BIO-WEST, Inc.
1812 Central Commerce Court
Round Rock, Texas 78664

MEMORANDUM

TO:	Nathan Pence, Chris Abernathy
FROM:	Ed Oborny
DATE:	December 29, 2016
SUBJECT:	**ITEM M NET DISTURBANCE AND INCIDENTAL TAKE ASSESSMENT FOR 2016 EARIP ITP ANNUAL REPORT**

EXECUTIVE SUMMARY

The EAHCP Incidental Take Permit (ITP) requires a Net Disturbance and Incidental Take assessment to be conducted at the conclusion of each year for incorporation into the ITP Annual Report. Requirement M (1a and 2a) of the ITP specifically addresses minimization and mitigation activities associated with the HCP. This requirement stipulates that over the course of any given year no more than 10% of a covered species occupied habitat can be affected by HCP mitigation and restoration activities. Following quantification of net disturbance specific to these activities, incidental take was calculated for the disturbed areas. However, that is only part of the overall incidental take assessment. Incidental take associated with implementation of all other applicable HCP covered activities was then characterized and quantified to the degree practical. For a more detailed description of methodologies and species specific results please refer to the Item M Net Disturbance (**SECTION 1**) and Incidental Take (**SECTION 2**) assessments of this technical memorandum. As in previous years, all 2016 assessments were performed in accordance with ITP requirements.

Table ES provides an overview of net disturbance percentages and a summary of incidental take for 2016. As shown in Table ES, only the fountain darter in the Comal System had a net disturbance when considering the project footprint for HCP mitigation and restoration activities overlaid on occupied habitat. The net disturbance was 3.3% of the total occupied habitat for the fountain darter in the Comal system. As shown in Table ES, there were no project footprints that overlapped with any of the occupied habitat for the endangered Comal invertebrates. In the San Marcos system, only the fountain darter had a net disturbance calculated at 4.1% of its total occupied habitat. For the San Marcos salamander, Texas blind salamander and Comal Springs riffle beetle, there were no HCP mitigation and restoration activities conducted in 2016 that directly impacted any documented occupied habitat or spring orifices where Texas blind salamander collections have been made over the years. In summary, the 10% disturbance rule (Item M [a]) was in compliance for 2016.

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

When examining 2016 impacts, conditions are in line with those characterized in the Biological Opinion as an average year. As such, we are confident the incidental take numbers summarized in Table ES and documented in this memorandum continue to justify the data sets used and methodologies employed in 2016 relative to performing an incidental take assessment within the context of the Biological Opinion. It is understood that adjustments to data sets and/or methodologies may be employed based on feedback from the USFWS, HCP Science Committee, HCP participants, or others as deemed appropriate by the EARIP.

Table ES. Summary of Impacted Habitat (m^2) and Net Disturbance and Incidental Take for HCP Covered Species compared against ITP Maximum Permit Amounts.

COVERED SPECIES PER SYSTEM	HCP Mitigation / Restoration		HCP Measures / Drought	Combined Impacted Habitat 2016 TOTAL (m^2)	INCIDENTAL TAKE		**2016 INCIDENTAL TAKE TOTAL**	ITP Maximum Permit Amount	ITP Permit Maximum minus (combined first four years)
	IMPACTED HABITAT (m^2)	NET Disturbance % OF TOTAL Occupied Habitat	IMPACTED HABITAT (m^2)		HCP Mitigation / Restoration	HCP Measures / Drought			
COMAL SYSTEM									
Fountain Darter	3,002	3.3%	3,637	**6,639**	4,503	5,456	**9,959**	797,000	748,386
Comal Springs Riffle Beetle	0	0.0%	0	**0**	0	0	**0**	11,179	8,933
Comal Springs Dryopid Beetle	0	0.0%	0	**0**	0	0	**0**	1,543	1,528
Peck's Cave Amphipod	0	0.0%	0	**0**	0	0	**0**	18,224	18,060
SAN MARCOS SYSTEM									
Fountain Darter	3,652	4.1%	3,697	**7,349**	5,478	5,545	**11,023**	549,129	496,190
San Marcos Salamander	0	0.0%	0	**0**	0	0	**0**	263,857	261,264
Texas Blind Salamander	0	0.0%	0	**0**	0	0	**0**	10	10
Comal Springs Riffle Beetle	0	0.0%	0	**0**	0	0	**0**	n/a	n/a

SECTION 1: ITEM M NET DISTURBANCE ASSESSMENT

Requirement M (1a and 2a) of EAA's USFWS threatened and endangered species permit (#TE63663A-0) addresses minimization and mitigation activities associated with the HCP. The requirements for Item M (1a and 2a) are stated below directly from the permit:

1 Comal Springs, Landa Lake, and the Comal River
   a. The Permittees will limit disturbance of the (a) substrate, (b) water quality, (c) plants, and (d) animals of the Comal Springs, Landa Lake, and Comal River to no more than 10% of the occupied habitat on an annual basis when implementing HCP measures such as habitat and riparian restoration efforts that may directly or indirectly affect species considered here;

2 San Marcos Springs, Spring Lake, and the San Marcos River
   a. The Permittees will limit disturbance of the (a) substrate, (b) water quality, (c) plants, and (d) animals of the San Marcos Springs, Spring Lake, and the San Marcos River to no more than 10% of the occupied habitat on an annual basis when implementing HCP measures such as habitat and riparian restoration efforts that may directly or indirectly affect species considered here;

All activities described in this memorandum pertain to the HCP Covered species that are actively authorized (Item H: 1-6) in 2016 for incidental take via EAA's ITP permit. This includes:

- Fountain darter
- Comal Springs riffle beetle
- Comal Springs dryopid beetle
- Peck's Cave amphipod
- Texas Blind salamander
- San Marcos salamander

Although the Texas cave diving beetle, Texas troglobitic water slater, and Comal Spring salamander are listed in the permit, the conditions in the Permit are not active in 2016 as none of these species are presently listed as threatened or endangered with this directly acknowledged (Item H: 7-9) in the permit. Additionally, Item I of the permit acknowledges that only if the San Marcos gambusia is located or found in the study area, will take provisions apply. As this has not occurred in 2016, the San Marcos gambusia is not included in this Item M assessment. Finally, being a plant, Texas wild-rice is not allotted incidental take provisions under this federal permit, so it is not germane to the Item M assessment.

Documentation of baseline habitat conditions: For the six actively covered HCP species (listed above) maps of occupied habitat for the Comal and San Marcos Springs/River systems were prepared in GIS, based on EAA biological monitoring data (BIO-WEST 2002 – 2013a,b; BIO-WEST 2014a,b; BIO-WEST 2015a,b; BIO-WEST 2016a,b; BIO-WEST 2017a,b) and other existing sources for the HCP covered species.

Prior to the original Item M assessment, specific discussions were held with staff from the USFWS Austin Ecological Services (ES) office to establish the appropriate definition and description of "occupied" habitat. Based on those initial and subsequent conversations with USFWS ES, "occupied" habitat is presently defined as 1) areas in the Comal and San Marcos systems where the covered species have been physically collected or visually documented, and 2) aquatic vegetation (including Texas wild-rice) types specific to the fountain darter that have been routinely sampled over the past decade through biological monitoring with documented occupancy. Table 1 summarizes the occupied habitat in meters squared (m^2) for each of the covered species pertinent to the Item M assessment. Figures for each species are presented following the discussion in each respective section. As per the ITP and USFWS Austin ES guidance, the 2016 assessment is representative of conditions at the start of calendar year 2016 including any mitigation / restoration measures that resulted in a change in occupied habitat for any of the covered species.

Comal System

The fountain darter has been extensively sampled throughout the Comal system via the long-term biological monitoring program conducted by EAA. Drop netting has occurred in dominant aquatic vegetation types within representative sampling reaches for over a decade. On a broader scale, dipnetting for fountain darters has occurred throughout the Comal system over time. Finally, sampling via other collection techniques, seining, snorkel, and SCUBA have been conducted in the Comal system as well. For the fountain darter Item M assessment (represented in Table 1 and Figure 1), only known collection locations and aquatic vegetation that has been routinely sampled and documented as supporting darters throughout the system were counted. Although, fountain darters have been physically collected as well as visually documented on bare substrate, this is not common in the Comal system. As such, bare substrate was not counted as occupied habitat for the fountain darter in the Comal system. Figure 1 shows the occupied habitat for the fountain darter throughout the Comal System with the quantification of area presented in Table 1.

TABLE 1 – OCCUPIED HABITAT

ITEM M - SPECIES	OCCUPIED HABITAT (m^2)	NOTES AND ASSUMPTIONS
COMAL SPRINGS / RIVER		
Fountain Darter	91,461	Based on collections and known occurrence in aquatic vegetation types sampled over the course of the HCP biological monitoring. Sampling included drop netting, dip netting, snorkel, SCUBA, and seining throughout the Comal system. Although fountain darters have been collected on bare substrate on occasion, no bare areas were included in this assessment.
Comal Springs Riffle Beetle	1,672	Based on collection of individuals via cotton lure, drift net, or quadrat sampling over the years. An area of 1 m^2 around each collection point was included but did not include any overlap between collection points.
Peck's Cave Amphipod	1,466	This species is considered subterranean and thus subsurface habitat is the more appropriate calculation. The total area of subsurface habitat for this species is presently unknown. Surface habitat was based on collection of individuals via cotton lure and drift net sampling. An area of 0.5 m^2 around each collection point was included but did not include any overlap between collection points.
Comal Springs Dryopid Beetle	350	This species is considered subterranean and thus subsurface habitat is the more appropriate calculation. The total area of subsurface habitat for this species is presently unknown. Surface habitat was based on collection of individuals via cotton lure and drift net sampling. An area of 0.5 m^2 around each collection point was included but did not include any overlap between collection points.
SAN MARCOS SPRINGS / RIVER		
Fountain Darter	89,958	Based on collections and known occurrence in aquatic vegetation types (including Texas wild-rice) sampled over the course of HCP biological monitoring. Sampling included drop netting, dip netting, snorkel, SCUBA, and seining throughout the San Marcos system. Although fountain darters have been collected on bare substrate in the river on occasion, no bare river areas were included in this baseline assessment. In contrast, bare substrate areas in Spring Lake were included for this assessment as fountain darters have frequently been observed inhabiting these areas within Spring Lake. Finally, although fountain darters have been collected further upstream in the slough arm of Spring Lake, those collections are considered seasonal at this time and thus were not included in the overall area calculated.
San Marcos Salamander	2,520	Based on observation or collection of individuals via snorkel / SCUBA over the course of HCP biological monitoring. Also, based on collections conducted by the USFWS San Marcos Aquatic Resources Center.
Texas Blind Salamander	n/a	This species is considered subterranean and thus subsurface habitat is the appropriate calculation. As such, no surface habitat was calculated as "occupied habitat" for this species.
Comal Springs Riffle Beetle	11	Based on collection of individuals via cotton lure and drift net sampling. An area of 1 m^2 around each collection point was included but did not include any overlap between collection points.

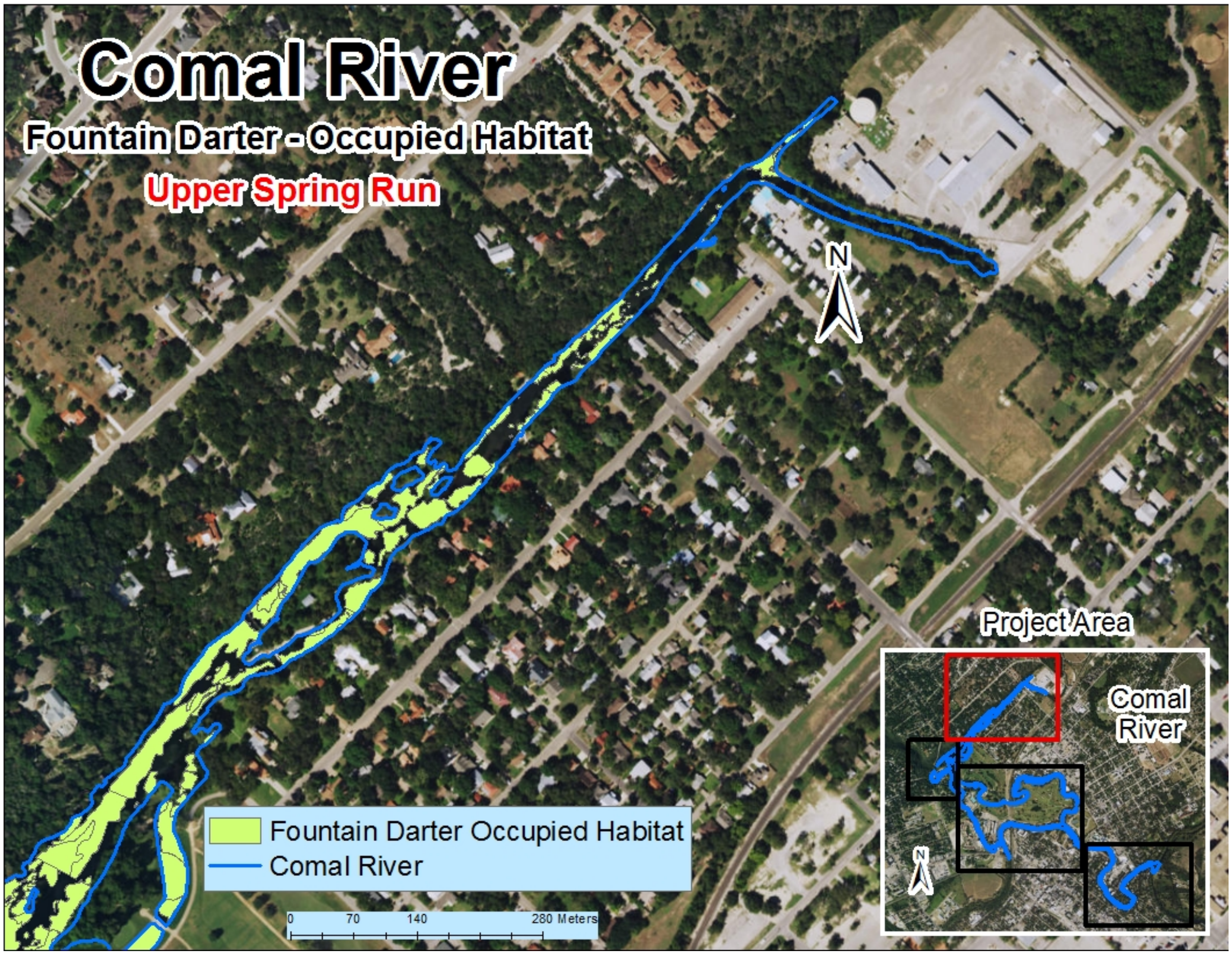


Figure 1: Fountain Darter 2016 Occupied Habitat – Upper Spring Run (Comal System)

Although not as extensive as for the fountain darter, routine sampling for the Comal Springs riffle beetle has also occurred. Over the years, sampling has been conducted by quadrats, drift netting, and cotton lures. In the early 1990's extensive sampling in the Spring Runs was conducted by Dr. David Bowles, with those data included in this assessment (Bowles et al. 2003). Additionally, Mr. Randy Gibson (USFWS San Marcos Aquatic Resource Center [SMARC]) has collected Comal invertebrates at locations throughout the system for a number of projects and for refugia purposes over time. The EAA biological monitoring program has routinely sampled for the Comal Springs riffle beetle within sample reaches in the Comal system. Additional locale data were collected in 2016 as part of HCP focused applied research efforts. As noted in previous years, based on the sample techniques over time and experience and guidance of Mr. Randy Gibson the determination was made to include a 1 m^2 area surrounding each known collection location to quantify overall surface area of occupied habitat for the 2016 assessment. It is noted that only surface habitat area was calculated for this assessment, as the extent of subsurface habitat utilization by this species is presently unknown. Figure 2 shows the occupied habitat for the Comal Springs riffle beetle throughout the Comal System with the quantification of area presented in Table 1.

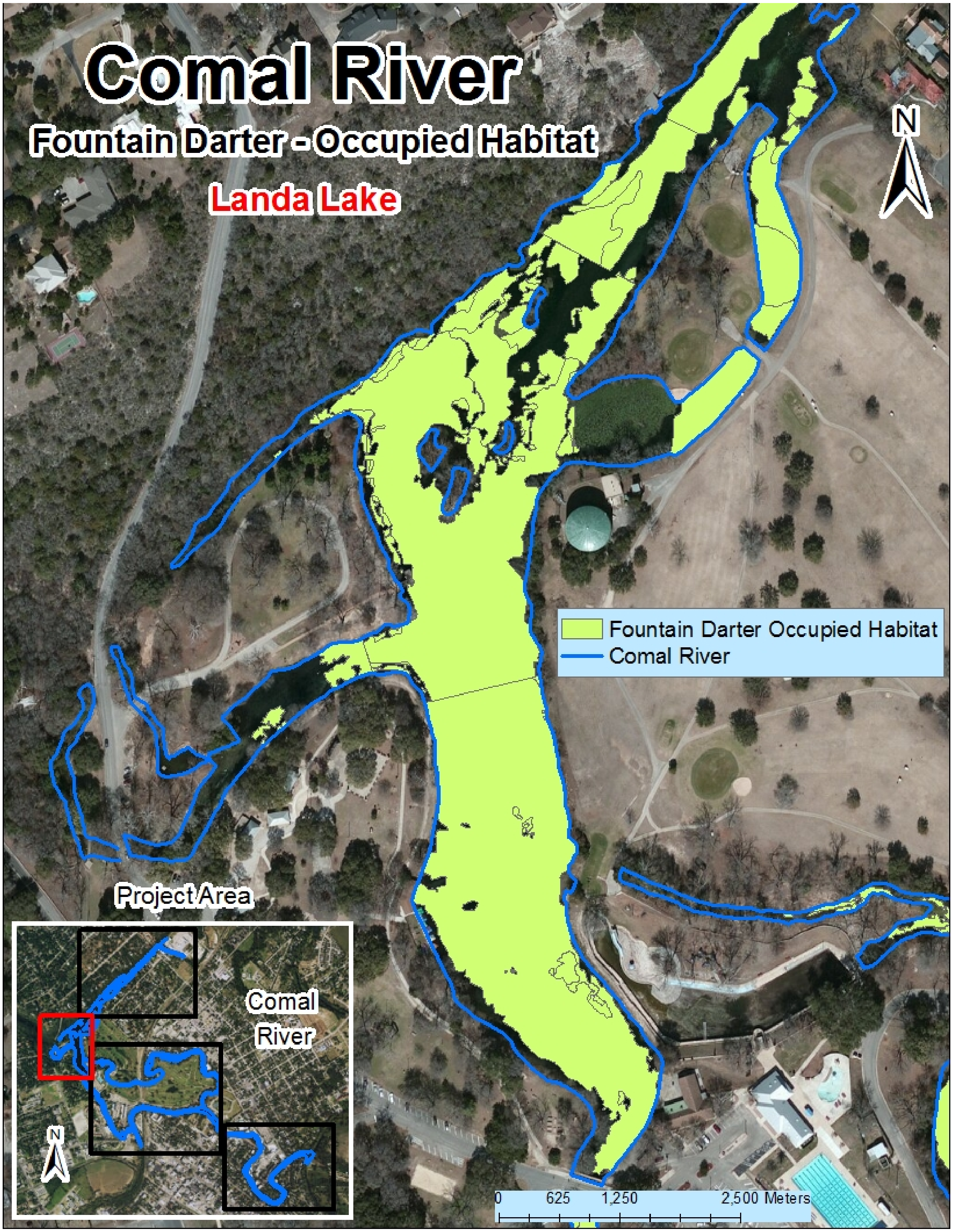


Figure 1 (continued): Fountain Darter 2016 Occupied Habitat – Landa Lake (Comal System).

