Appendix E

Streams and Rapid Geomorphic Method (RGA)

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TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

December 9, 2016

Martin C. Rochelle
Lloyd Gosselink Rochelle & Townsend, P.C.
816 Congress Avenue, Suite 1900
Austin, Texas 78701

Re: Request for Change in Flow Status Assigned to Bois d' Arc Creek

Dear Mr. Rochelle:

We have received your letter dated November 11, 2016, requesting that TCEQ review and reconsider the flow status of Bois d' Arc Creek. In your letter you suggested that TCEQ consider changing the flow status of Bois d' Arc Creek from perennial to intermittent in the Texas Surface Water Quality Standards (TSWQS). We are writing to let you know that we have considered this request, as well as the information provided during our meeting at TCEQ headquarters on December 1, 2016. As a part of our technical analysis of your request we have also reviewed available information collected by the United States Geological Survey, TCEQ, and our partners in the Clean Rivers Program.

We have developed preliminary changes to propose in the 2017 revisions to the TSWQS in response to your request. Our preliminary proposals for two reaches of Bois d' Arc Creek are described below. New language to be included in the 2017 revisions to the TSWQS is underlined; language to be removed is indicated with brackets:

- Revision of Existing Entry in Appendix D of the TSWQS for Bois d' Arc Creek in Fannin County (0202): <u>Intermittent stream with perennial pools</u> [Perennial stream] from the confluence with Sandy Creek <u>north of Dodd City</u> upstream to the confluence with Pace Creek. This portion of Bois d' Arc Creek will retain the currently assigned Intermediate aquatic life use and corresponding dissolved oxygen criteria of 4.0 mg/L for the 24-hour average, and 3.0 mg/L for the 24-hour minimum.
- New Entry in Appendix D of the TSWQS for Bois d' Arc Creek in Fannin County (0202): <u>Intermittent stream with perennial pools from the confluence with Sandy Creek near Davy Crocket Lake upstream to the confluence with Sandy Creek north of Dodd City</u>. This portion of Bois d' Arc Creek will be assigned a High aquatic life use and corresponding dissolved oxygen criteria of 5.0 mg/L for the 24-hour average, and 3.0 mg/L for the 24-hour minimum.

The review process for the TSWQS includes public notice and comment periods, as well as a public hearing, in accordance with federal and state requirements. We will consider additional information that may be submitted as a result of public comment. Revisions to the TSWQS must be approved by the Environmental Protection Agency prior to use in Clean Water Act activities such as assessments to develop the Texas Integrated Report of Surface Water Quality, wastewater permitting, and development of Total Maximum Daily Loads.

We are available to continue discussions regarding your request and the preliminary changes presented above. In addition, the staff of the Office of Water and I will be available for further coordination and discussion. Please contact Mr. Kelly Holligan at 512-239-2369 or by email at Kelly.Holligan@tceq.texas.gov regarding this matter.

Sincerely,

LStepney

L'Oreal W. Stepney, P.E.
Deputy Director, Office of Water
Texas Commission on Environmental Quality

Technical Memorandum on Rapid Geomorphic Assessment (RGA) for the Proposed Lower Bois d'Arc Creek Reservoir Site and Proposed Stream Mitigation

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TO: Robert McCarthy, NTMWD

CC: Simone Kiel, P.E.; Michael Votaw, P.W.S; Steve Watters, P.W.S

FROM: David Coffman, P.G., C.F.M.

SUBJECT: Rapid Geomorphic Assessment (RGA) for the Proposed Lower Bois d'Arc Creek Reservoir Site and Proposed Stream Mitigation

DATE: November 4, 2016, Updated January 27, 2017

PROJECT: NTD06128

1.0 INTRODUCTION

The North Texas Municipal Water District (NTMWD) is proposing to construct the Lower Bois d'Arc Creek Reservoir (LBCR) in Fannin County, TX. A rapid geomorphic assessment (RGA) of Bois d'Arc Creek and its four major tributaries within the footprint of the proposed LBCR was performed in 2008 to provide an estimate of baseline stream conditions (Freese and Nichols, 2008). At the time of this stream assessment, no functional or conditional stream assessment methods had been proposed, adopted, endorsed, or required by the U.S. Army Corps of Engineers (USACE) or other resource agencies having jurisdiction within the state of Texas. Applicants were encouraged to use best scientific judgement in employing tools to assess the function or condition of streams to be affected by the applicant's proposed project, LBCR. In March 2011 a draft methodology for stream (and wetland) condition assessment, Texas Rapid Assessment Method, Version 1.0 (TXRAM), was first published for use, testing, and public comment (USACE, 2011). The final TXRAM guidebook, Version 2.0, was issued by public notice published in October 2015 (USACE, 2015), seven years after fieldwork at the LBCR site was completed.

The data collection method and subsequent analysis used to assess the proposed LBCR site was also used to assess the streams on the proposed mitigation site, Riverby Ranch, in June 2014. A technical memorandum titled, Proposed Mitigation for Stream Impacts of the Proposed Lower Bois d'Arc Creek Reservoir – Rapid Geomorphic Assessment was submitted to NTMWD on November 12, 2014 ("the 2014 RGA memo"). It described how RGA scores were calculated to characterize baseline condition of streams at both the LBCR site and at Riverby Ranch. The memo also outlined how the proposed stream mitigation would compensate for the stream impacts caused by the proposed LBCR (Freese and Nichols, 2014).

NTMWD submitted the 2014 RGA memo to the USACE, who subsequently distributed it to the Cooperating Agencies working with the USACE on the Clean Water Act, Section 404 permit for the proposed LBCR. These agencies include the U.S. Environmental Protection Agency (EPA), U.S. Fish and Wildlife Service (USFWS), the Texas Commission on Environmental Quality (TCEQ), and Texas Parks and Wildlife Department (TPWD). A workshop was held on October 13, 2015 to discuss the RGA method and its application at the proposed reservoir site and the proposed mitigation site. The workshop was attended by representatives from USACE, EPA, USFWS, TCEQ, TPWD, NTMWD, and Freese and Nichols (See Attachment A).

During the workshop, the USACE and Cooperating Agencies requested additional RGA data be collected at the proposed reservoir site to supplement the 2008 data collection effort and assessment. In 2008, the RGA data collected on the main stem of Bois d'Arc Creek and four tributaries (Honey Grove Creek, Bullard Creek, Ward Creek, and Sandy Creek) were extrapolated to characterize all of the stream reaches in the proposed reservoir site. At the request of the resource agencies, the requested additional RGA data would be used to confirm the methodology used to characterize streams that were not directly measured in 2008.

The USACE worked with the Cooperating Agencies and NTMWD to identify 10 additional tributaries within the footprint of the proposed reservoir for additional RGA data collection. These tributaries included Allen's Creek, Burns Branch, Fox Creek, Onstott Creek, Pettigrew Branch, Sandy Branch, Stillhouse Branch, Timber Creek, Thomas Branch, and Yoakum Creek, with additional points on Honey Grove Creek, Sandy Creek, and Ward Creek. USACE approved the final locations of the additional RGA data collection sites via email to NTMWD and the Cooperating Agencies on December 7, 2015 (see Exhibit A and Attachment B).

The fieldwork to collect the supplemental RGA data took place during the week of January 11, 2016. Cooperating Agency members were invited to participate in the field data collection effort. In attendance during field work were Ed Parisotto and Robert Hoffman from USACE, Ryan McGillicuddy from TPWD, Robert McCarthy from NTMWD and Freese and Nichols staff.

The supplemental RGA data were collected using the same RGA methods as the previous investigations at the proposed reservoir site (2008) and the proposed mitigation site (2014). The findings of the supplemental data collection were presented in a technical memorandum entitled, Supplemental Rapid Geomorphic Assessment (RGA) Data Collection at the Proposed Lower Bois d'Arc Creek Reservoir Site. This memo was submitted to NTMWD on March 1, 2016. NTMWD subsequently submitted the memo to the USACE.

The USACE published an Approved Jurisdictional Determination (AJD) for the proposed reservoir site in August 2015. The AJD states that the proposed impact area contains 286,139 linear feet of Relatively Permanent Waters (RPWs) and 365,001 linear feet of non-relatively permanent waters (Non-RPWs), for a total of 651,140 linear feet of stream impacts.

Through additional communications with the USACE and cooperating agencies, NTMWD has revised the components of the stream mitigation plan and proposes the following five stream mitigation components to compensate for the impacts of the proposed reservoir:

- Riverby Ranch Existing Stream Restoration and Enhancement
- Riverby Ranch Stream Creation
- On-site Tributaries to Littoral Zone Wetlands
- Riverby Ranch WRP
- Upper Bois d'Arc Creek Mitigation Site Stream Enhancement

This memo summarizes all RGA assessments to date, and the results presented herein supersede those contained in all previous RGA memoranda. Specifically, this memorandum covers the following topics:

- The Lower Bois d'Arc Creek Reservoir Project RGA method and the calculation of Stream Quality Factor and Stream Quality Units
- RGA evaluation of the impacted streams at the proposed reservoir site, including the supplemental data collection effort (FNI, 2016) and the stream length presented in the AJD (USACE, 2015)
- Baseline condition assessment of five proposed stream mitigation opportunities in the Bois d'Arc Creek watershed
- The potential for ecological uplift in the mitigation streams generated through restoration and enhancement
- Proposed stream mitigation components to compensate for the impacts of the proposed reservoir

2.0 APPROACH AND METHODOLOGY

The following sub-sections provide descriptions of the RGA approach and how the RGA scores were used to derive Stream Quality Factor (SQF) and Stream Quality Unit (SQU) values for the proposed impact streams and mitigation streams. The rapid assessments were based on both anthropogenic and natural factors observed in the field and through comparison of the existing and historic channel pattern and geometry. The major factors evaluated were channel stability, vegetation/armoring, and potential in-stream habitat features. A description of the components used to develop the rapid stream assessments is presented below.

2.1 Rapid Geomorphic Assessment (RGA) Approach

The RGA approach integrates data from field and desktop sources into a quantitative and qualitative description of the features that affect stream stability and the potential for developing aquatic habitat features (Freese and Nichols, 2008). The RGA method is based on a rapid field assessment of stream properties and characteristics at representative field sites along the stream reaches being evaluated. Three forms are used to record data at each field point. The Data Collection sheet includes general stream information related to channel size and location. The Bank Stability form is used to record general bank geometry, information regarding riparian vegetation and rooting depths, and general bank armoring. The Channel Stability form is used to collect a variety of information related to the condition of the upper slopes, lower slopes, and channel bed. For each field point, data collected in the field forms are consolidated into a Channel Stability Rating System form. Examples of the four data forms are included in Attachment C. The following six categories are scored and summed to calculate a final RGA score for each field point out of a maximum possible 60 points, with higher values indicating more optimal stream conditions:

- Evidence of Bank Erosion
- Bank Root Zone
- Vegetative Bank Cover
- Bank Angle
- Sediment Transport
- Channel Alteration

2.2 Channel Stability Variables

Qualitative analysis of channel stability was the primary focus of the Rapid Geomorphic Assessment. The adverse consequences of stream channel instability are increased sediment supply, land loss, habitat deterioration, changes in long-term and short-term channel evolution, and loss of both physical and biological function of the stream.

Channel stability was inferred from field inspections, measurements of stream channel characteristics, and by comparing existing stream conditions to historic maps and aerial photography. Specific categories and variables included in the assessment were streambank erosion and angle, riparian and streambank vegetation, overall channel stability, sediment transport, and man-made channel alteration.

Streambank Erosion and Angle

The Bank Stability parameters included several related to the riparian vegetation and the bank angle. Although the Bank Erosion Hazard Index (BEHI) scoring system was not used, the method was referenced for help in determining the key parameters to be evaluated in relation to the channel erosion potential (Rosgen, 2006). Riparian vegetation plays a key role in bank stabilization. Banks with dense, deep rooting zones and in-channel vegetative cover in alluvium generally have stable banks while shallow, sparse roots and no in-stream vegetation result in unstable banks that are subject to mass wasting. Erosion potential related to bank angle (slope steepness) generally ranges from very low for flat slopes to extreme for steep slopes; however, there is a correction factor associated with bank angle to take into consideration the bank material (i.e. bedrock can be very stable at steep angles while sand and clay are not).

Riparian and Streambank Vegetation

Riparian vegetation performs several functions in a stream system including bank stabilization water quality protection, fish and wildlife habitat, and thermal cover for the stream. Bank stabilization and water quality are improved with good riparian buffers because the roots of trees and shrubs help hold stream banks in place, preventing erosion. Riparian vegetation also traps sediment and pollutants in land runoff before it reached the stream channel. The field data collected included information on the general type and condition of the riparian vegetation including an estimate of the percentage of the riparian vegetation that was trees, shrubs, and grasses. Rooting depth, root density and the percentage of the bank protected by vegetation are specific measurements that were taken at each data point. This information was used in both the preliminary bank stability and channel stability classifications.

Channel Stability

The channel stability rating system utilized for this assessment is based on the measurement of up to 15 variables that are specific to the channel bottom, the lower banks within the channel, and the upper banks of the channel. Although the Rosgen-Pfankuch rating system was not used, the method was referenced for help in determining the key parameters to be evaluated in relation to channel stability (Rosgen, 2006). The channel stability rating process evaluates the upper banks, lower banks, and streambed for evidence of excessive erosion or deposition, which are indicative of disequilibrium and can be used to identify potential aquatic habitat within a stream. The system quantitatively evaluates the potential for mass wasting of the stream banks, the detachability of bank and bed materials, channel capacity, and evidence of excessive erosion or deposition. The process provides a means for estimating general channel stability.

Sediment Transport

The description of depositional features utilized for this study is from Mollard (1973) and Galay et al. (1973) as modified by Rosgen (2006). Depositional features, or lack thereof, can be an indicator of channel aggradation or degradation and signal that the channel is experiencing instabilities. Field observations and interpretations of the depositional patterns were used in estimating the sediment transport competency of the channel. Depositional patterns in altered or degraded channel reaches aided in estimating the long-term stability of the channel reach under existing flow conditions.

Man-Made Channel Alterations

Man-made alterations consider man-induced changes to the natural stream system. These may include direct changes to the stream alignment (such as straightening of channels), use of culverts, construction of levees or dikes that alter connectivity with the floodplain, etc.

Photographs

In addition to the data discussed above, GPS-tagged photographs were taken at each data collection point to record visual observations. Photographs looking upstream and downstream were taken at each data point and, at some locations, photographs of the right and left banks were also taken.

Historical Aerial Photography

Current and historical aerial photographs of potential mitigation areas were used to evaluate changes in stream patterns, land use practices, and riparian vegetation over time. The impacts of these changes on the channel pattern and profile were evaluated and documented.

2.3 Channel Stability Rating System

All the variables discussed in Section 2.2 were assessed for each data point and consolidated into a Channel Stability Rating System form (Attachment C). The data were then used to determine a general RGA score (ranging from zero (0) to 60) for that portion of the creek. These classification sheets were then used in conjunction with field notes, aerial photographs, one-foot LIDAR generated topography and two-foot aerial topography to relate the measured and observed sections of the study reaches to other sections of the creeks to determine their RGA score. The stability rating system was developed by Freese and Nichols to provide an objective means for assigning values to the six major parameters identified on the Channel Stability Rating System form. To provide a quantitative measurement of the six evaluation factors, the system relies on the physical parameters measured and recorded on the data collection sheet, bank stability form, and channel stability form. Data are first recorded in the field on those forms and select photographs are attached for future reference. Finally, the information on those three forms is used to complete the Channel Stability Rating System form and subsequently calculate the RGA score. The weighting and scoring system was developed to provide an objective means for interpreting the data and classifying the stream reaches.

2.4 Stream Quality Factor

The RGA score (a number between zero (0) and 60) for a study site is normalized into a Stream Quality Factor (SQF) value by dividing the calculated RGA score by the maximum possible score of 60 points. SQF values are a quality weighting factor that are used to quantify the comparison between baseline stream characteristics of the study site to the stream conditions that are ecologically optimal. This SQF value is used to place a value on the impacted streams and to evaluate the success of the proposed stream mitigation. As with the RGA score, the higher the SQF, the higher the stream quality as based on geomorphic stream equilibrium.

2.5 Stream Quality Unit

The calculated SQF score for a study reach is multiplied by the length of the respective study reach to calculate the number of Stream Quality Units (SQUs) provided by the reach. SQUs quantify the relationship between stream characteristics and the length of stream with those characteristics. SQUs are essentially the mitigation currency for the LBCR RGA stream evaluation method.

3.0 EVALUATION OF PROPOSED STREAM IMPACTS FOR LOWER BOIS D’ARC RESERVOIR

Freese and Nichols (2008) provided RGA scores for Bois d’Arc Creek and its larger tributaries (Honey Grove Creek, Ward Creek, Sandy Creek and Bullard Creek) within the proposed reservoir pool. The 2016 supplemental data collection effort expanded the observed and recorded stream conditions to include 10 additional tributaries of Bois d’Arc Creek. In total, data were collected along the main stem of Bois d’Arc Creek and 14 tributaries within the footprint of the reservoir (Exhibit A).

The RGA scores for these assessed streams were converted to SQF values, and subsequently, the number of SQUs were calculated using the SQF value and the associated reach length. SQF values from the assessed streams were extrapolated to the tributaries upstream of the assessed reaches based on the location of the tributary confluence. For example, if a study reach of Honey Grove Creek had an SQF value calculated to be 0.25, then an unscored stream tributary to that study reach was assumed to also have an SQF value of 0.25. The total SQUs of Bois d’Arc Creek and its tributaries within the proposed reservoir pool, designated by the summed product of the SQU scores for all proposed impact streams and the respective lengths of proposed impacted stream, is 192,377. Table 1 shows the length of stream within the Lower Bois d’Arc Creek footprint by SQF and the corresponding calculated SQUs.

Table 1. Summary of Proposed Reservoir Site SQUs Incorporating 2016 RGA Field Data

Stream Quality Factor (SQF)	Existing Length (ft)	Stream Quality Unit (SQU)
0 - .09	35,261	2,368
.1 - .19	118,020	15,648
.2 - .29	163,585	37,261
.3 - .39	132,662	42,877
.4 - .49	144,541	63,635
.5 - .59	57,071	30,588
.6 - .69	0	0
.7 - .79	0	0
.8 - .89	0	0
.9 - .99	0	0
1.0	0	0
Total	651,140	192,377

4.0 DESCRIPTIONS OF POTENTIAL STREAM MITIGATION OPPORTUNITIES

Several opportunities have been identified that would provide compensatory stream mitigation for the impacts to streams caused by the construction of the proposed Lower Bois d'Arc Creek Reservoir. The five identified potential opportunities are as follows:

- Riverby Ranch existing stream restoration and enhancement
- Riverby Ranch stream creation by restoring meanders on straightened/channelized streams
- On-site tributaries to littoral zone wetlands
- Riverby Ranch Wetlands Reserve Program (WRP) area stream enhancement
- Upper Bois d'Arc Creek Mitigation Site stream enhancement

The following subsections briefly describe the six stream mitigation opportunities and how they were individually assessed using the RGA methodology.

4.1 Riverby Ranch Existing Stream Restoration and Enhancement

Riverby Ranch (excluding areas enrolled in the Wetlands Reserve Program (WRP)) contains 179,353 linear feet of RPWs and Non-RPWs that have been degraded over time by agricultural practices. During the RGA study of Riverby Ranch, 36 field points were evaluated to quantify characteristics of the existing streams on the ranch outside the WRP area (Exhibit B). The streams were each given a unique identifier/name and were divided into reaches based on morphological characteristics, cover types, stream order, tributary confluences, and field point RGA score (Exhibit C).

4.2 Riverby Ranch Stream Creation

The NTMWD is proposing to restore meanders to several first and second-order streams located on the ranch that have been historically straightened/channelized. Field observations and evaluation of current and historical aerial photographs were used to select existing streams on the ranch that would be suitable for meander creation and to calculate an appropriate sinuosity ratio for the created meanders. Through a desktop analysis of nearby reference reaches, it was determined that a sinuosity ratio of approximately 1.3 would be a reasonable ratio for the restored channels. Application of the 1.3 sinuosity ratio to streams suitable for meander creation results in approximately 32,597 additional linear feet of meandering stream on the ranch. The additional linear feet are only considered during the future conditions analysis because there are no baseline conditions present prior to the construction of the created meanders.

4.3 On-site Tributaries to Littoral Zone Wetlands

The RGA method was used to evaluate the baseline condition and potential future conditions of the tributary streams of the littoral zone wetlands that will form between elevations 534 and 541 ft. msl resulting from the proposed impoundment of Bois d'Arc Creek. The baseline RGA scores of the littoral zone tributary streams were extrapolated from the downstream stream reaches within the conservation pool of the proposed reservoir.

4.4 Riverby Ranch WRP

There are approximately 94,596 linear feet of stream within the WRP area on Riverby Ranch, including the channel of Bois d'Arc Creek. During the RGA study of Riverby Ranch, eight (8) field points were evaluated to quantify characteristics of the existing streams in the WRP area (Exhibit C). The study area within the WRP was divided into reaches based on morphological characteristics, cover types, stream order, tributary confluences, and field point RGA score.

4.5 Upper Bois d'Arc Creek Mitigation Site Stream Enhancement

The proposed Upper Bois d' Arc Creek (BDC) Mitigation Site is located along Bois d'Arc Creek upstream of the proposed LBCR in Fannin County, TX (Exhibit D). The approximately 1,900-acre site contains approximately 62,535 linear feet of RPW and Non-RPW, including the main channel of Bois d'Arc Creek. Eleven field points were evaluated using RGA to describe the existing condition of streams in the Upper BDC Mitigation Site. Most of the streams, including Bois d'Arc Creek, have bene heavily impacted by past and current agricultural actives, including channelization, straightening, and removal of riparian vegetation. During the RGA study of the Upper BDC Mitigation Site, 11 field points were evaluated to quantify characteristics of the existing streams within the proposed mitigation site. The streams were each were divided into reaches based on morphological characteristics, cover types, stream order, tributary confluences, and field point RGA score.

5.0 BASELINE CONDITIONS OF PROPOSED MITIGATION STREAMS

The following section discusses the calculations and results for baseline conditions of the potential mitigation opportunities. Table 2 presents a summary of the baseline conditions for the potential stream mitigation opportunities.

5.1 Riverby Ranch Existing Stream Restoration and Enhancement

RGA scores were applied to reaches based on the score of the most representative nearby field data point. The RGA score for reaches with two field data points was calculated as the average of the two field data points. The RGA scores for stream reaches that did not contain field data points were extrapolated from reaches with similar characteristics. Exhibit C illustrates the locations of the field data points and stream reaches on Riverby Ranch. The RGA score for each reach was converted to an SQF value, which was then multiplied by the length of the respective reach to calculate the SQU. The total baseline SQU value for Riverby Ranch, defined as the sum of the SQUs for each reach, was calculated to be 64,140. This total does not include streams within the WRP area.

5.2 Riverby Ranch Stream Creation

The restoration of meanders for historically straightened/channelized streams will create additional stream length that does not currently exist. For mitigation accounting purposes, the additional created stream length was designated a baseline RGA score and SQF of zero. Total number of baseline SQUs for this component was assumed to be zero due to the absence of preexisting stream length and the RGA score and SQF value of zero.

5.3 On-site Tributaries to Littoral Zone Wetlands

RGA scores for stream reaches within the pool of the proposed reservoir were extrapolated to the streams tributaries to the littoral zone wetlands between elevations 534 and 541 ft. msl. The RGA scores for the tributaries of the littoral zone wetlands were converted into SQF values, then multiplied by the stream length to calculate the total number of SQUs for each reach. The total baseline SQU value for the on-site littoral zone wetlands tributary streams was calculated to be 3,745.

5.4 Riverby Ranch WRP

RGA scores for the tributary streams in the WRP area were calculated the same way as the reaches throughout Riverby Ranch. For the segment of Bois d'Arc Creek within the WRP area, reach RGA scores were designated based on their respective field points within the WRP. The RGA scores were converted into SQF values, which were then multiplied by the lengths of the respective reaches to calculate the SQUs for each reach within the WRP area. The total number of baseline SQUs for streams within the WRP area, defined as the sum of the SQUs for each reach within the WRP area, was calculated to be 40,990.

5.5 Upper Bois d'Arc Creek Mitigation Site Stream Enhancement

RGA scores for the streams in the Upper BDC Mitigation Site were calculated the same way as the reached throughout Riverby Ranch and the WRP. The RGA scores were converted into SQF values, which were then multiplied by the lengths of the respective reaches to calculate the SQUs for each reach within the mitigation site. The total number of baseline SQUs for streams within the Upper BDC Mitigation Site, defined as the sum of the SQUs for each reach within the site, was calculated to be 17,119.

Table 2. Summary of the Baseline Conditions for the Potential Mitigation Opportunities

SQF	Riverby Ranch, Excluding WRP		Tributaries of Littoral Zone		Riverby Ranch WRP Area		Upper BDC Mitigation Site	
	Existing Length (ft)	SQU	Existing Length (ft)	SQU	Existing Length (ft)	SQU	Existing Length (ft)	SQU
0 - .09	8,507	457	11,447	954	7,649	382	15,032	1,253
.1 - .19	26,967	4,253	0	0	887	163	3,800	633
.2 - .29	47,789	10,764	10,022	2,098	0	0	14,641	3,684
.3 - .39	14,086	4,991	1,075	341	16,026	5,342	20,763	6,575
.4 - .49	37,838	17,395	0	0	46,721	21,504	1,483	692
.5 - .59	29,393	15,818	640	352	23,313	13,599	1,962	1,046
.6 - .69	10,905	7,239	0	0	0	0	4,854	3,236
.7 - .79	0	0	0	0	0	0	0	0
.8 - .89	3,868	3,223	0	0	0	0	0	0
.9 - .99	0	0	0	0	0	0	0	0
1.0	0	0	0	0	0	0	0	0
Total	179,353	64,140	23,184	3,745	94,596	40,990	62,535	17,119

1. Stream Creation is not shown because the baseline conditions are “0”.

6.0 EVALUATION OF POTENTIAL MITIGATION STREAM IMPROVEMENTS

The following section discusses the calculations and results for the potential future conditions of the identified mitigation opportunities. Stream quality improvement potential was estimated assuming appropriate application of potential stream improvement practices. Measures to attain the intended ecological uplift vary from site to site and may include one or more of the following practices:

- Laying back stream banks to reduce erosion and allow for vegetation establishment
- Removal of cattle and other negative anthropogenic influences
- Plugging or diverting drainage ditches
- Restoring meanders to stream channels which were previously straightened
- Establishing a balanced sediment supply
- Re-establishing hydrology by breaching existing dikes

The potential improvement practices directly correspond with the variables on the Channel Stability Rating System form, shown in Attachment C. For example, Table 3 shows that the calculated baseline RGA score for Bois d'Arc Tributary 2, Reach 1 (Figure 1) on Riverby Ranch was determined to be 3 out of 60 possible points, and the improved RGA score due to the application of improvement practices was 50 out of 60 possible points. The stream improvement practices and their expected results that provide the anticipated ecological uplift for this reach are shown in Table 4. Table 5 presents a summary of the mitigated conditions for the potential stream mitigation opportunities.

Table 3. Calculated baseline and potential improved RGA scores for Bois d'Arc Creek Tributary 2, Reach 1

Evaluation Category	Baseline RGA Score	Mitigated RGA Score
Evidence of Bank Erosion	0	8
Bank Root Zone	1	8
Vegetative Cover	2	8
Bank Angle	0	8
Sediment Transport	0	8
Channel Alteration	0	10
Total	3	50

Figure 1. Photograph looking upstream at reach of Bois d'Arc Creek Tributary 2, Reach 1

Table 4. Stream improvement practices and anticipated results for Bois d'Arc Creek Tributary 2, Reach 1

Improvement Practice	Post-Restoration Condition
Decrease streambank angle	Reduces the steepness of the streambank, allows for streambank vegetation to become established, reduces sediment supply from eroding streambanks, and increases floodplain connectivity
Reconnect the stream to the floodplain and reshape the channel	Energy dissipation during high-flow events, reduces sediment supply from eroding streambanks, improves groundwater/surface water exchange, establishes vertical and lateral stability, improves sediment transport capacity, improves bed form diversity, generates habitat, and improves water quality
Establish streambank vegetation and plant riparian buffer	Provides streambank stability, improves vegetated bank cover and bank root zone, provides shade and generates wood debris storage/habitat, reduces bank erosion, and improves water quality
Channelized stream converted to meandering systems	Provides adequate flow duration, increases floodplain connectivity, improves groundwater/surface water exchange, reduces sediment supply from eroding streambanks, establishes vertical and lateral stability, improves sediment transport capacity, improves bed form diversity, generates habitat and biodiversity, and improves water quality
Add bed form structure and complexity, e.g. instream structures	Energy dissipation during flow events, locally reduce shear stresses, generates wood debris storage, habitat and biodiversity, reduces bed and bank erosion, reduced sediment supply from eroding streambanks, improves bed form diversity and improves water quality
Remove Livestock and terminate agricultural practices	Improves vegetated bank cover and bank root zone, provides shade and generates wood debris storage, habitat and biodiversity, reduces bank erosion, reduces sediment supply from eroding streambanks and improves bed form diversity and improves water quality

6.1 Riverby Ranch Existing Stream Restoration and Enhancement

Mitigated SQUs for the reaches were calculated by estimating the uplift potential for each reach on the ranch and designating an uplift RGA score and SQF for the reach. Uplift potential was estimated assuming appropriate application of potential stream improvement practices. The mitigated SQUs for the reaches were calculated as a product of reach length and reach mitigated SQF. Reach mitigated SQUs were summed to calculate the total number of mitigated SQUs for the Riverby Ranch Property of 120,506, excluding streams in the WRP area.

