Appendix J | **2021 Item M Net Disturbance and Incidental Take Assessment for EARIP ITP Annual Report**

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MEMORANDUM

TO:	Scott Storment, Jamie Childers, Chad Furl
FROM:	Ed Oborny
DATE:	December 27, 2021
SUBJECT:	**ITEM M NET DISTURBANCE AND INCIDENTAL TAKE ASSESSMENT FOR 2021 EARIP ITP ANNUAL REPORT**

EXECUTIVE SUMMARY

The Edwards Aquifer Habitat Conservation Plan (HCP) 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 2021 assessments were performed in accordance with ITP requirements.

Table ES provides an overview of net disturbance percentages and a summary of incidental take for 2021. 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 < 0.5% of the total occupied habitat for the Fountain Darter in the Comal system. In the San Marcos system, only the Fountain Darter and San Marcos Salamander had net disturbance per this assessment with approximately 2.6% and < 0.5% of their total occupied habitat disturbed, respectfully. In summary, the ITP 10% disturbance rule (Item M [a]) was in compliance for 2021.

Table ES also shows the calculated incidental take for both systems with respect to the HCP covered species. The calculated value for the Fountain Darter in the Comal system was slightly lower in 2021 than observed during 2020. The primary cause for the slight decrease observed this year was that only one of the four study reaches exhibited a decline in aquatic vegetation greater than average conditions from spring to fall. In 2021, all invertebrate restoration activities occurred on shore resulting in no calculated incidental take for the listed Comal invertebrates. For the San Marcos system, incidental take for the Fountain Darter increased considerably in 2021 compared to 2020. The increase in the San Marcos system was primarily due to large reductions in aquatic vegetation from spring to fall in both the Spring Lake Dam and City Park study reaches. The installation of the Texas Wild-rice protection zone in the Spring Lake Dam reach created some minimal calculated take for the San Marcos Salamander, but the larger calculated take was a result of the spring to fall decline in aquatic vegetation in this reach. San Marcos restoration activities in 2021 did not overlap with invertebrate occupied habitat resulting in no calculated incidental take for these covered species.

The higher levels of calculated take in the Spring Lake Dam and City Park reaches in 2021 were a result of aquatic vegetation building up considerably in these reaches in 2020 when Covid-19 restrictions, that limited recreational access, were in place for many sections of the San Marcos River. When recreationalists were allowed full access to the river in 2021, the spring to fall vegetation declines were predictably larger than in previous years. Regardless, we are confident the incidental take numbers shown in Table ES and documented in this memorandum continue to justify the data sets used and methodologies employed in 2021 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 2021 TOTAL (m^2)	INCIDENTAL TAKE		**2021 INCIDENTAL TAKE TOTAL**	ITP Maximum Permit Amount	ITP Permit Maximum minus (combined first nine 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	473.0	0.46%	42.0	**515**	710	63	**773**	797,000	730,413
Comal Springs Riffle Beetle	0	0%	0	**0**	0	0	**0**	11,179	8,887
Comal Springs Dryopid Beetle	0	0%	0	**0**	0	0	**0**	1,543	1,527
Peck's Cave Amphipod	0	0%	0	**0**	0	0	**0**	18,224	18,057
SAN MARCOS SYSTEM									
Fountain Darter	2,490.0	2.6%	12,843.3	**15,333.3**	3,735.0	44,951.5	**48,686**	549,129	401,394
San Marcos Salamander	4.3	0.17%	236.0	**240.3**	12.9	708.0	**721**	263,857	260,462
Texas Blind Salamander	0	0%	0	**0**	0	0	**0**	10	10
Comal Springs Riffle Beetle	0	0%	0	**0**	0	0	**0**	n/a	n/a
Comal Springs Dryopid Beetle	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-1) 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 2021 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 2021 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 2021, 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 2014 - 2021a, 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) that has 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 with associated figures presented in Appendix A. As per the ITP and USFWS Austin ES guidance, the 2021 assessment is representative of conditions for calendar year 2021 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. Drop netting has occurred in dominant aquatic vegetation types within representative sampling reaches for over twenty years. On a broader scale, dip netting for Fountain Darters has occurred throughout the Comal system since 2000. 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 Appendix A), 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. Per the established methodology, the 2021 Fountain Darter occupied habitat was calculated using the most recent full system aquatic vegetation mapping supplemented with updated aquatic vegetation for the study reaches collected during the previous Fall monitoring.

Although not as extensive as for the Fountain Darter, routine sampling for the Comal Springs riffle beetle has also occurred since 2006. 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. Appendix A shows the documented occupied habitat for the Comal Springs riffle beetle in the Comal System with the quantification of area presented in Table 1. 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 these subterranean invertebrates are not found far from spring orifices, this area includes 0.5 m^2 around the orifices that these species have been collected in the Comal system. Appendix A shows documented 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.

TABLE 1. COVERED SPECIES OCCUPIED HABITAT (Figures depicting occupied habitat included in Appendix A)

ITEM M - SPECIES	OCCUPIED HABITAT (m^2)	NOTES AND ASSUMPTIONS
COMAL SPRINGS / RIVER		
Fountain Darter	103,909	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	1,681	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	1,640	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	362	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	95,287	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.
Comal Springs Dryopid Beetle	0.5	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 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 System

The Fountain Darter has been extensively sampled throughout the San Marcos system via the long-term biological monitoring program 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 nearly two decades. On a broader scale, dip netting 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. Appendix A shows the documented 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. The known collection locations and occupied habitat are depicted in Appendix A and quantified in Table 1. 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 noted in Table 1. Known collection areas are depicted in Appendix A for later use in the net disturbance assessment.

Although not as extensive as in the Comal systems, sampling for the Comal Springs riffle beetle and Comal Springs dryopid beetle has occurred in Spring Lake. Similar to the Comal system, the determination was made to include a 1 m^2 and 0.5 m^2 area surrounding each known collection location of Comal Springs riffle beetles and dryopid beetles, respectively, in the San Marcos system. This aided in the quantification of overall surface area of occupied habitat for the 2021 assessment. It is noted that only surface habitat area was calculated for this assessment, as the extent of subsurface habitat utilization by these species is presently unknown. Appendix A shows the occupied habitat for the Comal Springs riffle beetle and Comal Springs dryopid beetle, respectively in the San Marcos system with the quantification of area presented in Table 1.

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, Texas wild-rice protection zones
    - Non-native species removal
    - Restoration and maintenance of native aquatic vegetation
    - Sediment removal
    - Access Points and Bank Stabilization
    - Riparian restoration

For 2021 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 completed during 2016 and thus no calculations were included in the 2021 evaluation for that finished project. Similarly, the **Flow-split management** project was completed in spring 2014 and involved portions of Landa Lake and the Old Channel. Activities conducted in 2021 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 2021.

The **restoration and maintenance of native aquatic vegetation** project involved restoration activities in the Comal system as shown in Figure 1. These activities included routine aquatic gardening and restoration plantings of native aquatic vegetation. The 2021 project footprint for native vegetation restoration activities are 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 1). As noted in Table 2, the project footprint of the Native Aquatic Vegetation restoration effort in the Comal system encompassed 752 m^2 of which 473 m^2 overlaps with 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.

TABLE 2. Mitigation and Restoration Project Areas and Calculated Impact Area per Covered Species in 2021

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	--	--	--	--	--		
Restoration and maintenance of native aquatic vegetation	752	473	0	0	0		
Decaying vegetation removal	**A**	--	--	--	--		
Aeration program	Discontinued in 2018						
Gill parasite	0	0	0	0	0		
Riparian restoration	2,115	--	--	--	--		
Bank Stabilization	Completed in 2016						
Riffle beetle restoration	1,697	0	0	0	0		
Non-native animal species removal	**A**	--	--	--	--		
Sediment Island removal	Completed in 2013						
TOTAL	4,564	473	0	0	0		
CITY OF SAN MARCOS / TEXAS STATE UNIVERSITY							
Enhancement and restoration of Texas wild-rice	**B**	--	--	--		--	--
Management of recreation specific to Protection zones (only)	6,000	22.9	--	--		4.3	--
Non-native animal species removal	**A**	--	--	--		--	--
Restoration and maintenance of native aquatic vegetation	3,228	2,490	0	0		236	0
Sediment removal	**C**	--	--	--		--	--
Access Points and Bank Stabilization	**C**	--	--	--		0	0
Riparian restoration	52,956	0	0	0		0	0
TOTAL	62,184	2,512.9	0	0		240.3	0

A Throughout system – described in qualitative impacts discussion
B Project footprint is accounted for in Native Aquatic Vegetation restoration project
C No independent activities conducted in 2021.

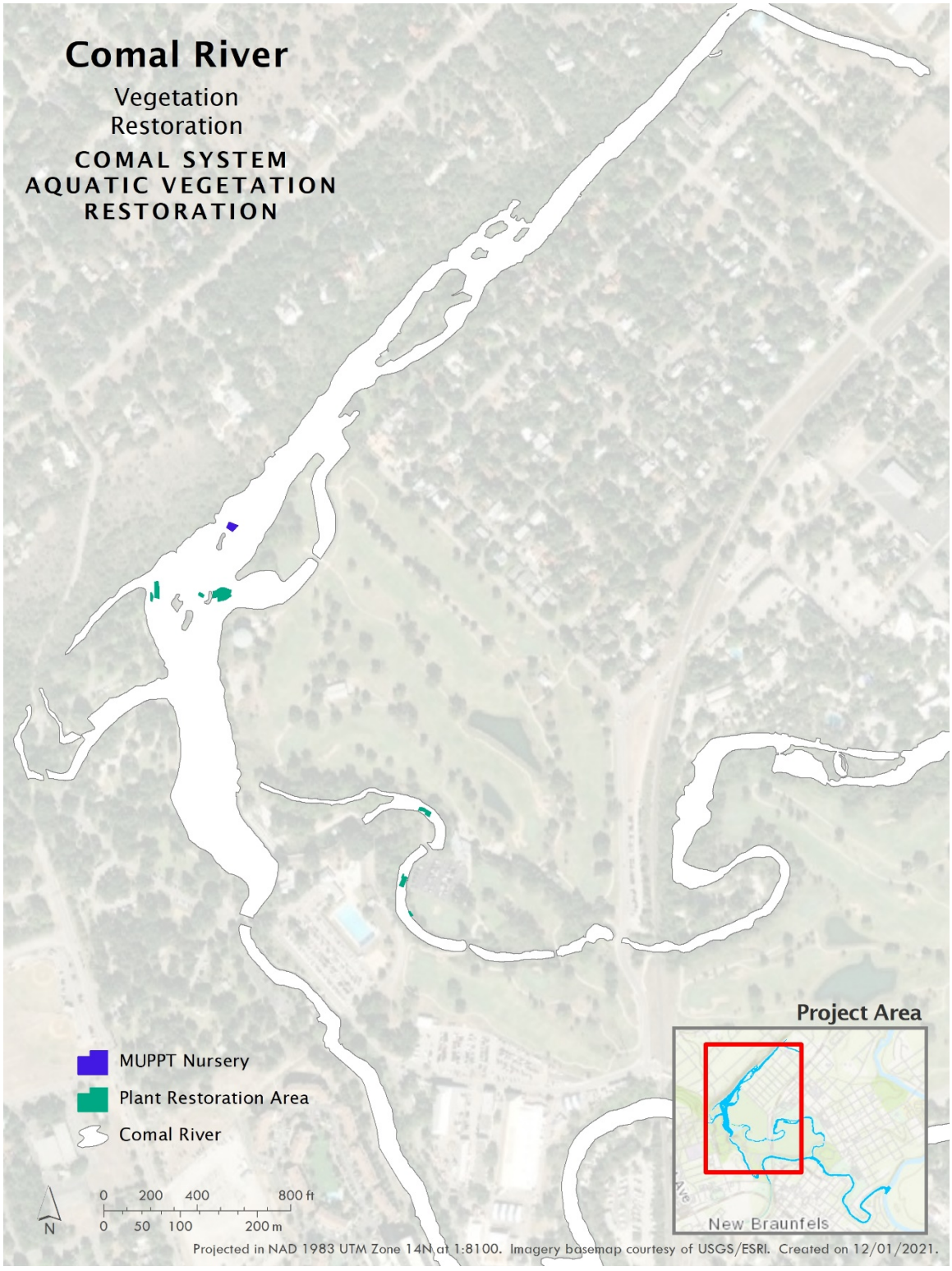

Figure 1. Restoration and Maintenance of Native Aquatic Vegetation project in the Comal system.

The **Sediment Island removal** project in the Old Channel was completed in 2013 and thus no calculations were included in the 2021 evaluation for that finished project. Activities associated with supplemental planting of native aquatic vegetation in that section of the Old Channel were covered under the native aquatic restoration project. 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 2021 for this activity. Temporary disturbance resulting from occasional foot traffic within Fountain Darter occupied habitat did occur as well as slightly elevated turbidity downstream from immediate work zone. The **Aeration** project in Landa Lake was discontinued in 2018 and thus no calculations were included in the 2021 evaluation.

The **Gill parasite** project was reduced to one-time water sampling at designated cross sections in 2021 via kayak and thus no impacts were noted for this activity. The **Riffle beetle restoration** project involved only on shore activities in 2021 (Figure 2). The project footprint occurred on the bank adjacent to Spring Run 3 where restoration consisted of planting native vegetation as a buffer between the park sidewalk and the spring run edge. The **Non-native animal species removal** project had a change of contractors in 2019 to Atlas Environmental who continued these duties in 2021. There is no project footprint map per their methodologies as it is now conducted throughout Landa Lake and the Comal River without permanent or temporary installation of equipment. Most all work was conducted via snorkel or SCUBA in areas of high fish density with non-native fish being speared. **Riparian restoration** was continued around Landa Lake in 2021 and involved a project footprint of 2,115 m^2. The riparian treatment areas are depicted on Figure 3 and quantified in Table 2. Similar to the more established HCP riparian restoration project in the San Marcos system, all activities were conducted on the banks and water's edge and did not overlap with any occupied habitat for the covered species.

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 4. 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 2021. 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 3,228 m^2 of which 2,490 m^2 overlaps with Fountain Darter occupied habitat. 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.

Total system discharge in the San Marcos River declined below 120 cfs during the spring and thus, four Texas wild-rice **Protection Zones** were incorporated in 2021 (Figure 5). These areas included Clear Springs river left; immediately below Sewell Park river right; directly across from the Veramendi access point river left; and Bicentennial Park river right. The total footprint of these areas resulted in the protection of approximately 6,000 m^2. The upstream protection zone in the eastern spillway below Spring Lake Dam was strategically placed over Fountain Darter and San Marcos salamander occupied habitat as well as Texas wild-rice. Although this area overlaps each of these covered species occupied habitats, the majority of the project footprint is a net benefit from the protection of recreation in these areas. The impact areas listed in Table 2 represent a 0.5 m swath across the floating buoy installation path of the protection zones to account for the placement of the floating buoys (45.85 total linear feet) used to deter recreators. As such, the total disturbance area for the four protection zones was 22.9 m^2 for the Fountain Darter and 4.3 m^2 for the San Marcos salamander which is only impacted by the upper portion of the protection zone just below Spring

Lake dam. Temporary disturbance of slightly elevated turbidity to downstream areas did result during buoy placement and retrieval.

As in years past, there is no project footprint map for the **Non-native animal 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.

There was no new work in 2021 with respect to **Access Points** or **Bank Stabilization** in the San Marcos system and thus no calculations were included in the 2021 evaluation. The **Riparian restoration** project along the San Marcos River in 2021 involved a project footprint of approximately 52,956 m^2. The active riparian treatment areas are depicted on Figure 6 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 2. Comal Springs Riffle Beetle Restoration project – Comal System.

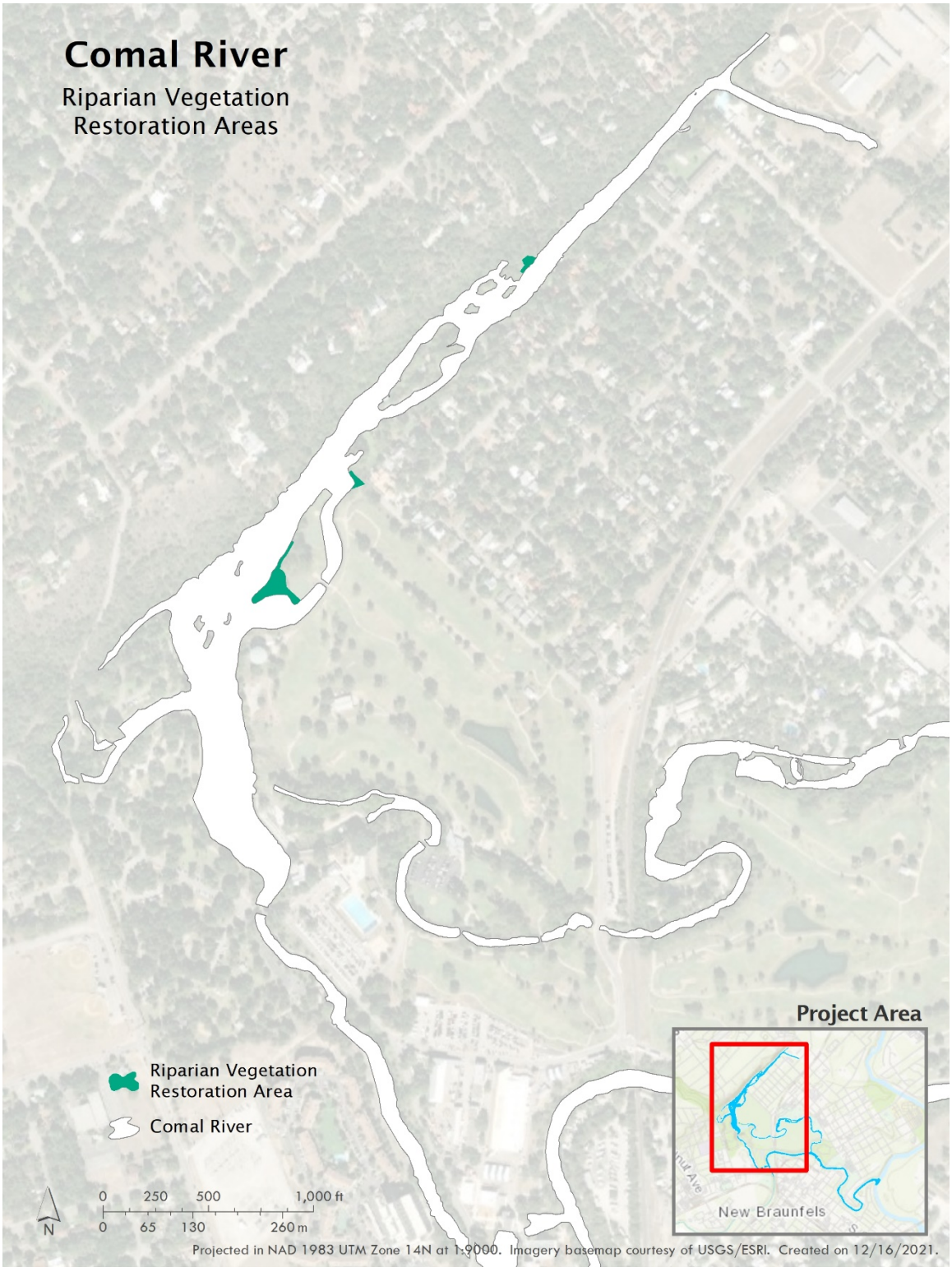

Figure 3. 2021 Riparian Vegetation Restoration Areas – Comal System.