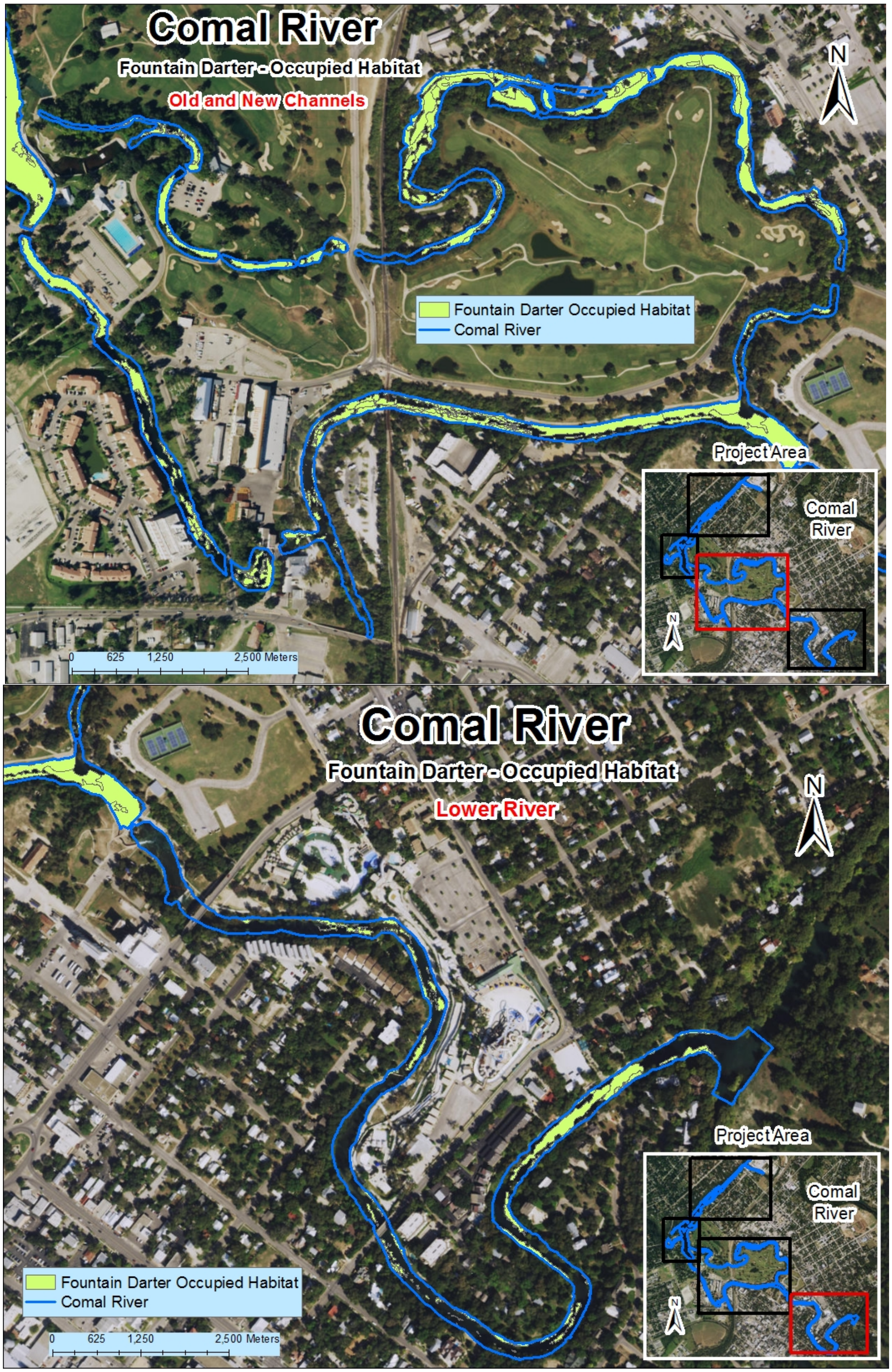


Figure 1 (continued): Fountain Darter 2016 Occupied Habitat – Old and New Channels (Top) and Lower Comal River (bottom) - (Comal System).

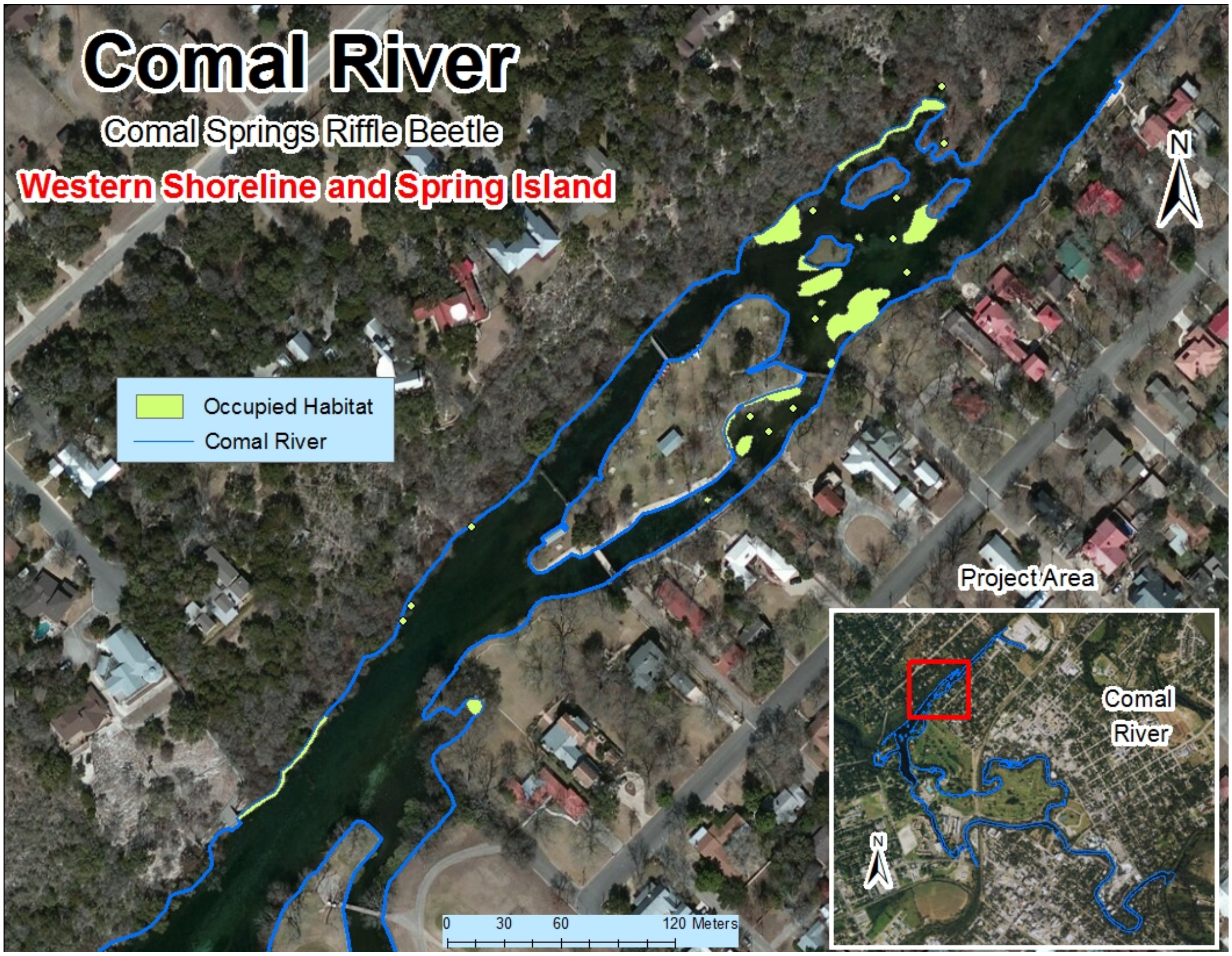


Figure 2: Comal Springs Riffle Beetle 2016 Occupied Surface Habitat – Spring Island and Western Shoreline areas (Comal System).

As described in the HCP, both the Peck's cave amphipod and Comal Springs dryopid beetle are subterranean species. Peck's cave amphipods are frequently found at the surface primarily in areas that Comal Springs riffle beetles are collected, whereas the Comal Springs dryopid beetle is less commonly found. As it is presumed that these subterranean invertebrates are not suited for survival in surface conditions, the decision was made to quantify 0.5 m^2 around the orifices that these species have been collected in the Comal system. As for the riffle beetle, sampling for these species over the years has been conducted by quadrats, drift netting, and cotton lures. Dr. Bowles and Mr. Gibson's data were again reviewed in detail as was the EAA biological monitoring database. For these two species, it is presumed that the majority of their occupied habitat is located subsurface. However, it is not possible to quantify the subsurface occupied habitat for these species at this time. Rather, the orifices where they have been collected are documented for further evaluation of potential impacts to these areas later in this memorandum. Figures 3 and 4 show occupied habitat for the Peck's Cave amphipod and Comal Springs dryopid beetle, respectively, throughout the Comal System with the quantification of surface habitat area presented in Table 1.

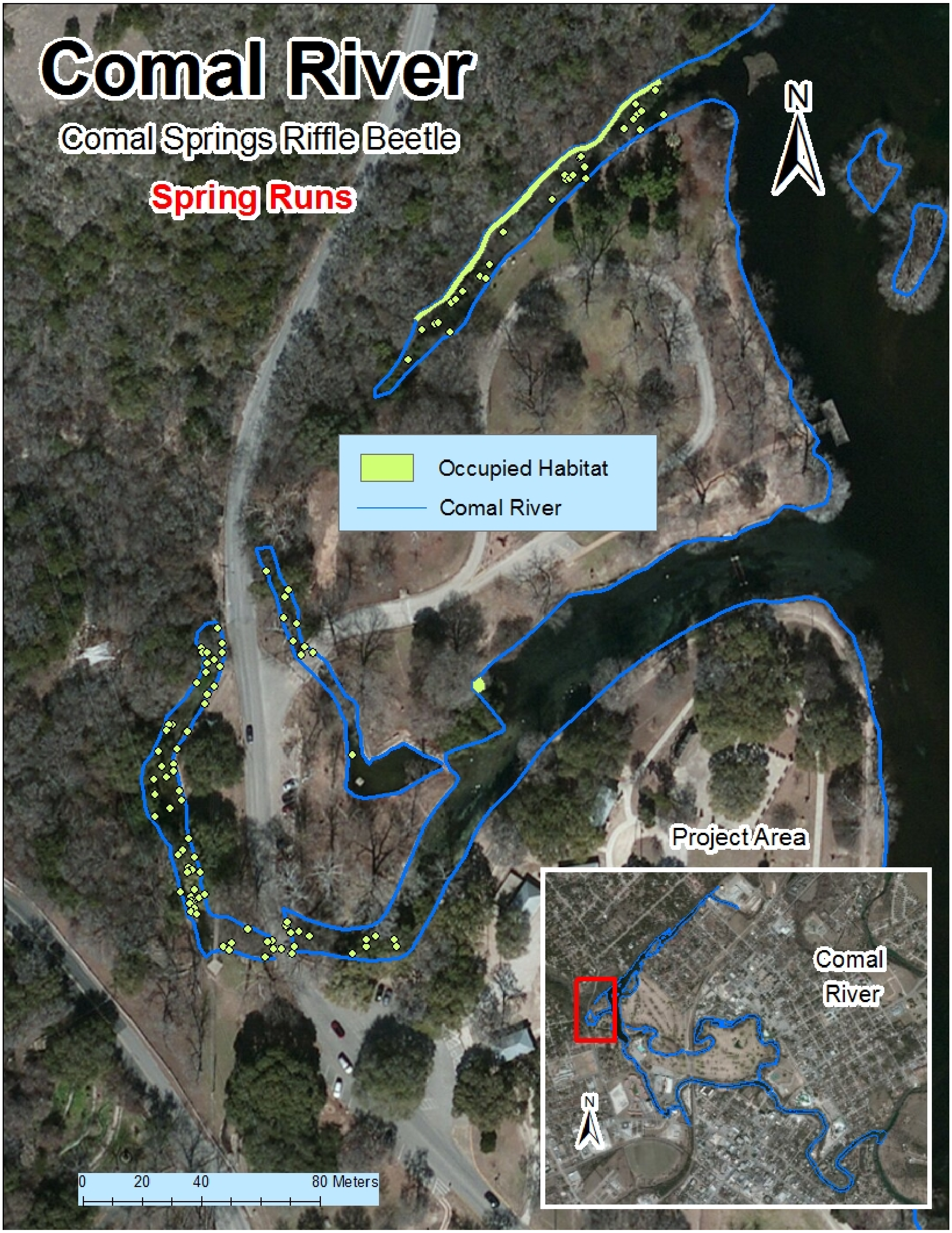


Figure 2 (continued): Comal Springs Riffle Beetle Occupied Surface Habitat – Spring Runs (Comal System).

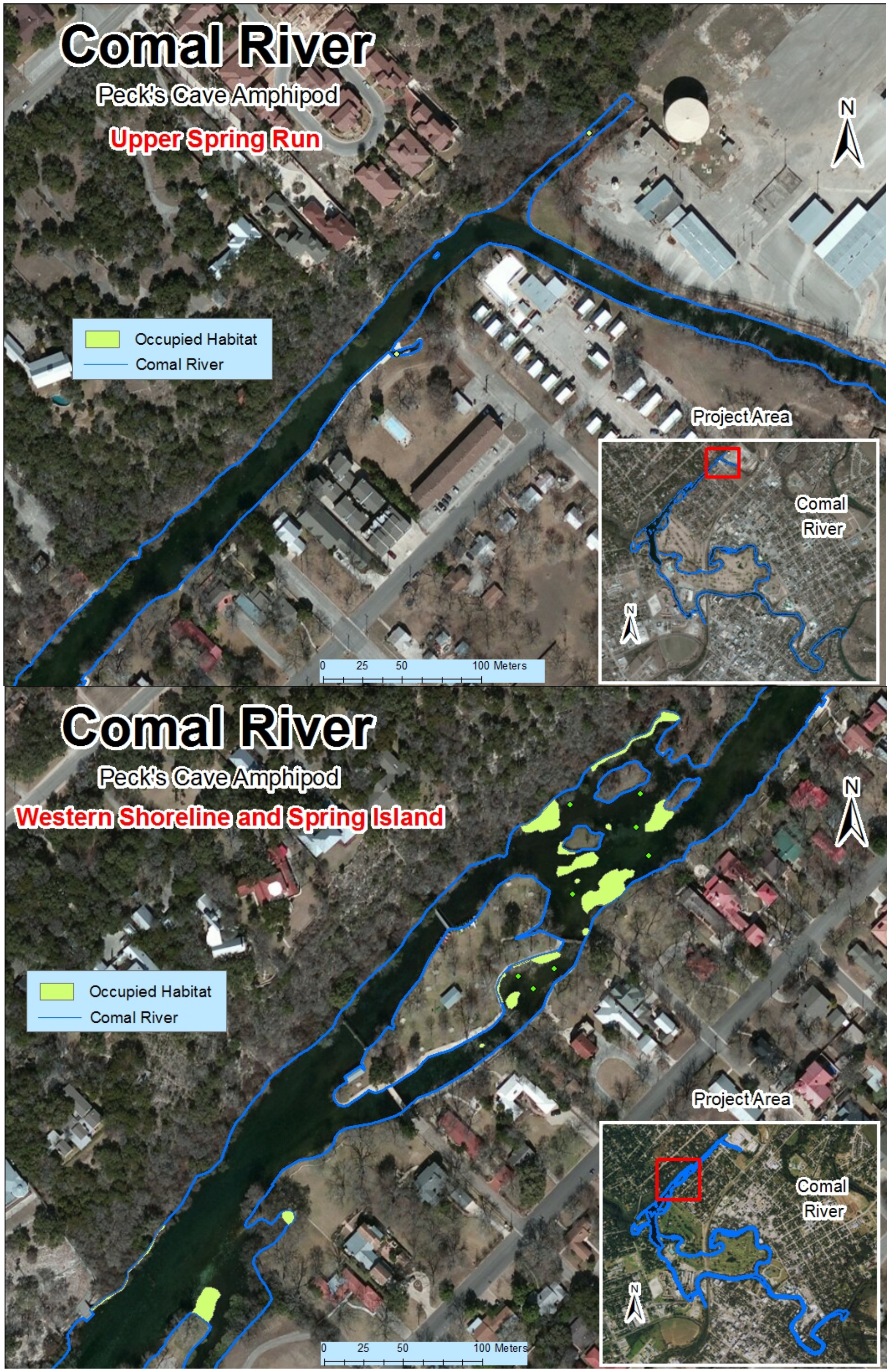


Figure 3: Peck's Cave Amphipod Occupied Surface Habitat – Upper Spring Run (top) and Spring Island and Western Shoreline areas (bottom) - (Comal System).

Figure 3 (continued): Peck's Cave Amphipod Occupied Surface Habitat – Spring Runs (Comal System).

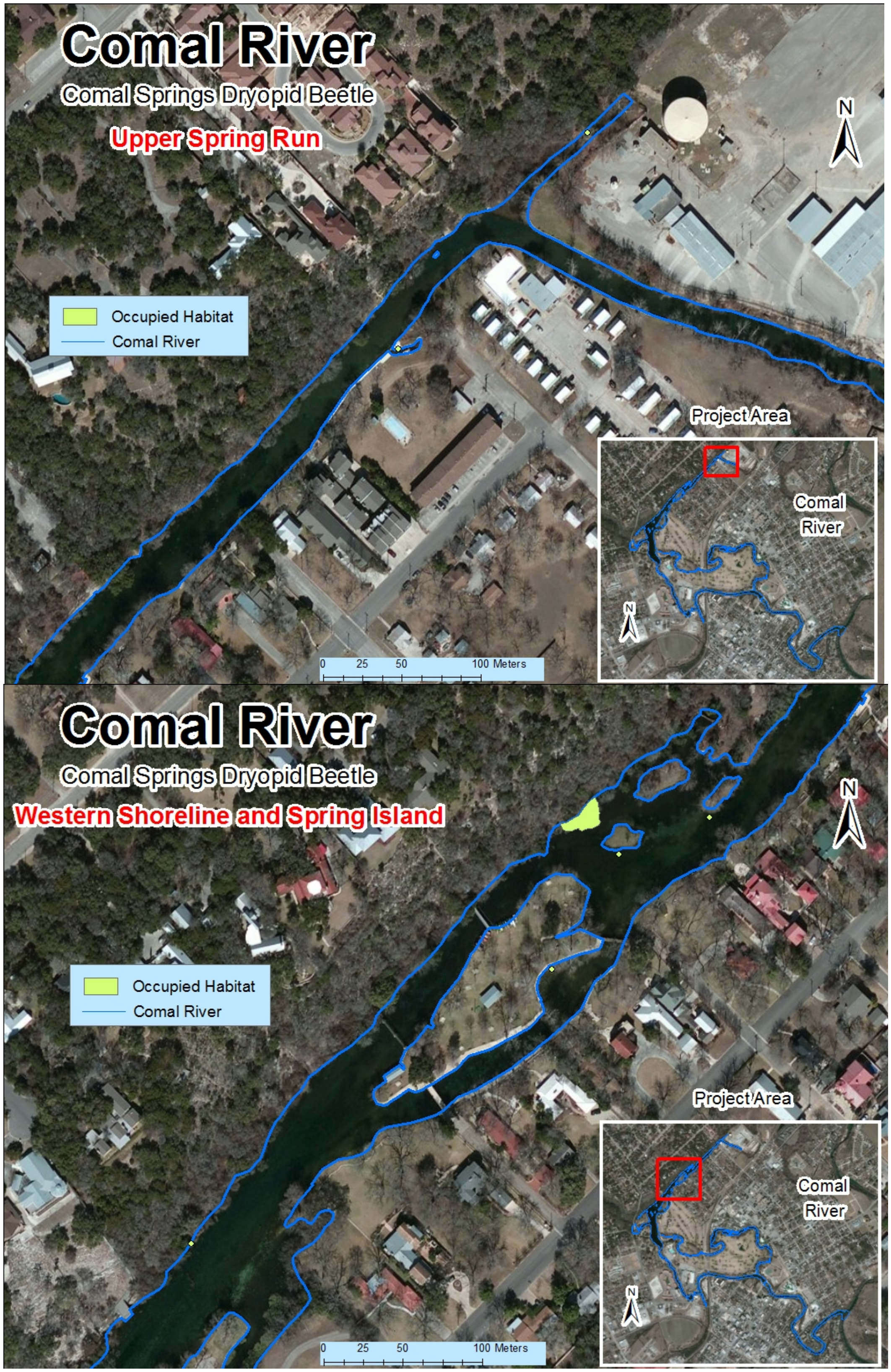


Figure 4: Comal Springs Dryopid Beetle Occupied Surface Habitat – Upper Spring Run (top) and Spring Island and Western Shoreline areas (bottom) - (Comal System).

Figure 4 (continued): Comal Springs Dryopid Beetle Occupied Surface Habitat – Spring Runs (Comal System).

San Marcos System

The fountain darter has been extensively sampled throughout the San Marcos system via the long-term biological monitoring program conducted by EAA as well as activities conducted by Texas State University over the years. For EAA biological monitoring, drop netting has occurred in dominant aquatic vegetation types within representative sampling reaches for over a decade. On a broader scale, dipnetting for fountain darters has occurred throughout the San Marcos system relative to EAA biological monitoring. Finally, sampling via other collection techniques, seining, snorkel, and SCUBA have been conducted in the San Marcos system over time by many researchers. For the fountain darter Item M assessment, only known collection locations and aquatic vegetation (including Texas wild-rice) that has been routinely sampled with documented occupancy throughout the system were counted.

Similar to the Comal system, although fountain darters have been physically collected and visually documented on bare substrate in the San Marcos River, this is not a common occurrence in the river. As such, bare substrate was not counted as occupied habitat for the fountain darter in the San Marcos River. In contrast, bare substrate and algae areas in Spring Lake were included for this assessment as fountain darters have frequently been observed inhabiting these areas within Spring Lake. Finally, although fountain darters have been collected further upstream in the slough arm of Spring Lake, those collections are considered seasonal at this time and thus were not included in the overall area calculated. Figure 5 shows the occupied habitat for the fountain darter throughout the San Marcos system with the quantification of area presented in Table 1.