6.2 Riverby Ranch Stream Creation

Mitigated RGA scores for the additional created stream length were extrapolated from the mitigated RGA scores of the associated stream. For example, if a straightened stream channel was estimated to receive a mitigated RGA score of 40, the additional stream length associated with that stream (calculated using a sinuosity ratio of 1.3) was also given a RGA score of 40. The RGA scores of the additional created stream length were converted to SQF values. The SQUs of the created stream length for each reach were calculated as the product of the mitigated SQF values and the anticipated additional created stream length for each reach. The total number of SQUs for created stream length on Riverby Ranch was calculated as the sum of the SQUs of the created stream length for each reach in which meanders were developed. The total number of SQUs for the created stream length resulting from the restoration of meanders was calculated to be 26,488. Stream reaches in the WRP were not considered suitable for meander creation.

6.3 On-site Tributaries to Littoral Zone Wetlands

The proposed mitigation plan intends to offer protection from future development and other non-compatible uses by establishing a site protection instrument up to elevation 541 ft. msl. at the proposed reservoir site. The cessation of farming practices such as the application of fertilizers and pesticides, removing cattle and other negative anthropogenic influences will benefit the littoral zone tributary streams and provide ecological uplift. The uplift due to the establishment of a site protection instrument and the removal of human influences is expected to be at least five (5) RGA points. Five RGA points were added to the baseline RGA score for each tributary stream to establish the mitigated RGA scores within the littoral zone wetlands. The mitigated RGA scores were converted to SQF values, which were used to calculate the SQUs, defined as the product of the SQF and the length of littoral zone tributary streams. The total number of mitigated SQUs for tributaries of the littoral zone wetlands, defined as the sum of all mitigated SQUs for the littoral zone tributary streams, was calculated to be 5,677.

6.4 Riverby Ranch WRP

Enhancement of streams within the WRP would include restoration of hydrology through modifications to the existing dike and drainage ditch that borders the east and west sides of the WRP area, and the creation of treed riparian corridors along selected existing stream alignments. The restoration of hydrology reconnects the watershed with its streams and floodplain. The uplift is reflected through a reduction in man-made influences on the stream and improved sediment transport. Establishing a treed riparian buffer will improve streambank stability, reduce bank erosion, provide shade to the stream, and generate wood debris storage/habitat.

Fluvial geomorphic principles support the hypothesis that as upstream reaches of streams are improved and become stabilized, the downstream reaches of the channel can experience indirect ecological uplift resulting from the upstream improvements, even with no direct channel work performed in the downstream reaches. For example, removing cattle and other agricultural practices, restoring meanders, modifying channel geometry to stable dimensions, and re-connecting the upstream channel to a floodplain would promote stability and provide uplift to the downstream reach by reducing the volume and velocity of incoming stream flow (thereby reducing channel erosion and bank failures), reducing incoming sediment and nutrient loads (that promote channel infilling and eutrophication), and providing a seed source for channel vegetation.

Additionally, changes in the hydrologic regime of Bois d'Arc Creek downstream of the proposed dam are expected to provide sufficient flows to benefit and maintain habitat and not cause erosion and channel degradation. Based on this assumption, RGA scores are expected to improve for the reaches of Bois d'Arc Creek downstream of the proposed dam.

Mitigated RGA scores for the streams in the WRP that were directly connected to upstream tributaries outside the WRP area were assigned based on the existing condition of the WRP streams and the anticipated future condition that would result from indirect uplift caused by upstream channel restoration efforts, modifications to the existing dike surrounding this area, and the establishment of treed riparian buffers. Mitigated RGA scores for Bois d'Arc Creek within the WRP were assigned based on the anticipated future condition that would result from the stabilized hydraulic regime downstream of the proposed dam and the re-establishment of hydrology to its tributaries. Mitigated RGA scores were converted to mitigated SQF values, and the mitigated SQUs for the WRP stream reaches were calculated as the product of length of the stream reach within the WRP area and the reach mitigated SQUs. Reach mitigated SQUs were summed to calculate the total number of mitigated SQUs for the streams in the WRP area on Riverby Ranch of 47,142.

6.5 Upper Bois d'Arc Creek Mitigation Site Stream Enhancement

The primary purpose of the Upper BDC Mitigation Site is to provide forested wetland mitigation to offset forested wetland impacts caused by the proposed reservoir. NTMWD is proposing to enhance streams in the Upper BDC Mitigation Site area by through planting of treed riparian buffers along the main stem of Bois d'Arc creek and tributaries. Establishing a treed riparian buffer will improve streambank stability, reduce bank erosion, provide shade to the stream, and generate wood debris storage/habitat.

The uplift due to the establishment of a site protection instrument and the removal of human influences is expected to be at least five (5) RGA points. Therefore, five RGA points were added to the baseline RGA score for each stream to establish the mitigated RGA scores within the Upper BDC Mitigation Site. The establishment of new treed riparian buffers and the enhancement of existing treed buffers is expected to generate additional uplift, but NTMWD is not proposing to take credit for this uplift. The mitigated RGA scores were converted to SQF values, which were used to calculate the SQUs, defined as the product of the SQF and the length of littoral zone tributary streams. The total number of mitigated SQUs for streams in the Upper BDC Mitigation Site, defined as the sum of all mitigated SQUs for the streams at the site, was calculated to be 22,330.

Table 5. Summary of the Mitigated Conditions for the Potential Mitigation Opportunities

SQF	Riverby Ranch, Excluding WRP		Riverby Ranch Stream Creation		Tributaries of Littoral Zone		Riverby Ranch WRP Area		Upper BDC Mitigation Site	
	Mitigated Length (ft)	SQU	Mitigated Length (ft)	SQU	Mitigated Length (ft)	SQU	Mitigated Length (ft)	SQU	Mitigated Length (ft)	SQU
0 - .09	0	0	0	0	0	0	0	0	0	0
.1 - .19	1,907	286	0	0	11,447	1,908	4,502	825	15,032	2,505
.2 - .29	10,584	2,486	0	0	4,399	1,246	3,045	791	3,800	950
.3 - .39	18,167	6,457	0	0	5,623	1,687	0	0	14,641	4,904
.4 - .49	10,517	4,381	0	0	1,075	430	23,048	9,637	20,763	8,305
.5 - .59	6,762	3,719	0	0	0	0	40,688	21,025	1,483	816
.6 - .69	27,288	16,505	2,852	1,711	640	406	23,313	14,864	1,962	1,210
.7 - .79	1,215	911	0	0	0	0	0	0	4,854	3,640
.8 - .89	102,913	85,761	29,745	24,777	0	0	0	0	0	0
.9 - .99	0	0	0	0	0	0	0	0	0	0
1.0	0	0	0	0	0	0	0	0	0	0
Total	179,353	120,506	32,597	26,488	23,184	5,677	94,596	47,142	62,535	22,330

7.0 COMPENSATORY MITIGATION SUMMARY AND PROPOSED MITIGATION PLAN COMPONENTS

The total number of SQUs of Bois d'Arc Creek and its tributaries within the proposed reservoir pool is 192,377. Mitigation for the impacted streams would be achieved through the five (5) mitigation components listed in Table 6.

As shown in Table 6, only the uplift that will be generated by stream enhancement in the Riverby Ranch WRP area are included in the total proposed mitigation. This is because the streams located within the WRP area are currently protected in perpetuity under the NRCS WRP instrument. The total number of SQUs generated by the five mitigation components compensate for the stream losses in the proposed reservoir pool with a total of 181,153 SQU mitigation credits, resulting in a deficit of 11,224 SQUs. Table 6 summarizes the total number of baseline and mitigated condition SQUs for the five proposed mitigation components.

Table 6 Baseline, mitigated, and uplift SQUs for proposed stream mitigation components

Mitigation Component	Baseline SQU	Mitigated SQU	SQU Uplift
Riverby Ranch Restoration and Enhancement	64,140	120,506	56,366
Riverby Ranch Creation	0	26,488	26,488
Riverby Ranch WRP Area	40,990	47,142	6,152
On-Site Tributaries to Littoral Zone Wetlands	3,745	5,677	1,932
Upper BDC Mitigation Site	17,119	22,330	5,211
Total	125,994	222,143	96,149
Total Stream Impacts	192,377		
Total Stream SQU Mitigation Credits		181,153*	

*Total stream SQU mitigation credits is the sum of the total (baseline plus uplift) mitigated SQUs for each mitigation component less the baseline SQUs for the for Riverby Ranch WRP Area. The baseline SQUs for the WRP Area are excluded from the credit calculation because this area is currently protected through the WRP.

8.0 REFERENCES

Freese and Nichols, 2008, Rapid Geomorphic Assessment of Bois d'Arc Creek and its Tributaries for the Lower Bois d'Arc Creek Reservoir Project: Prepared for North Texas Municipal Water District

Freese and Nichols, 2014, Proposed Mitigation for Stream Impacts of the Proposed Lower Bois d'Arc Creek Reservoir – Rapid Geomorphic Assessment: Prepared for North Texas Municipal Water District

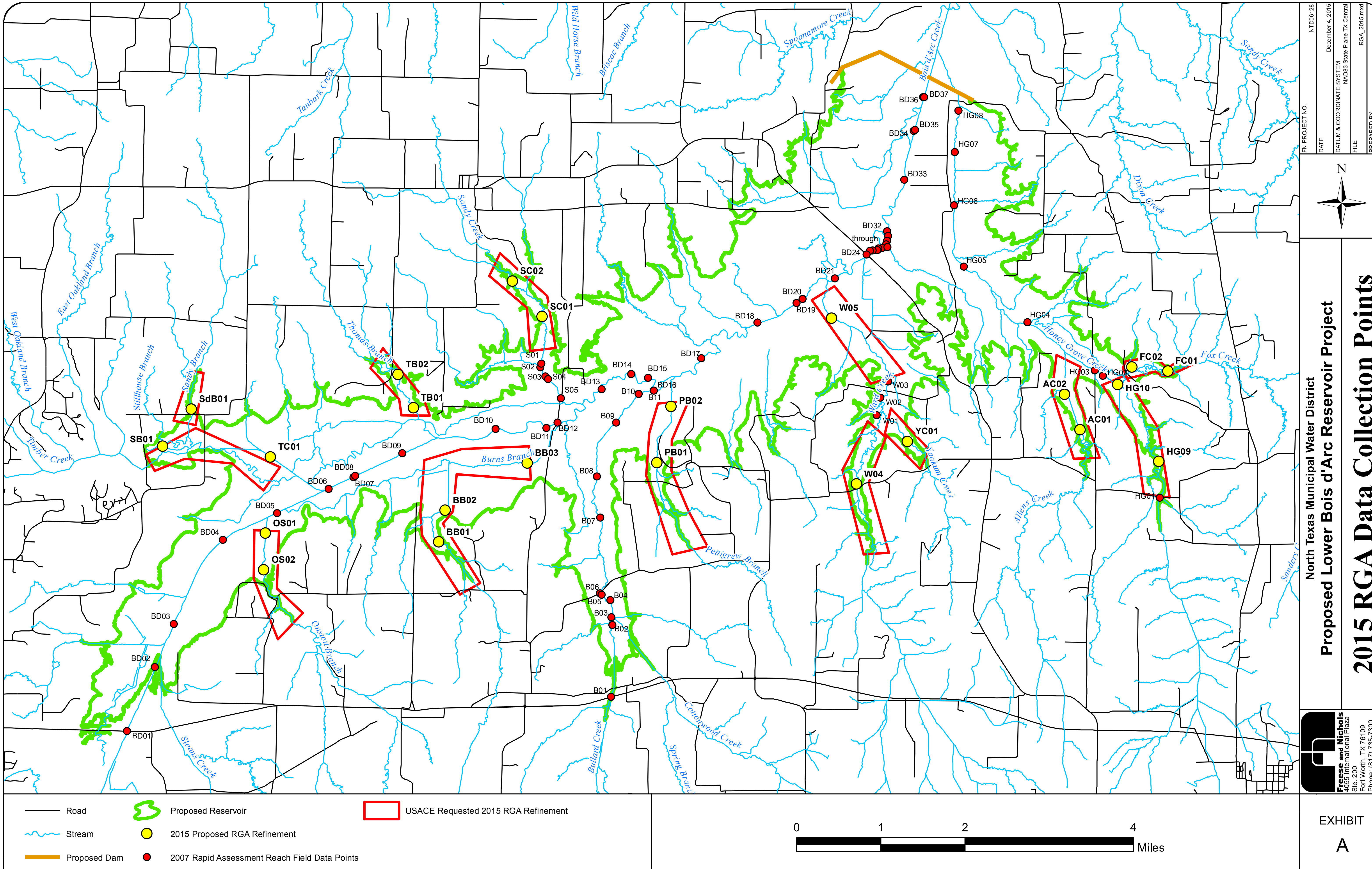
Freese and Nichols, 2016, Supplemental Rapid Geomorphic Assessment (RGA) Data Collection at the Proposed Lower Bois d'Arc Creek Reservoir Site: Prepared for North Texas Municipal Water District.

U.S. Army Corps of Engineers. 2011. Joint Public Notice CESWF-11-TXRAM announcing release of the *Draft Texas Rapid Assessment Method (TXRAM), Wetland and Streams Modules, Version 1.0. Final Draft.* March 24, 2011.

U.S. Army Corps of Engineers. 2015. Joint Public Notice CESWF-11-TXRAM announcing release of the *Final Texas Rapid Assessment Method (TXRAM), Wetland and Streams Modules, Version 2.0.* October 13, 2015.

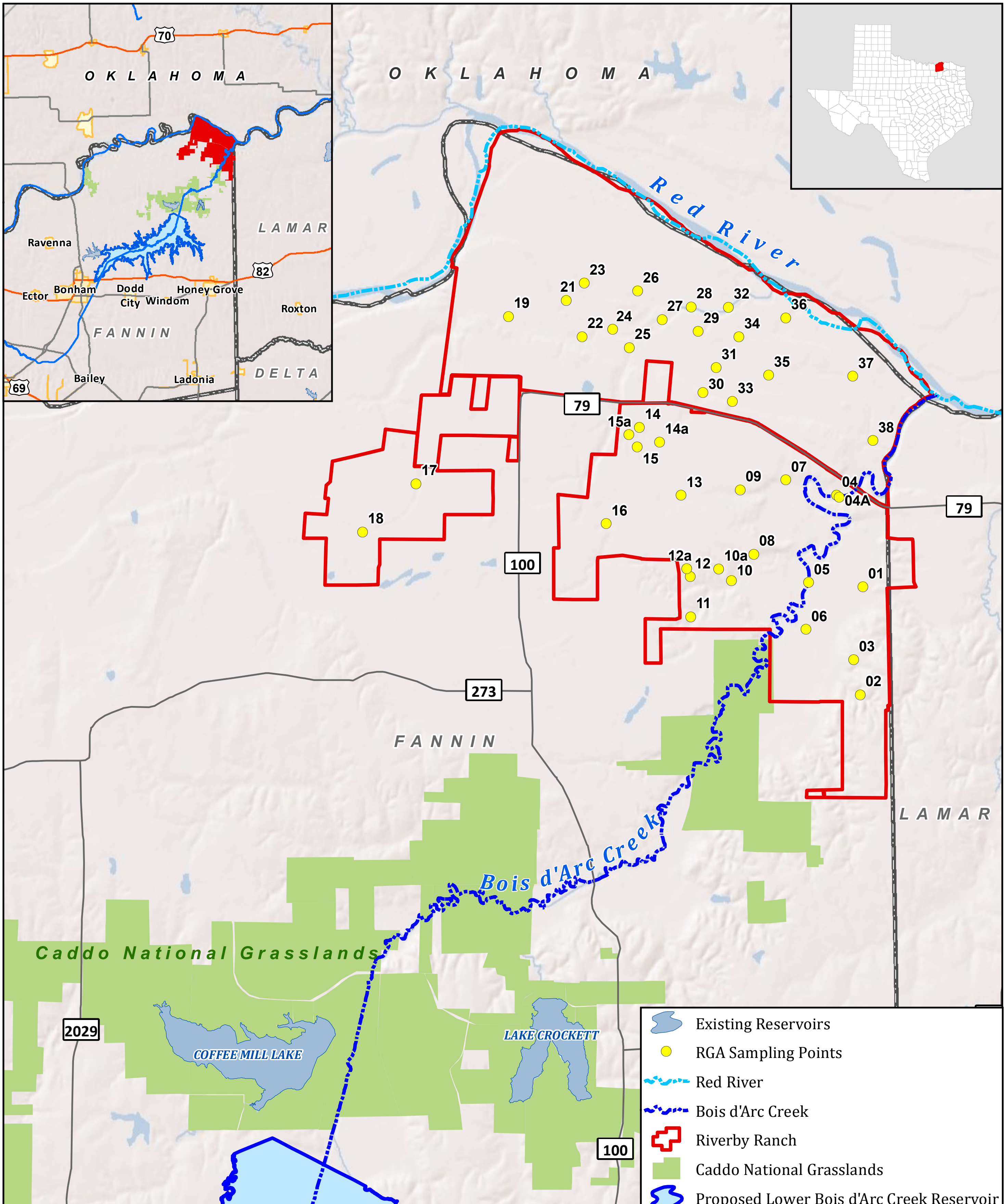
Rosgen, David, 2006, Watershed Assessment of River Stability and Sediment Supply: Wildland Hydrology, Fort Collins, CO.

EXHIBITS



APPENDIX E

Document Path: H:\ENVIRONMENTAL\LBD_RGA_2015\RGA_2015.mxd Austin Network



FREESE AND NICHOLS

Freese and Nichols, Inc.
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

N W E S

NORTH TEXAS MUNICPAL WATER DISTRICT

Riverby Ranch

Location Map

0 2 4 Miles

FN JOB NO	NTD06128
FILE NAME	Location.mxd
DATE	11/4/2016
SCALE	1:96,411
DESIGNED	SSJ
DRAFTED	dkc

B

EXHIBIT

APPENDIX E

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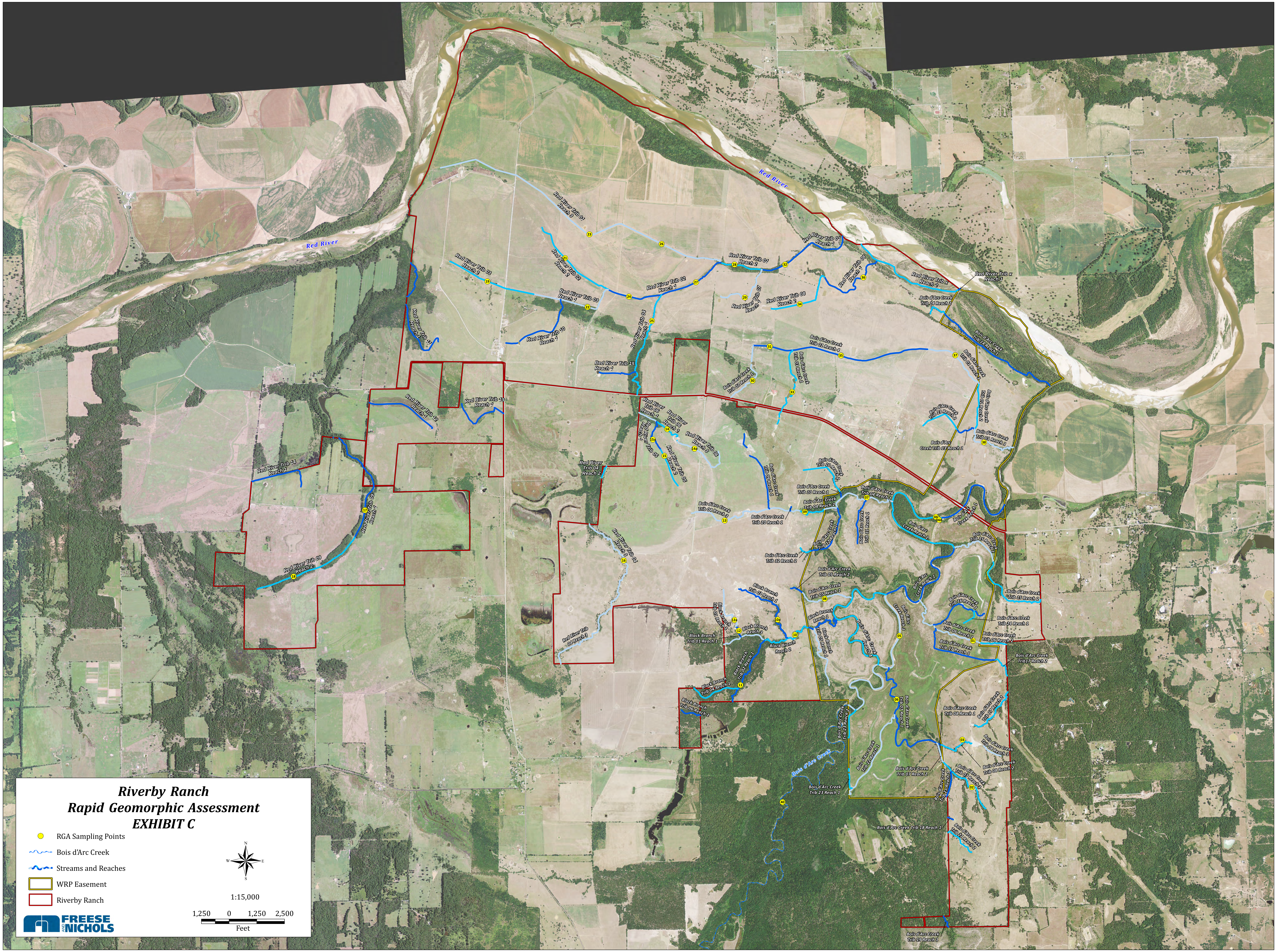
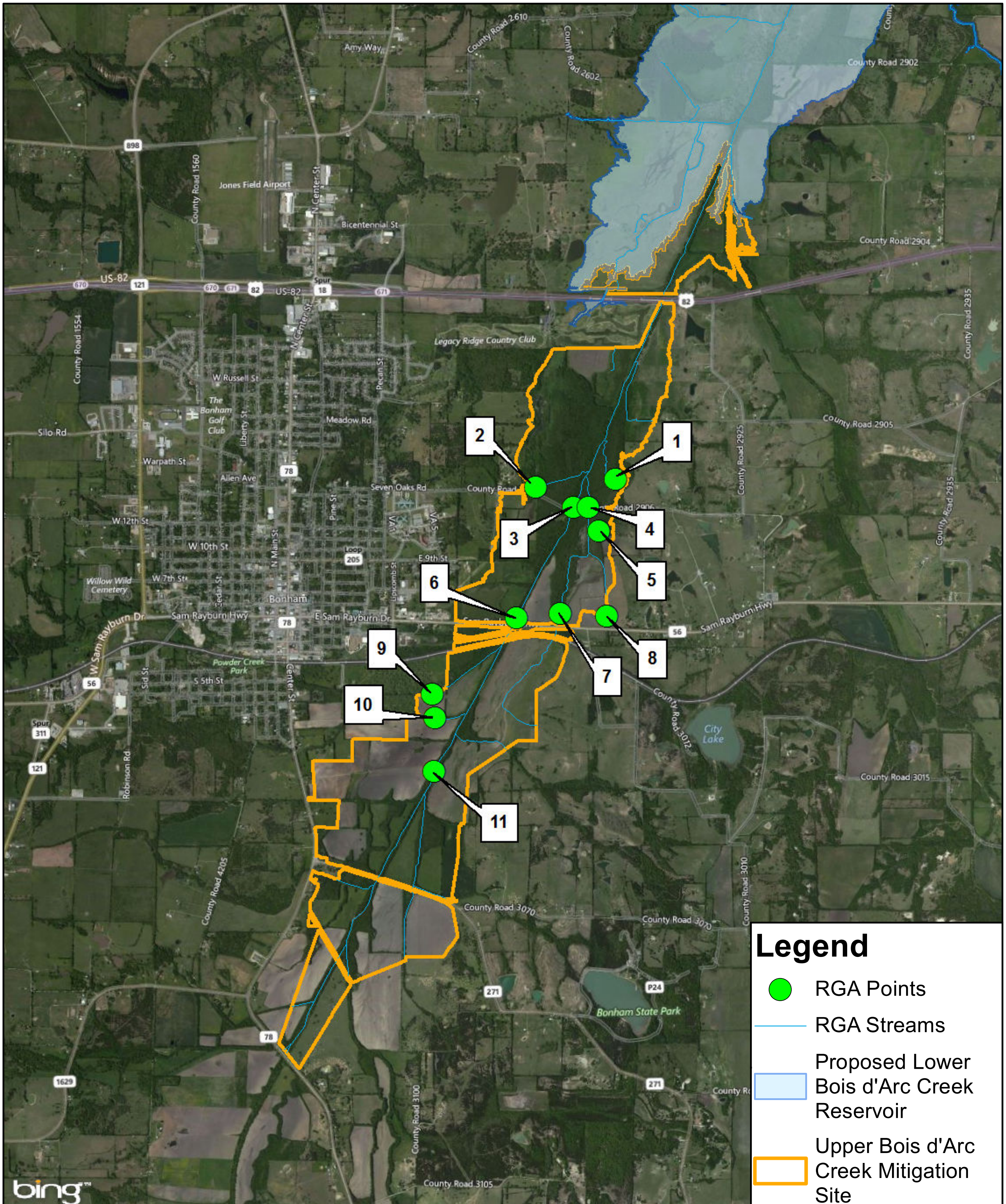

Riverby Ranch
Rapid Geomorphic Assessment
EXHIBIT C
RGA Sampling Points
Bois d'Arc Creek
Streams and Reaches
WRP Easement
Riverby Ranch
1:15,000
1,250 0 1,250 2,500
Feet
FREESE NICHOLS
Red River
Red River
Bois d'Arc Creek



NORTH TEXAS MUNICPAL WATER DISTRICT

Upper Bois d'Arc Creek Mitigation Site

RGA Locations

0 4,000 8,000 Feet

Freese and Nichols, Inc.
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

FN JOB NO	NTD06128
FILE NAME	Upper_BDC_Mitigation_Area_RGA_8x11.mxd
DATE	11/4/2016
SCALE	1:48,000
DESIGNED	SSJ
DRAFTED	02405

D

EXHIBIT

APPENDIX E

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NAD 1983 StatePlane Texas North Central FIPS 4202 Feet

Attachment A

October 2015 RGA Workshop Attendees

1. USACE
    a. Andy Commer
    b. Ed Parisotto

2. USEPA
    a. Maria Martinez
    b. Keith Hayden
    c. Alison Kitto

3. USFWS
    a. Sid Puder

4. TPWD
    a. Tom Heger
    b. Ryan McGillicuddy

5. TCEQ
    a. Peter Schaffer

6. Solv
    a. Leon Kolankiewicz

7. NTMWD
    a. Robert McCarthy
    b. Ashley Burt

8. FNI
    a. Simone Kiel
    b. Steve Watters
    c. David Coffman
    d. Stephanie Coffman
    e. Velita Cardenas
    f. Michael Votaw
    g. Randall Howard

9. Lloyd Gosselink
    a. Sara Thornton

10. Baylor University
    a. Dr. Peter Allen

Attachment B

Email: LBRC RGA “ground truthing” of data

From:	Robert McCarthy
To:	Mike Rickman; Billy George; Sara Thornton; Steve Watters; Michael Votaw; Randall Howard; Simone Kiel
Subject:	Fwd: LBCR RGA "ground truthing" of data
Date:	Monday, December 07, 2015 10:42:07 AM
Attachments:	RGA_2015.pdf RGA_2015_DataPoints_20151204.zip FW LBCR RGA ground truthing of data (UNCLASSIFIED).msg

Fyi

RM:
Sent via the Samsung GALAXY S5

-------- Original message --------
From: "Parisotto, Edward SWT" <Edward.Parisotto@usace.army.mil>
Date: 12/7/2015 9:00 AM (GMT-06:00)
To: "Crawford, Dorothy" <Crawford.Dorothy@epa.gov>, "Kitto, Alison" <Kitto.Alison@epa.gov>, "Hayden, Keith" <Hayden.Keith@epa.gov>, "'sidney_puder@fws.gov'" <sidney_puder@fws.gov>, 'Ryan McGillicuddy' <Ryan.McGillicuddy@tpwd.texas.gov>, 'Tom Heger' <Tom.Heger@tpwd.texas.gov>, 'Peter Schaefer' <peter.schaefer@tceq.texas.gov>, "'robertpotts@fs.fed.us'" <robertpotts@fs.fed.us>, 'H M Williams' <hwilliams@sfasu.edu>, "Commer, Andrew SWT" <Andrew.Commer@usace.army.mil>, Robert McCarthy <rmccarthy@NTMWD.COM>, 'Leon Kolankiewicz' <Leon.Kolankiewicz@solvllc.com>, "Hoffmann, Robert SWT" <Robert.B.Hoffmann@usace.army.mil>, "Poulos, Lauren" <poulos.lauren@epa.gov>
Subject: FW: LBCR RGA "ground truthing" of data

Team,
Please reference my November 13th email regarding RGA "truthing". The Corps received valuable comments from some of you and appreciate the time you have taken to provide that input. The Corps has finalized the required additional field work with the applicant.