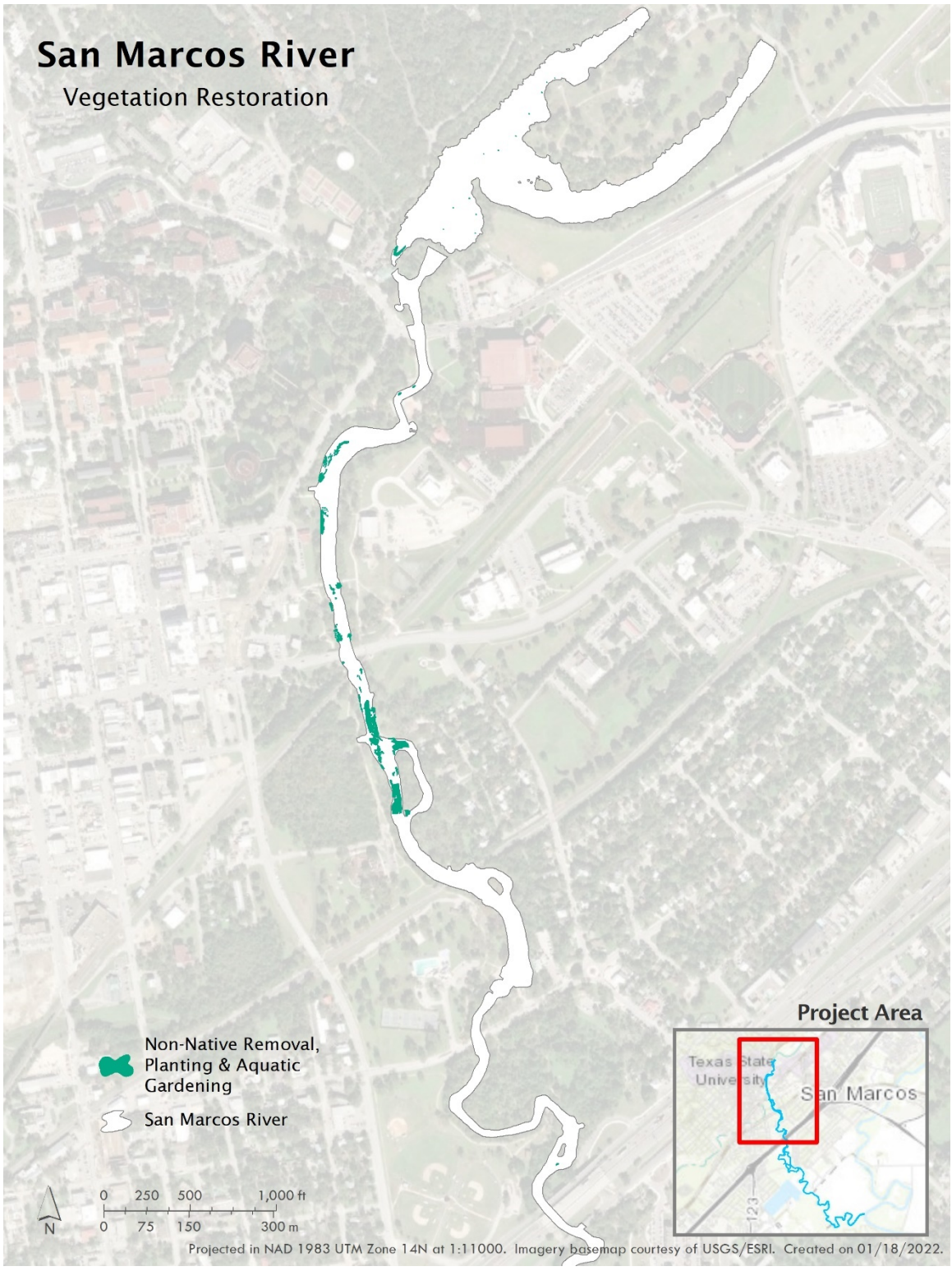

Figure 4. Restoration and Maintenance of Native Aquatic Vegetation and Enhancement of Texas wild-rice projects – San Marcos River.

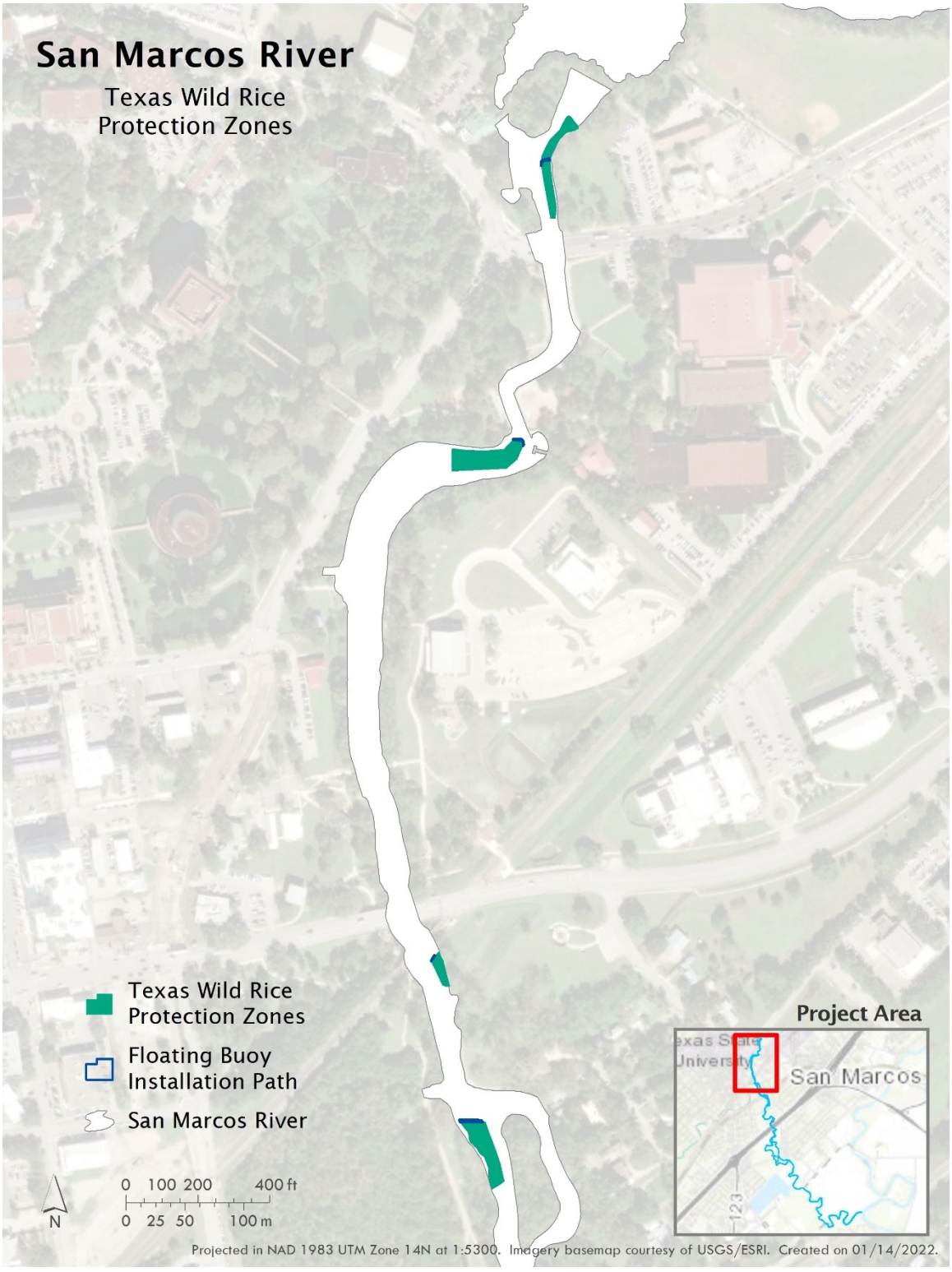

Figure 5. Four Texas wild-rice Protection Zones installed during 2021 – San Marcos River.

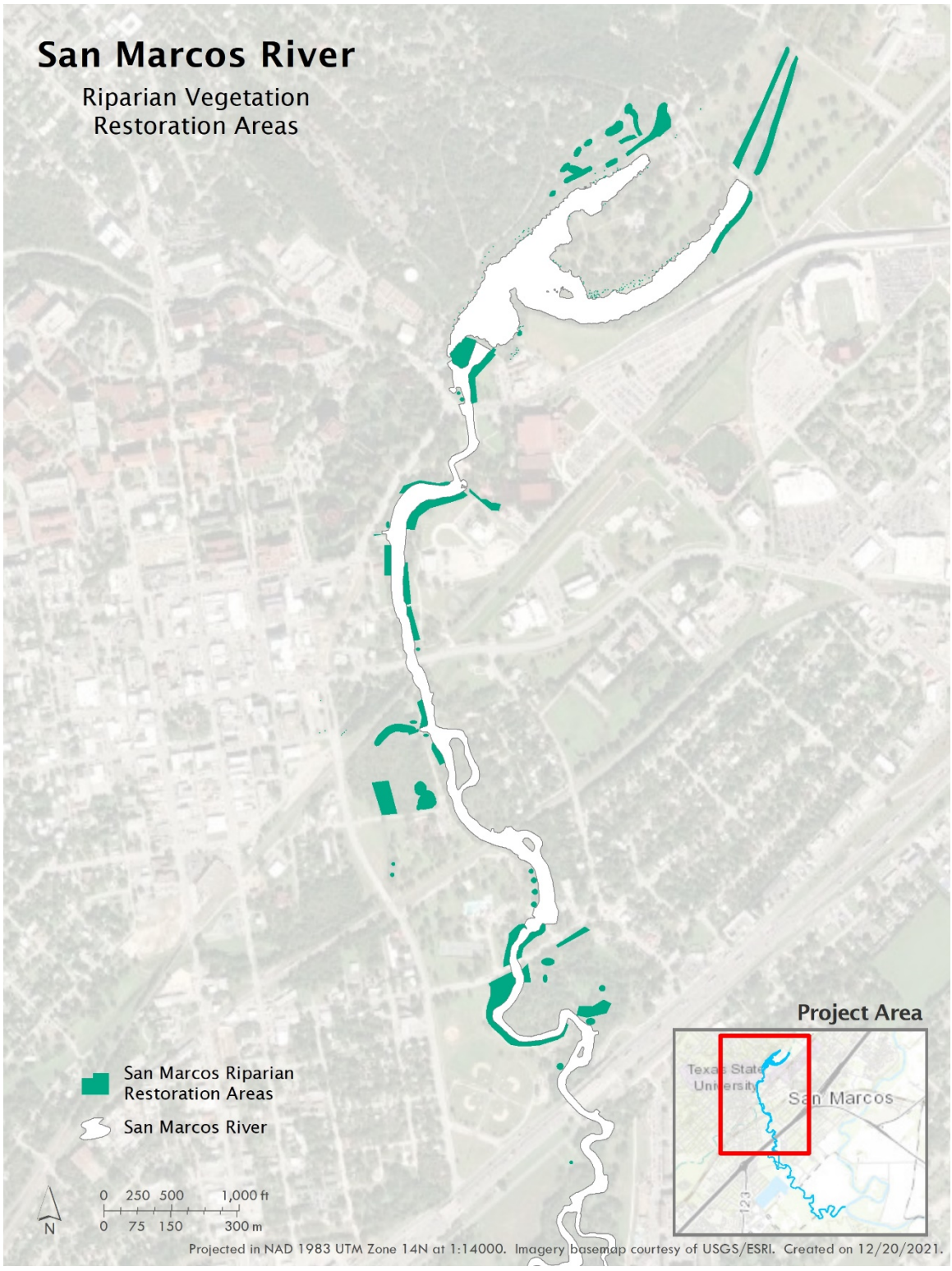

Figure 6. 2021 Riparian Restoration areas – San Marcos River.

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. The focus was on quantifying the direct impacts 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 Fountain Darter had < 0.5% of its total occupied habitat disturbed (Table 3) in the Comal system.

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	103,909	473	< 0.5%
Comal Springs riffle beetle	1,681	0	--
Comal Springs dryopid beetle	362 [A]	0	--
Peck's Cave amphipod	1,640 [A]	0	--
CITY OF SAN MARCOS / TEXAS STATE UNIVERSITY			
Fountain Darter	95,287	2,512.9	2.6%
San Marcos salamander	2,520	4.3	< 0.5%
Texas blind salamander	[B]		
Comal Springs riffle beetle	11	0	0
Comal Springs dryopid beetle	0.5 [A]	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 and San Marcos Salamander had net disturbance per this assessment with approximately 2.6% and < 0.5% of their total occupied habitat disturbed, respectfully. For the Texas blind salamander, Comal Springs riffle beetle and Comal Springs dryopid beetle, there were no activities conducted in 2021 that directly impacted any of the locations or orifices where collections have routinely been made over the years. As such, no direct impacts to subterranean or aquifer habitat was experienced from 2021 HCP mitigation and restoration measures in the San Marcos system.

In summary, the ITP 10% disturbance rule (Item M [a]) was in compliance for 2021.

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 2021 as a result of implementation of the 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 understand the assessment, it is vital to understand what "take" and "incidental take" 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 the Items described below.

Item T 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 U 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 lists 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 2021 for incidental take via EARIP's ITP. This includes the Fountain Darter, Comal Springs riffle beetle, Comal Springs 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 Springs salamander are listed in the permit, the conditions in the ITP are not active in 2021 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 2021, 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 activity 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 activity 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 activity 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.

2021 INCIDENTAL TAKE ASSESSMENT

The 2021 incidental take assessment described in this section was conducted in the same manner as previous years 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 2021. 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.

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 2021 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 7 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 8 and include the Spring Lake Dam sample reach, City Park sample reach, and the I35 sample reach. For both systems (Figures 7 and 8), 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.

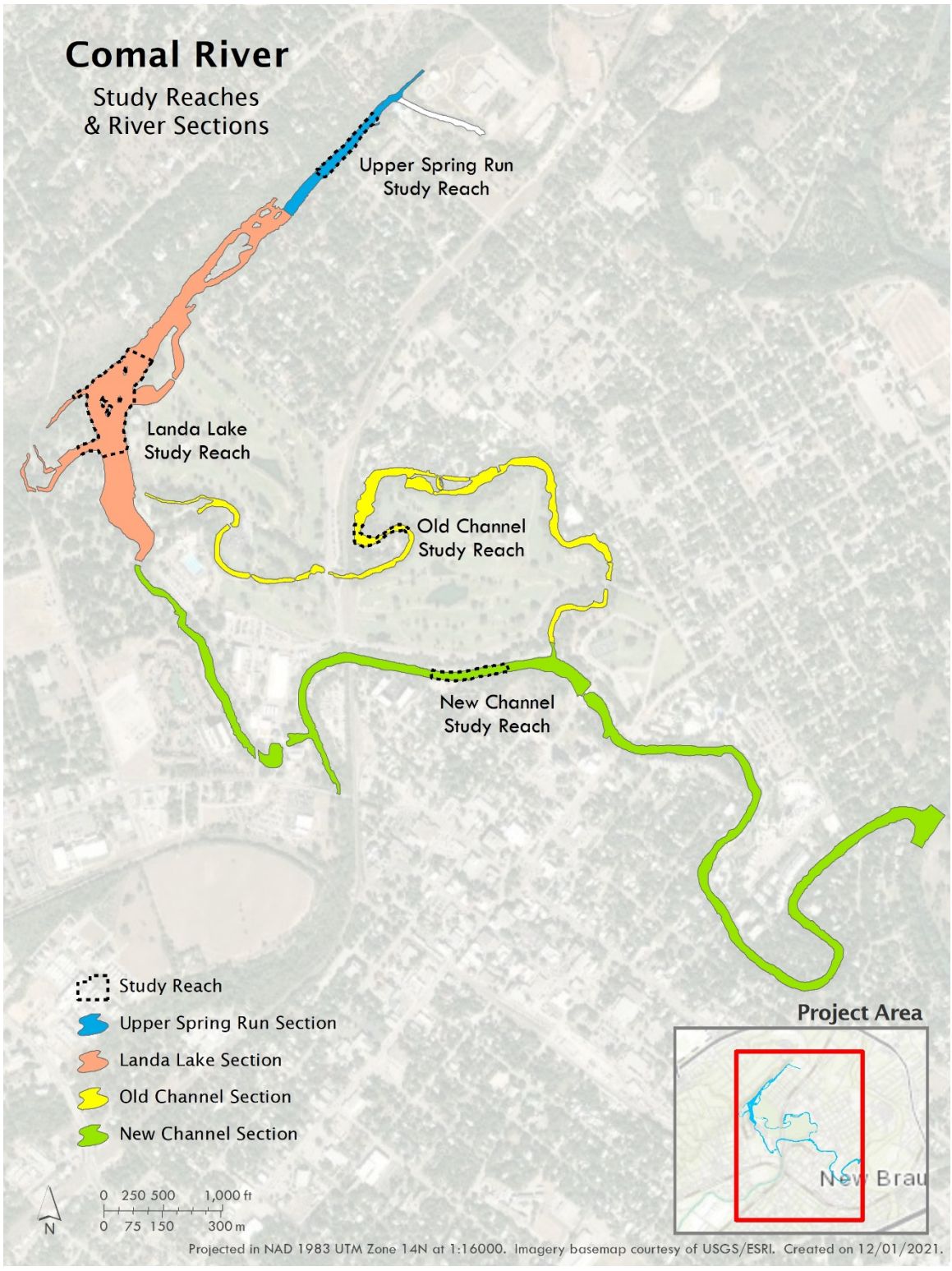

Figure 7. Study Reaches (4) for the Comal System and Corresponding River Section.

