# Appendix M

## City of San Marcos, Texas State University, and Texas Parks & Wildlife Department Reports/Documents

1 The Meadows Center, Texas State University, *Images of the October 2015 Flood Event* Biology Field Crew Habitat Conservation Plan, San Marcos

2 *Conservation Crew Report Summer 2015*

3 *2014-2015 Progression, Biology Field Crew, Habitat Conservation Plan, San Marcos*

4 *Propagation of Texas Wild Rice and Other Native Plants for Habitat Restoration in the San Marcos River, 2015 Final Report*

5 *Concept Design: Hopkins Drainage Channel Water Quality Retrofits* 2015 San Marcos Water Quality Protection Plan

6 Texas State 2015 *Integrated Pest Management Plan* Golf Course Management Plan

7 TPWD Regulations Regarding State Scientific Areas

# Appendix M1

## The Meadows Center, Texas State University, *Images of the October 2015 Flood Event* Biology Field Crew Habitat Conservation Plan, San Marcos

# Images of the October 2015 Flood Event

Biology Field Crew
Habitat Conservation Plan, San Marcos

## Contents

# About

Enclosed are images depicting the flood event that occurred in the San Marcos River between October 29th and November 1st, 2015. The primary focus of this document is to depict how the flood affected aquatic vegetation in the river. The flood caused scouring in several areas of the river, including areas designated as Biology Field Crew work sites and areas that are non-work sites. The flood also caused sediment deposition in areas designated as Biology Field Crew work sites and areas that are non-work sites. GIS vegetation mapping data is currently being calculated to assess the extent of vegetation displacement and loss within the habitat. Areas of clear, significant vegetation loss have been noted in this document. **Note: when viewing this document digitally as a PDF, you may access any section by clicking the figure number in the table above.**

# I. Flooding

The flood event occurred over the period of October 29th through November 1st, 2015. Though some images below are from the beginning of the flood on October 29th, others are from the days following due to safety concerns. Dates of images are noted in the captions.

*Figure 1 A mosaic of headwaters on November 3rd, 2015.*

*Figure 2 View of Sessom Dr. on October 30th, 2015.*

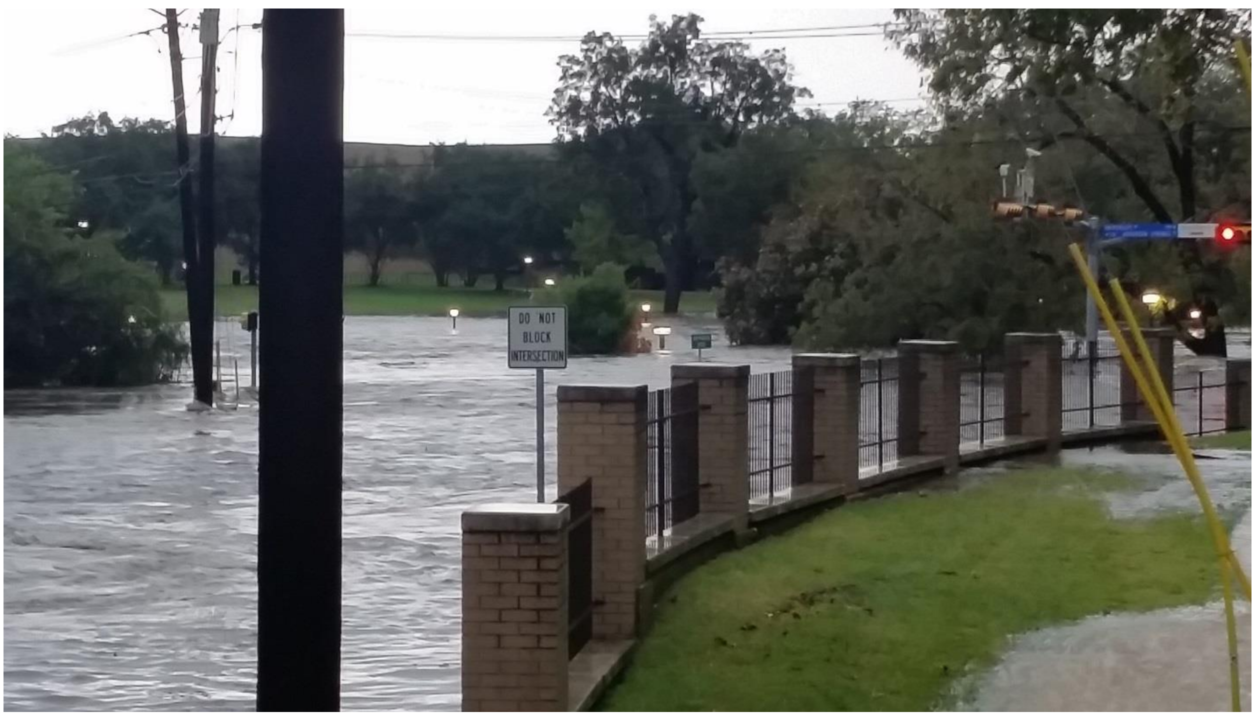


*Figure 3 Image of Sessom Dr. and Aquarena Dr. intersection on October 30th, 2015.*

*Figure 4 Additional image of Sessom Dr. taken October 30th, 2015.*

*Figure 5 Mosaic of Sewell Park just after the flood, taken on November 3rd, 2015.*

*Figure 6 Mosaic of City Park on November 3rd, 2015.*

*Figure 7 City Park on October 31st, 2015.*

*Figure 8 City Park river access point on October 31st, 2015.*

*Figure 9 Mosaic of Purgatory Creek on November 3rd, 2015.*

*Figure 10 Mosaic of Cypress Island on November 3, 2015.*

*Figure 11 Cypress Island bridge on October 31st, 2015.*

*Figure 12 Rio Vista Dam on October 31st, 2015.*

# II. Saltgrass Shoal

The flood waters deposited sediment along the west bank of the river within the headwaters area near Saltgrass. This formed a large shoal composed of small cobble and silt.

*Figure 13 A mosaic of headwaters taken on November 12, 2015.*

*Figure 14 A larger image of the shoal at headwaters, taken on November 12, 2015.*

## III. Areas that Experienced Vegetation Loss

In terms of aquatic vegetation, vegetation loss appears to have occurred most prevalently amongst the invasive, non-native species *Hydrilla verticillata*. However, further research is necessary to substantiate this observation. Vegetation loss within Biology Field Crew work sites and non-work sites have been noted below.

# III.I. Work Sites

## III.I.I Sewell Park

*Figure 15 Sewell Park at Aquarena Dr. on October 29th, 2015.*

*Figure 16 Sewell Park at Aquarena Dr. on November 9th, 2015.*

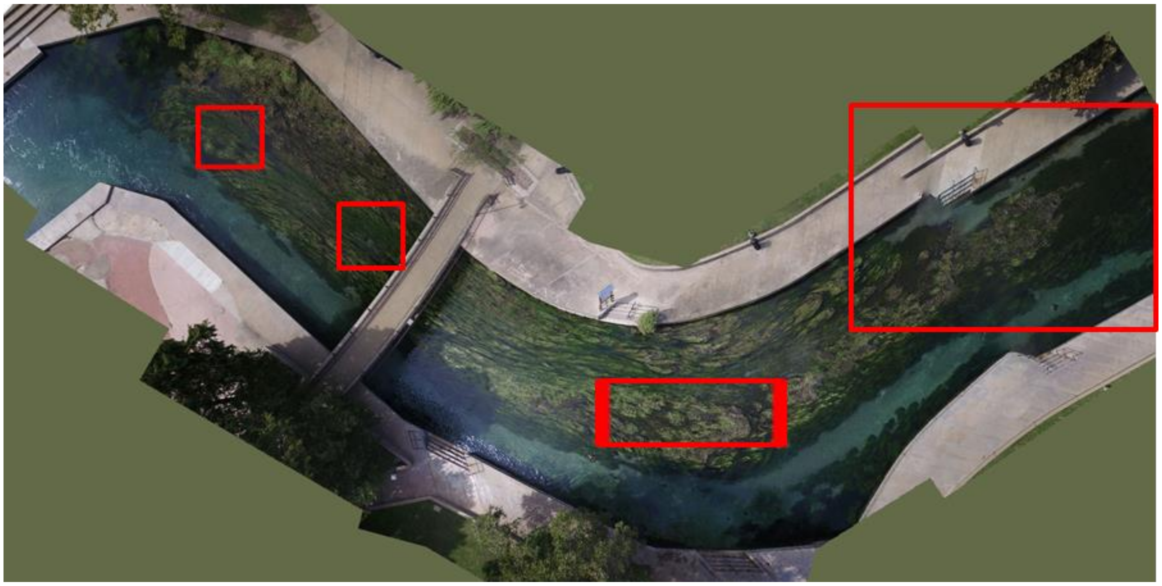

*Figure 17 Sewell Park at the first walking bridge, October 29th, 2015.*

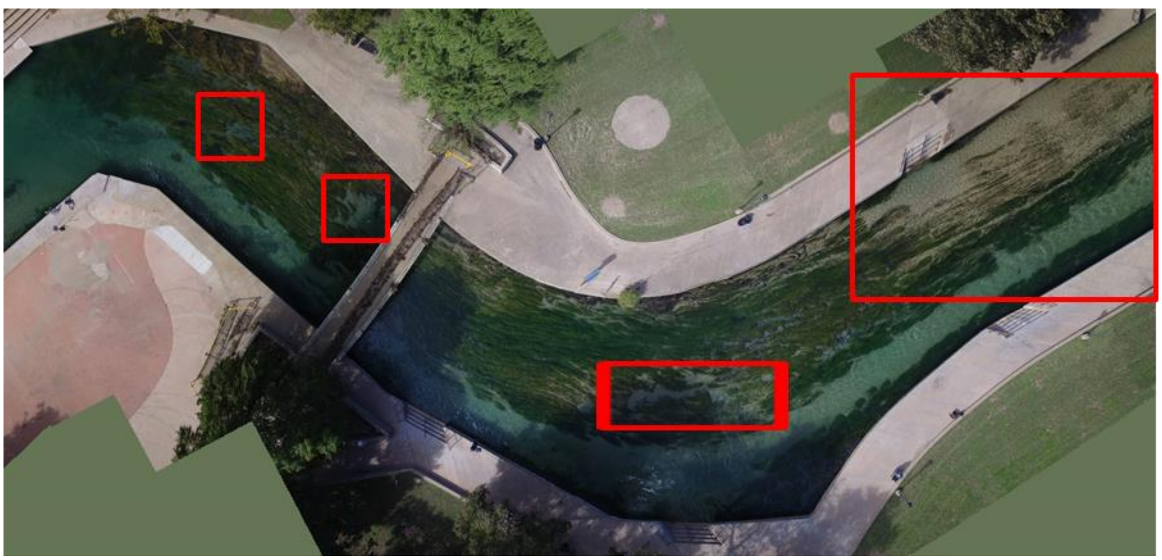

*Figure 18 Sewell Park at the first walking bridge, November 9th, 2015. Areas of vegetation loss have been highlighted in red.*

III. I. II “Site 1”

*Figure 19 Image of the bend at Site 1, just past the walking bridge in Sewell Park, taken June 26, 2015.*

*Figure 20 Image of the bend at Site 1, taken November 9th, 2015. The location of the previous image is highlighted in red.*

*Figure 21 Image of Site 1, further down the bend, taken before the flood in 2015.*

*Figure 22 Image of Site 1, further down the bend, taken November 9th, 2015. The location of the previous image is highlighted in red.*

### III. I. III City Park

*Figure 23 City Park at Lion's Club, October 29th, 2015.*

*Figure 24 City Park at Lion's Club, November 9th, 2015. Lost vegetation is highlighted in red.*

*Figure 25 City Park upstream from the walking bridge, October 29th, 2015.*

*Figure 27 City Park upstream from the walking bridge, November 9th, 2015. Lost vegetation is highlighted in red.*

## III. I. IV. Purgatory Creek

*Figure 28 Image of Purgatory Creek taken November 12, 2015. A pre-flood image of this area was not available. However, the area that experienced vegetation loss has been highlighted in red.*

III. I. V. Cypress Island

*Figure 29 Cypress Island on September 9th, 2015.*

*Figure 30 Cypress Island on November 12th, 2015.*

## III.II. Non-Work Sites

For the purpose of this document, areas designated as non-work sites for the Biology Field Crew include sites that are near or around work sites that were not physically altered by the crew. For example, Cypress Island is a site that was worked by the crew, however, there are areas of Cypress Island that were not worked (such as the right bank). Non-work sites may also include areas of the Upper San Marcos River that are not necessarily near or around work sites, such as the bend between Site 1 and City Park.

### III.II.I. Site 1 Bend

A pre-flood image is not available for the Site 1 Bend. However, area of loss has been highlighted in the image below.

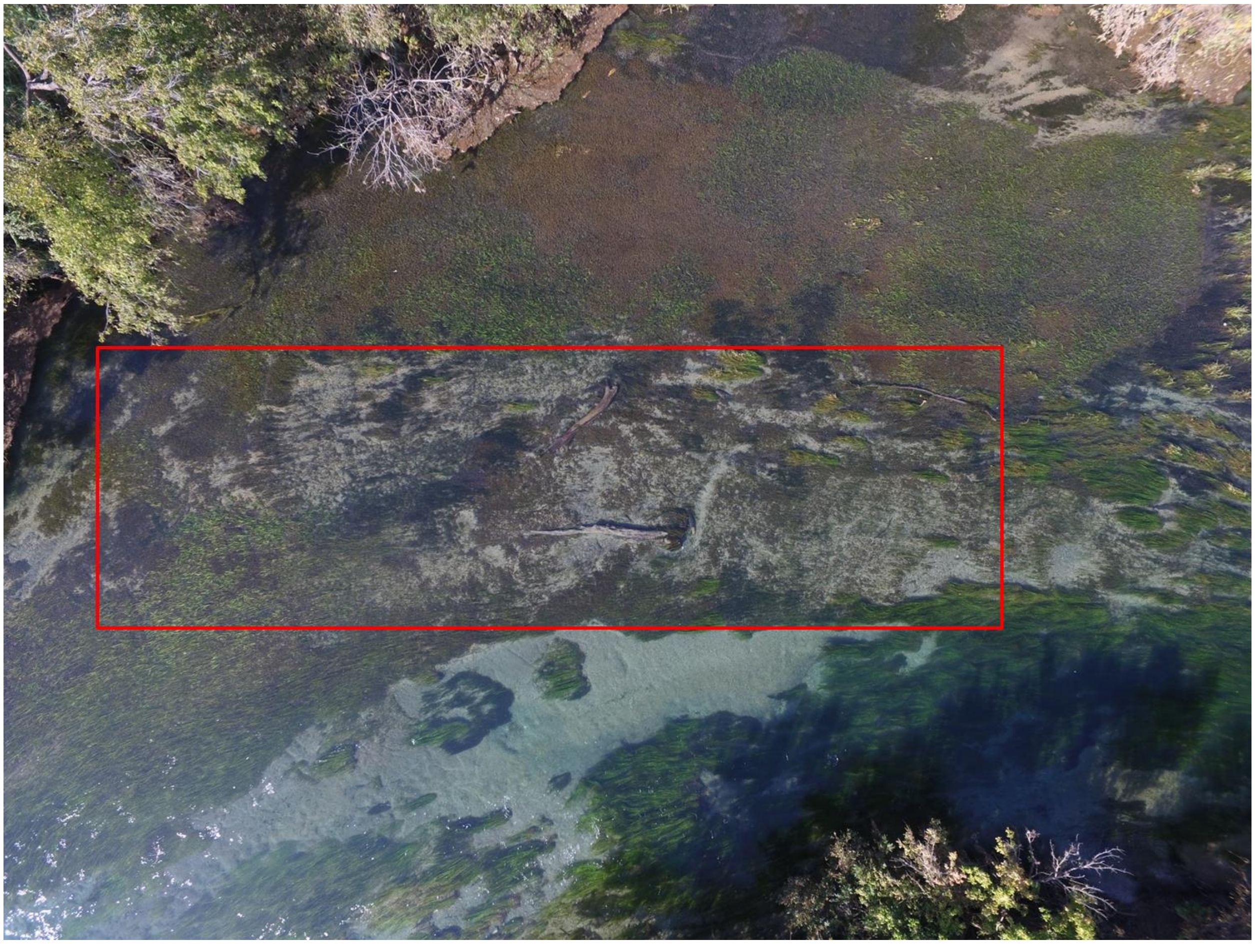

*Figure 31 Image of Site 1 Bend taken November 9th, 2015. Area of loss highlighted in red.*

### III.II.II Cypress Island

*Figure 32 Image of Cypress Island taken September 9th, 2015. The area highlighted was an area of extremely dense* Hydrilla verticillata.

*Figure 33Image of Cypress Island taken November 9th, 2015. The area highlighted is now mostly silt, with a significantly less dense occurrence of* Hydrilla verticillata.

# IV. Areas that Did Not Experience Vegetation Loss

Areas that have been observed to have minimal loss have been noted below.

# IV.I. Work Sites

## IV.I.I. Sewell Park

*Figure 34 Sewell Park on October 29th, 2015.*

*Figure 35 Sewell Park on November 9th, 2015. Non-loss areas are highlighted in red.*

*Figure 36 Mosaic of Sewell Park on October 29th, 2015.*

*Figure 37 Mosaic of Sewell Park November 9th 2015. Non-loss areas are marked in red.*

### IV.I. II. "Site 1"

A pre-flood aerial image of non-loss areas at Site 1 is not available at this time. However, the areas that did not experience loss are outlined in the post-flood image below.

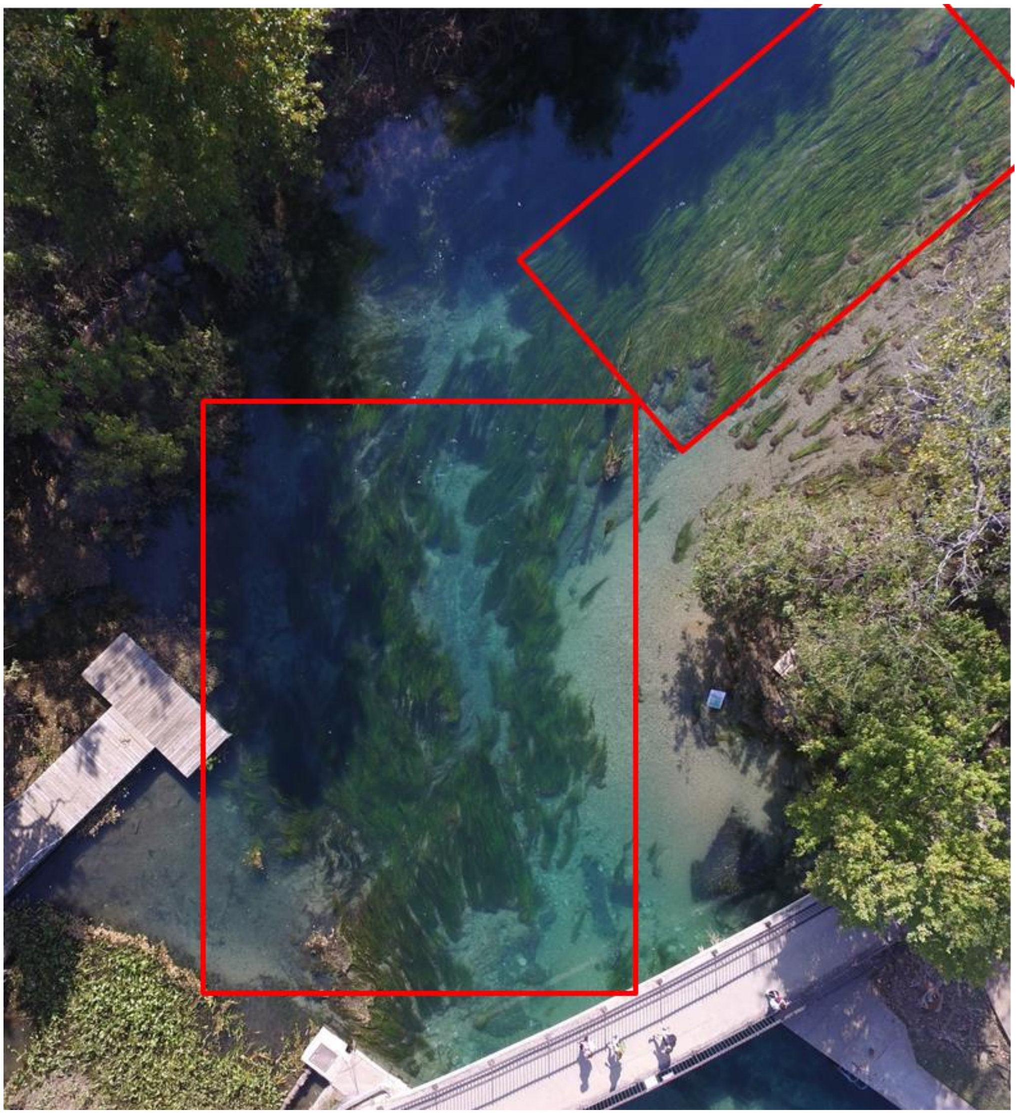

*Figure 38 Image of Site 1 taken November 9th, 2015. It is important to note that within the section marked on the left, there is some degree of thinning within the stands of Zizania texana. However, a larger percentage of the vegetation remains than was lost.*

*Figure 39 A mosaic of Site 1 taken November 9th, 2015. Areas that did not experience loss are highlighted in red.*

## IV.I.III. City Park

*Figure 40 Image of City Park taken October 29th, 2015.*

*Figure 41 Image of City Park taken November 9th, 2015. Areas of non-loss are highlighted in red.*

## IV.I. IV. Purgatory Creek

*Figure 42 Image of Purgatory Creek taken October 6th, 2015.*

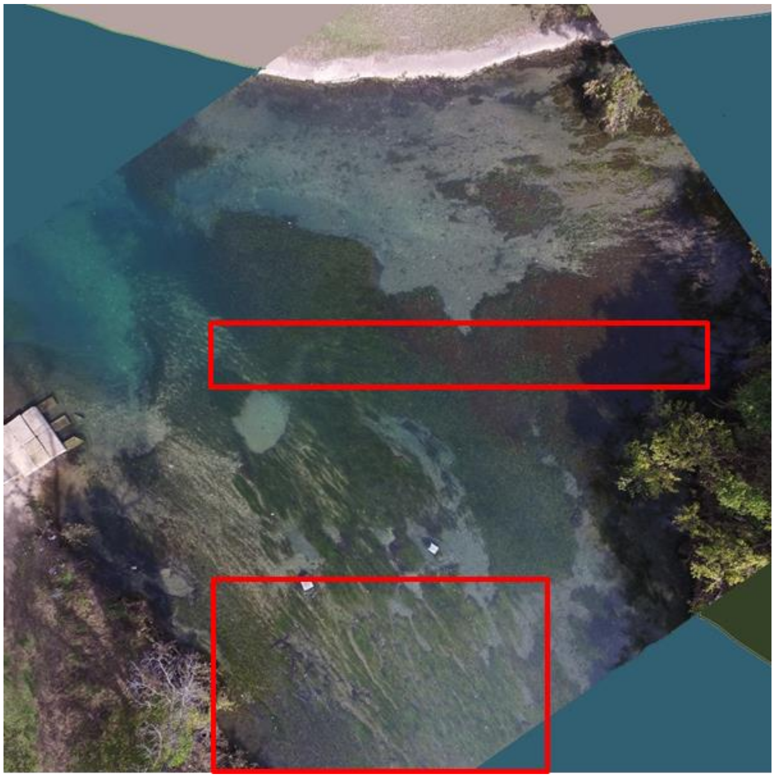

*Figure 43 Image of Purgatory Creek taken November 6th, 2015. Areas of non-loss are highlighted in red.*

## IV.I.V. Cypress Island

*Figure 44 Cypress Creek on September 9th, 2015.*

*Figure 45 Cypress Island on November 12, 2015. Areas of non-loss are highlighted in red.*

## IV.II. Non-Work Sites

For the purpose of this document, areas designated as non-work sites for the Biology Field Crew include sites that are near or around work sites that were not physically altered by the crew. For example, Cypress Island is a site that was worked by the crew, however, there are areas of Cypress Island that were not worked (such as the right bank). Non-work sites may also include areas of the Upper San Marcos River that are not necessarily near or around work sites, such as the bend between Site 1 and City Park.