The San Marcos salamander has been routinely sampled over the years by both the EAA biological monitoring program as well as by the USFWS SMARC for refugia collection purposes. Additional efforts relating to master's thesis and other research have been conducted by Texas State University as well as sampling efforts specific to construction projects involving maintenance to Spring Lake Dam (western and eastern spillways). SCUBA and snorkel sampling has been conducted in the eastern spillway below Spring Lake Dam as well as the Big Riverbed and Hotel areas of Spring Lake over the past decade. In addition, the USFWS SMARC has sampled nearly all the spring orifices and surrounding areas within Spring Lake. The known collection locations and occupied habitat are depicted in Figure 6 and quantified in Table 1. It is likely that the overall distribution of San Marcos salamanders is a bit larger in Spring Lake as not all bare substrate areas have been sampled to date. However, for the 2016 assessment, only documented collection areas were included.

As documented in the HCP, the Texas blind salamander is an aquifer/cave dwelling species. Unlike the subterranean Comal invertebrates which can be found in and around orifices in surface habitat at times, blind salamanders are collected as they are expelled from the aquifer. As such, there is no surface habitat designated for the Texas blind salamander as footnoted in Table 1. Known collection areas are depicted in Figure 7 for later use in the net disturbance assessment.

Although not as extensive as in the Comal systems, sampling for the Comal Springs riffle beetle has occurred in the San Marcos system. Following up on an earlier documentation of this species in the San Marcos system via drift net, Mr. Randy Gibson set cotton lures throughout the upper portion of the San Marcos system with the main focus occurring in Spring Lake. During those and subsequent efforts, the only documented occupied habitat has been the Hotel Area in the uppermost portion of Spring Lake (Gibson et al. 2008; Gonzales 2008). As for this species in the Comal system, the determination was made to include a 1 m^2 area surrounding each known collection location to quantify overall surface area of occupied habitat for the 2016 assessment. It is noted that only surface habitat area was calculated for this assessment, as the extent of subsurface habitat utilization by this species is presently unknown. Figure

8 shows the occupied habitat for the Comal Springs riffle beetle in the San Marcos system with the quantification of area presented in Table 1.

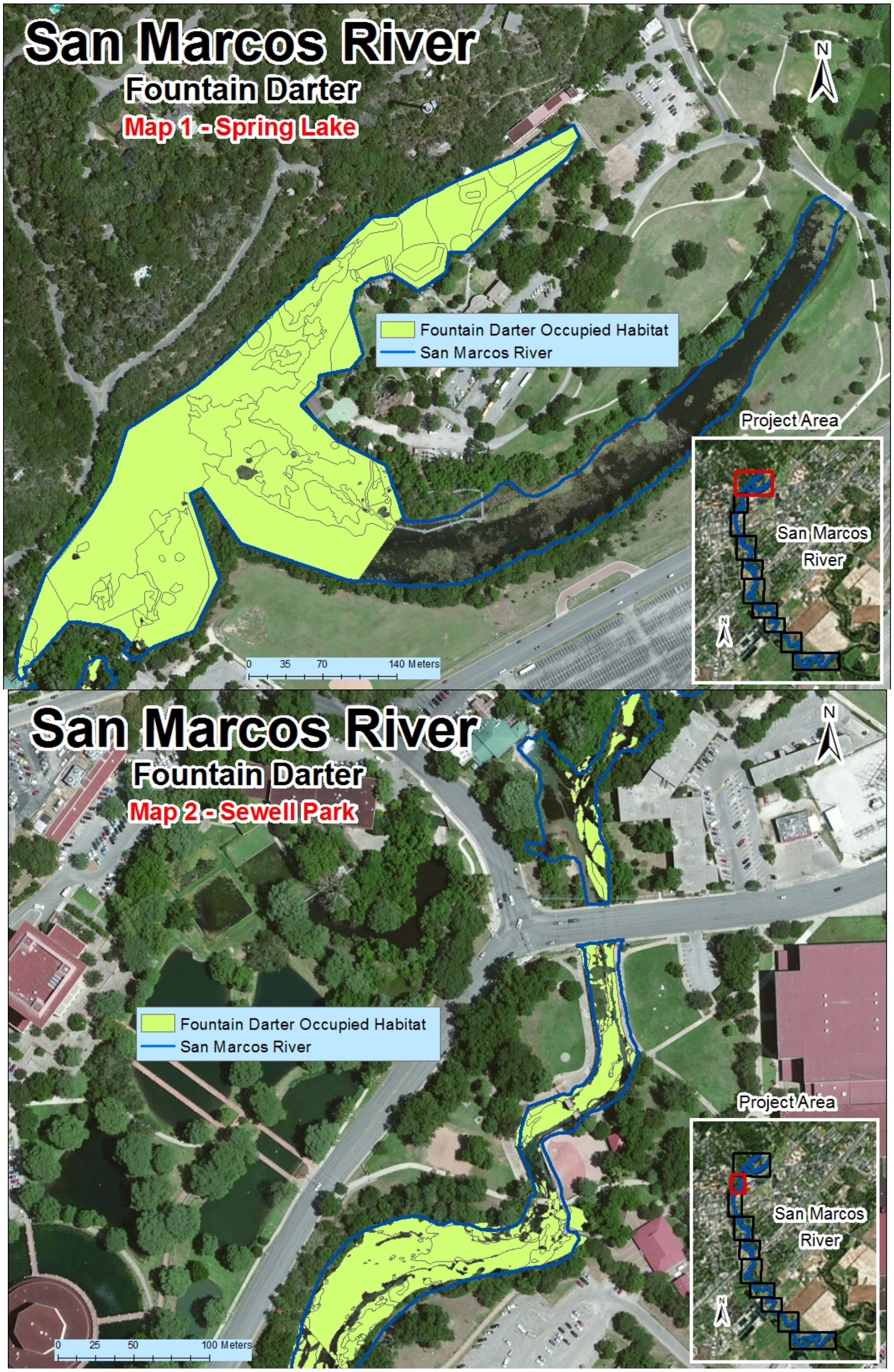


Figure 5: Fountain Darter 2016 Occupied Habitat – San Marcos System

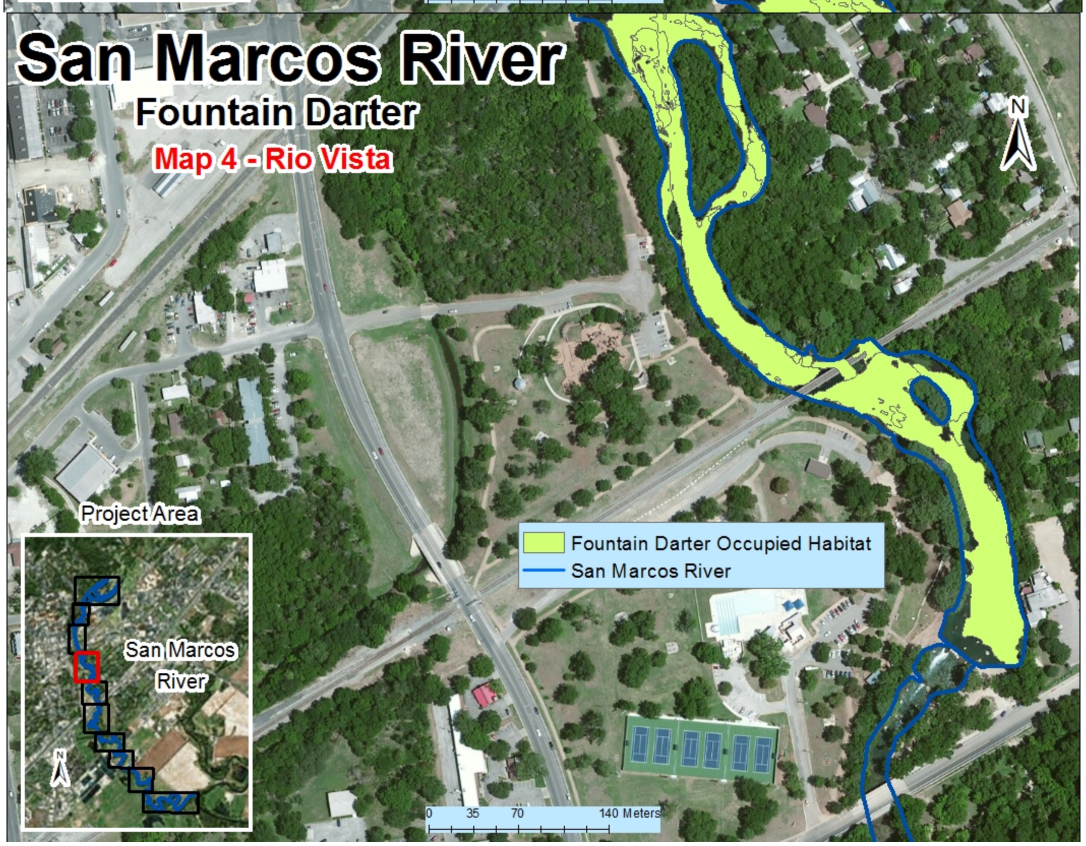
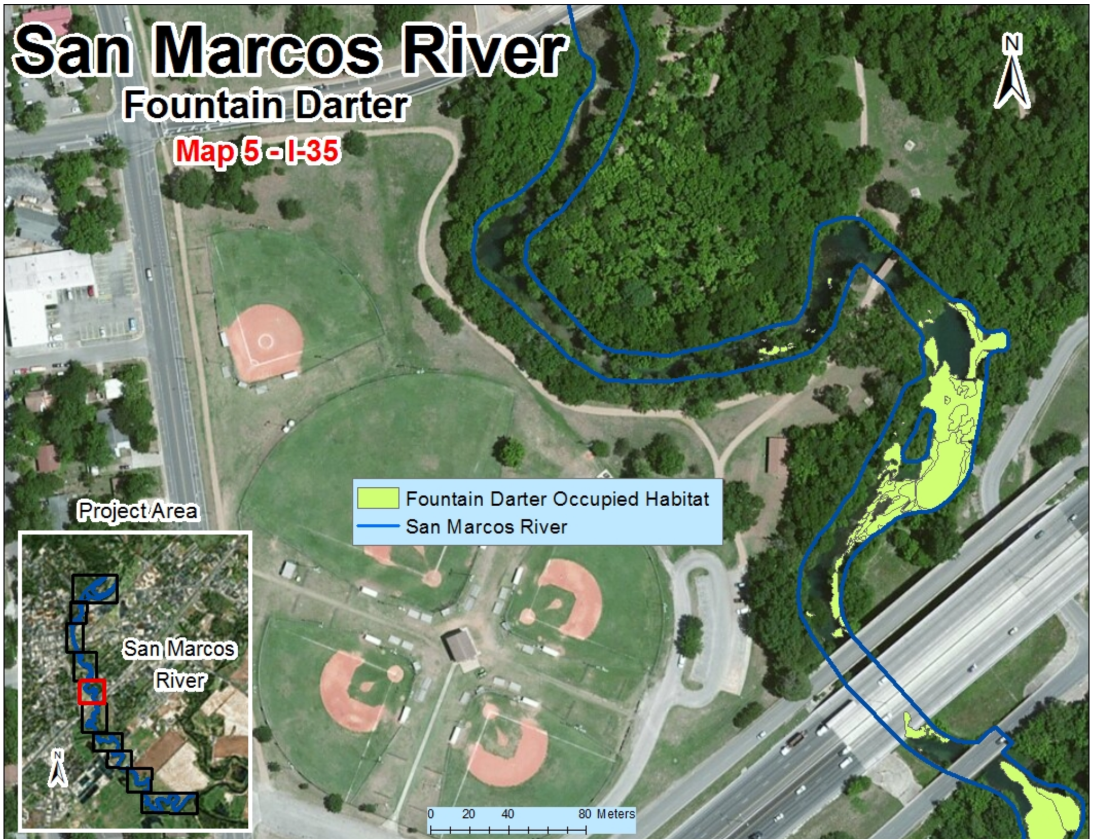