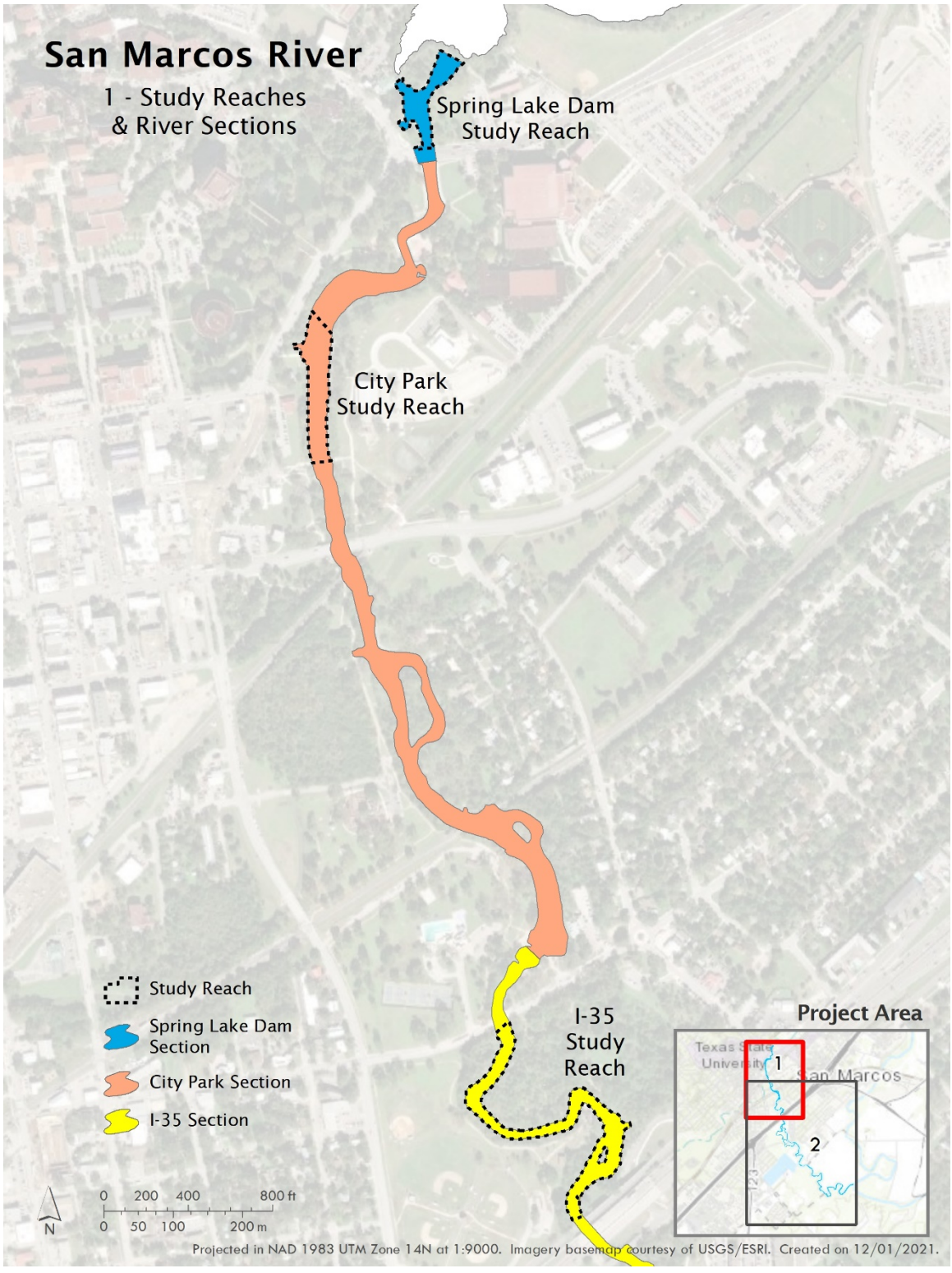

Figure 8. Study Reaches (3) for the San Marcos System and Corresponding River Section.

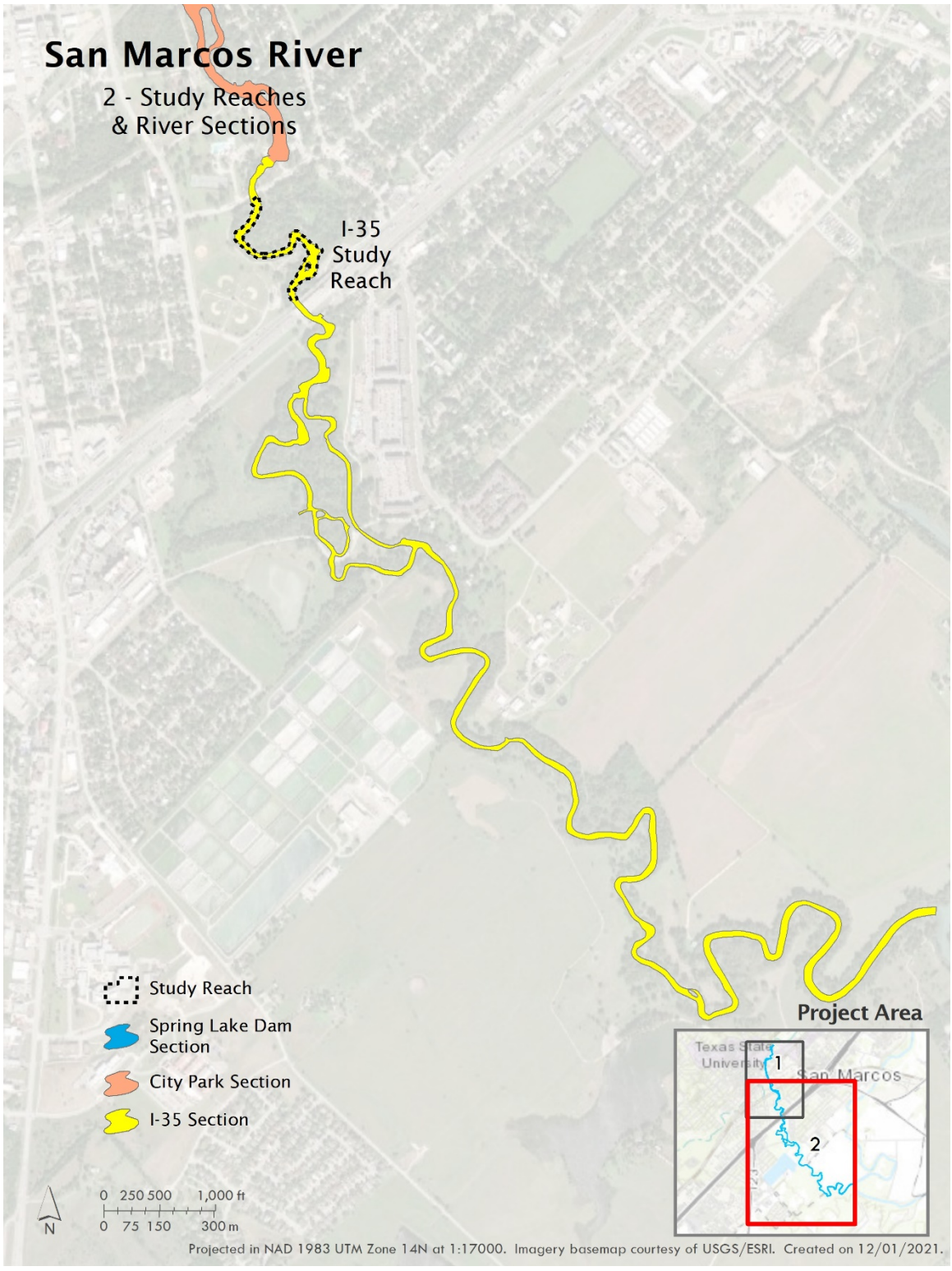

Figure 8 cont. I35 Study Reach and Corresponding Lower River Section in the San Marcos System.

Table 4 shows the total aquatic vegetation (m^2) present in each of the four 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 extended 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. 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. Figure 9 shows the Comal River hydrograph over the biological monitoring program time period with the larger daily average peak flows noted.

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
Spring_17	4/24/2017	429	2914	4/21/2017	438	19631	4/25/2017	428	1011	4/26/2017	424	1223
Fall_17	10/16/2017	288	2047	10/16/2017	288	18714	10/17/2017	282	821	10/18/2017	277	2224
Spring_18	4/272018	277	2409	4/23/2018	283	19019	5/1/2018	273	877	4/24/2018	280	1637
Fall_18	10/4/2018	322	1603	10/8/2018	332	17499	10/11/2018	334	1053	10/12/2018	329	2579
Spring_19	4/19/2019	358	2088	4/252019	363	18925	4/19/2019	358	302	4/22/2019	355	2104
Fall_19	9/5/2019	313	1922	9/4/2019	312	18496	9/9/2019	318	535	9/16/2019	306	2221
Spring_2020	5/24/2020	304	1621	5/24/2020	304	18811	5/27/2020	304	398	5/28/2020	304	2315
Fall_2020	9/24/2020	278	1434	9/23/2020	279	17344	9/15/2020	268	560	9/18/2020	269	3008
Spring_2021	4/19/2021	205	1403	4/19/2021	205	18154	4/20/2021	203	378	4/21/2021	200	2516
Fall_2021	9/16/2021	265	1785	9/21/2021	264	18144	9/15/2021	266	779	10/22/2021	286	2511

"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

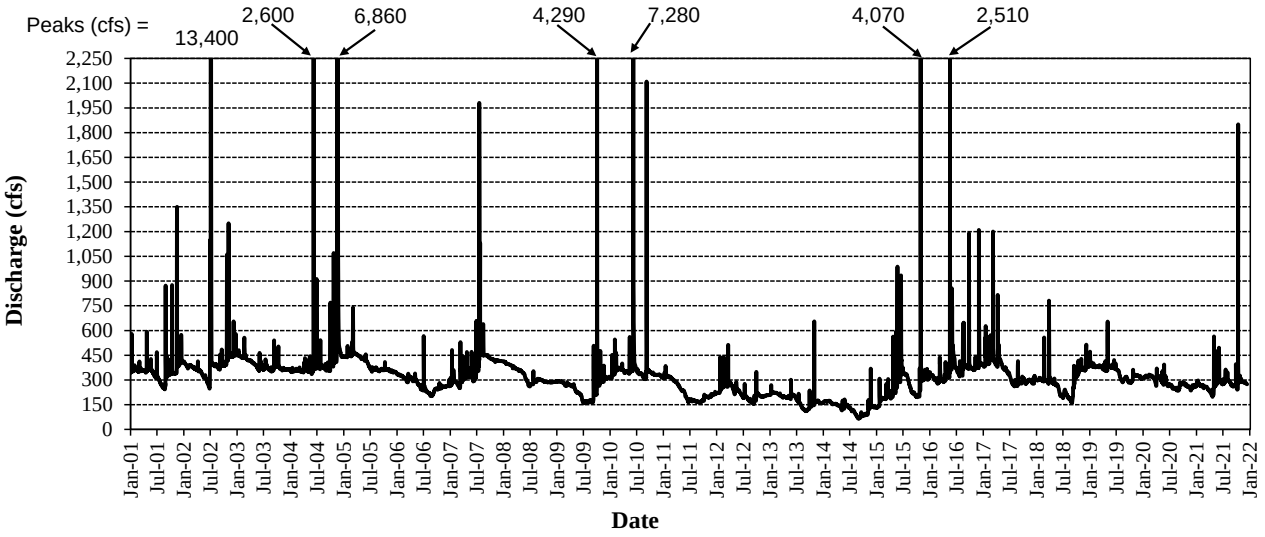

Figure 9. Comal River hydrograph presented as daily discharge over the biological monitoring period.

Table 5 shows the total aquatic vegetation (m^2) present in each of the three 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 10 depicts the San Marcos River hydrograph over the biological monitoring time period which also includes daily average peak flows and dates experienced.

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
Spring_17	4/17/2017	297	1366	4/18/2017	293	3681	4/20/2017	292	1404
Fall_17	10/11/2017	202	1373	10/12/2017	203	2840	10/9/2017	205	1881
Spring_18	4/18/2018	177	1553	4/18/2018	177	3024	4/19/2018	177	2011
Fall_18	10/3/2018	172	1386	10/3/2018	172	2395	10/5/2018	174	2040
Spring_19	4/3/2019	238	1799	4/9/2019	264	3071	4/11/20019	243	2317
Fall_19	10/3/2019	187	1690	10/2/2019	186	2778	10/4/2019	185	2194
Spring_2020	5/14/2020	165	1817	5/15/2020	166	3723	5/16/2020	172	2651
Fall_2020	9/25/2020	139	1749	9/29/2020	137	3376	9/30/2020	137	2039
Spring_2021	4/14/2021	106	2060	4/15/2021	103	4139	4/13/2021	100	2170
Fall_2021	10/5/2021	137	1583	10/5/2021	137	2250	10/4/2021	144	2235

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

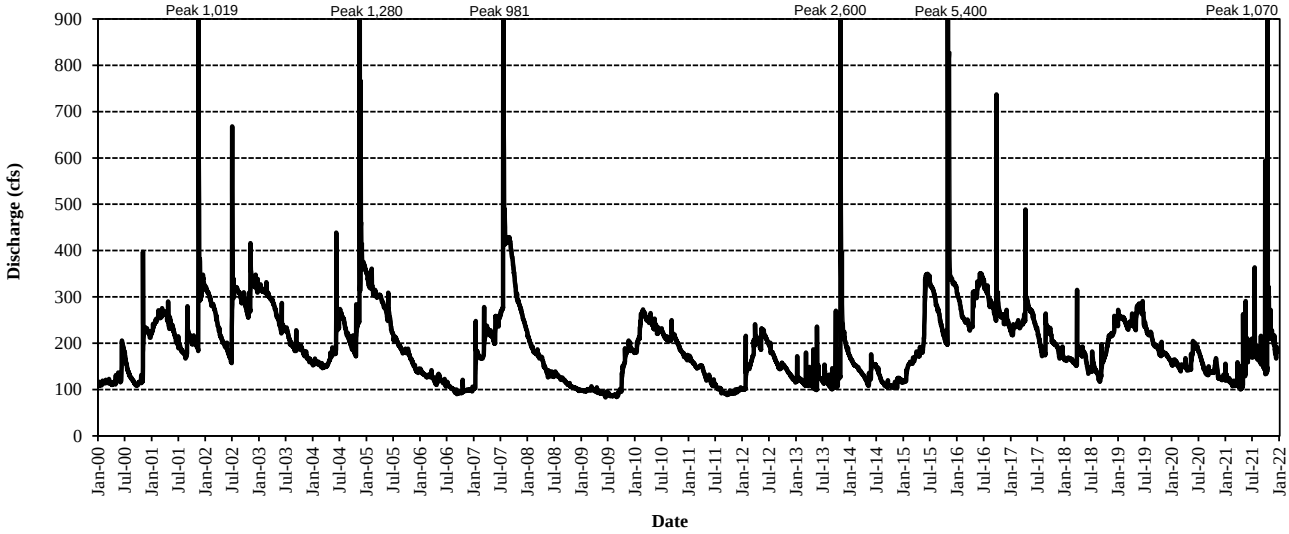

Figure 10. San Marcos River hydrograph presented as daily discharge over the biological monitoring period.

Table 6 shows the percentage retention in aquatic vegetation observed from spring to fall for average and drought years as well as individually for 2021. As evident in Table 6, only the New Channel had a decline relative to average conditions in overall aquatic vegetation in 2021 from spring to fall in the Comal system. In the San Marcos system, both the Spring Lake Dam and City Park sample reaches experienced declines (relative to average conditions) in aquatic vegetation from spring to fall in 2021 (Table 6).

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	83.34%	95.98%	102.58%	122.40%	89.22%	91.74%	97.76%
Drought Years	51.58%	92.38%	103.43%	123.45%	72.97%	76.97%	101.37%
Spring 2021 coverage (m^2)	1,403.01	18,154.30	377.60	2,516.20	2,060.30	4,139.30	2,170.00
Fall 2021 coverage (m^2)	1,785.40	18,144.20	779.10	2,511.30	1,583.20	2,249.80	2,234.70
2021 Spring to Fall Retention	127.25%	99.94%	206.33%	99.81%	76.84%	54.35%	102.98%

Table 7 shows the conversion process from percentage retention between spring and fall aquatic vegetation during average years when compared directly to 2021. Using the Spring Lake Dam sample reach as an example, there is an 89% retention during average years. This implies that under average conditions in the Spring Lake Dam reach there is a 11% decline in aquatic vegetation 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 (89.22% [average] – 76.84% [2021] = -12.38%) is the value used to assess the overall loss of Fountain Darter occupied habitat within this river section. As shown in Table 7, only the New Channel reach in the Comal system showed a 2021 decline greater than average conditions resulting in 42 m^2 of impacted habitat. Both the Spring Lake Dam and City Park study reaches in the San Marcos River experienced declines greater than average during 2021. The total Fountain Darter occupied habitat designated for the Spring Lake Dam section is 1,907 m^2 and City Park section is 33,718 m^2 (Table 7). The percent difference from these reaches multiplied by the total m^2 from the entire section results in 236 m^2 and 12,607 m^2, respectively (Table 7). For this incidental take assessment, those values are considered the amount of habitat that was impacted by the HCP Measures and Drought category for those particular river sections.

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	83.34%	95.98%	100%	100%	89.22%	91.74%	97.76%
2021 Actual	127.25%	99.94%	206.33%	99.81%	76.84%	54.35%	102.98%
	HABITAT CALCULATIONS applied to river sections						
Difference between Average and 2021 (%)	0%	0%	0%	0.19%	12.38%	37.39%	0%
Total Fountain Darter Occupied Habitat (m^2) per entire river section	4,281	54,919	23,084	21,625	1,907	33,718	6,472
2021 Total Impacted Area (m^2)	0	0	0	42	236	12,607	0

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 2021 (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 and displayed in Appendix A. No critical low flows occurred during 2021 which allowed Comal invertebrate occupied habitat to remain inundated and supported by spring flow and flowing water throughout the year. 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 2021. 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 2021 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 a 236 m^2 impacted area calculated for the Spring Lake Dam reach.

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 2021, 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.

In 2021, 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 used the densities of the covered species recorded over time via EAA biological monitoring in both systems prior to HCP implementation. 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 25th, 50th (median), 75th, and 90th percentile along with the mean density are included. Furthermore, only the spring and fall data sets 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 m^2) 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. For the Comal Springs dryopid beetle, limited captures over time resulted in only using the mean presented 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 mean 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 30% of the total occupied habitat was impacted for the Fountain Darter in the San Marcos system that would leave 70% of the occupied habitat for the Fountain Darter. For the incidental take calculation, the median density for the Fountain Darter (3.5 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 2021, thus they were not considered for causes of incidental take in this year's assessment. Figures 11 and 12 show water temperature ranges observed in each system over the course of 2021.