## IV.II.I. Headwaters

*Figure 46 A mosaic of headwaters taken November 9th, 2015.*

IV.II.I. “Site 1” Bend

*Figure 47 Image of Site 1 Bend taken November 9, 2015. Area of non-loss highlighted in red.*

IV.II. II. Purgatory Creek

*Figure 48 Mosaic of Purgatory Creek taken November 12th, 2015. A pre-flood image of this area could not be found. However, areas of non-loss have been highlighted in red.*

*Figure 49 Purgatory Creek on October 6th, 2015.*

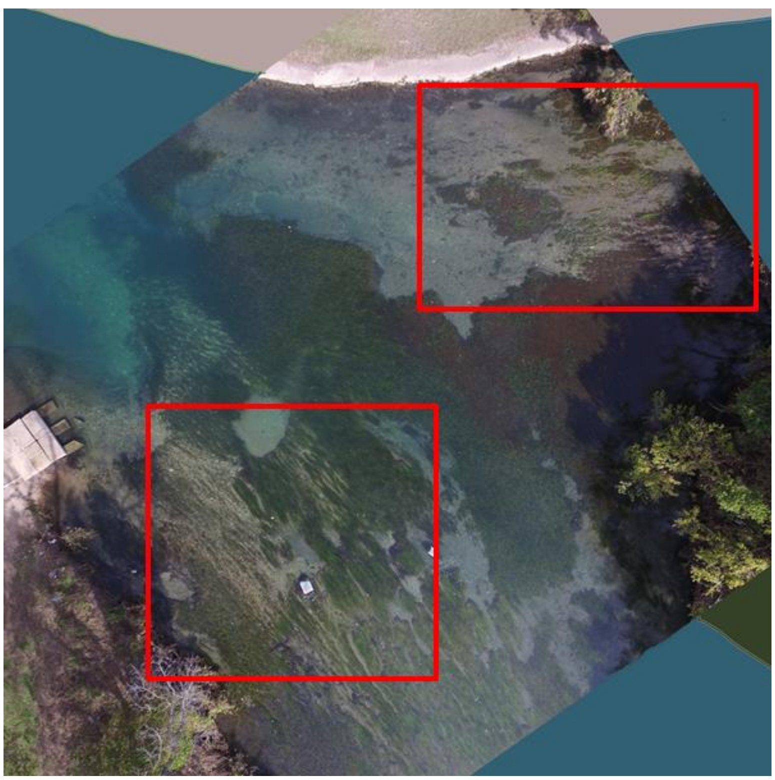

*Figure 50 Purgatory Creek on November 6th, 2015. Areas of vegetation loss have been highlighted in red.*

*Figure 51 Mosaic of Purgatory Creek taken November 12, 2015. A pre-flood image of this area could not be found. However, the non-loss areas have been highlighted.*

Appendix M2

*Conservation Crew Report Summer 2015*

# Conservation Crew Report Summer 2015

Recreational Presence: Recreation on the San Marcos River started later than normal this season due to the Memorial Day flood and subsequent closing of park and river for 2 weeks. Recreation picked up and remained steady throughout the summer, spiking on Labor Day Weekend. We noticed a drastic increase in recreation and litter this year compared to previous years.

The Conservation Crew:

- Led a three day environmental educational field trip for Travis Elementary 4th grade classes. The students toured the Surface Water Treatment Plant and the San Marcos Aquatic Resource Center where they learned about where and how we get our drinking water and the importance of threatened and endangered species that live in our river and aquifer. There were several stations along the river where the Conservation Crew talked about the geology of the Edwards Aquifer, uniqueness of the San Marcos Springs, introduction of invasive species, Texas wild-rice, litter, and erosion. The HCP Program plans to lead fieldtrips next year that will reach all SMCISD 4th grade students. See Figures 1-5.
- Assisted citizens who were evacuated at Hernandez Elementary School.
- Pushed vegetation mats off of TWR and removed washed up vegetation debris from the parks.
- Removed litter and flood debris from headwaters to Stokes Park. See Figures 6 – 12.
- Remove litter from trails, parks, litter boats and river substrate as a result of recreation. See Figure 13. See Table 1 for Total River Removal for CC. See Table 2 for CC and PTR Total Litter Removal.
- Removed degraded noodles from the SSA enclosure t-posts. We are currently researching another material that will serve the same purpose but not degrade.
- Assessed riparian plantings after flood. Noted very little damage has occurred and a layer of beneficial and organic silt has been deposited.
- Noted the first day was very slow due to unusually cool weather.
- Observed two civilian divers helping remove trash.
- Spotted a small amount of elephant ear regrowth under the Hopkins Bridge and the footbridge at Bicentennial. Communicated this tour our invasive removal contractor.
- Noticed a lot of water lettuce at the Sewell SSA. Removed water lettuce that had accumulated around floating boat dock a Sewell Park. See Figures 14-17.
- Cleaned up flood debris and litter from headwaters to Stokes Park. Noticed Thompson's Island needs trash cans so that river users can responsibly dispose of their litter. Moved several large neighborhood recycling/trash bins and pallets from Thompson's Island to side of Capes Rd. for pick up. Helped load all hazardous materials with Green Guy Recycling (gasoline cans, motor oil, W-D 40, heavy grease, cleaning supplies, etc.) to be disposed of properly.
- Assisted with repairs on memorial cypress cages.
- Flipped litter boat right side up after flood. Noted front handle on litter boat at Hopkins Bridge was damaged from flood. The rear handle is in good condition, but is held on by 2

carabineers and needs to be addressed soon. Lock and chain has been moved to the rear handle and is now secured.

- Noted the TWR in river is looking healthy.
- Cleaned out the dirt deposited along the side walk from Crooks to Wild Annex Park. Added mulch along sides of sidewalk to reduce future erosion.
- Noted erosion issues at Capes Rd. and have reported this. See Figure 18.
- Found iPod at Ramon Lucio Park and returned to Parks & Rec lost and found.
- Removed ragweed from Dogbeach. See Figures 19-20.
- Added three signs at Dogbeach to educate river users about riparian restoration efforts. See Figure 21.
- Watered recent plantings along the river on a weekly basis.
- Removed invasive regrowth.
- Added mulch to Rio Vista gardens after flood waters washed away previous mulch. See Figure 22.
- Added cages around cypress trees at Rio Vista and Ramon Lucio.
- Reported a tree branch has fallen over along path way to Rio Vista from the NC. This has been by PARD. See Figure 23.
- Observed people consistently walking behind fences at Rio Vista plantings at cypress trees. Fences have been extended to enclose completely around the tree to cut off access to the plantings from the river side.
- Noted graffiti on HCP sign at Ramon Lucio. Graffiti has been removed. See Figure 24.
- Noted sign is down at Rio Vista Gardens. Sign has been re-installed.
- All t-posts are now capped with PVC pipe to address the issue of pool noodles tearing off easily.
- Were thanked by two elderly men for our efforts.
- Dad and daughter inquired about our weeding activities and we got to see him explain it to his daughters how invasives are bad and we should keep them out of this area.
- Helped 3 girls who flipped their canoe; two of them didn’t know how to swim. We retrieved their life jackets that they weren’t wearing as they hung on to the trash boat.
- A few more people expressed gratitude for what we were doing; one guy asked how he could volunteer.
- Inspected all access points for undermining.
- Noticed a very large amount of trash at Rio Vista.
- Noticed litter behind barriers near pedestrian bridges at City Park – later removed litter.
- Reported illegal spear fishers at Rio Vista to Park Rangers. Witnessed more illegal spear fishing days later. Individuals said they called and got permission. We left a message with the Park Rangers.
- Removed 11 bags worth of litter in one shift! Litter has become a serious issue and is becoming difficult to keep up with.

- Noticed large amounts of paper mulberry coming back at Rio Vista. EBR has been notified and is treating this area.
- Notified individuals not to walk inside fenced riparian area at Upper Sewell Park.
- Noted some of our plantings have been torn out of the ground at Ramon Lucio. We salvaged and replanted everything we could. See Figure 25.
- Had a good conversation with another spear fisher who was very receptive of info and stopped.
- Noticed park trash cans overflowing very frequently, especially at Rio Vista and Veramendi Parks. Recommend trash cans be emptied more frequently. See Figures 26-29.
- Pushed vegetated mats off TWR. See Figures 30 & 31.
- Surveyed river users about perception and values of the SMR for a University student's thesis study.
- Witnessed a lady intentionally litter, and took this opportunity to educate her.
- Stopped river users from jumping off of bridge at Sewell Park.
- Removed t-post enclosures at Bicentennial and Hopkins SSA's as a safety measure due to increased flow rate recommended by COSM.
- Repaired sign at City Park.
- Encouraged kids to not litter.
- Removed invasive regrowth at City Park – chinaberry and Johnson grass.
- Coordinated and led a two-day volunteer planting event for a high school group at City Park. Planted prohibitives, vines and various riparian and littoral plants.
- Planted leftover plants along bank in Wildlife Annex Park.
- Painted new litter boat sign and cleaned connex (storage container).
- Assisted with measuring and collecting data during the 5-day TWR Survey.
- Added mulch to a planting site at Ramon Lucio after heavy rains washed most of the previous mulch away.
- Removed ragweed at Dogbeach Park, uncovering many native plantings that were previously overshadowed and outcompeted.
- Removed trash behind the riparian fences.
- Reported graffiti on Hopkins Bridge.
- Sprayed WD-40 to all locks (riparian fence gates and litter boats) to keep them working properly.
- Installed rip rap concrete bags (harden underwater) to undermined access points at Veramendi, Bicentennial and Rio Vista Parks. After installation, CC assessed how well the concrete bags served their purpose, and made recommendations for additional bags as well as rebar and stake stabilization. See Figure 32.
- Removed and treated invasive regrowth with USFWS at Rio Vista Park.
- Constructed and installed litter boat sign to the new boat (third boat). Chained boat under Rio Vista Bridge.

- Flushed out and cleaned irrigation system at City Park in preparation for TCEQ temporary water permit.
- Spread chipped mulch piles between terracing at Dogbeach.
- Spoke to several people at Ramon Lucio who expressed gratitude towards CC's work and also expressed their own concerns on the health of the river and importance of conservation.
- Collected TWR tillers for SMARC.
- Rehung SSA sign at Hopkins SSA.
- Added additional mulch to the Rio Vista Gardens planting areas.
- Repaired riparian fence at Rio Vista Gardens.
- Have noticed TWR is growing strong near Sewell Park.
- Noticed many individuals with glass containers. One individual stated they know the law but did it anyway. Enforcement and fines are necessary to correct this behavior.
- Removed at least 20 glass bottles from bottom of river between Hopkins bridges and noted plenty more still there.
- Added mulch to trees at River house access point and Rio Vista Garden plantings.
- Participated in the Passport SMTX and Business Expo events with an HCP booth educating people about the HCP, litter, endangered/threatened species and pollution using an interactive watershed model. See Figures 33 & 34.
- As requested by PARD, CC has prepared an assessment report and provided recommendations for repair to a cavity under the lower Rio Vista access point due to a safety concern. See Figure 35.

# Appendix M3

## *2014-2015 Progression, Biology Field Crew Habitat Conservation Plan, San Marcos*

# 2014-2015 Progression

Biology Field Crew
Habitat Conservation Plan, San Marcos

## Contents



## About

Enclosed are images depicting the progression of work sites from 2014 to 2015 following non-native species removal and planting in the San Marcos River. **Note: when viewing this document digitally as a PDF, you may access any section by clicking the figure number in the table above.**

## I. Sewell Park

Sagittaria planted in 2014 at the dock in Sewell Park notably persisted through the November 2015 flood (Figure 1 and 2).

*Figure 1 Sagittaria at the dock at Sewell Park, June 2014.*

*Figure 2 Sagittaria at Sewell Park dock, November 2015. Though the dock was moved by the flood, the Sagittaria covers the same area.*

# II. Site 1

Although some *Zizania texana* (Texas wild rice) at Site 1 was lost to sediment deposition in the November flood (see document "Images of November 2015 Flood"), Texas wild rice still constitutes the greatest amount of aerial coverage for vegetation in this work-site (Figure 3 and 4).

*Figure 3* Zizania texana *at Site 1, 2014.*

*Figure 4* Zizania texana *at Site 1, November 2015. Texas wild rice closer to the bank is currently non-emergent, yet abundant.*

# III. City Park

Texas wild rice at city park expanded from 2014 - 2015, particularly near the walking bridge and along the right bank of the river, as seen in the Figures 5-7.

*Figure 4 City Park from the walking bridge, February 2014.*

*Figure 5 City Park from the walking bridge, November 2014.*

*Figure 6 City Park from the walking bridge, April 2015. Zizania texana has expanded considerably throughout the area, particularly along the banks.*

# IV. Cypress Island

Cypress Island, located just upstream of Rio Vista Dam, became a work site for Texas State during 2015. An aerial image of Cypress Island from 2013 shows the area filled with dense masses of *Hydrilla verticillata* with very little, if any, stands of Texas wild rice (Figure 8). As of October 2015, *Hydrilla verticillata* coverage was reduced by 850.7$m^2$ with many stands of Texas wild rice, as well as other native plant species now present (Figure 9).

*Figure 7 Cypress Island, 2013. Areas of dense Hydrilla verticillata have been highlighted in red. Imagery is provided by NAIP Satellite Imagery captured in 2013.*

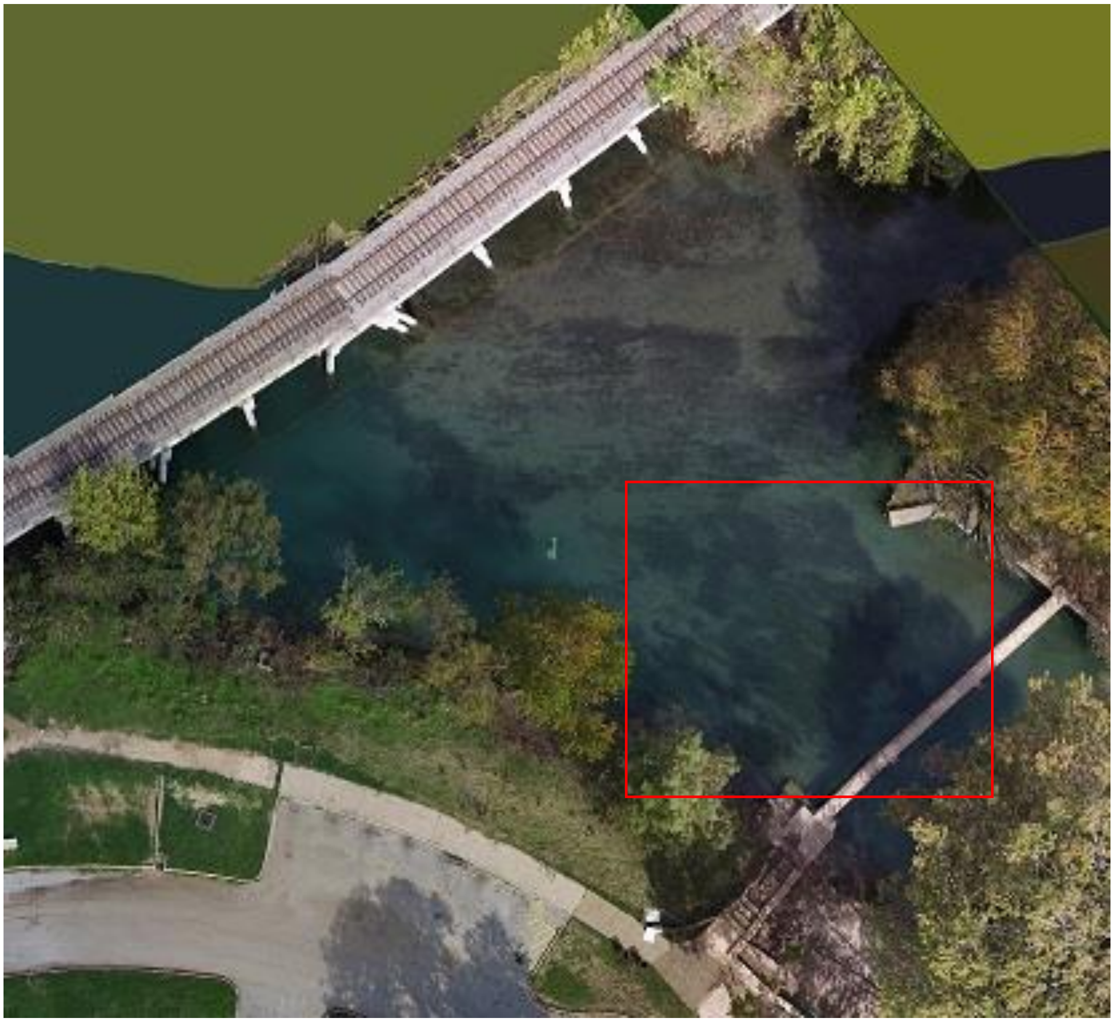

*Figure 8 Cypress Island in November, 2015. The main area by the bridge, which now consists of Texas wild rice and star grass, is highlighted in red.*

Appendix M4

*Propagation of Texas Wild Rice and Other Native Plants for Habitat Restoration in the San Marcos River, 2015 Final Report*

# Propagation of Texas Wild Rice and Other Native Plants for Habitat Restoration in the San Marcos River

## 2015 Final Report

## City of San Marcos Grant

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*"The findings and conclusions in the report are those of the author and do not necessarily represent the views of the U.S. Fish and Wildlife Service."*

## November 3, 2015

## INTRODUCTION

Texas wild rice (*Zizania texana* Hitchcock; TWR) occurs in a single population within a 4.5 km stretch of the San Marcos River and is listed as a federally endangered species. The plant prefers shallow water less than 1m deep in currents where flow rates are greater than 0.5 m $s^{-1}$. Current and past activities such vegetation removal, exotic vegetation, erosion, stream channelization, recreation, and dam construction have resulted in a decline of TWR and other native aquatic plants. These activities along with intentional and unintentional introductions of non-native plants have led to an increase in some highly invasive plants such as *Hydrilla verticillata* and *Hygrophila polysperma* invading TWR habitat. Restoration work funded by the Edward's Aquifer Authority is intended to restore disturbed habitats and establish populations of TWR and native aquatic plants. Two of the goals of the Edwards Aquifer Recovery Implementation Program (EARIP) are to protect species that are designated as threatened or endangered under state and federal laws and the enhancement and restoration of TWR and establishment of native plants.

At the San Marcos Aquatic Resources Center (SMARC), the U.S. Fish and Wildlife Service has the ability to mass produce Texas wild rice, aquatic, riparian, and terrestrial plants for restoration efforts in the San Marcos River. For large scale production of these plants, a variety of propagation techniques are required including seed germination, division, fragments, cuttings, and small seedlings. SMARC has a wide variety of tanks, outdoor raceways, and ponds suitable to produce various types of plants. Plant production occurs in a 400 $m^2$ greenhouse, and two 90 $m^2$ shade houses are on order and will be constructed in early 2015 for maintaining terrestrial plants.

Under a grant from the City of San Marcos, the SMARC began a program in 2013 to propagate these plants that included the hiring of an additional botanist, installing an outdoor irrigation system for riparian and terrestrial plants, and refining outdoor pond as storage areas for plants. Plants produced at the SMARC are available as needed to contractors hired by the City of San Marcos for replanting in the San Marcos River. As contractors remove plants from the SMARC, empty tanks are refilled with plants within 2 to 3 days resulting in a continuous supply of plants for restoration work in the river.

## METHODS

***Texas wild rice*** - Texas wild rice was propagated from seeds collected from experimental plants in greenhouse tanks and outdoor ponds at the SMARC, and from San Marcos River sections A and B during 2015. Experimental TWR are from free floating tillers or TWR plants grown from seeds of an unknown source. Mature seeds were collected from the panicle by gently pulling upwards until seeds were released. Mature seeds were defined as seeds that are plump, filled out and either green or brown in color. Seeds were placed in a plastic bag during collection, and counted and potted within 24 hours following collection.

Soil type consisted of a bulk soil mix from Gardenville in San Marcos, and was comprised of a mixture of top soil, compost, orange sand (iron source), and cedar flakes. Nitrogen (nitrate) and phosphorus content were 46 and 115 ppm (mg/kg), respectively. No additional nutrients were added to the soil. All TWR and other native aquatic plants were potted in this soil mixture.

Texas wild rice seeds were placed on top of 20 cm layer of inundated soil in 3,785 $cm^3$ pots and covered with pea gravel to secure the seeds from floating in the water. Seeds were spread out evenly within each pot, and gently pushed into the saturated soil and gravel mixture. Pots were then placed in 0.75 m of water in a 3.7 x 1.3 x 0.75 m tank. Flow was provided in the tanks at a rate of ca. 0.15 m/s using a small submersible pumps (EcoPlus 264 GPH Submersible Pump), and water input occurred through a hose at a rate of 11 L per minute.

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

***Aquatic plants***- All aquatic plants (Table 1) were propagated from stem fragments 10 to 30 cm in length and potted in 255 $cm^3$ pots in soil as described above for TWR. Three fragments of each species were potted in each pot. Aquatic plants were collected from multiple locations in the San Marcos River and brought back to the SMARC. All aquatic plants were treated for 30 minutes with a 1% sodium chloride solution to remove snails and other organisms from the plants. Following potting, plants were placed in 0.3 x 0.3 x 1.2 m tank with a water input of 11 L per minute. Plants were maintained in the pots until collected by contractor for replanting in the river. If plants growth reached the top of the water column or plants became emergent, the plants were trimmed back 10 to 15 cm below the top of the water column. *Sagittaria platyphylla* was the only aquatic plants other than TWR propagated from seeds. Seeds of *Sagittaria platyphylla* were placed on top of saturated soil in 2 cm of water to allow for germination. Once the seeds germinated, the seedlings were potted in a 255 $cm^3$ pot and submerged in water in a 0.3 x 0.6 x 2.4 m tank.

***Riparian and terrestrial plants*** - Riparian (Table 2) and terrestrial (Table 3) seeds and plants were collected along and adjacent to the San Marcos River, the City of San Marcos Nature Center, Ringtail Ridge Natural Area, and Spring Lake Natural Area. Plants were propagated from seeds, division, fragments, cuttings, and seedlings. Seeds, seedlings, and other plant parts were potted in a commercially purchased potting soil (Sta-Green Flower and Vegetable Soil) in pots ranging in size from 255 to 3,932 $cm^3$ depending on the size of the plant, root length, and expected growth rate at the time of potting. Plants that developed root growth through the pots were repotted into larger pots.