Attached is a map and data points that the applicant is required to assess utilizing the same RGA method used previously for this project. The field work is tentatively scheduled for the week of 11 January 2016. Field contacts numbers are Michael Votaw, 817-676-3610 or Steve Watters, 817-706-5733.

I will still be the POC for coordination if you plan on monitoring the field work OR schedule changes need to be made (due to weather). If for some reason I am not available, feel free to contact Robert McCarthy at 469-626-4635.

I want to thank each of you again for all of you time and assistance with the evaluation of this field work.

Respectfully,
Ed

Ed Parisotto
Supervisory Regulatory Project Manager
Tulsa District U.S. Army Corps of Engineers
(918) 669-7549 / Fax: (918) 669-4306
http://www.swt.usace.army.mil/Missions/Regulatory.aspx
You are invited to complete our Regulatory Service Survey at:

http://corpsmapu.usace.army.mil/cm_apex/f?p=136:4:0

-----Original Message-----
From: Robert McCarthy [mailto:rmccarthy@NTMWD.COM]
Sent: Friday, December 04, 2015 3:42 PM
To: Parisotto, Edward SWT <Edward.Parisotto@usace.army.mil>
Cc: spw@freese.com; Mike Rickman <mrickman@NTMWD.COM>; Billy George <bgeorge@NTMWD.COM>; mpv@freese.com
Subject: [EXTERNAL] LBCR RGA "ground truthing" of data

Ed,

Pease see attached a revised RGA "ground truthing" map (and associated shapefiles) on which we relocated the following stream assessment points in response to EPA's November 20, 2015 comment.

- Relocated site TC01 to Stillhouse Branch and renamed it SB01.
While reviewing the stream assessment site placement on Timber Creek, it became apparent that the site that had been labeled SB01 (in the November 2, 2015 email) was actually on an inactive, historic channel of Timber Creek. The name of the point was changed to TC01 and the point was moved northeast, out of the USACE proposed 2015 RGA ground truthing site box, onto the active channel of Timber Creek, which is a previously straightened reach.

With regard to schedule, we are tentatively planning to conduct the RGA ground truthing field study during the week of January 11, 2016. This field schedule is dependent on USACE concurrence with our proposed stream assessment locations as well as weather/field conditions. We'll firm up the field logistics as we get closer to January 11.

Please let me know if you have any questions.

Robert McCarthy
Permit Manager
North Texas Municipal Water District
505 E. Brown St.
P.O. Box 2408
Wylie, Texas 75098
Telephone (469) 626-4633
Email: rmccarthy@ntmwd.com

Attachment C

Example RGA Field Forms and Channel Stability Rating System Form

Data Collection Sheet

Sheet No.

Date:		Stream Name:	
Project Name:	Lower Bois d'Arc Creek Reservoir Phase II	Coordinates:	
Project Number:	NTD06128	Field Crew:	

Channel Characteristics:				**Stream Size: Category (Bankfull Width, ft)**					
Average Bank Width:		OHWM Width:		S-1 (<1)	❑	S-6 (50-75)	❑	S-11 (350-500)	❑
Average Bank Depth:		Circle: Perennial, Intermittent, or Ephemeral		S-2 (1-5)	❑	S-7 (75-100)	❑	S-12 (500-1000)	❑
Average Stream Bed Depth:				S-3 (5-15)	❑	S-8 (100-150)	❑	S-13 (>1000)	❑
Average Water Width:		Circle: Clear or Turbid		S-4 (15-30)	❑	S-9 (150-250)	❑		
Average Water Depth:		Water Color:		S-5 (30-50)	❑	S-10 (250-350)	❑		
Maximum Water Depth:									

Substrate:				**Debris/Blockages:**		*B.D.= Beaver Dams			
Silt/Clay	❑	Boulder (>10")	❑	D1: None	❑	D5: Extensive	❑	D9: B.D. - Abandoned	❑
Sand	❑	Bedrock	❑	D2: Infrequent	❑	D6: Dominating	❑		
Gravel (.25"-2.5")	❑	Concrete	❑	D3: Moderate	❑	D7: B.D. - Few	❑	D10 - Human Influences	❑
Cobble (2.5"-10")	❑	Organic	❑	D4: Numerous	❑	D8: B.D. - Frequent	❑		

Instream Cover:				**Riparian Zone:**			
Undercut Banks	❑	Deep Pools	❑	Forest	❑	Scrub/Shrub	❑
Shallows	❑	Overhanging Vegetation	❑	Pasture	❑	Row-Crop	❑
Boulders	❑	Emergent/Submergent Vegetation	❑	Paved	❑	Residential	❑
Oxbows	❑	Logs/Brush	❑	Old-Field/ROW	❑	Width of Riparian Zone	

Riparian Vegetation:

Category	Percent Aerial Cover	Percent Site Coverage	Species Composition	Percent of Total
Canopy Layer				
Shrub Layer				
Herbaceous				
Leaf or Needle Litter				
Bare Ground				

Photos:	**Additional Notes:**

APPENDIX E

BEHI Variable Worksheet

Stream:	Reach:	Cross Section:
Observers:		Date:

						BEHI Score
Bank Height/Max Depth Bankfull (C)						
Study Bank Height (ft)	(A)	Bankfull Height (ft)	(B)	(A)/(B) =	(C)	
Root Depth/Bank Height (E)						
Root Depth (ft)	(D)	Study Bank Height (ft)	(A)	(D)/(A) =	(E)	
				Weighted Root Density (F)		
				Root Density (%)	(F)	
				Bank Angle (G)		
				Bank Angle (Degrees)	(G)	
				Surface Protection (H)		
				Surface Protection (%)	(H)	

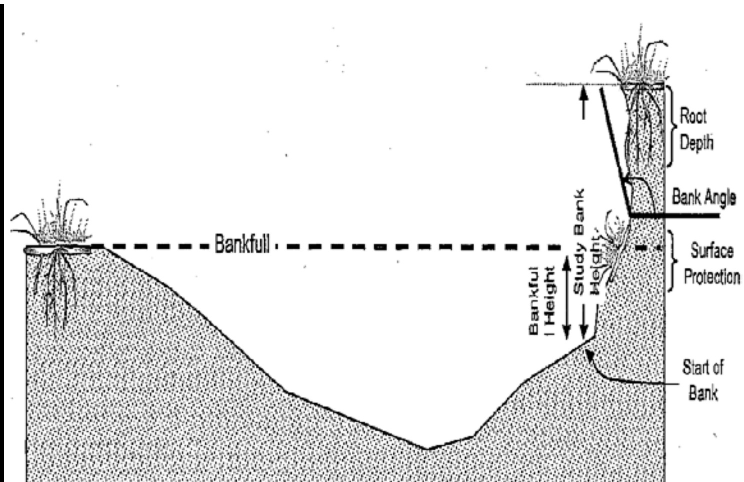
Bank Material Adjustment		
Bedrock (Overall Very Low BEHI) Boulders (Overall Low BEHI) Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust Gravel (Add 5-10 points depending percentage of bank material that is composed of sand) Sand (Add 10 points) Silt Clay (no adjustment)	**Bank Materials Adjustment**	
	Stratification Adjustment Add 5-10 points, depending on position of unstable layers in relation to bankfull stage	

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME		
						ADJECTIVE RATING and **TOTAL SCORE**	
5 - 9.5	10 - 19.5	20 - 29.5	30 - 39.5	40 - 45	46 - 50		

Bank Sketch

Vertical Distance (ft)

Horizontal Distance (ft)



APPENDIX E

Pfankuch Channel Stability Form

Stream: ____________________ Reach: ____________________ Date: __________ Observers: ____________________ Comments: ____________________

Location	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper Banks	1	Landform Slope	Bank slope gradient <30%.	2	Bank slope gradient 30-40%.	4	Bank slope gradient 40-60%.	6	Bank slope gradient 60%+.	8
	2	Mass Wasting	No evidence of past or future mass wasting.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly year long.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris Jam Potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative Bank Protection	90%+ plant density. Vigor and variety suggest a deep, dense soil binding root mass.	3	70-90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50-70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species & less vigor indicating poor, discontinuous, and shallow root mass.	12
Lower Banks	5	Channel Capacity	Ample for present plus some increases. Peak flows contained. (W/D)/(W/Dref) < 1.1, BHR = 1.0 - 1.1	1	Adequate. Bank overflows are rare. (W/D)/(W/Dref) = 1.1 - 1.2, BHR = 1.1 - 1.3	2	Barely contains present peaks. Occasional overbank floods. (W/D)/(W/Dref) = 1.2 - 1.6, BHR = 1.3 - 1.5	3	Inadequate. Overbank flows common. (W/D)/(W/Dref) > 1.6, BHR > 1.5	4
	6	Bank Rock Content	65%+ w/ large angular boulders. 12"+ common.	2	40-65%. Mostly boulders and small cobbles 6-12".	4	20-40%. With most in the 3-6" diameter class.	6	<20% rock fragments of gravel sizes, 1-3" or less.	8
	7	Obstructions to Flow	Rocks and logs firmly embedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12-24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate deposition of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges, surfaces smooth, flat.	2	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e. 35-65% mixture range.	3	Predominantly bright, 65%+, exposed or scoured surfaces.	4
	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	8
	13	Bottom Size Distribution	No size change evident. Stable material 80-100%.	4	Distribution shift light. Stable material 50-80%.	8	Moderate change in sizes. Stable materials 20-50%.	12	Marked distribution change. Stable materials 0-20%.	16
	14	Scouring and Deposition	<5% of bottom affected by scour or deposition.	6	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too.	1	Common. Algae forms in low velocity and pool areas. Moss here, too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	4
			Excellent Total =		**Good Total =**		**Fair Total =**		**Poor Total =**	

Stream Type	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**D3**	**D4**	**D5**	**D6**
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. Unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

Stream Type	**DA3**	**DA4**	**DA5**	**DA6**	**E3**	**E4**	**E5**	**E6**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
Fair (Mod. Unstable)	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

Grand Total =	
Existing Stream Type =	
Potential Stream Type* =	
Modified Channel Stability Rating =	

* Rating should be adjusted to Potential Stream Type, not existing.

APPENDIX E

Riverby Ranch Streams
Channel Stability Rating System

Reach: ____________________

Rapid Assessment Stream Stability Rating

○ Excellent ○ Good ○ Fair ● Poor

Field Data Point	**Station**	
	To	From

Extrapolated Stations		
To	From	Reasoning

Classification Basis								
Evaluation Category	Excellent (9 - 10)		Good (6 - 8)		Fair (3 - 5)		Poor (0 - 2)	
Evidence of Bank Erosion	Little to no evidence of bank sloughing, slumping, or failure. (< 10%)		Infrequent evidence of bank sloughing, slumping, or failure. Mostly healed over. (10-29.9%)		Recent evidence of bank sloughing, slumping, or failure. High potential during flood events. (30-50%)		High evidence of bank sloughing, slumping, or failure. (>50%)	
Bank Root Zone	Banks comprised of highly resistant tree/plant/soil material.		Banks comprised of moderately resistant tree/plant/soil material		Banks comprised of highly erodible tree/plant/soil material and material is compromised.		Banks comprised of highly erodible tree/plant/soil material and material is severely compromised.	
Vegetative Bank Cover	Abundant cover (>70%)		Moderate cover (40-69.9%)		Infrequent cover (10-39.9%)		Little to no cover (<10%)	
Bank Angle	3H:1V or flatter		2H:1V - 3H:1V		1H:1V - 2H:1V		1H:1V or steeper	
Sediment Transport	Point bars small and stable, well vegetated and/or armored with little or no fresh sand.		Mix of point bars and few side bars.		Moderate amount of mid-channel bars and side bars.		Stream branching with mid-channel bars and islands or no depositional features.	
Channel Alteration	No manmade channel alteration.		Infrequent amount of manmade channel alteration.		Moderate amount of manmade channel alteration.		Extensive amount of manmade channel alteration.	
Total		0		0		0		0

Description:

Score	Rapid Assessment Stream Stability Rating
51 - 60	Excellent Condition
37 - 50	Good Condition
20 - 36	Fair Condition
< 20	Poor Condition

Total Score	0

APPENDIX E

Attachment D

RGA Calculations Tables

Proposed Lower Bois d'Arc Creek Reservoir Site

GNIS_Name	RGA Score	Length (ft)	SQF	SQU	Flow Type
Allens Creek	12	2,785	0.20	557	Intermittent
Allens Creek	8	4,327	0.13	577	Intermittent
Allens Creek	8	1,498	0.13	200	Intermittent
Allens Creek	12	2,909	0.20	582	Intermittent
Allens Creek	8	262	0.13	35	Intermittent
UT of Allens Creek	12	924	0.20	185	Intermittent/Ephemeral
UT of Allens Creek	8	629	0.13	84	Intermittent/Ephemeral
UT of Allens Creek	8	290	0.13	39	Intermittent/Ephemeral
Bois d'Arc Creek	14	1,895	0.23	442	Intermittent
Bois d'Arc Creek	13	1,950	0.22	422	Intermittent
Bois d'Arc Creek	5	1,614	0.08	135	Intermittent
Bois d'Arc Creek	13	1,426	0.22	309	Intermittent
Bois d'Arc Creek	14	2,093	0.23	488	Intermittent
Bois d'Arc Creek	18	548	0.30	164	Intermittent
Bois d'Arc Creek	18	3,128	0.30	938	Intermittent
Bois d'Arc Creek	25	3,373	0.42	1,406	Intermittent
Bois d'Arc Creek	14	1,518	0.23	354	Intermittent
Bois d'Arc Creek	13	1,046	0.22	227	Intermittent
Bois d'Arc Creek	19	2,412	0.32	764	Intermittent
Bois d'Arc Creek	7	5,727	0.12	668	Intermittent
Bois d'Arc Creek	13	177	0.22	38	Intermittent
Bois d'Arc Creek	28	4,191	0.47	1,956	Intermittent
Bois d'Arc Creek	25	1,148	0.42	478	Intermittent
Bois d'Arc Creek	33	2,220	0.55	1,221	Intermittent
Bois d'Arc Creek	33	455	0.55	251	Intermittent
Bois d'Arc Creek	33	285	0.55	157	Intermittent
Bois d'Arc Creek	28	4,402	0.47	2,054	Intermittent
Bois d'Arc Creek	14	2,670	0.23	623	Intermittent
Bois d'Arc Creek	27	4,062	0.45	1,828	Intermittent
Bois d'Arc Creek	18	4,200	0.30	1,260	Intermittent
Bois d'Arc Creek	18	661	0.30	198	Intermittent
Bois d'Arc Creek	33	4,798	0.55	2,639	Intermittent
Bois d'Arc Creek	18	2,768	0.30	830	Intermittent
Bois d'Arc Creek	24	463	0.40	185	Intermittent
Bois d'Arc Creek	33	598	0.55	329	Intermittent
Bois d'Arc Creek	33	2,160	0.55	1,188	Intermittent
Bois d'Arc Creek	7	3,062	0.12	357	Intermittent
Bois d'Arc Creek	33	1,078	0.55	593	Intermittent
Bois d'Arc Creek	33	9	0.55	5	Intermittent
Bois d'Arc Creek	19	3,297	0.32	1,044	Intermittent
Bois d'Arc Creek	17	697	0.28	198	Intermittent
Bois d'Arc Creek	17	1,001	0.28	284	Intermittent
Bois d'Arc Creek	25	1,640	0.42	683	Intermittent
Bois d'Arc Creek	28	225	0.47	105	Intermittent
Bois d'Arc Creek	14	151	0.23	35	Intermittent
Bois d'Arc Creek	14	1,394	0.23	325	Intermittent
Bois d'Arc Creek	18	350	0.30	105	Intermittent

Proposed Lower Bois d'Arc Creek Reservoir Site

GNIS_Name	RGA Score	Length (ft)	SQF	SQU	Flow Type
Bois d'Arc Creek	8	303	0.13	40	Intermittent
Bois d'Arc Creek	13	70	0.22	15	Intermittent
Bois d'Arc Creek	27	1,019	0.45	459	Intermittent
Bois d'Arc Creek	28	2,724	0.47	1,271	Intermittent
Bois d'Arc Creek	14	502	0.23	117	Intermittent
Bois d'Arc Creek	23	261	0.38	100	Intermittent
Bois d'Arc Creek	14	186	0.23	44	Intermittent
Bois d'Arc Creek	18	732	0.30	220	Intermittent
UT of Bois d'Arc Creek	5	2,219	0.08	185	Intermittent/Ephemeral
UT of Bois d'Arc Creek	5	1,594	0.08	133	Intermittent/Ephemeral
UT of Bois d'Arc Creek	18	9,928	0.30	2,978	Intermittent/Ephemeral
UT of Bois d'Arc Creek	18	233	0.30	70	Intermittent/Ephemeral
UT of Bois d'Arc Creek	13	4,629	0.22	1,003	Intermittent/Ephemeral
UT of Bois d'Arc Creek	18	705	0.30	212	Intermittent/Ephemeral
UT of Bois d'Arc Creek	27	96	0.45	43	Intermittent/Ephemeral
UT of Bois d'Arc Creek	27	2,035	0.45	916	Intermittent/Ephemeral
UT of Bois d'Arc Creek	5	30	0.08	2	Intermittent/Ephemeral
UT of Bois d'Arc Creek	14	2,271	0.23	530	Intermittent/Ephemeral
UT of Bois d'Arc Creek	14	2,163	0.23	505	Intermittent/Ephemeral
UT of Bois d'Arc Creek	5	479	0.08	40	Intermittent/Ephemeral
UT of Bois d'Arc Creek	18	3,939	0.30	1,182	Intermittent/Ephemeral
UT of Bois d'Arc Creek	14	2,404	0.23	561	Intermittent/Ephemeral
UT of Bois d'Arc Creek	14	1,122	0.23	262	Intermittent/Ephemeral
UT of Bois d'Arc Creek	19	9,904	0.32	3,136	Intermittent/Ephemeral
UT of Bois d'Arc Creek	27	634	0.45	285	Intermittent/Ephemeral
UT of Bois d'Arc Creek	18	535	0.30	161	Intermittent/Ephemeral
UT of Bois d'Arc Creek	27	2,814	0.45	1,266	Intermittent/Ephemeral
UT of Bois d'Arc Creek	5	67	0.08	6	Intermittent/Ephemeral
UT of Bois d'Arc Creek	14	5,664	0.23	1,322	Intermittent/Ephemeral
UT of Bois d'Arc Creek	18	136	0.30	41	Intermittent/Ephemeral
UT of Bois d'Arc Creek	5	381	0.08	32	Intermittent/Ephemeral
UT of Bois d'Arc Creek	18	4,550	0.30	1,365	Intermittent/Ephemeral
UT of Bois d'Arc Creek	5	56	0.08	5	Intermittent/Ephemeral
UT of Bois d'Arc Creek	18	555	0.30	166	Intermittent/Ephemeral
UT of Bois d'Arc Creek	23	466	0.38	179	Intermittent/Ephemeral
UT of Bois d'Arc Creek	5	906	0.08	76	Intermittent/Ephemeral
UT of Bois d'Arc Creek	14	5,659	0.23	1,320	Intermittent/Ephemeral
UT of Bois d'Arc Creek	14	2,472	0.23	577	Intermittent/Ephemeral
UT of Bois d'Arc Creek	18	10	0.30	3	Intermittent/Ephemeral
UT of Bois d'Arc Creek	5	212	0.08	18	Intermittent/Ephemeral
UT of Bois d'Arc Creek	5	2,034	0.08	170	Intermittent/Ephemeral
UT of Bois d'Arc Creek	18	912	0.30	274	Intermittent/Ephemeral
UT of Bois d'Arc Creek	18	32	0.30	10	Intermittent/Ephemeral
UT of Bois d'Arc Creek	5	219	0.08	18	Intermittent/Ephemeral
UT of Bois d'Arc Creek	13	1,886	0.22	409	Intermittent/Ephemeral
UT of Bois d'Arc Creek	28	4,933	0.47	2,302	Intermittent/Ephemeral
UT of Bois d'Arc Creek	28	999	0.47	466	Intermittent/Ephemeral

Proposed Lower Bois d'Arc Creek Reservoir Site

GNIS_Name	RGA Score	Length (ft)	SQF	SQU	Flow Type
UT of Bois d'Arc Creek	27	2,577	0.45	1,160	Intermittent/Ephemeral
UT of Bois d'Arc Creek	5	2,443	0.08	204	Intermittent/Ephemeral
UT of Bois d'Arc Creek	28	600	0.47	280	Intermittent/Ephemeral
UT of Bois d'Arc Creek	28	6,454	0.47	3,012	Intermittent/Ephemeral
UT of Bois d'Arc Creek	27	2,272	0.45	1,022	Intermittent/Ephemeral
UT of Bois d'Arc Creek	28	5,391	0.47	2,516	Intermittent/Ephemeral
UT of Bois d'Arc Creek	28	338	0.47	158	Intermittent/Ephemeral
UT of Bois d'Arc Creek	28	1,867	0.47	871	Intermittent/Ephemeral
UT of Bois d'Arc Creek	13	2,835	0.22	614	Intermittent/Ephemeral
UT of Bois d'Arc Creek	14	2,973	0.23	694	Intermittent/Ephemeral
UT of Bois d'Arc Creek	5	2,631	0.08	219	Intermittent/Ephemeral
UT of Bois d'Arc Creek	27	3,645	0.45	1,640	Intermittent/Ephemeral
UT of Bois d'Arc Creek	14	4,141	0.23	966	Intermittent/Ephemeral
UT of Bois d'Arc Creek	14	11,142	0.23	2,600	Intermittent/Ephemeral
UT of Bois d'Arc Creek	27	4,796	0.45	2,158	Intermittent/Ephemeral
UT of Bois d'Arc Creek	18	307	0.30	92	Intermittent/Ephemeral
UT of Bois d'Arc Creek	5	1,898	0.08	158	Intermittent/Ephemeral
UT of Bois d'Arc Creek	5	538	0.08	45	Intermittent/Ephemeral
UT of Bois d'Arc Creek	14	5,819	0.23	1,358	Intermittent/Ephemeral
UT of Bois d'Arc Creek	18	4,336	0.30	1,301	Intermittent/Ephemeral
UT of Bois d'Arc Creek	27	7,210	0.45	3,244	Intermittent/Ephemeral
UT of Bois d'Arc Creek	14	5,612	0.23	1,309	Intermittent/Ephemeral
UT of Bois d'Arc Creek	18	603	0.30	181	Intermittent/Ephemeral
UT of Bois d'Arc Creek	5	1,098	0.08	92	Intermittent/Ephemeral
UT of Bois d'Arc Creek	18	1,380	0.30	414	Intermittent/Ephemeral
UT of Bois d'Arc Creek	27	4,911	0.45	2,210	Intermittent/Ephemeral
UT of Bois d'Arc Creek	28	4,412	0.47	2,059	Intermittent/Ephemeral
UT of Bois d'Arc Creek	5	80	0.08	7	Intermittent/Ephemeral
UT of Bois d'Arc Creek	14	275	0.23	64	Intermittent/Ephemeral
UT of Bois d'Arc Creek	28	126	0.47	59	Intermittent/Ephemeral
UT of Bois d'Arc Creek	14	264	0.23	62	Intermittent/Ephemeral
UT of Bois d'Arc Creek	14	53	0.23	12	Intermittent/Ephemeral
Bullard Creek	19	4,893	0.32	1,549	Intermittent
Bullard Creek	19	2,612	0.32	827	Intermittent
Bullard Creek	11	2,032	0.18	372	Intermittent
Bullard Creek	33	305	0.55	168	Intermittent
Bullard Creek	13	1,057	0.22	229	Intermittent
Bullard Creek	13	2,133	0.22	462	Intermittent
Bullard Creek	33	946	0.55	520	Intermittent
Bullard Creek	12	1,198	0.20	240	Intermittent
Bullard Creek	15	928	0.25	232	Intermittent
Bullard Creek	12	1,127	0.20	225	Intermittent
Bullard Creek	11	4,631	0.18	849	Intermittent
Bullard Creek	25	3,359	0.42	1,400	Intermittent
UT of Bullard Creek	13	23	0.22	5	Intermittent/Ephemeral
UT of Bullard Creek	12	1,702	0.20	340	Intermittent/Ephemeral
UT of Bullard Creek	11	3,121	0.18	572	Intermittent/Ephemeral

GNIS_Name	RGA Score	Length (ft)	SQF	SQU	Flow Type
UT of Bullard Creek	13	346	0.22	75	Intermittent/Ephemeral
UT of Bullard Creek	13	1,429	0.22	310	Intermittent/Ephemeral
Burns Branch	9	903	0.15	135	Intermittent
Burns Branch	31	9,077	0.52	4,690	Intermittent
Burns Branch	12	4,080	0.20	816	Intermittent
Burns Branch	9	3,680	0.15	552	Intermittent
Burns Branch	9	847	0.15	127	Intermittent
UT of Burns Branch	7	3,203	0.12	374	Intermittent/Ephemeral
UT of Burns Branch	9	630	0.15	95	Intermittent/Ephemeral
UT of Burns Branch	9	480	0.15	72	Intermittent/Ephemeral
UT of Burns Branch	33	4,129	0.55	2,271	Intermittent/Ephemeral
UT of Burns Branch	7	4,693	0.12	548	Intermittent/Ephemeral
UT of Burns Branch	7	2,738	0.12	319	Intermittent/Ephemeral
UT of Burns Branch	33	798	0.55	439	Intermittent/Ephemeral
UT of Burns Branch	7	4,652	0.12	543	Intermittent/Ephemeral
UT of Burns Branch	12	2,803	0.20	561	Intermittent/Ephemeral
Cottonwood Creek	12	182	0.20	36	Intermittent
Cottonwood Creek	12	3,897	0.20	779	Intermittent
Fox Creek	12	1,391	0.20	278	Intermittent
Fox Creek	22	1,299	0.37	476	Intermittent
Fox Creek	12	126	0.20	25	Intermittent
Fox Creek	12	961	0.20	192	Intermittent
Fox Creek	22	522	0.37	192	Intermittent
Fox Creek	12	366	0.20	73	Intermittent
Fox Creek	12	972	0.20	194	Intermittent
Fox Creek	12	1,476	0.20	295	Intermittent
Fox Creek	22	481	0.37	176	Intermittent
UT of Fox Creek	22	79	0.37	29	Intermittent/Ephemeral
UT of Fox Creek	12	2,896	0.20	579	Intermittent/Ephemeral
UT of Fox Creek	22	417	0.37	153	Intermittent/Ephemeral
UT of Fox Creek	12	1,968	0.20	394	Intermittent/Ephemeral
UT of Fox Creek	12	764	0.20	153	Intermittent/Ephemeral
Honey Grove Creek	1	328	0.02	5	Intermittent
Honey Grove Creek	1	2,416	0.02	40	Intermittent
Honey Grove Creek	34	1,625	0.57	921	Intermittent
Honey Grove Creek	10	967	0.17	161	Intermittent
Honey Grove Creek	31	1,800	0.52	930	Intermittent
Honey Grove Creek	34	1,619	0.57	918	Intermittent
Honey Grove Creek	24	666	0.40	266	Intermittent
Honey Grove Creek	6	2,140	0.10	214	Intermittent
Honey Grove Creek	24	1,510	0.40	604	Intermittent
Honey Grove Creek	31	3,674	0.52	1,898	Intermittent
Honey Grove Creek	6	1,549	0.10	155	Intermittent
Honey Grove Creek	6	1,170	0.10	117	Intermittent
Honey Grove Creek	6	1,635	0.10	163	Intermittent
Honey Grove Creek	34	2,398	0.57	1,359	Intermittent
Honey Grove Creek	24	2,556	0.40	1,022	Intermittent