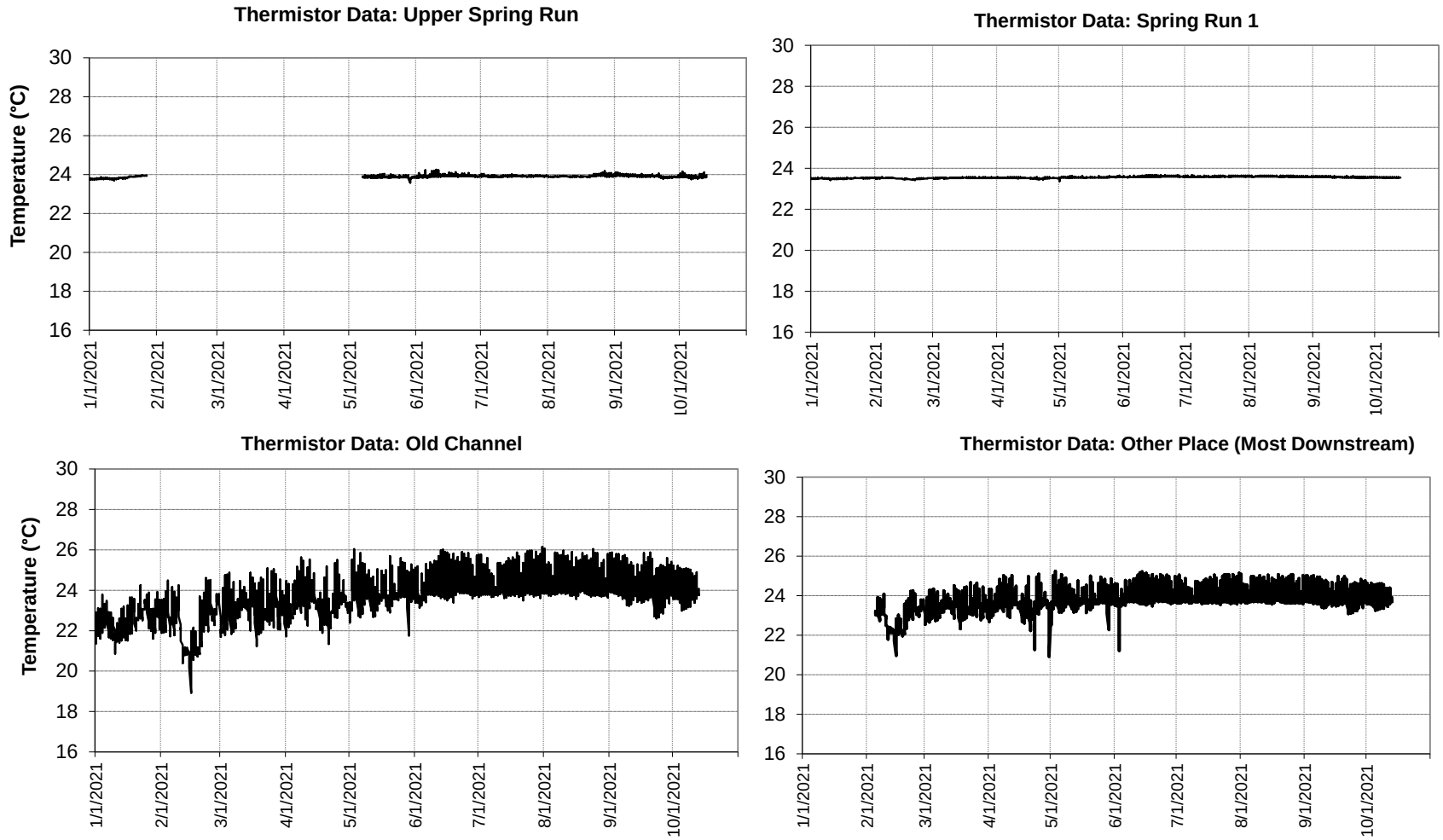

Figure 11. Thermistor data collected during 2021 at four select sites extending upstream to downstream in the Comal System.

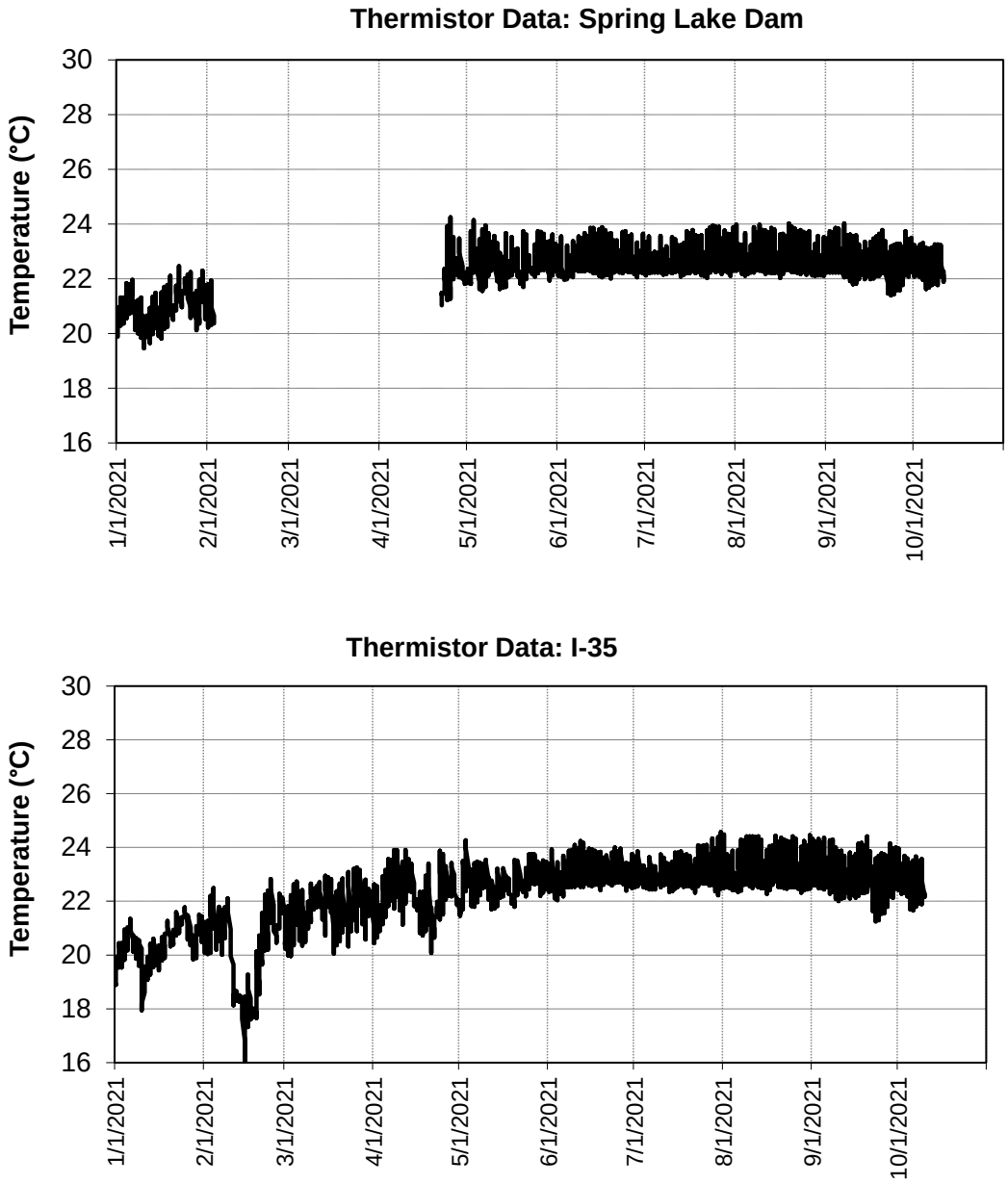

Figure 12. Thermistor data collected during 2021 at Spring Lake Dam and I-35 reaches of the San Marcos River.

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. 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.

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
2021 Impacted Area (m^2)	473	42	2,357	12,843	133	0
Total Occupied Habitat (m^2)	103,909.00	103,909.00	42,096.52	42,096.52	53,190.59	53,190.59
% of Occupied Habitat Impacted	0.46%	0.04%	5.60%	30.51%	0.25%	0.00%
Corresponding Habitat Percentile Density (individual/m^2)	1.50	1.50	1.50	3.50	1.50	--
Water Temperature Percentile Density adjustment	N/A	N/A	N/A	N/A	N/A	--
2021 Incidental Take Estimate	709.50	63.00	3,535.50	44,951.45	199.50	0
2021 TOTAL INCIDENTAL TAKE PER SYSTEM	773		48,686			

Comal Springs invertebrates:
There was no impacted habitat reported for the Comal Springs invertebrates in 2021, thus no incidental take was calculated for these species in 2021.

San Marcos salamander: Table 11 shows the incidental take calculated for the San Marcos salamander in the San Marcos system (San Marcos River and Spring Lake) relative to the HCP mitigation and restoration activities as well as the HCP measures and drought. In all instances the percentage of impacted areas was less than 16% of the total occupied habitat and thus the 25th percentile density was applied. In 2021, all impacted area was below Spring Lake Dam so only the San Marcos River 25th percentile density was applied.

Table 11. Calculated Incidental Take for the San Marcos salamander based on impacted habitat.

SAN MARCOS SALAMANDER PARAMETERS	SAN MARCOS SYSTEM			
	San Marcos River		Spring Lake	
	HCP Mitigation / Restoration	HCP Measures / Drought	HCP Mitigation / Restoration	HCP Measures / Drought
2021 Impacted Area (m^2)	4.3	236	0	0
Total Occupied Habitat (m^2)	1,530	1,530	990	990
% of Occupied Habitat Impacted	0.3%	15.4%	0.0%	0.0%
Corresponding Percentile Density (individual/m^2)	3.00	3.00	--	--
2021 Incidental Take Estimate	13	708	0	0
2021 TOTAL INCIDENTAL TAKE	721			

Texas blind salamander: There was no impacted habitat reported for the Texas blind salamander in 2021, thus no incidental take was calculated for the Texas blind salamander in 2021.

COMPILATION OF RESULTS AND SUMMARY

Table 12 summarizes the 2021 impacted habitat area and incidental take attributed to the HCP relative to the ITP permit amount. Per the established methodologies, only the Fountain Darter and San Marcos Salamander experienced incidental take during 2021.

Table 12. 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 2021 TOTAL (m^2)	INCIDENTAL TAKE		2021 INCIDENTAL TAKE TOTAL	ITP Maximum Permit Amount	ITP Permit Maximum minus (combined first 9 years)
	HCP Mitigation / Restoration	HCP Measures / Drought		HCP Mitigation / Restoration	HCP Measures / Drought			
COMAL SYSTEM								
Fountain Darter	473.0	42.0	**515.0**	709.5	63.0	**773**	797,000	730,413
Comal Springs Riffle Beetle	0	0	**0**	0	0	**0**	11,179	8,887
Comal Springs Dryopid Beetle	0	0	**0**	0	0	**0**	1,543	1,527
Peck's Cave Amphipod	0	0	**0**	0	0	**0**	18,224	18,057
SAN MARCOS SYSTEM								
Fountain Darter	2,490.0	12,843.3	**15,333.3**	3,735.0	44,951.5	**48,686**	549,129	401,394
San Marcos Salamander	4.3	236.0	**240.3**	12.9	708.0	**721**	263,857	260,462
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
Comal Springs Dryopid Beetle	0	0	**0**	0	0	**0**	n/a	n/a

The calculated value for the Fountain Darter in the Comal system was lower in 2021 than observed during 2020. The primary cause for the slight decrease observed this year was that none of the four study reaches exhibited declines in aquatic vegetation greater than average conditions from spring to fall. In 2021, all invertebrate restoration activities occurred on shore resulting in no calculated incidental take for the listed Comal invertebrates. For the San Marcos system, incidental take for the Fountain Darter increased considerably in 2021 compared to 2020. The increase in the San Marcos system was primarily due to large reductions in aquatic vegetation from spring to fall in both the Spring Lake Dam and City Park study reaches. The installation of the Texas Wild-rice protection zone in the Spring Lake Dam reach created some minimal calculated take for the San Marcos Salamander, but the larger calculated take was a result of the spring to fall decline in aquatic vegetation in this reach. San Marcos restoration activities in 2021 did not overlap with invertebrate occupied habitat resulting in no calculated incidental take for these covered species.

The higher levels of calculated take in the Spring Lake Dam and City Park reaches in 2021 were a result of aquatic vegetation building up considerably in these reaches in 2020 where Covid-19 restrictions, that limited recreational access, were in place for many sections of the San Marcos River. When recreationalists were allowed full access to the river in 2021, the spring to fall vegetation declines were predictably larger

than in previous years. Regardless, we are confident the incidental take numbers shown in Table 12 and documented in this memorandum continue to justify the data sets used and methodologies employed in 2021 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

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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.

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

(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.

APPENDIX A Covered Species 2021 Occupied Habitat Maps

Comal Springs / River

Comal River

Fountain Darter

1 - UPPER SPRING RUN

Occupied Habitat

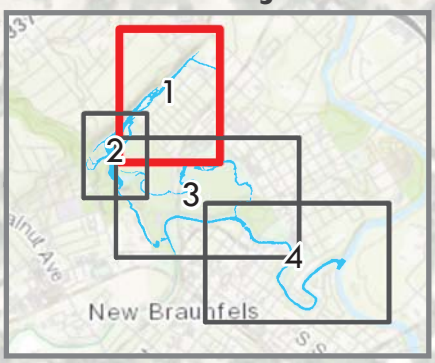
Comal River

N

0 125 250 500 ft

0 25 50 100 m

Project Area

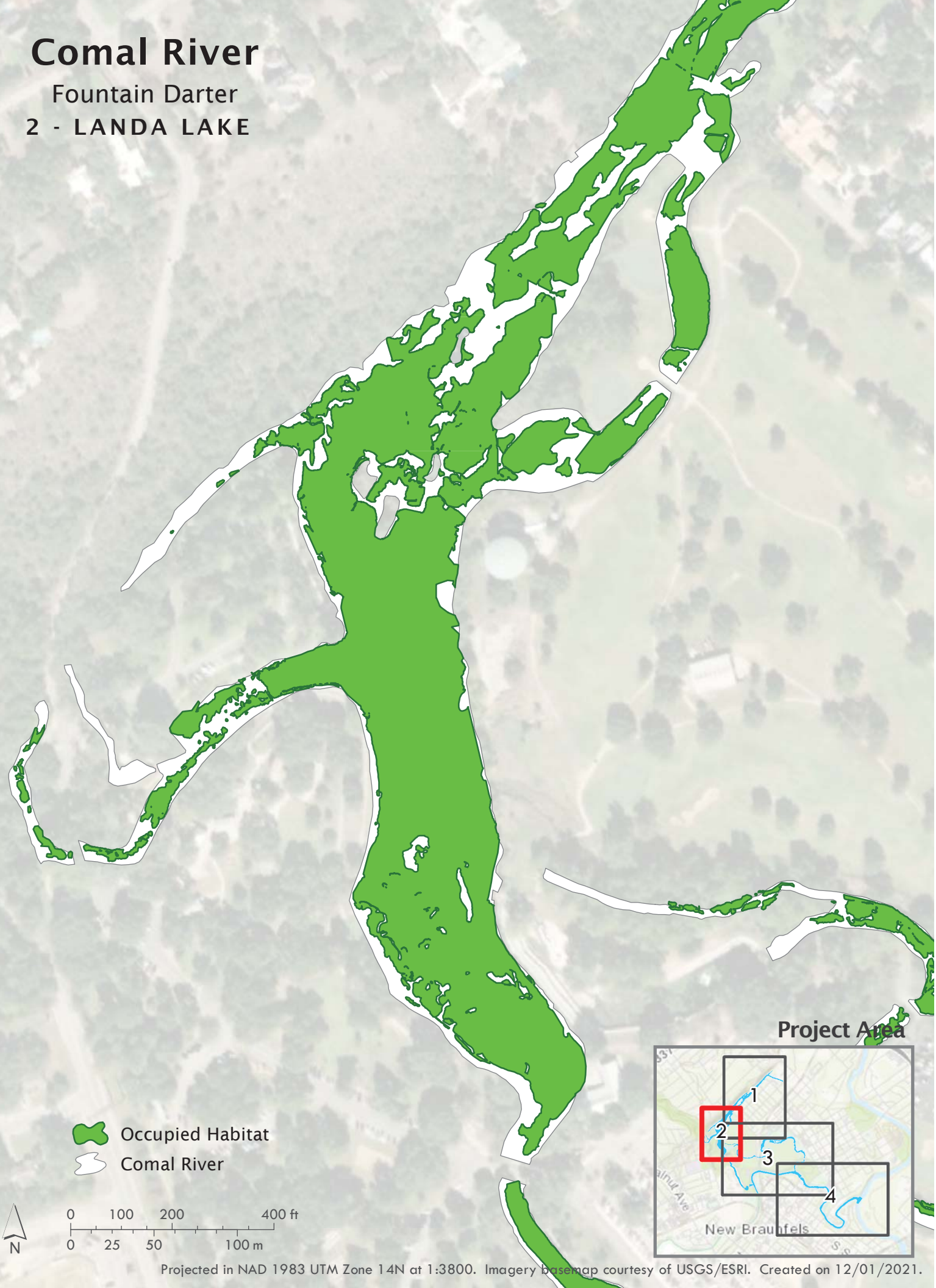


Projected in NAD 1983 UTM Zone 14N at 1:6000. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