Seeds were sown on top of 15 to 20 cm saturated soil in 3,785 $cm^3$ pots and mashed into the first 0.5 cm of the soil. Pots with seeds were maintained in various tanks and Rubbermaid containers at a water level of 0.5 to 1.5 cm to keep the soil moist to promote seed germination. Germinated seeds with greater than two leafs (dicots) or greater than 2.5 cm in height (monocots) were transplanted into 255 to 1,020 $cm^3$ pots.

Seedlings were dug up on site at San Marcos Nature Center and Ringtail Natural Area by probing 4 to 6 cm around the edges with a knife and pulling the plant from the loose soil. Seedlings were potted in 1,020 $cm^3$ pots. Cactus pads were collected from Ringtail Natural Area and potted in 255 to 1,020 $cm^3$ pots.

Seeds of some species were scarified (seed coat nicked or filed), placed in water for 24 hours, and placed between moist paper in Petri dishes to examine germination. These species included: *Acacia minuata*, *Celtis canadensis, Colubrina texensis, Mimosa biancifera, Parkinsonia aculeata, Sophora secundiflora, and Ulmus crassifolia.*

## RESULTS

***Texas wild rice -*** During 2015, TWR seeds collected from refugia plants and wild plants in the San Marcos River were potted for germination with germination rates averaging 69%. All TWR seeds that germinated were potted, and the mean survival rate of seedlings at 1 to 4 months was 82 %.

No quantitative values were measured, but TWR seedlings under greenhouse conditions began to emerge at 4 to 6 weeks under 0.15 m/s flow conditions, and flower at ca. 4-5 months. At 5 to 6 months, TWR plants began to lose vigor under these greenhouse conditions, exhibit senescence, develop multiple tillers, and form an extensive root system outside the pots. TWR seedlings are ready for planting in the San Marcos at 8-10 weeks post-potting.

From the seedlings grown at SMARC, 4,176 TWR plants were provided to the contractors for replanting in the San Marcos River (Table 4). TWR plants propagated for restoration work in the river that were not utilized by contractors were maintained at SMARC. These plants will be used as nursery stock and for collection of TWR seeds for plant production or planted in the lower section of the river in 2016. Currently, SMARC has ca. 400 Texas wild rice plants available to contractors. An additional 1200 seedlings are ready for potting.

***Aquatic plants***- A total of 1,959 aquatic plants were provided to contractors for replanting in the San Marcos River (Table 4). Of these, the majority were *Ludwigia repens* (n = 1,175), *Heteranthera liebmannii* (n = 442), and *Sagittaria platyphylla* (n = 297). In the summer of 2015, contractors begin requesting propagation of Illinois pondweed (*Potamogeton illinoensis*) and 45 plants were produced. The overall mortality of these three plants was less than 5% at three months. However, after three months, growth of these plants resulted in competition and mortality increased. When contractors take plants for replanting in the river, SMARC staff refill the tanks within 2 weeks based on plants requested by the contractor. Turnover time, between initial potting and plant establishment, at SMARC is approximately 3-6 weeks for all species.

All aquatic plants propagated at SMARC were easily propagated from 10 to 30 cm fragments. No quantitative measures were taken, but new growth was observed within 7 to 10 days after potting. Within 8 to 12 weeks, tanks containing aquatic plants were overgrown and plants were rooting in nearby pots. Often extensive root mats developed among multiple pots and the plants were difficult to separate. There was also a loss of vigor and some senescence in many aquatic plants after 8 weeks. With *Ludwigia repens*, the larvae of a moth, *Parapoynx obsculralis*, can seasonally defoliate entire tanks during the spring and late fall of the plant within 2-3 weeks if the plant is allowed to become emergent. Cutting the plants to a level below water prevents this from occurring.

***Riparian and terrestrial plants***- Production of riparian and terrestrial plants increased in 2014 and a total of 1,384 riparian and terrestrial plants were provided to the City of San Marcos (Table 4). A stock of ca. 800 riparian plants are currently available at SMARC including *Bacopa caroliniana*, *Carex emoryi*, *Cephalanthus occidentalis*, *Hydrocotyle umbellate*, *Juncus texanus*, *Justica americana*, *Leersia oryzoides*, *Marsilea macropoda*, *Salix nigra*, and *Taxodium distichum*.

*Salix nigra* and *Sambucus canadensis* were propagated from cuttings of woody stems placed in water with a success rate of > 75%. Roots began to develop in 15 to 20 days for these two species from cuttings potted in saturated soil or placed in water. Seed germination was successful for *Platanus occidentalis* with an estimated germination success of 5 to 10%. *Cephalanthus occidentalis* was successfully germinated from seeds with a germination rate of <3%, and ca. 240 plants are available at SMARC. *Tripsacum dactyloides* seed germination was less than 1.0%, but seeds that did germinate exhibited a greater than 90% survival as seedlings. A low success of less than <1.0% was observed for germination of *Taxodium distichum* seeds. Of the thousands of seeds potted, only 122 *Taxodium distichum* seedlings developed. All seeds of

*Taxodium distichum* were collected from the 2014 seed crop and many were infested with boring insect larvae. *Andropogon glomeratus* and *Carex emoryi* were successfully propagated from root division. Large clumps of these species can be dug up in the lower portions of the San Marcos River below Cumming's Dam and divided into multiple plants. Survival rates of these two species following division were greater than 90%.

A stock of ca. 600 terrestrial plants including graminoids, forbs, shrubs, and trees are currently available at SMARC. In addition, several hundred seedlings less than 10 cm will need time to grow and develop prior to field planting.

*Chasmanthium latifolium*is was easily propagated from seeds with a germination success of ca. 10%. Current stock of this species at SMARC is 50 seedlings. *Panicum virgatum* was propagated from seeds and division. The success rate for germination of *Panicum virgatum* was ca. 5 to 10%. There are ca. 40 mature pots and 40 seedling pots of *Panicum virgatum* currently available for replanting along the river at SMARC. *Ehretia anacua* exhibits seed germination rates of ca. 20% and 40 seedlings are available at SMARC. Four species of xeric plants for upland restoration were easily propagated with seed scarification that included *Colubrina texensis, Condalia hookeri, Mimosa biancifera,* and *Parkinsonia aculeata*. These four plants are bushy and thorny and can be used as barriers to limit or prevent river access. Germination rates of these species were ca. 70 to 80 % using scarified seeds. *Quercus virginiana* seed germination and seedling development was successful in October 2013. The seedlings were placed in larger pots to observe development. The survival success of digging up 10 to 20 cm seedlings of *Celtis canadensis* and *Ulmus crassifolia* was ca. 50%, but both species were also germinated from seeds with a germination rate of <5%.

## DISCUSSION

***Texas wild rice*** - Production of Texas wild rice was successful from seed germination with a high survival rate of TWR seedlings at four months. Texas wild rice seedlings should be planted in the river less than three months following potting at SMARC to reduce competition, flowering, and tiller production. Preferably, TWR plants should be planted in the San Marcos River 8-10 weeks after potting of seedlings. Large scale propagation of TWR is dependent on obtaining 6,000 to 7,000 viable seeds per year. To achieve this, the SMARC has established experimental and refugia TWR in which seeds are collected. In addition, seeds will be collected from San Marcos River sections A and B if mass flowering occurs again in 2016. The use of outdoor ponds for maintaining Texas wild rice and other aquatic plants has not been successful at SMARC due to heavy infestations of algae in the summer, but some experiments are being conducted with copper for control of algae.

***Aquatic plants*** - The use of 10 to 30 cm fragments with or without aerial roots for *Ludwigia repens*, *Heteranthera liebmannii*, and *Potamogeton illinoensis* propagation is very effective and can result in a ca. 3 week turnover time between potting at SMARC and replanting in the river. *Sagittaria platyphylla* can be grown from seeds or collected from rhizome sprouts in the San Marcos River. Aquatic plants are easily produced and the development of nursery stock at SMARC will allow continuous production and turnover of these plants for restoration efforts in the San Marcos River. At the SMARC, the production of aquatic plants is only limited by space.

***Riparian and terrestrial plants***-The production of riparian plants during 2015 was successful in producing species such as Acer negundo, *Carex emoryi*, *Cephalanthus occidentalis*, *Populus deltoids*, *Salix nigra*, and *Sambucus Canadensis, Taxodium distichum*. The production of grasses and sedges can be very effective from seed germination and division, but the production of shrubs and trees will require a minimum of 10 to 12 months to allow the seedlings to reach 0.25 m in height. To supplement the supply of *Taxodium distichum*, seedlings may have to be purchased from a commercial nursery while more effective methods are developed to grow this species from seeds at the SMARC.

The use of commercially purchased potting soil compared to the bulk soil used for aquatic plants has resulted in better seed germination during 2015. The bulk soil contains a large of amount of clay that probably limits root growth in young seedlings. After switching to potting soil, seed germination has increased substantially with 75% of the native plants being propagated.

From 2013-2015, the SMARC staff and volunteers have been collecting seeds at the San Marcos Nature Center and along the San Marcos River. SMARC staff also collects numerous seeds and seedlings from native riparian and terrestrial species. Seeds are potted in saturated soil at the SMARC greenhouse and monitored for germination. Excess seeds are labeled (data and location) and stored in glass vials. In the 2015, the goal at SMARC is to maintain a stock of 50 to 100 specimens of each riparian plant.

Terrestrial shrubs and trees will require a longer time of 6 to 12 months or one growing season to develop into plants greater than 0.25 m in height that can be transplanted along the upper banks of the San Marcos River.

During 2015, success was achieved with seed germination and seedling production for *Acer negundo*, *Aesculus pavia*, *Andrpogon virginicus*, *Callicarpa americana*, *Celtis laevigata*, *Chasmanthium latifolium*, *Colubrina texensis*, *Condalia hookeri*, *Ehretia anacua*, *Mimosa borealis*, *Mimosa biancifera*, *Panicum virgatum*, *Parkinsonia aculeata*, *Platanus occidentalis*, *Sambucus canadensis*, *Sophora secundiflora*, *Tripsacum dactyloides*, *Ulmus americana*, and *Ungnadia speciose*.

For most terrestrial species, low germination rates (1 to 5%) were obtained. Collection of large numbers (5000+) of seeds will be the key to maintaining stock of seedling and saplings at SMARC. Seeds of species are collected as they mature, then potted for germination, and seedlings removed and repotted. Excess seeds are stored, and a desiccator was purchased to prolong viability and prevent molding. The propagation of large diversity of native plants found on the San Marcos River will result in a more diverse upland community.

One factor that impacts the ability to produce shrubs and trees from seeds is after-ripening in which seeds need additional time to germinate after being released from the plants. Delayed germination in seeds due to after-ripening is determined by moisture content in the seed, light, aeration, temperature, and the seed coat. With species such as *Colubrina texensis* and *Parkinsonia aculeata* germination was achieved by scarification of the seed coat and soaking the seeds in water for 24 to 48 hours. Other species may need prolonged periods of chilling to germinate. At the SMARC, the seeds of some riparian and terrestrial plants are currently maintained in a refrigerator for 60 to 120 days and will be tested for germination after a chilling period. Various other methods are being tested at the SMARC to improve seed germination that include increasing aeration in the soil mixture using sand, pea gravel and mulch, increasing or decreasing soil moisture, and exposure to sunlight. Production of shrubs and trees will remain limited for some species until effective methods are developed to propagate these species from seeds.

***Logistics*** - The coordination of the timing between the potting of plants at the SMARC and when the contractor takes the plant is important. Based on observations during 2013 to 2015, aquatic plants potted at SMARC need to planted in the river within 2 to 3 months following potting. Riparian plants maintained in outdoor ponds in 2-4 cm of water need to be planted within 6 months. Texas wild rice should be planted at 6-8 weeks following potting of seedlings. If plants are not planted within this time period, the plants outgrow their pots and their roots form extensive mats with other plants that are difficult to separate without possible damage to the plants. Algae can become a problem over time and requires additional maintenance and affect plant normal growth. The formation of extensive and tangled roots masses after 3 months within a tank of 68 to 396 potted plants results in mortality or highly stressed plants when the pots are separated.

***Resources*** - Within the SMARC greenhouse, a minimum of 5,824 aquatic plants in 255 $cm^3$ pots can be maintained. Other tank space is available as needed with some tanks set aside for quarantine and refugia TWR plants and others for research projects. Current tanks available at SMARC greenhouse for aquatic plants production include various sizes (Table 5).

Additional space is available for thousands of aquatic, riparian, and terrestrial plants in 0.04 ha outdoor ponds and raceways once flow systems are installed.  In September 2013, SMARC staff installed a 40 $m^2$ sprinkler system to maintain sapling and small shrubs and trees outside and free up greenhouse space.  An addition outdoor pond with shade cloth was initiated in 2014 to provide a site for shade tolerant riparian and terrestrial species with a timed irrigation system is planned for a 0.2 ha site in 2014 for production of riparian and terrestrial plants. Two 89 $m^2$ shade houses (89 $m^2$) were purchased in November 2015 for housing terrestrial plants, and will be constructed in early 2016.

**Additional Projects**

***Research*** (San Marcos River) - A long-term research project was initiated in May of 2014 to evaluate several Texas wild rice planting patterns in the San Marcos River with individual and groups of Texas wild rice. Five plots were set up in the San Marcos River on May 20, 2014 to evaluate planting methods of Texas wild rice tillers, seedlings, and mature plants.  The plots were replicated in 2015 with additional plots installed in 2016.  Supplemental plantings will occur near each plot throughout the year.  The project goal is to increase the area coverage of Texas wild rice in the lower section of the river.  Through February 2015, Texas wild rice more than doubled for all treatments but the May 24, 2015 flood scoured the plants and resulted in a large loss of area coverage and overall survival (Table 6).  All plots planted in 2015 were scoured and no plants survived the May 2015 flood.

Table 1.  List of aquatic plants being produced and the propagation methods at the U.S. Fish and Wildlife Service's San Marcos Aquatic Resources Center.

| Plant Species | Common Name | Propagation Method |
|---|---|---|
| *Heteranthera liebmannii* | Water stargrass | Fragments |
| *Ludwigia repens* | Creeping primrose willow | Fragments |
| *Potamogeton illinoensis* | Illinois pondweed | Fragments |
| *Sagittaria platyphylla* | Grassy arrowhead | Seeds, division |
| *Zizania texana* | Texas wild rice | Seeds, tillers |

Table 2. List of riparian plants being produced and the propagation methods at the U.S. Fish and Wildlife Service’s San Marcos Aquatic Resources Center.

| Plant Species | Common Name | Propagation Method |
| --- | --- | --- |
| *Bacopa caroliniana* | Water hyssop | Cuttings, division |
| *Carex crus-corvi* | Crow-foot caric sedge | Seeds, division |
| *Carex emoryi* | Emory's sedge | Seeds, division |
| *Cephalanthus occidentalis* | Buttonbush | Seeds |
| *Cyperus setigerus* | Lean flatsedge | Seeds, division |
| *Eleocharis montevidensis* | Sand spikerush | Division |
| *Equisetum hyemale* | Horsetail | Cuttings, division |
| *Hydrocotyle* spp. | Pennywort | Division |
| *Juncus texanus* | Texas rush | Cuttings, division |
| *Justicia americana* | American water willow | Division |
| *Leersia oryzoides* | Rice cutgrass | Seeds, seedlings |
| *Marsilea macropoda* | Water clover | Division |
| *Pluchea odorata* | Purple pluchea | Seeds |
| *Salix nigra* | Black willow | Cuttings |
| *Taxodium distichum* | Bald cypress | Seeds, seedlings |

Table 3. List of terrestrial plants being produced and the propagation methods at the U.S. Fish and Wildlife Service's San Marcos Aquatic Resources Center.

| Plant Species | Common Name | Propagation Method |
|---|---|---|
| *Acacia minuata* | Huisache | Seeds |
| *Acer negundo* | Box elder | Seedlings, cuttings |
| *Aesculus pavia* | Red buckeye | Seeds |
| *Andropogon glomeratus* | Bushy bluestem | Seeds |
| *Berberis trifoliolata* | Agarita | Seeds, cuttings |
| *Bouteloua gracilis* | Blue grama | Seeds, division |
| *Callicarpa americana* | Beautyberry | Seeds |
| *Campsis radicans* | Trumpet creeper | Division |
| *Carya illinoinensis* | Pecan | Seeds |
| *Celtis canadensis* | Sugarberry | Seedlings |
| *Chasmanthium latifolium* | Broadleaf woodoats | Seeds |
| *Colubrina texensis* | Hog plum | Seeds |
| *Condalia hookeri* | Brasil | Seeds |
| *Cornus drummondii* | Rough leaf dogwood | Seeds |
| *Diospyros texana* | Texas persimmon | Seeds |
| *Ehretia anacua* | Anacua | Seeds, cuttings (?) |
| *Eysenhardtia texana* | Texas kidneywood | Seeds |
| *Fraxinus texensis* | Texas ash | Seeds |
| *Juglans microcarpa* | Texas walnut | Seeds |
| *Juniperus ashei* | Ashe juniper | Seeds |
| *Mimosa biancifera* | Cats claw mimosa | Seeds |
| *Mimosa borealis* | Pink mimosa | Seeds |
| *Muhlenbergia lindheimeri* | Lindheimer muhly | Seeds, division |
| *Opuntia leptocaulis* | Pencil cactus | Fragments |
| *Opuntia macrorhiza* | Prickly pear cactus | Fragments |
| *Panicum virgatum* | Switchgrass | Seeds, division |
| *Parkinsonia aculeata* | Retama | Seeds |
| *Platanus occidentalis* | Sycamore | Seeds, Seedlings |
| *Populus deltoides* | Cottonwood | Seeds |
| *Prosopis glandulosa* | Honey mesquite | Seeds |
| *Prunus mexicana* | Mexican plum | Seeds, cuttings |
| *Ptela trifoliata* | Wafer-ash | Cuttings |
| *Quercus macrocarpa* | Bur oak | Seeds |
| *Quercus virginiana* | Live oak | Seeds |
| *Rhus virens* | Evergreen sumac | Seeds |
| *Sambucus canadensis* | Elderberry | Seeds, cuttings |
| *Sapindus saponaria* | Western soapberry | Seeds |
| *Schizachyrium scoparium* | Little bluestem | Seeds, division |
| *Sophora secundiflora* | Texas mountain laurel | Seeds, seedlings |
| *Tripsacum dactyloides* | Eastern gamagrass | Seeds, division |
| *Ulmus americana* | American elm | Seeds |
| *Ulmus crassifolia* | Cedar elm | Seeds, seedlings |
| *Ungnadia speciosa* | Mexican buckeye | Seeds, seedlings |

Table 4. Plant species, common names, and number of plants provided to the City of San Marcos during 2015 for restoration efforts in the San Marcos River.

| | | |
|---|---|---|
| **Aquatic Plants** | | |
| Grassy arrowhead | *Sagittaria platyphylla* | 297 |
| Creeping primrose willow | *Ludwigia repens* | 1,175 |
| Illinois pondweed | *Potamogeton illinoensis* | 45 |
| Texas wild rice | *Zizania texana* | 4,176 |
| Water stargrass | *Heteranthera liebmannii* | 442 |
| | | ∑ = 6,135 |
| **Riparian and Terrestrial Plants** | | |
| American elm | *Ulmus americana* | 31 |
| Anaqua | *Ehretia anacua* | 22 |
| Baby blue eyes | *Nemophila phacelioides* | 20 |
| Bald cypress | *Taxodium distichum* | 61 |
| Beautyberry | *Callicarpa americana* | 8 |
| Black walnut | *Juglans nigra* | 19 |
| Black willow | *Salix nigra* | 31 |
| Box elder | *Acer negundo* | 36 |
| Brushy bluestem | *Andropogon virginicus* | 30 |
| Buttonbush | *Cephalanthus occidentalis* | 90 |
| Cedar elm | *Ulmus crassifolia* | 19 |
| Cottonwood | *Populus deltoids* | 36 |
| Crow-foot sedge | *Carex crus-corvi* | 25 |
| Dewberry | *Rubus trivialis* | 1 |
| Eastern gamagrass | *Tripsacum dactyloides* | 105 |
| Eastern redbud | *Cercis canadensis* | 6 |
| Elderberry | *Sambucus canadensis* | 57 |
| Emory's sedge | *Carex emoryi* | 233 |
| Inland sea oats | *Chasmanthium latifolium* | 117 |
| Lean flatsedge | *Cyperus setigerus* | 12 |
| Lindheimer's muhly | *Muhlenbergia lindheimeri* | 4 |
| Mexican buckeye | *Ungnadia speciose* | 12 |
| Mexican plum | *Prunus mexicana* | 11 |
| Osage-orange | *Maclura pomifera* | 4 |
| Pecan | *Carya illinoinensis* | 25 |
| Pencil cactus | *Opuntia leptocaulis* | 40 |
| Pink mimosa | *Mimosa borealis* | 27 |
| Possumhaw | *Ilex decidua* | 8 |
| Prickly pear cactus | *Opuntia macrorhiza* | 15 |
| Red buckeye | *Aesculus pavia* | 8 |

| | | |
|---|---|---|
| Retama | *Parkinsonia aculeate* | 12 |
| Rough-leaf dogwood | *Cornus drummondii* | 3 |
| Switchgrass | *Panicum virgatum* | 93 |
| Sycamore | Platunus occidntalis | 48 |
| Texas ash | *Fraxinus texensis* | 16 |
| Texas mountain laurel | *Sophora secundiflora* | 20 |
| Texas rush | *Juncus texanus* | 60 |
| Trumpet creeper | *Campsis radicans* | 4 |
| Western soapberry | *Sapindus saponaria* | 15 |
| | | $\sum = 1,384$ |

Table 5. San Marcos Aquatic Resources Center greenhouse tanks available for aquatic plant production and the number of 255 $cm^3$ pots they can hold.