Proposed Lower Bois d'Arc Creek Reservoir Site

GNIS_Name	RGA Score	Length (ft)	SQF	SQU	Flow Type
Honey Grove Creek	24	1,526	0.40	610	Intermittent
Honey Grove Creek	23	2,965	0.38	1,137	Intermittent
Honey Grove Creek	6	53	0.10	5	Intermittent
Honey Grove Creek	6	57	0.10	6	Intermittent
Honey Grove Creek	6	546	0.10	55	Intermittent
Honey Grove Creek	1	65	0.02	1	Intermittent
Honey Grove Creek	1	1,451	0.02	24	Intermittent
Honey Grove Creek	24	1,379	0.40	552	Intermittent
Honey Grove Creek	31	840	0.52	434	Intermittent
Honey Grove Creek	23	231	0.38	88	Intermittent
Honey Grove Creek	10	1,370	0.17	228	Intermittent
Honey Grove Creek	1	116	0.02	2	Intermittent
Honey Grove Creek	1	782	0.02	13	Intermittent
UT of Honey Grove Creek	10	3,257	0.17	543	Intermittent/Ephemeral
UT of Honey Grove Creek	24	2,229	0.40	891	Intermittent/Ephemeral
UT of Honey Grove Creek	24	58	0.40	23	Intermittent/Ephemeral
UT of Honey Grove Creek	24	2,521	0.40	1,008	Intermittent/Ephemeral
UT of Honey Grove Creek	24	195	0.40	78	Intermittent/Ephemeral
UT of Honey Grove Creek	24	4,333	0.40	1,733	Intermittent/Ephemeral
UT of Honey Grove Creek	23	4,687	0.38	1,797	Intermittent/Ephemeral
UT of Honey Grove Creek	6	1,507	0.10	151	Intermittent/Ephemeral
UT of Honey Grove Creek	1	1,855	0.02	31	Intermittent/Ephemeral
UT of Honey Grove Creek	24	3,127	0.40	1,251	Intermittent/Ephemeral
UT of Honey Grove Creek	24	418	0.40	167	Intermittent/Ephemeral
UT of Honey Grove Creek	31	6,715	0.52	3,469	Intermittent/Ephemeral
UT of Honey Grove Creek	24	2,962	0.40	1,185	Intermittent/Ephemeral
UT of Honey Grove Creek	6	272	0.10	27	Intermittent/Ephemeral
UT of Honey Grove Creek	24	1,981	0.40	792	Intermittent/Ephemeral
UT of Honey Grove Creek	31	5,486	0.52	2,834	Intermittent/Ephemeral
UT of Honey Grove Creek	6	942	0.10	94	Intermittent/Ephemeral
UT of Honey Grove Creek	24	4,851	0.40	1,940	Intermittent/Ephemeral
UT of Honey Grove Creek	1	1,546	0.02	26	Intermittent/Ephemeral
UT of Honey Grove Creek	24	63	0.40	25	Intermittent/Ephemeral
UT of Honey Grove Creek	24	2,695	0.40	1,078	Intermittent/Ephemeral
UT of Honey Grove Creek	24	715	0.40	286	Intermittent/Ephemeral
UT of Honey Grove Creek	6	1,198	0.10	120	Intermittent/Ephemeral
UT of Honey Grove Creek	24	6,861	0.40	2,744	Intermittent/Ephemeral
UT of Honey Grove Creek	34	1,494	0.57	847	Intermittent/Ephemeral
Onstott Branch	19	1,327	0.32	420	Intermittent
Onstott Branch	20	3,307	0.33	1,102	Intermittent
Onstott Branch	19	3,173	0.32	1,005	Intermittent
UT of Onstott Branch	19	351	0.32	111	Intermittent/Ephemeral
Pettigrew Branch	11	887	0.18	163	Intermittent
Pettigrew Branch	8	5,854	0.13	781	Intermittent
Pettigrew Branch	11	3,211	0.18	589	Intermittent
Pettigrew Branch	11	1,687	0.18	309	Intermittent
Pettigrew Branch	11	589	0.18	108	Intermittent

Proposed Lower Bois d'Arc Creek Reservoir Site

GNIS_Name	RGA Score	Length (ft)	SQF	SQU	Flow Type
UT of Pettigrew Branch	11	2,230	0.18	409	Intermittent/Ephemeral
UT of Pettigrew Branch	11	130	0.18	24	Intermittent/Ephemeral
UT of Pettigrew Branch	11	1,680	0.18	308	Intermittent/Ephemeral
Sandy Branch	17	878	0.28	249	Intermittent
Sandy Branch	17	1,270	0.28	360	Intermittent
Sandy Branch	17	2,835	0.28	803	Intermittent
UT of Sandy Branch	17	205	0.28	58	Intermittent/Ephemeral
UT of Sandy Branch	17	3,373	0.28	956	Intermittent/Ephemeral
Sandy Creek	19	3,236	0.32	1,025	Intermittent
Sandy Creek	7	938	0.12	109	Intermittent
Sandy Creek	7	1,383	0.12	161	Intermittent
Sandy Creek	13	1,388	0.22	301	Intermittent
Sandy Creek	13	2,148	0.22	465	Intermittent
Sandy Creek	7	470	0.12	55	Intermittent
Sandy Creek	7	129	0.12	15	Intermittent
Sandy Creek	7	725	0.12	85	Intermittent
Sandy Creek	7	983	0.12	115	Intermittent
Sandy Creek	19	1,098	0.32	348	Intermittent
Sandy Creek	18	599	0.30	180	Intermittent
Sandy Creek	13	211	0.22	46	Intermittent
Sandy Creek	13	2,109	0.22	457	Intermittent
UT of Sandy Creek	7	319	0.12	37	Intermittent/Ephemeral
UT of Sandy Creek	13	1,521	0.22	330	Intermittent/Ephemeral
UT of Sandy Creek	7	4,325	0.12	505	Intermittent/Ephemeral
UT of Sandy Creek	13	1,912	0.22	414	Intermittent/Ephemeral
UT of Sandy Creek	13	889	0.22	193	Intermittent/Ephemeral
UT of Sandy Creek	13	5,003	0.22	1,084	Intermittent/Ephemeral
UT of Sandy Creek	13	1,296	0.22	281	Intermittent/Ephemeral
Sloans Creek	5	1,468	0.08	122	Intermittent
Sloans Creek	5	230	0.08	19	Intermittent
UT of Sloans Creek	5	655	0.08	55	Intermittent/Ephemeral
Stillhouse Branch	19	1,859	0.32	589	Intermittent
Stillhouse Branch	19	80	0.32	25	Intermittent
Stillhouse Branch	19	1,507	0.32	477	Intermittent
UT of Stillhouse Branch	19	1,163	0.32	368	Intermittent/Ephemeral
Thomas Branch	21	2,032	0.35	711	Intermittent
Thomas Branch	21	3,267	0.35	1,144	Intermittent
Thomas Branch	15	280	0.25	70	Intermittent
Thomas Branch	7	340	0.12	40	Intermittent
Thomas Branch	21	589	0.35	206	Intermittent
Thomas Branch	7	496	0.12	58	Intermittent
Thomas Branch	7	1,243	0.12	145	Intermittent
Thomas Branch	15	1,319	0.25	330	Intermittent
UT of Thomas Branch	7	605	0.12	71	Intermittent/Ephemeral
UT of Thomas Branch	7	1,679	0.12	196	Intermittent/Ephemeral
UT of Thomas Branch	33	1,748	0.55	961	Intermittent/Ephemeral
UT of Thomas Branch	7	6,640	0.12	775	Intermittent/Ephemeral

Proposed Lower Bois d'Arc Creek Reservoir Site

GNIS_Name	RGA Score	Length (ft)	SQF	SQU	Flow Type
UT of Thomas Branch	33	2,815	0.55	1,548	Intermittent/Ephemeral
UT of Thomas Branch	7	4,825	0.12	563	Intermittent/Ephemeral
UT of Thomas Branch	21	102	0.35	36	Intermittent/Ephemeral
UT of Thomas Branch	7	1,084	0.12	126	Intermittent/Ephemeral
UT of Thomas Branch	7	1,581	0.12	184	Intermittent/Ephemeral
UT of Thomas Branch	21	1,141	0.35	399	Intermittent/Ephemeral
UT of Thomas Branch	7	1,011	0.12	118	Intermittent/Ephemeral
UT of Thomas Branch	7	3,523	0.12	411	Intermittent/Ephemeral
UT of Thomas Branch	7	5,084	0.12	593	Intermittent/Ephemeral
Timber Creek	20	70	0.33	23	Intermittent
Timber Creek	20	774	0.33	258	Intermittent
Timber Creek	20	384	0.33	128	Intermittent
Timber Creek	20	2,272	0.33	757	Intermittent
Timber Creek	20	1,218	0.33	406	Intermittent
Timber Creek	20	221	0.33	74	Intermittent
Timber Creek	20	751	0.33	250	Intermittent
Timber Creek	20	56	0.33	19	Intermittent
Timber Creek	20	1,951	0.33	650	Intermittent
Timber Creek	20	2,378	0.33	793	Intermittent
Timber Creek	20	3,235	0.33	1,078	Intermittent
UT of Timber Creek	20	7,742	0.33	2,581	Intermittent/Ephemeral
UT of Timber Creek	20	3,356	0.33	1,119	Intermittent/Ephemeral
UT of Timber Creek	20	880	0.33	293	Intermittent/Ephemeral
UT of Timber Creek	20	1,416	0.33	472	Intermittent/Ephemeral
UT of Timber Creek	20	6,055	0.33	2,018	Intermittent/Ephemeral
Ward Creek	28	2,191	0.47	1,022	Intermittent
Ward Creek	28	5,089	0.47	2,375	Intermittent
Ward Creek	14	1,268	0.23	296	Intermittent
Ward Creek	28	2,098	0.47	979	Intermittent
Ward Creek	15	3,995	0.25	999	Intermittent
Ward Creek	28	1,018	0.47	475	Intermittent
Ward Creek	14	862	0.23	201	Intermittent
Ward Creek	15	3,119	0.25	780	Intermittent
Ward Creek	14	905	0.23	211	Intermittent
Ward Creek	14	879	0.23	205	Intermittent
Ward Creek	14	659	0.23	154	Intermittent
Ward Creek	14	400	0.23	93	Intermittent
Ward Creek	14	97	0.23	23	Intermittent
Ward Creek	14	36	0.23	8	Intermittent
Ward Creek	14	194	0.23	45	Intermittent
Ward Creek	14	114	0.23	27	Intermittent
Ward Creek	14	41	0.23	10	Intermittent
Ward Creek	14	39	0.23	9	Intermittent
Ward Creek	14	400	0.23	93	Intermittent
Ward Creek	14	163	0.23	38	Intermittent
Ward Creek	28	2,145	0.47	1,001	Intermittent
Ward Creek	28	888	0.47	414	Intermittent

Proposed Lower Bois d'Arc Creek Reservoir Site

GNIS_Name	RGA Score	Length (ft)	SQF	SQU	Flow Type
UT of Ward Creek	15	5,617	0.25	1,404	Intermittent/Ephemeral
UT of Ward Creek	14	699	0.23	163	Intermittent/Ephemeral
UT of Ward Creek	28	1,625	0.47	758	Intermittent/Ephemeral
UT of Ward Creek	28	1,415	0.47	660	Intermittent/Ephemeral
UT of Ward Creek	28	822	0.47	383	Intermittent/Ephemeral
UT of Ward Creek	14	60	0.23	14	Intermittent/Ephemeral
UT of Ward Creek	28	2,865	0.47	1,337	Intermittent/Ephemeral
UT of Ward Creek	28	1,026	0.47	479	Intermittent/Ephemeral
UT of Ward Creek	14	575	0.23	134	Intermittent/Ephemeral
UT of Ward Creek	14	223	0.23	52	Intermittent/Ephemeral
Yoakum Creek	5	1,006	0.08	84	Intermittent
Yoakum Creek	5	4,694	0.08	391	Intermittent
UT of Yoakum Creek	5	151	0.08	13	Intermittent/Ephemeral

		Existing					Mitigation 2016		
Label	**Reach**	**Length (ft)**	**Field Type**	**RGA Score**	**SQF**	**Stream Quality Unit (SQU)**	**RGA Score**	**SQF**	**Stream Quality Unit (SQU)**
Black Branch	2	2,787	Perennial	26	0.43	1,208	36	0.6	1,672
Black Branch	3	2,105	Perennial	7	0.12	246	17	0.3	596
Black Branch Trib 01	1	600	Ephemeral	7	0.12	70	36	0.6	360
Black Branch Trib 01	2	2,186	Ephemeral	31	0.52	1,130	50	0.83	1,822
Black Branch Trib 02	1	3,506	Intermittent	23	0.38	1,344	33	0.6	1,929
Black Branch Trib 03	1	3,868	Ephemeral	50	0.83	3,223	50	0.8	3,223
Black Branch Trib 04	1	1,350	Ephemeral	23	0.38	518	33	0.6	743
Black Branch Trib 06	1	956	Ephemeral	23	0.38	367	33	0.6	526
Bois d'Arc Creek Trib 01	3	3,040	Ephemeral	3	0.05	152	50	0.8	2,533
Bois d'Arc Creek Trib 01	4	8,066	Ephemeral	28	0.47	3,764	50	0.8	6,722
Bois d'Arc Creek Trib 02	1	2,970	Ephemeral	3	0.05	149	50	0.8	2,475
Bois d'Arc Creek Trib 04	2	1,430	Intermittent	13	0.22	310	50	0.8	1,192
Bois d'Arc Creek Trib 04	3	3,038	Ephemeral	40	0.67	2,025	50	0.8	2,532
Bois d'Arc Creek Trib 06	2	1,215	Intermittent	35	0.58	709	45	0.8	911
Bois d'Arc Creek Trib 07	3	3,163	Intermittent	11	0.18	580	21	0.4	1,107
Bois d'Arc Creek Trib 08	2	1,718	Intermittent	12	0.20	344	22	0.4	630
Bois d'Arc Creek Trib 08	3	921	Intermittent	11	0.18	169	21	0.4	322
Bois d'Arc Creek Trib 09	1	3,417	Ephemeral	40	0.67	2,278	50	0.8	2,848
Bois d'Arc Creek Trib 10	2	2,343	Ephemeral	13	0.22	508	50	0.8	1,953
Bois d'Arc Creek Trib 12	2	586	Ephemeral	13	0.22	127	50	0.8	488
Bois d'Arc Creek Trib 13	2	2,006	Ephemeral	31	0.52	1,036	50	0.8	1,671
Bois d'Arc Creek Trib 14	2	1,012	Ephemeral	28	0.47	472	38	0.6	641
Bois d'Arc Creek Trib 15	2	1,973	Ephemeral	11	0.18	362	50	0.8	1,644
Bois d'Arc Creek Trib 19	1	602	Intermittent	11	0.18	110	21	0.4	211
Bois d'Arc Creek Trib 20	1	193	Ephemeral	40	0.67	128	50	0.8	160
Bois d'Arc Creek Trib 21	1	1,169	Intermittent	11	0.18	214	21	0.4	409
Bois d'Arc Creek Trib 21	2	1,551	Ephemeral	11	0.18	284	21	0.4	543
Bois d'Arc Creek Trib 18	1	258	Ephemeral	11	0.18	47	21	0.4	90
Red River Trib 01	1	4,582	Perennial	16	0.27	1,222	21	0.4	1,604
Red River Trib 01	2	1,907	Perennial	4	0.07	127	9	0.2	286
Red River Trib 01	3	12,707	Ephemeral	32	0.53	6,777	50	0.8	10,589
Red River Trib 02	1	3,156	Perennial	9	0.15	473	14	0.2	736
Red River Trib 02	2	4,298	Ephemeral	18	0.30	1,289	50	0.8	3,582
Red River Trib 03	1	3,937	Intermittent	28	0.47	1,837	50	0.8	3,281
Red River Trib 03	2	4,090	Ephemeral	28	0.47	1,908	50	0.8	3,408
Red River Trib 04	1	3,107	Perennial	8	0.13	414	13	0.2	673
Red River Trib 04	2	559	Intermittent	12	0.20	112	22	0.4	205
Red River Trib 04	3	3,420	Intermittent	12	0.20	684	36	0.6	2,052
Red River Trib 05	2	1,861	Ephemeral	39	0.65	1,209	50	0.8	1,551
Red River Trib 06	1	902	Ephemeral	14	0.23	210	50	0.8	751
Red River Trib 06	3	2,778	Ephemeral	22	0.37	1,018	50	0.8	2,315
Red River Trib 07	1	1,482	Ephemeral	34	0.57	840	50	0.8	1,235
Red River Trib 08	1	3,703	Ephemeral	12	0.20	741	50	0.8	3,086
Red River Trib 08	2	3,308	Ephemeral	34	0.57	1,875	50	0.8	2,757
Red River Trib 09	1	5,333	Intermittent	14	0.23	1,244	36	0.6	3,200
Red River Trib 09	2	3,980	Ephemeral	26	0.43	1,725	36	0.6	2,388
Red River Trib 10	1	3,703	Ephemeral	28	0.47	1,728	50	0.8	3,086
Red River Trib 11	1	1,895	Intermittent	14	0.23	442	24	0.4	758
Red River Trib 11	1	2,061	Ephemeral	14	0.23	481	24	0.4	824
Red River Trib 12	1	3,273	Ephemeral	28	0.47	1,528	50	0.8	2,728
Red River Trib 13	1	1,876	Ephemeral	28	0.47	876	50	0.8	1,564
Red River Trib 14	1	2,947	Ephemeral	28	0.47	1,375	38	0.6	1,867
Red River Trib 15	1	848	Ephemeral	9	0.15	127	50	0.8	706
Red River Trib x	2	5,219	Perennial	16	0.27	1,392	26	0.4	2,261
Bois d'Arc Creek Trib 05	2	590	Ephemeral	3	0.05	29	50	0.8	492
Bois d'Arc Creek Trib 17	2	3,644	Intermittent	12	0.20	729	22	0.4	1,336
Red River Trib 05	1	1,500	Ephemeral	14	0.23	350	50	0.8	1,250
Red River Trib 02	1.1	2,492	Intermittent	9	0.15	374	50	0.8	2,077
Red River Trib 04	1.1	2,216	Perennial	8	0.13	295	13	0.2	480
Red River Trib 04	3	4,217	Ephemeral	12	0.20	843	36	0.6	2,530
Bois d'Arc Creek Trib 04	3	2,094	Ephemeral	40	0.67	1,396	50	0.8	1,745
Red River Trib 09	2	1,123	Intermittent	26	0.43	487	36	0.6	674
Red River Trib 11	1	1,173	Intermittent	14	0.23	274	24	0.4	469
Red River Trib 01	3	1,650	Intermittent	32	0.53	880	50	0.8	1,375
Red River Trib 07	1	1,444	Intermittent	34	0.57	818	50	0.8	1,203
Black Branch Trib 04	1	949	Intermittent	23	0.38	364	33	0.6	522
Bois d'Arc Creek Trib 15	2	1,832	Intermittent	11	0.18	336	50	0.8	1,527
Red River Trib 03	1	63	Ephemeral	28	0.47	30	50	0.8	53
Bois d'Arc Creek Trib 04	3	163	Intermittent	40	0.67	109	50	0.8	136
Red River Trib 06	2	33	Ephemeral	14	0.23	8	50	0.8	27
Red River Trib 06	2	1,272	Ephemeral	14	0.23	297	50	0.8	1,060
Red River Trib 15	1	689	Ephemeral	9	0.15	103	50	0.8	574

		Existing					Mitigation 2016		
Label	Reach	Length (ft)	Field Type	RGA Score	SQF	Stream Quality Unit (SQU)	RGA Score	SQF	Stream Quality Unit (SQU)
Red River Trib 13	1	855	Ephemeral	28	0.47	399	50	0.8	712
Red River Trib 04	3	1,240	Intermittent	12	0.20	248	36	0.6	744
Red River Trib 04	3	499	Intermittent	12	0.20	100	36	0.6	299
Bois d'Arc Creek Trib 03	1	989	Ephemeral	31	0.52	511	50	0.8	824
Bois d'Arc Creek Trib 03	1	734	Ephemeral	31	0.52	379	50	0.8	612
Bois d'Arc Creek Trib 03	1	1,565	Ephemeral	31	0.52	809	50	0.8	1,304
Bois d'Arc Creek Trib 15	2	137	Intermittent	11	0.18	25	50	0.8	114
Bois d'Arc Creek Trib 12	2	23	Ephemeral	13	0.22	5	50	0.8	19
Bois d'Arc Creek Trib 04	3	102	Ephemeral	40	0.67	68	50	0.8	85
Bois d'Arc Creek Trib 04	3	38	Ephemeral	40	0.67	25	50	0.8	32
Red River Trib 06	3	249	Ephemeral	22	0.37	91	50	0.8	207
Red River Trib 06	2	42	Ephemeral	14	0.23	10	50	0.8	35
Red River Trib 15	1	147	Ephemeral	9	0.15	22	50	0.8	123
Red River Trib 11	1	169	Ephemeral	14	0.23	39	24	0.4	68
Red River Trib 13	1	126	Ephemeral	28	0.47	59	50	0.8	105
Red River Trib 04	3	63	Intermittent	12	0.20	13	36	0.6	38
Red River Trib 04	3	68	Intermittent	12	0.20	14	36	0.6	41
Bois d'Arc Creek Trib 03	1	106	Ephemeral	31	0.52	55	50	0.8	88
Red River Trib 08	1	97	Ephemeral	12	0.20	19	50	0.8	81

Riverby Ranch Stream Creation

Label	Reach	Field Type	Additional Length (ft)	RGA Score	SQF	Stream Quality Unit (SQU)
Bois d'Arc Creek Trib 01	3	E	912	50	0.83	760
Bois d'Arc Creek Trib 01	4	E	2420	50	0.83	2,016
Bois d'Arc Creek Trib 02	1	E	891	50	0.83	743
Bois d'Arc Creek Trib 03	1	E	1018	50	0.83	849
Bois d'Arc Creek Trib 04	3	E	923	50	0.83	769
Bois d'Arc Creek Trib 04	3	I	707	50	0.83	590
Bois d'Arc Creek Trib 09	1	E	1025	50	0.83	854
Bois d'Arc Creek Trib 10	2	E	703	50	0.83	586
Bois d'Arc Creek Trib 13	2	E	602	50	0.83	501
Red River Trib 01	3	E	6,498	50	0.83	5,415
Red River Trib 01	3	I	844	50	0.83	703
Red River Trib 02	1.1	I	1,135	50	0.83	946
Red River Trib 02	2	E	822	50	0.83	685
Red River Trib 03	1	I	1,821	50	0.83	1,518
Red River Trib 03	2	E	1,862	50	0.83	1,552
Red River Trib 04	3	I	1587	36	0.60	952
Red River Trib 04	3	E	1265	36	0.60	759
Red River Trib 05	1	E	450	50	0.83	375
Red River Trib 05	2	E	558	50	0.83	465
Red River Trib 06	2	E	258	50	0.83	215
Red River Trib 06	3	E	908	50	0.83	757
Red River Trib 07	1	E	445	50	0.83	370
Red River Trib 07	1	I	433	50	0.83	361
Red River Trib 08	1	E	1140	50	0.83	950
Red River Trib 08	2	E	992	50	0.83	827
Red River Trib 10	1	E	1,197	50	0.83	998
Red River Trib 13	1	E	857	50	0.83	714
Red River Trib 15	1	E	323	48	0.80	258

On-site Tributaries to Littoral Zone Wetlands

	Existing					Mitigation		
GNIS_Name	Length	RGA Score	Type 2	SQF	Stream Quality Unit (SQU)	RGA Score	SQF	Stream Quality Unit (SQU)
Unnamed	194	5	Intermittent/Ephemeral	0.08	16	10	0.17	32
Unnamed	550	33	Intermittent/Ephemeral	0.55	302	38	0.63	348
Sloans Creek	5,201	5	Intermittent	0.08	433	10	0.17	867
Unnamed	1,685	13	Intermittent/Ephemeral	0.22	365	18	0.30	506
Timber Creek	90	33	Intermittent	0.55	50	38	0.63	57
Bullard Creek	1,047	13	Intermittent	0.22	227	18	0.30	314
Unnamed	584	5	Intermittent/Ephemeral	0.08	49	10	0.17	97
Unnamed	770	5	Intermittent/Ephemeral	0.08	64	10	0.17	128
Sloans Creek	15	5	Intermittent	0.08	1	10	0.17	3
Sloans Creek	85	5	Intermittent	0.08	7	10	0.17	14
Unnamed	1,235	5	Intermittent/Ephemeral	0.08	103	10	0.17	206
Unnamed	144	5	Intermittent/Ephemeral	0.08	12	10	0.17	24
Spring Branch	122	12	Intermittent	0.20	24	17	0.28	35
Unnamed	64	5	Intermittent/Ephemeral	0.08	5	10	0.17	11
Unnamed	95	5	Intermittent/Ephemeral	0.08	8	10	0.17	16
Unnamed	48	5	Intermittent/Ephemeral	0.08	4	10	0.17	8
Unnamed	10	5	Intermittent/Ephemeral	0.08	1	10	0.17	2
Unnamed	5	5	Intermittent/Ephemeral	0.08	0	10	0.17	1
Unnamed	2,438	5	Intermittent/Ephemeral	0.08	203	10	0.17	406
Bullard Creek	104	13	Intermittent	0.22	23	18	0.30	31
Bullard Creek	1,456	13	Intermittent	0.22	315	18	0.30	437
Unnamed	53	13	Intermittent/Ephemeral	0.22	11	18	0.30	16
Unnamed	103	13	Intermittent/Ephemeral	0.22	22	18	0.30	31
Unnamed	468	13	Intermittent/Ephemeral	0.22	101	18	0.30	140
Unnamed	464	13	Intermittent/Ephemeral	0.22	100	18	0.30	139
Unnamed	191	13	Intermittent/Ephemeral	0.22	41	18	0.30	57
Cottonwood Creek	406	12	Intermittent	0.20	81	17	0.28	115
Cottonwood Creek	25	12	Intermittent	0.20	5	17	0.28	7
Cottonwood Creek	1,613	12	Intermittent	0.20	323	17	0.28	457
Cottonwood Creek	516	12	Intermittent	0.20	103	17	0.28	146
Cottonwood Creek	18	12	Intermittent	0.20	4	17	0.28	5
Unnamed	23	5	Intermittent/Ephemeral	0.08	2	10	0.17	4
Unnamed	124	5	Intermittent/Ephemeral	0.08	10	10	0.17	21
Unnamed	165	5	Intermittent/Ephemeral	0.08	14	10	0.17	28
Unnamed	248	5	Intermittent/Ephemeral	0.08	21	10	0.17	41
Unnamed	876	12	Intermittent/Ephemeral	0.20	175	17	0.28	248
Unnamed	77	12	Intermittent/Ephemeral	0.20	15	17	0.28	22
Unnamed	678	12	Intermittent/Ephemeral	0.20	136	17	0.28	192
Unnamed	5	12	Intermittent/Ephemeral	0.20	1	17	0.28	1
Unnamed	39	13	Intermittent/Ephemeral	0.22	9	18	0.30	12
Unnamed	12	13	Intermittent/Ephemeral	0.22	3	18	0.30	4
Stillhouse Branch	119	19	Intermittent	0.32	38	24	0.40	48
Stillhouse Branch	956	19	Intermittent	0.32	303	24	0.40	382
Cottonwood Creek	62	12	Intermittent	0.20	12	17	0.28	18

