOTALS
Aquatic Maintenance (approximate dives)	15	15	15	15	15	25	25	10	15	15	20	0	195
Aquatic Maintenance Dive Hours (average 1.25 hours/dive)	19	19	19	19	19	31	31	13	19	19	25	0	244
AquaCorps Diving Volunteers	103	46	123	127	87	104	92	103	108	106	56	96	1,151
Diving for Science (D4S) Dive Hours (average 1.25 hours/dive)	129	58	154	159	109	130	115	129	135	133	70	120	1,439

Harvester Boat: Maintenance 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 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 (y^3)/per cutting. The total estimated harvest is approximately 1,112.5 y^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 contractor by pushing and removing floating mats, as specified in the EAHCP.

Proposed Activities for 2018:

Texas State will continue to implement floating vegetation mat and litter removal consistent with protocols established in the EAHCP and in the 2018 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*, *2017 Compliance Actions*, and *Proposed Activities for 2018* related to this Conservation Measure, please refer to the discussion under **Chapter 3.0** – PLAN IMPLEMENTATION IN 2017, **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:

- Reduce diversion by two cfs when the USGS gauge at University Bridge reads 80 cfs (reduction made below Spring Lake Dam).
- 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).
- Reduce diversion by all but one cfs when the USGS gauge at University Bridge reads 49 cfs (reduction made in the Sewell Park reach).
- Cease all surface water diversions when the USGS gauge at University Bridge reads 45 cfs.

2017 Compliance Actions:

Texas State did not reduce permitted pumping in 2017 to meet EAHCP requirements, since total San Marcos River flows did not reach trigger points (i.e., < 80 cfs). Texas State uses Certificate 18-3866-401 to fill campus ponds. Certificate 18-3866-400 is a pump at Sewell Park that is used to supply the Armory Field (City Park) and the Sewell Park/Jowers complex. Texas State has not used it in a couple of decades because, when it's needed most, the allocation is cut in half. Plus, the water was not filtered adequately so it created clogging issues, so it is unlikely to ever be used.

The total volume of surface water diversions from Spring Lake (Certificate 18-3865) was 15 ac-ft/year for 2017; well below the permitted 100 ac-ft/year. Maximum instantaneous diversion rates are not available.

Proposed Activities for 2018:

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*, *2017 Compliance Actions*, and *Proposed Activities for 2018* related to this Conservation Measure, please refer to the discussion under **Chapter 3.0**

– PLAN IMPLEMENTATION IN 2017, **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 and the COSM will conduct a study of sediment removal options to determine the best procedure to remove this sand and gravel bar that minimizes impacts to listed species. Texas State will submit the study for review though the AMP and implement the actions coming out of that process.

2017 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 2016 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 that further increased the deposition at the sediment bar. Therefore, it was decided and approved through the AMP that the EAHCP would take preventative rather than reactive action by addressing erosion in Sessom Creek, which is the primary source of sediment for the Sessom Creek sand bar.

Proposed Activities for 2018:

A natural creek stabilization design will be completed for Sessom Creek from LBJ Drive to just above Loquat, with construction planned to begin in 2019.

3.4.8 Diving Classes in Spring Lake (EAHCP §5.4.7)

EAHCP Obligations:

Every diver participating in the Texas State DAC 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.

2017 Compliance Actions:

MCWE updated the Spring Lake Management Plan to reflect all the requirements under the EAHCP and ITP. This includes the following EAHCP measures:

1) Spring Lake Dive Authorization Program (§5.4.7.1)

2) Texas State Continuing Education (§5.4.2)

3) Texas State SCUBA Classes (§5.4.7.3)

The revised plan implements the EAHCP requirements with the following restrictions:

1) Spring Lake Dive Authorization Program – No more than 16 volunteer divers/day and < 8 at one time

2) Texas State Continuing Education – 12 divers/class; < 3 classes/day; restricted to the Dive Training Area

3) Texas State SCUBA Classes – 12 students/class; < 3 classes/day; restricted to the Dive Training Area

The revised Spring Lake Management Plan was submitted and approved by the President's Cabinet in 2012. As part of this effort, MCWE implemented a Diving Program Control Board that reviews all diving activities within Spring Lake to ensure they comply with the Spring Lake Management Plan and the EAHCP. These efforts also include the development of the Spring Lake Dive Accident Management Plan and revised D4S Program, which has implemented a more rigorous training program that includes expanded training and orientation on the endangered species. Diving activities in Spring Lake are summarized in **Table 3.4-2**.

Table 3.4-2. Diving Activities in Spring Lake in 2017

Activity FY 2017	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Reporting Period Totals
Aquatic Maintenance (approximate dives)	15	15	15	15	15	25	25	10	15	15	20	0	**185**
Texas State Student Dives	0	1	45	90	12	12	96	1	10	31	46	0	**344**
Public Divers	185	293	286	271	292	167	196	147	107	126	68	183	**2,321**
Volunteer Divers	103	46	123	127	87	104	92	103	108	106	56	96	**1,151**
Research Dives	4	6	8	10	13	2	8	2	2	8	10	2	**75**
External Dives (EAA, USFWS, etc.)	2	2	2	12	14	2	2	10	2	25	10	2	**85**
New volunteers	28	5	21	24	20	10	21	15	18	12	11	14	**199**
Wounded Warriors (groups not individuals)	0	2	0	0	2	0	2	0	0	0	0	0	**6**
TOTALS	**337**	**370**	**500**	**549**	**455**	**322**	**442**	**288**	**262**	**323**	**221**	**297**	**4,366**

Proposed Activities for 2018:

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 the MCWE 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.

2017 Compliance Actions:

The Chief Science Officer at the MCWE chairs the Spring Lake Environmental Committee, which oversees all access to Spring Lake. To this end, MCWE developed an online access request form (http://www.meadowscenter.txstate.edu/ReserveSpecialEvents/SpringLakeAccess.html). Each request is reviewed by the 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 3.4-3** summarizes the research/access activities in Spring Lake in 2017.