Figure 5 (continued): Fountain Darter 2016 Occupied Habitat – San Marcos System



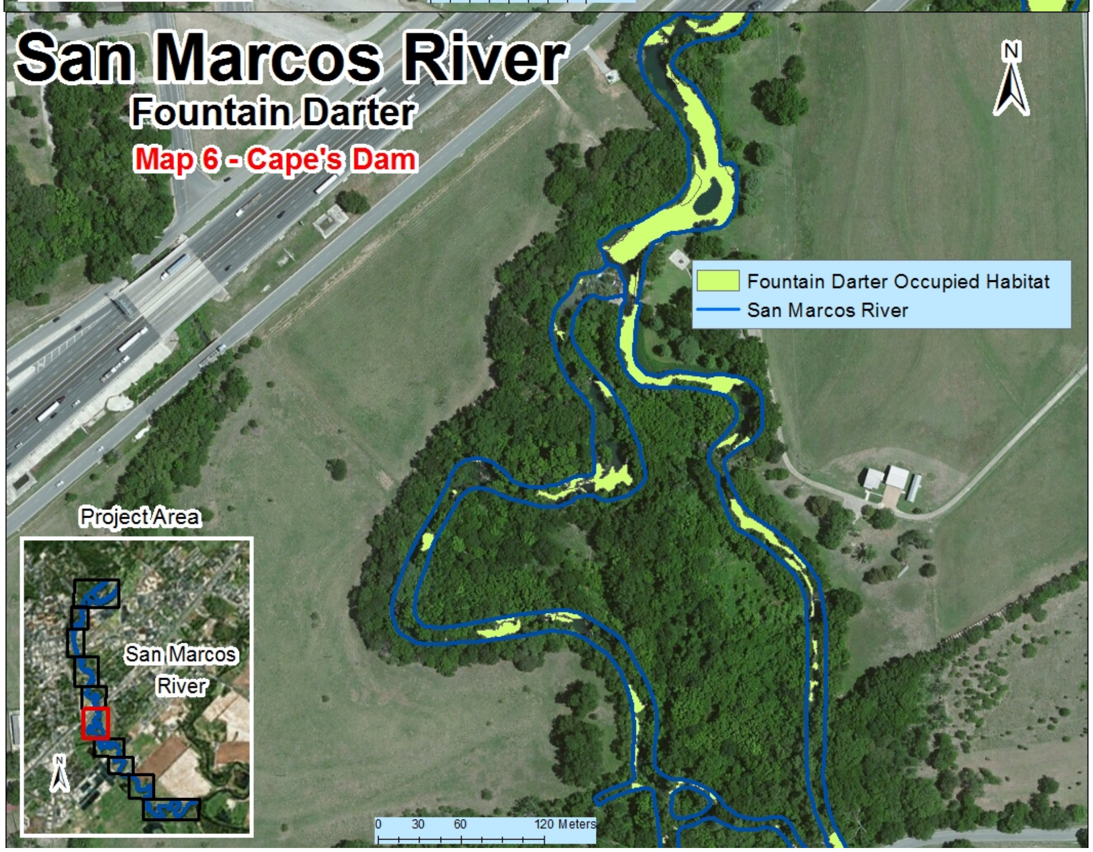


Figure 5 (continued): Fountain Darter 2016 Occupied Habitat – San Marcos System

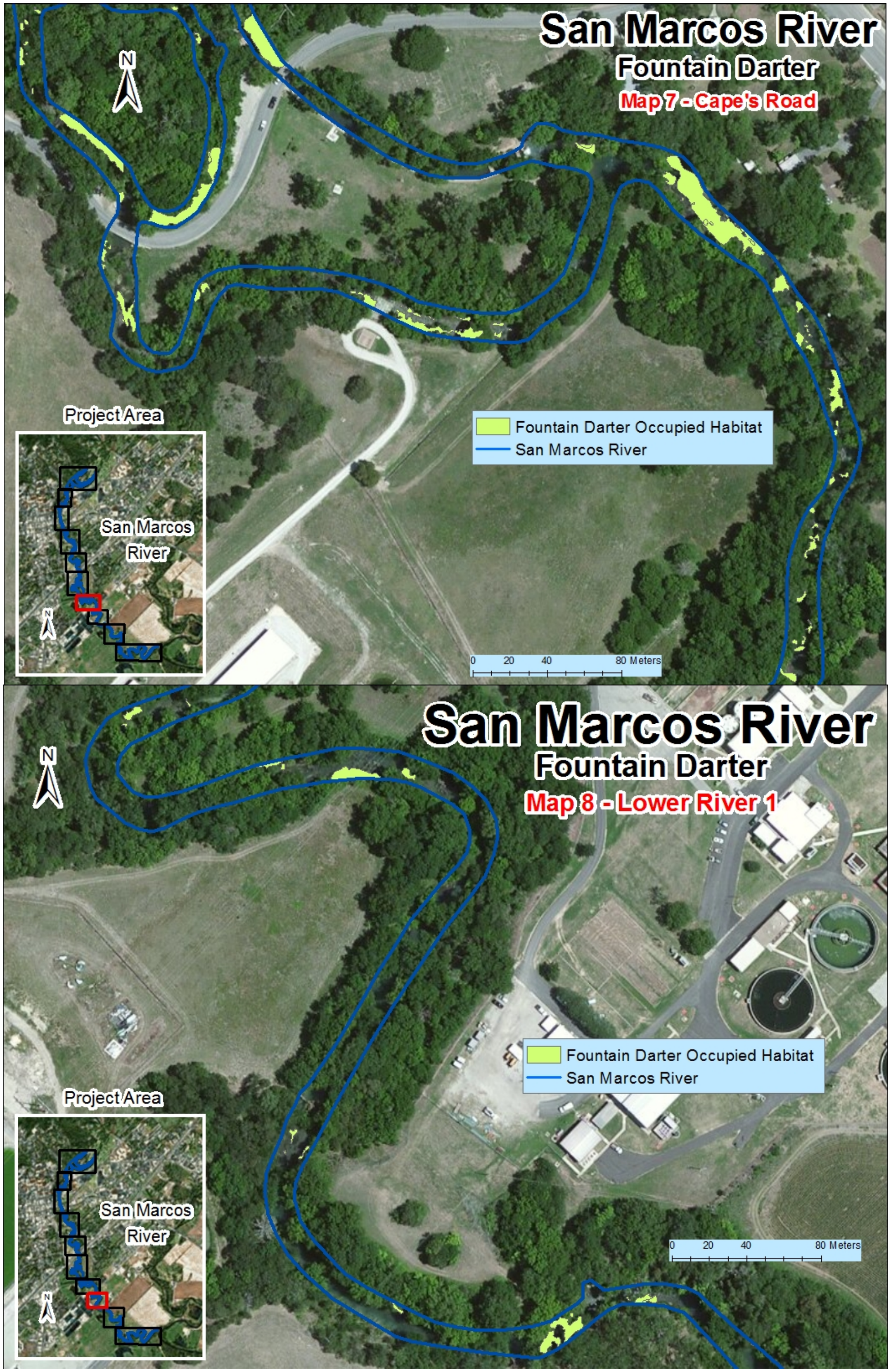


Figure 5 (continued): Fountain Darter 2016 Occupied Habitat – San Marcos System

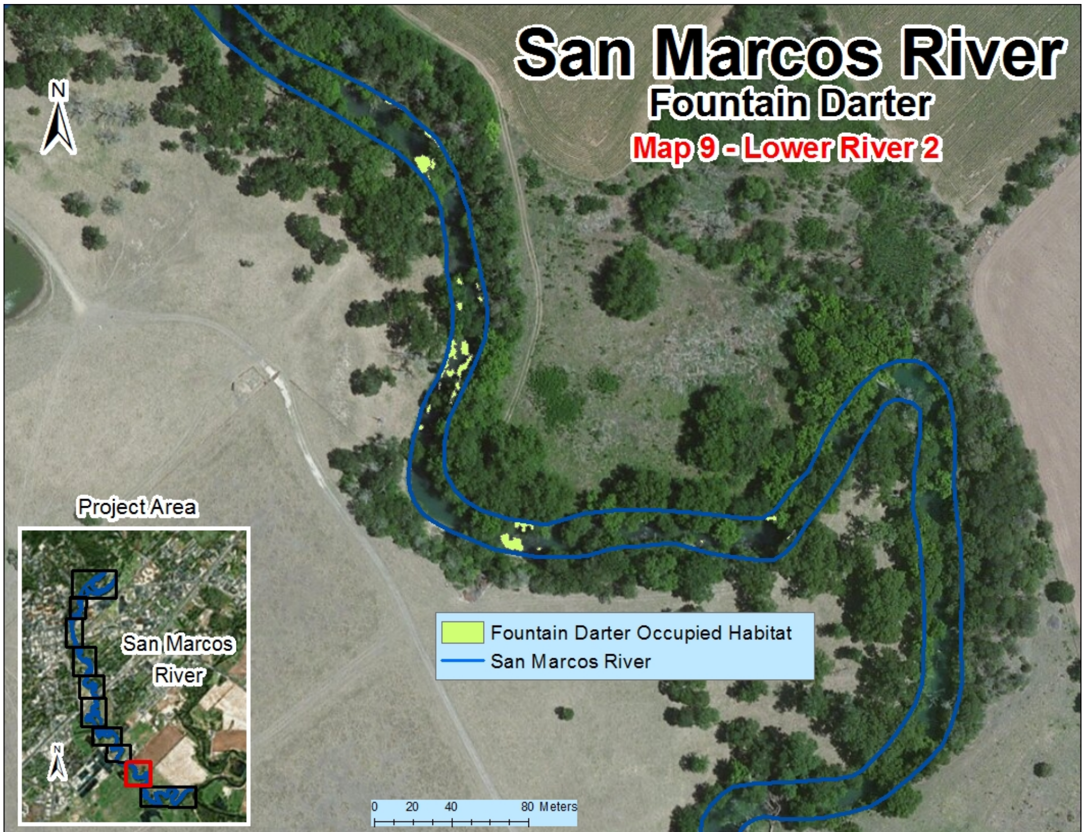


Figure 5 (concluded): Fountain Darter 2016 Occupied Habitat – San Marcos System

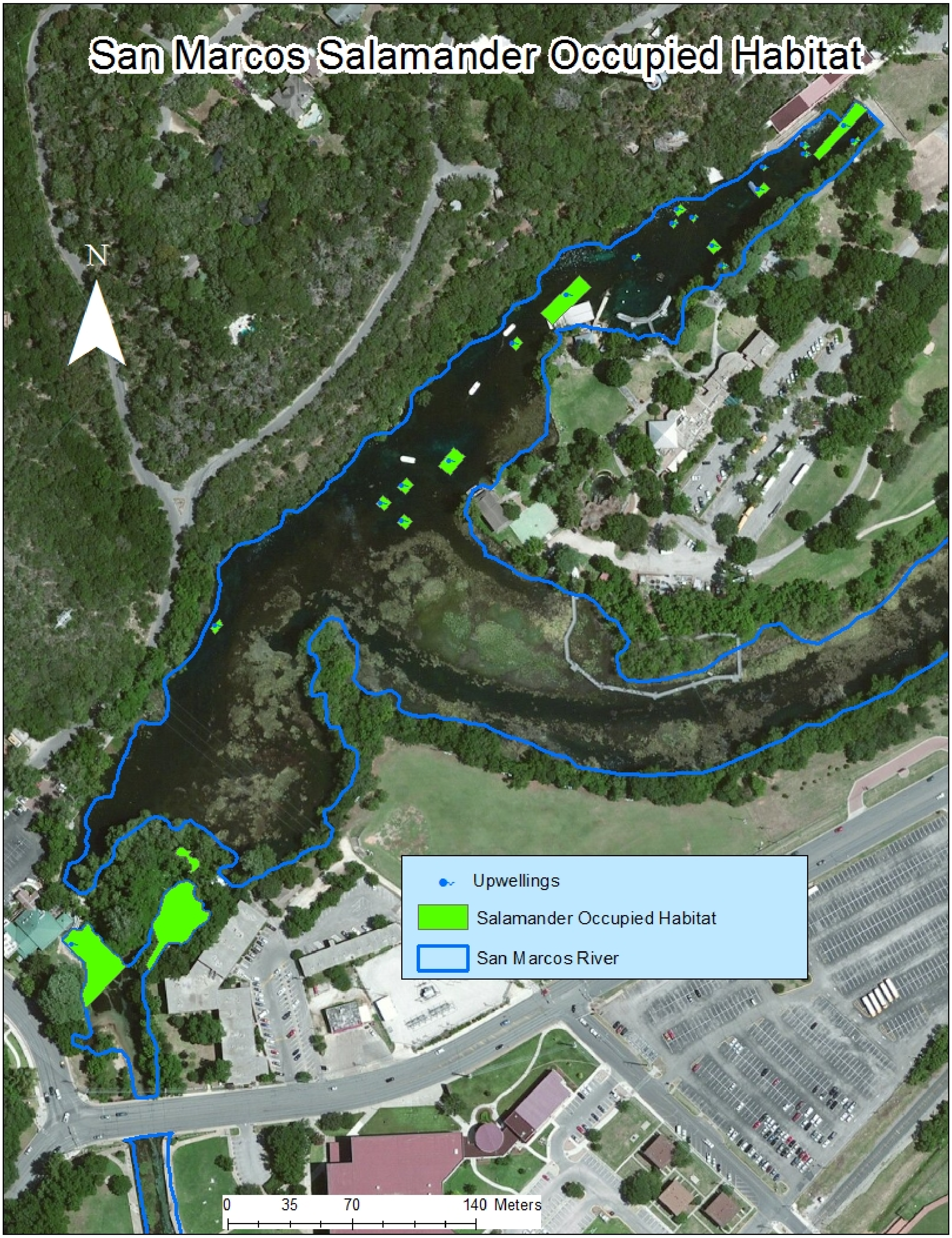


Figure 6: San Marcos Salamander 2016 Occupied Habitat – San Marcos System

Figure 7: Texas Blind Salamander Routine Collection Locations – San Marcos System

Figure 8: Comal Springs riffle beetle Surface 2016 Occupied Habitat – San Marcos System

Documentation of HCP mitigation areal extent per project: Descriptions of the HCP minimization and mitigation measures for the City of New Braunfels, City of San Marcos, and Texas State University are presented in the ITP Annual Report and will not be duplicated in this memorandum.

Item M of the ITP requires an assessment of the direct HCP mitigation and restoration activities conducted each year. The direct HCP mitigation and restoration activities relative to Item M are listed below for the City of New Braunfels, City of San Marcos and Texas State University.

- City of New Braunfels (projects derived from Item 2f in permit)
    - Flow-split management
    - Restoration and maintenance of native aquatic vegetation (Old Channel and Landa Lake)
    - Decaying vegetation removal
    - Aeration and water quality sonde in Landa Lake
    - Gill parasite
    - Riparian restoration and bank stabilization
    - Riffle beetle restoration

  - Non-native species removal
  - Sediment Island removal
- City of San Marcos and Texas State University (projects derived from Item 3d and the second 4e in permit)
  - Enhancement and restoration of Texas wild-rice
  - Management of recreation specific to State Scientific Areas (only)
  - Non-native species removal
  - Restoration and maintenance of native aquatic vegetation
  - Sediment removal
  - Access Points and Bank Stabilization
  - Riparian restoration

For 2016 activities, pertinent to these projects, the areal extent of the project footprint has been quantified in Table 2 and depicted in subsequent figures per project. The project footprints were then overlaid on the occupied habitat maps in GIS and calculations of "Impact" area were performed. The results for each project and covered species are presented in Table 2.

Comal System

The **Old Channel bank stabilization** project construction was initiated and completed during 2016. Field activities and construction zones constituted the project footprint of 6,341 m^2 for this project (Figure 9). All in-channel activities and disturbance (895 m^2) associated with this project were directly accounted for in this assessment even though overlap with Old Channel native vegetation restoration activities did occur.

The **Flow-split management** project was completed in spring 2014 and involved portions of Landa Lake and the Old Channel. Activities conducted in 2016 involved routine operation and maintenance that did not extend out beyond the existing renovated structure. As such, there was no additional footprint for this project in 2016.

The **restoration and maintenance of native aquatic vegetation** project involved restoration activities in Landa Lake and New Channel (Figure 10a), the Upper Spring Run (Figure 10b) and the Old Channel (Figure 11) of the Comal system. These activities included the removal of non-native aquatic vegetation and subsequent restoration of native aquatic vegetation. The 2016 project footprints for native vegetation restoration are depicted in the aforementioned figures with areas (m^2) quantified in Table 2. Additionally, the MUPPT nursery area used to propagate native aquatic vegetation for restoration activities is also considered part of the project footprint (Figure 10a).

As noted in Table 2, the project footprint of the Native Aquatic Vegetation restoration effort in the Comal system encompassed 3,615 m^2 which overlapped with 2,063 m^2 of occupied fountain darter habitat. There was not any overlap with occupied habitat for the endangered Comal invertebrates. Although not quantified for this assessment, disturbance from foot traffic to and from these locations and from slightly elevated turbidity during non-native vegetation removal did temporarily occur.

The **Sediment Island removal** project in the Old Channel was completed in 2013 and thus no calculations were included last year or in the 2016 evaluation for that finished project. Activities associated with supplemental planting of native aquatic vegetation in that section of the Old Channel were covered under native aquatic restoration project.

TABLE 2 – Mitigation and Restoration Project Areas and Calculated Impact Area per Covered Species

HCP ACTIVITY	Project Footprint Area (m^2)	"Impact Area" Overlap with Occupied Habitat for Covered Species (m^2)					
		Fountain darter	Comal Springs riffle beetle	Comal Springs dryopid beetle	Peck's Cave amphipod	San Marcos salamander	Texas blind salamander
CITY OF NEW BRAUNFELS							
Flow-split management	0	0	--	--	--		
Restoration and maintenance of native aquatic vegetation	3,615	2,063	0	0	0		
Decaying vegetation removal	**A**	--	--	--	--		
Aeration, Water Quality Sonde	4.5	4.5	0	0	0		
Gill parasite	12	12	0	0	0		
Riparian restoration and bank stabilization	6,341	895	--	--	--		
Riffle beetle restoration	3,350	0	0	0	0		
Non-native species removal	35	27	0	0	0		
Sediment Island removal	Completed in 2013 – No activities in 2016						
TOTAL	13,358	3,002	0	0	0		
CITY OF SAN MARCOS / TEXAS STATE UNIVERSITY							
Enhancement and restoration of Texas wild-rice	**B**	--	--			--	--
Management of recreation specific to Exclusion zones (only)	**C**	--	--			--	--
Non-native species removal	**A**	--	--			--	--
Restoration and maintenance of native aquatic vegetation	3,930	3,570	0			0	0
Sediment removal	86	82	0			0	0
Access Points and Bank Stabilization	0	0	0			0	0
Riparian restoration	20,218	0	0			0	0
TOTAL	24,234	3,652	0			0	0

A Throughout system – described in qualitative impacts discussion

B Project footprint is accounted for in Native Aquatic Vegetation restoration project

C No exclusion zones were established in 2016 because of the higher than average flow conditions

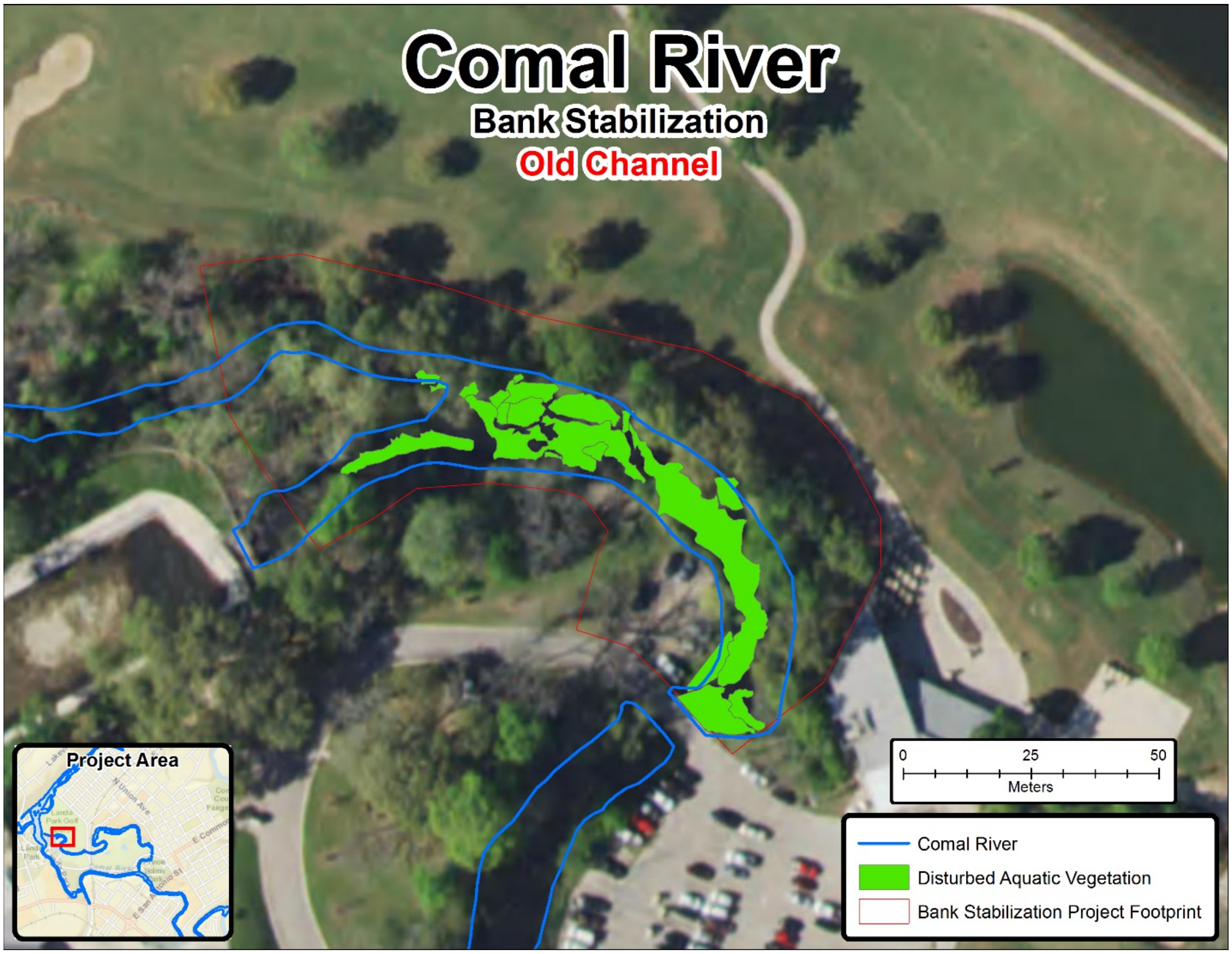


Figure 9: Old Channel Bank Stabilization Project (Comal system)

As presented in previous years, there is no project footprint map for the **Decaying Vegetation Removal** project as it was conducted throughout the main portion of Landa Lake and the New Channel on an as needed basis when floating mats of aquatic vegetation had built up. As such, no quantified area of impact was designated in 2016 for this project in Table 2. Temporary disturbance resulting from foot traffic within fountain darter occupied habitat did occur as well as slightly elevated turbidity downstream from immediate work zone.

The **Aeration and water quality** sonde project consisted of the installation of a series of aerators in Landa Lake as well as the installation of a water quality sonde in the lake for continual real-time measurements. The original project footprint for these components was small (Figure 10a, Table 2) and considered the same in subsequent years including 2016 to accommodate any maintenance, calibration or repair activities that were conducted. As the aerators and water quality sonde were placed within native aquatic vegetation, there was a direct overlap with 4.5 m^2 of occupied fountain darter habitat. As noted for other projects, short-term and limited exposure disturbance is experienced from foot traffic when calibrating the water quality sonde or maintenance of the aerators is required.

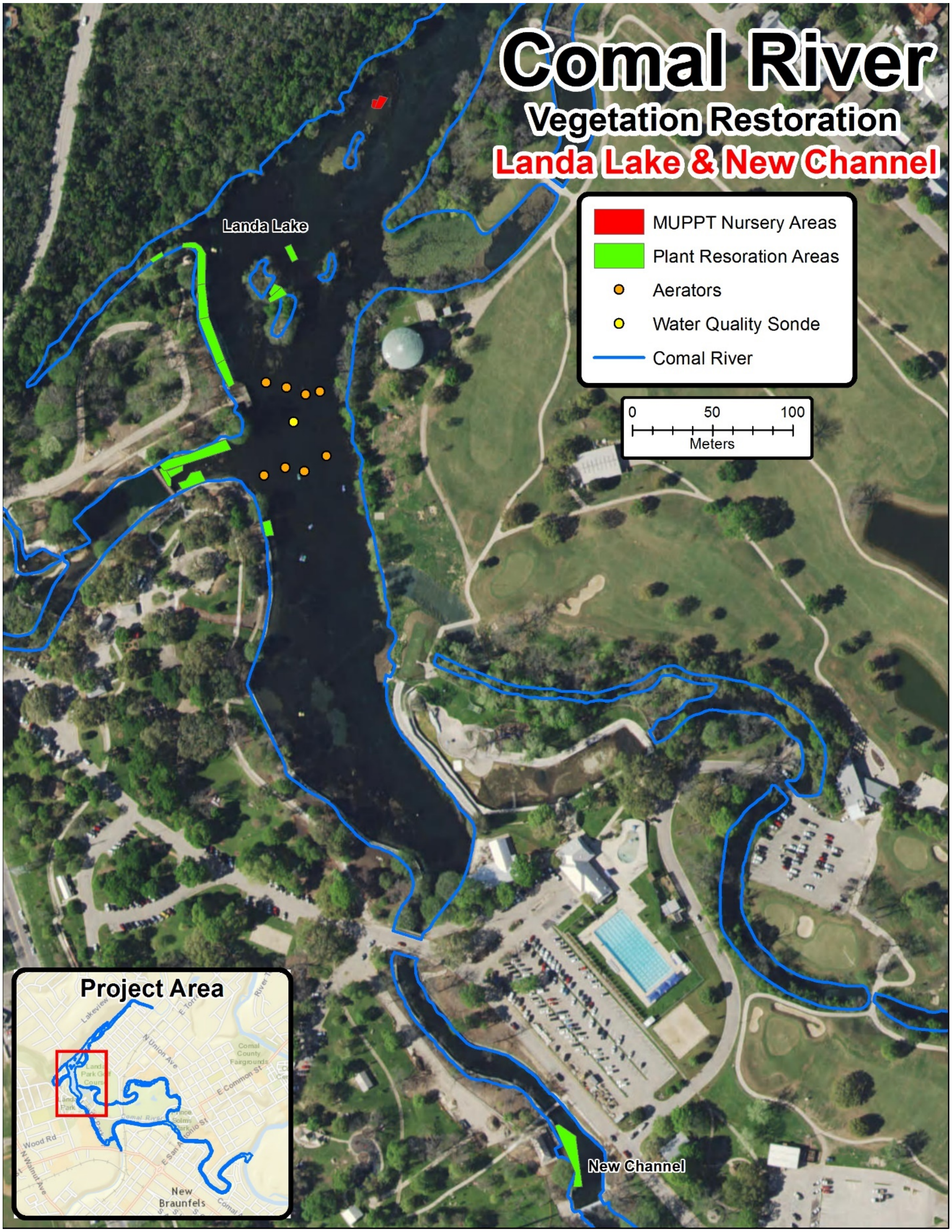


Figure 10a: Restoration and Maintenance of Native Aquatic Vegetation project and Aeration and Water quality sonde project – Landa Lake and New Channel (Comal system)

Figure 10b: Restoration and Maintenance of Native Aquatic Vegetation project – Upper Spring Run (Comal system).

Figure 11: Restoration and Maintenance of Native Aquatic Vegetation project – Old Channel (Comal River)

The **Gill parasite** project involved snail density quadrat sampling that disturbed the entire substrate in multiple locations (Figure 12, Table 2). The overall project footprint involved 12 m^2 overlapping fountain darter occupied habitat. For all Gill Parasite project activities (snail density sampling and water sampling cross sections) temporary disturbance from foot traffic in and around the areas/transects as well as slightly elevated turbidity downstream did occur.

The **Riffle beetle restoration** project involved only on shore activities in 2016 (Figure 13). The project footprint was made up of erosion control zones that were maintained along the banks of the western shoreline and Spring Run 3. Although the project footprint consisted of 3,350 m^2, all of this area was out of the water and thus did not overlap with any Covered Species occupied habitat.

The **Non-native species removal** project involved using four fyke nets during each trapping session. Fyke nets are passive traps that have 50-foot leads that guide fish into a 12-foot long by 3-foot wide hoop net. Additionally, three gill nets were used in the central portion of Landa Lake and a series of nutria traps were deployed along the banks of the Comal system. The fyke nets, gill nets and nutria trap locations are depicted in Figure 14. The footprint of the fyke nets, gill nets and nutria traps is presented in Table 2 along with the overlap of fountain darter occupied habitat. In addition to these activities, biologists snorkeled early in the morning and late in the afternoon (high times of fish activity) in areas of high fish density and speared non-native fish as well as hand picking giant ramshorn snails. Temporary disturbance resulting from foot traffic within fountain darter occupied habitat did occur around the fyke nets as well as slightly elevated turbidity downstream when nets were being placed, checked, and removed.