		Existing					Mitigation		
Label	Reach	Length (ft)	Field Stream Type	RGA Score	SQF	Stream Quality Unit (SQU)	RGA Score	SQF	Stream Quality Unit (SQU)
Black Branch	1	2,524	P	26	0.43	1,094	34	0.57	1,430
Black Branch Trib 05	1	3,251	I	35	0.58	1,896	37	0.62	2,005
Bois d'Arc Creek	4	8,334	P	29	0.48	4,028	32	0.53	4,445
Bois d'Arc Creek	1	10,574	P	27	0.45	4,758	30	0.50	5,287
Bois d'Arc Creek	2	7,021	P	29	0.48	3,394	32	0.53	3,745
Bois d'Arc Creek	3	9,505	P	27	0.45	4,277	30	0.50	4,753
Bois d'Arc Creek Trib 01	2	2,158	E	3	0.05	108	15	0.25	539
Bois d'Arc Creek Trib 01	1	2,730	E	25	0.42	1,137	30	0.50	1,365
Bois d'Arc Creek Trib 04	1	4,170	I	3	0.05	209	11	0.18	765
Bois d'Arc Creek Trib 05	1	2,703	I	35	0.58	1,577	37	0.62	1,667
Bois d'Arc Creek Trib 06	1	4,292	I	35	0.58	2,504	39	0.65	2,790
Bois d'Arc Creek Trib 07	1	6,800	I	20	0.33	2,267	24	0.40	2,720
Bois d'Arc Creek Trib 07	2	888	I	11	0.18	163	17	0.28	252
Bois d'Arc Creek Trib 08	1	211	I	20	0.33	70	24	0.40	84
Bois d'Arc Creek Trib 10	1	332	I	3	0.05	17	11	0.18	61
Bois d'Arc Creek Trib 11	1	2,113	E	20	0.33	704	24	0.40	845
Bois d'Arc Creek Trib 12	1	2,727	E	35	0.58	1,591	37	0.62	1,682
Bois d'Arc Creek Trib 13	1	989	E	3	0.05	49	25	0.42	412
Bois d'Arc Creek Trib 14	1	6,033	E	28	0.47	2,815	28	0.47	2,815
Bois d'Arc Creek Trib 15	1	2,707	I	35	0.58	1,579	39	0.65	1,759
Bois d'Arc Creek Trib 16	1	3,017	I	35	0.58	1,760	39	0.65	1,961
Bois d'Arc Creek Trib 17	1	3,807	E	35	0.58	2,221	39	0.65	2,474
Bois d'Arc Creek Trib 22	1	4,657	E	20	0.33	1,552	24	0.40	1,863
Bois d'Arc Creek Trib 23	1	843	I	20	0.33	281	24	0.40	337
Bois d'Arc Creek Trib 23	2	1,401	P	20	0.33	467	24	0.40	561
Bois d'Arc Creek Trib 24	1	809	P	35	0.58	472	39	0.65	526

Upper Bois d'Arc Creek Mitigation Site Stream Enhancement

	Existing					Mitigation		
GNIS Name	Length	RGA Score	Type	SQF	Stream Quality Unit (SQU)	RGA Score	SQF	Stream Quality Unit (SQU)
Pig Branch	1,913	19	Intermittent	0.32	606	24	0.40	765
Pig Branch	26	5	Intermittent	0.08	2	10	0.17	4
Davis Creek	972	19	Intermittent	0.32	308	24	0.40	389
Cooper Creek	324	19	Intermittent	0.32	103	24	0.40	130
Bois d'Arc Creek	2,027	19	Intermittent	0.32	642	24	0.40	811
Bois d'Arc Creek	6,303	5	Intermittent	0.08	525	10	0.17	1,050
Bois d'Arc Creek	1,332	15	Intermittent	0.25	333	20	0.33	444
Bois d'Arc Creek	1,058	5	Intermittent	0.08	88	10	0.17	176
Bois d'Arc Creek	3,152	19	Intermittent	0.32	998	24	0.40	1,261
Bois d'Arc Creek	174	5	Intermittent	0.08	15	10	0.17	29
Bois d'Arc Creek	1,935	19	Intermittent	0.32	613	24	0.40	774
Bois d'Arc Creek	2,623	5	Intermittent	0.08	219	10	0.17	437
Bois d'Arc Creek	737	19	Intermittent	0.32	233	24	0.40	295
Bois d'Arc Creek	1,419	19	Intermittent	0.32	449	24	0.40	568
Bois d'Arc Creek	665	15	Intermittent	0.25	166	20	0.33	222
Bois d'Arc Creek	3,800	10	Intermittent	0.17	633	15	0.25	950
Bois d'Arc Creek	345	19	Intermittent	0.32	109	24	0.40	138
Bois d'Arc Creek	2,370	15	Intermittent	0.25	593	20	0.33	790
Bois d'Arc Creek	160	15	Intermittent	0.25	40	20	0.33	53
Bois d'Arc Creek	77	15	Intermittent	0.25	19	20	0.33	26
Bois d'Arc Creek	133	15	Intermittent	0.25	33	20	0.33	44
Bois d'Arc Creek	147	15	Intermittent	0.25	37	20	0.33	49
Bois d'Arc Creek	1,050	5	Intermittent	0.08	87	10	0.17	175
Unnamed	34	15	Intermittent/Ephemeral	0.25	9	20	0.33	11
Unnamed	2,100	15	Intermittent/Ephemeral	0.25	525	20	0.33	700
Unnamed	1,064	5	Intermittent/Ephemeral	0.08	89	10	0.17	177
Unnamed	26	40	Intermittent/Ephemeral	0.67	18	45	0.75	20
Unnamed	1,962	32	Intermittent/Ephemeral	0.53	1,046	37	0.62	1,210
Unnamed	1,393	16	Intermittent/Ephemeral	0.27	372	21	0.35	488
Unnamed	1,212	19	Intermittent/Ephemeral	0.32	384	24	0.40	485
Unnamed	1,483	28	Intermittent/Ephemeral	0.47	692	33	0.55	815
Unnamed	892	40	Intermittent/Ephemeral	0.67	594	45	0.75	669
Unnamed	11	5	Intermittent/Ephemeral	0.08	1	10	0.17	2
Unnamed	123	5	Intermittent/Ephemeral	0.08	10	10	0.17	20
Unnamed	2,873	19	Intermittent/Ephemeral	0.32	910	24	0.40	1,149
Unnamed	971	40	Intermittent/Ephemeral	0.67	648	45	0.75	729
Unnamed	333	15	Intermittent/Ephemeral	0.25	83	20	0.33	111
Unnamed	692	19	Intermittent/Ephemeral	0.32	219	24	0.40	277
Unnamed	1,722	15	Intermittent/Ephemeral	0.25	430	20	0.33	574
Unnamed	454	5	Intermittent/Ephemeral	0.08	38	10	0.17	76
Unnamed	500	40	Intermittent/Ephemeral	0.67	334	45	0.75	375
Unnamed	17	5	Intermittent/Ephemeral	0.08	1	10	0.17	3
Unnamed	160	15	Intermittent/Ephemeral	0.25	40	20	0.33	53
Unnamed	1,042	19	Intermittent/Ephemeral	0.32	330	24	0.40	417
Unnamed	743	40	Intermittent/Ephemeral	0.67	495	45	0.75	557
Unnamed	28	15	Intermittent/Ephemeral	0.25	7	20	0.33	9
Unnamed	2,130	5	Intermittent/Ephemeral	0.08	177	10	0.17	355
Unnamed	2,120	19	Intermittent/Ephemeral	0.32	671	24	0.40	848
Unnamed	3,958	15	Intermittent/Ephemeral	0.25	989	20	0.33	1,319
Unnamed	1,240	40	Intermittent/Ephemeral	0.67	827	45	0.75	930
Unnamed	28	15	Intermittent/Ephemeral	0.25	7	20	0.33	9
Unnamed	482	40	Intermittent/Ephemeral	0.67	321	45	0.75	361

Appendix F

Downstream Impact Assessment

Technical Memorandum on Assessment of Potential Impacts of Wetlands Downstream of LBCR

MEMORANDUM

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

TO: Robert McCarthy, NTMWD

FROM: Steve Watters, Simone Kiel

SUBJECT: Assessment of Potential Impacts of Wetlands Downstream of LBCR

DATE: June 3, 2016

PROJECT: NTD06128

Executive Summary

Freese and Nichols, Inc. conducted a desktop analysis of the potential impacts to the riparian corridor downstream of the proposed Lower Bois d'Arc Creek Reservoir (LBCR) dam. This analysis expands upon the previous downstream habitat study that was incorporated in Appendix C of the Supplemental Instream Flow Study (Freese and Nichols, Inc., 2010), which is included in Attachment 1 of this memorandum.

The current study focused on the identification of potential wetlands downstream of the LBCR dam, expected changes to local hydrology, and potential impact to the associated forest community. The study found that there are approximately 2,000 acres of riparian bottomland hardwood forests, including potential forested wetlands, within the two-year floodplain downstream of the proposed LBCR dam. With the construction of the LBCR there will be some changes in overbanking flows, but the wetland community will continue to receive sufficient hydrology from direct precipitation, overbanking flows, and discharge of subsurface water from springs and seepage along the margins of the stream valley. Specifically, the downstream corridor is expected to continue to function as bottomland riparian forest after the construction of LBCR for the following reasons:

- Hydric soils will remain and continue to be supported by periods of saturation and inundation during the growing season.
- The existing riparian bottomland hardwood community is comprised of facultative species, which are "equally likely to occur in wetlands and non-wetlands." (Lichvar et al., 2012).
    - Existing species can tolerate hydrology changes.
    - There are no expected changes to plant communities or wildlife habitat.
- Multiple sources of hydrology will remain to support wetlands.

1.0 Introduction

As part of the Supplemental Instream Flow Study report (Freese and Nichols, 2010), FNI prepared an assessment of the potential impacts on the floodplain of Bois d'Arc Creek downstream of the proposed dam, specifically those effects that pertain to expected modification of overbanking flows that are associated with the construction of the LBCR, henceforth called "FNI 2010 study". This assessment addressed the potential impacts to hydrology and sedimentation, floodplain morphology, riparian vegetation, and wildlife. It included literature research and site-specific data collection for vegetative cover.

The conclusions of the FNI 2010 study noted that the potential impacts to the downstream floodplain of Bois d'Arc Creek would likely be limited due to several factors: (1) the existing community is not dependent upon overbank flow for reproduction and overall success; many of the species along Bois d'Arc Creek riparian corridor are equally as likely to occur in uplands as in wetlands; (2) the local site conditions (e.g., rainfall, soil type, and land cover) supplement floodplain hydrology; (3) the proposed release of base and pulse flows would result in stream bed saturation and channel connectivity and promote growth of streambank vegetation; (4) the reduction in magnitude and frequency of highly erosive flows would stop degradation and allow the stream to aggrade over time, thereby increasing the potential for floodplain connectivity; and (5) contributing downstream hydrology provides instream flow and supplements floodplain connectivity. The study also noted that certain aspects of the riparian corridor may even be improved as a result of the dam, including increased streambank stabilization, vegetation growth, and gain of hard mast producing woody species. A copy of this study is included in Attachment 1.

As a follow-on to the FNI 2010 study, the USACE requested that NTMWD provide information on the water sources for the potential wetlands located in the downstream floodplain corridor. This memorandum addresses that request. Please note that all maps (Figures) associated with this discussion are shown at the end of the memorandum.

1.1 <u>Data Sources</u>

Data sources for this study include field data collected in the downstream corridor for the Supplemental Instream Flow Study (FNI, 2010) and the Hydrogeomorphic Methodology (HGM) studies by Dr. Hans Williams (2011 and 2016 in-progress), site-specific topographic data, available desktop mapping resources, and project-specific hydrologic models. The data sources and tools are described below.

National Wetlands Inventory (NWI). This data, developed by the U.S. Fish and Wildlife Service (USFWS), was used in conjunction with hydric soils mapping and hydrologic modeling to identify potential wetlands in the downstream corridor.

Soil Survey Geographic Database (SSURGO). Soils data for Fannin County was downloaded from the USDA Geospatial Data Gateway. SSURGO is shown as map units which can then be joined with data tables to define various soil conditions. The two soil characteristics used in this analysis were hydric soils and texture.

LiDAR elevation data. Aerial photography of the Bois d'Arc Creek watershed was flown in 2007 and November 2010. The high resolution LiDAR with a vertical accuracy of 95% at 0.6-foot resolution was used to generate 1-foot elevation contours. These contours, along with hand surveyed stream cross-sections were used to develop the elevation mapping for the HEC-RAS (2D) model.

HEC-HMS. This is one of two hydrologic/hydraulic models developed by the USACE that were used to define the floodplain hydrology along Bois d'Arc Creek. This model applies specific rainfall events to the watershed and calculates the runoff hydrographs that are subsequently used in the HEC-RAS (2D) model.

HEC-RAS 2D. This is the second of the two hydrologic/hydraulic models developed by the USACE that were used to define the floodplain hydrology along Bois d'Arc Creek. HEC-RAS uses the runoff hydrographs generated by HEC-HMS to define the geographic boundaries of the floodplain associated with a specific rain event. The HEC-RAS 2D (Version 5.0) is an updated model that allows the user to better define floodplain hydrology over the entire watershed and better represents the hydraulic flows of the tributaries to Bois d'Arc Creek.

Downstream Study (FNI, 2010). In 2009 FNI staff collected vegetative data and evaluated flood tolerance of the species in the downstream corridor based on wetland indicator status (USDA-NRCS, Region 6) and anaerobic soil tolerance (USDA-NRCS 2010). The results of this data collection were incorporated into the FNI 2010 study.

Stephen F. Austin HGM Study (Dans and Williams, 2011). Under contract with the USEPA, Darinda Dans and Dr. Hans Williams of Stephen F. Austin State University conducted field testing of the R*egional Guidebook for Applying the Hydrogeomorphoric Approach to the Functional Assessment of Forested Wetlands in Alluvial Valleys of East Texas* to assess wetland functions of the Lower Bois d'Arc Creek Impoundment Project in Fannin County, Texas and to determine appropriate adjustments to apply to variables for use of the *Guidebook* in Fannin County.

Bonham Rain Gauge. Historical precipitation was obtained from the National Weather Service for rainfall recorded at the City of Bonham from 1903 to the present. The data was downloaded from http://www.srh.weather.gov/fwd/?n=bonhamclimatology.

2.0 Study Area

The study area addressed in this memorandum consisted of the corridor located within the two-year floodplain downstream of the proposed LBCR dam site to the Red River (Figure 1). Potential wetlands within this corridor were delineated using a desktop, GIS-based approach to identify the intersection of the existing two-year floodplain, NWI wetlands (emergent, shrub/ forested wetlands) and hydric soils. The definition of wetlands as used by the USACE are areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. To better understand the potential wetlands in the downstream corridor from the LBCR dam, a review of these three characteristics was conducted. The resulting overlap of these three resource layers were assumed to represent the criteria that define a regulatory wetland: wetland hydrology, hydrophytic vegetation, and hydric soils.

2.1 Wetland Hydrology

The two-year floodplain was selected to define the study area because this is the area identified as being inundated at least 50 percent of the years. The existing floodplain was defined through hydraulic and hydrologic modeling of Bois d'Arc Creek. The length of the floodplain is approximately 20 river miles from the proposed LBCR dam to the Red River confluence. The hydraulic/hydrologic analyses are discussed in a technical memorandum in Attachment 2. Due to the nature of the local topography and historical modifications to Bois d'Arc Creek, the two-year floodplain varies from less than 0.5 mile to about 1 mile in width. It should be noted that the floodplains for less frequent storms (i.e., 5-year and 10-year floods) are similar in location and width. This is because the floodplain is bordered by steeper topography, which funnels the flood water through this corridor. The existing two-year floodplain (i.e., without the proposed dam) is shown on Figure 1.

2.2 Hydric Soils

The presence of hydric soils is a key indicator of potential wetland occurrence. The presence of hydric soils was estimated using the Soil Survey Geographic Database (SSURGO). Hydric soils are shown on Figure 2.

2.3 Hydrophytic Vegetation

For the purposes of this assessment, the National Wetlands Inventory (NWI) map data developed by the USFWS was used to identify the locations of potential wetlands by vegetation type downstream of the proposed LBCR dam (Figure 2). The NWI wetlands mapped within the study corridor included emergent and forested/shrub wetlands. The NWI relies on trained image analysts to identify and classify wetlands and deep water habitats from aerial imagery. The wetland areas are located along the riparian corridor of Bois d'Arc Creek downstream of the proposed dam and seem to closely follow the footprint of the existing 2-year floodplain (Figure 3).

2.4 Study Area Wetlands

Based on the overlap, i.e., intersection, of the two-year floodplain, NWI forested wetlands, and mapped hydric soils in the Bois d'Arc Creek corridor downstream of the proposed dam site, the estimated area of existing wetlands downstream of the dam is 2,001 acres. The desktop-delineated wetlands, which are the primary focus of the current study, are shown in Figure 4.

3.0 Characteristics of Downstream Wetlands

3.1 Vegetative Cover

As part of Dans and Williams (2011) study, data were collected at 13 NWI forested wetland sites (59 total plots) both within the proposed reservoir pool area and within the Caddo National Grasslands located downstream of the proposed dam site. In 2015, additional data were collected by Stephen F. Austin staff in the Caddo National Grasslands (Camp et al, 2016). In 2010, FNI conducted limited habitat evaluation studies in the downstream corridor (Attachment 1). To assess potential impacts of the construction of the LBCR dam to the study area wetlands, FNI used tree species identified in these studies to create a tree species list to represent the current tree community assemblage for Bois d'Arc Creek. This list is consistent with the tree species identified in the FNI 2010 study. Each species was then assigned its respective wetland indicator status according to the 2014 National Wetland Plant List (Lichvar, et al., 2014). These data are summarized in Table 1. Table 2 defines each wetland indicator status with comments on occurrence, and Table 3 defines the flood tolerance indices.

Table 1. Tree Species Identified in the Downstream Corridor

Scientific Name	Common Name	Indicator Status	Flood Tolerance
Acer negundo	Box elder	FAC	T
Celtis laevigata	Sugarberry	FAC	T
Cornus sp.	Dogwood sp.	FAC*	I
Fraxinus pennsylvanica	Green ash	FAC	VT
Gleditsia triacanthos	Honey locust	FACU	IT
Maclura pomifera	Bois d'Arc	FACU	No data
Populus deltoides	Cottonwood	FAC	VT
Quercus macrocarpa	Bur oak	FACU	T
Quercus pagoda	Cherrybark oak	FAC	No data
Quercus stellata	Post oak	FACU	I
Salix nigra	Black willow	FACW	VT
Ulmus spp.	Elm spp.	FAC**	T

*assumed *Cornus drummondii* (Roughleaf dogwood); **assumed *Ulmus crassifolia* (Cedar elm)

Table 2. Wetland Indicator Status Ratings with Definitions (Lichvar, et al. 2012).

Indicator Status	Abbreviation	Definitions
Obligate	OBL	Almost always occur in wetlands.
Facultative Wetland	FACW	Usually occur in wetlands, but may occur in non-wetlands.
Facultative	FAC	Occur in wetlands and non-wetlands.
Facultative Upland	FACU	Usually occur in non-wetlands, but may occur in wetlands.
Upland	UPL	Almost never occur in wetlands.

Table 3. Flood Tolerance Indicator Status Ratings with Definitions (Teskey, et al. 1978).

Indicator Status	Abbreviation	Definitions
Very Tolerant	VT	Can withstand flooding for two or more growing seasons.
Tolerant	T	Can withstand flooding for most of one growing season.
Intermediately Tolerant	IT	Able to survive flooding for periods between 1-3 months during growing season.
Intolerant	I	Cannot withstand flooding for short periods (1 month or less) during growing season.

In the Bois d'Arc Creek downstream riparian corridor, the riparian woodland community is currently most similar to the forest cover type described as Sugarberry-American Elm-Green Ash (Society of American Foresters; Smith et al., 2001). These woodlands are typically found at transitional elevations between poorly drained flats (e.g., overcup oak-water hickory stands) and well-drained ridges (e.g., sweetgum-willow oak stands).

The wetland community observed in the Bois d'Arc Creek watershed is commonly limited to one to three dominant tree species with green ash, a pioneer species that readily invades cutover sites in the project area, being the most prevalent. This is indicative of the maturity of the wetland forest (immature) and the nature of the logging activities that have been on-going for decades.

3.2 Wetland Hydrology. For an area to have sufficient hydrology to support wetlands, the area must be inundated or saturated for two weeks of the growing season for most years. The growing season for the study area is March through October. There are four potential sources of water for the wetlands in the Bois d'Arc Creek watershed. These include:

1. Overbank flows from tributaries and Bois d'Arc Creek
2. Direct precipitation
3. Overland flow
4. Discharge of subsurface water from springs and seeps along the margins of the stream valley or into wetland depressions

A brief description of these sources and the potential impacts of the proposed dam on the water source is discussed in the following sections.

4.0 Sources of Water

4.1 Overbank Flows

Bois d'Arc Creek is a highly altered stream system due to years of channelization and drainage improvements. As a result, there are parts of the creek that are deeply incised and have little connectivity with the adjacent floodplain. The existing floodplain identified in Figure 1 is partially the result of overbanking flows from local tributaries and the connectivity of Bois d'Arc Creek to the floodplain through drainage ditches and other depressional areas. During very high flows, Bois d'Arc Creek does overtop the existing channel.

Under existing conditions, the flood hydrograph in Bois d'Arc Creek at the LBCR dam location has a characteristic double peak that occurs over an approximate two-day period. After two days, the flows return very quickly to pre-rain event levels. When the reservoir spills, the flow from the reservoir continues for more than six days before returning to pre-rain event levels. The flashy nature of the existing stream system provides flood waters to the adjacent floodplain and wetlands, but overbank flows are only one source of hydrology necessary to meet the wetland hydrology criterion of two consecutive weeks of inundated or saturated conditions.

To better understand the connectivity of Bois d'Arc Creek to the floodplain and assess the potential impacts of the LBCR dam on overbank flows, a detailed hydrologic/hydraulic study was conducted.

This study evaluated the Bois d'Arc Creek floodplain under five conditions:

1. Two-year flood event without the LBCR dam (the existing condition)
2. Two-year flood event with the LBCR dam in place and no spills from the reservoir
3. Two-year flood event with the LBCR dam in place and spills from the reservoir
4. Five-year flood event with the LBCR dam in place and no spills from the reservoir
5. Five-year flood event with the LBCR dam in place and spills from the reservoir

The two-year rainfall event was selected because it represents the flood conditions in at least 50 percent of the years. The five-year rainfall event was also analyzed because the HGM functional assessment model for forested wetlands considers the five-year floodplain in the evaluation of riverine wetlands. For the conditions with no spills from the reservoir, it was assumed that the only water released through the dam would be the 3 cfs base flow required by the LBCR water right permit. The creek was modeled as if only the 3 cfs flow was in the creek before the two-year event was applied. This was a conservative assumption, especially during the rainy season in May and June. For the conditions with the reservoir spilling, it was assumed that the reservoir was full before the rain event and the upstream flood waters were routed through the reservoir prior to spilling downstream. This provided some attenuation of the flood hydrograph.

For the two-year flood rainfall event with the LBCR dam in place and no spills, flows in Bois d'Arc Creek and associated tributaries would continue to provide overbanking flows to the adjacent floodplain and wetland areas. As shown on Figure 5, overbanking flows would inundate the lower lying areas within the floodplain. The areas not being inundated tend to be immediately adjacent to the creek bank, which may be due to spoils that were placed next to the creek bank when it was channelized and/or sediment deposits from prior overbank floods. Additional areas may be flooded and/or retain water from direct precipitation but may not be differentiated in the model simply due to the one-foot resolution of the LiDAR data. When the dam spills, Figure 6 shows that additional areas within the two-year floodplain would be inundated.

For the five-year flood event with the LBCR dam in place and no spills, nearly all of the existing wetland areas within the floodplain would be inundated as shown on Figure 7. When the dam spills, Figure 8 shows that additional areas within the five-year floodplain would be inundated.

Figure 9 shows only the wetland area that is not inundated under a 5-year event with spills. After adjusting for very small out-areas (non-contiguous areas that are less than 0.25 acres), the total acreage of potential wetlands that is not inundated is 162 acres. [Note: this adjustment was made because the LiDAR tool did not include smoothing of the elevation data, which results in these small out-parcels. Also, if these areas are truly higher and not inundated, they are surrounded by inundated areas such that the underlying soils would likely be saturated. The total acreage of these out-parcels is 43 acres.]

A summary of the inundated areas and potential wetlands for the different scenarios is presented in Table 4.

Table 4: Summary of Inundated Areas under Different Flood Conditions[1]

Wetland Type	Study Area (Acres)	2 Year Flood With Dam No Spills (Acres)	2 Year Flood With Dam Spilling (Acres)	5 Year Flood With Dam No Spills (Acres)	5 Year Flood With Dam Spilling (Acres)
Freshwater Emergent Wetland	149	109	113	134	140
Freshwater Forested/ Shrub Wetland	1,852	954	1,224	1,495	1,657
Total	**2,001**	**1,063**	**1,336**	**1,629**	**1,796**

1. These values do not include the adjustment for out-parcels that are less than 0.25 acres. The total acreage of these out-parcels is 43 acres.

4.2 Direct Precipitation

One of the four sources of water for forested wetlands downstream of the proposed LBCR is direct precipitation. Fannin County receives over 41 inches of rainfall in most years. In 2015, the area received over 76 inches of rain. Most of the precipitation occurs during the early growing season in March through June with over 5 inches of rainfall occurring in May. Figure 10 shows the average monthly precipitation for Fannin County near Bonham.

Figure 10 Average Monthly Precipitation at Bonham, TX

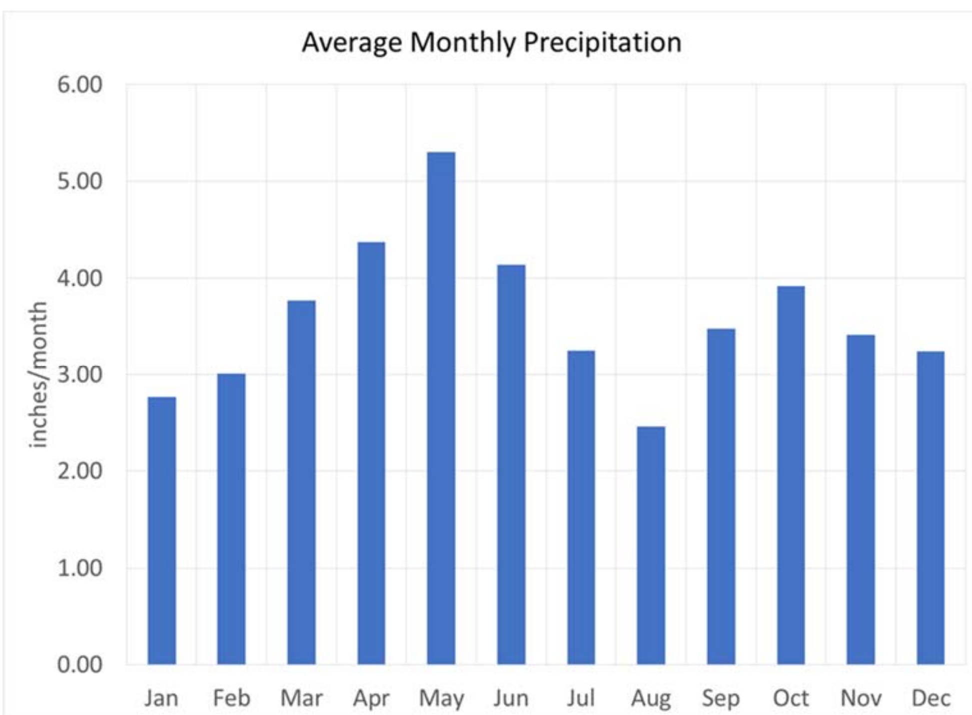


Figure 11 shows the median rainfall over two-week intervals, which relates to the wetland hydrology criterion (i.e., saturation or inundation for approximately two weeks during the growing season in most years). During the growing season the median rainfall is 1.63 inches over 14 days. As shown on Figure 6, the four highest consecutive rainfall periods are from the end of April through mid-June, with median rainfall levels ranging from 2.69 to 2.25 inches over 14 days. The total median rainfall over this 8-week period is 9.9 inches. Direct precipitation on wetlands is, by itself, a considerable source of water for saturation or inundation for a two-week period depending on antecedent soil moisture conditions and frequency of rainfall. Of course, precipitation doesn't just fall directly on wetlands, it also covers adjacent areas and finds its way to wetlands by other routes too. A summary of the local precipitation data is presented in Table 5.