Table 3.4-3. Research and/or Access Activities on Spring Lake in 2017

Approved Research Activities FY 2017				
Researcher	**Department /Agency**	**Duration**		**Description**
Nick Menchaca	Atlas Environmental	09/01/14	Still Active	Invasive animal removal
Eric Ruckstuhl; Aaron Hoot	EBR Enterprises	09/01/14	Still Active	Invasive vegetation removal
Andrew Johnston	Halff Engineering	09/01/14	Still Active	Assess Burleson's Dam
Edmund Oborny	BIO-WEST	10/28/12	Still Active	EARDC salamander survey
Catlin Gabor	Texas State Biology	4/09/16	Still Active	Character of sex pheromone in sailfin mollies
Randy Gibson	USFWS	12/5/14	Still Active	Set/check Diversion trap
Francis Rose	Texas State Biology	9/01/12	Still Active	Trapping/monitoring turtle community
Valentin Cantu	USFWS	09/01/14	Still Active	Collecting wild San Marcos Salamanders
Mary Wicksten	Texas A&M Biology	2/16/15	Still Active	Gastrotrich collecting
Catlin Gabor	Texas State Biology	3/03/17	3/01/18	Lab instruction for Bio course
Kristy Kollaus	Texas State Biology	6/06/16	6/07/16	Fish specimen collections for instructional dissections
Kristy Kollaus	Texas State Biology	2/13/17	1/31/17	Ecology aspects of the big claw river shrimp
Gerry Cochran	Texas Water Safari	--	--	--
Melissa Nicewarner	Back on my Feet	10/15/16	10/15/16	Trail Race

Table 3.4-3. Research and/or Access Activities on Spring Lake in 2017

Approved Research Activities FY 2017				
Researcher	**Department /Agency**	**Duration**		**Description**
Allison Tanna	Continuing Ed. Dept	11/4/16	11/4/16	Indoor/outdoor spaced used for conference
Clay Bales	Blanco River Reforestation Project	11/17/16	12/9/17	Collecting cypress cones /Blanco River restoration
Austin Bohannon	Wildlife Biology-Bio	6/4/17	5/20/18	Water Hyacinth Sampling Aquatic sieve
Ally Hoffman	Journalism/ Mass Comm	4/8/2017	4/8/17	Spring Lake Art Showcase with Music
Kent Griffin	Health Human Performance TPWD	6/22/17	6/30/17	assess the impact of outdoor education on behavior
David Lemke	Biology	6/18/17	8/31/17	Collection of plant specimens
James Lovegren	L&L Growers / TreeFolks Inc.	02/15/17	10/14/17	Seed collection for company; Denied
Ken Mix	Agriculture	3/31/17	3/31/17	soil sampling and wetland plant id/collection
Weston Nowlin	BIO-WEST	3/29/17	3/29/17	collect amphipods (*Crangonyx psuedogracilis*)
Brady Parrish	UT Austin/ Eric Schlegel	6/12/17	6/26/17	scuba diving, videography; Denied; no certs
David Pietruszynski	Seagrass Consulting LLC	5/08/17	5/12/17	H2O project 360 video camera and tripod
Jeremiah Pizana	Rotary Club of San Marcos	9/17/17	9/17/17	Run, Swim, bike triathlon
Mariah Roca	Sacred Springs Powwow	11/3/17	11/5/17	Annual Powwow
Rebekah Rylander	Bio Dept Wildlife	03/01/17	12/31/17	social dynamics of the black-crested titmouse in a fragmented Urban Enviro
Siedel Nick	Campus Rec- Sports Clubs	3/31/17	4/02/17	Texas State Triathlon run, swim, bike
Brad Smith	Facilities/Grounds	11/7/16	11/28/16	Tree planting Arbor Day event
Christi Townsend	Geography Dept.	10/03/17	10/06/17	Lab 10- Fluvial Geomorphology stream discharge
Aaron Wallendorf	MCWE	8/01/17	Still Active	Installation of Floating Dock

Proposed Activities for 2018:

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.

2017 Compliance Actions:

The Texas State golf course has closed and Texas State plans to convert the area to accommodate other campus sports. No progress has been made toward this conversion. Land management will continue to follow a Management Plan and IPMP guidelines based on both the EAHCP (EAHCP §5.4.9) and the Spring Lake Management Plan.

Proposed Activities for 2018:

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.

2017 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 7,816 glass-bottom boat tours and 511 canoe/kayak tours were conducted in 2017.

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 2018:

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*, *2017 Compliance Actions* and *Proposed Activities for 2018* related to this Conservation Measure, please refer to the discussion under **Chapter 3.0**

– PLAN IMPLEMENTATION IN 2017, **subsection 3.3.5** – Reduction of Non-Native Species Introduction (EAHCP §5.3.5), of 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, 2017 Compliance Actions* and *Proposed Activities for 2018* related to this Conservation Measure, please refer to the discussion under **Chapter 3.0** – PLAN IMPLEMENTATION IN 2017, **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, 2017 Compliance Actions* and *Proposed Activities for 2018* related to this Conservation Measure, please refer to the discussion under **Chapter 3.0** – PLAN IMPLEMENTATION IN 2017, **subsection 3.3.9** – Control of Harmful Non-Native and Predator Species (EAHCP §5.3.9), of 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 2017, **subsection 3.3.15 –** Challenges Observed and Identified Solutions, of this Annual Report.

3.5 San Antonio Water System

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)

SAWS is one of the largest water and wastewater systems in the United States and serves a population of 1.8 million. As a municipally-owned utility, SAWS serves most of Bexar County and the surrounding area. 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 (SAWS ASR) in southern Bexar County is a key Conservation Measure for the EAHCP. This Conservation Measure, among other things, involves the injection, storage, and potential recovery 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 between the EAA and SAWS for the 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 EAHCP. The day-to-day operation of the SAWS 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 report its injection, storage, and recovery activities (EAHCP §5.5.1, page 5-38). The ILC provides additional detail on these activities as well as the other activities necessary to implement the SAWS ASR Program.

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. The SAWS ASR Program under the EAHCP and the ILC consists of three primary components: (1) injection, storage, and potential recovery of "EAHCP Groundwater"[10] in and from the SAWS ASR; (2) acquisition by the EAA of leases and leases options of EAHCP Groundwater for delivery to SAWS for injection and storage into the SAWS ASR, and (3) forbearance by SAWS during times of certain defined drought conditions of its right to make withdrawals from the Aquifer under its EAA-issued groundwater withdrawal permits. The EAA has the obligation to acquire 50,000 ac-ft/year of EAHCP Groundwater through leases and lease options in three prescribed tiers - Tier I being leases (16,667 ac-ft), Tier II being lease options that trigger when the ten-year rolling recharge average to the Aquifer is equal to or less than 572,000 ac-ft/year (16,667 ac-ft/yr), and Tier III being lease options that trigger when the ten-year rolling recharge average to the Aquifer is equal to or less than 472,000 ac-ft/year (16,667 ac-ft/yr). The EAA is to then required to sublease to SAWS (through a "notice of availability") any EAHCP Groundwater it may acquire in order for SAWS to inject and store in the SAWS ASR. SAWS may then potentially recover such stored EAHCP Groundwater under the terms and conditions of the ILC to offset any forbearance obligation it may have relative to its EAA-issued groundwater withdrawal permits under the EAHCP and the ILC. SAWS has the general duty to inject and store in the SAWS ASR and credit to the EAA any EAHCP Groundwater that the EAA may present to SAWS through a "notice of availability.