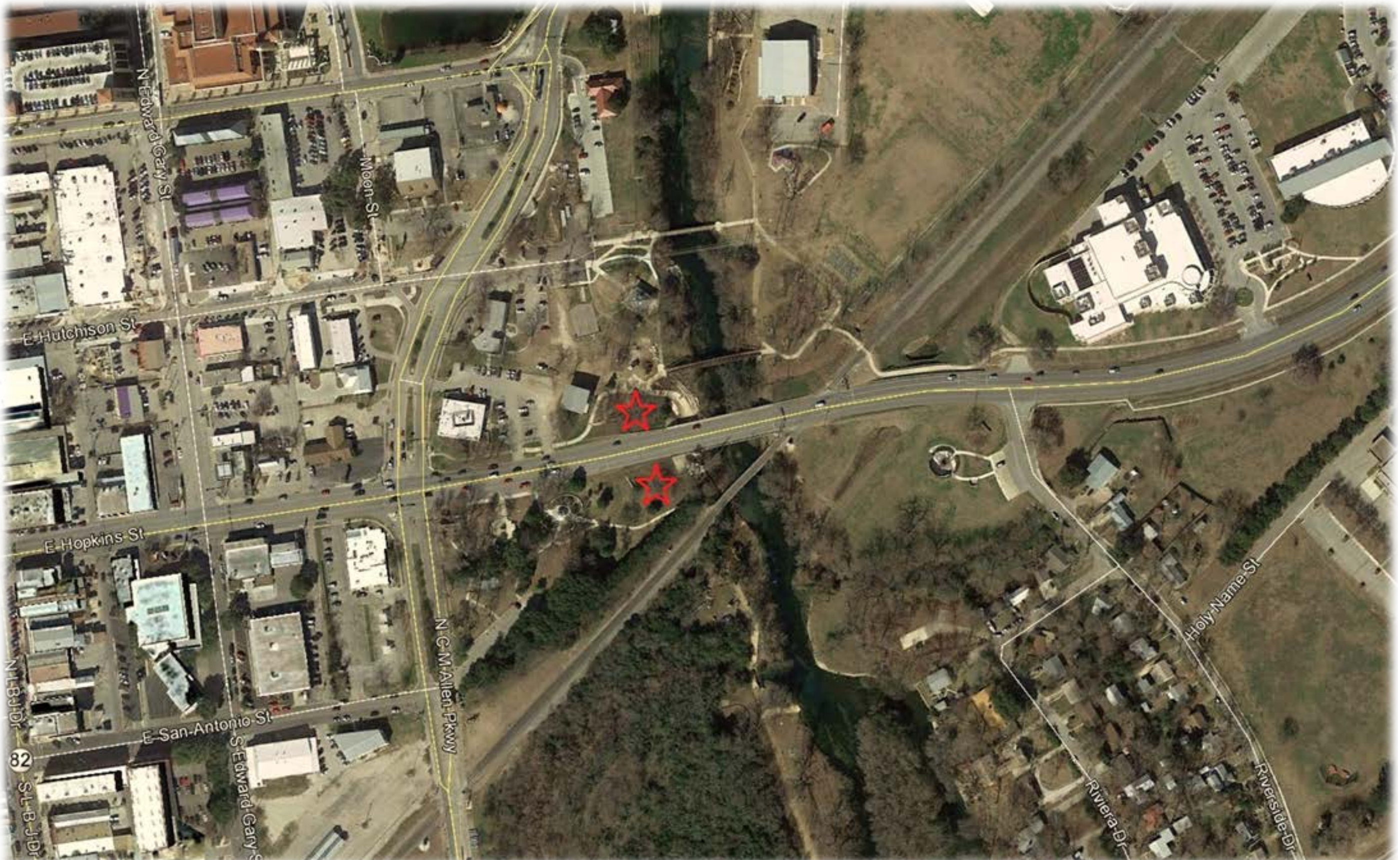
| Tank Dimensions | Number of Tanks Available | Number of 255 $cm^3$ Pots per tank | Total Number of 255 $cm^3$ pots per tank size |
|---|---|---|---|
| 0.3 x 0.3 x 1.2 m | 20 | 68 | 1,360 |
| 0.3 x 0.6 x 2.4 m | 10 | 288 | 2,880 |
| 0.9 x 0.9 x 3.0 m | 4 | 396 | 1,584 |

Table 6. Texas wild rice planted at various life history forms and ages and monitored for above ground biomass (area coverage) from May 2014 to August 2015. Table values represent the means (n = 5) and standard error for each treatment. Plants that did not survive were excluded from analysis.

| Treatment (age at planting) | Mean area coverage ($m^2$) and SE | | | | Survival (%) 14 mo post-planting |
|---|---|---|---|---|---|
| | May 2014 | Sept 2014 | Feb 2015 | August 2015 | |
| Tiller (unknown) | 0.12 (0.02) | 0.45 (0.04) | 0.62 (0.08) | 0.05 (0.015) | 40 |
| Seedlings (2 wk) | 0.01 (<0.01) | 0.14 (0.06) | 0.32 (0.06) | 0.004 (0.002) | 20 |
| 8 weeks (peat pot) | 0.21 (0.03) | 1.26 (0.31) | 1.69 (0.37) | 0.02 (0.005) | 40 |
| 6 months | 0.15 (0.03) | 0.82 (0.18) | 1.42 (0.36) | 0.06 (0.015) | 40 |
| 2 years | 0.47 (0.04) | 0.56 (0.07) | 1.04 (0.29) | 0 (0) | 0 |

Appendix M5

*Concept Design: Hopkins Drainage Channel Water Quality Retrofits* 2015 San Marcos Water Quality Protection Plan




Concept Design:

# Hopkins Drainage Channel Water Quality Retrofits

2015

San Marcos Water Quality Protection Plan

Prepared by:
John Gleason LLC
and
Complete Watershed Solutions

January 16, 2015

# 1.0 INTRODUCTION

Two retrofit projects (sedimentation ponds) were recommended in the Edwards Aquifer Habitat Conservation Plan (HCP) for the City of San Marcos. The first is to be located at Veramendi Park while the second is to be an expanded drainage ditch along Hopkins Street near San Marcos Plaza. A site visit to evaluate these locations revealed numerous site constraints that would make design and construction of these ponds challenging. Trails, gazebos, trees, the roadway, and the river bound the areas in question. Furthermore, sharp elevation changes occur in the roadside ditches as they approach their outfall with the river. Nevertheless, these two sites have potential and were included in the 2015 San Marcos Water Quality Protection Plan potential projects database (#10290 and #10291), modeling was completed, and they were ranked with other possible water quality retrofits. The rest of this report details concept design information for these two possible retrofits as requested by the City of San Marcos.

# 2.0 HOPKINS DRAINAGE CHANNEL POND 1 IN SAN MARCOS PLAZA

A drainage channel flows in an easterly direction through the park area known as San Marcos Plaza and adjacent to Hopkins Street to the north. The existing tree-lined channel has a storm sewer outfall at the upstream end along with a concrete flume that conveys runoff into the channel from San Marcos Plaza and a second storm sewer outfall near the Grant Harris Jr. Building parking lot. The drainage area of approximately 9.7 acres was delineated in GIS using City of San Marcos data (topography, storm sewer data, aerial photographs) and then field-verified during a rain event. Impervious cover was estimated in GIS to be 7 acres (or 72%) using City of San Marcos impervious cover data supplemented with aerial photography. Photos of the area are shown in Figures 2-1 through 2-4. In 2014, a trail was constructed across the downstream portion of the channel with a corrugated metal pipe conveying wet weather flows beneath to the San Marcos River. Based on NRCS Soil Maps and a site visit, Type D soils exist on site that drain slowly so infiltration-type BMPs are not recommended without an underdrain.

## 2.1 Recommended BMP

An in-line, extended detention basin is recommended in this location as it will make the best use of available space for stormwater treatment. A biofiltration facility with stacked detention might also be feasible but would have a smaller water quality volume, be more expensive to construct/maintain, and with close proximity to the river may experience issues with filtration media scour during flood events. Figure 2-5 depicts the drainage area, location and potential footprint of this BMP.

## 2.2 Project Elements

The following elements are recommended for this project:

- Earthwork to maximize water quality volume
- Earthen berm or concrete wall at downstream end to capture and treat stormwater prior to entering the river
- Outlet structure designed to convey treated stormwater underneath the trail and to the river
- Potential utility relocation
- Landscaping to ensure the pond is aesthetically pleasing for such a high visibility location

Figure 2-1 Existing Flume Looking Downstream at Hopkins Drainage Channel 1

Figure 2-2 Existing Storm Sewer Outfall Looking Upstream

**Figure 2-3 Existing Trail, Corrugated Metal Pipe Culvert, and Proximity to Bridge and River**

**Figure 2-4 San Marcos Plaza Contributing Drainage and Park Amenities**

## 2.3 Project Benefits

With an estimated surface area of approximately 4,650 square feet and estimated average depth of 4 feet, a water quality capture volume of 18,600 cubic feet would be available. Modeling shows a BMP of this approximate size and a 48-hour drawdown time would treat 80% of all runoff conveyed to it over the course of a typical year and remove approximately 6.4 lbs of Total Phosphorus (TP) at an estimated capital cost of $57,000. The annualized cost per pound of TP removed (including operation and maintenance) would be ($2,250 / lb TP), which is competitive compared to others evaluated but smaller scale in terms of pollution removal. For example, the project suggested at the wastewater treatment plant is estimated to remove approximately 140 lbs of TP per year at $911 per lb.

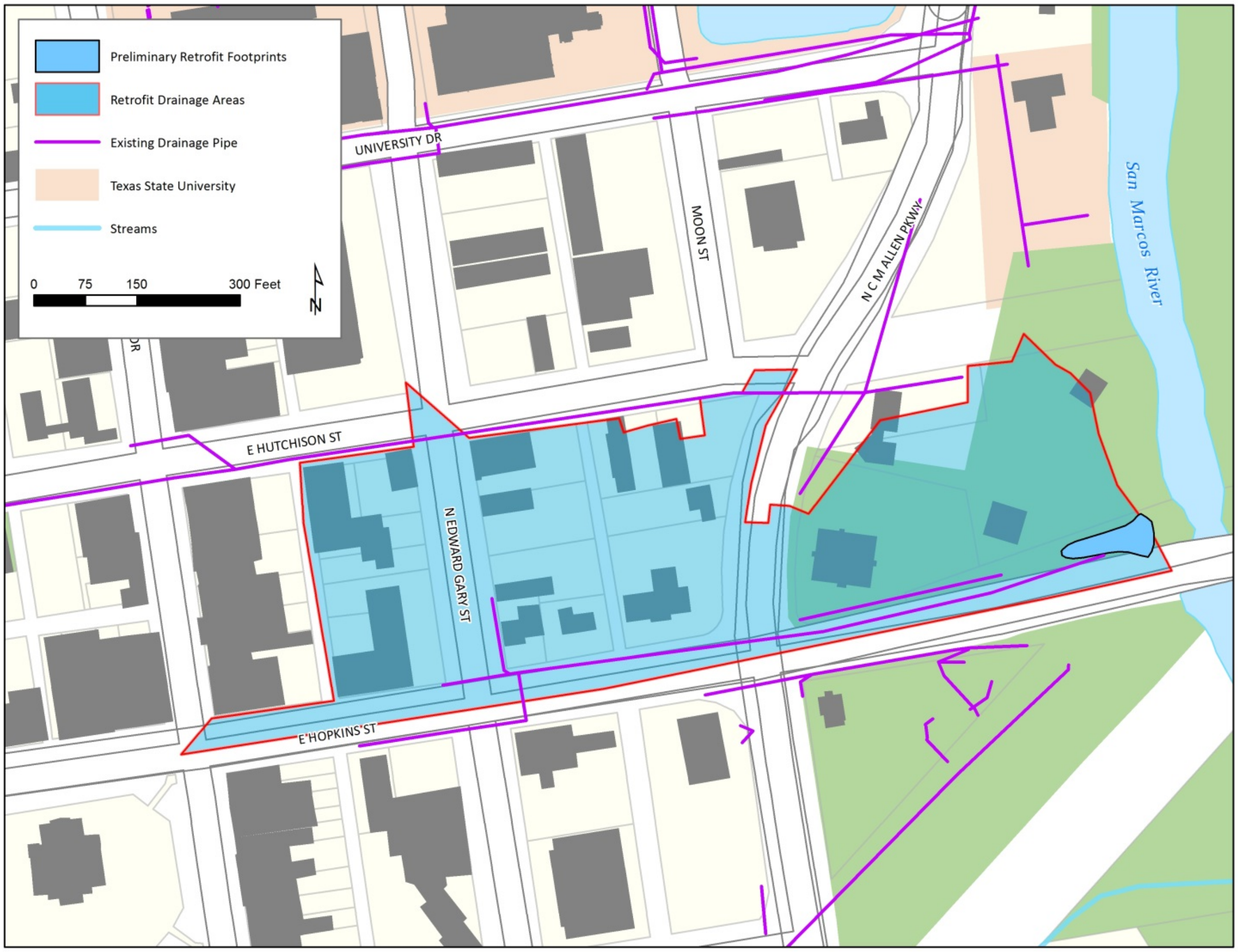
## 2.4 Project Challenges

The ground elevations and site constraints are challenging at this location to create an extended detention pond with significant volume. The site falls approximately 6 feet in the direction of flow and approximately 6 to 8 feet perpendicular to the direction of flow. The channel is also relatively narrow at approximately 53 feet wide. Site constraints include Hopkins Street (and associated bridge supports), the San Marcos River, trails/sidewalks, the existing storm sewer outfall, and amenities such as trees and a gazebo associated with San Marcos Plaza.

## 2.5 Related Planning Documents

Vision San Marcos shows this location to be existing park land and no conflicts are apparent.

**Figure 2-5 Hopkins Drainage Channel Pond 1 near San Marcos Plaza**




## 3.0 HOPKINS DRAINAGE CHANNEL POND 2 IN VERAMENDI PARK

A drainage channel flows in an easterly direction through Veramendi Park, adjacent to Hopkins Street to the south. The grass-lined channel contains three storm sewer outfalls, one of which is below-grade and does not drain well. Erosion issues were also observed in the channel along with a gabion-style grade control structure and concrete flume that were likely installed to control these problems (see Figures 3-1 through 3-4). The drainage area of approximately 15 acres was delineated in GIS using City of San Marcos data (topography, storm sewer data, aerial photographs) and then field-verified during a rain event. Impervious cover was estimated in GIS to be 9.9 acres (or 66%) using City of San Marcos impervious cover data supplemented with aerial photography. In 2014, a trail was constructed across the downstream portion of the channel with a corrugated metal pipe conveying wet weather flows beneath to the San Marcos River. Based on NRCS Soil Maps and a site visit, Type D soils appear to exist in this area that drain slowly so infiltration-type BMPs are not recommended without an underdrain.

**Figure 3-1 Two Storm Sewer Outfalls and Proximity to Veramendi Park Amenities**

**Figure 3-2 Gabion Grade Control Structure, Trail, Steep Slopes, Trees, Hopkins Street Bridge**

**Figure 3-3 Third Storm Sewer Outfall Below Grade and Drainage Issue**

3.1 Recommended BMP

An in-line, extended detention basin is recommended in this location as it will make the best use of available space for stormwater treatment. A biofiltration facility with stacked detention might also be feasible but would have a smaller water quality volume, be more expensive to construct/maintain, and with close proximity to the river may experience issues with filtration media scour during flood events. Figure 3-5 depicts the drainage area, location and potential footprint of this BMP.

3.2 Project Elements

The following elements are recommended for this project:

- Earthwork to maximize water quality volume and resolve drainage and erosion problems

- Earthen berm or concrete wall at downstream end to capture and treat stormwater prior to entering the river
- Outlet structure designed to convey treated stormwater underneath the trail and to the river
- Potential utility relocation
- Landscaping to ensure the pond is aesthetically pleasing for such a highly visible location

**Figure 3-4 Erosion on Left Bank (Looking Upstream)**

3.3 Project Benefits

With an estimated surface area of approximately 8,015 square feet and estimated average depth of 4 feet, a water quality capture volume of 32,060 cubic feet would be available. Modeling shows a BMP of this approximate size and a 48-hour drawdown time would treat 87% of all runoff conveyed to it over the course of a typical year and remove approximately 18 lbs of TP at an estimated capital cost of $98,000. The annualized cost per pound of TP removed (including operation and maintenance) would be ($953 / lb TP), which is very cost effective compared to others evaluated but smaller scale in terms of pollution removal. For example, the project suggested at the wastewater treatment plant is estimated to remove approximately 140 lbs of TP per year at $911 per lb. In addition to a water quality benefit, this project would resolve the erosion and drainage issues that currently exist.

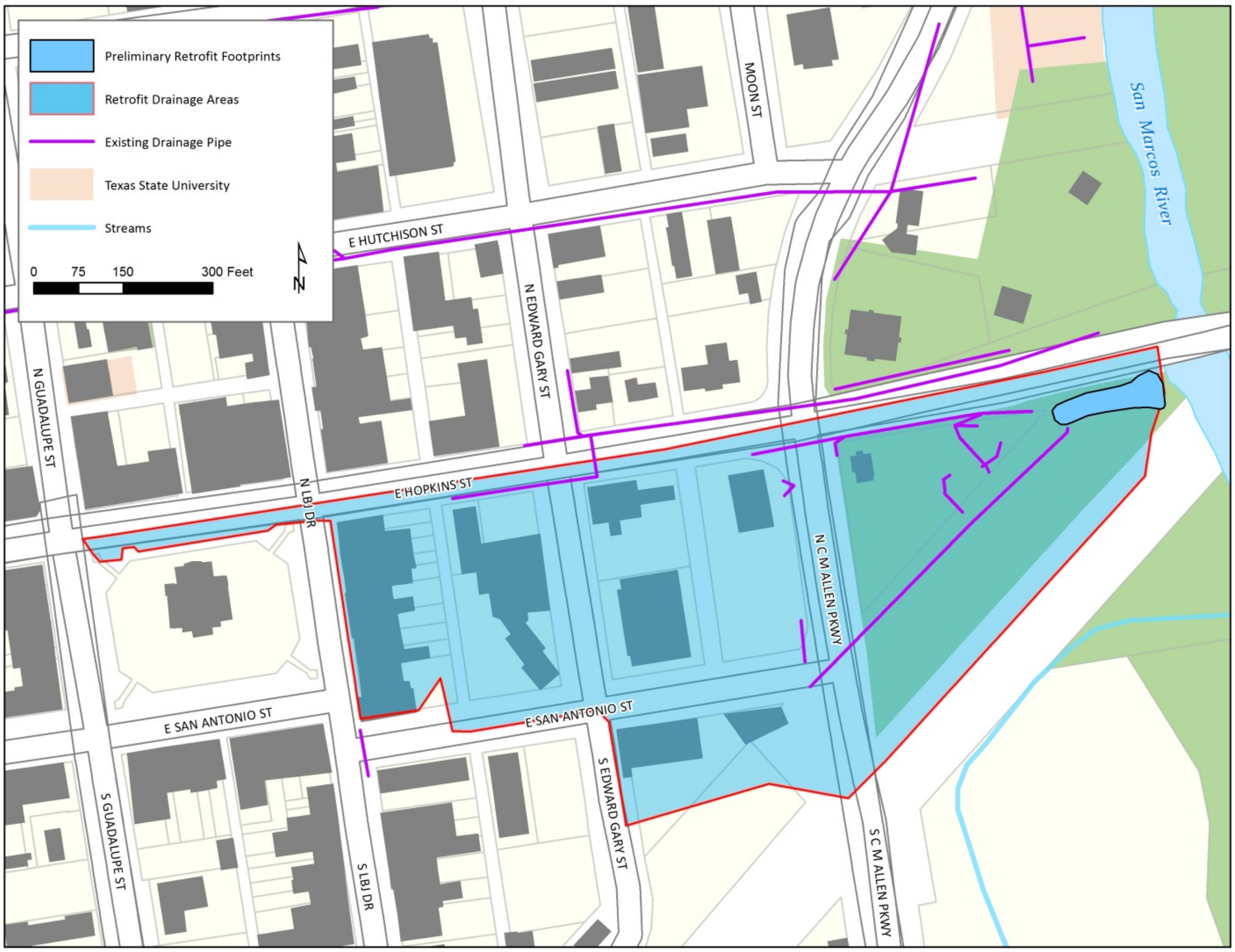
3.4 Project Challenges

The ground elevations and site constraints are challenging at this location to create an extended detention pond with significant volume. The site falls approximately 6 feet in the direction of flow and approximately 6 to 8 feet perpendicular to the direction of flow. The channel is also relatively narrow at approximately 52 feet wide. Site constraints include Hopkins Street (and associated bridge supports), a wastewater line at the upstream end of the channel, and Veramendi Park amenities such as trees and historical plaques.

### 3.5 Project Challenges

Vision San Marcos shows this location to be existing park land and no conflicts are apparent.

**Figure 3-5 Hopkins Drainage Channel Pond 2 near Veramendi Park**




## 4.0 Summary and Conclusion

The potential water quality retrofits in the Hopkins Street drainage channels at San Marcos Plaza and Veramendi Park are significant because they are recommended by the HCP and drain portions of downtown San Marcos, which is highly urbanized and lacks open space for centralized BMPs. Since these parcels are owned by the City, land acquisition is not an issue and the City has control over land use. These ponds would also be highly visible and could serve to educate the public on San Marcos River protection efforts and the role BMPs can assist in this goal while also being aesthetically pleasing amenities. As presented in the 2015 WQPP report, these opportunities were ranked in a retrofit prioritization matrix that considers pollution removal potential, cost effectiveness, feasibility, anticipated owner support, and demonstration value. Both ponds ranked as having high potential, particularly the one in Veramendi Park given that it drains a larger portion of downtown San Marcos and has potential for a larger volume. Both ponds are recommended for further design and construction consideration.

# Appendix M6

# Texas State 2015 *Integrated Pest Management Plan* Golf Course Management Plan

**17 April 2015**

**Texas State Golf Course**

**Integrated Pest Management Plan**

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## I. Introduction

The Texas State Golf Course recognizes the potentially serious risks inherent in using chemical pesticides on the campus – especially in an environmentally sensitive setting like ours at Spring Lake.

Several examples of cultural methods to control pests include optimizing turf health through turf management practices to enhance natural plant resistance to pest infestation, optimizing habitats for beneficial species, and minimizing turf damage resulting from routine golf course operations. On occasion, when cultural practices are not fully effective at controlling pests, the use of pesticides to manage pest damage may be necessary. An essential component of the Integrated Pest Management Plan (IPM) is the coordination of the ongoing use of cultural methods with the selective use of these agents as a means of minimizing the need for pesticide application. Accordingly, the IPM provides Texas State Golf Course a sound working framework for the selection and implementation of the most environmentally sound solutions to manage golf course pest problems.

Because of the location of the golf course, adjacent to the environmentally sensitive Spring Lake, activities and materials used at the golf course are routinely monitored by the Spring Lake Manager and the Spring Lake Environmental Review Committee as part of the Spring Lake Management Plan. This monitoring, including routine tests of water quality in Spring Lake, assure that golf course activity has minimal impact on the unique ecosystems found in the lake.

## II. IPM Definition

Integrated Pest Management is a sustainable approach to managing pests and minimizing the economic, health, and environmental risks. A primary goal of an IPM plan is to protect the environment and human health while running an economically viable golf course**.**

## III. IPM Objectives

- Minimize potential hazards to human health and the environment
- Optimize playing conditions of the golf course
- Control operating costs
- Utilize effective monitoring to enable selective control of pest populations
- Minimize pesticide use through targeted application while optimizing pesticide efficacy
- Sustain high turf grass quality
- Maintain health of landscape elements such as trees, plants, and natural areas

## IV. IPM Structure

(Not needed)

## V. Area Definition

The Texas State Golf Course is a 9-hole golf course that borders Spring Lake in San Marcos, Texas. The property is owned by Texas State University and considered part of campus.

a. Turfgrass areas

Bermuda grass is the turfgrass used on all areas of the golf course (tees, fairways, greens). Common Bermuda grass makes up tee areas and fairways while putting surfaces consist primarily of a 419 Bermuda grass.

b. Non-turfgrass areas

Non-turfgrass areas consist of bunkers, ornamental plantings, trees, aquatic areas, and natural areas.

1. Bunkers

Six green-side bunkers are located throughout the golf course. Bunker management will be confined to routine maintenance including edging, raking and smoothing of sand contained within the bunkers.

2. Ornamental Plantings

A small number of ornamentals plants and shrubs are located in flower bed areas throughout the golf course

3. Natural Areas

Natural areas at Texas State University Golf Course are areas adjacent to golf course greens, tees and fairways/roughs that are comprised of native plant material. These areas will be left unmanaged to provide a wildlife corridor through the property as well as to serve as an environment and habitat for the native bird and animal population.