Figure 11 Average 14-Day Precipitation at Bonham, TX

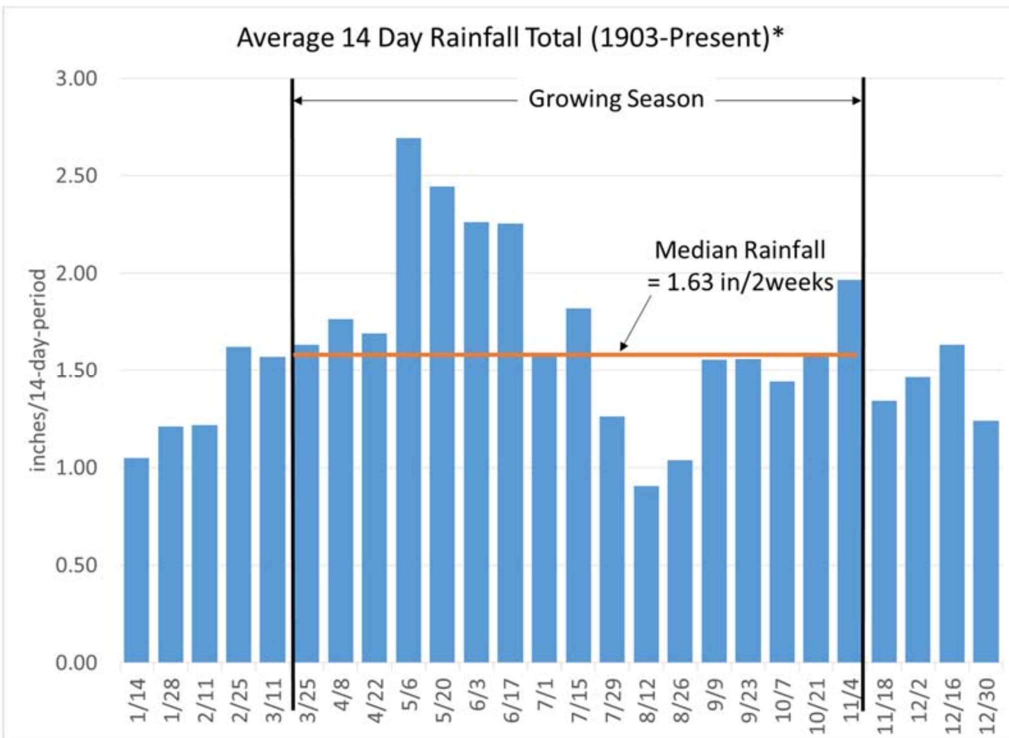


Table 5 Summary of Precipitation at Bonham, TX

	All Year			Growing Season		
	7-day Total	**14-day Total**	**Annual Total**	**7-day Total**	**14-day Total**	**Season Total**
Median	0.77	1.57	41.16	0.81	1.63	33.22
Average	0.80	1.61	41.77	0.87	1.74	33.55
Std Dev	0.22	0.44	10.20	0.25	0.49	9.39

4.3 Overland Flow

Overland flow is a result of precipitation that falls on the landscape and runs off. Such runoff occurs only after rainfall interception storage by vegetation, debris and other non-permeable objects is satisfied and when the precipitation rate exceeds the infiltration capacity of soils. Thus, overland flow, or runoff, is the excess precipitation that isn't retained by interception or infiltration. Overland flow from local areas surrounding wetlands, which are typically depressional features on the landscape, is another source of wetland hydrology. The magnitude of overland flow contribution to wetland hydrology for a given storm event increases with intensity and duration of the event, and it is greater when antecedent moisture conditions in soil and watershed micro-depressions are wetter.

4.4 Discharge of Subsurface Water from Springs and Seeps

Another source of water for the downstream wetland hydrology is local ponding. Both direct precipitation and ponded water can act as recharge to alluvial sediments. This water then travels through the near surface soils as interflow and is observed as seepage in the bottomland flats. Ponded water and interflow can sustain wetland hydrology over a longer period than overbanking flows, which deliver a lot of water in a short time frame and then recede, contributing to the saturation of these areas.

To assess the locations of ponded water and potential for interflow, the HEC-RAS 2D model was used to simulate a flood over the vicinity of the study area and then the flood waters were allowed to drain. Local ponding areas were identified where water remained after the drainage. These areas are shown in dark blue on Figure 12. As previously noted, ponded areas shown are a minimum of 12-inches deep due to the resolution of the LiDAR imagery and resulting elevation contours. There may be additional ponded areas that cannot be identified because the depth is less than 12 inches. Based on this analysis, there are approximately 160 acres of ponded areas within the study area and 135 acres of ponded areas within relatively permeable (coarse loamy and loamy) soils located within a mile of the floodplain that could act as potential recharge areas for interflow.

The potential for recharge and interflow is directly related to the permeability of the local soils. Permeable soils generally include coarser textured soils (loams and sands). Finer textured soils (clays) as identified along the Bois d'Arc Creek bottoms tend to have low permeability. As shown on Figure 11, there are coarse loamy and loamy soils bordering the floodplain on both the north and south banks of Bois d'Arc Creek. These areas would likely provide wetland hydrology through ponding and interflow from the alluvial sediments.

Groundwater seepage is similar to interflow but occurs due to the geologic and geomorphic characteristics of the watershed and can be realized as springs. Springs often are groundwater that travels through an alluvial aquifer and discharges along topographic breaks such as stream banks. Gunnar Brune, author of *Springs of Texas* (Brune, 1981), identified 11 springs in Fannin County. Some of these springs have stopped flowing or have reduced flow due to groundwater pumpage and declining groundwater levels. Several springs are still active, including Bois d'Arc Spring that is located about 2 kilometers northeast of Lake Coffee Mill dam. According to Brune (1981), the springs flow from the base cliff of Bonham sandstone on top of Eagle Ford shale toward Bois d'Arc Creek. Other springs were observed by FNI staff on property near Bois d'Arc Creek, located midway between FM 100 and FM 79.

The source of water for groundwater discharges that contribute to wetlands adjacent to Bois d'Arc Creek typically derives from precipitation that infiltrates the soil surface and flows underground by the force of gravity. It can be local or it can be recharge from outside the watershed. Figure 13 shows the local topography of the Bois d'Arc Creek downstream of the LBCR dam. The red areas depicted on Figure 13 are the surrounding elevated upland potential recharge areas, which occur all along the south side of the creek valley and along the western part of the northern creek valley. These uplands rise approximately 300 feet above the floodplain.

Local groundwater in the study area include the Red River Alluvium, Woodbine Aquifer and local alluvium (perched aquifer). The Red River Alluvium is a shallow aquifer along the Red River and consists of alluvial sediments. This aquifer is likely not a source for interflow through the bluffs, but it does contribute to wetland hydrology near the confluence with the Red River as the alluvium is recharged by precipitation and flows from the Red River. The Woodbine Aquifer is a minor aquifer, but provides considerable amounts of local groundwater. The Woodbine Formation is composed of water-bearing sandstones interbedded with shales and clays, outcropping along the Red River. Within the study area, the Woodbine can be found near the surface to more than 500 feet deep. This formation could be a source for springs along Bois d'Arc Creek. The most likely source for springs is perched groundwater, as described by Brune (1981). This is water that has infiltrated the overlying alluvial soils and travels along an impermeable layer, such as tight clays or shale. Water would flow along these layers until it is discharged at a break in the land surface, such as a stream or depressional area. This source of water would provide wetland hydrology over a sustained period of time since it is not directly related to flood waters.

5.0 Conclusions

As discussed, wetlands are identified based on the presence of hydric soils, wetland vegetation and wetland hydrology. Based on our previous evaluation of potential impacts within the downstream corridor and the current study, the wetlands downstream of the proposed LBCR dam are expected to be sustained after the dam is in place.

The hydric soils located in the floodplain will remain. No action is proposed that would displace or alter the existing hydric soils.

The wetland vegetation is not expected to change as a result of altered flows with the proposed dam in place. Of the 12 tree species identified in previous studies, 11 (92%) are classified as facultative or facultative upland, suggesting a community prone to temporary, or seasonal, rather than semi-permanent flooding. Because the tree vegetative community is dominated by facultative (equally likely to occur in wetlands or uplands) and facultative upland (usually occur in non-wetlands) species, potential reductions of overbanking events from Bois d'Arc Creek are not anticipated to result in a change, or shift, in the species composition.

As noted in the FNI 2010 study (Appendix C), the changes in hydrology with the proposed LBCR in place may allow for greater species diversity, including hard mast trees, which are important to wildlife habitat. The reduced frequency and magnitude of large floods and improved reliability of stream flow throughout the year due to required environmental flow releases is expected to create a more suitable habitat for riparian plant growth and development. Construction of the proposed LBCR will provide a more diverse and stable ecosystem in the downstream area.

There are multiple sources of hydrology to sustain the wetland community downstream of the proposed LBCR dam. Overbanking flows will continue with the LBCR dam in place, based on the results of modeling two-year flood hydrology. In most years, there will be inundation of much of the downstream wetlands solely from overbanking flows, and 84% of the downstream wetlands are expected to be inundated at least every five years. When the reservoir is spilling, inundation increases to 92% of the downstream wetlands. Three additional sources of wetland hydrology, including direct precipitation, overland flow, and subsurface discharge through springs and seeps, are not expected to change with the construction of the dam. These sources are important in providing the hydrology necessary to sustain inundation and/or saturation for two weeks during the growing season in most years. When all four sources of wetland hydrology are considered, there will be sufficient wetland hydrology for the downstream wetlands following the development of the proposed LBCR.

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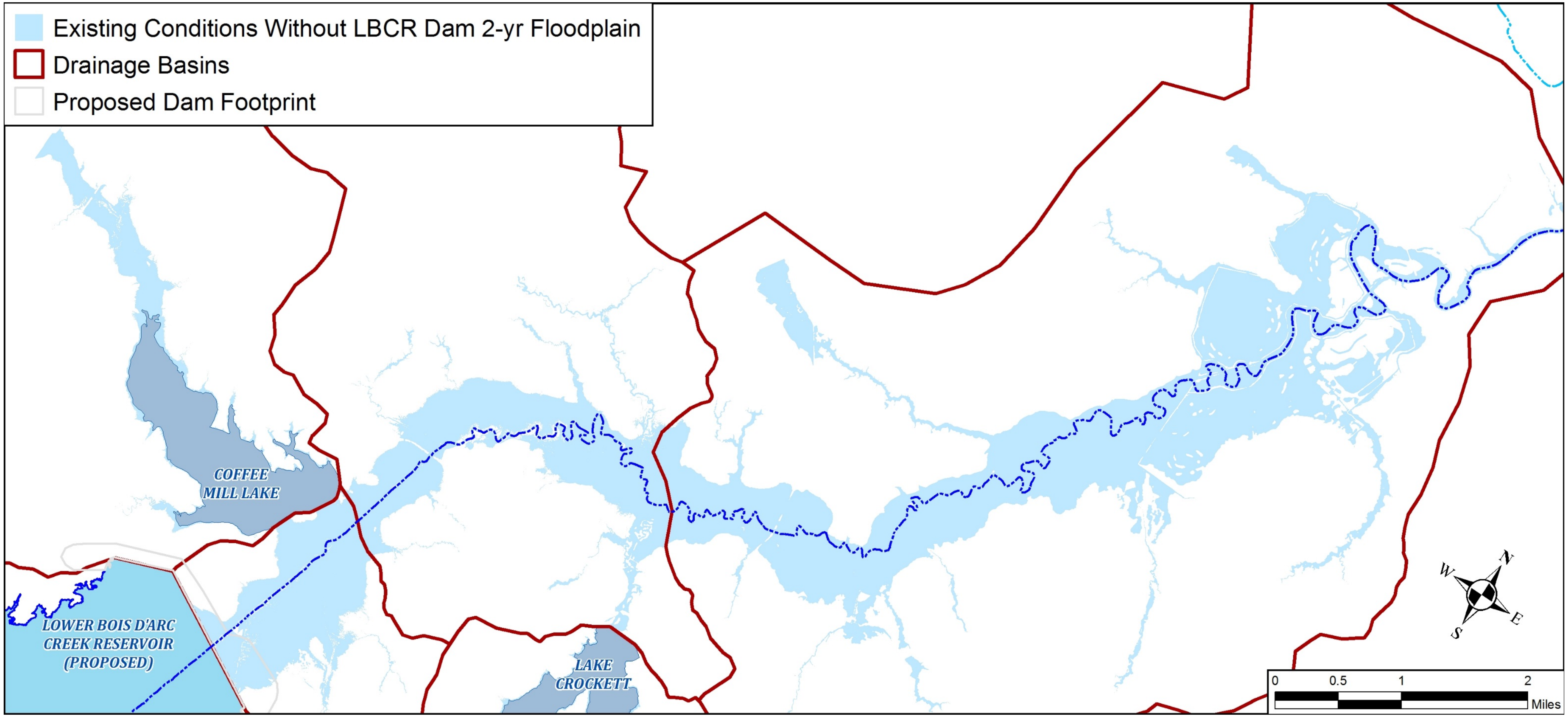