When the level of the Edwards Aquifer index well J-17 is less than 630 ft msl and the ten-year rolling recharge average of the Aquifer is less than or equal to 500,000 ac-ft/year, 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, and instead, at its option and discretion, to offset its forbearance from Edwards pumping, recover EAHCP Groundwater from the SAWS ASR for distribution to its customers.

SAWS will make every effort to meet the presumptive 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.

[10] EAHCP Groundwater is essentially defined by the ILC as the leases and lease options acquired by the EAA of EAA-issued groundwater withdrawal permits for the purpose of supplying SAWS with a water supply to inject and store in the SAWS ASR for the purposes of Section 5.5.1 of the EAHCP.

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. Phase 1 of the WRIP has been constructed and is operational between the Twin Oaks ASR facility and the newly-commissioned Old Pearsall Road pump-station. Interconnects between these two facilities have been constructed, enhancing the water distribution capacity of the WRIP. WRIP Phase 2, scheduled to begin construction in 2018/2019 and to be completed in 2020, will allow for additional distribution/recharge capacity to and from the Anderson Pump Station.

2017 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 and EAA actions related to fulfilling these responsibilities in 2017 are provided below in **subsections 3.5.1.1 – 3.5.1.4**.

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 groundwater 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 and Staff Work Group

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. 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. **Table 3.5-1** lists the members of the SAWS ASR Regional Advisory Group for 2017.

Table 3.5-1. Members of the SAWS Aquifer Storage and Recovery Regional Advisory Group in 2017

Entity	Appointee	Alternate
SAWS	Darren Thompson	Patrick Shriver/Roger Placencia
SAWS	Matthew Diggs	Roger Placencia
SAWS	Karen Guz	No alternate named
SAWS	Parviz Chavol	Roger Placencia
EAA	Roland Ruiz	Marc Friberg
Irrigator	Rader Gilliland	Adam Yablonski
Small Municipal	Bruce Alexander	No alternate named
Springs Communities	Roger Biggers	Trino Pedraza
Environmental Interest	Cindy Loeffler	No alternate named
Industry	Buck Benson	Louisa Eclarinal
Downstream Interest	Tommy Hill	Charlie Hickman
EAHCP Program Manager	Nathan Pence	No alternate named

The second group is a Staff Work Group. SAWS is responsible for organizing and facilitating the Staff Work Group between staffs of SAWS and the EAA. Per the requirement on pages 44 and 45 of the ILC, an eight person Staff Work Group consisting of four members of SAWS' staff and four members of the EAA's staff. The members are to have experience in evaluating drought conditions, factors affecting Aquifer levels and springflows at Comal Springs, meteorology, Aquifer and springflow modeling, or related expertise, and provides advice to each agency regarding their respective duties and obligations under the ILC for the implementation of the Program.

In 2017, both groups met in compliance with the EAHCP and the ILC. The SAWS ASR Regional Advisory Group met on February 14, 2017.

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 2017, SAWS has recharged through injection and stored 82,708 ac-ft of EAHCP Groundwater as shown in **Figure 3.5-1** below. Beneficial rainfall in 2017 enabled injection and storage of EAHCP Groundwater for a good part of th year. However, there was a three-month span that EAHCP Groundwater was not able to be injected and stored because of circumstances related to WRIP construction and commissioning.

Table 3.5-2. SAWS/EAA Aquifer Storage and Recovery Lease Options by Tiers

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

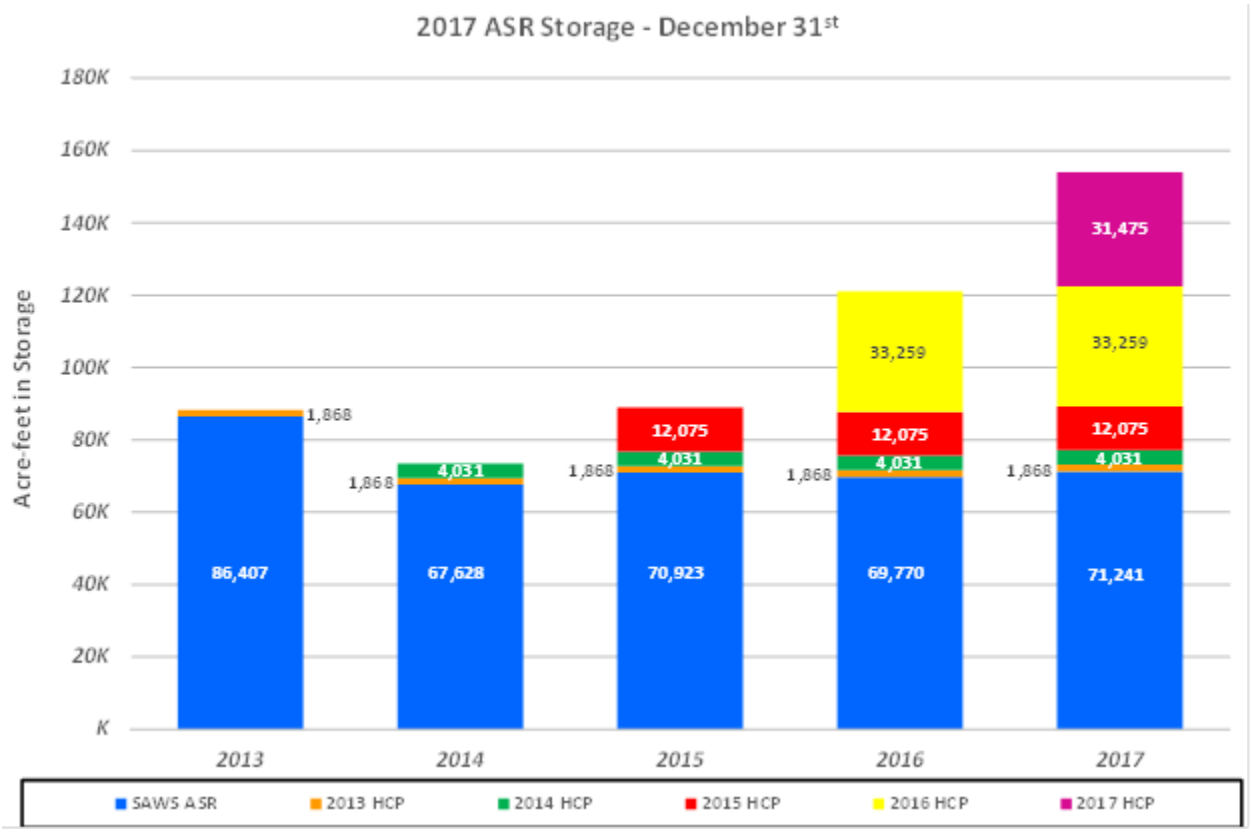

Figure 3.5-1. Total EAHCP water stored at the SAWS ASR facility (2013 – 2017).