4. Buffer Zones

Buffer zones at the Texas State Golf Course are areas adjacent to Spring Lake that will receive no application of fertilizer, fungicides, insecticides, or broadleaf herbicides. Currently, a minimum 10-foot buffer zone is maintained. The buffer zones are defined by a series of wooden posts and chains. This area will left to grow naturally. Any maintenance of this area will be done in consultation with the Spring Lake Manager, the Spring Lake Environmental Review Committee and University Grounds Maintenance.

5. Cart Paths and Service Roads

The golf course has a continuous cart path that extends from tee to green and tee of the next hole. Cart paths are partially paved while the majority are gravel.

## VI. Turfgrass Management Practices

The primary objective of the Integrated Pest Management program is to optimize turfgrass vigor utilizing sound cultural practices as a means of preventing and/or minimizing pest infestation. The primary cultural practices of turfgrass management at the Texas State Golf Course include mowing, fertilization, and irrigation. Secondary cultural practices include aeration, thatch management, topdressing, overseeding, and sod replacement.

A. Primary Cultural Practice

1. Mowing

Mowing will be performed on an as-needed basis and mowing frequency is area dependent. During the growing season, mowing of greens will occur approximately five times a week, mowing of tees and fairways will occur one time per week.

Mowing heights will be adjusted for individual areas based on seasonal/cultural conditions. Mowing heights will be 1/8 – 3/16 inches for putting greens. The fairways will be mowed at ¾ inches and the lengths of the roughs vary from 1-3 inches. Buffer zones will not be mowed, but left in a natural state.

2. Fertilization

Management of nutrients is essential for development of turf vigor. Management of turf fertility involves the understanding of soil composition, plant nutrient requirements, fertility management history, use of soil/tissue test information, and applications of the appropriate fertilizer formulations at the proper time. Additionally, the availability of beneficial soil microbes and biological amendments will be considered when managing the soil nutrient program. The objective of the fertilizer program is to provide optimal nutrient availability to turf while simultaneously avoiding the application of excess nutrients to avoid nutrient runoff/leaching, disease development and weed infestation. Accordingly, every effort will be made to minimize fertilizer application in an effort to strike a balance between optimizing turf vigor and preventing nutrient runoff and/or leaching.

The fertilizer treatment plan/schedule will be reviewed at the beginning of each year with the Spring Lake Manager. Any unique situation that may occur requiring deviation from the projected schedule will be reviewed with the Spring Lake Manager. An annual report of all application of fertilizers made during the year will be provided to the Spring Lake Manager.

a. Fertilizer Treatment Areas

Fertilizer applications are only applied on the putting surfaces and tee areas as needed.

b. Fertilizer Application

Fertilizer application equipment is calibrated prior to use to ensure proper rate of application. Fertilizer will not be applied if heavy rain is forecasted following the potential application event. Liquid applications will not be sprayed in high winds.

c. Fertilizer Storage

All fertilizers are maintained in our maintenance shop protected from the weather.

d. Fertilizer Documentation

All fertilizer applications will be documented. Information recorded will include date of application, location of application, total area treated, formulation of fertilizer(s), rate of application expressed as lbs. of N/1,000 ft2, total quantity of product applied, and the applicator(s) name.

3. Irrigation

The distribution of adequate water onto turf via irrigation without over-watering is essential to turf health. In addition to providing optimal moisture levels for turf, irrigation practices are designed to conserve water whenever possible. During periods of hot weather, dry areas will be hand-watered in mid-afternoon as required, and the irrigation system runs overnight Irrigation system on timer and has evapotranspiration sensor on it to make necessary adjustments Finally, wetting agents may be used when necessary to improve water infiltration for localized dry spots and other hydrophobic areas of turf. Wetting agents will be applied in accordance with label rates and recommendations.

a. Water Source

The Texas State Golf Course pumps water directly out of Spring Lake to irrigate 7.5 of our 9 holes. City water is used to irrigate the other 1.5.

b. Irrigation System

The current irrigation control system is outdated. We plan to upgrade our control system when it can be afforded. Areas of localized dryness will be treated by hand watering or by the use of sprinklers.

d. Water Conservation

The irrigation system and program are designed to prevent over-application of water as a means of optimizing turf vigor and conserving water. The areas requiring the most frequent irrigation will be greens and tees. Because it represents a substantial percentage of the overall turfgrass area, the fairways and rough will be irrigated using the deep and infrequent methodology in order to conserve water. This methodology will be carefully monitored to ensure that low areas are not overwatered. "Out-of-play" areas will receive no irrigation due to the plant species abilities to extract required moisture through their deep roots.

B. Secondary Cultural Practice

1. Aerification

Aerification is the practice of removing soil cores from turf and is performed to reduce turf compaction. This practice enhances the movement of air, water and nutrients in the soil and is a useful technique to manage thatch layers. Additionally, solid tine aerification is another means of reducing compaction without removing soil.

Aerification will occur primarily on greens and tee surfaces on a regular basis, at least twice a year. Aeration will be typically performed during periods of active turf growth in the early spring, early summer and fall. Additional aeration may occur at the discretion of the Superintendent. In the case of greens, topdressing sand will be applied to fill the core spaces resulting from the aeration treatment. Finally, deep tine or aerification may be performed once every few years to aerify at depths of up to 10 inches to improve drainage whenever needed.

2. Thatch Management

Thatch is a layer of organic debris and the roots, crowns, and stems of grass that exists between the soil and the turf canopy. In the absence of cultural management, this layer becomes thicker over time, resulting in sub-optimal turf growth. Management of thatch is particularly important on greens and consists primarily of aerification and topdressing practices. Efforts will be made to maintain the thatch layer on greens at a depth of 0.5 inches. Thatch management practices will include hollow core aerification, solid core aerification and vertical mowing.

3. Topdressing

The practice of topdressing consists of the application of a layer of sand to greens and is used to assist in thatch layer management and to provide a smooth and firm playing surface. Topdressing applications typically follow the aerification or verticutting of greens, and will also be made in the absence of aerification ("light" topdressing). Following the application of sand, the sand will be lightly brushed into the turf surface.

4. Overseeding

Overseeding is the selective application of turfgrass seed to improve areas of turf depletion and to bolster turf density. Overseeding will be performed in the late fall.

5. Sod Replacement

Occasionally, problems with diseased, damaged, or weedy turf cannot be remedied by cultural practices. Under these circumstances, affected areas of turf will be removed, and fresh turf obtained from a turf farm will be used as replacement.

## VII. Tree Management

1. Tree Maintenance

Trees will routinely be monitored for overall health, influence on playing characteristics, the presence of insects and diseases, influence on surrounding turf and ornamentals, and hazard potential. In general, insect and diseases pests are tolerated. Established trees do not require supplemental watering except in situations of extreme drought. Trees will be pruned to optimize health, allow passage of light, minimize hazard, and manage pests. A commercial tree service will be consulted regarding trees that have disease and/or pest problems beyond the normal scope of golf course management practices. Any trimming of Oak trees on the golf course will be painted with a protective sealant immediately to protect from Oak wilt.

2. Tree Removal

Factors that will determine if a tree is a candidate for removal (e.g., disease, age, hazard) will be evaluated by the Texas State Golf Course Superintendent and then consulted with the Risk Management office on campus. Upon the determination that tree removal is necessary, the tree will be removed by the Texas State Golf Course staff, or when necessary, by a commercial tree service.

## VIII. Composting and Organic Materials Management

Debris of all kinds is regularly picked up off the golf course. Debris consists of grass clippings, leaves, branches and larger limbs or logs.

Grass clippings, leaves and other compostable materials are taken to the University compost area. Woody plants, branches and logs are taken to the base of the hill along our 5$^{th}$ hole. These branches are chipped into mulch once or twice per year when time permits.

## IX. Potential pests of golf course turf grass

1. Weeds: Any plant other than the desired turf grass may be considered a weed in turf grass. Specific weeds that are commonly encountered on the golf course include Crab grass, Dallis grass, St. Augustine, Spurge, Goose grass and many others, including annual and perennial species.

2. Turfgrass diseases: Leaf spot (Helminthosporium spp.), brown patch (Rhizoctonia spp.), rust (Puccinia spp.), spring dead spot (Leptosphaeria korrae), pythium (Pythium spp.), dollar spot (Sclerotonia homoeocarpa) and take-all patch (Gaeumannomyces graminis).

Crab grass

Dallis grass

Bluegrass

Spurge

Goose grass

## X. Pest Threshold Levels

A. Weeds: The goal for the Texas State Golf Course is not to eliminate all weeds; it is to keep weed numbers low enough to prevent significant visual damage. Turf is a very dynamic ecosystem, and even under optimum grass-growing conditions some weeds will become established. Even height smooth turf is required on the golf course. Treatment for weeds will be considered necessary if weed growth causes the turf surface to be too uneven for golf.

B. Diseases: Turf diseases, if encountered, will be managed quickly after discovery to minimize the spread of disease.

C. Insects: Even height smooth turf is required on golf course playing surfaces. The presence of an infestation will be verified prior to treatment. Treatment for insect infestation will be considered necessary when damage is noticeable, unsightly and/or impacting play on the golf course. Several treatment thresholds are noted in the following information.

1. Armyworms: identified by either a professional landscape maintenance company or trained University staff and treated at 5 per square foot.

2. Chinch bugs: identified by either a professional landscape maintenance company or trained University staff by flushing with water and treated when characteristic damage is evident.

3. Fire ants: identified by either a professional landscape maintenance company or trained University staff by characteristic mound, aggressive behavior or biting; treated when at leastone colony exists in a sensitive area, or several colonies exist in a non-sensitive area.

4. Grubs: identified by either a professional landscape maintenance company or trained University staff and verified by digging, and treated at a minimum of 5 \ per square foot.

5. Mole crickets: identified by either a professional landscape maintenance company or trained University staff and treated at 3 per square foot.

6. Sod webworms: identified by either a professional landscape maintenance company or trained University staff and treated at 5 per square foot.

## XI. Pesticides

All pesticides used on the golf course are reviewed annually with the Spring Lake Environmental Review Committee to guard against negative impact to Spring Lake and its unique ecosystems. Any modifications to this schedule are made in consultation with the Spring Lake Environmental Review Committee. All pesticides are applied by individuals trained and certified in their use, and are applied strictly following the product's recommended application method.

The following pesticides are currently used on the golf course: Pre-emergent (Crab grass/goose grass), fungicide (Rubigan), Ant bait (Advion), broad leaf herbicide (Speed Zone or Q4), insecticide (Talstar), grassy weed herbicide (Revolver).

*Product description and labels for all of these products can be found online.*

## XII. Facilities Description

All storage and disposal of materials strictly adhere to University policies and procedures (cite University UPPS dealing with storage and disposal of hazardous materials) The methodology is reviewed with the University Office of Risk Management.

1. Maintenance Building

Maintenance functions are performed in a dedicated maintenance building. The building is physically segregated into two main areas (outdoor and indoor). The indoor area consists of office space, tool and small equipment storage, and the staff restroom. The outdoor area is used for large equipment storage, fertilizer storage, fuel and pesticide storage.

a. Maintenance Shop

This area is where all equipment maintenance and repair work will be performed. All fluids and solvents required for maintenance and repair will be maintained within this area and used fluids and solvents will be disposed of according to federal, state, and local guidelines.

b. Equipment Storage

This area will contain all equipment used in golf course maintenance operations including mowers, tractors, and fertilizer and pesticide application equipment.

c. Fertilizer Storage

All fertilizer is stored in a dry, well-ventilated environment that has restricted access.

d. Pesticide Storage

All pesticides are stored in a well-ventilated storage area that has restricted access.

2. Petroleum Fluid Storage and Disposal

a. Fluid Storage

All oils, solvents, lubricants, and antifreeze will be stored in dedicated areas on secondary containment systems.

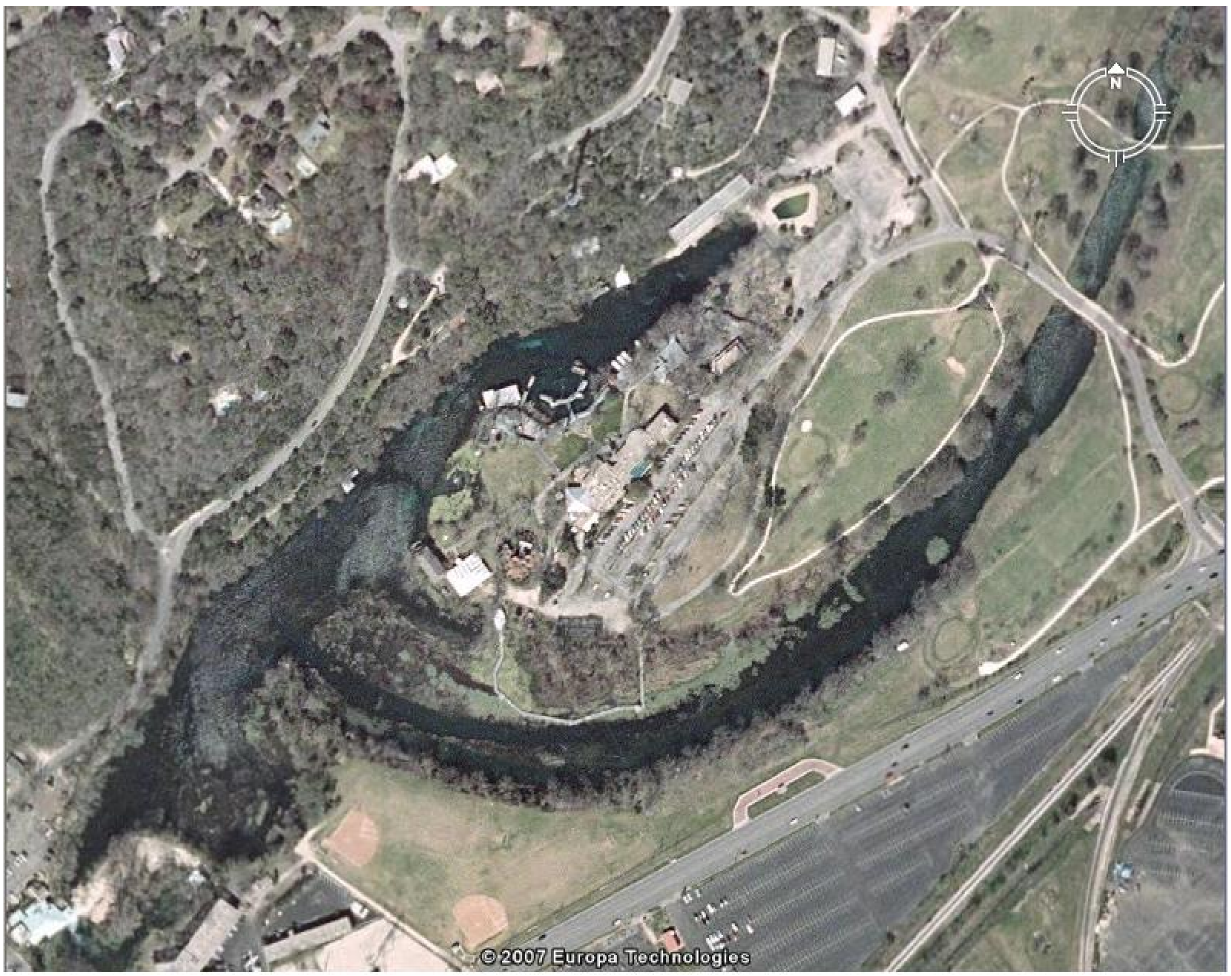
c. Fluid Disposal

Used fluids will be disposed of according to state and local regulations.

3. Fuel

Fuel is stored in a locked cabinet in a covered and locked outdoor area.

**Spring Lake Management Plan**



# I. Table of Contents

## II. Introduction

Spring Lake and the surrounding lake habitat are part of Texas State University-San Marcos. The university is a public, student-centered, doctoral-granting institution dedicated to excellence in serving the educational needs of the diverse population of Texas and the world beyond. We value engaged teaching and learning, and research, scholarship, and creative activity, among other pursuits. Therefore, Spring Lake and the surrounding habitat will be managed in accordance with the university's mission.

### A. *Significance of Spring Lake*

The San Marcos Springs, which bubble up from the Edwards Aquifer to fill Spring Lake, are the second largest spring system in Texas. They have never stopped flowing in recorded history and have more environmental stability and flow of any spring system in the southwestern United States. Archaeological research indicates that the area surrounding Spring Lake has been inhabited for over 12,000 years serving populations of Paleo-Indians through the earliest European settlers.

Spring Lake constitutes the headwaters of the San Marcos River that extends 68.2 miles to its confluence with the Guadalupe River, and continues another 196 miles to the Gulf of Mexico. The San Marcos River supplies drinking water for many communities in the watersheds of the San Marcos River and Guadalupe River, including San Marcos (49,000 residents) and Victoria(60,000 residents).

Spring Lake also provides critical habitat to several threatened or endangered species protected by the federal Endangered Species Act of 1973. This law prohibits any actions that jeopardize the continued existence of these listed species or causes destruction or adverse modification of the critical habitat of these species. Substantial civil and criminal penalties including fines and imprisonment may be levied against persons who knowingly violate provisions of this act.

Protection and careful management of Spring Lake is key to minimizing any negative impacts to the unique hydrological, cultural, economic and biological resources found there.

### B. *Purpose for the Spring Lake Management Plan*

The major objectives for the development of the Spring Lake Management Plan are:

1. To manage the lake in such a way as to support and enhance the University's efforts in teaching, research/scholarship, and service;
2. To assure that the University fulfills its commitment to be a good steward of Spring Lake by carefully managing and maintaining the healthy ecosystems that exist in the lake;
3. To formalize the process by which decisions are made regarding access to and use of Spring Lake;
4. To emphasize the use of scientific data to support management decisions that are made; and
5. To provide guidelines regarding access and use of Spring Lake to individuals and organizations wanting to engage in teaching, research or service activities in the lake.

# III. Spring Lake Management

## A. *Management Goal and Objectives*

Texas State's goal is to provide effective stewardship of the existing springs and lake habitat in accordance with the university's mission. Responsibility for stewardship of Spring Lake and the fulfillment of this goal has been assigned to the Provost and Vice President for Academic Affairs. The Provost has delegated the responsibility for management of Spring Lake to the Executive Director of the River Systems Institute.

The main objectives of the River Systems Institute in the management of Spring Lake are to protect its healthy ecosystems, to provide research and educational opportunities in and around Spring Lake, and to provide access to Spring Lake for service activities. Crucial to undertaking these objectives is the establishment of several overriding indicators that reflect healthy ecosystems within Spring Lake. During the first year of implementation of this management plan, a blue-ribbon commission of faculty and researchers will establish acceptable ranges for key data that will be collected on the ecosystems in Spring Lake, as well as a monitoring protocol for assessing these data. It is these key indicators that will be monitored by RSI to determine the health of the lake.

Further, the River Systems Institute will work to:

- Research, develop, and establish baseline data on the existing conditions of the lake and the ecological health of the system.
- Continually perform or review ongoing monitoring that will indicate the overall conditions and health of the system in order to identify changes or negative impacts that may occur over time.
- Administer programs that comply with the Endangered Species Act and the Edwards Aquifer Recovery Implementation Program Habitat Conservation Plan.
- Manage the lake in such a way that will either enhance or minimally impact critical habitat for the aquatic and riparian resources.
- Ensure that any impact to the lake from human use through educational or research programs is scientifically justified and will not result in long term impacts or degrade the overall integrity of the lake ecosystem.
- Encourage use of Spring Lake for educational, research and service activities which support the University's mission.

B. ***Spring Lake Management***

Figure 1 reflects the organization structure for management of the lake.

**Spring Lake Management Organization Structure**

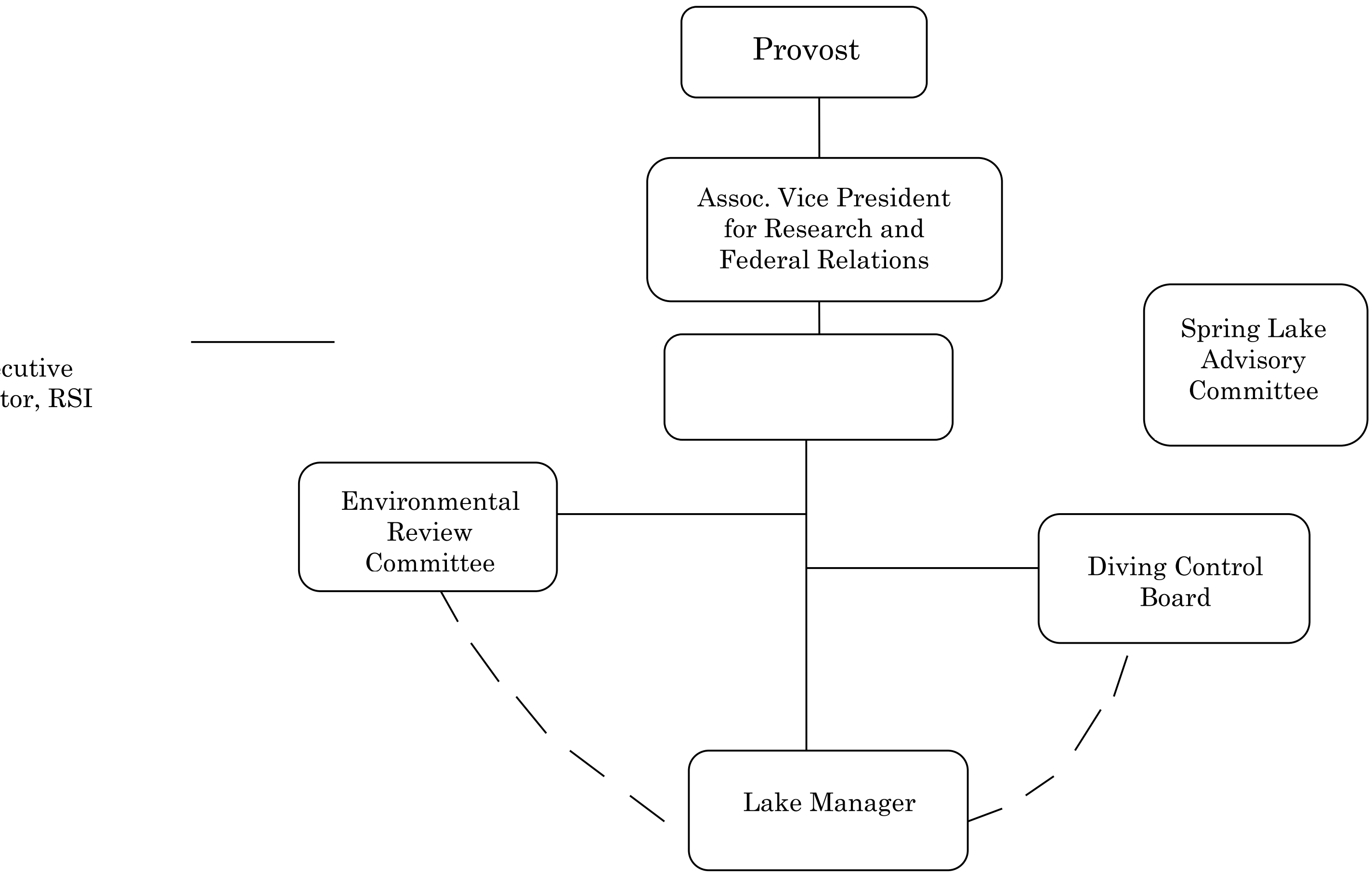



**Figure 1**

The Executive Director of the River Systems Institute has oversight responsibility for Spring Lake. He has assigned responsibility for management of all daily activities in the lake to the Lake Manager.