Comal River

Fountain Darter

2 - LANDA LAKE



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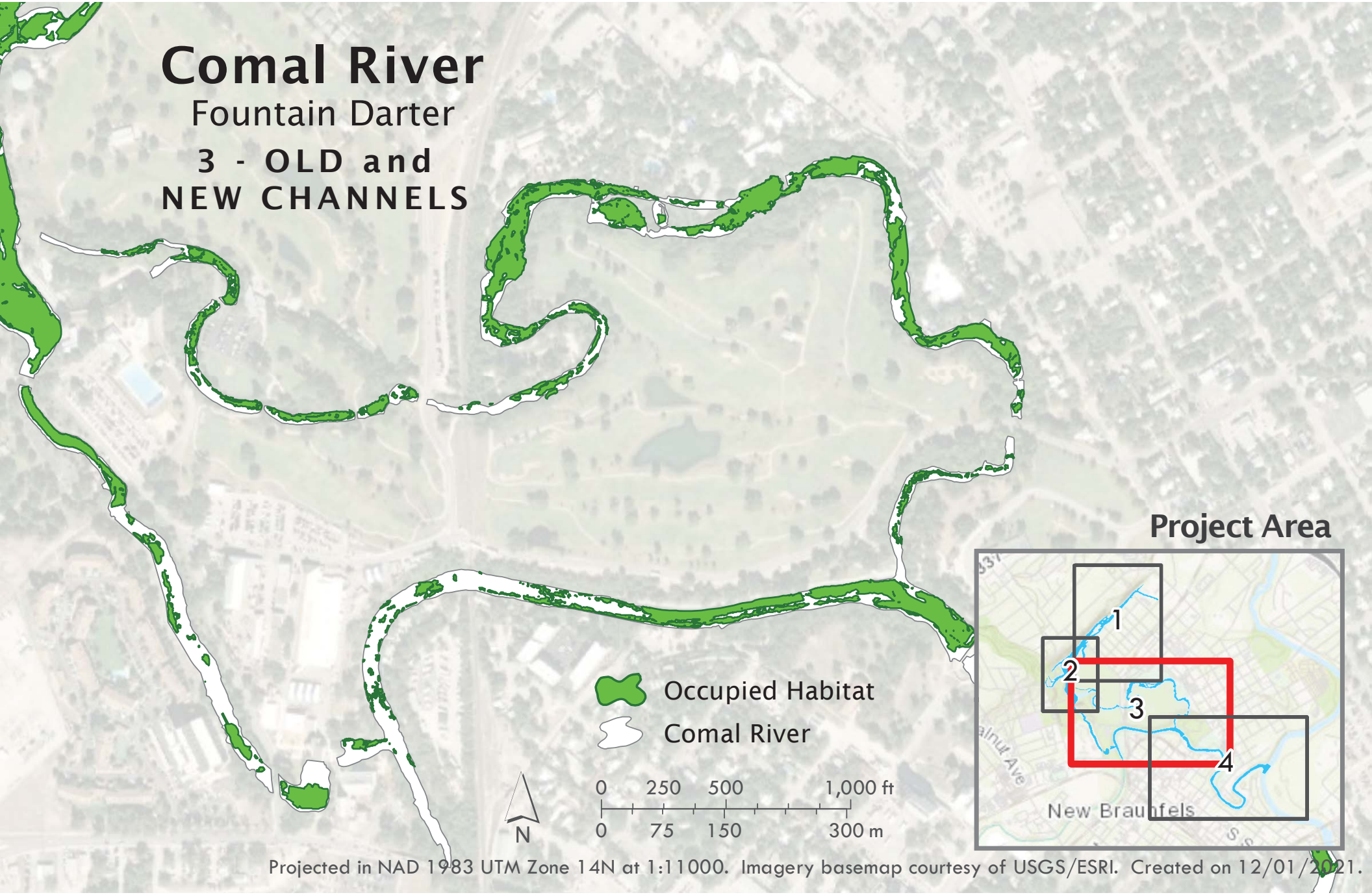
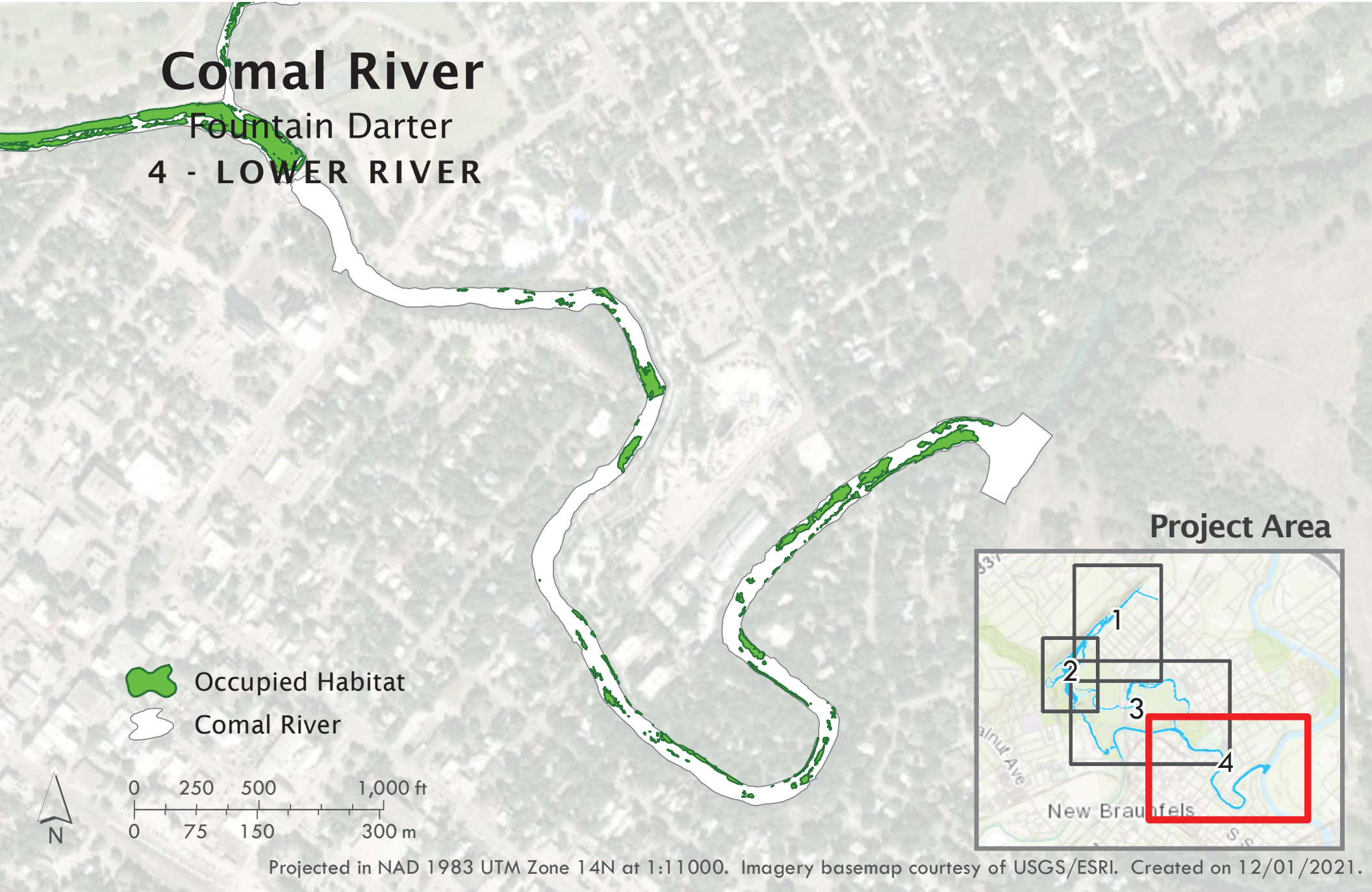

Comal River
Fountain Darter
3 - OLD and
NEW CHANNELS
Occupied Habitat
Comal River
N
0 250 500 1,000 ft
0 75 150 300 m
Project Area
1
2
3
4
New Braunfels
Projected in NAD 1983 UTM Zone 14N at 1:11000. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

Comal River

Fountain Darter

4 - LOWER RIVER

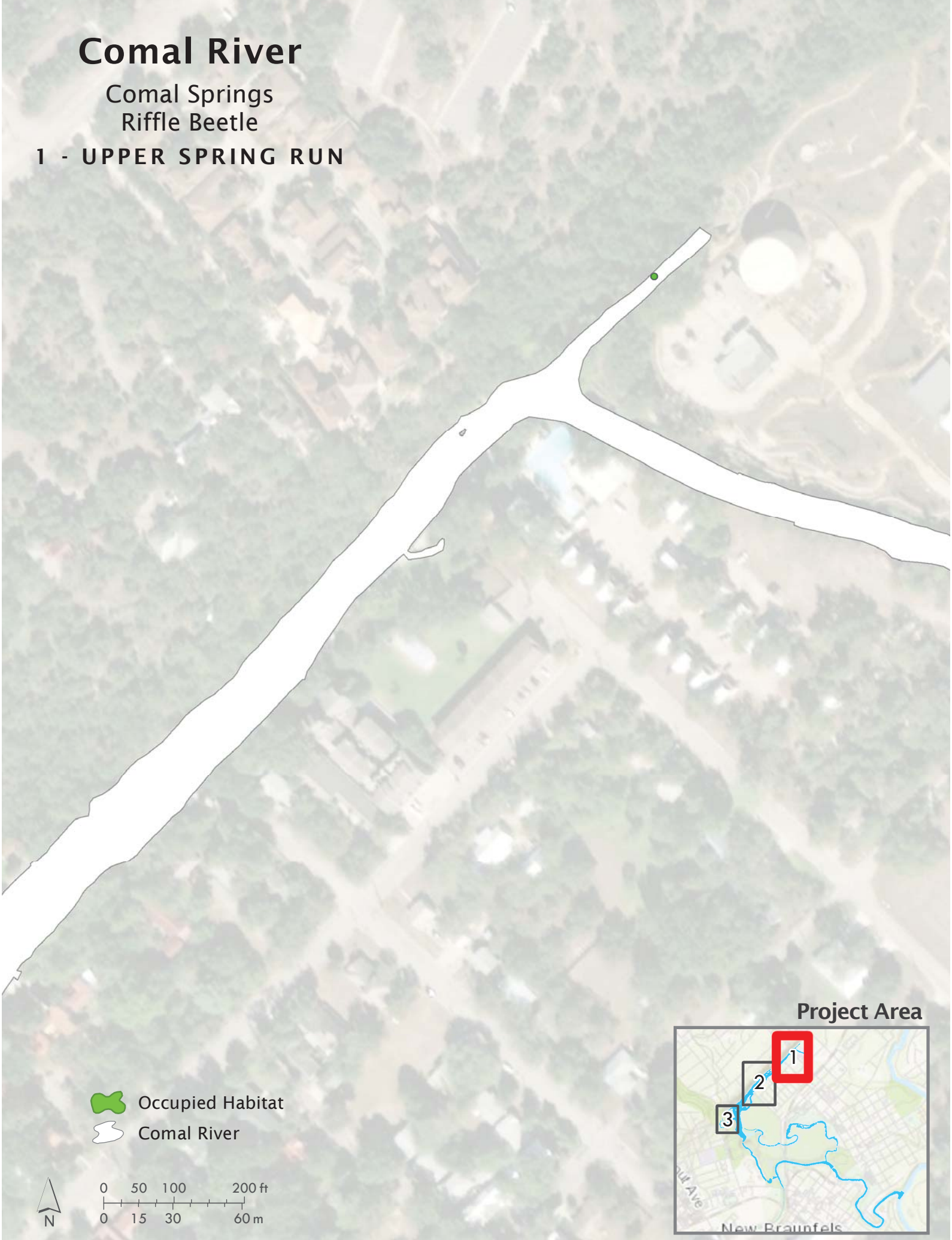


Projected in NAD 1983 UTM Zone 14N at 1:11000. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

Comal River

Comal Springs Riffle Beetle

1 - UPPER SPRING RUN

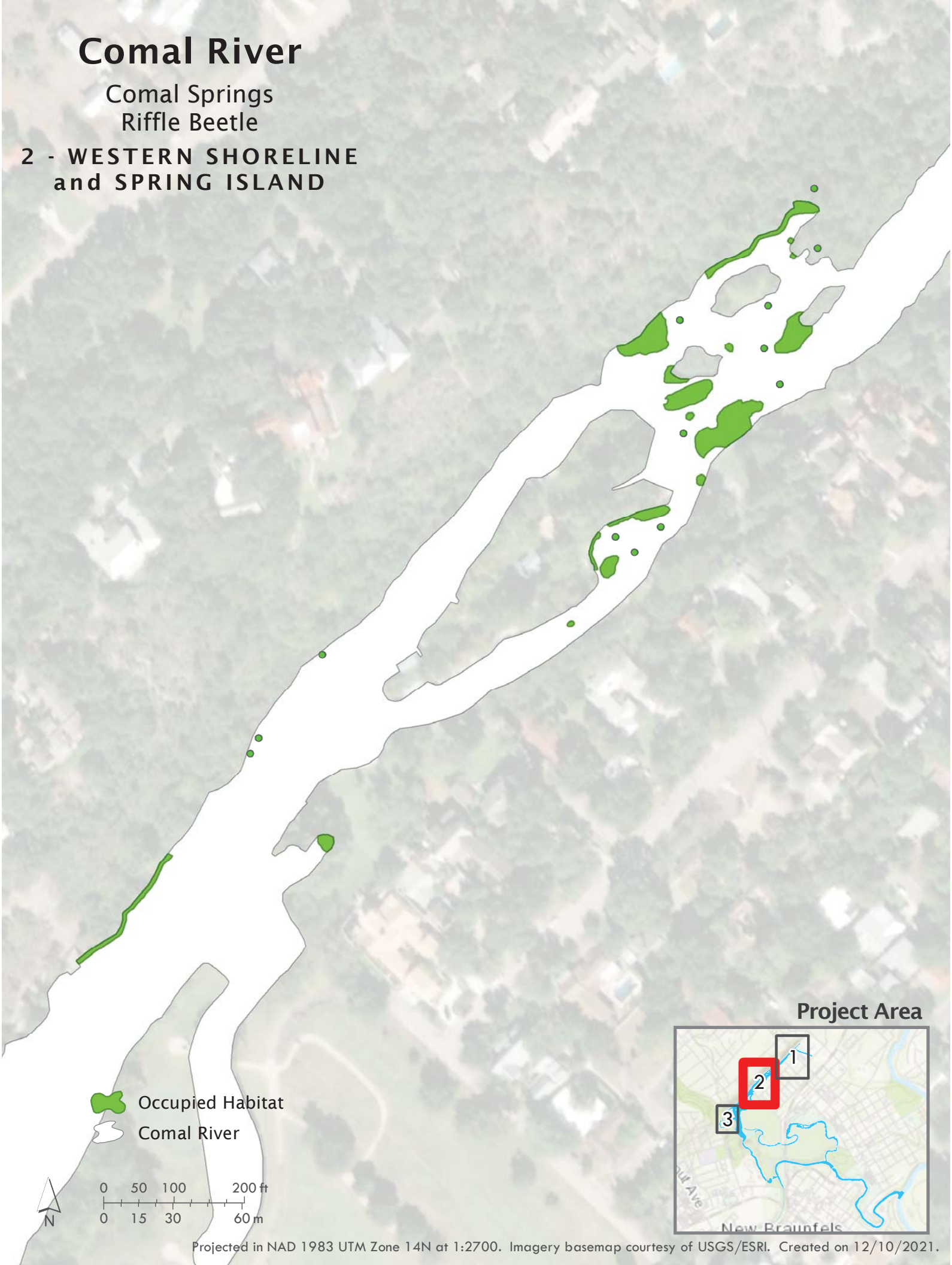


Projected in NAD 1983 UTM Zone 14N at 1:2700. Imagery basemap courtesy of USGS/ESRI. Created on 12/10/2021.

Comal River

Comal Springs Riffle Beetle

2 - WESTERN SHORELINE and SPRING ISLAND

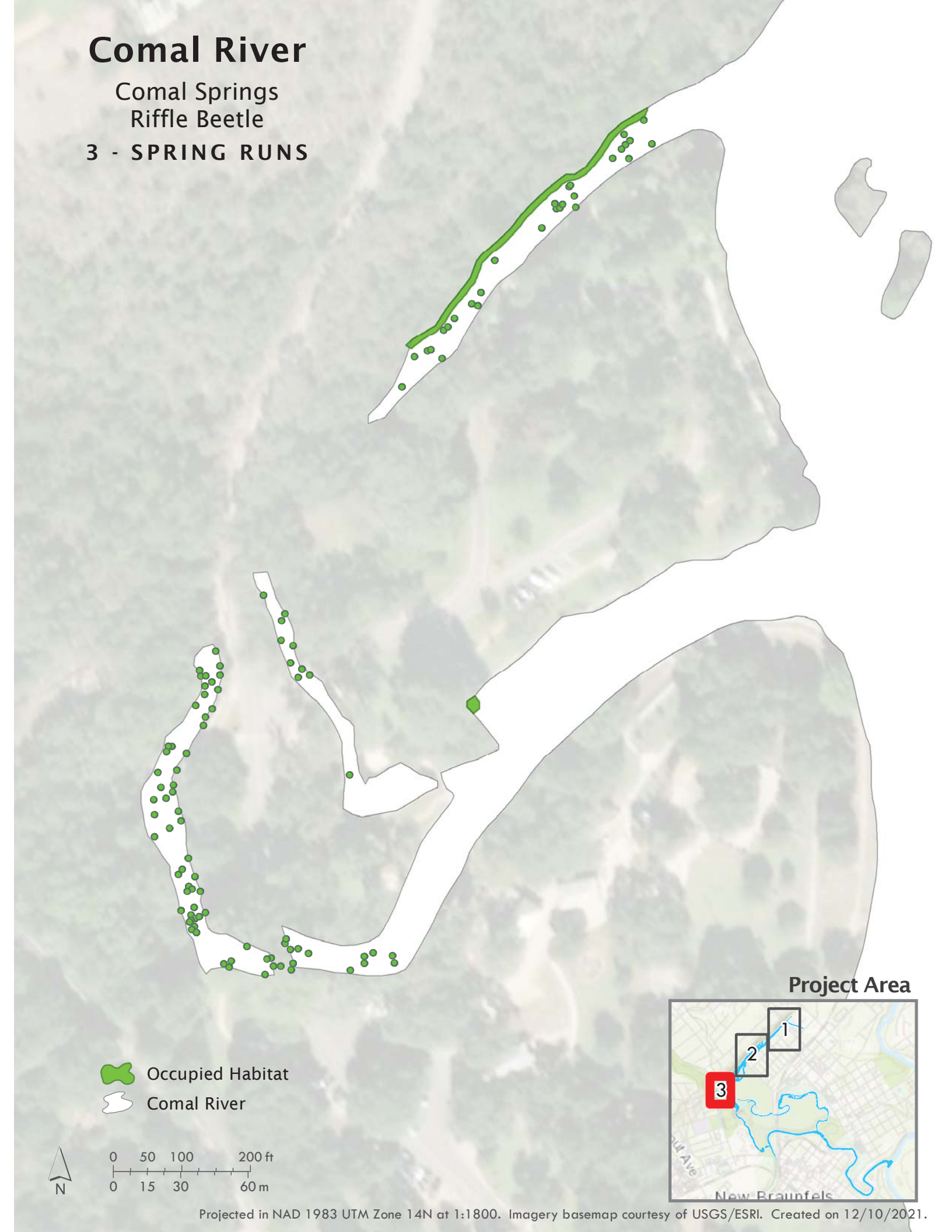


Projected in NAD 1983 UTM Zone 14N at 1:2700. Imagery basemap courtesy of USGS/ESRI. Created on 12/10/2021.

Comal River

Comal Springs
Riffle Beetle

3 - SPRING RUNS

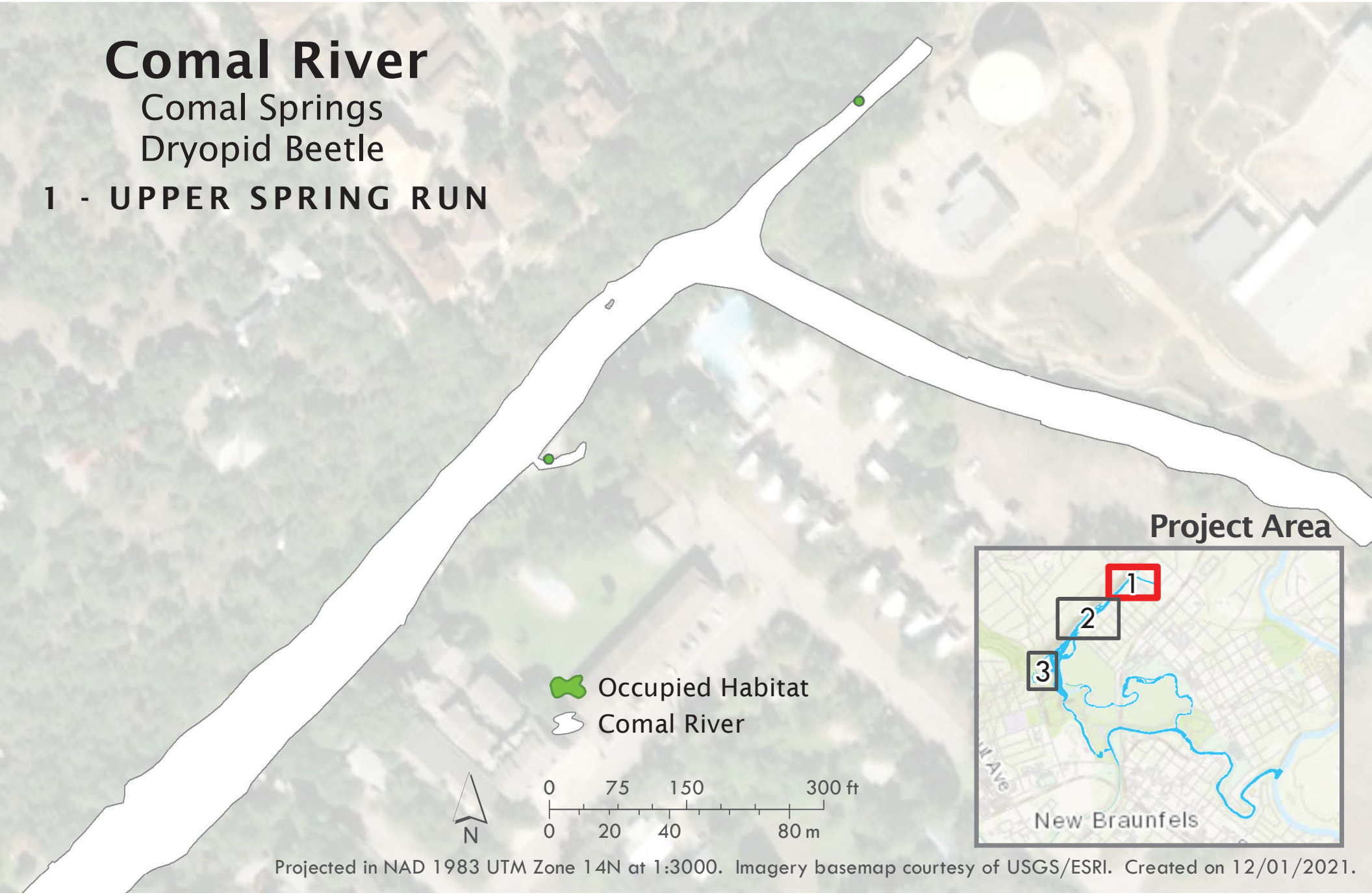


Projected in NAD 1983 UTM Zone 14N at 1:1800. Imagery basemap courtesy of USGS/ESRI. Created on 12/10/2021.