3.5.1.3 Edwards Aquifer Authority Notices of Availability to San Antonio Water System

Of the total 32,583 ac-ft under lease by the EAA in 2017, EAA transferred to SAWS 31,475 ac-ft in 2017 (**Table 3.5-3**). The EAA issued two NOAs to SAWS in January and February, and one subsequent reduction amendment in November that was necessary in order to comply with 2017 CPMP reductions.

Table 3.5-3. SAWS Aquifer Storage and Recovery Notices of Availability in 2017

NOA #	Date Effective (through December 31, 2017)	Total Ac-ft Acquired	Total Ac-ft Authorized
2017 NOA #1	1/5/17	31,734.57	31,734.57
2017 NOA #2	2/10/17	848.44	848.44
TOTALS*		**32,583.01**	**32,583.01**

* EAA issued a reduction amendment to SAWS effective November 18, 2017, reducing the total ac-ft of NOAs issued from 32,583.010 ac-ft to 31,475.188 ac-ft.

3.5.1.4 Groundwater Rights Pooling Program for Aquifer Storage and Recovery

By a "master agreement," the EAA has created a program whereby EAA permit holders may contribute any "unpumped amount" under their permits into a "pool" administered by the EAA for the purpose of transfer to SAWS so that SAWS may recharge through injection such water into the SAWS ASR for the purpose of springflow protection under Section 5.5.1 of the EAHCP. This "pooling" program is complementary to the formal EAA ASR leasing program. No groundwater withdrawal rights were made available to SAWS under this program in 2017.

Proposed Activities for 2018:

In 2018, SAWS and the EAA 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

Relative to SAWS' operation and maintenance of the SAWS ASR to accomplish the purposes of Section 5.5.1 of the EAHCP and the ILC, there were no unauthorized or unexpected activities at the SAWS Twin Oaks ASR facility in 2017. The facility is gated, fenced, and patrolled regularly.

As discussed in **subsection 3.5.1.2** of this chapter, the EAA has faced Edwards water market headwinds in acquiring the 50,000 ac-ft of leases and lease options in support of the SAWS ASR Program. The EAA has initiated an Adaptive Management Proposal in 2017 with the view towards resolving some of the current program's structural issues with regard to the "tiering" of such leases/lease options and creating market products that will be better received. This recommendation is further discussed under **Chapter 6.0** of this Annual Report.

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 designated 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).

In order to protect existing and restored fountain darter habitat, TPWD, in coordination with the CONB, will also pursue creation of SSAs 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.

2017 Compliance Actions:

The EAHCP requires that TPWD pursue creation of SSAs in the San Marcos and Comal rivers. To preserve Texas wild-rice during low flows and to minimize the impacts of recreation, TPWD designated 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 M2**).

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.

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 2017.

Proposed Activities for 2018:

In 2018, TPWD will work to expand its 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 an 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 2017

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 2017, **Section 3.1** – Edwards Aquifer Authority, of this Annual Report.

4.1 Routine Decisions

There were no Routine AMP Decisions made in 2017.

4.2 Nonroutine Decisions

In 2017, the Permittees conducted an analysis of the current Impervious Cover/Water Quality Protection measures in San Marcos and New Braunfels (EAHCP §5.7.6) and Sediment Removal (EAHCP §5.3.6 and §5.4.4), as well as Minimizing Impacts of Contaminated Runoff (EAHCP §5.7.4). In these analyses, Nonroutine Adaptive Management Proposals were brought forward and ultimately reviewed by the EAHCP Committee members.

The Nonroutine Adaptive Management Proposal included two sets of modifications to the EAHCP:

1) Proposed Substitution of Sedimentation Ponds under "Minimizing Impacts of Contaminated Runoff"
2) Sediment Removal and Impervious Cover/Water Quality Protection

Proposed Substitution of Sedimentation Ponds under "Minimizing Impacts of Contaminated Runoff"

Since implementation of the EAHCP began in 2013, the COSM and Texas State strategically focused EAHCP programmatic activities related to water quality protection in the Spring Lake and Upper San Marcos River watershed – including "Minimizing Impacts of Contaminated Runoff" (EAHCP §5.7.4) – in the development of a water quality protection planning document to guide COSM's implementation of a comprehensive program "to protect water quality and reduce the impacts of impervious cover."

Considerable research and technical analysis concerning the Spring Lake and Upper San Marcos River watershed, and how to best protect water quality in this watershed, went into the WQPP. Through this exercise, the WQPP identifies and recommends an array of structural elements, design features, and planning mechanisms to provide a comprehensive water quality protection program.

In the course of reviewing the WQPP to inform the implementation of COSM/Texas State's water quality protection commitments, COSM identified two potential advantageous alternatives to the Veramendi and Hopkins sedimentation ponds prescribed in the EAHCP for the "Minimizing Impacts of Contaminated Runoff" (EAHCP §5.7.4) Conservation Measure. These "advantageous alternatives" are:

1) A preexisting sedimentation pond ("Downtown Pond") in need of repairs, located on COSM property at the corner of N. C.M. Allen Parkway and E. Hutchison St.; and

2) An as-yet unbuilt sedimentation pond ("City Park Pond") proposed for construction, to be located on COSM property in City Park, adjacent to the San Marcos Recreation Hall parking lot.

Figure 4.2-1 displays the locations of each of the four sedimentation ponds in relation to one another in the City of San Marcos.

Figure 4.2-1. Locations of four sediment ponds in San Marcos.

The COSM took into account several metrics in evaluating the Downtown and City Park sedimentation ponds as potential substitutions for the Veramendi and Hopkins sedimentation ponds, respectively. Improvements upon the original pond locations include drainage area and overall TSS removed per year. The total drainage area for both ponds add up to treat two times the original area, thus increasing the estimated TSS removed per year by approximately 3,500 lbs.