The Spring Lake Advisory Committee will advise the Executive Director on any activity occurring in and around Spring Lake, and will be a conduit to interested stakeholders regarding activities occurring in and around Spring Lake. The Executive Director will routinely consult with the Advisory Committee regarding use of Spring Lake and the impacts upon this resource. Reports will be provided to the Committee reflecting requested activities impacting the lake and disposition of these requests. All annual reports on the health of the ecosystems in Spring Lake will be shared with the Committee. All proposed modifications to Spring Lake policies and procedures will be vetted through the Spring Lake Advisory Committee.

The Executive Director, in consultation with the Associate Vice President for Research & Federal Programs, will appoint members to the Spring Lake Advisory Committee. These members will be the chair of the Biology Department, the chair of the Anthropology Department, the chair of the Geography Department, the Associate Vice President for Facilities, the Director of Campus Recreation, the Director of the Edwards Aquifer Research and Data Center, the Associate VPFSS for Planning, a representative of the City of San Marcos, a representative of US Fish and Wildlife, and a representative of the San Marcos River Foundation.

The Environmental Review Committee will assist the Executive Director in deciding which requests for access and use of Spring Lake are granted.
The Executive Director, in consultation with the Associate Vice President for Research & Federal Programs, will appoint members to the Environmental Review Committee. These members will be the Chief Science Officer of RSI, the City Watershed Protection Manager, two University faculty members with expertise in aquatic ecosystems and one faculty member with knowledge of the cultural resources located at the Spring Lake site.

The Diving Control Board will assist and advise the Executive Director on all scuba diving activities occurring in the lake to assure that such activities are procedurally safe and environmentally sensitive.
The Executive Director, in consultation with the Associate Vice President for Research & Federal programs, will appoint members to the Diving Control Board. These members will be the Director of Aquarena Center, the Chief Science Officer of RSI, the Diving Safety Officer, a representative of the Center for Archeological Studies, a faculty member from Health and Human Performance and a faculty member with expertise in aquatic ecosystems.

The Lake Manager will monitor, index, and catalog the activities and scientific studies conducted by all entities working on, in, or around Spring Lake. An index of these activities and studies will be maintained as an appendix to the Lake Management Plan. The River Systems Institute will maintain an archive of scientific studies conducted on, in, or around Spring Lake.

The Lake Manager, in collaboration with the Environmental Review Committee, will annually review the Spring Lake Management Plan and on-going activities in Spring Lake, and recommend to the Executive Director changes or actions needed to ensure the ongoing health of the system and the continued success of the listed species. The Lake Manager is responsible for annually updating the Spring Lake Management Plan to incorporate approved changes.

# IV. Policy Guidelines

## A. *Coordination and Management of Spring Lake*

**1.** The Lake Manager is responsible for the daily use and maintenance of Spring Lake. These responsibilities include:

- Monitoring of all activity on Spring Lake
- Maintenance of records of all activity occurring on the lake

- Monitoring of key indicators(developed in conjunction with the Environmental Review Committee), on the health of the lake
- In consultation with the Environmental Review Committee, annually informing the Executive Director of RSI of activities occurring on the lake and the impact of these activities on the health of the lake
- Ensuring that proper protocols are being followed for access to and conduct of activities in the lake
- Compiling, submitting and maintaining records on all reports required by regulatory agencies regarding the lake

**2.** The Environmental Review Committee will assess requests to use the lake and will assist the Lake Manager in assessing the health of ecosystems in the lake.

**3.** The Diving Control Board will assess requests to dive in the lake and will assist the Lake Manager in monitoring diving activities in the lake.

## B. ***Research Activities in Spring Lake***

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

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

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

**3.** A copy of the final report and any publications on a research project should be provided to the Lake Manager

**4.** The Lake Manager will compile an annual summary of the research conducted in the lake, including statements on the impact of these activities on the health of the lake, and update Appendix F.

## C. ***Education Activities in Spring Lake***

**1.** Proposals for educational activities in Spring Lake must be submitted to the Environmental Review Committee, through the Lake Manager, for review and approval.

**2.** Proposals for educational activities must be submitted in writing and include:

- Name and contact information of the responsible party conducting the activity,
- Purpose and expected outcomes of the activities,
- Description of activities, including, if appropriate, measures to be taken to minimize any impact on endangered species or their habitat, or any cultural resources found at the lake,
- Description of equipment, (See Equipment in Lake section E)
- Number of participants,
- Expected impact, and
- Duration

**3.** Once an activity is completed, a summary report of the educational activity will be provided to the Lake Manager.

**4.** Annually the Lake Manager will compile a summary of the educational activities conducted in the lake, including statements on the impact of these activities on the health of the lake, and update Appendix F.

## D. *Special Events in Spring Lake*

**1.** Proposals for special events in Spring Lake must be submitted to the Environmental Review Committee, through the Lake Manager, for review and approval.

**2.** Proposals for special events must be submitted in writing and include:

- Name and contact information of the responsible party conducting the event,
- Purpose and expected outcomes of the event,
- Description of activities, including, if appropriate, measures to be taken to minimize any impact on endangered species or their habitat, or any cultural resources found at the lake,
- Description of equipment,(See Equipment in Lake section E)
- Number of expected participants,
- Expected impact, and
- Duration

**3.** Once the special event is completed, a summary report of the event will be provided to the Lake Manager.

**4.** Annually the Lake Manager will compile a summary of the special events conducted in the lake, including statements on the impact of these events on the health of the lake, and update Appendix F.

## E. ***Equipment in Spring Lake***

**1.** All equipment placed in Spring Lake for research, educational purposes, or special events must be approved by the Lake Manager. The Manager will consult with the Environmental Coordinating Committee to ensure the proposed equipment has scientific value and any negative impacts to the lake are minimal.

**2.** All equipment must be properly washed/disinfected on-site using the process approved by the Lake Manager before being placed in the lake.

**3.** All equipment that is left in the lake must have responsible party contact information attached to equipment and on file with the Lake Manager.

**4.** Equipment must be removed by the responsible party promptly at the end of the project period. Equipment not promptly removed by the responsible party will be removed by the Lake Manager and all associated costs billed to the responsible party.

**5.** The Lake Manager will maintain a record of equipment installed in the lake.

## F. ***Access to Spring Lake***

**1.** Access to Spring Lake is strictly controlled and regulated in accordance to federal, state and local laws. City ordinance and state law designate the public waters of Spring Lake as restricted to activities authorized by the University.

**2.** All access to Spring Lake must be approved by the Lake Manager, in consultation with the Environmental Review Committee.

**3.** All activities involving access to the lake, including glass bottom boat operations, will abide by the rules and intentions of the Edwards Aquifer Recovery Implementation Program Habitat Conservation Plan.

**4.** Boat (canoe, kayak) use for educational activities, excluding glass bottom boats:

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

**5.** Glass Bottom Boats:

- Boats that have been exposed to other aquatic environments will be washed/disinfected in accordance with the approved protocol (see Equipment in Lake above).

- To ensure safety and operational efficiency, all boat traffic will be coordinated with all on-going monitoring, research, maintenance, and educational programs.

## G. *Scuba Activities in Spring Lake*

The Diving Control Board will assist and advise the Executive Director on all scuba activities occurring in Spring Lake. It is responsible for:

- Developing and maintaining a Diving Manual for Spring Lake. This manual sets forth the criteria to be met before an individual is authorized to dive in Spring Lake. It contains procedures and protocols to be observed by all diving operations in the Lake that:
  - Protect and preserve the natural and cultural resources found in the Lake
  - Ensure that diving activities support the educational and research programs at Texas State
  - Establish standards for training, certification and equipment maintenance such that all diving operations are environmentally sensitive and procedurally safe
  - Protect divers from occupational injury and illness.
- Establishing and/or approving diver training programs for Spring Lake.
- Reviewing and approving requests for diving operations in Spring Lake.
- Advising the Lake Manager and the Diving Safety Officer on monitoring diving activities in Spring Lake.

**1.** Requests for individuals to dive in Spring Lake must be submitted to the Diving Control Board, through the Lake Manager, for review and approval. These requests must be submitted in writing and include:

- Name and contact information for each individual who will be diving
- Diving experience and certifications of each diver
- Whether divers have been authorized to dive in Spring Lake
- Description of diving activities in which each individual will engage, including specific areas of Spring Lake that activities will occur, including, if appropriate, measures to be taken to minimize any impact on endangered species or their habitat, or cultural resources found at the lake
- Description of any equipment that will be brought into lake for diving activities
- Timeline for diving activities

**2.** All diving activities will be confined to the designated training area in Spring Lake, unless specifically approved by the Lake Manager.

**3.** The Diving Safety Officer, using guidelines set out in the Diving Safety Manual for Spring Lake, will determine which individuals are qualified to dive in Spring Lake. Individuals determined not qualified to dive in Spring Lake by the Diving Safety Officer may appeal this decision to the Diving Control Board.

4. The Diving Safety Officer will monitor all diving activities in Spring Lake, assuring all guidelines contained in the Diving Safety Manual for Spring Lake are observed.

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

### H. *Conduct on Spring Lake*

All University regulations dealing with conduct of individuals on University property will be enforced at Spring Lake. The unique resources found at this site require that conduct of individuals accessing and using Spring Lake not harm or disturb these resources. Protocols for enforcement of University regulations regarding individual conduct at Spring Lake will be developed by the Executive Director in consultation with the Spring Lake Advisory Committee.

## V. Key Processes

### A. *Indexing, cataloging and monitoring activities and studies conducted in the Lake*

The Lake Manager will maintain records of all activities and studies requested for Spring Lake and will annually update the Spring Lake Projects/Monitoring chart in Appendix F with information on all approved activities. Upon updating Appendix F, the Lake Manager will prepare a brief report to the Executive Director of RSI, with copies to the Environmental Review Committee, of all activities occurring in Spring Lake during the past year, impacts these activities had on the health of the lake, and any concerns or issues arising from these activities.

### B. *Site Maintenance: Aquatic Vegetation*

Spring Lake will be maintained in an aesthetically pleasing manner. Boat paths and spring openings will be maintained such that guests are easily able to view the springs from glass bottom boats.

Boat lanes will be maintained by means of a harvester boat operated by qualified Lake Maintenance staff. The harvester will run as seasons dictate.

Spring openings will be gardened by Lake Maintenance staff and by certified “Diving for Science” volunteers under staff supervision. These gardening activities will be dictated by seasonal requirements and include removal of invasive plant species and reintroduction of approved native plants. Underwater gardening activities will be monitored by the Lake Manager, in consultation with the Diving Safety Officer.

### C. *Site Maintenance: Wetlands Area and Boardwalk*

The wetlands area and wetlands boardwalk will be maintained aesthetically to provide park guests with the opportunity to observe the fauna and flora resident in this unique ecosystem. Lake Maintenance staff will be responsible for the maintenance and repair of the boardwalk, the removal of non-native plants throughout the wetlands area and the planting of native plants in this area. Aquarena Center staff, under the supervision of the Lake Manager, will be responsible for the annual review and update of interpretive information provided on the boardwalk.

### D. *Site Maintenance: Golf Course and Grounds*

The golf course and grounds will be maintained in an aesthetically pleasing, yet environmentally sensitive manner. It is the responsibility of the Golf Course Manager to maintain the course and grounds in accordance with the Integrative Pest Management Plan (IPM). This plan will describe the activities and materials to be used to control pests (i.e. insects, weeds, and other living organisms requiring control) on the golf course in a way that minimally impacts the environment. The IPM will be developed and updated by the Golf Course Manager, in consultation with the Lake Manager and the Environmental Review Committee.
The Golf Course Manager will consult with the Lake Manager on any unique situation that may arise outside of routine maintenance that could impact Spring Lake.
Each year the Golf Course Manager will report to the Lake Manager detailed information on maintenance activities and materials used during the year.

### E. *Conflict Resolution*

If an individual or organization is not satisfied with any decision on a request to have access to or use of Spring Lake, he may appeal the decision to the Executive Director of RSI.
Conflicts between the Environmental Review Committee and the Lake Manager will be resolved by the Executive Director of RSI.

## VI. Strategic Plan for Spring Lake

Program goals and objectives for Spring Lake will be a component of the strategic plan for the River Systems Institute and will be developed through the University's strategic planning process. The Spring Lake Advisory Committee and the Environmental Review Committee will be consulted in the development of program goals and objectives for Spring Lake.

## VII. Current Activities on Spring Lake

A number of activities reoccur in Spring Lake each year in support of the University's teaching, research and service mission.

Teaching: HHP uses Spring Lake for the open water requirements of its scuba diving classes; generally 400-500 students make 1-2 dives in the Spring Lake Dive Training Area each year as part of these requirements. Over 3250 students take a glassbottom boat tour each year as part of a University seminar class or other organized class. Biology, Geography and Anthropology occasionally conduct portions of research courses or independent study courses in Spring Lake; such courses typically involve a small number of students each year. Appendix F contains detailed information on classes held in Spring Lake during the past year.

Research: Several academic departments are annually involved in research studies in Spring Lake. These studies range from collection and sampling of biological species in the lake to hydrological studies of the lake to archaeological investigations. Generally 8-12 research studies are conducted in the lake each year. In addition, several departments, as well as a number of federal and state agencies monitor equipment collecting on-going data about the lake and its ecosystems. Typically 8-10 of these monitoring activities occur each month. Appendix F contains details on the research and monitoring activities occurring in Spring Lake during the last year.

Public Service: Several categories of public service activities occur in Spring Lake each year: (1) environmental education; (2) scuba; (3) stewardship; and (4) special events. Environmental education tours conducted on glassbottom boats or glassbottom kayaks involve over 100,000 individuals each year. Generally 1-5 boats are on the lake six-eight hours a day; depending on the season (i.e. attendance is greatest during summer months and least during winter months). In addition to the glassbottom boat tour, school groups, involving 25,000 students annually, participate in other activities in and around the lake, ranging from wetlands boardwalk tour to water sampling or bug collection. Scuba activities in Spring Lake include (a) training/authorization of divers to participate in supervised diving activities throughout the lake; (b) academic classes; (c) open-water checkout for noncredit classes; (d) habitat maintenance activities; and (e) research/data collection activities. Training/authorization dives involve 300-350 individuals each year undergoing 36-48 hours of training on how to dive in Spring Lake, understanding not only safety issues of scuba diving, but also understanding the unique species and cultural resources found in the lake and how to assure that these resources are not harmed or disturbed during diving activities. Open water checkout dives for both academic scuba classes and noncredit scuba classes involve 1-2 dives each year by 2500 individuals. Both training dives and checkout dives are confined to the Spring Lake Dive Training Area. Habitat maintenance activities and research/data collection activities involve RSI staff and faculty, students and volunteers who have been trained and authorized to dive throughout Spring Lake. Generally these activities occur weekly and involve 40-50 individuals each year. Stewardship activities focus on the removal of exotic plants throughout the lake and replacement with native plants. Some of these activities occur underwater as part of the habitat maintenance /underwater gardening activities conducted by staff and trained volunteers. Most stewardship activities occur along the shoreline of the lake and in the wetlands area, and are conducted by volunteers supervised by RSI staff; over 2900 volunteers provide 7000-8000 hours in stewardship activities each year. Several special event activities occur in Spring Lake each year. The two largest events are the Texas Water Safari, which involves around 200 individuals launching canoes at the headwaters of the lake to begin a 260 mile race to the Texas coast; and the Texas State Triathlon which has the 500 meter swim component of the race for its 300 participants in Spring Lake. Both of these events occur only once each year. Appendix F contains details on the public service activities occurring in Spring Lake during the past year.

## VIII. Contact Information

The following individuals have responsibilities for policies and procedures contained in this management plan:

- Executive Director
  River Systems Institute
  Andrew Sansom
  Texas Rivers Center
  Sansom@TXSTATE.EDU
  512/245-9200
- Lake Manager
  River Systems Institute
  Ron Coley
  Aquarena Center
  RC13@TXSTATE.EDU
  512/245-7539
- Chief Science Officer
  River Systems Institute
  Thom Hardy
  Texas Rivers Center
  Thom.Hardy@TXSTATE.EDU
  512/245-6729
- Diving Safety Officer
  River Systems Institute
  Frederick Hanselmann
  Texas Rivers Center
  FH16@TXSTATE.EDU
  512/245-2724
- Golf Course Manager
  Campus Recreation
  Ryan Zimmerman
  Golf Course Pro Shop
  RZ10@TXSTATE.EDU
  512/245-2392

# IX. Appendices

## A. *Historical Perspective of Spring Lake*

Archaeological research indicates that the area around San Marcos Springs (i.e. Spring Lake) has been inhabited for over 12,000 years. Early Spanish missionaries traveling the El Camino Real de los Tejas described the springs as “leaping, sparkling waters”.

In 1849, General Edward Burleson, Vice President of the Republic of Texas established a homestead at the site and created Spring Lake by building a dam on the San Marcos River to supply power to his grist mill.

In 1926, A. B. Rogers purchased the Burleson tract and transformed the site into “one of the greatest playgrounds of Texas and the Southwest”. Rogers wanted visitors to enjoy and appreciate the natural beauty of the San Marcos River. In 1929 Rogers opened Spring Lake Park Hotel; in 1946 Rogers began construction of a tourist resort featuring glass bottom boats, a submarine theatre, and an underwater show with aquamaids, swimming clowns and a swimming pig. In 1950, Aquarena Springs Resort and Theme Park had its grand opening. By 1970 Aquarena was the leading paid tourist attraction in the State, and only exceeded in the annual number of visitors by the Alamo and the State Capitol.

In 1986, John Baugh bought Aquarena from the Rogers family and continued to operate the theme park and hotel; however the more modern theme parks in San Antonio and Houston severely cut into the number of visitors to Aquarena.

In 1994, the University bought the 90 acre park from Baugh. Since then the University has steadily moved to incorporate this unique resource into enhancing the University’s mission. The focus has turned from theme park attractions to education and research activities regarding the natural and cultural resources found at the site. The old hotel has been renovated to house the River Systems Institute which provides research and educational activities on the study and protection of Texas rivers. The glass bottom boats have become a key element in educating the public on the appreciation and protection of our natural and cultural resources.

Today the Spring Lake site has over 100,000 visitors participate annually in environmental education tours; faculty and students from several academic departments conducting research activities; and numerous volunteers participating in stewardship efforts to protect the unique resources found at the site.

## B. *Baseline Data on Spring Lake (2009-2010)*

### 1. Overview

Spring Lake is an approximately 18-acre horseshoe-shaped water body with two main regions: the Spring Arm and the Slough Run. Sink Creek, the Lake’s only significant surface water tributary, discharges into the Slough Arm of the Lake. Most of the hydrological inputs to the Lake occur from spring openings in the Spring Arm, where artesian spring water from the Edwards Aquifer emerges from approximately 200 openings.


**Figure 1: Aerial Photograph of Spring Lake**

## 2. Spring Lake Watershed

Area 172.3 Acres

Elevation Lowest – 574 ft. above sea level Highest – 754 ft. above sea level

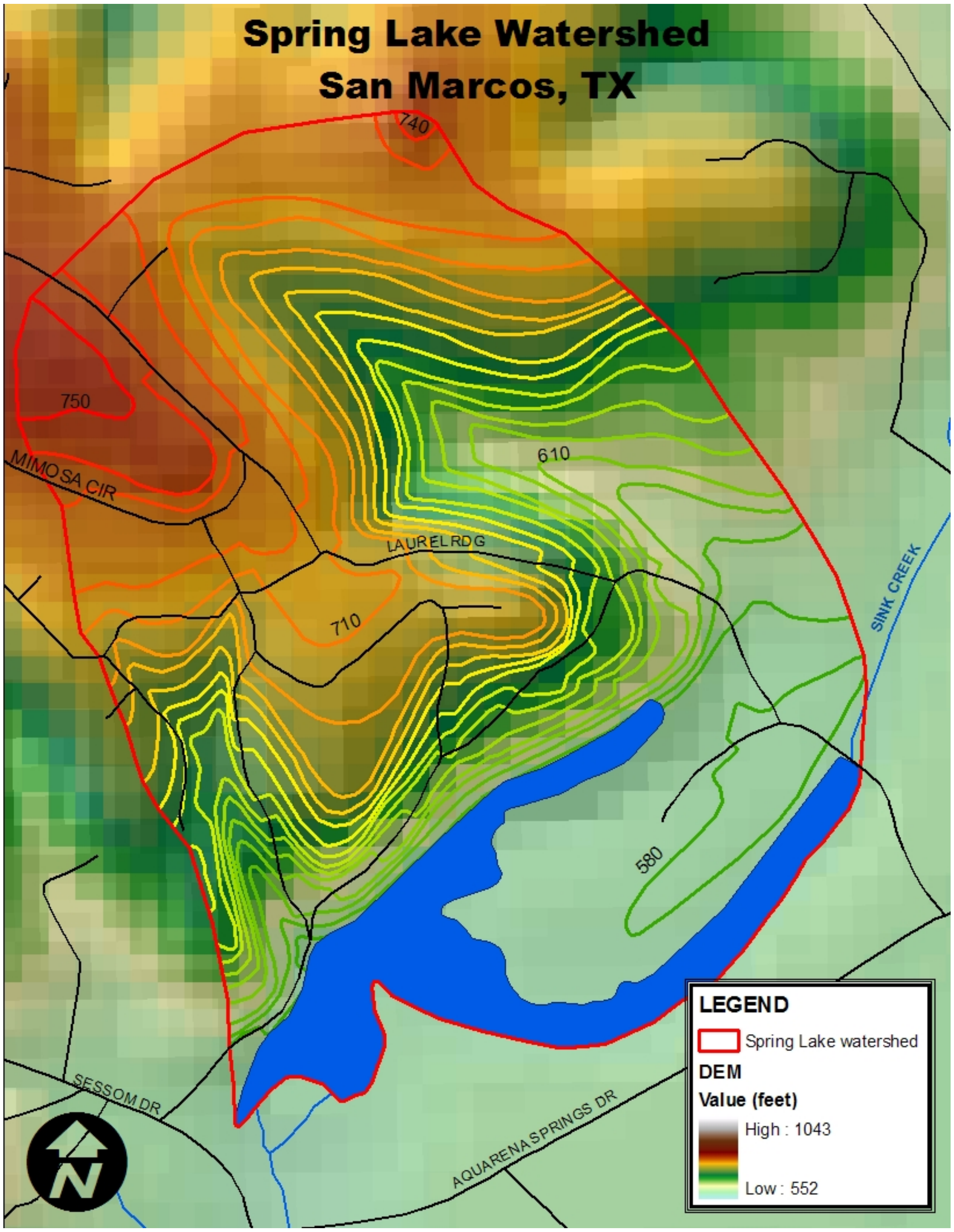



**Figure 2: Spring Lake Watershed Elevation**

**Table 1: Landownership in Spring Lake Watershed**

| LAND OWNERSHIP | ACRES | % WATERSHED |
|---|---|---|
| Private Residence | 65 | 37.8% |
| University | 52.8 | 30.6% |
| City of San Marcos | 41 | 23.8% |
| Texas Treatment Center | < 1 | < 1% |