Comal River

Comal Springs Dryopid Beetle

1 - UPPER SPRING RUN

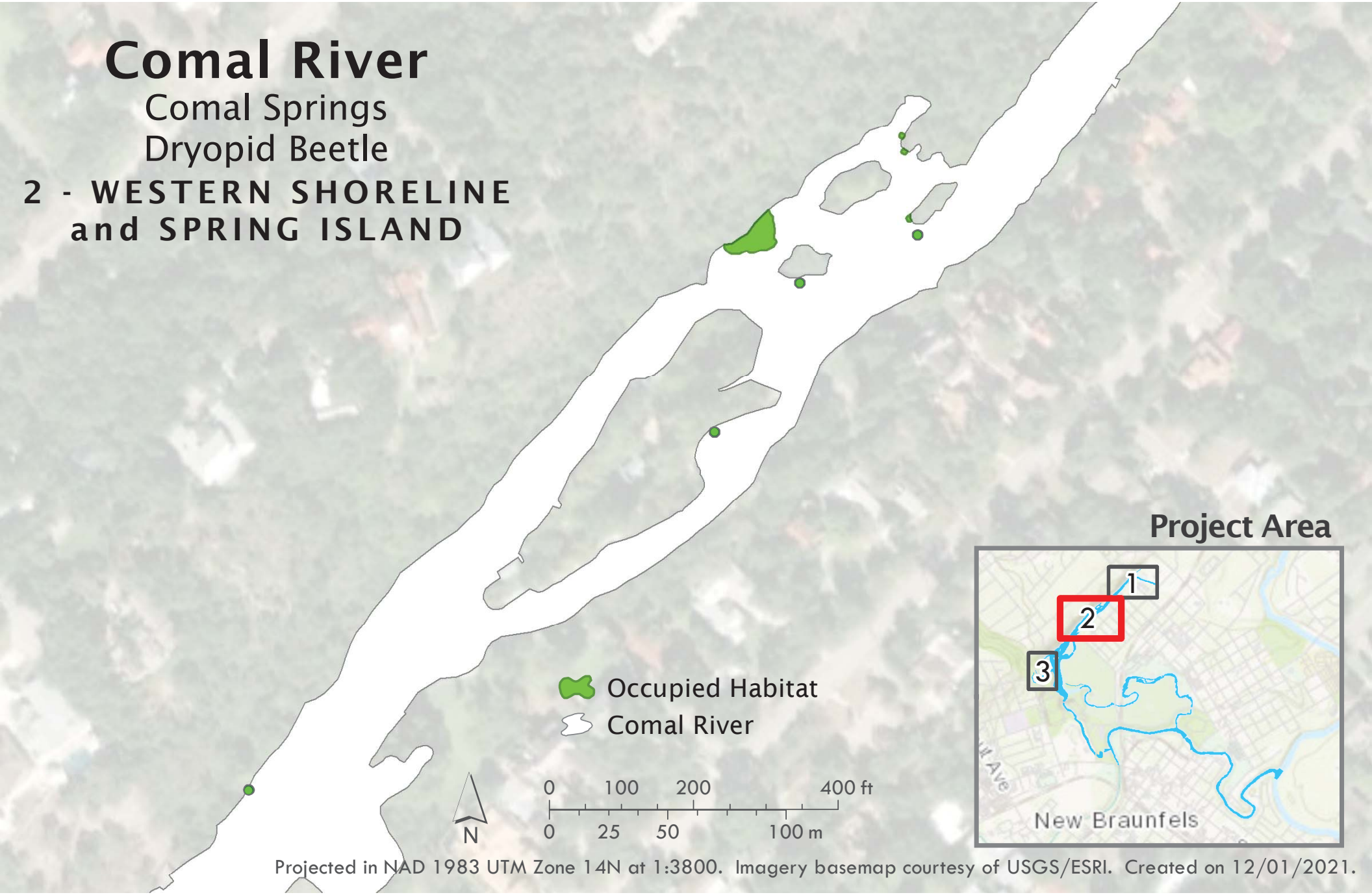


Projected in NAD 1983 UTM Zone 14N at 1:3000. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

Comal River

Comal Springs
Dryopid Beetle

2 - WESTERN SHORELINE and SPRING ISLAND

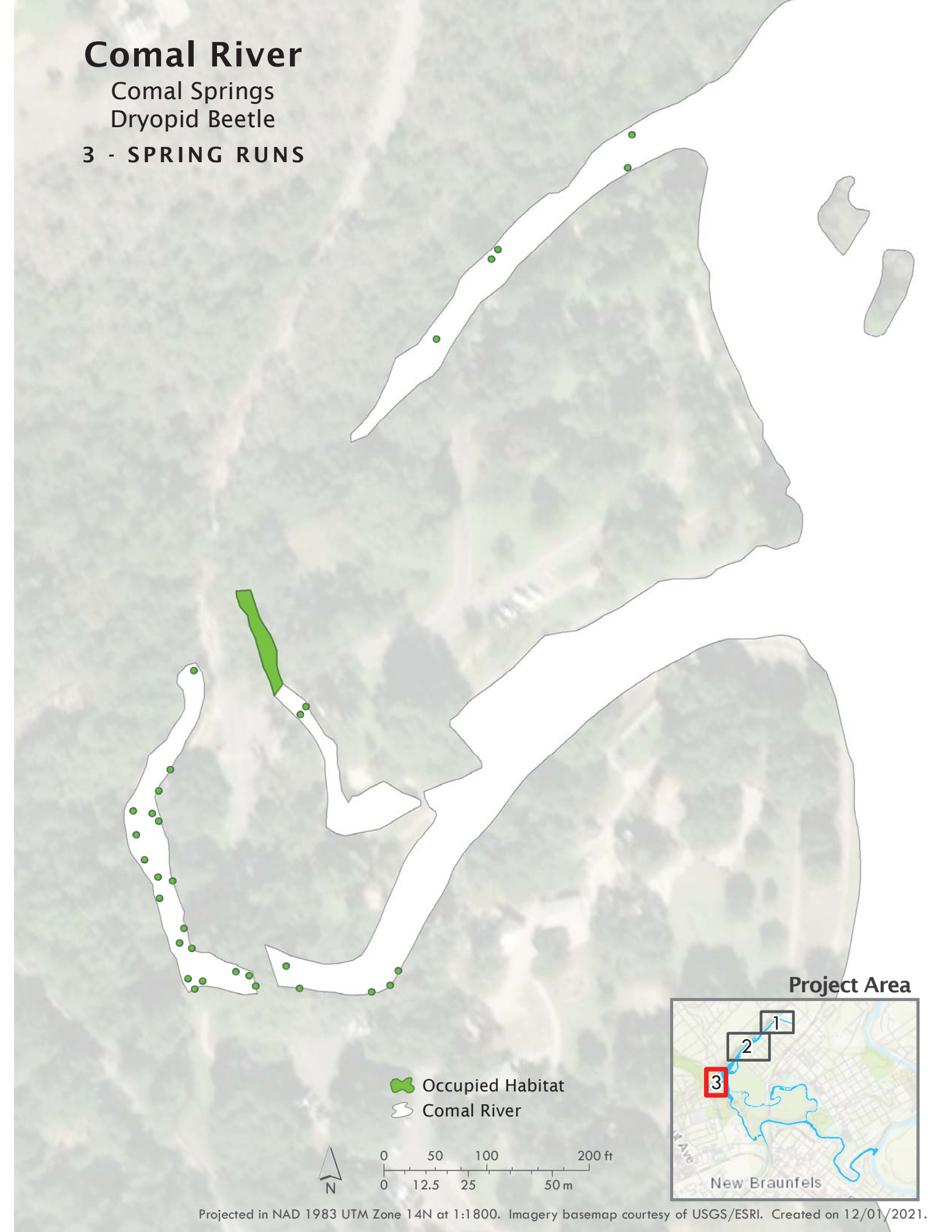


Projected in NAD 1983 UTM Zone 14N at 1:3800. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

Comal River

Comal Springs
Dryopid Beetle

3 - SPRING RUNS

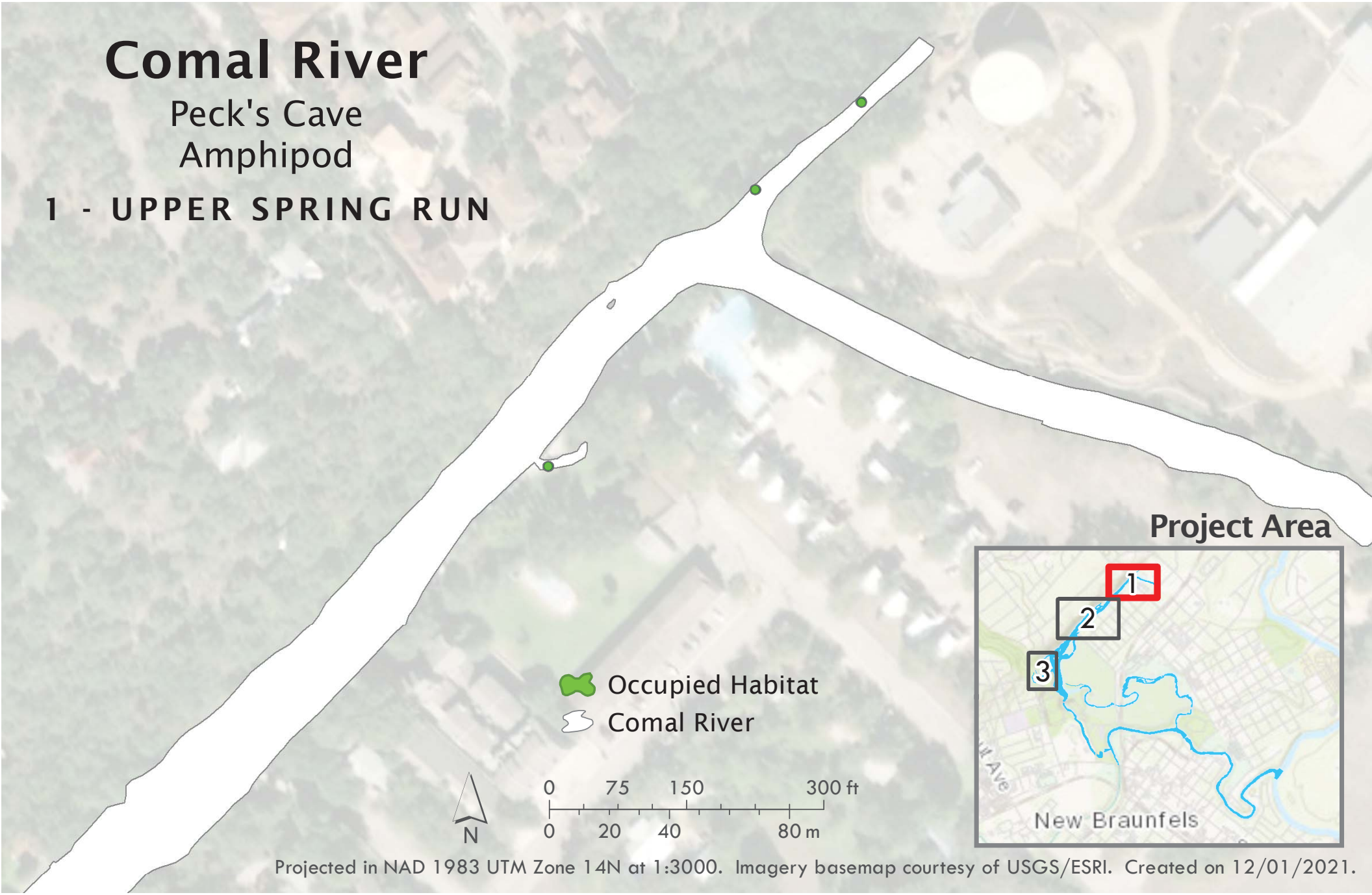


Projected in NAD 1983 UTM Zone 14N at 1:1800. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

Comal River

Peck's Cave Amphipod

1 - UPPER SPRING RUN

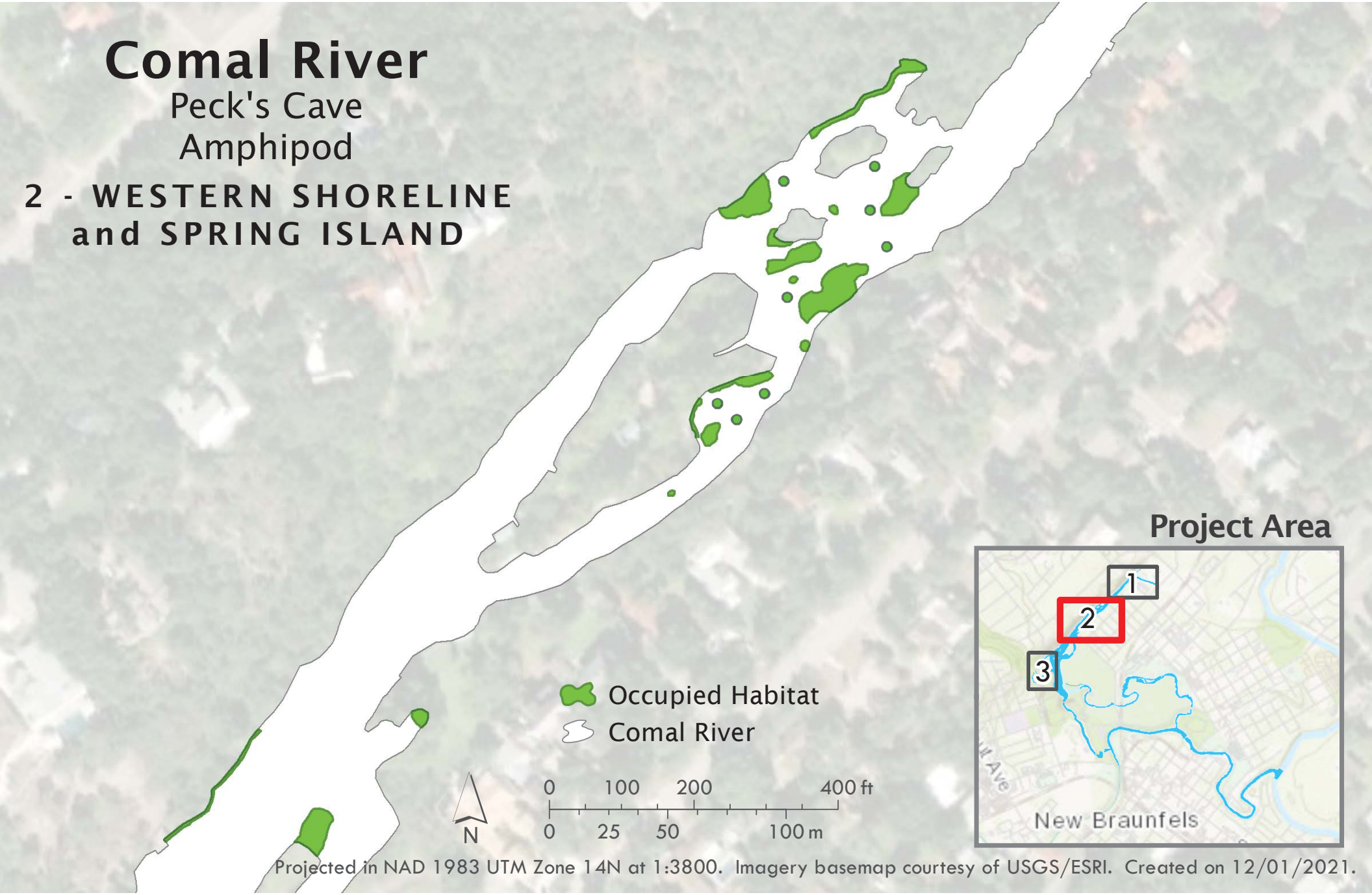


Projected in NAD 1983 UTM Zone 14N at 1:3000. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

Comal River

Peck's Cave Amphipod

2 - WESTERN SHORELINE and SPRING ISLAND



Projected in NAD 1983 UTM Zone 14N at 1:3800. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