On March 2, 2017, after receiving the input from the chairs and vice-chairs of the EAHCP Committees, the EAHCP Program Manager officially submitted this Nonroutine Adaptive Management Proposal to all members of the SC, SH and IC. In accordance with the procedural steps outlined in Article 7 of the FMA, the EAHCP Committees were convened to evaluate, review, and approve the proposal. On March 8, 2017, the SC convened a meeting, and evaluated and recommended the proposal to the SH as presented. The SC concluded that the originally-planned ponds may be necessary in the future. Additionally, there were concerns regarding site constraints and a need for additional metrics to be calculated.

On March 16, 2017, the SH was convened and by consensus, recommended the proposal to the IC for approval and adoption.

Finally, in accordance with Article 7 of the FMA, also on March 16, the IC met and unanimously approved the SH recommendation for the Nonroutine Adaptive Management Proposal. **Appendix A8** is the EAHCP Nonroutine Adaptive Management Proposal, **Appendix A9** is the SC's SER, and **Appendix A10** is the SH's report.

On March 17, 2017, this Nonroutine Adaptive Management decision was submitted to the USFWS.

Sediment Removal and Impervious Cover/Water Quality Protection

The EAHCP has identified increased rates of sedimentation, due in part to increased urbanization, in the San Marcos River. Sedimentation is thought to impact Texas wild-rice by smothering or burying stands, leading to increased mortality and reduction of suitable habitat. Until 2017, sediment removal (via hydrosuction) was the sole method contemplated in the EAHCP to reduce the threat sediment loading presents to Texas wild-rice survival and enhancement.

This reactive approach to sediment management has proven costly and ineffective. As experience in implementing this measure was gained since 2013, issues were identified and, in parallel, possible alternative strategies for addressing sediment loading at the source were developed. Since 2013, data has been collected through the EAHCP Annual Report that supports the need to pursue an alternative strategy. Such strategies include a proactive approach that attempts to prevent, and/or mitigate for, sediment runoff in the watershed to protect water quality and the Covered Species habitat.

While the EAHCP specified sediment removal as the recommended strategy to manage sediment in the San Marcos River, removal seems to not effectively address the sources of excess sediment, which continues to be deposited through contributing creeks, specifically observed at Sessom Creek following the October 2015 flood – providing evidence that the effort is not a sustainable use of funds. The sediment volume removed from 2013 – 2016, and the costs associated, can be seen in the data provided in **Table 4.2-1**.

Table 4.2-1. Sediment Removal Results (2013 – 2016)

Year	Volume Removed (m^3)	Annual Cost	Cost per m^3
2013	48	$151,800.00	$3,450.00
2014	20	$180,000.00	$9,000.00
2015	85	$219,450.00	$2,612.50
2016	28	$193,042.00	$6,894.36
TOTAL	**181**	**$744,292.00**	**$4,228.93**
AVERAGES PER YEAR	**45.25**	**$186,073.00**	**$4,228.93**

A sediment mitigation strategy is proposed to focus on sediment removal at the source because prevention can have fewer impacts, and be more sustainable and cost effective. Sediment removal in the river does not address the actual sources of sediment, such as stream erosion, thus sedimentation impacts will likely be persistent and recurring. Sediment prevention techniques could include stream restoration using Natural Channel Design methods, stabilization of eroding stream beds and banks, riparian enhancement, and stormwater BMPs that reduce erosive flows.

In identifying that a source control approach may be most effective in managing sediment loading in the San Marcos River, the EAHCP Program Manager and the SC jointly determined to create the San Marcos Water Quality Protection Work Group. This Work Group was intended to provide scientific review and input on questions related to the COSM's and Texas State's implementation of the EAHCP Sediment Removal Conservation Measures, as well as the Impervious Cover/Water Quality Protection Conservation Measure (EAHCP §5.3.6, §5.4.4 and §5.7.6). This Work Group was comprised of members drawn from the SC as well as external experts with experience related to water quality protection projects.

Work Group members were presented with results from investigations, as part of the San Marcos River Water Quality Protection Plan (WQPP), which provides strong evidence that Sessom Creek has a higher sediment loading rate than other watersheds that drain into the upper reaches of the San Marcos River north and just below of IH-35 (**Appendix I7**).

The EAHCP contemplated mitigating for non-point source pollution through the Impervious Cover/Water Quality Protection Conservation Measure (EAHCP §5.7.6). According to this measure, the COSM and CONB are to implement LID programs near the springs ecosystems. This effort was considered through the EARIP LID/Water Quality Work Group and recorded in their final report (Appendix Q of the EAHCP). These programs were intended to mitigate for pollution from nonpoint sources such as parking lots and residential lawns; especially during periods of low-flow where pollutant presence could reduce the survivability of the Covered Species.

These LID programs, including an incentive program for private land owners, required in the EAHCP was suggested to not only improve the water quality protection near the springs, but also to gain public participation in the effort to protect the Covered Species. Unfortunately, in both San Marcos and New Braunfels city employees found little private interest in the program. Staff spent time developing criteria yet, due to the limited private residents along the San Marcos and Comal rivers, the incentive program was quickly replaced with a concentration on the implementation of strategic stormwater control measures that could maximize the effort and dollars allotted to improving water quality. Lists of control measures were developed for both the COSM and CONB in separate WQPPs.

Ultimately, a source control approach; that is, reduce erosion and sedimentation in the watershed has been adopted by both COSM and CONB. This could be a less expensive and more sustainable approach than sediment removal for COSM and Texas State. Under the AMP, the goal of the sediment removal tasks in the river could be accomplished with source control measures; thus, this information serves as the basis for this Nonroutine AMP Proposal.

On August 1, 2017, after receiving the input from the chairs and vice-chairs of the EAHCP Committees, the EAHCP 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 August 25, 2017, the SC convened in a meeting, and evaluated and recommended the proposal to the SH as presented.

On September 21, 2017, the SH was convened and by consensus, recommended the proposal to the IC for approval and adoption.

Finally, in accordance with Article 7 of the FMA, also on September 21, 2017, the IC met and unanimously approved the SH recommendation for the Nonroutine Adaptive Management Proposal. **Appendix A11** is the EAHCP Nonroutine Adaptive Management Proposal, **Appendix A12** is the SC's SER, and **Appendix A13** is the SH's report.

On October 20, 2017, this Nonroutine Adaptive Management decision was submitted to the USFWS.