Figure 1 Existing 2-Year Floodplain on Bois d'Arc Creek

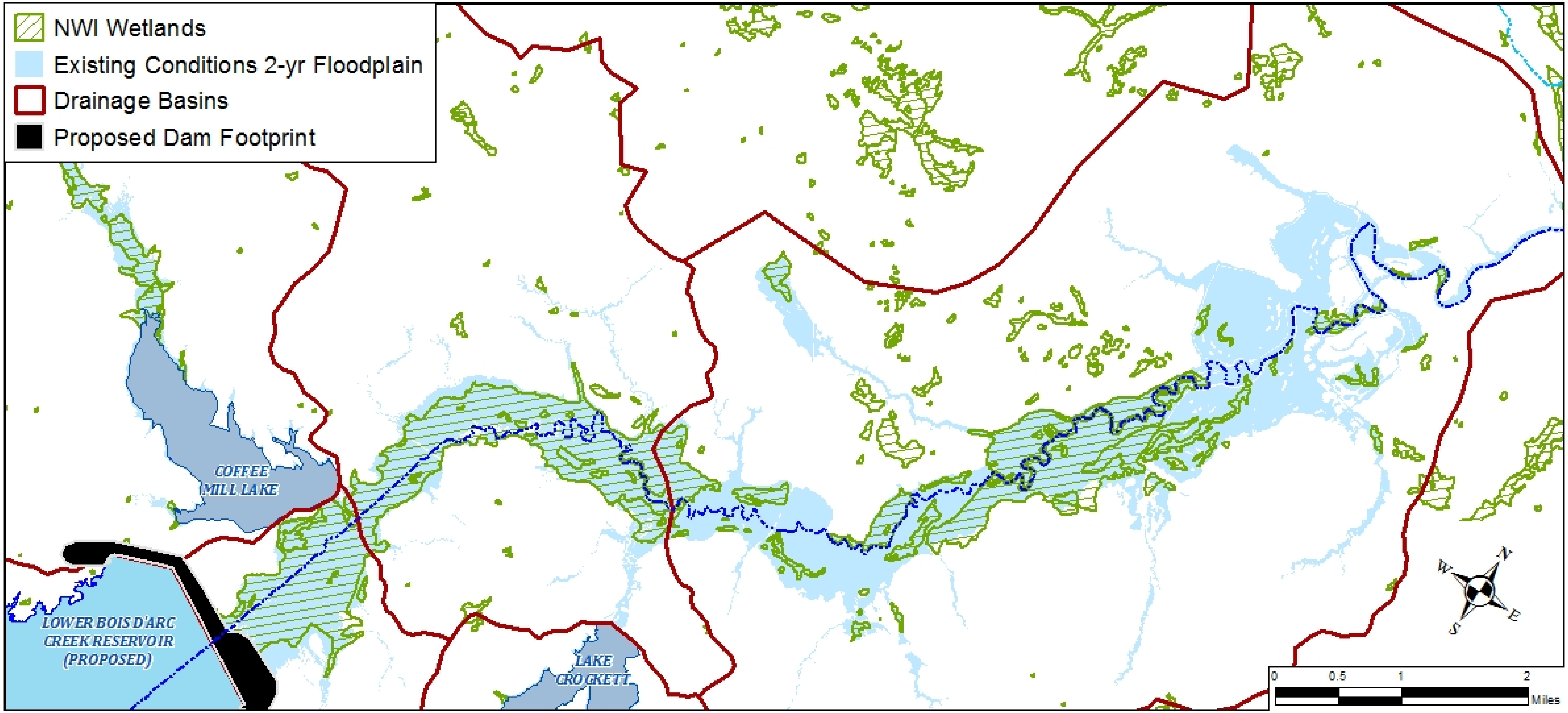

Figure 2 NWI Wetlands Downstream of LBCR Dam

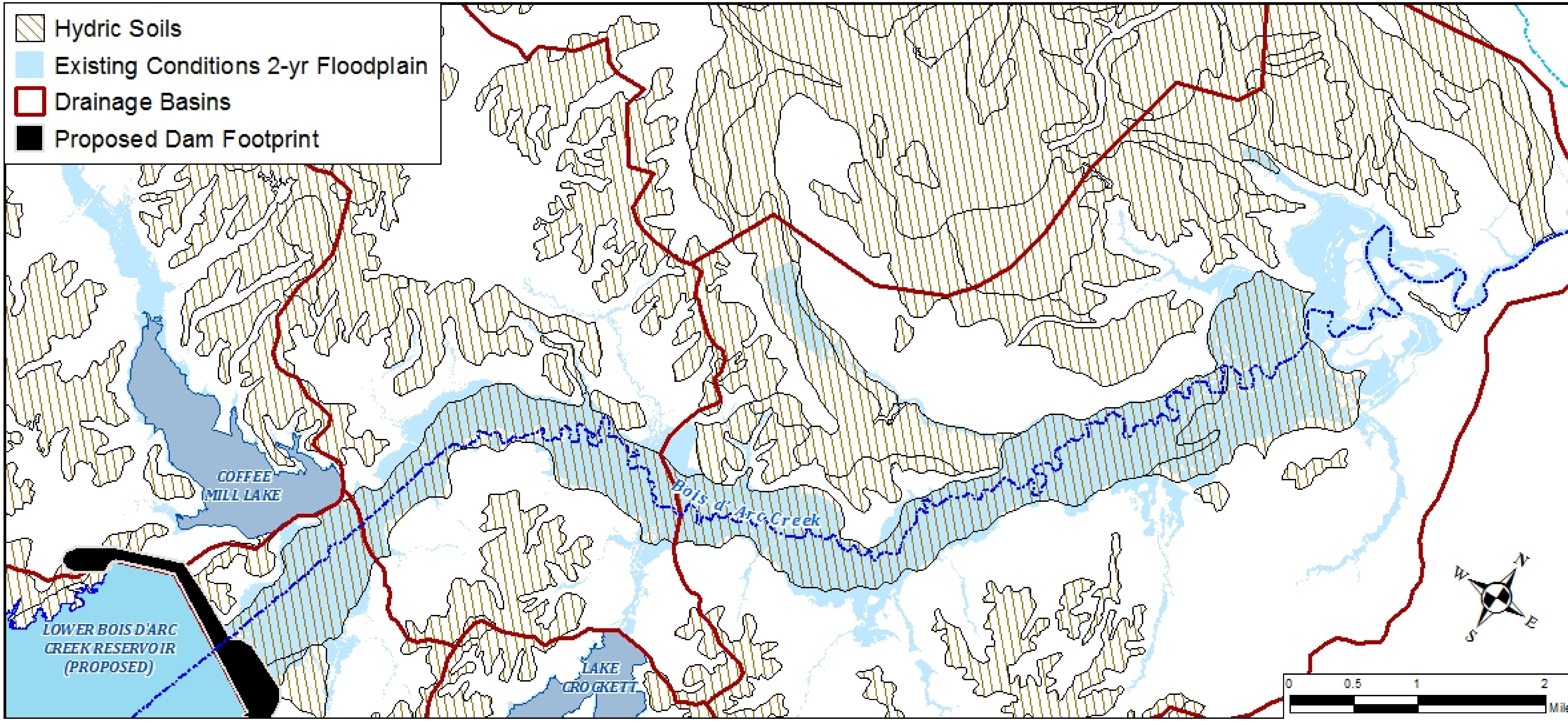

Figure 3 Hydric Soils

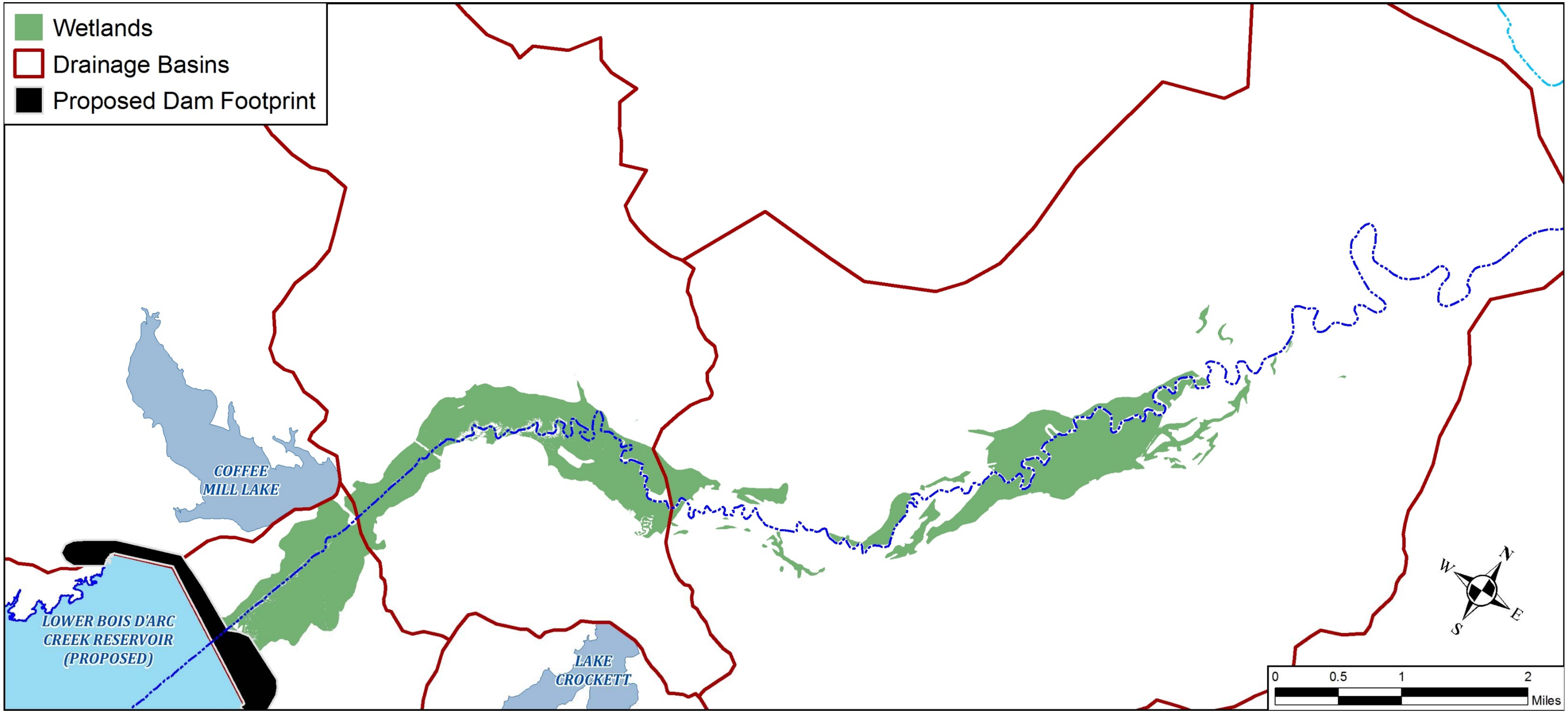

Figure 4 Estimated extent of wetlands based on desktop analysis

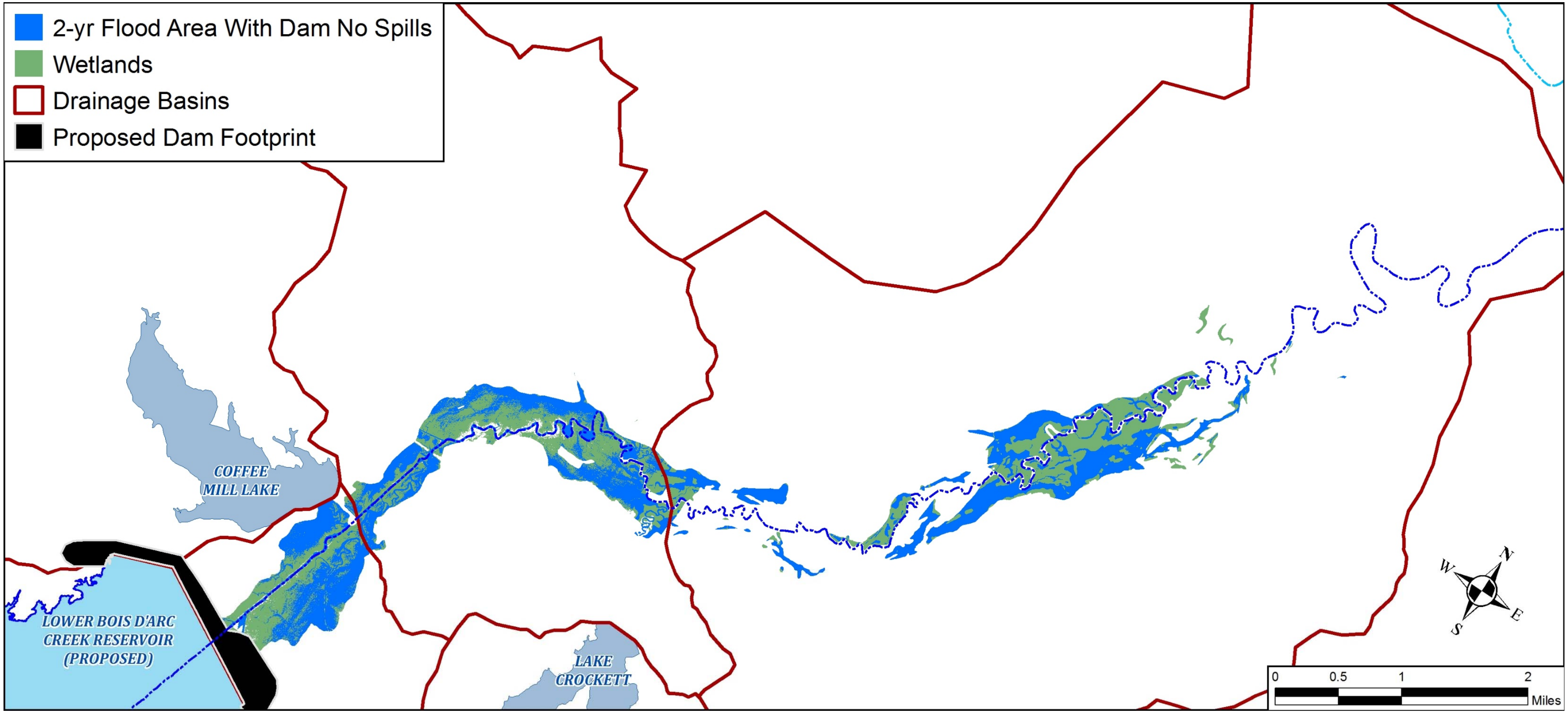

Figure 5 2-Year Flood Event – Inundation Area with LBCR Dam, No Spills from LBCR

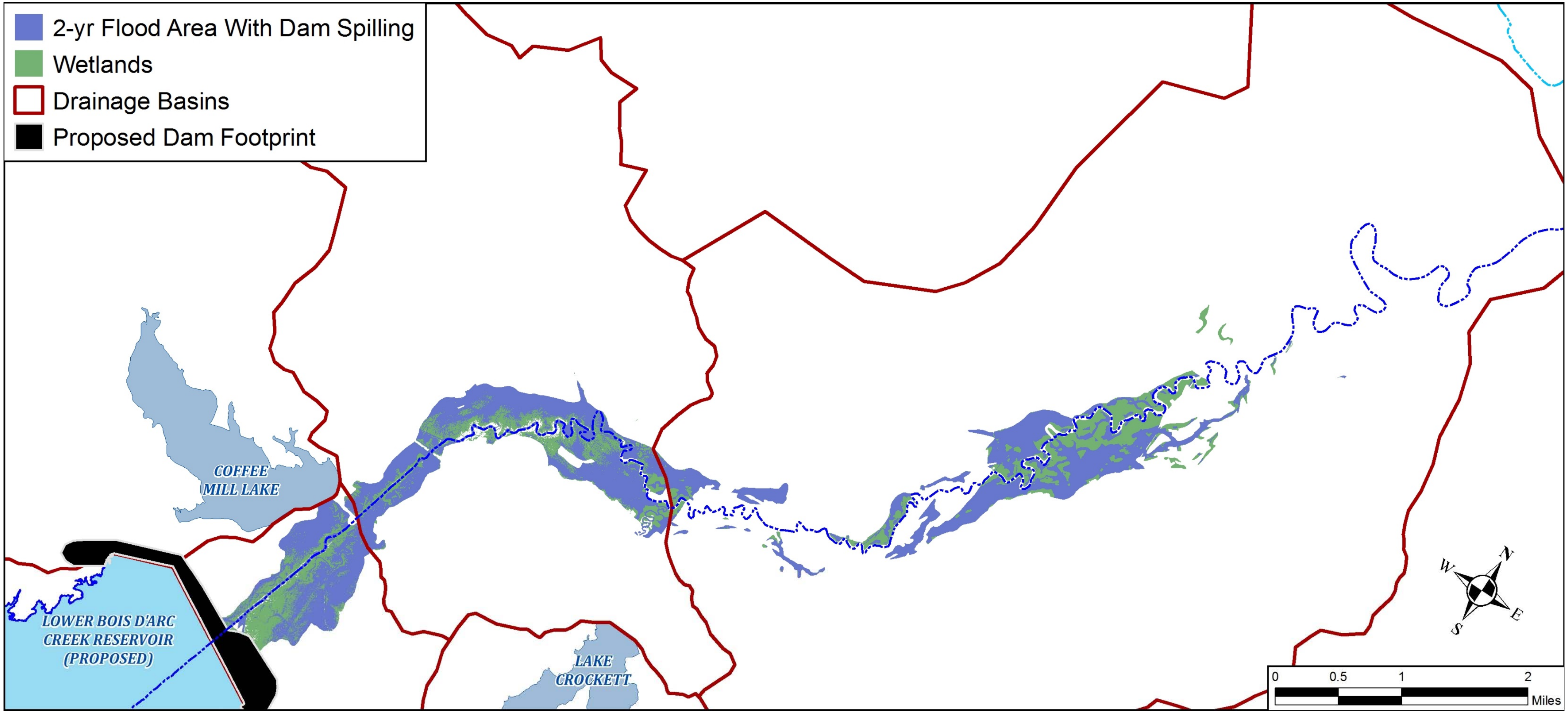

Figure 6 2-Year Flood Event – Inundation Area with LBCR Dam, Spills from LBCR

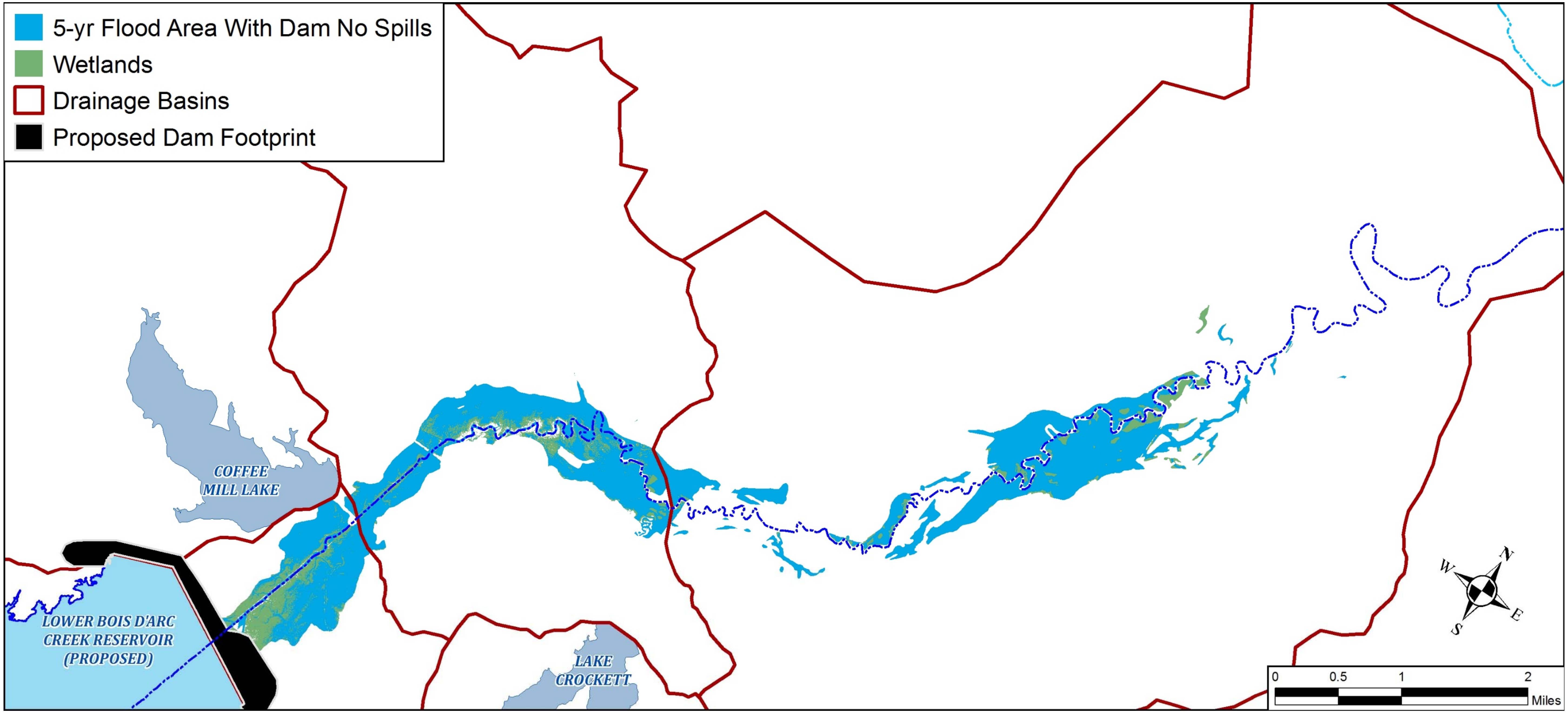

Figure 7 5-Year Flood Event – Inundation Area Wetlands with LBCR Dam, No Spills from LBCR

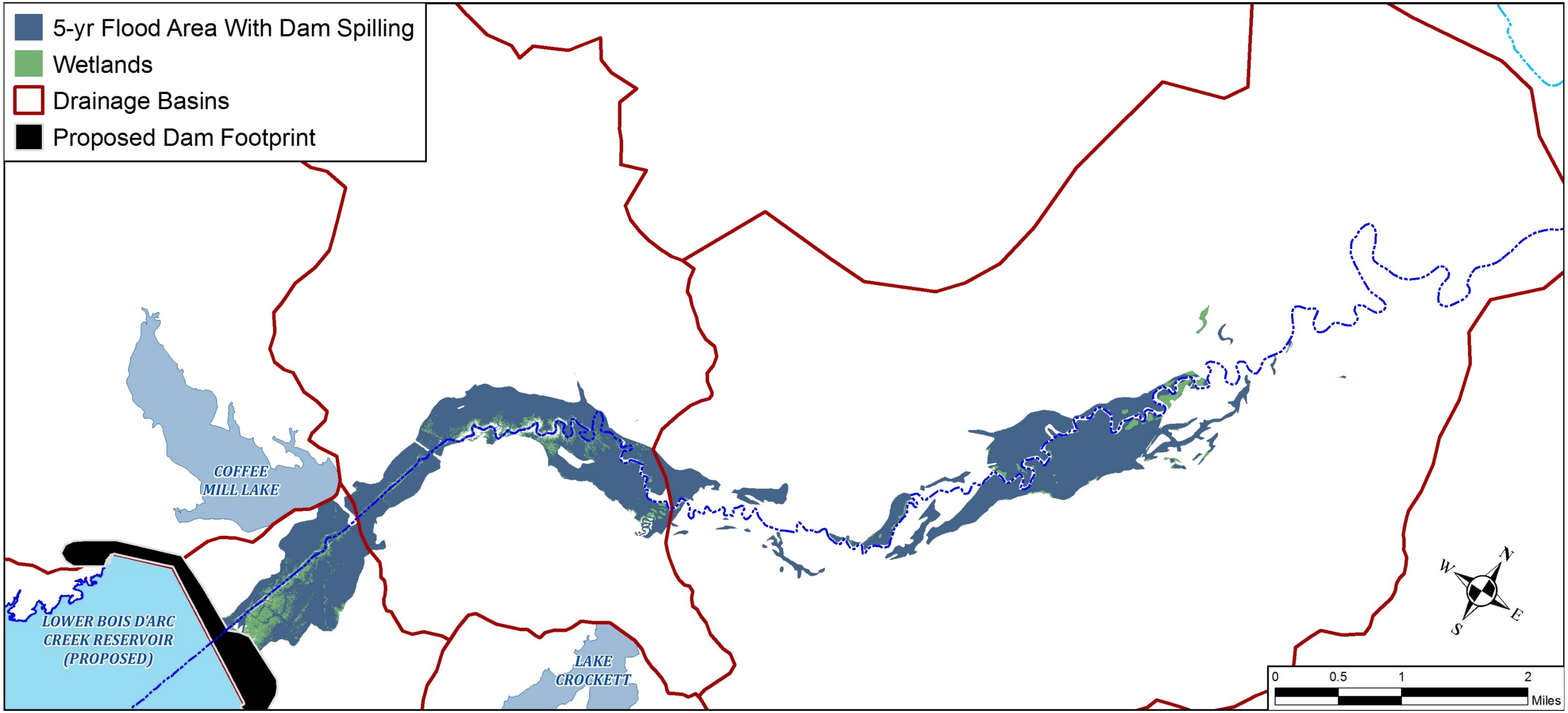

Figure 8: 5-Year Flood Event – Inundation Area with LBCR Dam, Spills from LBCR

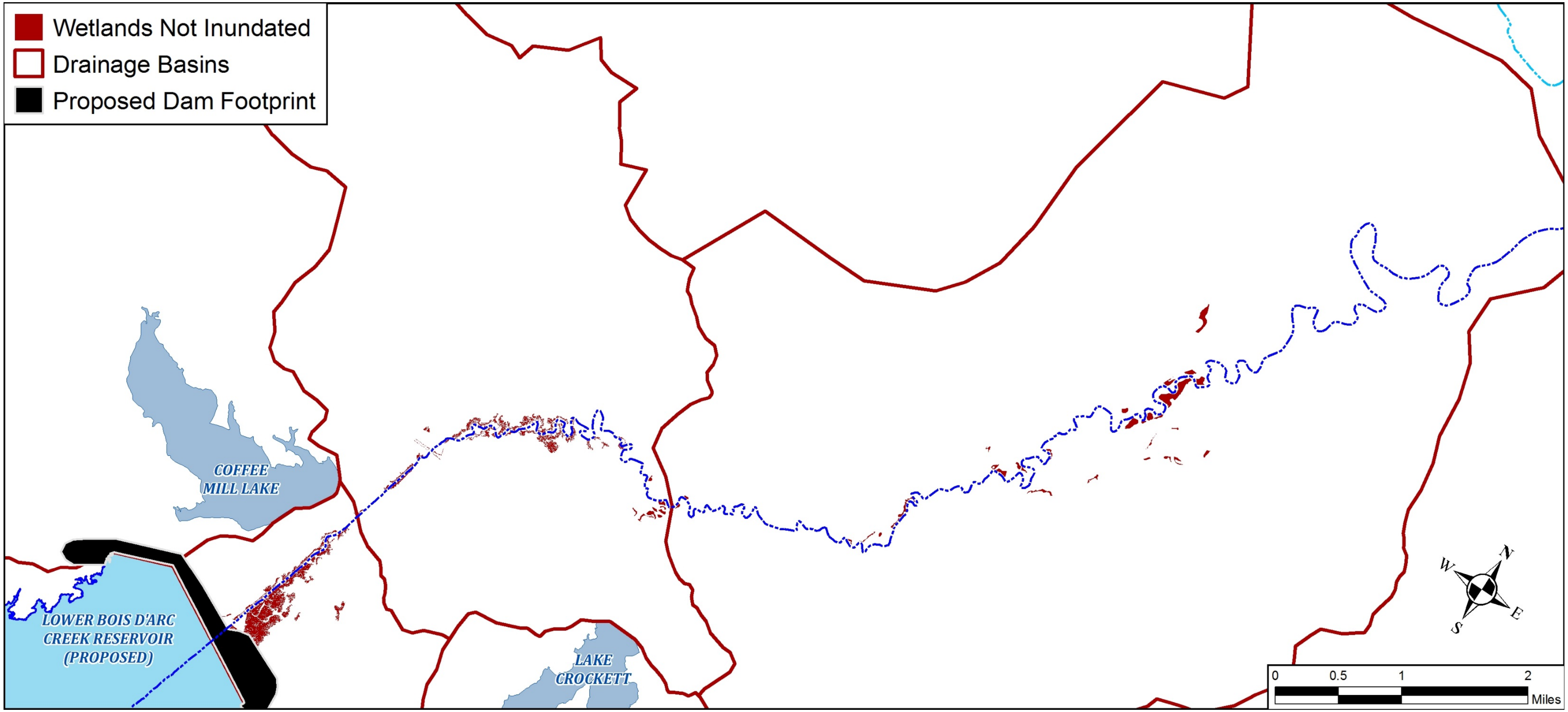

Figure 9 Areas not Inundated under the 5-Year Flood with Spills

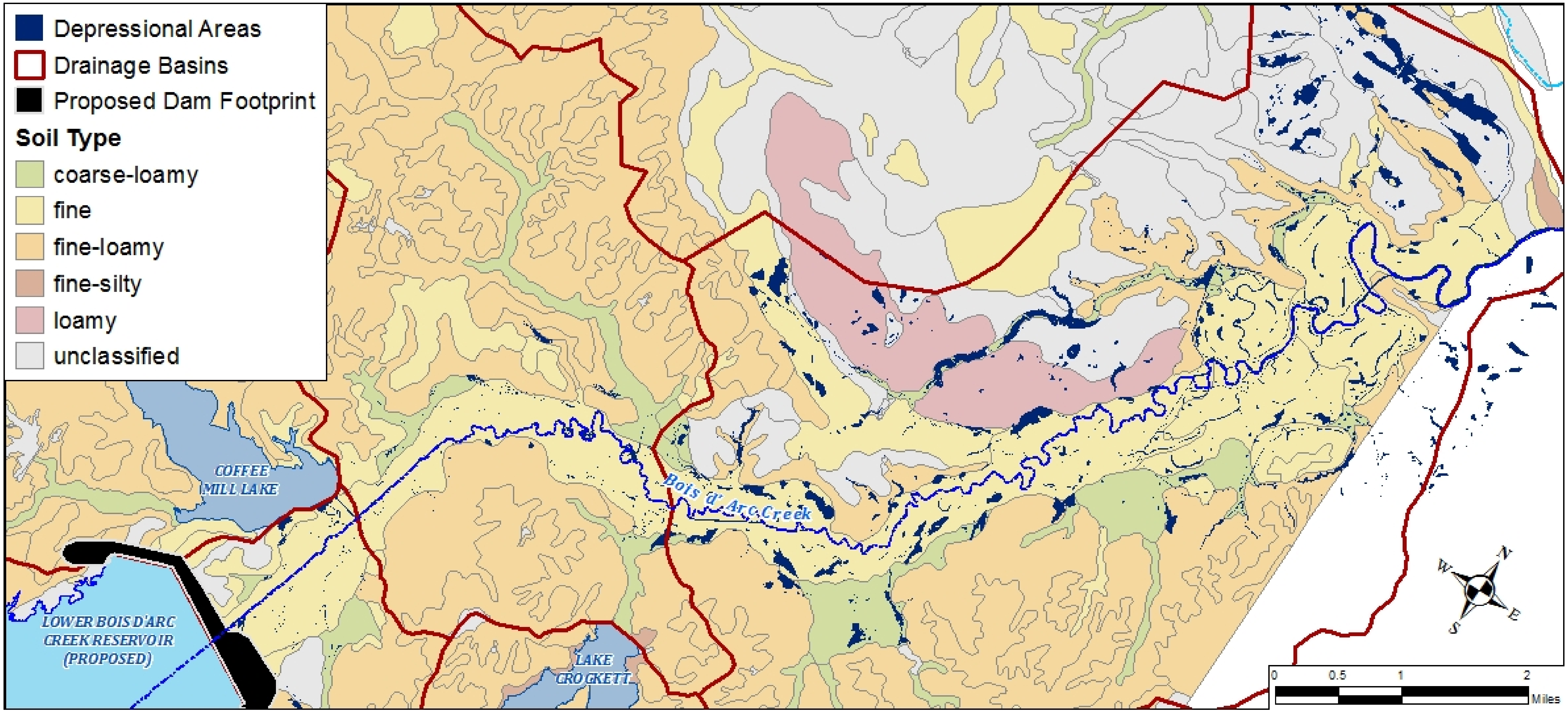

Figure 12 Ponding, Recharge and Interflow Potential

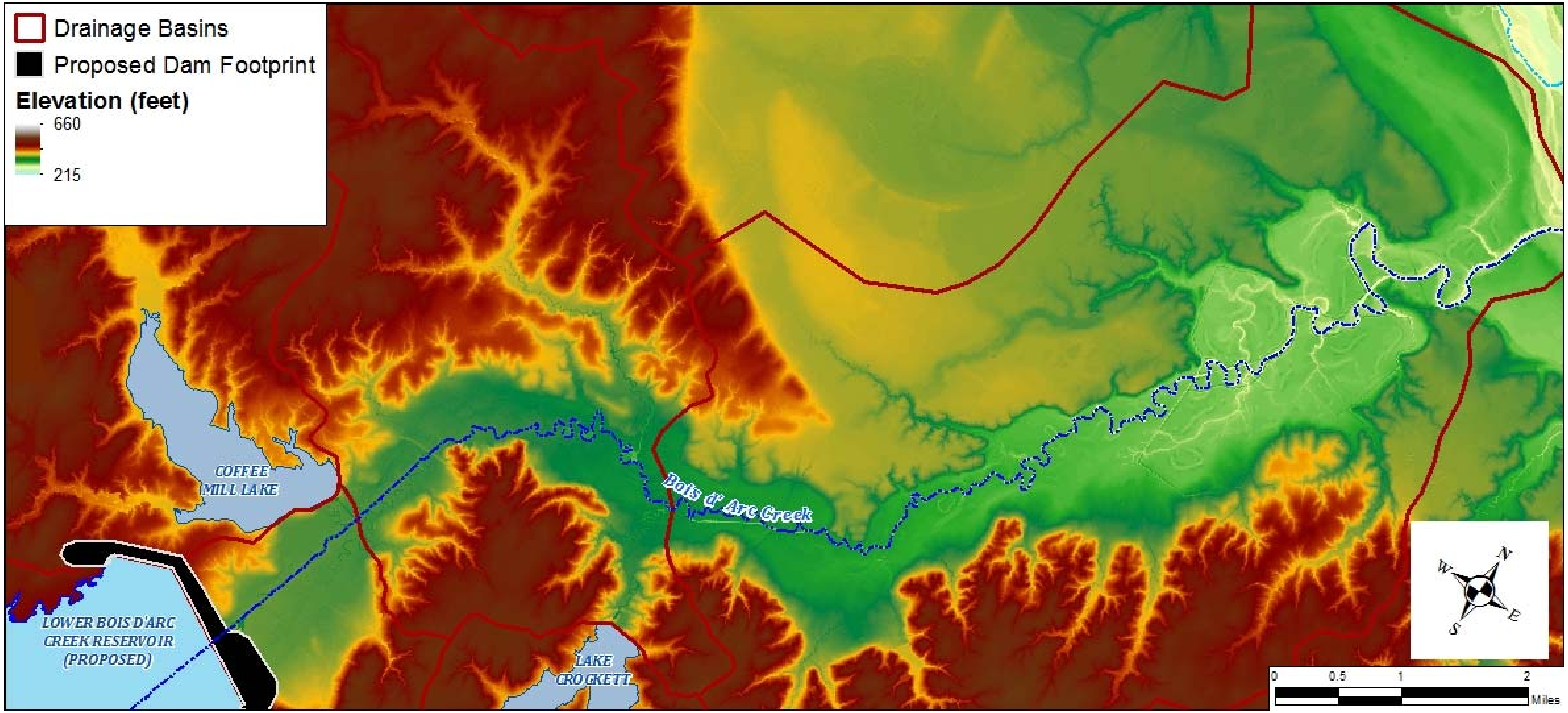

Figure 13 Topography of Bois d'Arc Creek Watershed Downstream of LBCR Dam

ATTACHMENT 1

APPENDIX C Downstream Corridor Impacts

Supplemental Instream Flow Study, September 2010

C-1 INTRODUCTION

The flow regime of Bois d'Arc Creek has evolved over time. More than 100 years ago, the channel was a meandering stream that moved flood waters slowly through the basin to the Red River. Today, the creek responds to rain events by moving flood waters quickly through the channel, which is observed in the rapid rise and fall of flood waters. This response results in continued downcutting of the channel and potential future disconnect between the channel and riparian corridor. The proposed flow regime for Bois d'Arc Creek is expected to reduce the downcutting and may contribute to aggradation of the stream, which would better serve the downstream riparian corridor. This flow regime is based on three components defined for the Texas Instream Flow Program (TIFP), and is expected to be sufficient to protect the instream flow needs of the channel and the associated riparian corridor.

Overbanking flows are the fourth category of environmental flow criteria established by the TIFP. The proposed flow regime for Bois d'Arc Creek excludes deliberate releases from the reservoir to produce overbanking flows. This recommendation was supported by the results of the hydrological, biological, and fluvial geomorphological components of the 2010 *Instream Flow Study*, as high flows were shown to be erosive and destructive to existing instream habitats. It is also consistent with the Texas Commission on Environmental Quality's (TCEQ) position to not require overbank releases in water rights permits, as indicated by agency staff during meetings for the Bois d'Arc Creek instream flow study. Deliberate overbanking or flooding flows create liability issues relating to potential property damage and/or loss of life.

A sound ecological environment, as defined for the Bois d'Arc Creek *Instream Flow Study* (FNI, 2010), requires environmental flow releases that provide sufficient stream power to move sediment in the channel to promote habitat diversity without creating excessive stream bed and bank erosion. The recommended pulse release amount to meet this criterion is 50 cfs. This flow, while sufficient to meet this goal, will not generate overbank flows by itself. The anticipated change in the number and frequency of overbank flows may result in potential impacts to the instream and floodplain environments downstream of the proposed dam. Potential impacts and established mitigation for instream impacts associated with the proposed Lower Bois d'Arc Creek Reservoir project were addressed in the 2010 *Instream Flow Study* report and supported with this Supplemental Report. The primary purpose of this Appendix is to address potential impacts to the floodplain of Bois d'Arc Creek downstream of the proposed dam, specifically those effects that pertain to expected modification of overbanking flows.

C-2 POTENTIAL IMPACTS OF LOWER BOIS D'ARC CREEK RESERVOIR ON DOWNSTREAM FLOODPLAIN

In a comprehensive report on Dams and Development (WCD, 2000), the World Commission on Dams documented potential environmental impacts of dams (Petts, 1984). These potential impacts can be considered within a hierarchical framework of interconnected effects, with differing levels of impacts.

Considerations of potential impacts to the downstream floodplain environments include abiotic variables relating to hydrology, water quality, and sediment loading. The proposed project ecosystem and reservoir purpose (i.e., whether water is extracted, diverted, or released) dictate the extent of change to downstream floodplain hydrology and sedimentation processes (WCD, 2000). Significant changes associated with the abiotic variables can result in altered floodplain morphology and riparian vegetation. These are dependent on the extent of impacts created by dam operations, local conditions, and the characteristics of the stream prior to dam (Acreman, 2000). Potential changes to the biological environment are the result of the integrated effects of these impacts. Complex interactions may take place over many years before a new "ecological equilibrium" is achieved (McCartney et al., 2000).

The proposed flow regime for Lower Bois d'Arc Creek Reservoir may result in changes to the downstream corridor. However, based on local conditions, these changes are not expected to have a negative impact, and may help contribute to maintaining a sound ecological environment in the area.

C-2.1 Potential Effects on Hydrology and Sedimentation

Several integrated factors determine how the modified flow regime and reduced sediment loading will impact the downstream floodplain. Overbanking flows can play a role in floodplain inundation duration and frequency, sediment deposition, and soil fertility (McCartney, 2000). Reducing overbanking flows may also influence longer-term processes of groundwater/aquifer recharge and connectivity. However, other factors such as current channel conditions, climatic conditions (e.g., precipitation), topography, soils, land cover, and dam design and operation will affect the level of impacts.

C-2.1.1 Hydrology

The current channel conditions of Bois d'Arc Creek are generally considered "poor" and in a state of disequilibrium and stream instability (FNI, 2010). Bois d'Arc Creek watershed is a highly channelized stream system (62%), with stream bank heights ranging between 20 to 30 feet. Stream channelization began in the 1920s; therefore, current stream conditions to a degree reflect over 90 years of altered stream-floodplain connectivity.

With the dam in place, hydrologic modeling results indicate that there will be fewer overbanking events along the downstream corridor of Bois d'Arc Creek; however, several other factors will continue to contribute to floodplain inundation. These include spills from the reservoir, effects associated with overbanking events associated with local tributaries, regional climatic conditions and existing riparian vegetation. Regionally, inundation is supplemented by high average annual rainfall and existing soils types (i.e. Tinn clay) with the slow permeability and low runoff potential (USDA, 2001). Behind the Gulf Coastal Plains and the Pacific Northwest, East Texas receives among the highest average rainfall in the conterminous U.S. (about 42-44 inches/year). Additionally, 42 percent of the downstream floodplain (modeled post-dam) is part of the Caddo National Grasslands. The relatively undisturbed vegetative state of these areas potentially promotes water retention and encourages soil infiltration (Acreman, 2000).

Hydrological effects of dams become less significant with distance downstream because the area of uncontrolled catchment of the watershed increases. The frequency of tributary confluence and their hydrological contribution play a large role in determining the length of stream affected by an impoundment (Acreman, 2000). Below the proposed Bois d'Arc Creek reservoir, there are numerous contributing tributaries (Figure C-2). These tributaries provide additional stream flow to Bois d'Arc Creek as well as the potential to provide overbanking flows to the adjacent floodplain.

Altered drainage systems, such as Bois d'Arc Creek, create reduced groundwater-surface water interaction and modify infiltration processes resulting in decreased groundwater recharge (Winter et al., 1998). The floodplain soils are documented to have a deep groundwater table (greater than six feet) (USDA, 2001). Groundwater-stream channel interaction may actually increase as a result of the proposed environmental flow regime, as it maintains steady base flows throughout the year. This can promote lateral connectivity between the active channel and the near surface groundwater table (Winter et al., 1998).

C-2.1.2 Sedimentation

The majority of impacts associated with reduced sediment loading occur within the active channel, though overbanking flows do contribute fluvial sediment deposits and associated soil nutrients to the adjacent floodplain (Ligon et al., 1995).

Over the course of the modeled historical hydrological record, overbanking events in Bois d'Arc Creek occur on average three times per year. With continued channel incision and degradation, the frequency of overbanking flows could decrease, limiting sediment and nutrient deposition as compared to pre-channelized stream conditions. The 2010 *Instream Flow Study* proposed environmental flow regime incorporates pulse flow events (50 cfs) to maintain or improve channel characteristics by minimizing erosional processes and promoting the establishment of stream bank vegetation. With the proposed flow regime, the channel is expected to aggrade over time, increasing potential connectivity with the adjacent floodplain. (See discussion on Yegua Creek in Section C-2.2.1.)