Comal River

Peck's Cave
Amphipod

3 - SPRING RUNS

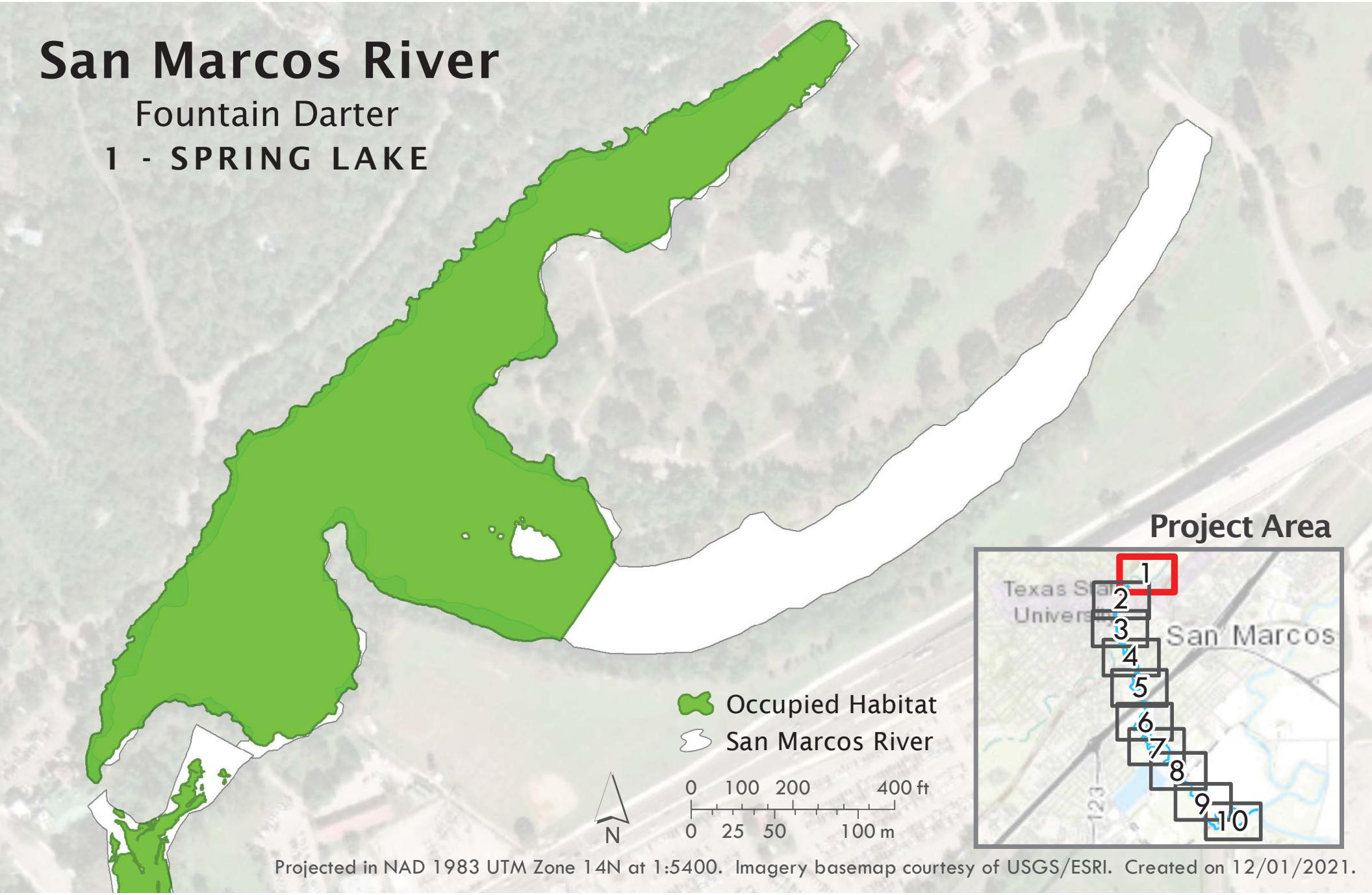
Projected in NAD 1983 UTM Zone 14N at 1:1800. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

San Marcos Springs / River

San Marcos River

Fountain Darter

1 - SPRING LAKE

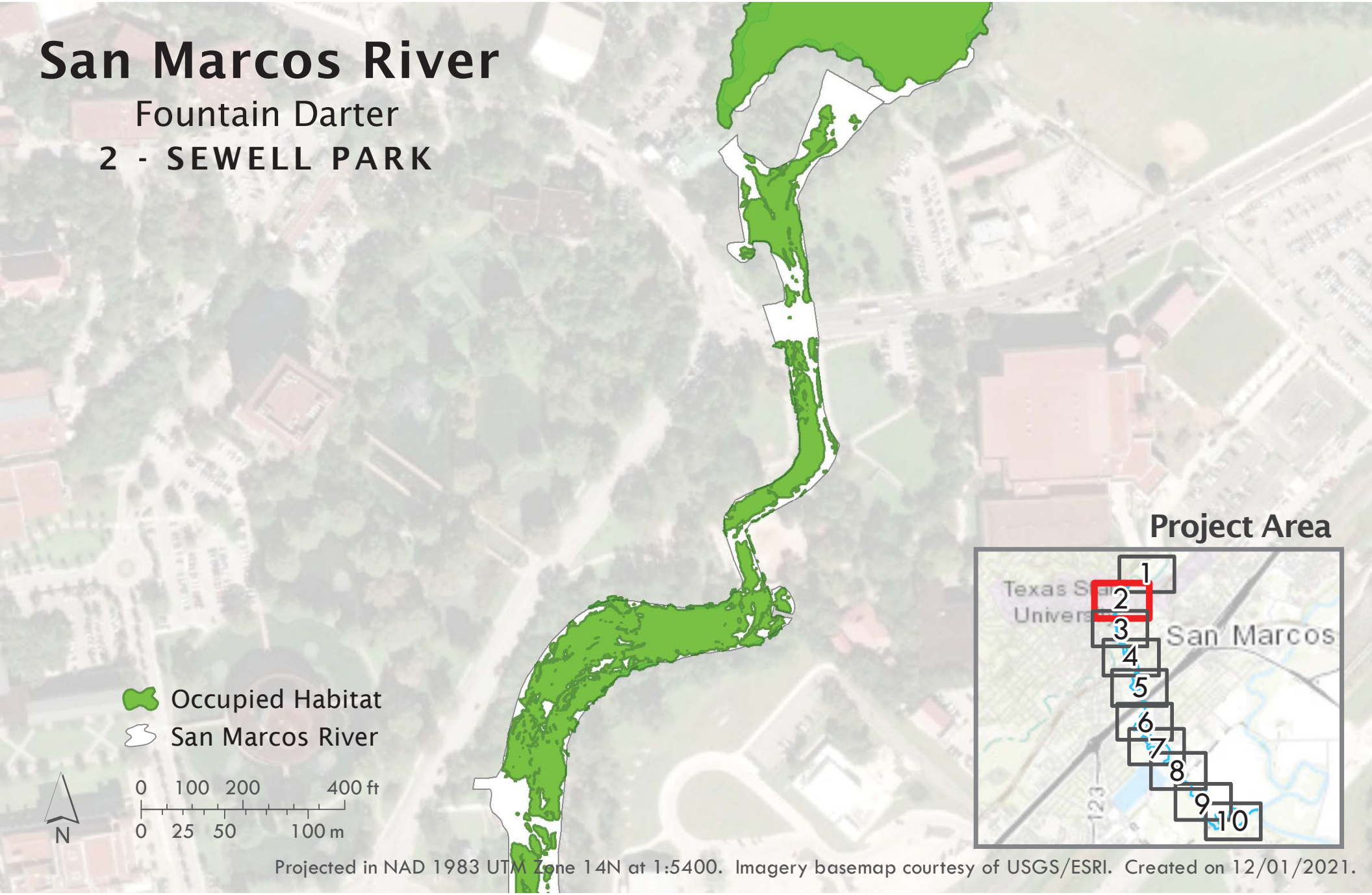


Projected in NAD 1983 UTM Zone 14N at 1:5400. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

San Marcos River

Fountain Darter

2 - SEWELL PARK

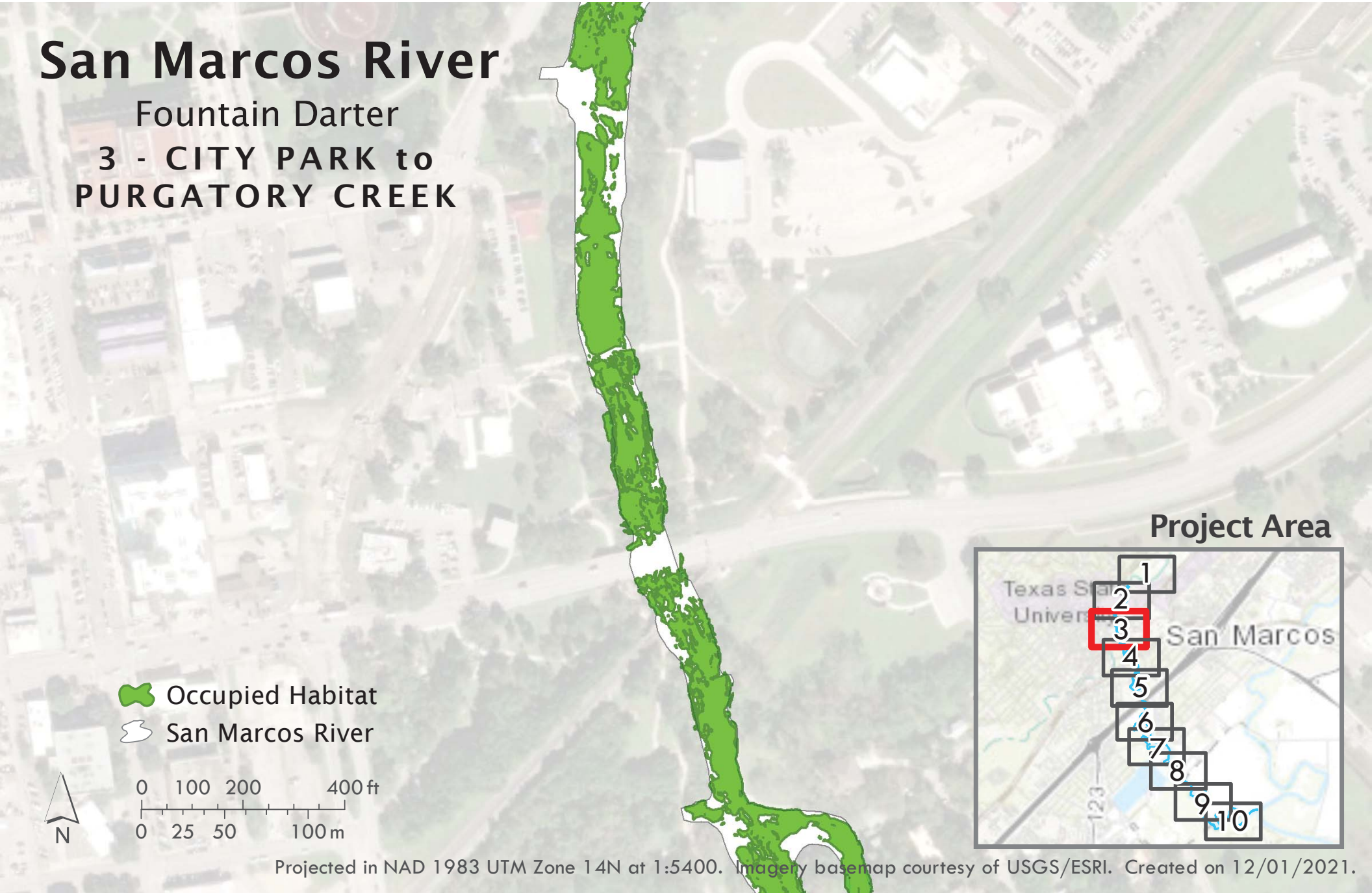


Projected in NAD 1983 UTM Zone 14N at 1:5400. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

San Marcos River

Fountain Darter

3 - CITY PARK to PURGATORY CREEK



Projected in NAD 1983 UTM Zone 14N at 1:5400. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

San Marcos River

Fountain Darter

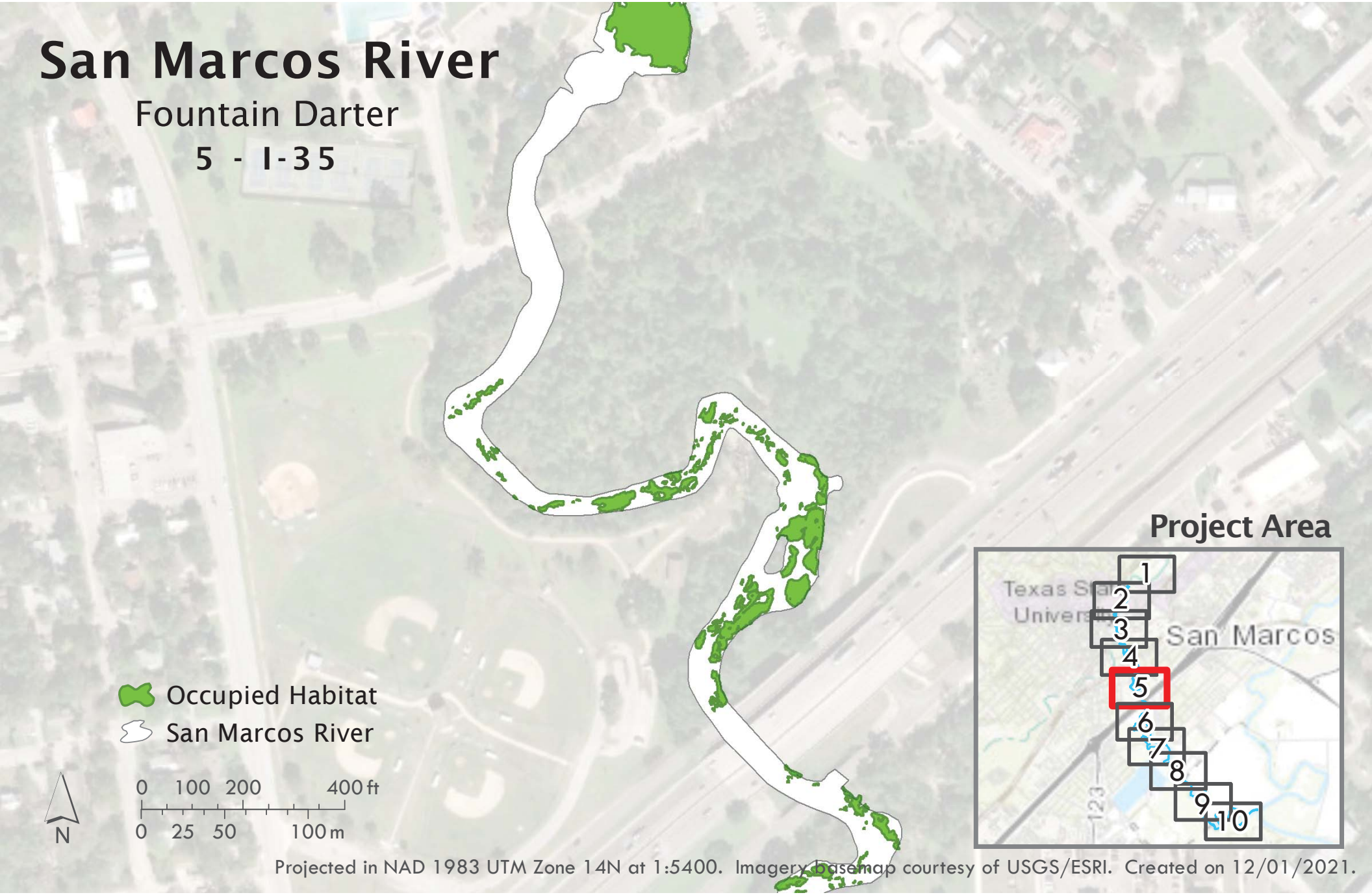
4 - RIO VISTA

Projected in NAD 1983 UTM Zone 14N at 1:5400. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

San Marcos River

Fountain Darter

5 - I-35

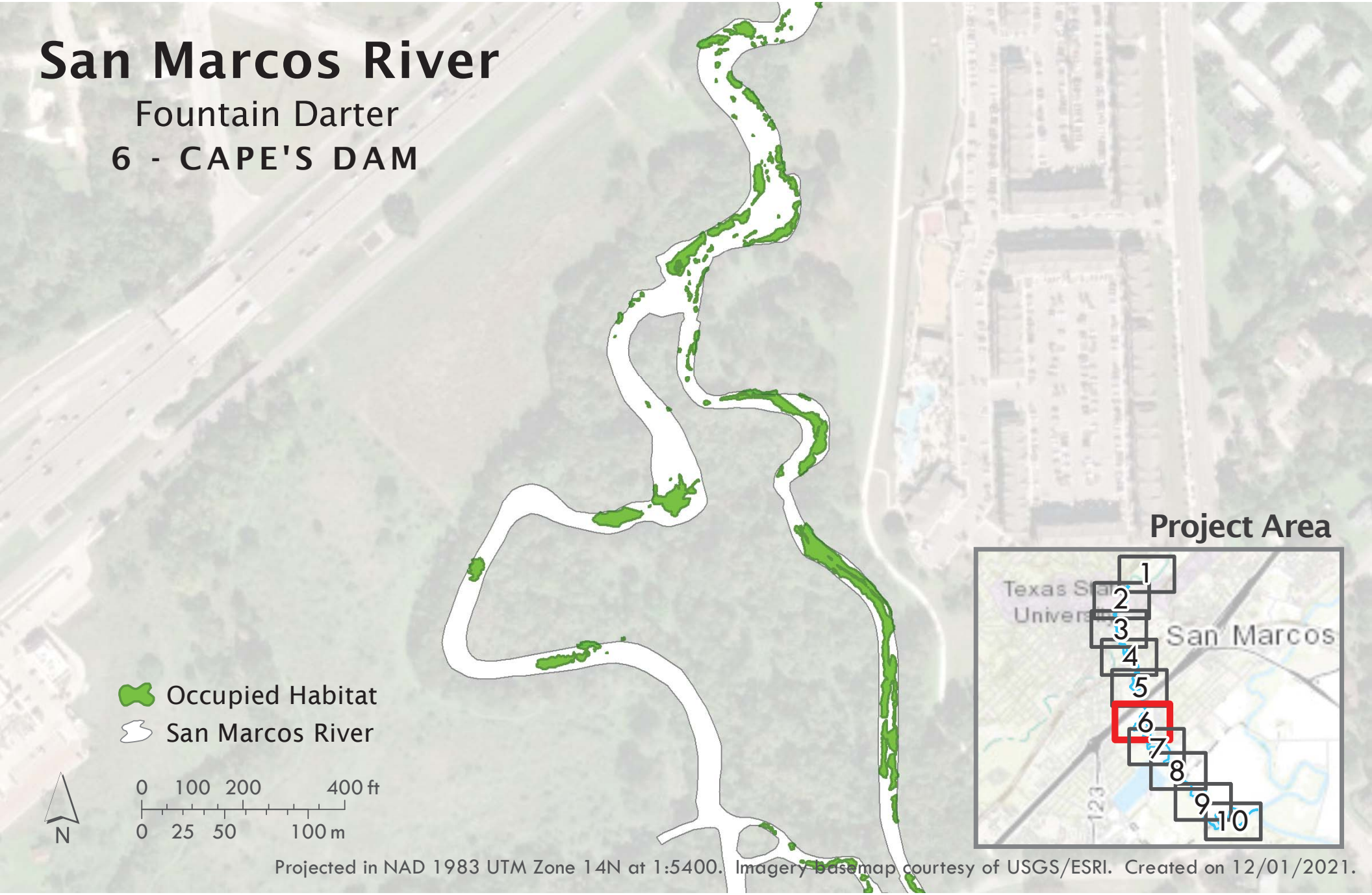


Projected in NAD 1983 UTM Zone 14N at 1:5400. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

San Marcos River

Fountain Darter

6 - CAPE'S DAM

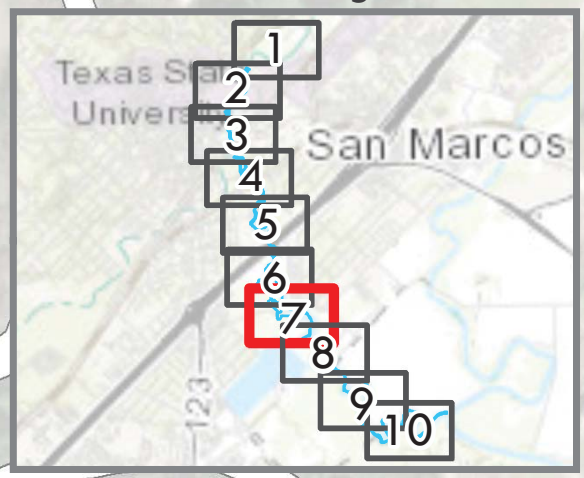


Projected in NAD 1983 UTM Zone 14N at 1:5400. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