On December 12, 2017, the USFWS approved the amendment. For additional discussion regarding this Nonroutine AMP, please refer to discussion earlier in this Annual Report in **Chapter 3.0** – PLAN IMPLEMENTATION IN 2017, **subsection 3.1.11.2** – Amendments, Informational Memoranda, and Clarifications.

4.3 Strategic Adaptive Management Process Decisions

As stated above, Strategic AMP decisions are not planned until 2018.

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5.0 2017 ANNUAL TAKE ESTIMATES

The EAHCP Incidental Take Permit (ITP) requires a Net Disturbance and Incidental Take assessment to be conducted at the conclusion of each year for incorporation into the ITP Annual Report. Condition M (1a and 2a) of the ITP specifically addresses minimization and mitigation activities associated with the EAHCP. This requirement 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 (SECTION 1) and Incidental Take (SECTION 2) Assessments for 2017 EAHCP ITP Annual Report" technical memorandum dated December 22, 2017, located in **Appendix N**. As in previous years, all 2017 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 2017. As shown in **Table 5.0-1**, the fountain darter and all three listed invertebrates 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 approximately 2 percent of the total occupied habitat for the fountain darter and less than 1 percent for each of the three federally-listed invertebrates in the Comal system. In the San Marcos system, only the fountain darter and San Marcos salamander had net disturbances calculated at approximately 3 percent and less than 1 percent, respectively, of their total occupied habitat. For the Texas blind salamander, CSRB, and Comal Spring dryopid beetle there were no Conservation Measure activities conducted in the San Marcos system in 2017 that directly impacted any documented occupied habitat or spring orifices where these species collections have been made over the years. In summary, the net disturbance in 2017 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 system with respect to the EAHCP Covered Species. The calculated value for the fountain darter was slightly less in 2017 than observed during 2016. The primary cause for the decrease for the fountain darter was stable flow conditions in 2017, which resulted in less spring to fall aquatic vegetation (habitat) reductions caused by scour. Unlike 2016, there was take associated with EAHCP Conservation Measure activities for the Comal invertebrates in Spring Run #3. In previous years, all invertebrate restoration activities have occurred on shore, whereas in 2017, native aquatic vegetation was planted in key areas within Spring Run #3 to support invertebrate habitat stability.

For the San Marcos system, incidental take for the fountain darter went down slightly in 2017 compared to 2016. Slight reductions were due to a reduced restoration footprint in 2017 relative to previous years. The return of Texas wild-rice exclusion zones in 2017 resulted in a minor amount of incidental take being calculated for the San Marcos salamander. When examining 2017 results, 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 2017 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 (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 2017 TOTAL (m^2)	Incidental Take		2017 Incidental Take Total	ITP Maximum Permit Amount	ITP Permit Maximum Minus (Combined First Five Years)
	Impacted Habitat (m^2)	Net Disturbance % Of Total Occupied Habitat	Impacted Habitat (m^2)		EAHCP Mitigation/ Restoration	EAHCP Measures/ Drought			
COMAL SYSTEM									
Fountain Darter	2,126	2.2%	954	**3,080**	3,189	1,431	**4,620**	797,000	743,766
Comal Springs Riffle Beetle	7	< 1%	0	**7**	46	0	**46**	11,179	8,887
Comal Springs Dryopid Beetle	0.5	< 1%	0	**0.5**	1	0	**1**	1,543	1,527
Peck's Cave Amphipod	2.5	< 1%	0	**2.5**	3	0	**3**	18,224	18,057
SAN MARCOS SYSTEM									
Fountain Darter	2,754	2.9%	4,072	**6,826**	4,131	6,108	**10,239**	549,129	485,951
San Marcos Salamander	12	< 1%	0	**12**	36	0	**36**	263,857	261,228
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
Comal Springs Dryopid Beetle	0	0.0%	0	**0**	0	0	**0**	N/A	N/A

Table 5.0-2 provides an estimate of the accumulated 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 Covered Species in 2017. In the Comal system in 2017, incidental take for fountain darters (4,620) was almost half that in 2016 (9,959) 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 2017, incidental take for fountain darters (10,239) was about 800 less than that in 2016 (11,023) 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 (2013-2017)

Spring System	Species (Common Name)	ITP Take Limit	2013 Take	2014 Take	2015 Take	2016 Take	2017 Take	TOTAL Take	Remaining ITP Take*
Comal	Fountain Darter	797,000	10,482	23,060	5,115	9,959	4,620	**53,236**	743,766
	Comal Springs Riffle Beetle	11,179	681	1,564	0	0	46	**2,291**	8,887
	Comal Springs Dryopid Beetle	1,543	13	2	0	0	1	**16**	1,527
	Peck's Cave Amphipod	18,224	81	82	0	0	3	**166**	18,057
San Marcos	Fountain Darter	549,129	16,698	11,909	13,295	11,023	10,239	**63,164**	485,951
	San Marcos Salamander	263,857	1,053	482	1,059	0	36	**2,630**	261,228
	Texas Blind Salamander	10	0	0	0	0	0	**0**	10
	Comal Springs Riffle Beetle	N/A	0	0	0	0	0	**0**	N/A
	Comal Springs Dryopid Beetle	N/A	0	0	0	0	0	**0**	N/A

* The accumulation of annual totals from previous take report numbers show a difference by one or two individuals. Calculation discrepancies are due to rounding to the whole number. The discrepancy found in the San Marcos fountain darters occurs due to a change that happened after the 2013 ITP was created. In early 2014, the San Marcos fountain darter numbers were recalculated to account for Texas wild-rice, increasing the 2013 take by 14 fountain darters.

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6.0 RECOMMENDATIONS MOVING FORWARD

The Permittees are now in their sixth 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 2018.

6.1 Edwards Aquifer Authority

Aquifer Storage and Recovery

At the time of this writing, the EAA is intending to submit a formal proposal for a Nonroutine AMP action involving a series of modifications to the ASR leasing program from its original design in the EAHCP. The proposal does not involve modification to the main objectives of the program, but rather presents alternatives to the process by which the objectives are achieved. Specifically, due to lack of participation in the current lease/lease option structure, the proposed changes are an attempt to optimize the program's success by creating a more desirable product by implementing the following objectives:

1) Replace the current, three-tiered leasing/forbearance agreement structure with a two-tiered leasing structure that coordinates existing long-term leases with new long-term forbearance agreements (together providing control of the necessary 50,000 ac-ft/year of Edwards Aquifer groundwater);
2) Exercise (trigger) forbearance in years following a recognition of the Ten-year Rolling Average of the Estimated Annual Recharge to the Aquifer declining to amounts at or below 500,000 ac-ft per annum.