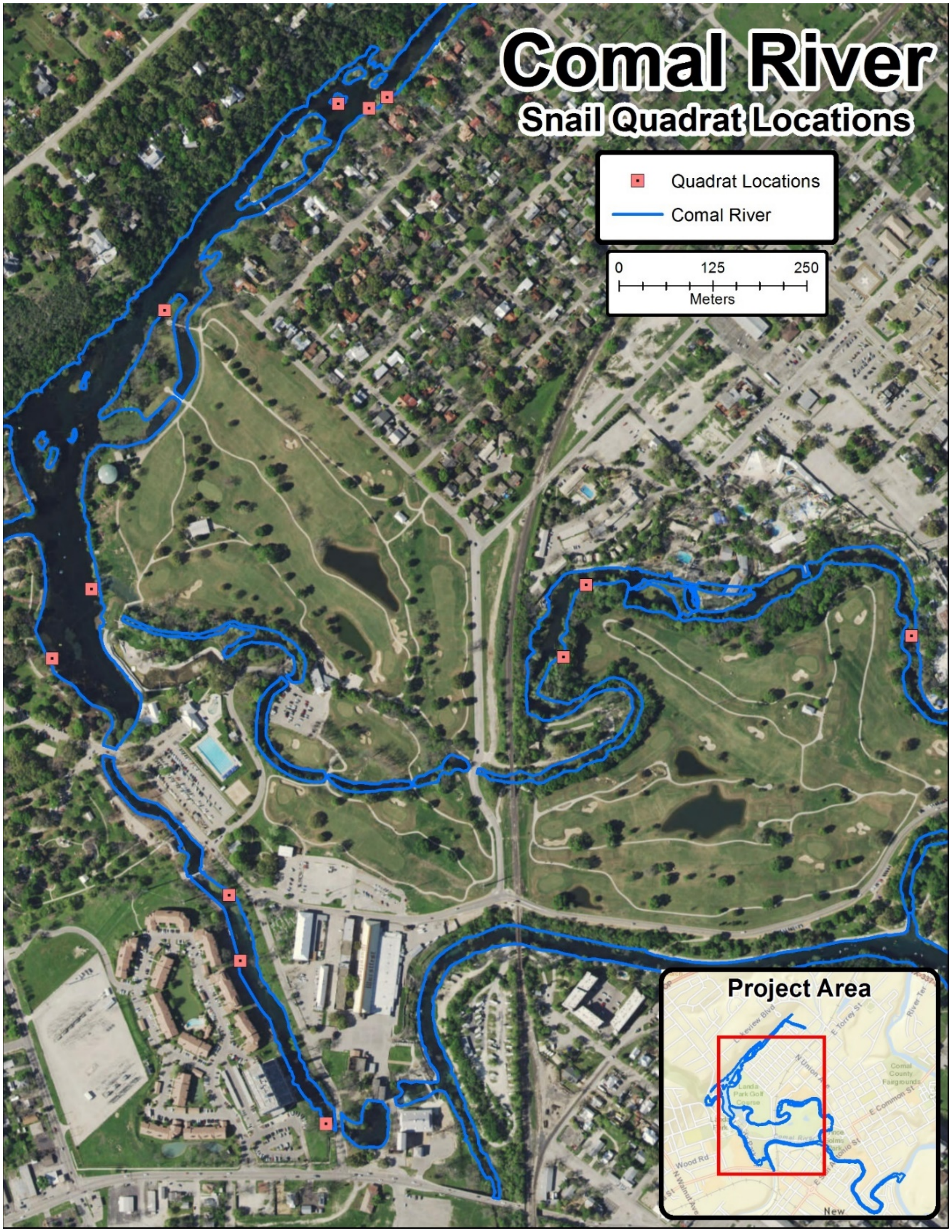


Figure 12: Gill Parasite project – Snail Quadrat Locations

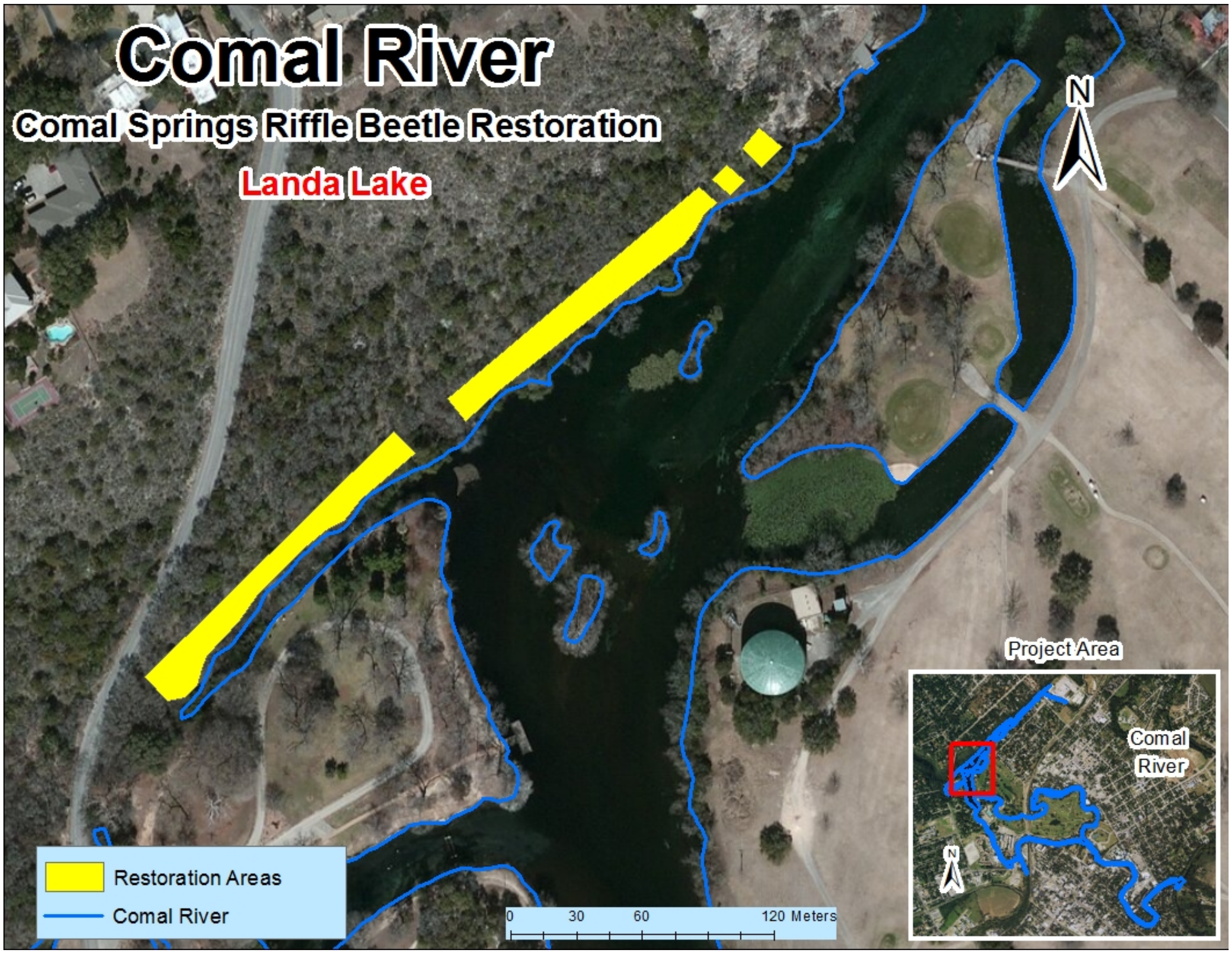


Figure 13: Comal Springs Riffle Beetle Restoration project – Comal System.

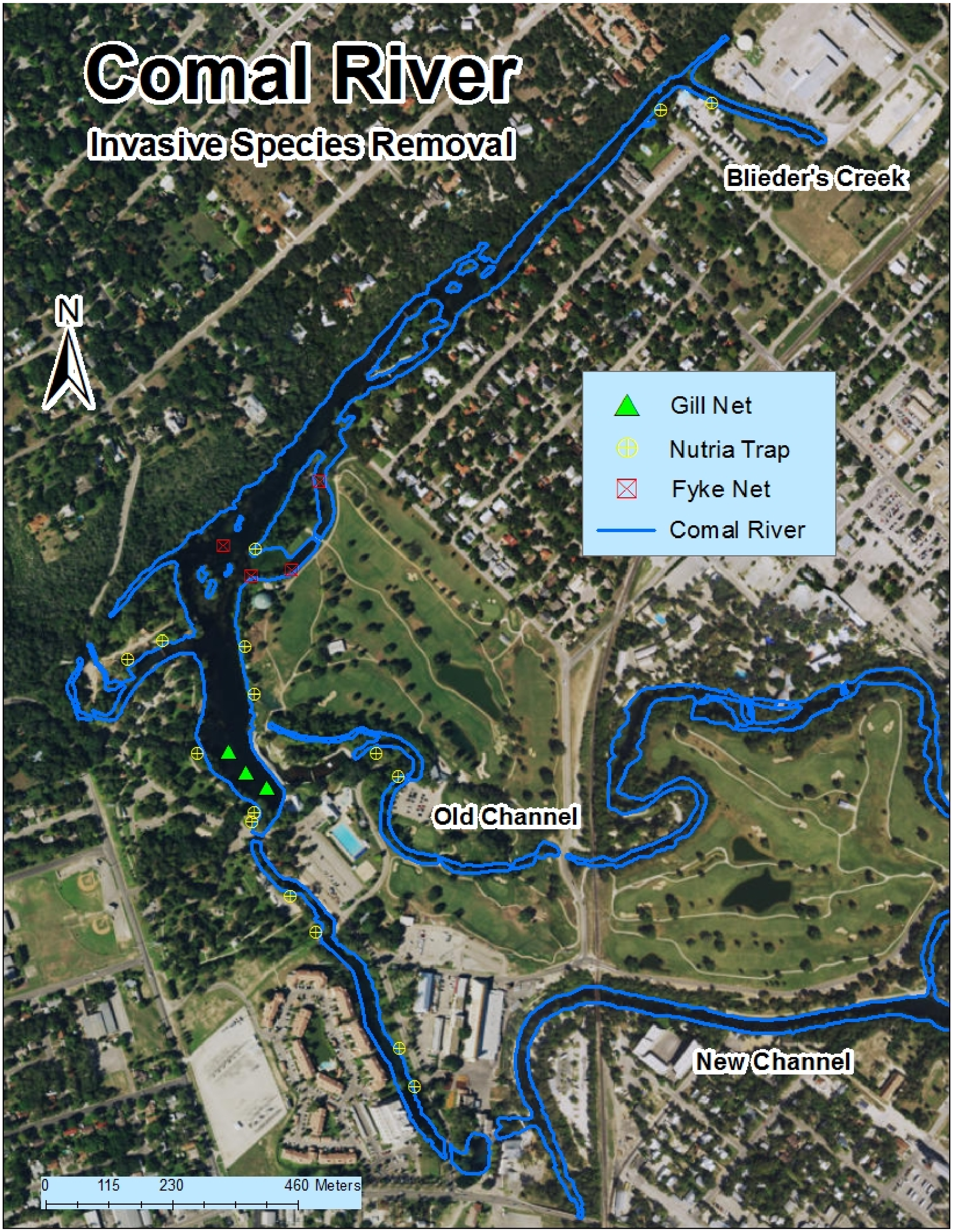


Figure 14: Non-native Animal Species Removal Project – Comal System.

San Marcos System

The **Enhancement and restoration of Texas wild-rice** and **Restoration and maintenance of native aquatic vegetation** project areas are depicted in Figure 15. As described in the ITP Annual Report, select non-native aquatic vegetation was removed from these areas allowing native vegetation (including Texas wild-rice) to expand over 2016. Native aquatic vegetation was also planted in cleared areas within these sections to promote restoration activities where practical and appropriate. As evident in Table 2, the working project area supports a footprint of 3,930 m^2 of which 3,570 m^2 overlaps with fountain darter occupied habitat (Table 2). This includes 85 m^2 (not included in figures) of aquatic vegetation restoration in Spring Lake immediately above the dam. Although not quantified for this assessment, disturbance from foot traffic to and from these locations and from slightly elevated turbidity during non-native vegetation and sediment island removal did temporarily occur.

There is no project footprint map for the **Exclusion zones** within the State Scientific Areas in 2016 as the higher than average flow conditions experienced the entire year eliminated the need for these structures.

There is no project footprint map for the **Non-native species removal** project as it was conducted throughout Spring Lake and the San Marcos River without permanent or temporary installation of equipment. Most work was conducted via snorkel or SCUBA in areas of high fish density with non-native fish being speared.

The **Sediment Removal** project areas are depicted on Figure 16. Fine sediment was carefully removed from within these boundaries following the protocols described in HCP annual work plans. The overall project footprint was 86 m^2 of which 82 m^2 overlapped with fountain darter occupied habitat in the San Marcos River (Table 2). Temporary disturbance from foot traffic to and from these locations and from slightly elevated turbidity during fine sediment removal did occur. The **Bank stabilization** projects were completed in 2014 and thus no project footprint was reported this year.

The **Riparian restoration** project along the San Marcos River in 2016 involved the largest project footprint (20,218 m^2) of any HCP restoration project in either spring system. The active riparian treatment areas are depicted on Figure 17 and quantified in Table 2. As in years past, the riparian restoration project took place on the banks and water's edge and did not overlap with any occupied habitat for the covered species.

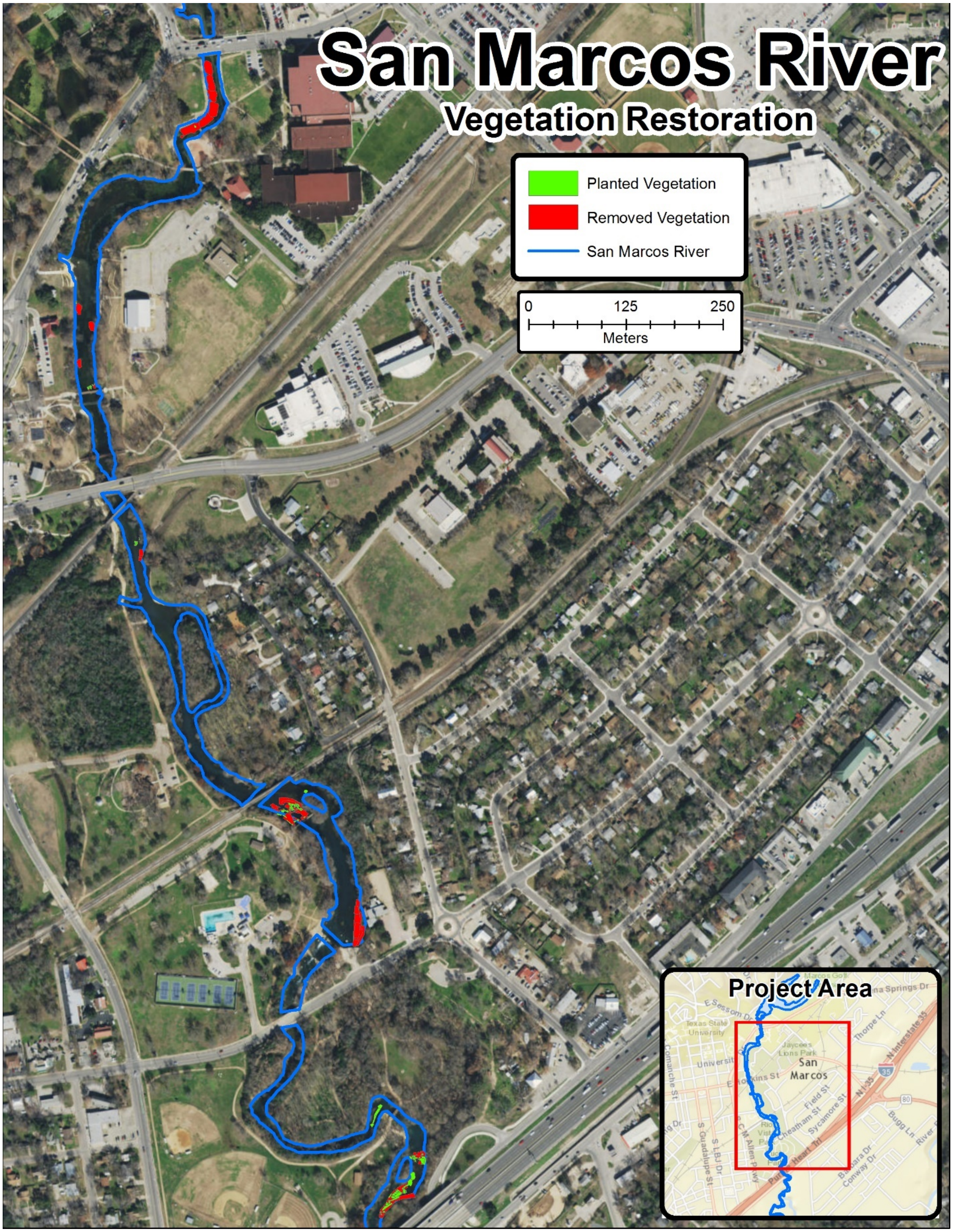


Figure 15: Restoration and Maintenance of Native Aquatic Vegetation and Enhancement of Texas wild-rice projects – San Marcos River.

Figure 16: 2016 Sediment Removal areas – San Marcos River.

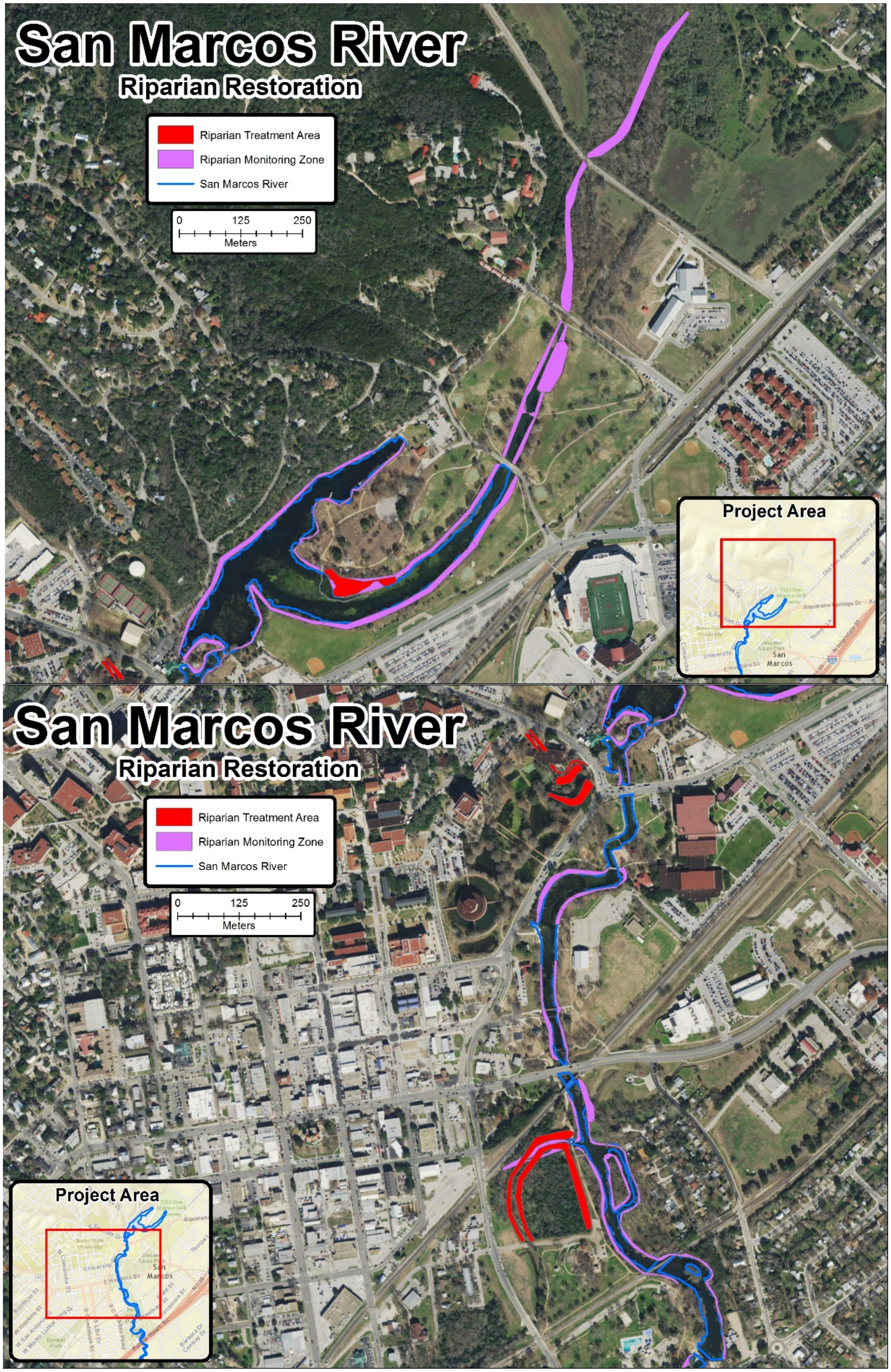


Figure 17: 2016 Riparian Restoration areas – San Marcos River.