San Marcos River

Fountain Darter

7 - CAPE'S ROAD



Occupied Habitat

San Marcos River

N

0 100 200 400 ft

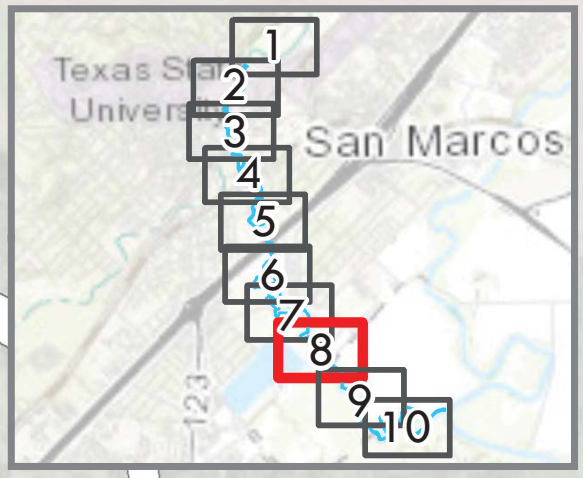
0 20 40 80 m

Projected in NAD 1983 UTM Zone 14N at 1:5400. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

San Marcos River

Fountain Darter

8 - LOWER RIVER 1



Occupied Habitat

San Marcos River

N

0 100 200 400 ft

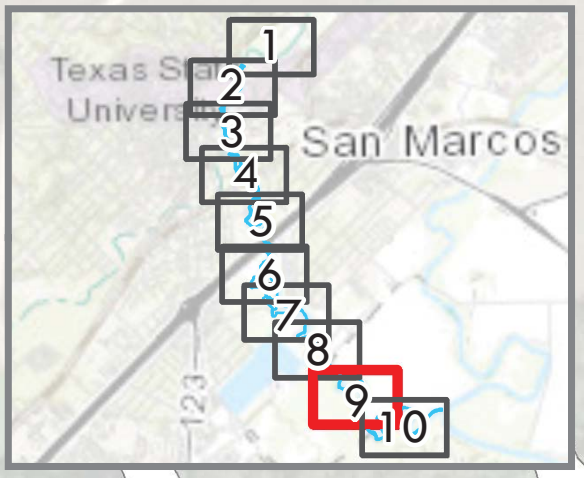
0 25 50 100 m

Projected in NAD 1983 UTM Zone 14N at 1:5400. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

San Marcos River

Fountain Darter

9 - LOWER RIVER 2



Occupied Habitat

San Marcos River

N

0 100 200 400 ft

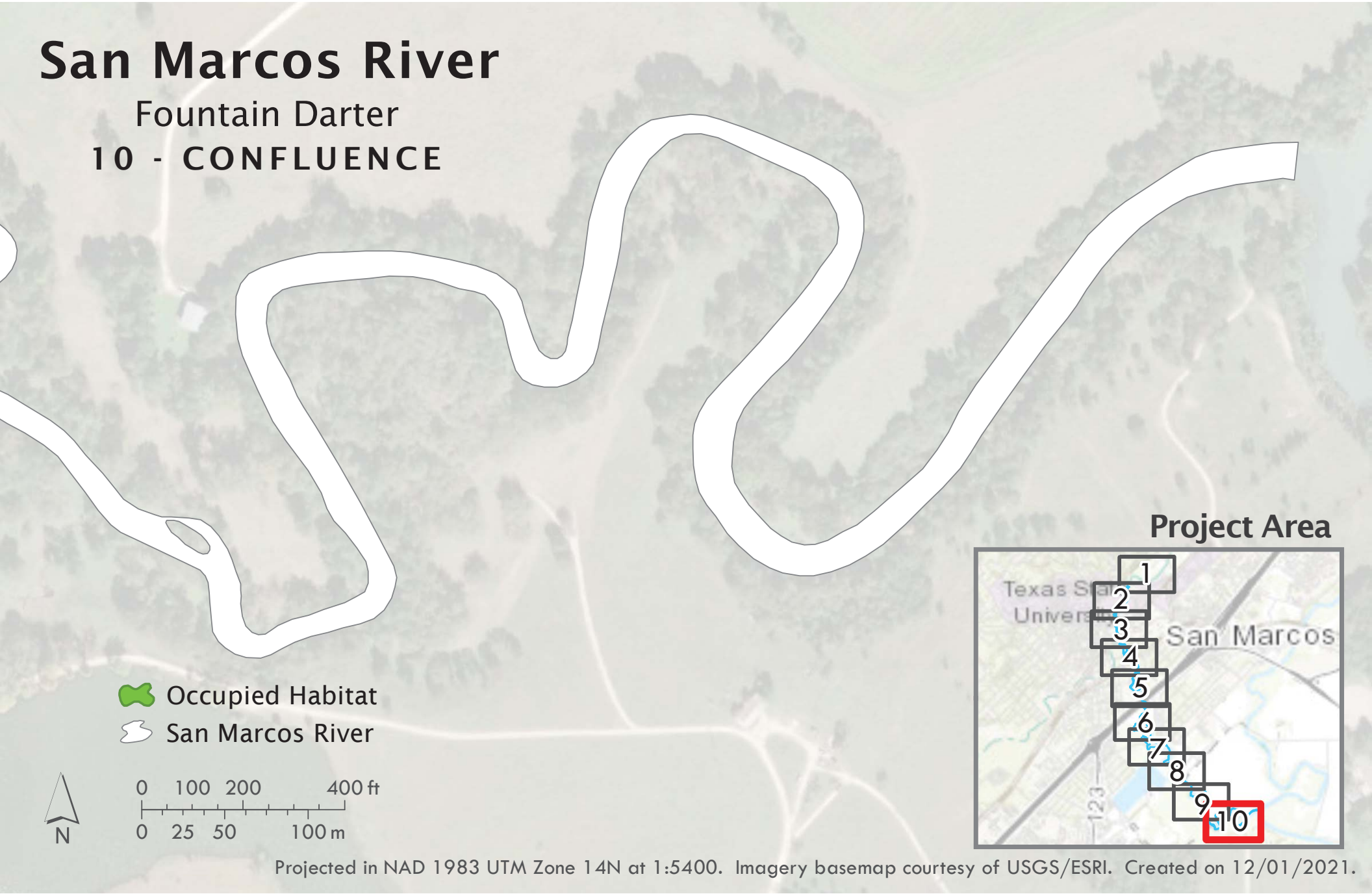
0 25 50 100 m

Projected in NAD 1983 UTM Zone 14N at 1:5400. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

San Marcos River

Fountain Darter

10 - CONFLUENCE



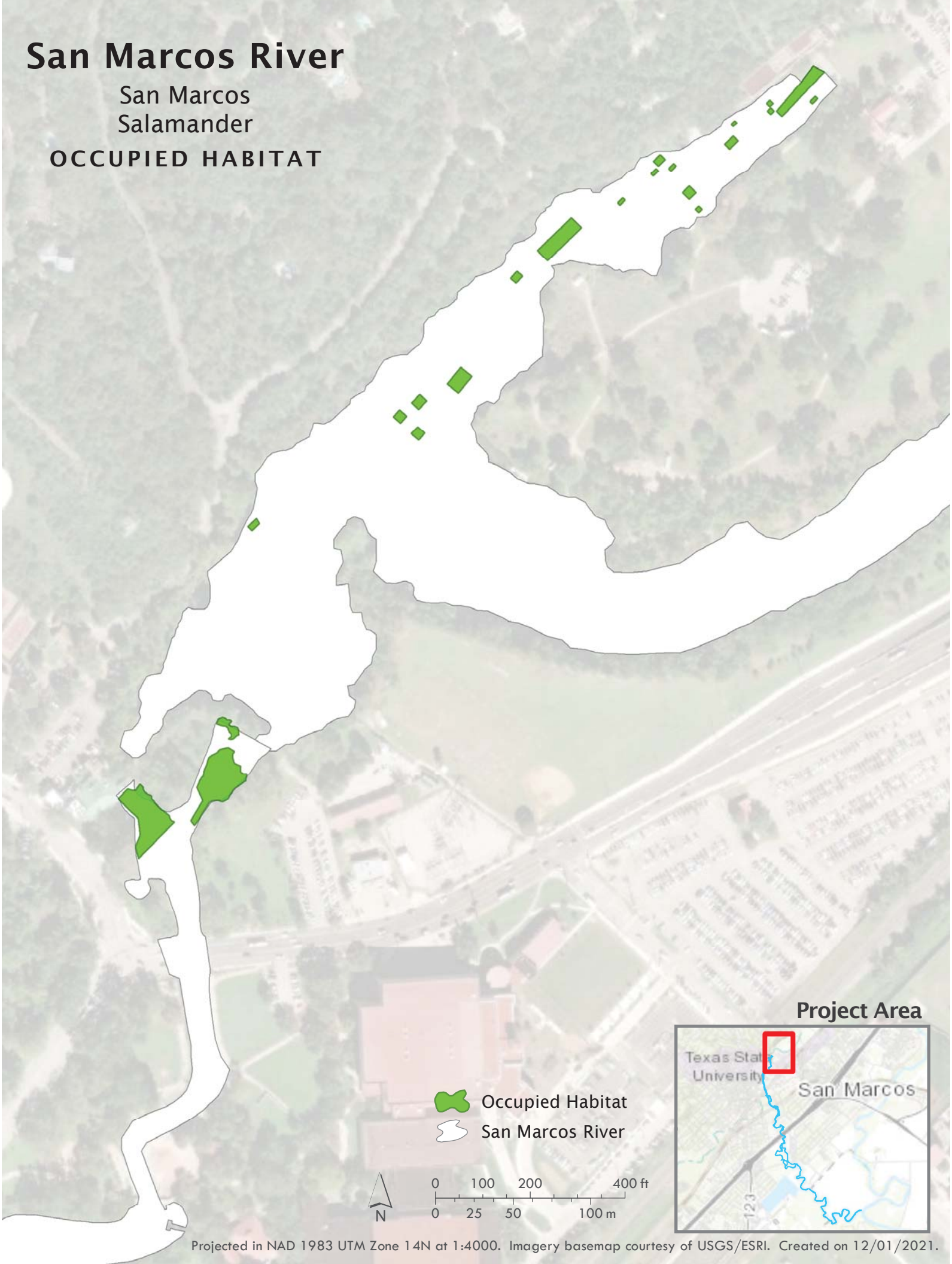
Project Area

Projected in NAD 1983 UTM Zone 14N at 1:5400. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

San Marcos River

San Marcos
Salamander

OCCUPIED HABITAT



Projected in NAD 1983 UTM Zone 14N at 1:4000. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

San Marcos River

Comal Springs Riffle Beetle

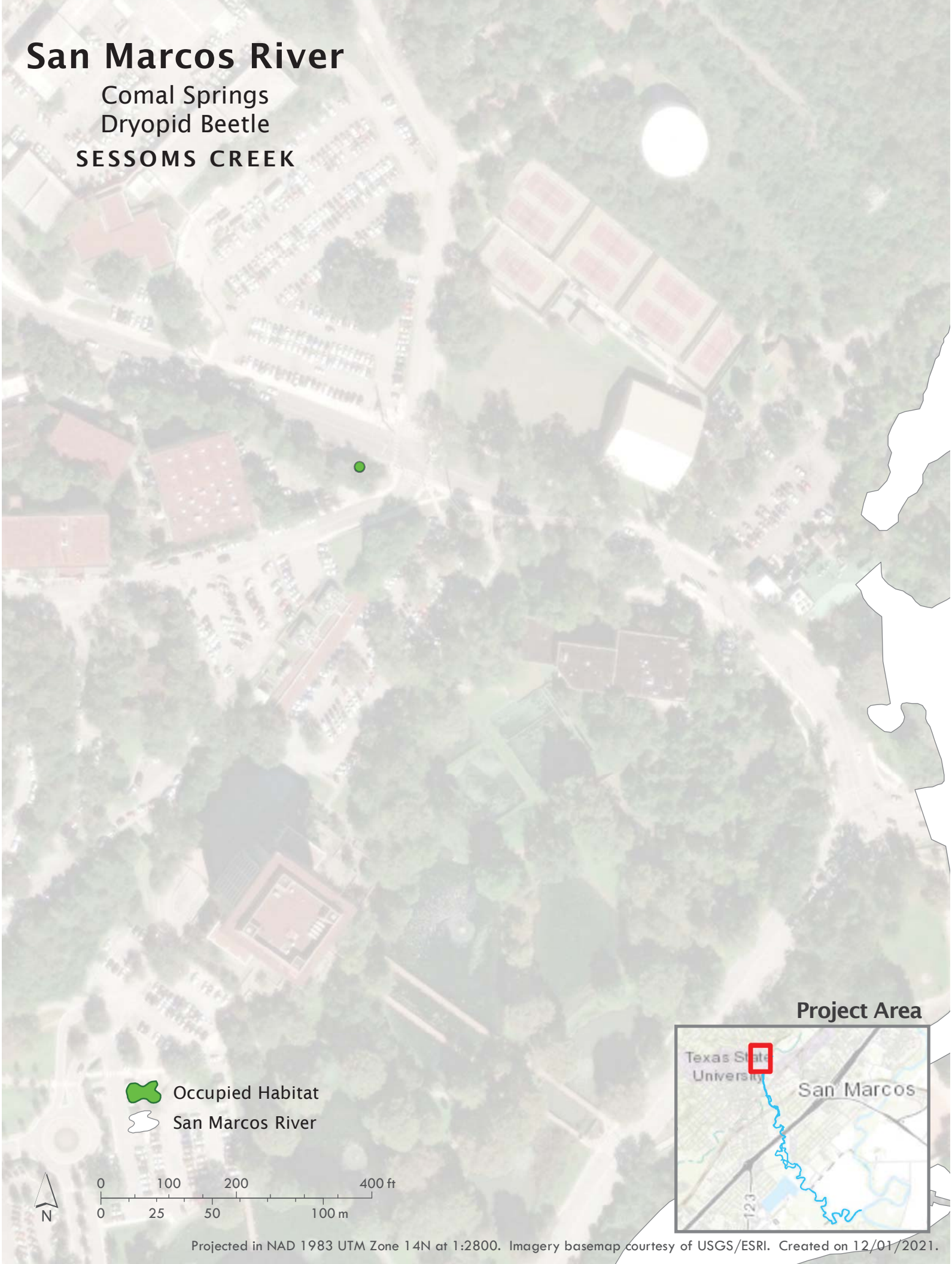
SPRING LAKE

Projected in NAD 1983 UTM Zone 14N at 1:1000. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

San Marcos River

Comal Springs
Dryopid Beetle

SESSOMS CREEK

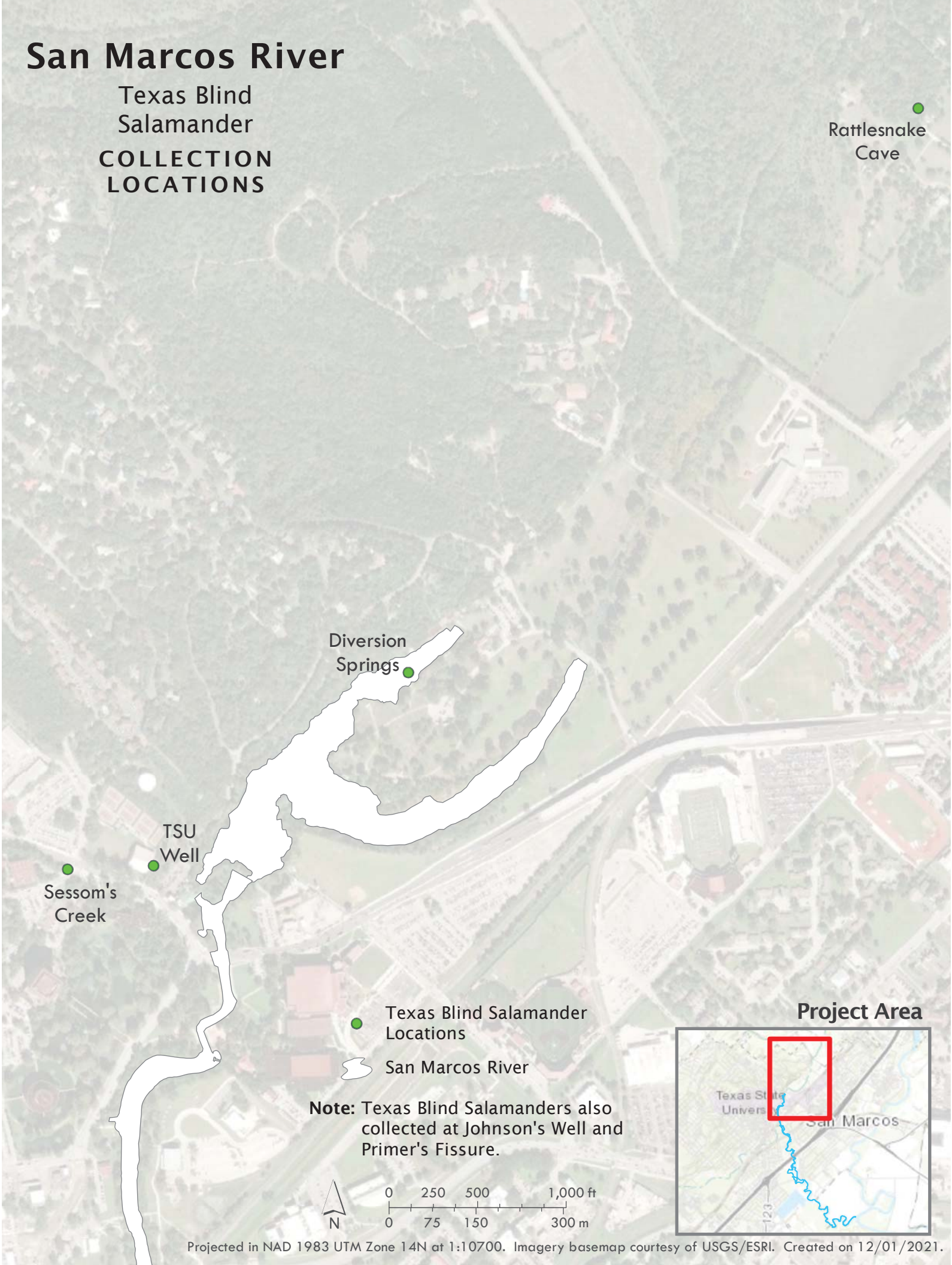


Projected in NAD 1983 UTM Zone 14N at 1:2800. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.

San Marcos River

Texas Blind Salamander

COLLECTION LOCATIONS



Projected in NAD 1983 UTM Zone 14N at 1:10700. Imagery basemap courtesy of USGS/ESRI. Created on 12/01/2021.