The proposed Nonroutine AMP would essentially accomplish the following administrative changes:

1) Three tiers will be replaced by two tiers;
2) The first tier will be outright leases in a sliding scale from 16,667 ac-ft/year to 10,000 ac-ft/year over the duration of the ITP;
3) The second tier will be forbearance agreements on a sliding scale from 33,333 ac-ft/year to 40,000 ac-ft/year over the duration of the ITP – dependent upon the amount of water contained in the tier one leases; and
4) Forbearance will be required in the Calendar Year following the year in which the EAA receives the Estimated Annual Recharge to the Aquifer and the Ten-year Rolling Average is ≤ 500,000 ac-ft.

No changes to either the objectives or goals of the springflow protection measure are proposed. All potential changed will be included in the AMP Proposal, which facilitates the committee vetting process of all AMP decisions made. This includes discussion and approval by the SC, SH, and IC. Once the AMP proposal is approved, EAA will market the long-term forbearance agreement product through various outreach efforts.

Refugia

Per the terms of the contract approved in November 2016, USFWS will preserve the capacity for the Covered Species to be re-established at the Comal and San Marcos rivers if extirpation in the wild were to occur. This effort will be achieved through duplicated off-site refugia populations of the Covered Species. The primary off-site refugia is located at the SMARC with the second being located at the UNFH.

During the 2018 calendar year, USFWS will complete construction of EAA physical infrastructure used to house the Covered Species as well as continue to collect species for their standing-stock population. While construction has will be ongoing throughout 2018, salvage refugia populations are already intact at these facilities.

Other

As part of its Program Administration responsibilities, in 2018, EAA will prepare and implement a plan for the Strategic AMP process – a process which will result in Phase II decisions.

Additionally, in 2018 EAHCP staff will play close attention to what has been reported in the Biological Monitoring data as declining numbers of the CSRB. Staff will pursue further analysis to determine possible causes and mitigation strategies of such causes as well as convene a CSRB Work Group to determine any potential research and alternative monitoring methods to add confidence to the data collected.

6.2 City of New Braunfels

Habitat Protection and Restoration

In 2018, 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 continue their riparian restoration program along the banks of the Old Channel of the Comal River and Spring Run #3. Specifically, riparian restoration efforts along the Old Channel will include planting native plants in areas where non-native plants were removed in 2017. Non-native plant species will continue to be systematically removed along the banks of the Old Channel downstream of Elizabeth Street through the Old Channel LTBG Reach. In order to protect CSRB habitat within Spring Run #3, riparian vegetation will be planted along the southeast bank of the spring run in order to create a riparian buffer area in place of an existing walk path.

Water Quality Protection

Habitat protection efforts in 2018 will also include the design and construction of stormwater treatment infrastructure identified in the City's WQPP. The CONB will move forward with design and construction of a bioretention basin at the end of North Houston Avenue that will help to infiltrate and filter urban stormwater runoff prior to entering the Upper Spring Run area of Landa Lake. The CONB will also design a permanent stormwater control, to be constructed in 2019, that will filter and reduce the volume of stormwater runoff from the Landa Park Golf Course parking lot prior to entering the Old Channel. Both

water quality protection projects are expected to remove stormwater-related contaminants prior to reaching the Comal River system.

6.3 City of San Marcos/Texas State University

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 Watershed Protection Plan. In 2018, the COSM/Texas State will construct two stormwater controls to minimize the impacts from stormwater runoff that were designed in 2017. Also, in 2018, the COSM/Texas State will design several stormwater controls for construction along the middle reach of Sessom Creek. This work is to capture and treat stormwater runoff from a heavily developed watershed.

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. Work done over the past five years has almost completed the water quality buffer from the headwaters to IH-35. In 2018, the COSM/Texas State will focus on establishing a riparian planting program on private riverside parcels, as well as maintain existing restored areas for reemerging non-natives.

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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 2016 and 2017. 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 2016

Adams, W. G. 2016. The protracted dispute over the Edwards Aquifer: Revisiting and reframing multiparty stakeholder conflicts in management, regulation, allocation, and property rights. Dissertation, Texas State University, San Marcos, Texas, USA.

This dissertation discussed multi-party issues surrounding the Edwards Aquifer and provided background on stakeholder concerns for the Aquifer from 1997 to the present, by revisiting and building on a previous study conducted in 2003 by Putnam and Peterson. Using a qualitative, "framing" approach and interviews with stakeholders, the study examined the key stakeholder groups, the results of Texas Senate Bill 3 in 2007, and changing climate and population patterns to assess how the original debate on management and water allocation in the Edwards Aquifer has changed over time.

Agare, O. O. 2016. Seasonal and longitudinal investigation on the impacts of recreational activities on the aquatic macroinvertebrate community within the San Marcos River. Thesis, Texas State University, San Marcos, Texas, USA.

This thesis described a quantitative study of macroinvertebrate community structure and drift during periods of human recreational use of the San Marcos River. The study found that macroinvertebrate community structure varied with vegetation and substrate type. However, the farthest downstream study site also showed differences in community structure that were correlated to turbidity and substrate factors. Macroinvertebrate drift was correlated to benthic abundance and was observed to follow a typical circadian pattern, but was not correlated to recreation use or seasonal differences.

Scanes, C. M. 2016. Fish community and habitat assessments within an urbanized spring complex of the Edwards Plateau. Thesis, Texas State University, San Marcos, Texas, USA.

This thesis assessed biotic integrity of the fish community and quantified fish community structure and habitat associations within wadeable and non-wadeable areas of the Comal springs complex. The study observed 25 fish species and over 23,000 individual fishes. Most of the fishes were a spring-associated type. Differences in the spring-associated fish richness measure and relative abundance of species were noted in two reaches of the springs complex that had high recreational

use. The endangered fountain darter was observed often and was not strongly associated with vegetation in this study.

7.2 Literature from 2017

Biles, K. S. 2017. Understanding key factors influencing habitat quality for the endangered fountain darter (*Etheostoma fonticola*) in the Comal River. Thesis, Baylor University, Waco, Texas, USA.

This thesis studied the effects of water, sediment, and macrophyte quality on fountain darter habitat in Landa Lake on the Comal River. Water quality and sediment measurements found that phosphorus may be a limiting nutrient. An experiment, which looked at the effects of crayfish herbivory on macrophyte production, found that fertilizing the plants may exacerbate herbivory. Dissolved oxygen conditions over time and space also generally correlated with flow conditions, but benthic vegetation and vegetation mats may cause local decreases in dissolved oxygen.