F

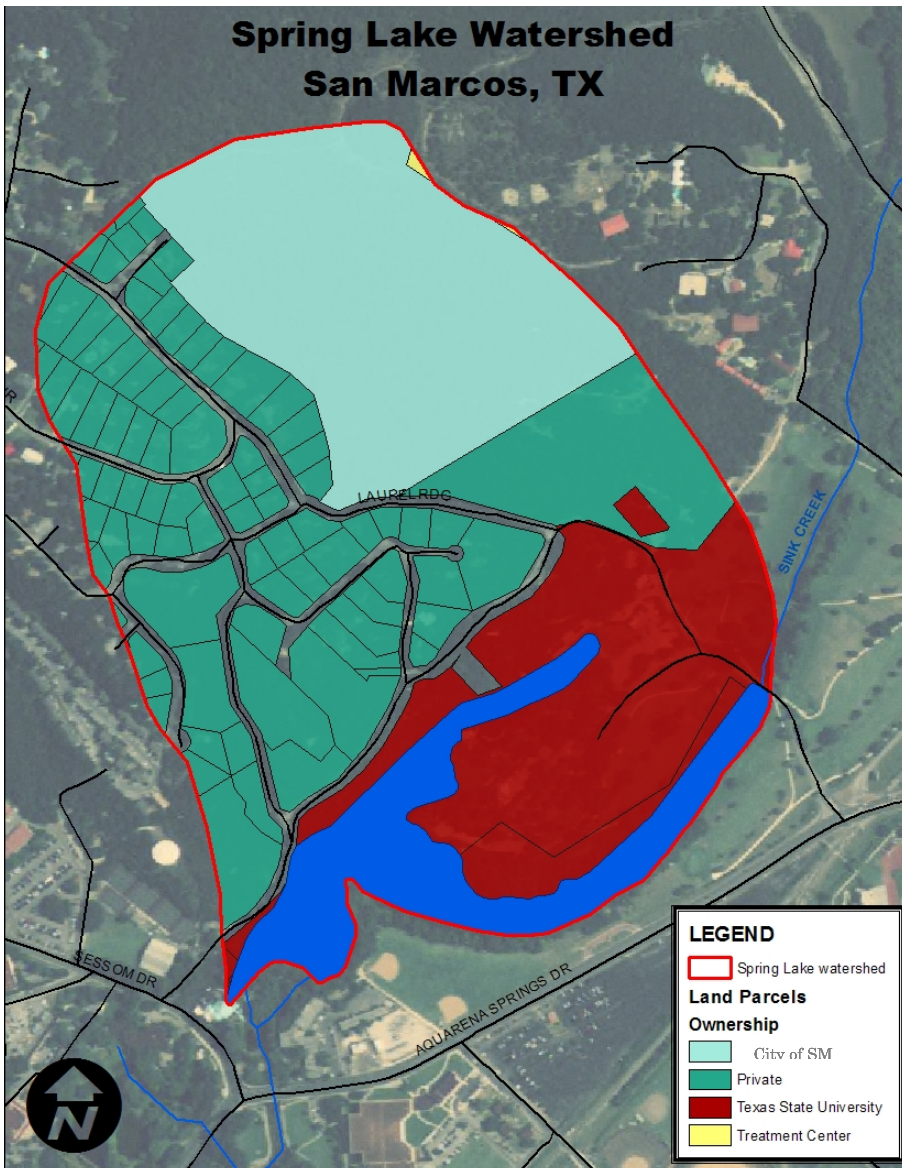


Figure 3: Spring Lake Watershed Land Ownership

## 3. Spring Lake Bathymetry

| | |
|---|---|
| Range of Depth | .1-28 feet |
| Average Depth Main Lake | 10 feet |
| Average Depth Including Slough | 4 feet |

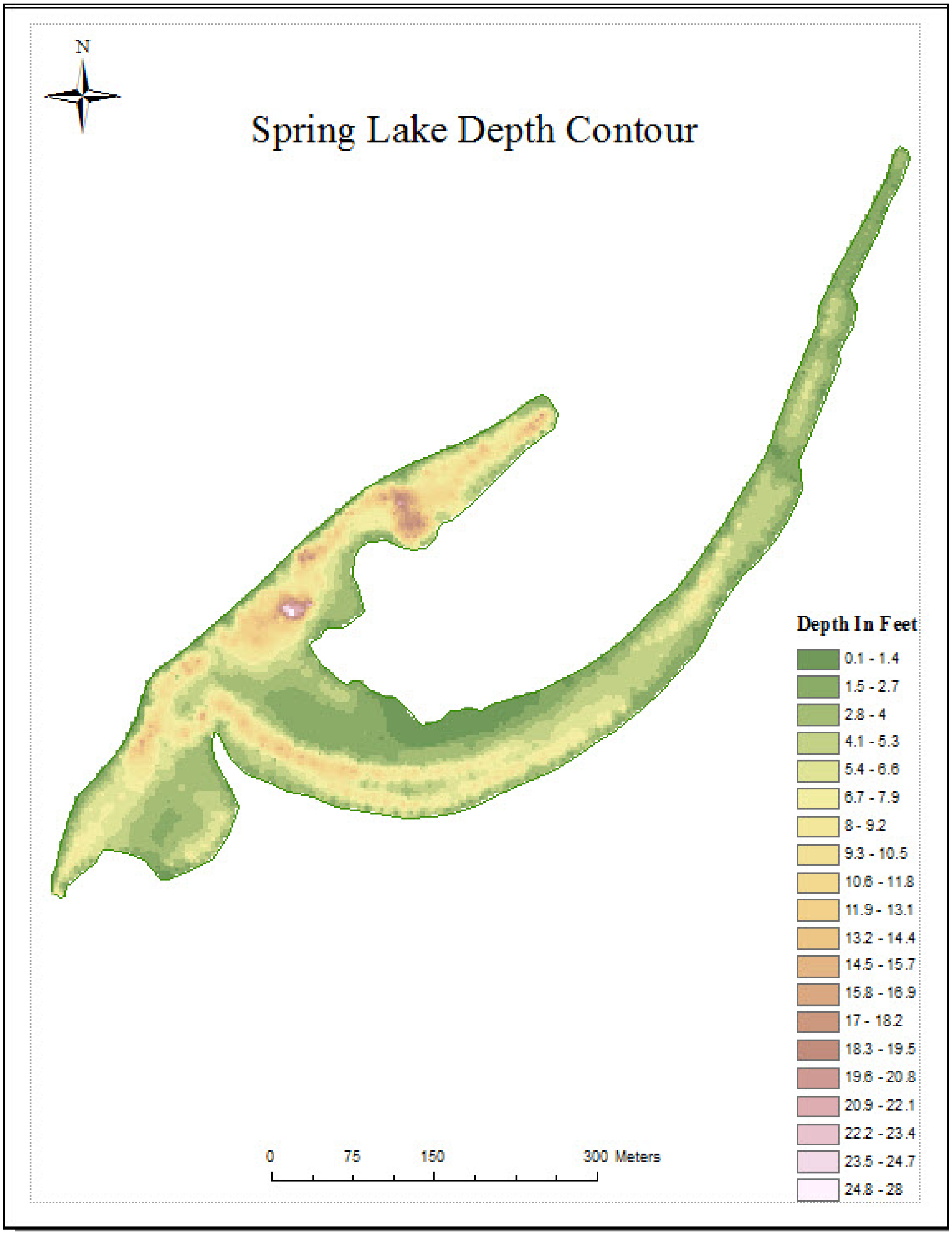



**Figure 4: Spring Lake Depth Contours**

## 4. Spring Lake Water Quality

| Parameters | Texas Surface Water Standards (TCEQ) | Hotel Springs | Deep Hole Spring |
|---|---|---|---|
| D.O. mg/L | > 5.0 | 5.92 | 6.45 |
| pH | 6.5-9.0 | 6.92 | 7.37 |
| Nutrients: K mg/L | | 1.92 | 1.89 |
| Ni mg/L | NO3 ~2.0 | 1.40 | 1.51 |
| Phosphates mg/L | | | |
| bacteria cfu/100m² | E. coli <394 | | |
| turbidity NTU | | 0.28 | 1.17 |
| chlorophyll | | | |
| Temp ° C | | 21.58 | 18.93 |
| conductivity µ mohs/cm | 250-950 | 693 | 681 |

## 5. Spring Lake Water Quantity

| | |
|---|---|
| Record Low Spring Flow | 46 cfs (August, 1958) |
| Record High Spring Flow | 451 cfs (March, 1992) |
| Average Spring Flow | 160 cfs |

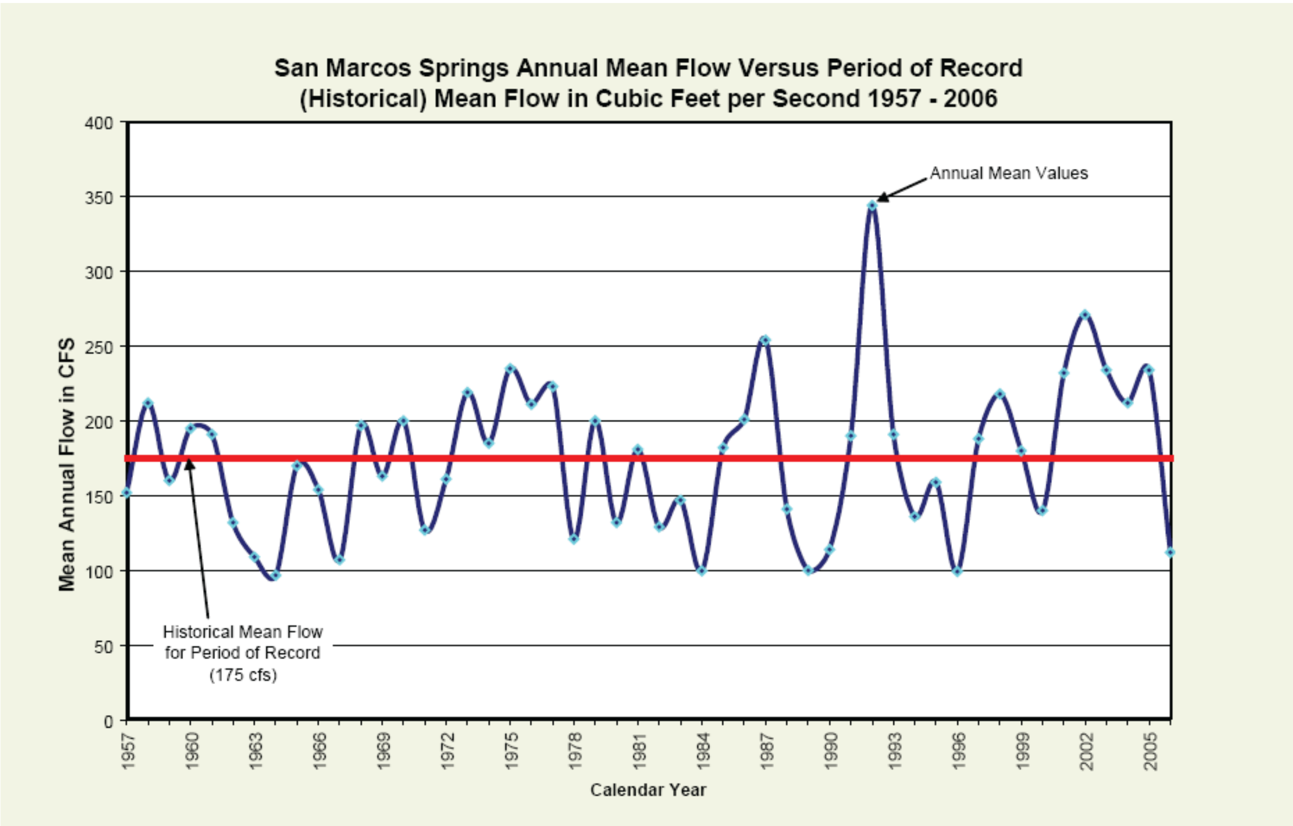



**Figure 5: Comparison of San Marcos Springs annual mean flow and historical mean flows from the Edwards Aquifer Authority Hydrologic Data Report for 2006**

## 6. Spring Lake Diversions

| Water Right:<br>TCEQ Certificate 18-3865 | Max Allowed | 2010 Use |
|---|---|---|
| • Irrigation Use | 100 ac/ft/yr | 26 ac/ft/yr |
| • Municipal Use | 513 ac/ft/yr | Not Used |
| • Industrial Use | 534 ac/ft/yr | 60 ac/ft/yr |
| • Hydroelectric Use | 30,262 ac/ft/yr | Not Used |
| • Artificial Waterfall | 700 ac/ft/yr | Not Used |

### C. ***Spring Lake Indicators of Ecosystem Health***

A primary objective of the River Systems Institute is to manage Spring Lake so as to protect the healthy ecosystems that exist in the Lake. This appendix will describe the key indicators that will be maintained and monitored to reflect the health of the Lake. A blue-ribbon commission of faculty and researchers will identify these indicators and establish acceptable ranges to be maintained in order to provide healthy ecosystems in the Lake.

## D. *Spring Lake Endangered Species*

The U.S. Fish and Wildlife service, through authority granted by the Endangered Species Act of 1973, have listed the following species, found in Spring Lake, as endangered or threatened:

| **Endangered Species** | **Threatened** | **Extinct** | **Date Listed** | **Where they are found** |
|---|---|---|---|---|
| Fountain Darter – Etheostoma fonticola | | | 10/13/1970 | Upper 3 miles of the San Marcos River and the Comal River |
| Texas Wild Rice – Zizania texana | | | 5/27/1978 | Upper 1.5 miles of the San Marcos River |
| Texas Blind Salamander | | | 3/11/1967 | Edwards Aquifer under San Marcos |
| | San Marcos Salamander – Eurycea nana | | 7/14/1980 | Spring Lake and immediately below Dam (in rocky areas 150 m below) |
| Comal Springs Dryopid Beetle | | | 12/18/1997 | Historically, from headwaters to Thompson's Island |
| Comal Springs Riffle Beetle | | | 12/18/1997 | Historically, from headwaters to Thompson's Island |
| Peck's Cove Amphipod | | | 12/18/1997 | Historically, from headwaters to Thompson's Island |
| | | Gambusia – Gambusia georgei | 7/14/1980 | Historically, from headwaters to Thompson's Island |

## E. ***Edwards Aquifer Recovery Implementation Program Habitat Conservation Plan***

The following information, pertaining to activities in Spring Lake, have been excerpted from the draft Edwards Aquifer Recovery Implementation Program Habitat Conservation Plan. A copy of the entire plan can be found at http://earip.org/Resources.aspx under "Revised Final Draft of HCP".

### Chapter 5 MINIMIZATION AND MITIGATION MEASURES SPECIFICALLY DESIGNED TO CONTRIBUTE TO RECOVERY

The ESA requires the HCP to specify what steps the applicants will take to minimize and mitigate the impacts which will likely result from the anticipated incidental take associated with the Covered Activities. 16 U.S.C § 1539(a)(2)(A). In order to issue and incidental take permit, FWS must find that the applicants "will, to the maximum extent practicable, minimize and mitigate the impacts of such taking." *Id.* at § 1539(a)(2)(A)(B)(ii).

This chapter presents the conservation measures that the Applicants commit to carry out to minimize and mitigate the incidental take resulting from the Covered Activities to the maximum extent practicable. Additionally, some measures identified in the Sections below go beyond the "minimize and mitigate" standard and actually contribute to the recovery of the Covered Species. Each measure identifies the impact of the anticipated incidental take to be addressed and how the measure positively addresses that impact.

### 5.4 Texas State University

#### 5.4.1 Texas Wild-Rice Enhancement and Restoration

Texas State University will partner with the City of San Marcos to undertake a program of Texas wild-rice enhancement and restoration in Spring Lake and the San Marcos River within the University's campus boundaries as described in Section 5.3.1 above.

#### 5.4.2 Management of Recreation in Key Areas

Texas State University will partner with the City of San Marcos to control recreation in Spring Lake and the San Marcos River within Texas State University campus boundaries. To minimize the impacts from recreation, Texas State University will establish permanent access points on the east and west banks of the San Marcos River between Spring Lake dam and the Aquarena Drive bridge, and other areas as determined during the AMP. These areas will serve as entry and exit ways that could be used by canoeists, tubers, swimmers, etc. Areas between access points will be planted with vegetation that discourages streamside access (*e.g.*, prickly pear and acacia). Additionally, TPWD intends to create State Scientific Area in the San Marcos Springs ecosystem and River that would limit recreation in these areas during low flow conditions. (*See* Section 5.6.1). With the exception of the eastern spillway immediately below Spring Lake Dam, none of the protected areas would extend across the entire river channel which would allow longitudinal connectivity throughout the river. Kiosks showing access points, exclusion zones, and associated educational components will be installed at key locations.

#### 5.4.3 Management of Vegetation

#### 5.4.3.1 Management of Submerged and Floating Aquatic Vegetation in Spring Lake

To mitigate the impacts of incidental take on Covered Species from recreation, Texas State University will manage aquatic vegetation in Spring Lake through use of its harvester boat and through hand cutting of vegetation by divers authorized to dive in Spring Lake. Each week about five springs will be cut, thus returning to cut the same springs every two to three weeks. During summer algal blooms, the springs will be managed more frequently (up to four springs per day), but mostly to remove algae. Texas State employees and supervised volunteers will fin the area around the springs to remove accumulated sediment, and then clear a 1.5-meter radius around each spring opening in Spring Lake with a scythe. Over the next 1.5-meter radius around the spring opening, they will shear vegetation to a height of 30 cm, and then to one meter over the following three meter radius. Plant material will not be collected, but carried away by the current. Cumulatively, about six meters of vegetation around each spring opening will be modified. Mosses will not be cut. The volume of plant material to be removed will vary by the amount of time between cuttings, and season. The harvester boat will remove a range of 15-to-20 boatloads of plant material a month from Spring Lake. The harvester will clear the top meter of the water column, cutting vegetation from sections one, two, and three once a week. (*See* Figure 5.2). The harvested vegetation will be visually checked by driver for fauna caught in the vegetation. If the driver observes fauna, he/she will stop work and put the animal(s) back into Spring Lake if appropriate. Texas State employees and supervised volunteers are trained to recognize the Covered Species through the Diving for Science program (Section 5.4.8.1), and avoid contact with them. Vegetation mats will be removed from zones four and five on an as-needed basis. (Figure 5-2). The total area cut will equal about nine surface acres. One permanent full-time person (Spring Lake Area Supervisor) is responsible for running the harvester and managing the removal of vegetation around the spring openings. The Spring Lake Area Supervisor also schedules cleanup of nuisance floating species such as water hyacinth and water lettuce from Spring Lake. The floating plants will be collected by hand and shaken prior to removal from the river to dislodge any aquatic species caught in the plant. The plants will be deposited into dump trucks and taken to the River System Institute compost area.

#### 5.4.3.2 Management of Aquatic Vegetation from Sewell Park to City Park

To mitigate the impacts of incidental take from recreational activities, Texas State University will push floating vegetation downstream of any Texas wild-rice stands. Inorganic litter will be picked up weekly from the San Marcos River from Sewell Park to City Park during the recreational season (Memorial Day to Labor Day) and monthly during offseason. Texas State University will monitor downstream Texas wild-rice stands to keep the stands clear of drifting vegetation. Divers will not pick up litter in or around Texas wild-rice stands. University employees or others will be trained by the TPWD to recognize Texas wild-rice and to protect the plant stand while removing the accumulated floating plant material. On Texas wild-rice stands, Texas State University employees will lift (not push) the floating material from the top of the Texas wild-rice stands and allow it to float downstream. Downstream accumulations of plant material will be removed by the City of San Marcos to avoid impacts to Texas wild-rice further downstream.

**Figure 5.2:** Aquatic Harvester Zones

Zone 1_Headwater Springs; Crater Bottom, Salt and Pepper 1&2, Weissmuller

Zone 2_ Boat Path; Diversion, Cream of Wheat, Ossified Forest

Zone 3_Boat Path; River Bed, Catfish Hotel, Deep Hole, Harvester Channel

Zone 4_Boat Path; Archeology Site, Kettleman's, University Seminar Boat Path and Dock

Zone 5_ Sink Creek/slough channel

### 5.4.4 Sediment Removal in Spring Lake and from Spring Lake Dam to City Park

Monitoring of the San Marcos River since 1990 reveals that sediment production has increased from 160 m3/yr to 920 m3/yr due to a combination of upstream flood control dams and sediment inflow increases (Earl and Wood 2002). Deposition of sediments on or around Texas wild-rice strands causes direct mortality by smothering or burying strands. Texas State University will mitigate the impacts of incidental take from diving activities, research activities, recreation and pumping during low flow periods by removing sediment from key areas of Texas wild-rice habitat in Spring Lake and from Spring Lake dam to City Park. Hydrosuction will be used to remove accumulations of sediment. The silt will be vacuumed using a hose that has an end piece covered by a 0.25-inch mesh screen to prevent suctioning biota greater than 0.25 inch in diameter. The divers doing the hydrosuctioning will take the following measures to minimize loss/harm of biota in the area. Vegetation will be finned before turning on the pump. Finning will encourage the darters and other biota to move out of the area. Divers will be trained to recognize all stages of listed species from larval to adult. The nozzle of the vacuum will be kept down in the soil and not allowed to swing through the water column during the operation. In addition, placement of stakes around the area to be suctioned will keep divers away from stands of Texas wild-rice. An observer will be on the bank to monitor the effluent for presence of listed species and all other biota, as well as for the safety of the diver. Sediment samples will be sent to TCEQ for contaminant testing per TCEQ requirements.

### 5.4.5 Diversion of Surface Water

Under TCEQ Certificates 18-3865 and 18-3866, Texas State University's total diversion rate from the headwaters of the San Marcos River for consumptive use is limited to 8.1 cfs. (*See* Section 2.5.5). The total diversion rate from Spring Lake is limited to 4.88 cfs; the total diversion rate from the San Marcos River at Sewell Park is limited to 3.22 cfs. (*See* Section 2.5.5.1 and 2.5.5.2 respectively). To minimize the impacts of these diversions, when flow at the USGS gauge at the University Bridge reaches 80 cfs, Texas State University will reduce the total rate of surface water diversion by 2 cfs, *i.e.*, to a total of approximately 6.1 cfs. This reduction in pumping will occur at the pump just below Spring Lake Dam in order to maximize the benefits to salamanders, Texas wild-rice, and other aquatic resources in the San Marcos River below Spring Lake Dam. The University will reduce the total rate of surface water diversion by an additional 2 cfs when the USGS gauge reaches 60 cfs. The additional 2 cfs reduction will be made from the pumps located in the slough arm of Spring Lake, and, therefore, maximize the benefits to the aquatic resources within the main stem San Marcos River below Spring Lake Dam. When the USGS gauge reaches 49 cfs, Texas State University will reduce the total diversion rate to 1 cfs. This further reduction will be made by restricting the pumps located in the Sewell Park reach. The diversion of water will be suspended when the springflow reaches 45 cfs.