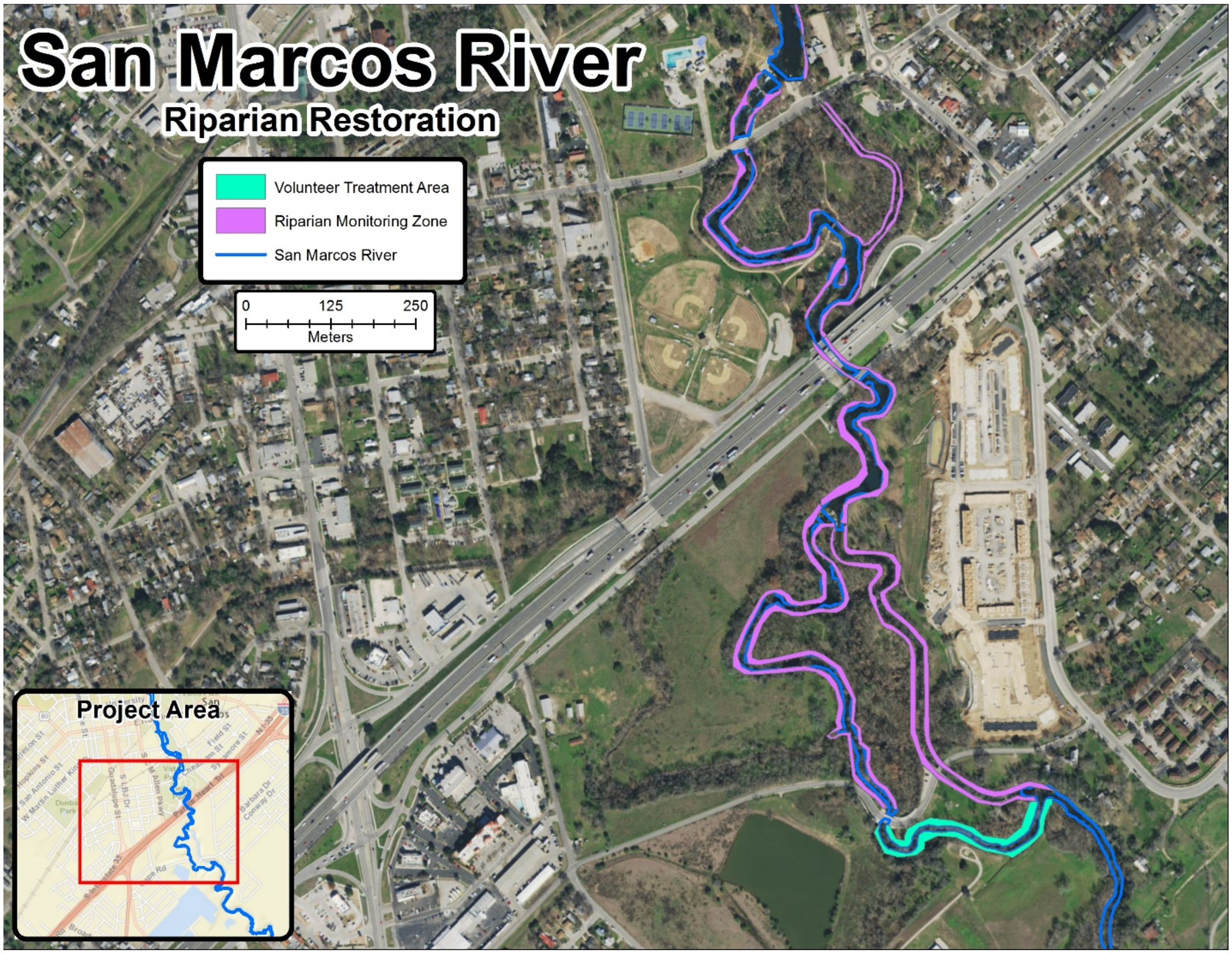


Figure 17 (continued): 2016 Riparian Restoration areas – San Marcos River.

Net Disturbance Assessment:

As described above, the baseline maps of occupied habitat versus the HCP project footprint maps were examined to quantify the area of potential effects from mitigation and restoration activities as required in Item M (1a and 2a). This included a system-wide assessment of net disturbance and net benefit. The focus was on quantifying the direct impacts (removal of non-native vegetation, removal of sediment, permanent placement of equipment, etc.) via areal coverage of activity, but temporary disturbance from slightly elevated turbidity and increased foot traffic were also described.

Table 3 shows the Net Disturbance calculation which is simply the sum of all project impact area that is overlaying baseline occupied habitat for a given covered species per system. As shown in Table 3, only the fountain darter in the Comal System had a net disturbance when considering the project footprints overlaid on occupied habitat. The net disturbance was 3.3% of the total occupied habitat for this species. As shown in Table 2, there were no project footprints that overlapped with any of the occupied habitat for the endangered Comal invertebrates. Additionally, for the subterranean species, there was no project impacts noted that directly affected spring orifices that could have resulted into changes to subterranean habitat.

TABLE 3 - NET DISTURBANCE AREA AND PERCENTAGE OF TOTAL PER SPECIES PER SYSTEM

COVERED SPECIES	Total Occupied Habitat (m^2)	Net Disturbance	
		Impact Area (m^2)	% of Total
CITY OF NEW BRAUNFELS			
Fountain Darter	91,461	3,002	3.3%
Comal Springs riffle beetle	1,672	0	0
Comal Springs dryopid beetle	350 [A]	0	0
Peck's Cave amphipod	1,466 [A]	0	0
CITY OF SAN MARCOS / TEXAS STATE UNIVERSITY			
Fountain Darter	89,958	3,652	4.1%
San Marcos salamander	2,520	0	0
Texas blind salamander	[B]		
Comal Springs riffle beetle	11	0	0

[A] Although a minimal amount of surface habitat was documented for the baseline and comparison purposes, this species is subterranean and utilizes subsurface habitat.

[B] No surface habitat documented for this species.

In the San Marcos system, only the fountain darter had a net disturbance (4.1%) of its total occupied habitat) per this assessment. Higher than average flow conditions experienced the entire year eliminated the need for recreational exclusion structures in designated State Scientific areas in 2016. This modification eliminated any project footprint over San Marcos salamander habitat and thus the reason no impacts were noted for this species in 2016 compared to previous years. For the Texas blind salamander and Comal Springs riffle beetle, there were no activities conducted in 2016 that directly impacted any of the orifices where collections have routinely been made over the years. As such, no direct impacts to subterranean or aquifer habitat was experienced from 2016 HCP mitigation and restoration measures in the San Marcos system.

In summary, the 10% disturbance rule (Item M [a]) was in compliance for 2016.

SECTION 2 - INCIDENTAL TAKE

All discussions presented in this section relate back to the USFWS Biological and Conference Opinions for the Edwards Aquifer Recovery Implementation Program Habitat Conservation Plan – Permit TE-63663A-0 (Consultation No. 21450-2010-F-0110), hereafter, Biological Opinion. The goal of this section is to characterize and quantify to the degree practical the Incidental Take that occurred in 2016 as a result of implementation of the EA HCP. This incidental take exercise builds upon the occupied habitat characterization and net disturbance assessment discussed in Section 1 relative to Requirement M (1a and 2a) of EARIP's ITP. As discussed above, the net disturbance assessment specifically addressed mitigation and restoration activities associated with the HCP. However, that net disturbance quantification represents only the baseline component of one aspect of the incidental take assessment. In addition to assigning incidental take to the disturbed areas from HCP mitigation and restoration activities, this assessment characterizes and quantifies to the degree practical the incidental take associated with implementation of all other applicable HCP covered activities. Thus, the two categories carried forward through this section include 1) HCP Mitigation and Restoration and 2) HCP Measures and Drought.

BACKGROUND

To comprehend the assessment, it is vital to understand what "take" and "incidental take" actually are. Section 8 of the Biological Opinion describes and defines "Take" as follows, "Take is defined by the Service as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harass is further defined by the Service as an intentional or negligent act or omission which creates the likelihood of injury to a listed species by annoying it to such an extent as to significantly disrupt normal behavioral patterns, which include, but are not limited to, breeding, feeding and sheltering (50 CFS §17.3). Harm is also further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by impairing behavioral patterns, including breeding, feeding, and sheltering. Incidental take is defined by the Service as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity." As such and as referenced above, the goal of this assessment is to characterize and quantify Incidental Take to the degree practical.

Specific to the EARIP ITP, an incidental take assessment is relative to Items S and T as described below.

Item S 3. "The Permittees will develop and oversee a monitoring program to identify and assess potential impacts, including incidental take, from Covered Activities and provide a better understanding and knowledge of the species' life cycles and desirable water quality- and springflow-related habitat requirements of the Covered Species (Section 6.3 of the HCP)."

Item T 3i. "Effects on the Covered Species or Permit Area"

An intensive monitoring program is in place and being performed for the HCP. In fact, the biological monitoring program was instrumental in assessing the effects on the Covered species described in this memorandum.

Item G of EARIP's ITP addresses the covered animal species that are authorized for incidental take. There are 10 animal species with take authorization and 1 plant species for impact assessment only. All activities described in this section pertain to the HCP Covered species that are actively authorized (Item H: 1-6) in 2016 for incidental take via EARIP's ITP. This includes the fountain darter, Comal Spring riffle beetle, Comal Spring dryopid beetle, Peck's Cave amphipod, Texas blind salamander, and San Marcos Salamander. Although the Texas cave diving beetle, Texas troglobitic water slater, and Comal Spring salamander are listed in the permit, the conditions in the ITP are not active in 2016 as none of these species are presently listed as threatened or endangered with this directly acknowledged (Item H: 7-9) in the ITP. Additionally, Item I of the permit acknowledges that only if the San Marcos gambusia is located or found in the study area, will take provisions apply. As this has not occurred in 2016, the San Marcos gambusia is not included in this assessment. Finally, being a plant, Texas wild-rice is not allotted incidental take provisions under this federal permit.

HCP Covered Activities

Item L of EARIP's ITP outlines the covered activities under this permit. There are responsibilities associated with all five (EAA, City of New Braunfels, City of San Marcos, Texas State University, and San Antonio Water system) HCP participants. A detailed list and description of these activities are presented in the HCP (EARIP 2011) and thus are only presented in outline form below. All activities outlined are considered included in this assessment to the degree practical and appropriate at this time.

Edwards Aquifer Authority

- a Programs that implement the statutory function of the EAA Act
- b Minimization and Mitigation Activities

City of New Braunfels

- a Recreational activities within the City of New Braunfels's jurisdiction
- b Management of Ecosystems of Comal Springs, Landa Lake, and the Comal River
- c Diversion of water from the Comal River in accordance with State law
- d Maintenance and operation of the spring-fed pool
- e Operation of boats on the Comal River and Landa Lake
- f Minimization and Mitigation Activities
    - Flow split management
    - Native Aquatic vegetation restoration
    - Management of public recreation
    - Decaying vegetation removal and dissolved oxygen management
    - Management of harmful non-native animal species
    - Monitoring and management of gill parasite
    - Prohibition of hazardous materials transport
    - Restoration of native riparian vegetation
    - Reduction of non-native species introduction and live bait prohibition
    - Litter collection and floating vegetation management
    - Management of Golf Course Diversions and operations
    - Impervious cover / water quality protection
    - Removal of sediment

City of San Marcos

- a Recreational activities within the City of San Marcos's jurisdiction
- b Operation of boats on the San Marcos River and Spring Lake
- c Routine, minor repairs of infrastructure and facilities
- d Minimization and Mitigation Activities
  - Enhancement and restoration of Texas wild-rice
  - Management of public recreation
  - Management of aquatic vegetation and litter
  - Prohibition of hazardous materials transport
  - Reduction of non-native species introduction
  - Removal of harmful erosion-related sediment below Sewell Park
  - Designation of permanent access points and bank stabilization
  - Management of non-native plant species
  - Management of harmful non-native and predator species
  - Restoration of native riparian vegetation
  - Implementation of a City of San Marcos septic system registration and permitting program
  - Management of potentially contaminated runoff
  - Implementation of a City of San Marcos household hazardous waste program
  - Implementation of water quality protection and an impervious cover limitation program

Texas State University

- a Recreational activities within the University's jurisdiction
- b Educational activities
- c Management of the ecosystems of the San Marcos River and Springs
- d Permitted diversion of water from Spring Lake and the San Marcos River
- e Operation and maintenance of the University golf course and grounds
- f Minimization and Mitigation Activities
  - Enhancement and restoration of Texas wild-rice
  - Management of public recreation
  - Management of aquatic vegetation from Sewell Park to City Park
  - Removal of harmful erosion-related sediment in Spring Lake and from Spring Lake Dam
  - Management of surface water diversion
  - Restoration of native riparian vegetation
  - Removal of harmful erosion-related sand bar in Sessom's Creek
  - Management of research programs in Spring Lake
  - Reduction of non-native species introduction
  - Management of non-native plant species
  - Management of harmful non-native and predator species

San Antonio Water System

- a Pumping from the Edwards Aquifer and for use and operation of the SAWS ASR
- b Minimization and Mitigation Activities
  - Use of SAWS ASR for Springflow protection
  - Phase II Expanded Use of the SAWS ASR

The Biological Opinion summarizes the covered activities into two main types, 1) flow protection and springflow management measures including changes to EAA CPM pumping restrictions, the management and use of the SAWS ASR to support springflows, implementation of the VISPO program or equivalent necessary measures, and reductions of surface water diversions and 2) other covered activities including but not limited to sediment removal, water-based recreation, non-native species management, operation and maintenance of flow management infrastructure, and other considered activities. The Biological Opinion acknowledged that impacts from flow protection and springflow management measures would not be anticipated during average years, while impact from all other HCP activities could occur in all years.

2016 INCIDENTAL TAKE ASSESSMENT

The 2016 incidental take assessment described in this section was conducted in the same manner as the 2015 assessment by first being broken down into two distinct categories to be carried forward in the assessment. The first category involves HCP mitigation and restoration activities specifically accomplished within the two springs ecosystems. These projects were the focus of the SECTION 1 - Item M net disturbance assessment. The second category pertains to covered activities that are foundational components (flow protection and springflow management measures) and on-going activities (water borne recreation, water diversions, existing water management infrastructure and operation, etc.).

Each category is assessed independently below and then summed to represent the total amount of incidental take observed in 2016. Although calculated independently, a foundational first step to both assessments was the documentation of "occupied" habitat for the covered species as described in SECTION 1 (Table 1).

As described in SECTION 1, the baseline maps of occupied habitat versus the HCP project footprint maps were examined to quantify the area of potential effects from mitigation and restoration activities in Item M (1a and 2a) (Table 2). The focus was on quantifying the direct impacts (removal of non-native vegetation, removal of sediment, permanent placement of equipment, etc.) via areal coverage of activity, but temporary disturbance from slightly elevated turbidity and increased foot traffic were also qualitatively described. Table 3 in SECTION 1 shows the net disturbance calculation which is the sum of all project impact area that is overlaying baseline occupied habitat for a given covered species per system. As shown in Table 3, only the fountain darter in both systems had a net disturbance when considering the project footprint overlaid on occupied habitat.

HCP MEASURES and DROUGHT: Documentation of impacted habitat for all other applicable HCP Covered Activities

In addition to characterizing the impacted habitat from direct HCP mitigation measures and restoration activities as described SECTION 1, this assessment also addresses impacted habitat from all other applicable HCP Covered activities. As previously referenced, these other activities will be referred to as "HCP measures and drought" throughout the remainder of this assessment. As with the net disturbance assessment and Biological Opinion, this evaluation uses impacted habitat as the foundation for subsequent analysis. A discussion for each covered species is presented below.

Fountain darter:

A wealth of aquatic vegetation data over time is available per the long-term biological monitoring that has been conducted by EAA since 2000. The health and abundance of the fountain darter is strongly tied to the quantity and quality of aquatic vegetation present in both the San Marcos and Comal systems. As such, the determination was made to use the current aquatic vegetation data to characterize and quantify the amount of impacted habitat that occurred in 2016 relative to HCP measures and drought. Spring and fall sampling efforts for aquatic vegetation have been conducted in seven sample reaches (4 in Comal and

3 in San Marcos) since 2002. The sample reaches for the Comal System are shown in Figure 18 and include the Upper Spring Run sample reach, Landa Lake sample reach, New Channel sample reach, and Old Channel sample reach. The sample reaches for the San Marcos system are shown in Figure 19 and include the Spring Lake Dam sample reach, City Park sample reach, and the I35 sample reach. For both systems (Figures 18 and 19), the corresponding river section that corresponds to each sample reach is also shown.

The first step in this analysis was to compile all the spring and fall coverage of individual aquatic vegetation species from each of the seven sample reaches over time. All rooted aquatic vegetation per reach per event was combined into a total aquatic vegetation amount. Green algae were not included in the assessment because it is not rooted, is poor quality fountain darter habitat, and has a high level of variability from year to year. Although bryophytes are not rooted, they were included in the assessment for the slow moving sample reaches of Landa Lake and the Upper Spring Run in the Comal system only. The main river sections that support a defined channel and greater velocities result in highly variable conditions for the non-rooted bryophytes in the New and Old Channels of the Comal River and all three reaches in the San Marcos River. However, in the Landa Lake and Upper Spring Run sample reaches, relationships between bryophytes and total system discharge are apparent, and bryophytes provide high quality fountain darter habitat in these reaches.

Table 4 shows the total aquatic vegetation (m^2) present in each of the 4 study reaches in the Comal system over time. The color coding in Table 4 relates to "average" years [green], "flood event" years [blue], and "drought" years [orange]. Average years were determined as any year that exhibited over 225 cfs total system discharge throughout the majority of the year. The 225 cfs value was selected as it is the long-term average flow management objective specified in the HCP (EARIP 2011). In addition to being over 225 cfs, an average year for this assessment did not exhibit any flood events during the year or previous fall that substantially altered the aquatic vegetation within a given sample reach. If a flood event occurred in this manner and altered either the spring or fall aquatic vegetation amount, that year was discarded from the analysis. Finally, a drought year was determined as any year that exhibited total system discharge that went below 225 cfs for portions of the year. Concurrently, that drought year did not exhibit any flood events within the year that altered the aquatic vegetation in the sample reaches or it was discarded.

Figure 18. Sample Reaches (4) for the Comal System and Corresponding River Section.

Figure 19. Sample Reaches (3) for the San Marcos System and Corresponding River Section.

Figure 19 cont. I35 Sample Reach and Corresponding Lower River Section in the San Marcos System.

Table 4. Total Aquatic Vegetation in the Spring and Fall per reach on the Comal System over time.