Clark, M. K., K. G. Ostrand, and T. H. Bonner. 2017. Implications of piscine predator control on the federally listed fountain darter. Fisheries Management and Ecology 44: 292-297. doi: 10.1111/fme.12223.

This journal article examined the effects of predator-prey interactions in headwater spring communities that include the endangered fountain darter, red swamp crayfish, and largemouth bass. Different predator treatments as well as vegetation and temperature variations were studied in a series experimental trials. While vegetation did not affect predation and temperature showed some effect, largemouth bass treatments generally had higher fountain darter consumption than red swamp crayfish treatments. The study concluded that the recommended strategy of removing piscine carnivores like the largemouth bass appears to reduce fountain darter predation during low flow conditions.

Hahn, N. M. 2017. Rapid quantitative assessment to assist in identification of imperiled fishes. Thesis, Texas State University, San Marcos, Texas, USA.

This thesis used a multivariate, principal components analysis approach to develop a method to rank or assess the conservation status of freshwater fishes. Data and life history characteristics were collected for 50 species of rare to common fishes within three Texas ecoregions, across gradients of redundancy, representation, and resiliency. The study found that species ranks were similar to the Texas Species of Greatest Conservation Need list, with some discrepancies that could be linked to qualitative methods or expert opinion. Based on the life history data, the study also determined that higher ranked (more rare) species were also more likely to be associated with Aquifer-dependent surface waters.

Hooks, C. 2017. Amphibious assault: The case of the missing salamanders. Texas Monthly 45: 52-54.

This magazine article reported on the November 2016 disappearance of Texas blind salamanders from the San Marcos Aquatic Resources Center.

Hutchins, B. T. 2017. The conservation status of Texas groundwater invertebrates. Biodiversity and Conservation (online). 27 pages. doi:10.1007/s10531-017-1447-0.

This journal article reviewed the status of sixty-nine groundwater-obligate invertebrates recorded from Texas, including those found within the Edwards Aquifer.

Hutchinson, J. T. 2017. Propagation and production of an endangered aquatic macrophyte: Texas wildrice (*Zizania texana* Hitchc.). Native Plants Journal 18: 77-85. doi: 10.3368/npj.18.1.77.

This journal article reported the results of propagation and production studies of Texas wildrice at the San Marcos Aquatic Resource Center. Germination success and growth rates for seeds and tillers under different flow regimes were determined. Seed propagation was found to be a more efficient method of production. The study transplanted wildrice seedlings two to three months after germination and found that after eight months, the transplants had increased to cover four times the initial area.

Külköylüoğlu, O., D. Akdemir, M. Yavuzatmaca, B. F. Schwartz, and B. T. Hutchins. 2017. *Cypria* lacrima sp. Nov. A new Ostracoda (Candonidae, Crustacea) species from Texas, U.S.A. Zoological Studies 55: 10 pages. doi:10.6620/ZS.2017.56-15

This journal article described the features and distinguishing characteristics of a new ostracod species, which was collected from the well outflow pipe at the artesian well on the campus of Texas State University.

Külköylüoğlu, O., M. Yavuzatmaca, D. Akdemir, B. F. Schwartz, and B. T. Hutchins. 2017. *Lacrimacandona* n. gen. (Crustacea: Ostracoda: Candonidae) from the Edwards Aquifer, Texas (USA). Zootaxa 4277 doi: 10.11646/zootaxa.4277.2.6.

This journal article described the features and distinguishing characteristics of a new ostracod genera and type species, Lacrimacandona wisei, which was collected from the San Marcos artesian well on the campus of Texas State University.

Loáiciga, H. A. 2017. The safe yield and climatic variability: Implications for groundwater management. Groundwater 55: 334-345. doi: 10.1111/gwat.12481.

This journal article discussed methods for calculating the safe yield, or maxiumum amount of water that can be withdrawn without adverse effects to groundwater systems. The article indicated that high-quality, historical climatic, recharge, discharge, and groundwater extraction data are important in modeling the safe yield and for groundwater management planning. As an example, the safe yield for the Edwards Aquifer was calculated and found to be approximately half the average annual recharge.

Opsahl, S., M. Musgrove, and R. N. Slattery. 2017. Continuous monitoring and discrete water-quality data from groundwater wells in the Edwards Aquifer, Texas, 2014 – 2015. Texas Water Science Center, U. S. Geological Survey. doi:10.5066/F7Q23XC2.

This study report presented precipitation data and continuous water quality data for nitrate, conductance, and water level from two groundwater wells in the Edwards Aquifer.

Schindel, G. M. and M. Gary. 2017. Hypogene processes in the Balcones Fault Zone Segment of the Edwards Aquifer of South-Central Texas. Pp. 647-652 *In:* A. Klimchouk, A. N. Palmer, J. De Waele, A. S. Auler, and P. Audra (eds.). Hypogene karst regions and caves of the world. Cham, Switzerland: Springer. 911 pages. doi: 10.1007/978-3-319-53348-3_41.

This book chapter discussed the geological features of the Balcones Fault Zone and the below-surface (hypogene) processes that contribute to the karst characteristics of the Edwards Aquifer.

Weissenbuehler, A. 2017. Swimming with the salamanders: Building immersive experiences to promote conservation of the San Marcos River. Thesis, Texas State University, San Marcos, Texas, USA.

This master of fine arts thesis explored different design methods to protect Texas wild rice in the San Marcos River from damage by river users such as tubers and paddlers. Signs and buoys with catchy, yet educational, messages were tested on the river near wild rice habitat and reactions to the installations were recorded.

Wilson, W. D., J. T. Hutchison, and K. G. Ostrand. 2017. Genetic diversity assessment of *in situ* and *ex situ* Texas wild rice (*Zizania texana*) populations, an endangered plant. Aquatic Biology 136: 212-219. doi:10.1016/j.aquabot.2015.12.005.

This journal article compared the genetic diversity 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.

Wray, K. P. and S. J. Steppan. 2017. Ecological opportunity, historical biogeography and diversification in a major lineage of salamanders. Journal of Biogeography 44: 797-809. doi:10.1111/jbi.12931

This journal article presented a phylogenetic analysis of the Spelerpini group of salamanders, of which Eurycea is one of the most diverse and oldest genera. Results also showed strong support for a diversification rate shift among the Edwards Plateau neotenic Eurycea.

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