**Figure 5-3.** Texas State University Surface Water Diversions. The diversions are identified with stick pins. The diversions at the pump house (slough arm of Spring Lake) and industrial cooling towers are permitted under TCEQ Certificate 18-3865. The diversions at Sewell Park and the "ponds" are permitted under TCEQ Certificate 18-3866. (*See* Sections 2.5.5.1 and 2.5.5.2 respectively). The reductions in Texas State University's total diversion rate for consumptive use is summarized in Table 5-4 below:

| Streamflow (cfs) | Spring Lake Diversions (cfs) Cert. No. 18-3865 | San Marcos River Diversions (cfs) Cert. No. 18-3866 | Total Diversion Rate (cfs) |
|---|---|---|---|
| >80 | 4.9 | 3.2 | 8.1 |
| 80-60 | 2.9 | 3.2 | 6.1 |
| 60-49 | 0.9 | 3.2 | 4.1 |
| 49-45 | 1.0 | 0 | 1.0 |
| <45 | 0 | 0 | 0 |

**Figure 5-4.** Reductions in Surface Water Diversion Rates during Low Flow Conditions under Texas State University's TCEQ Certificates 18-3865 and 18-3866.

Texas State University uses a 0.25-inch mesh screen to cover the intake for surface water diversions. These screens are routinely inspected and cleaned. Fountain darters have not been observed when the screen is cleaned; however, there is a possibility for capture of adults against the screen, but not pulled into the pipeline. To avoid or minimize the impacts of the surface water diversions, the University will routinely monitor the screens to determine if any entrainment occurs and will make any necessary modifications to the screens to minimize any incident take from the operation of the diversions.

#### 5.4.6 Sessom Creek Sand Bar Removal

For decades, a sand and gravel bar has been building with each major rain event at the confluence of Sessom Creek and the San Marcos River. The bar is about two-thirds meter deep, 7 meters wide, and 21 meters long (98.5 m3). Over time it has widened, deepened, and constricted the river channel; furthermore, the continued expansion has covered a stand of Texas wild-rice. The bar has become vegetated with both littoral and terrestrial plants, and is used heavily by recreationists as it provides a shallow swimming area. To minimize and mitigate the impacts of incidental take from recreation, Texas State University and the City of San Marcos 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 University will submit the study for review though the AMP and implement the actions coming out of that process. A separate sediment retention pond has been constructed to minimize additional deposition to this area and will be maintained to maintain an effective level of performance.

#### 5.4.7 Diving Classes in Spring Lake

##### 5.4.7.1 The Diving for Science Program

To minimize the impacts of the Diving for Science Program that trains and authorizes individuals to dive in Spring Lake, individuals authorized through this program must demonstrate a knowledge of listed species found in the lake and their habitat, laws and regulations impacting these species, good buoyancy control, the ability to avoid contact with listed species, the ability to avoid disturbing critical habitat, and the ability to stay off the bottom of the lake. The program is taught as a two-day class with a maximum class size of 20 and is taught in the Dive Training Area. The program averages 350 trainees per year. Upon completion of this class, divers are allowed anywhere in Spring Lake to perform specific volunteer tasks such as finning spring areas covered with algae, and picking up litter. Projects are structured to minimize contact with listed species in an effort to ensure protection of listed species and their habitat. The Diving Supervisor coordinates and supervises all volunteer diving. No more than sixteen volunteer divers will be allowed in the lake per day, with no more than eight at one time. Any individual diving outside of the Dive Training Area has to have completed the Diving for Science Program.

#### 5.4.2 Texas State University Continuing Education

Texas State University Continuing Education classes for check-out dives will be conducted in the Dive Training Area. To minimize the impacts of these classes, class size will be limited to 12 students and no more than three classes will be conducted per day.

#### 5.4.7.3 Texas State SCUBA Classes

Texas State SCUBA classes will be conducted in the Dive Training Area. To minimize the impacts of these classes, class size will be limited to 12 students and no more than three classes will be conducted per day.

### 5.4.8 Research Programs in Spring Lake

To minimize the impacts of its research programs, all proposals to conduct research in Spring Lake will be reviewed by the River Systems Institute to ensure there is no impact on Covered Species or their habitat. If incidental take cannot be avoided, it will be minimized by educating the researchers as to the area where the listed species are located and by requiring measures to minimize any potential impacts. All diving in support of a research study will be provided by individuals who have completed the Diving for Science program. Nothing herein is intended to obviate the need for individual research projects to obtain a permit under 16 U.S.C. § 1539(a)(1).

### 5.4.9 Management of Golf Course and Grounds

To minimize any impacts of the use of fertilizers and pesticides to maintain the golf course and grounds, Texas State University will develop a golf course management plan that will document current practices and include an Integrated Pest Management Plan (IPMP). The golf course management plan and IPMP will incorporate environmentally sensitive techniques to minimize chemical application, improve water quality, and reduce negative effects to the ecosystem. Expanded water quality sampling targeted at Golf Course operations will be conducted as described in Section of 5.7.2. of the HCP. Changes in golf course management will be addressed through the AMP as set out in Article 7 of the FMA.

### 5.4.10 Boating in Spring Lake and Sewell Park

To minimize the impacts of boating on the Covered Species' habitat in Spring Lake, boats in Spring Lake will be confined to areas that are mowed by the harvester, thereby not impacting vegetation and specifically avoiding Texas wild-rice stands. Individuals will enter and exit boats at specified access points to avoid impacting the flora and fauna along the bank. All boats launched into Spring Lake will undergo a USFWSapproved process for cleaning. Further, canoeing/kayaking classes in the lake will be limited to no more than 2 classes per day and each class will be in the water no more than 1 hour. Classes will have a maximum of 20 students in 10 canoes. All classes will be supervised. To minimize the impacts of boating on the Covered Species' habitat in Sewell Park, canoeing/kayaking classes in Sewell Park will be confined to the region between Sewell Park and Rio Vista dam. Students will enter/exit canoes/kayaks at specified access points to avoid impacting the flora and fauna along the bank. Classes will be no longer than two hours and up to three classes will be held per day. Classes will have a maximum of 20 students in 10 canoes. All classes will be supervised.

### 5.4.11 Reduction of Non-Native Species Introduction

Texas State University will limit introductions of non-native species by aquarium dumps. Dumping aquariums into the San Marcos River and its tributaries will be minimized through education, including signage and brochures, and offering alternative disposal to citizens wanting to get rid of unwanted aquatic pets. Texas State University will partner with the City of San Marcos and local citizen groups to help distribute educational materials. Partnerships with the school districts will also be considered. Educational materials will also be provided to local pet shops.

### 5.4.12 Control of Non-Native Plant Species

Texas State University will partner with the City of San Marcos to implement a non-native plant replacement program for Spring Lake and the San Marcos River within the University's campus boundaries as described in Section 5.3.8 above.

### 5.4.13 Control of Harmful Non-Native and Predator Species

Texas State University will partner with the City of San Marcos to undertake a program of non-native and predator species control for Spring Lake and the San Marcos River within the University's campus boundaries as described in Section 5.3.9 above.

### F. *Activities in Spring Lake*

The following activities were conducted in Spring Lake during 2009-2010:
Teaching Activities

| Teaching | | | | |
|---|---|---|---|---|
| Class | Enrollment | Duration | Description | Damage to Lake |
| HHP | | | | |
| Beginning Scuba | 20 | November, 2009 | Six open water dives | Minimal |
| Beginning Scuba | 20 | November, 2009 | Six open water dives | Minimal |
| Beginning Scuba | 20 | November ,2009 | Six open water dives | Minimal |
| Beginning Scuba | 20 | November, 2009 | Six open water dives | Minimal |
| Beginning Scuba | 20 | June, 2010 | Six open water dives | Minimal |
| Beginning Scuba | 20 | June, 2010 | Six open water dives | Minimal |
| Beginning Scuba | 20 | June, 2010 | Six open water dives | Minimal |
| Beginning Scuba | 20 | June, 2010 | Six open water dives | Minimal |
| Beginning Scuba | 20 | June, 2010 | Six open water dives | Minimal |
| Beginning Scuba | 14 | June, 2010 | Six open water dives | Minimal |
| Beginning Scuba | 14 | June, 2010 | Six open water dives | Minimal |

Research Activities

| Research | | | | |
|---|---|---|---|---|
| Principal Investigator | Agency | Duration | Description | Damage to Lake |
| Drew Davis | Biology | 4/26-5/9/2010 | Collect Rio Grande cicls | |
| Carole Leezer | CAS | 4/29-5/6/2010 | Archaelogical shovel tests | None |
| Cassi Otera | USGS | 5/25/2010 | Install real time monitor | Minimal |
| Diane Wassenich | SMRF | 5/31/2010 | Removal of water hyacinth | Minimal |
| Brian Hunt | BSEACD | 6/21-7/12/2010 | Dye trace study | |
| Ben Hutchins | Biology | 8/3/2010 | Install sondes in springs | Minimal |

Public Service Activities

| Public Service | | | | |
|---|---|---|---|---|
| Organization | Participants | Duration | Description | Damage to Lake |
| RSI | 9 | 9/4-9/5/2009 | Diving for Science | Minimal |
| RSI | 10 | 10/2-10/3/2009 | Diving for Science | Minimal |
| RSI | 10 | 10/9-10/10/2009 | Diving for Science | Minimal |
| RSI | 10 | 10/23-10/24/2009 | Diving for Science | Minimal |
| RSI | 10 | 11/6-11/7/2009 | Diving for Science | Minimal |
| RSI | 11 | 11/13-11/14/2009 | Diving for Science | Minimal |
| RSI | 12 | 12/4-12/5/2009 | Diving for Science | Minimal |
| RSI | 8 | 1/8-1/9/2010 | Diving for Science | Minimal |
| RSI | 8 | 1/15-1/16/2010 | Diving for Science | Minimal |
| RSI | 8 | 2/13-2/14/2010 | Diving for Science | Minimal |
| RSI | 10 | 3/6-3/7/2010 | Diving for Science | Minimal |
| RSI | 10 | 3/20-3/21/2010 | Diving for Science | Minimal |
| RSI | 8 | 4/10-4/11/2010 | Diving for Science | Minimal |
| RSI | 9 | 5/8-5/9/2010 | Diving for Science | Minimal |
| RSI | 10 | 6/5-6/6/2010 | Diving for Science | Minimal |
| RSI | 13 | 6/19-6/20/2010 | Diving for Science | Minimal |
| RSI | 10 | 7/10-7/11/2010 | Diving for Science | Minimal |
| RSI | 12 | 7/17-7/18/2010 | Diving for Science | Minimal |
| RSI | 10 | 7/24-7/25/2010 | Diving for Science | Minimal |
| RSI | 12 | 8/7-8/8/2010 | Diving for Science | Minimal |
| RSI | 12 | 8/14-8/15/2010 | Diving for Science | Minimal |
| RSI | 12 | 8/21-8/22/2010 | Diving for Science | Minimal |
| RSI | 13 | 8/28-8/29/2010 | Diving for Science | Minimal |

| Public Service | | | | |
|---|---|---|---|---|
| Organization | Participants | Duration | Description | Damage to Lake |
| Dive Schools | Total of: 2500 | Varies during year | Open water check-out dive | Minimal |
| Southwest Aqua Sport | | | | |
| Hydrosports | | | | |
| Copelands | | | | |
| Ascuba Venture | | | | |
| Dive World San Antonio | | | | |
| Divemasters | | | | |
| Deep Blue Adventures | | | | |
| The Dive Shop | | | | |
| Houston Scuba Academy | | | | |
| Scuba Houston | | | | |
| Oceanic Ventures | | | | |
| Gigglin Marlin Divers | | | | |
| Scuba Divers Paradise | | | | |
| Island Divers | | | | |
| Lone Star | | | | |
| Arlington Scuba Center | | | | |
| Dive West | | | | |
| Aqua Adventures | | | | |
| Scuba Sphere | | | | |
| We B Divin | | | | |
| Surface Interval | | | | |
| Extreme Scuba | | | | |
| International Scuba | | | | |
| Scuba Center | | | | |
| Scuba Schools | | | | |
| Blue Dolphin Scuba | | | | |
| Lake Air Scuba | | | | |
| Toms Dive & Swim | | | | |
| Oak Hill Scuba | | | | |

| Public Service | | | | |
|---|---|---|---|---|
| Organization | Participants | Duration | Description | Damage to Lake |
| Dive World Austin | | | | |
| ScubaLand | | | | |
| Texas Water Safari | 199 | 6/22/2010 | Launch of canoe race to Texas Coast | Minimal |
| Texas State Triathlon | 327 | 4/10/2010 | 500 meter swim component of triathlon | Minimal |

## G. *Species Inventory – Spring Lake*

**Fish**

| Scientific Name | Common Name |
|---|---|
| ***Astyanax mexicanus*** | Mexican tetra (introduced) |
| ***Dionda episcopa*** | Roundnose minnow |
| ***Gambusia affinis*** | Western mosquitofish |
| ***Micropterus salmoides*** | Largemouth bass |
| ***Lepomis microlophus*** | Redear sunfish |
| ***Lepisosteus oculatus*** | Spotted gar |
| ***Etheostoma fonticola*** | Fountain darter |
| ***Lepisosteus osseus*** | Longnose gar |
| ***Fundulus notatus*** | Blackstripe topminnow |
| ***Gambusia geiseri*** | Largespring gambusia |
| ***Cyprinella venusta*** | Blacktail shiner |
| ***Notropis amabilis*** | Texas shiner |
| ***Notropis volucellus*** | Mimic shiner |
| ***Ictalurus punctatus*** | Channel catfish |
| ***Ameiurus melas*** | Black bullhead |
| ***Hypostomus plecostomus*** | Suckermouth catfish |
| ***Micropterus punctulatus*** | Spotted bass |
| ***Lepomis megalotis*** | Longear sunfish |
| ***Lepomis macrochirus*** | Bluegill |
| ***Lepomis cyanellus*** | Green sunfish |
| ***Lepomis auritus*** | Redbreast sunfish (introduced) |
| ***Cichlasoma cyanoguttatum*** | Rio Grande cichlid (introduced) |
| ***Oreochromis aureus*** | Blue tilapia (introduced) |
| ***Anguilla rostrata*** | American eel |
| ***Myleus pacu*** | Pacu (introduced) |
| ***Poecilia latipinna*** | Sailfin molly (introduced) |
| ***Poecilia formosa*** | Amazon molly |
| ***Hypostomus plecostomus*** | Suckermouth catfish (Introduced) |

**Macrophytes**

*Submerged*

| Scientific Name | Common Name |
|---|---|
| ***Sagittaria platyphylla*** | Delta arrowhead (native) |
| ***Vallisneria americana*** | American eelgrass (native) |
| ***Cabomba caroliniana*** | Fanwort (native) |
| ***Ceratophyllum demersum*** | Coontail (native) |
| ***Ludwigia repens*** | Water primrose (native) |
| ***Myriophyllum heterophyllum*** | Water-Milfoil (native) |
| ***Najas guadalupensis*** | Southern naiad (native) |
| ***Chara spp.*** | Stoneworts (native) |
| ***Amblystegium riparium*** | Aquatic moss (native) |
| ***Ricciocarpus natans*** | Liverwort (native) |
| ***Myriophyllum spicatum*** | Eurasian water milfoil (introduced) |
| ***Myriophyllum aquaticum*** | Parrot feather (introduced) |
| ***Hydrilla verticillata*** | Hydrilla (introduced) |
| ***Egeria densa*** | Brazilian elodea (introduced) |
| ***Hygrophila polysperma*** | Miramar weed (introduced) |

*Floating*

| Scientific Name | Common Name |
|---|---|
| ***Azolla caroliniana*** | Mosquito fern |
| ***Ceratopteris thalictroides*** | Watersprite (introduced) |
| ***Pistia stratiotes*** | Water lettuce (introduced) |
| ***Nuphar luteum*** | Spatterdock cow lilly |
| ***Eichhornia crassipes*** | Water Hyacinth (introduced) |
| ***Spirodela polyrrhiza*** | Duckmeat |
| ***Lemna minor*** | Common duckweed |
| ***Wolffia papulifera*** | Watermeal |

*Emergent*

| Scientific Name | Common Name |
|---|---|
| ***Typha domingensis*** | Tule, Southern cattail |
| ***Typha latifolia*** | Common cattail |
| ***Colocasia esculenta*** | Elephant Ear (introduced) |
| ***Echinodorus rostratus*** | Burhead |
| ***Limnophila sessiliflora*** | Ambulia (introduced) |
| ***Hydrocotyle umbellata*** | Water pennywort |

| | |
|---|---|
| ***Arundo donax*** | Giant reed (introduced) |
| ***Ranunculus sceleratus*** | Cursed buttercup (introduced) |

*Algae*

| Scientific Name | Common Name |
|---|---|
| ***Basicladia crassa*** | Chlorophyta |
| ***Basicladia chelonum*** | Chlorophyta |
| ***Cladophora glomerata*** | Chlorophyta |
| ***Closterium sp.*** | Chlorophyta |
| ***Gloeocystis sp.*** | Chlorophyta |
| ***Oedogonium sp.*** | Chlorophyta |
| ***Rhizoclonium hieroglyphicum*** | Chlorophyta |
| ***Symploca sp.*** | Chlorophyta |
| ***Lyngbya sp.*** | Cyanophyta |
| ***Calothrix sp.*** | Cyanophyta |
| ***Spirogyra sp.*** | Chlorophyta |
| ***Batrachospermum involutum*** | Rhodophyta |
| ***Compsopogon coeruleus*** | Rhodophyta |
| ***Compsopogon coeruleus*** | Rhodophyta |
| ***Sirodotia huillensis*** | Rhodophyta |
| ***Chaetophora elegans*** | Chlorophyta |
| ***Bulbochaete sp.*** | Chlorophyta |
| ***Ulothrix zonata*** | Chlorophyta |
| ***Coleochaete scutata*** | Chlorophyta |

**Invertebrates**

| Scientific Name | Common Name |
|---|---|
| ***Macrobrachium rosenbergii*** | Giant river prawn |
| ***Corbicula fluminea*** | Asian Clam (introduced) |
| ***Marisa cornuarietis*** | Giant Rams horn Snail (introduced) |
| ***Melanoides tuberculatus*** | Red rimmed melania (introduced) |
| ***Tarebia granifera*** | Quilted melania (introduced) |
| ***Elimia comalensis*** | Comal snail |
| ***Corydalus spp.*** | Dobsonfly |
| **Order: Ephemeroptera** | Dameselfly, Mayflies |
| **Pentagenia robusta** | Robust burrowing mayfly |
| ***Hydra spp.*** | Hydra |
| ***Astacoidea spp.*** | Crayfish |
| ***Amphipoda spp.*** | Side swimmers/ scuds |
| ***Macrobdella spp.*** | leech |
| **Order: Anisoptera** | Dragonfly |

**Turtles**

| Scientific Name | Common Name |
|---|---|
| ***Trachemys s. elegans*** | Red-eared slider |
| ***Pseudemys texana*** | Texas River Cooter |
| ***Sternotherus odoratus*** | Musk Turtle |
| ***Chelydra s. serpentina*** | Common Snapper |
| ***Apalone ferox*** | Florida soft shell (introduced) |
| ***Pseudemys nelsoni*** | Florida red-belly (introduced) |

**Endangered/Threatened Species**

| Scientific Name | Common Name |
|---|---|
| ***Eurycea rathbuni*** | Texas Blind Salamander |
| ***Eurycea nana*** | San Marcos Salamander |
| ***Etheostoma fonticola*** | Fountain Darter |
| **Elmidae spp.** | Riffle beetle |

**Birds**

| Scientific Name | Common Name |
|---|---|
| ***Ardea herodias*** | Great Blue heron |
| ***Butorides Virescens*** | Green Heron |
| ***Phalacrocorax auritus*** | Double-Crested Cormorant |
| ***Buteo lineatus*** | Red Shouldered Hawk |
| ***Chloroceryle americana*** | Kingfisher |
| ***Coragyps atratus*** | Black Vulture |
| ***Tyrannus forficatus*** | Scissor-tailed Flycatcher |
| ***Ardea alba*** | Great Egret |
| ***Fulica americana*** | American Coot |
| ***Quiscalus mexicanus*** | Great-tailed Grackle |
| ***Bombycilla cedrorum*** | Cedar waxwing |
| ***Cathartes aura*** | Turkey Vulture |
| ***Nyctanassa violacea*** | Yellow Crowned Night Heron |
| ***Nycticorax nycticorax*** | Black Crowned Night Heron |
| ***Pandion haliaetus*** | Osprey |
| ***Melanerpes aurifrons*** | Golden-fronted Woodpecker |
| ***Melanerpes carolinus*** | Red Bellied Woodpecker |
| ***Picoides scalaris*** | Ladder-backed Woodpecker |
| ***Colaptes auratus*** | Northern Flicker |
| ***Picoides pubescens*** | Downy Woodpecker |
| ***Sayornis phoebe*** | Eastern Phoebe |
| ***Myiarchus crinitus*** | Great Crested Flycatcher |
| ***Tyrannus verticalis*** | Western Kingbird |
| ***Tyrannus tyrannus*** | Eastern Kingbird |

| | |
|---|---|
| ***Lanius ludovicianus*** | Loggerhead Shrike |
| | |

# Appendix M7

# TPWD Regulations Regarding State Scientific Areas

**Texas Administrative Code**

| | |
|---|---|
| TITLE 31 | NATURAL RESOURCES AND CONSERVATION |
| PART 2 | TEXAS PARKS AND WILDLIFE DEPARTMENT |
| CHAPTER 57 | FISHERIES |
| SUBCHAPTER K | SCIENTIFIC AREAS |
| RULE §57.910 | San Marcos River State Scientific Area |

(a) Purpose. The San Marcos River State Scientific Area is established for the purpose of education, scientific research, and preservation of flora and fauna of scientific or educational value, specifically, the preservation of Texas wild-rice *(Zizania texana).*

(b) Boundaries. The San Marcos River State Scientific Area consists of the public waters of the San Marcos River from midstream to the boundary of public waters in the area within the following boundaries:

(1) 29 53 26.04 Lat N, 97 55 55.29 Long W (northeast boundary near Spring Lake Dam);

(2) 29 53 22.71 Lat N, 97 56 19.01 Long W (southeast boundary near the San Marcos Water Treatment Plant);

(3) 29 51 52.63 Lat N, 97 55 56.07 Long W (southwest boundary near the San Marcos Water Treatment Plant); and

(4) 29 51 53.92 Lat N, 97 55 31.94 Long W (northwest boundary near Spring Lake Dam).

(c) Restricted Areas. When the streamflow of the San Marcos River is measured at 120 cubic feet per second or less at the San Marcos River gaging station (United States Geological Survey gage 081705000 San Marcos River at San Marcos), the department may restrict areas within the boundaries described by subsection (b) of this section by means of clearly marked booms, buoys, and/or signage to reflect the fact that the area is restricted to unauthorized entry.

(d) Prohibited Acts. It is an offense for any person to:

(1) move, remove, deface, alter, or destroy any sign, buoy, boom, or other such marking delineating the boundaries of the San Marcos River State Scientific Area or a restricted area within the boundaries described by subsection (b) of this section;

(2) uproot Texas wild-rice within the San Marcos River State Scientific Area; or

(3) enter an area that is marked by signage, booms, buoys, or other apparatus clearly identifying the area as a restricted area, except as may be expressly authorized by the department or the U.S. Fish and Wildlife Service.

(e) Penalties. The penalty for violation of this section is prescribed by Parks and Wildlife Code, §13.112.

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**Source Note:** The provisions of this §57.910 adopted to be effective July 8, 2012, 37 TexReg 5133