Season	Upper Spring Run Reach			Landa Lake Reach			Old Channel Reach			New Channel Reach		
	Date	Total System Discharge (cfs)	Total Aquatic Vegetation (m^2)	Date	Total System Discharge (cfs)	Total Aquatic Vegetation (m^2)	Date	Total System Discharge (cfs)	Total Aquatic Vegetation (m^2)	Date	Total System Discharge (cfs)	Total Aquatic Vegetation (m^2)
Spring_02	5/14/2002	323	1569	5/16/2002	317	19497	5/15/2002	321	509	5/15/2002	321	3304
Fall_02	10/28/2002	421	2701	10/29/2002	417	19033	10/28/2002	421	486	11/21/2002	440	2555
Spring_03	4/22/2003	405	3909	4/23/2003	405	19351	4/24/2003	405	554	4/22/2003	405	3259
Fall_03	11/3/2003	368	2743	11/4/2003	364	17946	11/5/2003	361	872	11/5/2003	361	3588
Spring_04	4/22/2004	361	2744	4/25/2004	372	17241	4/21/2004	363	1226	4/21/2004	363	3576
Fall_04	10/19/2004	385	1584	10/20/2004	384	16102	10/21/2004	383	1173	10/19/2004	385	623
Spring_05	4/15/2005	445	2376	4/15/2005	445	18431	4/20/2005	444	1291	4/21/2005	443	18
Fall_05	10/3/2005	361	2968	10/4/2005	361	16754	10/5/2005	360	1752	10/3/2005	361	220
Spring_06	4/24/2006	298	3108	4/26/2006	294	17617	4/27/2006	294	1843	4/25/2006	296	325
Fall_06	11/7/2006	259	2574	11/13/2006	260	16870	11/13/2006	260	1760	11/16/2006	258	869
Spring_07	4/23/2007	317	3668	4/26/2007	333	18954	4/24/2007	315	1774	4/27/2007	343	1223
Fall_07	10/11/2007	426	3907	10/15/2007	426	19083	10/18/2007	423	1769	10/18/2007	425	1
Spring_08	4/17/2008	357	4218	4/22/2008	356	19908	4/18/2008	363	1587	4/18/2008	363	1566
Fall_08	10/23/2008	287	2470	10/28/2008	285	17310	10/24/2008	288	1647	10/24/2008	288	2895
Spring_09	4/22/2009	262	3278	4/24/2009	259	19640	4/27/2009	276	1731	4/22/2009	262	2695
Fall_09	10/13/2009	275	1819	10/14/2009	275	16330	10/15/2009	272	1823	10/15/2009	272	173
Spring_10	4/23/2010	352	2949	4/26/2010	349	19010	4/27/2010	349	1842	4/28/2010	347	230
Fall_10	10/22/2010	346	548	10/25/2010	335	15967	10/26/2010	336	1495	10/22/2010	346	363
Spring_11	4/25/2011	255	1345	4/26/2011	251	17703	4/25/2011	255	1814	4/27/2011	248	538
Fall_11	11/4/2011	193	789	11/7/2011	194	16049	11/8/2011	193	1954	11/4/2011	193	1484
Spring_12	5/5/2012	214	2792	5/6/2012	242	19349	5/9/2012	225	1942	5/21/2012	244	1999
Fall_12	10/31/2012	199	1348	10/29/2012	201	19735	10/31/2012	199	1939	10/31/2012	199	2569
Spring_13	4/10/2013	198	2143	4/11/2013	197	23092	4/11/2013	197	1527	4/12/2013	196	2596
Fall_13	10/18/2013	159	1020	10/18/2013	159	21595	10/21/2013	154	1402	10/22/2013	149	2893
Spring_14	4/7/2014	149	1511	4/8/2014	147	19233	4/4/2014	147	1319	4/15/2014	143	3249
Fall_14	10/24/2014	144	861	10/23/2014	145	17759	10/27/2014	141	1502	10/28/2014	141	3400
Spring_15	4/27/2015	249	1381	4/29/2015	227	16396	4/27/2015	249	1778	4/28/2015	237	2898
Fall_15	10/19/2015	203	1436	10/19/2015	203	17431	10/18/2015	208	1210	10/20/2015	201	3541
Spring_16	4/14/2016	303	1963	4/11/2016	296	17566	4/9/2016	299	794	4/8/2016	291	2377
Fall_16	10/19/2016	366	1610	10/18/2016	367	18945	10/20/2016	365	543	10/25/2016	362	2045

"AVERAGE YEAR" Total System discharge of >225 cfs throughout most of the year

"DROUGHT YEAR" Total System discharge of < 225 cfs discharge for most of the year

"FLOOD DISTURBANCE" Flood event affecting reach at some point between spring and fall or late fall previous year

As evident in Table 4, average and drought years were fairly consistent amongst reaches, but the Upper Spring Run and New Channel sample reaches were affected more frequently from flood-related high flow events. In late 2001, several pulse events propagated in the upper watershed and came primarily down Blieders Creek, whereas in many of the other years the majority of the pulses came down Dry Comal Creek and directly through the New Channel sample reach. The large event in June 2010 was the only high-flow event that negatively affected all four study reaches. It is also quite evident that drought conditions experienced in 2009 extended through 2014, with a temporary reprieve provided by the extreme 2010 high-flow event, and a more substantial reprieve in 2015 which continued through 2016. In fact, higher than average total system discharge conditions were experienced over the entire course of 2016. Figure 20 shows the Comal River hydrograph over the biological monitoring program time period with the larger daily average peak flows noted.

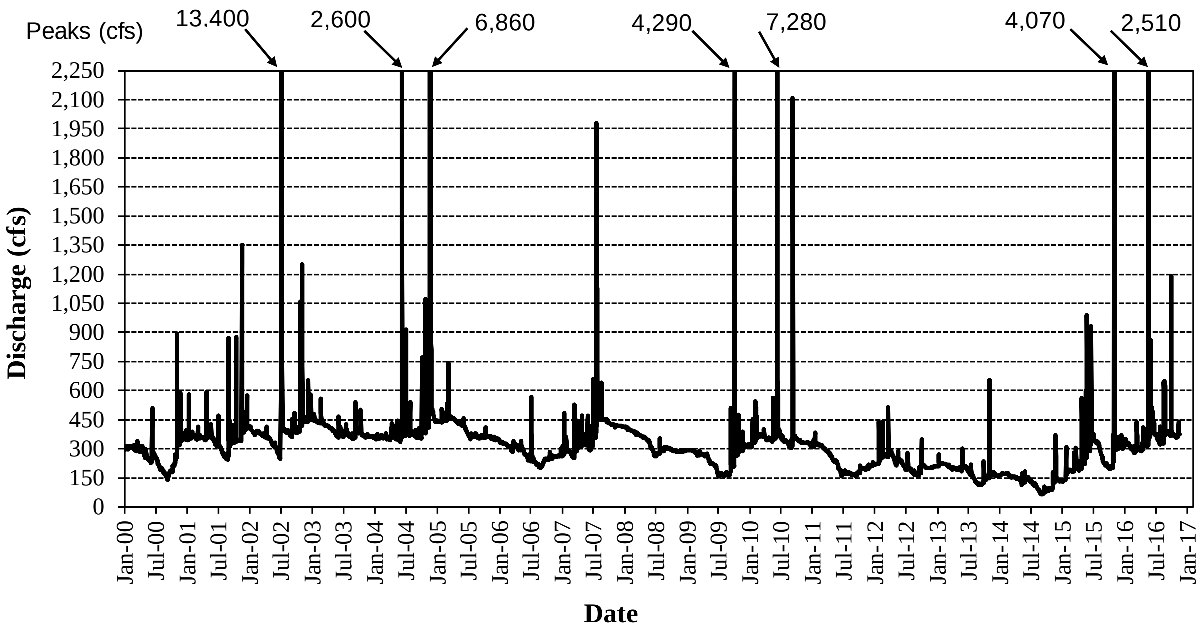


Figure 20: Comal River hydrograph presented as daily discharge over the biological monitoring period.

Table 5 shows the total aquatic vegetation (m^2) present in each of the 3 study reaches in the San Marcos system over time. Average years for the San Marcos River were determined as any year that exhibited over 140 cfs total system discharge throughout the majority of the year. The 140 cfs value was selected as it is the long-term average flow management objective specified in the HCP (EARIP 2011). Figure 21 depicts the San Marcos River hydrograph over the biological monitoring time period which also includes daily average peak flows and dates experienced. Similar to the Comal system, above average total system discharge was experienced in the San Marcos River for the entirety of 2016.

Table 5. Total Aquatic Vegetation in the Spring and Fall per reach on the San Marcos System over time

Season	Spring Lake Dam reach			City Park reach			I35 reach		
	Date	Total System Discharge (cfs)	Total Aquatic Vegetation (m^2)	Date	Total System Discharge (cfs)	Total Aquatic Vegetation (m^2)	Date	Total System Discharge (cfs)	Total Aquatic Vegetation (m^2)
Spring_02	5/8/2002	201	1673	5/7/2002	201	4905	5/6/2002	201	891
Fall_02	10/23/2002	263	1519	10/21/2002	258	4566	10/22/2002	259	685
Spring_03	4/11/2003	286	1778	4/9/2003	284	4976	4/10/2003	285	797
Fall_03	10/30/2003	179	1619	10/20/2003	190	4351	10/21/2003	187	684
Spring_04	4/15/2004	156	1725	4/13/2004	154	4620	4/14/2004	155	543
Fall_04	10/15/2004	179	1184	10/11/2004	181	4413	10/12/2004	178	900
Spring_05	4/11/2005	297	1084	4/13/2005	294	4243	4/12/2005	295	401
Fall_05	9/28/2005	182	1123	9/26/2005	183	4055	9/27/2005	184	556
Spring_06	4/19/2006	116	1225	4/17/2006	111	4617	4/18/2006	114	474
Fall_06	11/3/2006	97	1061	11/2/2006	97	4171	11/2/2006	97	902
Spring_07	4/18/2007	218	1385	4/17/2007	219	3554	4/19/2007	218	903
Fall_07	10/10/2007	325	1098	10/8/2007	332	4258	10/11/2007	322	840
Spring_08	4/16/2008	160	1426	4/14/2008	162	4748	4/17/2008	161	608
Fall_08	10/22/2008	107	1182	10/20/2008	108	3992	10/21/2008	108	784
Spring_09	4/28/2009	95	1236	4/29/2009	94	4307	4/29/2009	94	759
Fall_09	10/16/2009	153	802	10/12/2009	148	2690	10/12/2009	148	739
Spring_10	4/22/2010	253	1205	4/21/2010	255	4545	4/20/2010	254	626
Fall_10	10/20/2010	199	971	10/19/2010	201	3816	10/21/2010	198	653
Spring_11	4/28/2011	125	1400	4/21/2011	133	4457	4/22/2011	132	688
Fall_11	11/2/2011	94	998	11/1/2011	94	3050	11/3/2011	93	488
Spring_12	5/3/2012	190	1240	5/1/2012	191	4148	5/4/2012	190	474
Fall_12	10/24/2012	147	1091	10/23/2012	146	3103	10/25/2012	146	289
Spring_13	4/17/2013	108	2064	4/20/2013	108	5074	4/24/2013	107	495
Fall_13	10/14/2013	120	1283	10/10/2013	109	3699	10/11/2013	108	402
Spring_14	4/21/2014	123	1198	4/17/2014	123	3123	4/23/2014	121	1745
Fall_14	10/26/2014	105	911	10/17/2014	106	2663	10/18/2014	105	1519
Spring_15	4/14/2015	173	1272	4/15/2015	171	3387	4/14/2015	174	2065
Fall_15	10/12/2015	209	805	10/14/2015	206	2703	10/12/2015	206	1738
Spring_16	4/5/2016	237	1108	4/4/2016	235	3246	4/7/2016	238	1172
Fall_16	10/17/2016	268	1018	10/15/2016	270	2579	10/14/2016	272	1110

"AVERAGE YEAR" Total System discharge of >140 cfs throughout the year
"DROUGHT YEAR" Total System discharge of < 140 cfs discharge at some point within the year
"FLOOD DISTURBANCE" Flood event affecting reach after fall sampling period

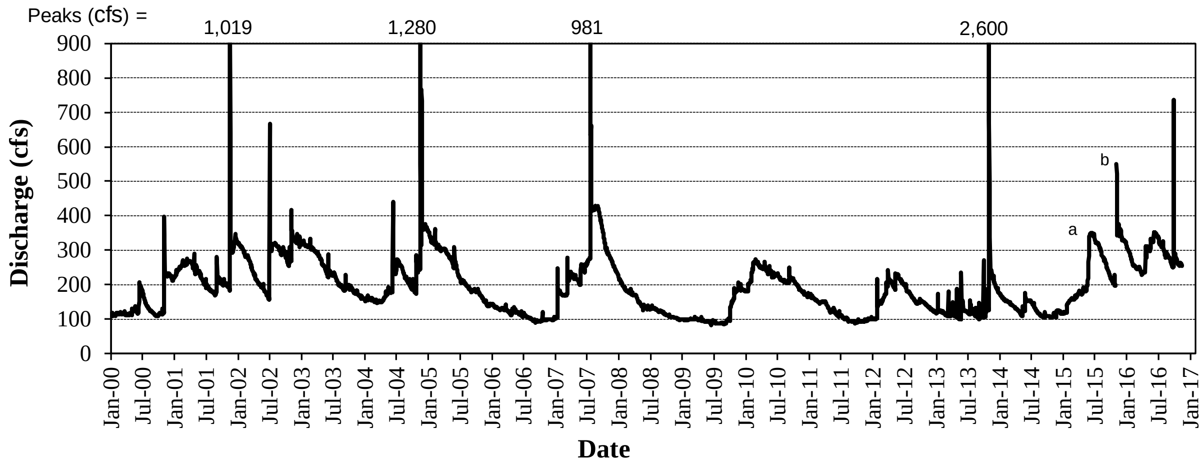


Figure 21: San Marcos River hydrograph presented as daily discharge over the biological monitoring period. [a] Memorial Day weekend flood 2015, USGS estimate not available. [b] Late-October flood 2015, USGS estimate not available.

Table 6 shows the percentage retention in aquatic vegetation observed from spring to fall for average and drought years as well as individually for 2016. As evident in Table 6, only the Upper Spring Run and Landa Lake sample reaches show a decline in overall aquatic vegetation from spring to fall during average years, with the Upper Spring Run sample reach exhibiting the largest decline. This is not surprising for any of the reaches in the Comal system. The Upper Spring Run sample reach exhibits the largest decline (14% decline or 86% retention, Table 6) as this stretch typically gets large green algae blooms in late summer resulting in a die off of bryophytes. Additionally, this reach of river is comparatively shallower and thus recreational activities play a more substantial role in affecting aquatic vegetation over the summer months. Landa Lake rooted aquatic vegetation remains extremely stable from year to year with only a 7% decline (93% retention, Table 6) resulting mainly from bryophytes. The bryophytes within Landa Lake show spring to fall variability but not to the level as experienced in the Upper Spring Run sample reach. Additionally, the green algae build-up in Landa Lake is considerably less than further upstream and there are only limited recreational activities in Landa Lake.

In the more channelized sections of the river with greater overall velocities, Old Channel and New Channel sample reaches, the lower discharge observed in the fall typically results in greater amounts of aquatic vegetation (over 100% retention indicating increases). The Old Channel sample reach is bordered by private property and thus, limited to no recreation occurs in this reach. The New Channel increase in aquatic vegetation from spring to fall is somewhat surprising considering the high level of recreation that occurs in this sample reach. However, this stretch of the New Channel is deep and most all the recreation is tubing that occurs on the surface. It is evident that the bulk of aquatic vegetation disturbance in the deeper portions of the New Channel is from pulse scour events rather than recreation.

Table 6. Percentage Retention of aquatic vegetation from Spring to Fall per sample reach per system.

Scenario	Percentage Retention in Aquatic Vegetation from Spring to Fall						
	Comal System Sample Reaches				San Marcos System Sample Reaches		
	Upper Spring Run	Landa Lake	Old Channel	New Channel	Spring Lake Dam	City Park	I35
Average Flow Condition Years	86%	93%	106%	118%	86%	91%	98%
Drought Years	52%	92%	103%	123%	73%	77%	101%
2016 Actual	82%	108%	104%*	86%	92%	79%	95%

* adjusted to include 288 m^2 of Hygrophila purposely removed prior to October 2016. That amount was added back to this total for the Old Channel reach because it has already been accounted for in the HCP Mitigation / Restoration calculations presented in Table 2.

During average drought conditions (as characterized by this assessment) observed to date, the same trend holds with the Upper Spring Run and Landa Lake sample reaches showing spring to fall declines in aquatic vegetation, with no declines evident in the Old and New Channel sample reaches. The Old Channel is controlled by culverts allowing for stable flow even during drought which is the likely explanation. In the New Channel sample reach, due to the combined effects of removing flood pulse events from the assessment, decreased water velocities, and consistently deeper depths (for the most part), aquatic vegetation growth from spring to fall increases even more during drought. A closer look at 2016 (Table 6) shows that it was similar to an average year for half the sample reaches, with the following notes for the Old and New Channels, respectively. During 2016, extensive aquatic vegetation restoration took place within the Old Channel study reach which resulted in the purposeful reduction of 288 m^2 of non-native *Hygrophila* between the spring and fall comprehensive mapping events. As this reduction in fountain darter habitat was counted as incidental take in the HCP mitigation / restoration measures documented above (Table 2), this vegetation amount was added back into the fall mapping total as not to cause a double accounting of this HCP sponsored activity. The uncharacteristic decline in the New Channel during 2016 was mainly caused by a moderate flow pulse coming down Dry Comal creek causing scour prior to the October mapping event. However, this reduction was included in the assessment to be conservative as high levels of recreational activity in the New Channel were also experienced in summer 2016.

In the San Marcos system, both the Spring Lake Dam (14% decline or 86% retention) and City Park (9% decline or 91% retention) sample reaches experience declines in aquatic vegetation during average years while the I35 sample reach remains stable (Table 6). During average drought conditions (as characterized by this assessment) observed to date, the same trend holds with the Spring Lake Dam (73% retention) and City Park (77% retention) sample reaches but to a greater degree, while aquatic vegetation in the I35 reach on average increases. This is a similar phenomenon as the New Channel sample reach at Comal, in that when discharge is lower, velocities are lower and the existing aquatic vegetation expands. This also highlights the role river recreation plays in the San Marcos River.

The two upstream sample reaches (Spring Lake Dam and City Park) are highly recreated compared to the I35 reach. However, one has to be careful not to jump to the conclusion that all the impacts in these upstream reaches are from recreation only based on the observation that the I35 reach actually increases during average drought years. The reason for caution is that the declines in aquatic vegetation in these two upstream reaches are a combination of the level of recreation coupled with the lower than average water depths. A closer look at 2016 (Table 6) for the San Marcos River shows spring to fall declines to aquatic vegetation was evident in all three sample reaches. However, the Spring Lake Dam reach was higher in retainage in the fall than under average conditions (Table 6). This most likely is a direct correlation with this area being physically fenced off from direct access to the river for the majority of the 2016. This provides a good example of the restorative capacity of the river when afforded the opportunity for reduced recreational pressure coupled with higher total system discharge conditions.

Table 7 shows the conversion process from percentage retention between spring and fall aquatic vegetation during average years when compared directly to 2016. Using the Upper Spring Run sample reach as an example, there is an 86% retention during average years. This implies that under average conditions a 14% decline in aquatic vegetation is observed from spring to fall each year. This amount is considered a pre-HCP condition because 1) it is calculated based on routine conditions prior to the HCP, and 2) during average years, a lot of HCP measures would not be actively engaged. As such, the difference in retention (86% - 82% = 4%) is the value used to assess the overall loss (or gain) of fountain darter occupied habitat within this river section. The total fountain darter occupied habitat designated for the Upper Spring Run reach is 2,163 m^2. The 4% difference from the reach is applied to the 2,163 m^2 from the entire section resulting in a habitat impact of 83 m^2. For this incidental take assessment, the 83 m^2 is considered the amount of habitat that was impacted by the HCP Measures and Drought category for this particular river section.

Table 7. Total Impacted Area (m^2) for the fountain darter based on percentage retention of aquatic vegetation from Spring to Fall per sample reach per system.

Scenario	Percentage Retention in Aquatic Vegetation from Spring to Fall						
	Comal System Sample Reaches				San Marcos System Sample Reaches		
	Upper Spring Run	Landa Lake	Old Channel	New Channel	Spring Lake Dam	City Park	I35
Average Flow Condition Years	86%	93%	100%	100%	86%	91%	98%
2016 Actual	82%	108%	104%*	86%	92%	79%	95%
	HABITAT CALCULATIONS applied to river sections						
Difference between Average and 2016 (%)	4%	0%	0%	14%	0%	12%	4%
Total Fountain Darter Occupied Habitat (m^2) per entire river section	2,163	45,750	18,091	25,457	769	28,909	7,497
2016 Total Impacted Area (m^2)	83	0	0	3,554	0	3,330	282

* adjusted to include 288 m^2 of Hygrophila purposely removed prior to October 2016. That amount was added back to this total for the Old Channel reach because it has already been accounted for in the HCP Mitigation / Restoration calculations presented in Table 2.

As evident in Table 7, the Upper Spring Run and New Channel sections exhibited impacted habitat conditions in 2016 on the Comal System. It should be noted that benefits from increased aquatic vegetation were not considered in this analysis. As such, all percentage retentions greater than 100% in

Table 6 were adjusted to 100% in Table 7 for the determination of impacted habitat. In the San Marcos system, both the City Park and I35 reaches showed reductions in percentage retention from spring to fall in aquatic vegetation in 2016 and thus, resulted in impacted habitat within those respective San Marcos River sections.

Comal Springs Invertebrates:

To calculate the impacted habitat area for the Comal Springs riffle beetle, Comal Springs dryopid beetle, and Peck's Cave amphipod, areas of disturbance in 2016 (not including the HCP mitigation and restoration measures assessed separately) were assessed and area of impact quantified by overlapping area of disturbance and occupied habitat. The occupied habitat maps for each of the Comal invertebrates are described in SECTION 1. In previous years, disturbances pertaining to HCP measures and drought to the Comal invertebrate species resulted from the drying of surface area in the spring runs, western shoreline, and Spring Island area in late summer/fall. However, because of above average total system discharge levels throughout 2016, all Comal springs invertebrate occupied habitat was inundated and supported springflow and or flowing water for the majority of 2016. As such, there was no take calculated for HCP measures and drought per established methodology. As in previous years no attempt was made to characterize subsurface habitat in this assessment.

San Marcos salamander:

As San Marcos salamander habitat below Spring Lake Dam and in Spring Lake remains fairly consistent from spring to fall, there was no attempt to quantify habitat changes similar to the fountain darter aquatic vegetation assessment. Additionally, there was no drying of surface habitat in the San Marcos system in 2016. As such, there was no quantification of disturbance using exposed surface area overlapping with occupied habitat. Therefore, the only known disturbance of occupied San Marcos salamander habitat in 2016 was from recreational activities below Spring Lake dam.

As there is not a quantification of recreation in this sample reach, the percentage of retention of aquatic vegetation in the Spring Lake dam reach calculated for the fountain darter was used (as in each previous year) for the San Marcos salamander as a surrogate for disturbance. As shown in Table 7, there was an increase in aquatic vegetation retention in the Spring Lake Dam study reach during 2016 resulting in no calculated impact to San Marcos salamander habitat below the dam.

Texas blind salamander: There is no surface habitat documented in the Item M assessment (SECTION 1) for the Texas blind salamander. There were no aquifer impacts noted via HCP measures or drought in 2016, and thus, no impacted habitat is reported for the Texas blind salamander in this assessment.

INCIDENTAL TAKE CALCULATIONS

The next step in the analysis is converting the impacted habitat area to incidental take of individuals so that a comparison can be made to the ITP permit. It is understood and should be emphasized that multiple ways of making a conversion from habitat area to incidental take can be performed, all of which involve a level of subjectivity and professional judgment. Based on USFWS acceptance following the first three annual assessments, the calculations for 2016 were conducted in the same manner.

In 2016, incidental take was again scaled in accordance with the condition of the system at that particular time. For instance, incidental take caused by a reduction of 10% of the occupied habitat in the system is not the same proportionally to a condition where 40%, 70%, or 90% of the occupied habitat is removed from the system. The rationale is that when only a small amount of habitat is removed, a large portion of quality habitat remains for the covered species to utilize. However, when larger portions of occupied habitat are reduced, the situation inherently becomes more stressful for the individuals. The word stressful is important in that take is more than just mortality as discussed at the start of this memorandum. In the Biological Opinion, the USFWS defines Take as "…. to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harass is further defined by the Service as an intentional or negligent act or omission which creates the likelihood of injury to a listed species by annoying it to such an extent as to significantly disrupt normal behavioral patterns, which include, but are not limited to, breeding, feeding and sheltering (50 CFS §17.3). Harm is also further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by impairing behavioral patterns, including breeding, feeding, and sheltering."

To explain the concept of non-proportional take as occupied habitat is reduced, it is important to start with mortality, but as described in the original HCP take assessment, incidental take goes beyond mortality. Habitat disturbances including physical (aquatic vegetation, silt-free substrate, etc.) and chemical (standard water quality parameters such as water temperature and dissolved oxygen) play a role in incidental take calculations as well. This is important in that one of the further definitions of "Harass" is that it annoys the individual or modifies its habitat to such an extent that behavior patterns (including breeding) are impaired. Of course there are other behavioral components that may be disrupted either through direct annoyance of the individual or through habitat modifications, such as feeding and sheltering. During HCP measures and drought, the loss or modification of habitat described in the previous section by definition clearly caused take beyond mortality. Considering that mortality represents a very small proportion of that number, characterizing the remaining amount becomes very important.

For this assessment, we examined the densities of the covered species recorded over time via EAA biological monitoring in both systems. The USFWS approach used the average density for covered species from the same biological monitoring program to make calculations in the biological opinion in many instances. For this assessment, the density statistics were broken down further to explore the component of scaling incidental take as habitat conditions get worse. Table 8 shows the density statistics chosen for each of the covered species. The 25^{th}, 50^{th} (median), 75^{th}, and 90^{th} percentile along with the mean density are included. Furthermore, only the spring and fall data sets since 2002 were used for these density statistics. The rationale is that under drought or following high-flow events the densities within aquatic vegetation types may not be representative of average conditions with which to apply to incidental take. Additionally, as more and more critical period (low and high) events get added, it skews the data set towards those events.

Table 8. Descriptive statistics of Covered Species density by System

Covered Species	Density (individuals per m²) Descriptive Statistics (Percentiles and Mean)				
	25	Median	Mean	75	90
Fountain Darter					
Comal system	1.50	6.00	11.35	15.50	29.30
San Marcos system	1.50	3.50	5.90	7.00	13.00
Comal Springs riffle beetle	6.60	9.10	10.71	12.40	19.38
Comal Springs dryopid beetle[A]	-	-	0.10	-	-
Peck's Cave amphipod	1.04	1.67	2.05	2.33	4.33
San Marcos salamander					
San Marcos River	3.00	6.00	6.08	8.50	10.5
Spring Lake	10.00	12.00	13.17	16.25	19.00

[A] Too few collected to use full set of descriptive statistics

The same spring and fall sample sets were used for each covered species. Fountain darter densities are presented by system and are comprised of drop net sampling in aquatic vegetation types used in the occupied habitat assessment. This approach deviates from the USFWS analysis in that only an average density calculated from both systems combined with all sample dates was included in the Biological Opinion.

For this assessment, San Marcos salamander densities were developed from the quantitative snorkel/SCUBA sampling being conducted during biological monitoring in the San Marcos system. Densities within the San Marcos River and Spring Lake occupied habitat were broken out separately as done in the Biological Opinion.

Densities for the Comal Springs riffle beetles were generated from the cotton lure sampling at three locations (Spring Run 3, Western Shoreline, and Spring Island area). Densities for the Peck's Cave amphipod were generated from the drift net sampling conducted over the main orifices at Spring Run 1, Spring Run 3, and Spring Run 7. In the case of the Comal Springs dryopid beetle, only 52 individuals have been collected to date using the drift net sampling methodology. As such, only the mean is presented for the Comal Springs dryopid beetle in Table 8. The Biological Opinion estimated the total surface population of Comal springs dryopid beetles in the Comal Spring system to be 1,839 individuals (USFWS 2010). To calculate their incidental take, they used a 5%, 10% rule based on an even distribution of individuals to come up with 9 individuals (1839 *.05 *.10 = 9.2). In doing so, the underlying assumption forced was that the overall area was 1,839 square feet or 1 individual per square foot. One individual per square foot equals 0.09 per m^2. Although the biological monitoring data has limited Comal Springs dryopid beetle observations, the calculated density of 0.10 individuals per m^2 is in line with the Biological Opinion estimate.

To account for a scaled approach for calculating incidental take (increased impacts with increased levels of habitat loss); the following schedule (Table 9) was used to determine which density statistic to multiply by impacted habitat area to generate the incidental take estimate. The schedule is based on remaining occupied habitat per covered species per system. For example, if 9% of the total occupied habitat was impacted for the fountain darter in the Comal system that would leave 91% of the occupied habitat for the fountain darter. For the incidental take calculation, the 25^{th} percentile density for the fountain darter (1.5 darters per m^2, Table 8) would be used to multiply against the total impacted area.

Table 9. Density assignment schedule based on remaining occupied habitat

Remaining Occupied Habitat Percentage	Corresponding Density Statistic
100 to 75	25%
74 to 50	Median
49-25	Mean
24-10	75%
9-0	90%

No standard water quality parameters were outside of a suitable range for the covered species in 2016, thus they were not considered for causes of incidental take in this assessment. Figures 22 and 23 show water temperature ranges observed in each system over the course of 2016.

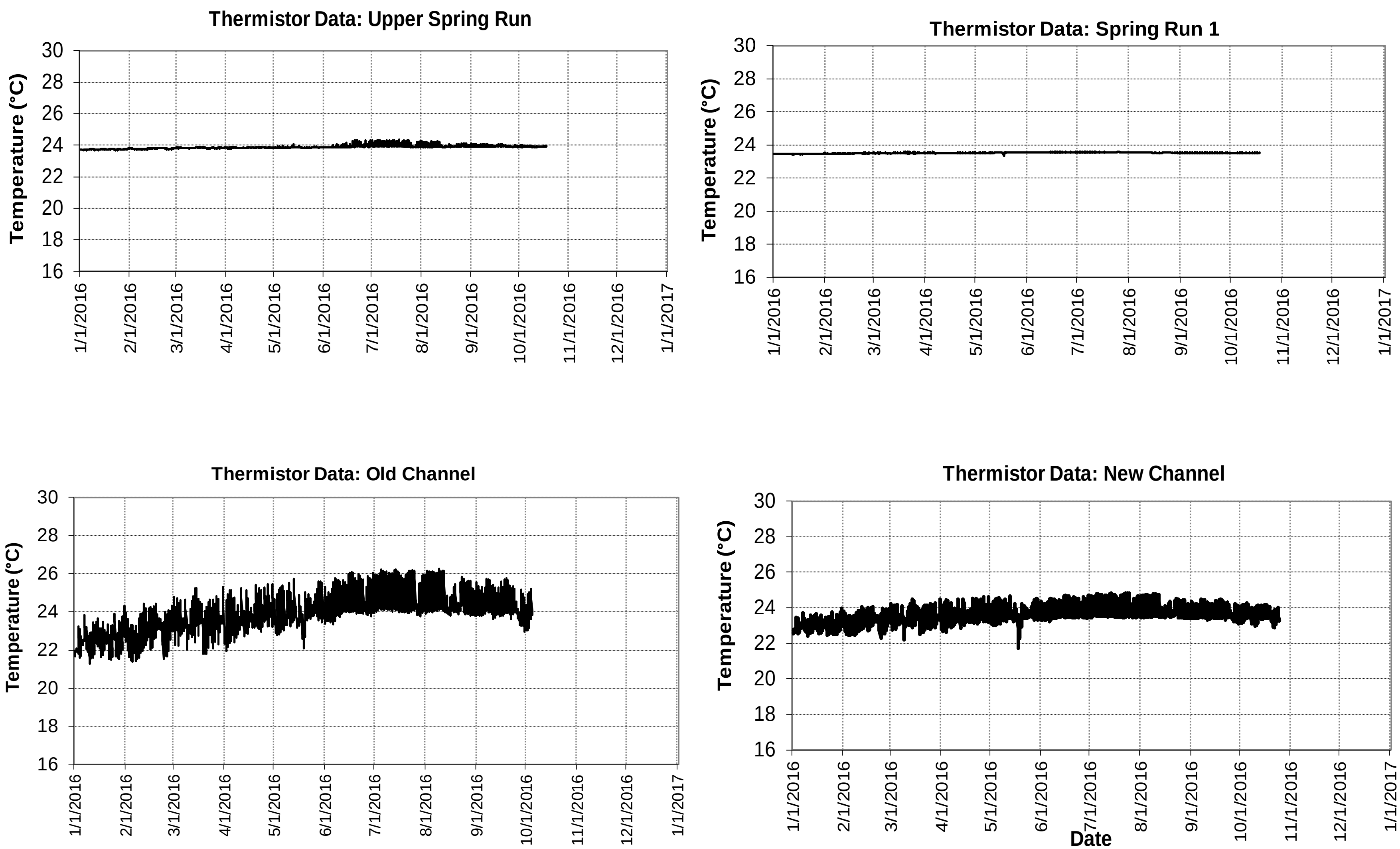


Figure 22: Thermistor data collected during 2016 at four select sites extending upstream to downstream in the Comal System.

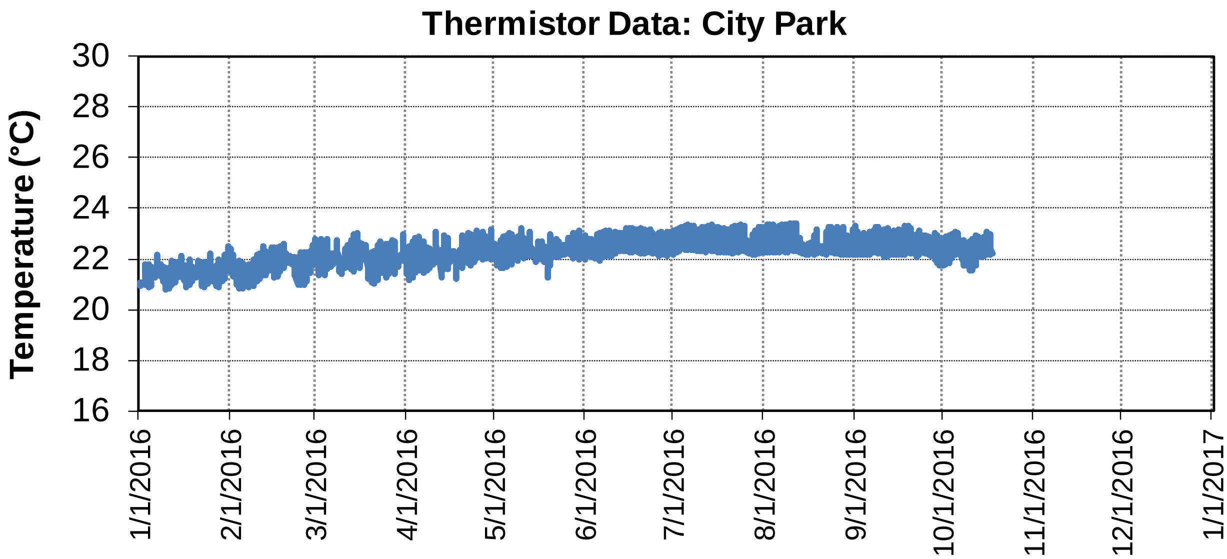


Figure 23: Thermistor data collected during 2016 at City Park reach of the San Marcos River.

Fountain darter:

Table 10 shows the incidental take calculated for the fountain darter in the Comal system and San Marcos system (San Marcos River and Spring Lake) relative to HCP mitigation and restoration activities as well as the HCP measures and drought. In all instances the percentage of impacted areas was less than 10% of the total occupied habitat and thus the 25th percentile density was applied to each reach.

It is important to keep the two categories (HCP mitigation / restoration and HCP measures / drought) separate in the analysis. The rationale is that HCP mitigation and restoration activities have a mandate to stay under 10% of the total occupied habitat or cease. Additionally, there is another clause in Item M of the ITP that these activities should cease under certain low-flow triggers if undesirable impacts are encountered. As such, any impacts from the HCP measures or drought should be calculated independently for an accurate comparison in future drought years.

Comal Springs invertebrates:
There was no impacted habitat reported for the Comal Springs invertebrates in 2016, thus no incidental take was calculated for these species in 2016.

San Marcos salamander: There was no impacted habitat reported for the San Marcos salamander in 2016, thus no incidental take was calculated for this species in 2016.

Texas blind salamander: There was no impacted habitat reported for the Texas blind salamander in 2016, thus no incidental take was calculated for the Texas blind salamander in 2016.

Table 10. Calculated Incidental Take for the fountain darter per system based on impacted habitat.

FOUNTAIN DARTER PARAMETERS	COMAL SYSTEM		SAN MARCOS SYSTEM			
			San Marcos River		Spring Lake	
	HCP Mitigation / Restoration	HCP Measures / Drought	HCP Mitigation / Restoration	HCP Measures / Drought	HCP Mitigation / Restoration	HCP Measures / Drought
2016 Impacted Area (m^2)	3,002	3,637	3,652	3,612	85	0
Total Occupied Habitat (m^2)	91,461	91,461	37,175	37,175	52,782	52,782
% of Occupied Habitat Impacted	3.28%	3.98%	9.82%	9.72%	0.16%	0.00%
Corresponding Habitat Percentile Density (individual/m^2)	1.50	1.50	1.50	1.50	1.50	--
Water Temperature Percentile Density adjustment	N/A	N/A	N/A	N/A	--	--
2016 Incidental Take Estimate	4,503	5,456	5,478	5,418	127	0
2016 TOTAL INCIDENTAL TAKE PER SYSTEM	9,959		11,023			

COMPILATION OF RESULTS AND SUMMARY

Table 11 summarizes the 2016 impacted habitat area and incidental take attributed to the HCP relative to the ITP permit amount. Per the established methodologies, only the fountain darter experienced incidental take during 2016.

Table 11. Summary of Impacted Habitat (m^2) and Incidental Take for HCP Covered Species compared against ITP Permit Amounts.

COVERED SPECIES PER SYSTEM	IMPACTED HABITAT (m^2)		HABITAT 2016 TOTAL (m^2)	INCIDENTAL TAKE		**2016 INCIDENTAL TAKE TOTAL**	ITP Maximum Permit Amount	ITP Permit Maximum minus (combined first 4 years)
	HCP Mitigation / Restoration	HCP Measures / Drought		HCP Mitigation / Restoration	HCP Measures / Drought			
COMAL SYSTEM								
Fountain Darter	3,002	3,637	**6,639**	4,503	5,456	**9,959**	797,000	748,386
Comal Springs Riffle Beetle	0	0	**0**	0	0	**0**	11,179	8,933
Comal Springs Dryopid Beetle	0	0	**0**	0	0	**0**	1,543	1,528
Peck's Cave Amphipod	0	0	**0**	0	0	**0**	18,224	18,060
SAN MARCOS SYSTEM								
Fountain Darter	3,652	3,697	**7,349**	5,478	5,545	**11,023**	549,129	496,190
San Marcos Salamander	0	0	**0**	0	0	**0**	263,857	262,323
Texas Blind Salamander	0	0	**0**	0	0	**0**	10	10
Comal Springs Riffle Beetle	0	0	**0**	0	0	**0**	n/a	n/a

Conditions experienced during 2016 remained improved over recent drought years (2013-1014) for this take assessment. The primary cause for this continued improvement was maintaining greater than average total system discharge which inundates surface habitat with flowing water throughout each system. When examining 2016 impacts, conditions are similar to "average" conditions characterized in the Biological Opinion. As such, we are confident the incidental take numbers summarized in Table 11 continue to justify the data sets used and methodologies employed in 2016 relative to performing an incidental take assessment within the context of the Biological Opinion. It is understood that adjustments to data sets and/or methodologies may be employed based on feedback from the USFWS, HCP Science Committee, HCP participants, or others as deemed appropriate by the EARIP.

REFERENCES

BIO-WEST, Inc., 2002-2013a, Comprehensive and critical period monitoring program to evaluate the effects of variable flow on biological resources in the Comal Springs/River aquatic ecosystem: Final Annual Reports (2002 through 2012) submitted to the Edwards Aquifer Authority, San Antonio, Texas, variously paginated.

BIO-WEST, Inc., 2002-2013b, Comprehensive and critical period monitoring program to evaluate the effects of variable flow on biological resources in the San Marcos Springs/River aquatic ecosystem: Final Annual Reports (2002 through 2012) submitted to the Edwards Aquifer Authority, San Antonio, Texas, variously paginated.

BIO-WEST 2014a. Habitat Conservation Plan Biological Monitoring Program. San Marcos Springs/River Ecosystem. 2013 Annual Report. Edwards Aquifer Authority. 80 p. plus Appendices.

BIO-WEST 2014b. Habitat Conservation Plan Biological Monitoring Program. Comal Springs/River Ecosystem. 2013 Annual Report. Edwards Aquifer Authority. 94 p. plus Appendices.

BIO-WEST 2015a. Habitat Conservation Plan Biological Monitoring Program. San Marcos Springs/River Ecosystem. 2014 Annual Report. Edwards Aquifer Authority. 67 p. plus Appendices.

BIO-WEST 2015b. Habitat Conservation Plan Biological Monitoring Program. Comal Springs/River Ecosystem. 2014 Annual Report. Edwards Aquifer Authority. 98 p. plus Appendices.

BIO-WEST 2016a. Habitat Conservation Plan Biological Monitoring Program. San Marcos Springs/River Ecosystem. 2015 Annual Report. Edwards Aquifer Authority. 68 p. plus Appendices.

BIO-WEST 2016b. Habitat Conservation Plan Biological Monitoring Program. Comal Springs/River Ecosystem. 2015 Annual Report. Edwards Aquifer Authority. 75 p. plus Appendices.

BIO-WEST 2017a. Habitat Conservation Plan Biological Monitoring Program. San Marcos Springs/River Ecosystem. 2016 Annual Report. Edwards Aquifer Authority. (In preparation).

BIO-WEST 2017b. Habitat Conservation Plan Biological Monitoring Program. Comal Springs/River Ecosystem. 2016 Annual Report. Edwards Aquifer Authority. (In preparation).

Bowles, D.E., Barr, C.B., and Stanford, R., 2003, Habitat and phenology of the endangered riffle beetle *Heterelmis comalensis* and a coexisting species, *Microcylloepus pusillus*, (Coleoptera: Elmidae) at Comal Springs, Texas, USA: Archiv fur Hydrobiologie, v. 156, p. 361–383.

Brandt T.M., K.G. Graves, C.S. Berkhouse, T.P. Simon, and B.G. Whiteside. 1993. Laboratory spawning and rearing of the endangered Fountain Darter. Progressive Fish-Culturist 55:149-156.

[EARIP] Edwards Aquifer Recovery Implementation Program. 2011. Habitat Conservation Plan and Appendices. December 2011.

Gibson, J. R., S. J. Harden, and J. N. Fries. 2008. Survey and distribution of invertebrates from selected springs of the Edwards Aquifer in Comal and Hays Counties, Texas. The Southwestern Naturalist 53 (1): 74-84.

Gonzales, Tina Katherine. 2008. Conservation genetics of the Comal Springs riffle beetle (*Heterelmis comalensis*) populations in central Texas, with examination of molecular and morphological variation in *Heterelmis* Sp. throughout Texas. Theses and Dissertations-Biology. Paper 15.

(USFWS) United States Fish and Wildlife Service, 2010, Biological and Conference Opinions of the Edwards Aquifer Recovery Implementation Program Habitat Conservation Plan Permit TE-63663A-O[Memorandum]. Albuquerque, NM: Department of the Interior 145-146.