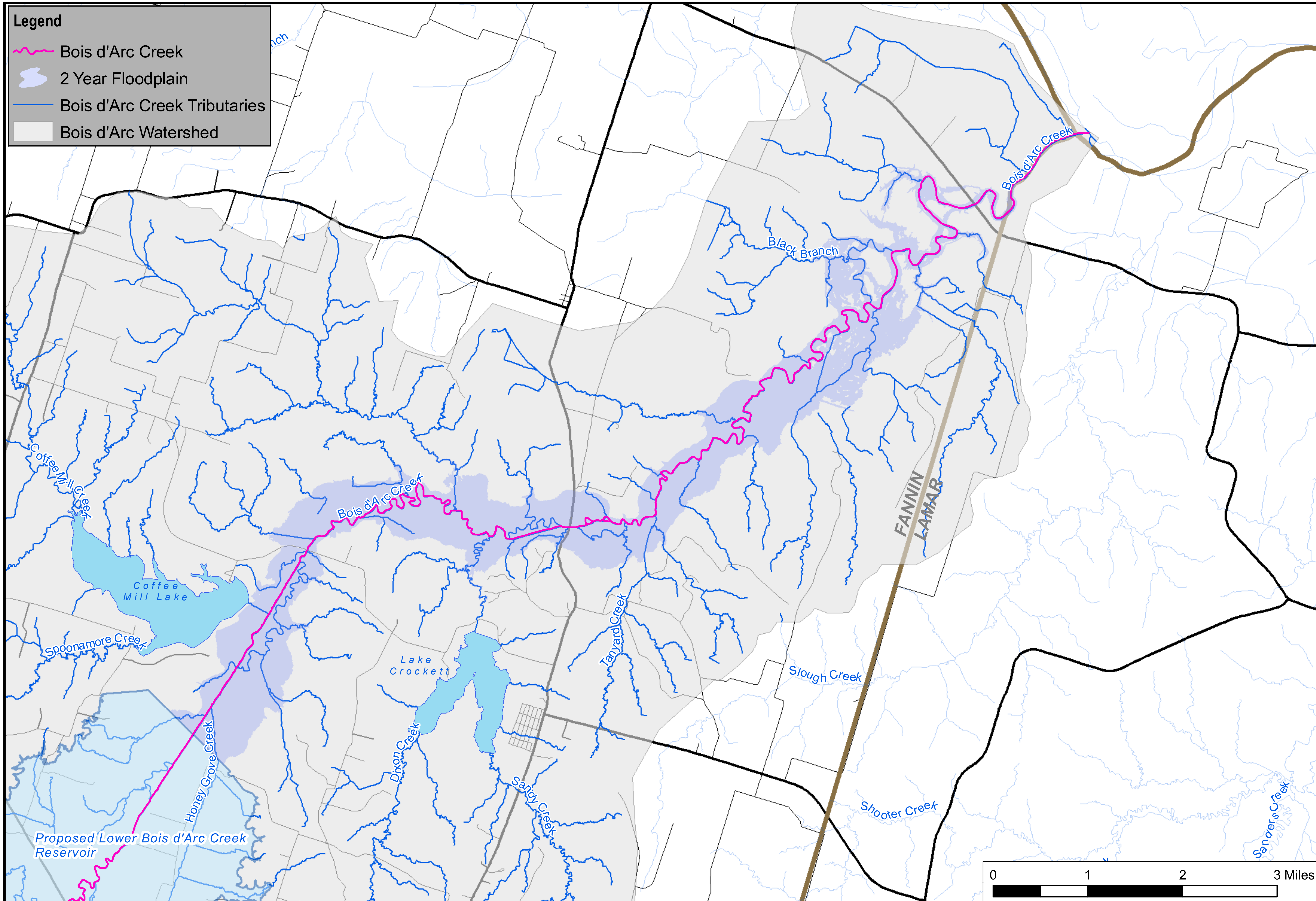

Figure C-2

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North Texas Municipal Water District
Proposed Lower Bois d'Arc Creek Reservoir

Contributing Downstream Tributaries

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

C-2.2 Potential Effects on Floodplain Morphology and Riparian Vegetation

C-2.2.1 Floodplain Morphology

Downstream of the proposed dam, the floodplain morphology of Bois d'Arc Creek has been affected by the historical upstream channelization practices. In general, the banks of Bois d'Arc Creek downstream of the proposed dam are actively eroding, resulting in channel widening (approximately 0.5 feet/year), incision, and bank steepening. Currently, all stream migration is confined within the incised channel; therefore, the proposed stable low flow reservoir releases are expected to promote floodplain retention through stream bank stabilization and channel aggradation.

Stream aggradation has been documented at other streams downstream of existing reservoir sites. In Yegua Creek, downstream of Somerville Dam, Somerville, TX, the channel capacity decreased following dam closure due to reduced flood flow frequency. Since construction of the dam, there has been an 85 percent reduction in flood peaks. Aggradation has caused the channel depth to decrease approximately 60 percent. Channel banks have remained stable as a result of increased vegetation density caused by increased low flows during the typically dry summer months. Decreased channel capacity allows for increased sediment delivery to the floodplain by flows that have been traditionally contained in a larger channel (Chin et al., 2002).

C-2.2.2 Riparian Vegetation

The inclusion of overbanking flows in the TIFP is often cited to maintain the ecological health of the downstream riparian corridor. Concerns with reduced overbanking include potentially decreased soil fertility and reduced "seedbed" area for riparian vegetation. However, impacts on riparian vegetation are site specific and depend, to a large extent, on dam operations and current site conditions (e.g., existing vegetative species, active channel width, land use, topography) (Acreman, 2000; Chang and Crowley, 1997; Williams and Wolman, 1984). In some instances, particularly in altered systems, regulated stream flows promote stream bank stabilization, vegetation growth, and species diversity.

For example, the riparian corridor below the Sam Rayburn Reservoir promotes greater species diversity than a relatively undisturbed corridor along the Neches River. For this assessment, streamflow and vegetation characteristics were compared between the study areas: 1) immediately below Sam Rayburn Dam in the Angelina River floodplain and 2) a relatively undisturbed area along the Neches River approximately 12 miles to the west. After impoundment, the monthly stream flows were higher in the summer months, duration of high flows was lower, and spring peak flows and flood conditions were reduced due to reservoir operation and management. Vegetation comparisons, including woody and herbaceous species in all strata of the forest stands at each site, indicated that the site immediately below Sam Rayburn Dam had greater species diversity, richness and evenness. The study concluded that the reduced flooding and moderation of stream flow variation created a more suitable habitat for plant growth and development. The dam created a more diverse and stable ecosystem in the downstream area (Chang and Crowley, 1997). Similar results could be expected to occur downstream of the Lower Bois d'Arc Creek Reservoir dam where the regulated flow regime would encourage channel bank stability and vegetative growth.

To assess the potential impacts from reduced overbanking events to the riparian vegetation along the downstream corridor, vegetative species were identified using the Habitat Evaluation Procedures (HEP) protocol and indicator species defined for the HEP survey of the proposed reservoir pool (FNI, 2007). A total of eight HEP points were collected in August 2009 as part of the downstream study. Both the species composition data from the 2007 HEP reservoir surveys and the downstream riparian corridor (2009) were used to establish a representative vegetative community assemblage for Bois d'Arc Creek. Each species' wetland indicator status (USDA-NRCS, Region 6) and anaerobic soil tolerance (USDA-NRCS 2010) were used as surrogates for flood tolerance. Table C-1 defines wetland indicator status with comments on occurrence, and Tables C-2 and C-3 identify HEP documented species by vegetative strata (i.e., trees, shrubs, and herbaceous) with wetland indicator status and anaerobic soil tolerance.

As described in Table C-1 wetland plant species except for obligates (OBL) can, to various degrees, grow in non-wetland conditions. Facultative species may occur equally in wetland or non-wetland conditions. The anaerobic tolerance of a species is also an indicator of a species' ability to grow in hydric soils, which can produce anaerobic (no free oxygen) conditions during periods of inundation. Non-wetland species actually have none to low tolerance of anaerobic soils conditions.

In the Bois d'Arc Creek downstream riparian corridor, the riparian woodland community is currently most similar to the forest cover type described as Sugarberry-American Elm-Green Ash (Society of Foresters; Allen et al., 2001). These woodlands are typically found at transitional elevations between poorly drained flats (e.g., overcup oak-water hickory stands) and well-drained ridges (e.g., sweetgum-willow oak stands). In total, one-third of the tree species are classified as facultative upland or upland species, suggesting a community prone to temporary rather than semi-permanent flooding. Every vegetative strata was dominated by facultative species (equally likely to occur in wetlands or uplands), and would be considered drought-tolerant.

Table C-1 Wetland Indicator Categories with Comments on Occurrence (USDA-NRCS, 2010)

Wetland Type	Indicator Code	Comment
Obligate Wetland	OBL	Occurs almost always (estimated probability 99%) under natural conditions in wetlands.
Facultative Wetland	FACW	Usually occurs in wetlands (estimated probability 67%-99%), but occasionally found in non-wetlands.
Facultative	FAC	Equally likely to occur in wetlands or non-wetlands (estimated probability 34%-66%).
Facultative Upland	FACU	Usually occurs in non-wetlands (estimated probability 67%-99%), but occasionally found on wetlands (estimated probability 1%-33%).
Obligate Upland	UPL	Occurs in wetlands in another region, but occurs almost always (estimated probability 99%) under natural conditions in non-wetlands in the project region. If a species does not occur in wetlands in any region, it is not on the National List of Plant Species that Occur in Wetlands..

Table C-2 Plant Species of the Bois d'Arc Creek Riparian Woodlands and Bottomland Hardwood Forest with Wetland Indicator Status and Anaerobic Soil Tolerance -2007 HEP Study at the Proposed Lower Bois d'Arc Creek Reservoir Site

Wetland Indicator Status	*TREES*			*SHRUBS*			*HERBACEOUS*		
	Observed Species	**Anaerobic Tolerance**	***% of Total***	**Observed Species**	**Anaerobic Tolerance**	***% of Total***	**Observed Species**	**Anaerobic Tolerance**	***% of Total***
OBL				Button Bush	High		Duckweed	High	
			0	Water Hickory	Medium	***10***	Sedge Species	Medium - High	***20***
FACW	Box-Elder	Medium		Box-Elder	Medium		Cherokee Sedge	--	
	Green Ash	Medium		Deciduous Holly	Medium		Frog Fruit	--	
	Black Willow	High		Green Ash	Medium				
				False Willow	High				
			33	Black Willow	High	***25***			***20***
FAC	Cedar Elm	None		Yaupon	None		Poison Ivy	--	
	Honey Locust	None		Cedar Elm	None		Virginia Wildrye	--	
	Sugarberry	Medium		Cottonwood	High		Virginia Creeper	Medium	
				Honey Locust	None		Ragweed	None	
				Poison Ivy	--		Inland Sea Oats	Medium	
				Ragweed	--		Trumpet Vine	None	
				Sugarberry	Medium				
			33	False Willow	--	***40***			***60***
FACU	Red Mulberry	Medium		Eastern Red Cedar	Low				
	Winged Elm	Low		Western Soapberry	None				
				Red Mulberry	Medium				
				Winged Elm	Low				
			22	Coral Berry	None	***25***			***0***
UPL	Bois d'Arc	None	***11***			***0***			***0***

Table C-3 Plant Species of the Bois d'Arc Creek Riparian Woodlands and Bottomland Hardwood Forest with Wetland Indicator Status and Anaerobic Soil Tolerance -Data Points Downstream of Proposed dam Site

Wetland Indicator Status	*TREES*		*SHRUBS*	
	Observed Species	**Anaerobic Tolerance**	**Observed Species**	**Anaerobic Tolerance**
OBL	Water Locust	Low		
FACW	Green Ash	Medium	Box-Elder	Medium
			Deciduous Holly	Medium
			Green Ash	Medium
FAC	Bur Oak	None	Cedar Elm	None
	Cedar Elm	None	Honey Locust	None
	Sugarberry	Medium	Northern Catalpa	None
			Roughleaf-Dogwood	
			Sugarberry	Medium
			Yaupon	None
FACU	Eastern Red Cedar	Low	Eastern Red Cedar	Low
			Western Soapberry	None
UPL	Bois d'Arc	None	Bois d'Arc	None

Several facultative upland species were found in adjacent upland areas (Table C-4) that were not found in the riparian woodlands and bottomland hardwood forests of Bois d'Arc Creek. Over time, if the downstream riparian corridor experiences a decline in facultative wetland species (e.g., green ash, box-elder, deciduous holly) there is potential to gain hardmast producing species (e.g., southern red oak, post oak, black cherry) from the adjacent uplands. An increase in these species will help to mediate faunal impacts and increase available habitat types.

Table C-4 Plant Species of the Lower Bois d'Arc Creek Upland Deciduous Forest with Wetland Indicator Status and Anaerobic Tolerance

Wetland Indicator Status	TREES Observed Species	TREES Anaerobic Tolerance	TREES *% of Total*	SHRUBS Observed Species	SHRUBS Anaerobic Tolerance	SHRUBS *% of Total*	HERBACEOUS Observed Species	HERBACEOUS Anaerobic Tolerance	HERBACEOUS *% of Total*
OBL			***0***			***0***			***0***
FACW							Beggars Ticks	Medium	
			0	Green Ash	Medium	***6***	Cherokee Sedge	--	***10***
FAC	Cedar Elm	None		Common Persimmon	None		Alabama-Supplejack	--	
	Common Persimmon	None		Hawthorn	Medium - High		Blackberry		
	Honey Locust	None		Honey-Locust	None		Canada Wildrye	--	
	Sugarberry	Medium		Roughleaf-Dogwood	Low		Common Greenbriar	Low	
	Water Oak	Medium		Sugarberry	Medium		Dewberry	None	
							Grape Vine	--	
							Poison Ivy	--	
							Spike Uniola	--	
							Tick Seed	Medium	
							Tick Trefoil	Medium	
							Trumpet Creeper	None	
							Virginia Creeper	None	
							Virginia Wildrye	Medium	
			50			***31***		--	***65***
FACU	Black Cherry	None		American-Beautyberry	None		Carolina Snailseed	--	
	Eastern Red Cedar	Low		Black Cherry	None		Frostweed	--	
	Post Oak	Low		Coral Berry	None		Prickly Pear	--	
	Southern Red Oak	None		Eastern Red Cedar	Low		Yellow-Woodsorrel	--	
				Gum Bumelia	--				
				Post Oak	Low				
				Rusty Blackhaw	None				
				Winged Elm	Low				
			40	Yaupon Holly	None	***56***			***20***
UPL	Bois d'Arc	None	***10***	Eastern Redbud	None	***6***	Threeseed-Mercury	--	***5***

C-2.3 *Potential Effects on Downstream Fauna*

The integrated effects of impacts can lead to changes to the biological environment. These include potential impacts to species close to the top of the food chain (e.g., fish, birds, and mammals), and can be the result of direct habitat loss, reduced resource availability, or reduced habitat quality. In some cases, there have been noted increases in habitat availability and quality associated with the shift in riparian vegetation.

Wildlife species observed and habitat quality data collected during HEP surveys were used to characterize the current habitat conditions along Bois d'Arc Creek and to evaluate future conditions. In the HEP procedure, a set of evaluation species were selected by state and federal resource agency representatives and current habitat conditions were evaluated in light of the optimum habitat characteristics for these species (FNI, 2008). Habitat quality is expressed in terms of a Habitat Suitability Index (HSI), and ranges from 0.0 to 1.0 (i.e., unsuitable to suitable). This metric was used as a surrogate to estimate current habitat quality in accordance with HEP protocols.

Bois d'Arc Creek riparian woodland and bottomland hardwood evaluation species were the Barred Owl, Downy Woodpecker, Wood Duck, Fox Squirrel, and Raccoon (Table C-5). The 2007 HEP study indicated that the quality of riparian woodland and bottomland hardwood wildlife habitat was fairly poor, with HSI values ranging from 0.03 to 0.52 (Table C-6). The HEP study of the downstream sites conducted in 2009 indicated that these areas might also have poor quality habitat for all species except the downy woodpecker. The measured habitat characteristics used to assess habitat availability were compared to potential impacts associated with reduced overbanking flows. Table C-7 identifies these habitat characteristics and the associated predicted change represented as +/0/- (i.e., positive, neutral, or negative, respectively).

Based on the predicted changes to the downstream riparian corridor, habitat quality and availability are expected to increase. Improvements to wildlife habitat quality would result from the continued maturation of the forest within the current floodplain, and a potential shift in vegetative composition. Primary effects of a shift in vegetation might include: (1) increased hardmast producers, (2) decreased shrubs and herbaceous species (e.g., green ash), and (3) increased heterogeneity in canopy cover. In protected areas, such as the corridor through the Caddo National Grasslands, such a vegetative shift would expect to be minimal due to the existing closed canopy that limits seedbed areas. Areas where a vegetative shift would have the greatest potential impact are areas that could be disturbed by logging, fire, insects or disease. The combination of forest maturation and potential vegetative shift would increase resource availability, while providing habitat for nesting, foraging, and refugia. The proposed steady base flow releases will also provide permanent water for wildlife species.

Table C-5 Wildlife Species of the Bois d'Arc Creek Riparian Woodland and Bottomland Hardwood

Observed Species	Evaluation Species
Birds	
American Crow	Barred Owl
Barred Owl	Downy Woodpecker
Carolina Chickadee	Wood Duck
Carolina Wren	
Downy Woodpecker	
Hummingbird	
Indigo Bunting	
Mourning Dove	
Northern Cardinal	
Northern Parula	
Red-eyed Vireo	
Tufted Titmouse	
White-eyed Vireo	
Wood Duck	
Yellow-billed Cuckoo	
Mammals	
Beaver (chew marks)	Fox Squirrel
Hog (tracks)	Raccoon
Raccoon (tracks)	

Table C-6 Baseline habitat Suitability Index (HSI) Values of the Bois d'Arc Creek Riparian Woodland and Bottomland Hardwood

Evaluation Species	HSI Values	
	Reservoir	*Downstream*
Barred Owl	0.14	0.14
Downy Woodpecker	0.34	0.71
Fox Squirrel	0.03	0.1
Raccoon	0.52	0.26
Wood Duck	0.22	0.0

Table C-7 Predicted Changes in Quality of Habitat Variables Measured in the Downstream Portion of the Lower Bois d'Arc Creek Riparian Woodland / Bottomland Hardwood After Dam Construction

Evaluation Species	Habitat Characteristic	Potential Impact	Predicted Change
Barred Owl	Number of large trees	Growth with Age	+
	Average diameter of overstory trees	Growth with Age	+
	Canopy cover of overstory trees	Growth with Age	+
Downy Woodpecker	Basal area	Growth with Age	+
	Number of large snags	Reduced flooding	-
Fox Squirrel	Canopy closure of large trees that produce hard mast	Growth with Age	+
	Distance to available grain	Agricultural Production Not Expected	0
	Average diameter of overstory trees (inches)	Growth with Age	+
	Percent tree canopy closure	Growth with Age	+
	Percent shrub crown cover	Increased shrub/herbaceous mortality	+
Raccoon	Distance to water	Permanent base flows	+
	Water regime (Permanent, Semi-permanent, or Ephemeral)	Permanent base flows	+
	Overstory forest size class	Growth with Age	+
	Number of refuge sites	Increased Tree Mortality with Age	+
Wood Duck	Number of potentially suitable tree cavities	Increased Tree Mortality with Age	+
	Number of nest boxes (management tool)	-	+
	Percent of water surface covered by potential brood cover	Reduced inundation duration	-
	Percent of water surface covered by potential winter cover	Reduced inundation duration	-

C-3 CONCLUSIONS

Potential impacts to the downstream floodplain of Bois d'Arc Creek would likely be limited by several factors: (1) the existing community is not dependent upon overbank flow for reproduction and overall success. Many of the species along Bois d'Arc Creek riparian corridor are equally likely to occur in uplands; (2) the local site conditions (e.g., rainfall, soil type, and land cover) supplement floodplain inundation; (3) the proposed release of steady base flows should increase channel-groundwater connectivity and promote growth of streambank vegetation; (4) the reduction in highly erosive flows would allow the stream to aggrade over time increasing the potential for floodplain connectivity; and (5) contributing downstream hydrology provide instream flow and supplement floodplain connectivity. Certain aspects of the riparian corridor may even be improved as a result of the dam, including increased streambank stabilization, vegetation growth, and gain of hardmast producing woody species.

ATTACHMENT 2

Technical Memorandum on Downstream Flood Mapping of High Frequency Events

Lower Bois d'Arc Creek

Technical Memorandum on Downstream Flood Mapping of High Frequency Events Lower Bois d'Arc Creek

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TO: Project File

CC: Simone Kiel, P.E.

FROM: Patrick Miles, P.E.

SUBJECT: Lower Bois d'Arc Creek Reservoir
Downstream Flood Mapping for High Frequency Events

DATE: June 3, 2016

PROJECT: NTD06128

STATE OF TEXAS
JAMES PATRICK MILES II
113113
LICENSED
PROFESSIONAL ENGINEER
6-3-16

FREESE AND NICHOLS, INC.
TEXAS REGISTERED ENGINEERING
FIRM F- 2144

The purpose of this memorandum is to document the processes and results of recent updated hydraulic modeling downstream of the Lower Bois d'Arc Creek Reservoir (LBCR) Dam. Throughout the process of preparing permitting documents and designing the dam and appurtenant structures, Freese and Nichols has developed a suite of hydrologic and hydraulic models for Lower Bois d'Arc Creek and its overall watershed. These models represent flood events ranging from a one half-year return period up to the Probable Maximum Flood. For the purposes of the study documented by this memorandum, the modeling efforts focused on smaller, more frequent events characterized as the 2-year and 5-year events.

Precipitation Data

Precipitation depth-duration-frequency data was obtained from a combination of National Weather Service Technical Paper No. 40 (TP-40) and Technical Memorandum NWS HYDRO-35. The point rainfall data was adjusted by the areal reduction factors provided by TP-40, in order to account for the large drainage area of the total watershed. The table below presents the precipitation depths for given combinations of frequency event and duration. This data was input to the hydrologic model as a critically stacked, 24-hour rainfall distribution for each storm event.

Frequency Event	Precipitation Depth (inches)							
	5 min	15 min	60 min	2 hr	3 hr	6 hr	12 hr	24 hr
2-year	0.49	1.06	1.26	1.71	1.97	2.49	3.10	3.69
5-year	0.57	1.24	1.56	2.29	2.58	3.33	4.14	4.96

Hydrologic Model

The hydrologic model was compiled in HEC-HMS, Version 3.5, and consists of 11 drainage basins upstream of the dam site and 5 basins between the dam site and the confluence with the Red River. The model utilizes an initial and constant loss method based on soil parameters and the Snyder Unit Hydrograph method for runoff transformation. The model accounts for three existing reservoirs within the watershed: Lake Bonham, which is upstream of the dam site, and Coffee Mill Lake and Lake Crockett, which are located shortly downstream from the dam site. For the purposes of this study, the hydrologic model was not altered in any way from the existing model of previous studies.

Hydraulic Model

From previous studies, a one-dimensional hydraulic model was built in HEC-RAS, Version 4.1, representing the full length of Lower Bois d'Arc Creek from about 4 miles south of Bonham to the confluence with the Red River. For the purposes of this study, the existing one-dimensional model was utilized to route the upstream flow hydrographs to the location of the dam site. A new two-dimensional model was constructed in HEC-RAS, Version 5.0, representing the area from the dam site to the Red River confluence. The two-dimensional model is based on LiDAR topography data and able to more accurately depict the flow conditions of the downstream area and of specific interest to this study – low flows, out of banks, shallow floodplains, etc.

Boundary conditions for the two-dimensional model consist of lateral inflow hydrographs and downstream normal depth calculations. Inflow hydrographs were developed from the 5 downstream basins in the hydrologic model; however, the hydrographs were distributed by drainage area ratios along all the small tributaries to Lower Bois d'Arc Creek for a total of 22 lateral inflow locations. A separate boundary condition represents the hydrographs from upstream of the dam. For existing conditions, this simply represents the combined hydrograph for the upstream areas of the watershed. For with dam conditions, this hydrograph represents releases from the dam and/or spillway discharges. A constant base flow of 4,000 cfs was assumed on the Red River.

Model Run Scenarios

Four conceptual scenarios were developed for the model runs: *Existing Conditions*, *With Dam–No Spills*, *With Dam–Median Conditions,* and *With Dam–Spilling*. Each scenario is described in more detail in the following paragraphs:

Existing Conditions

This scenario represents the hydrology of existing conditions without any dam or impoundment in place. The upstream drainage area hydrographs are routed through Lower Bois d'Arc Creek via the existing one-dimensional model, as described previously.

With Dam–No Spills

This scenario represents the worst-case condition where the only flows out of the dam are the required environmental base flow releases, assumed to be a constant 3 cfs for the duration of the model run. Downstream runoff hydrographs from the uncontrolled drainage basins still provide flows to the downstream areas.

With Dam–Median Conditions

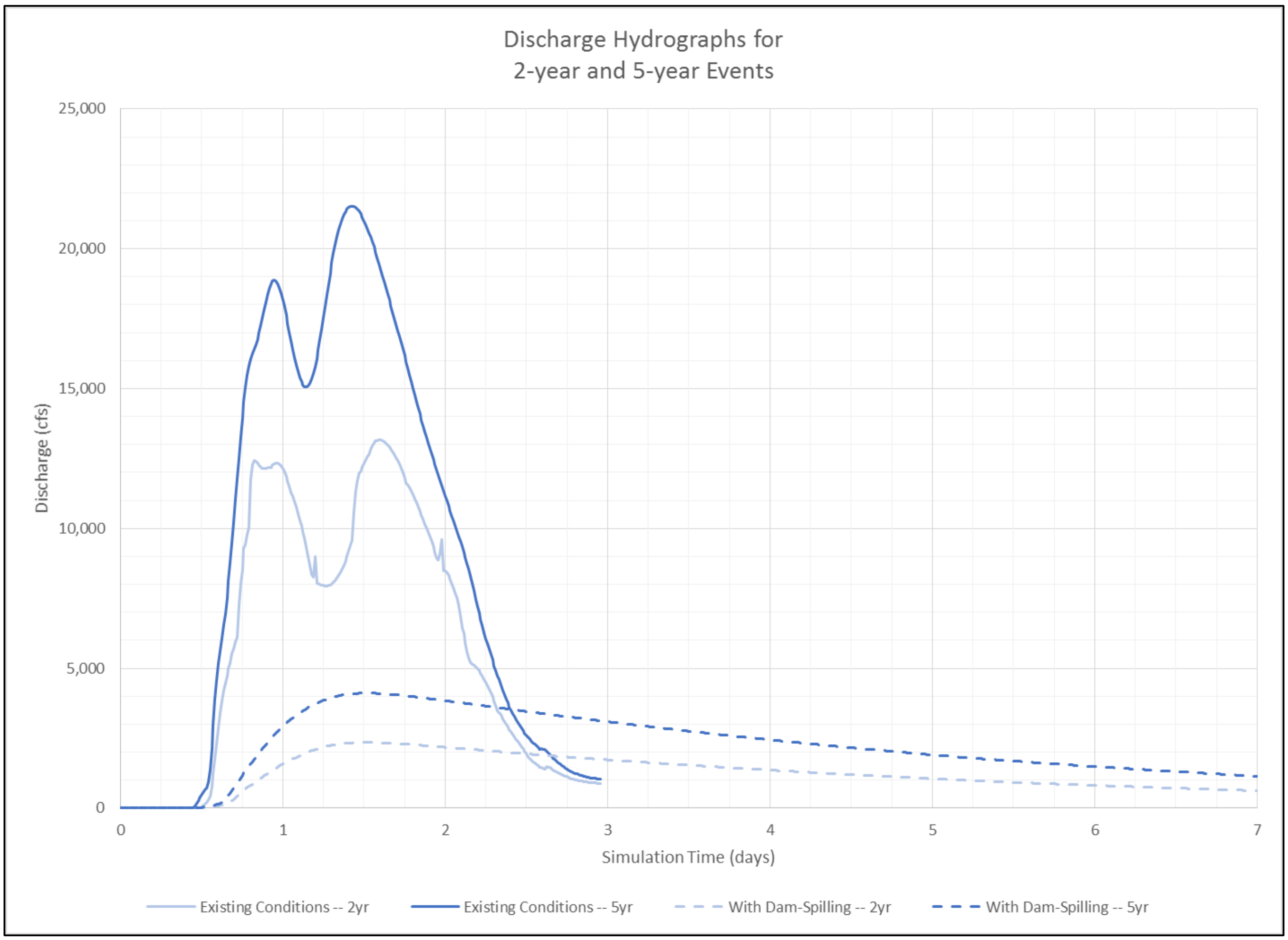
This scenario was not computed in the two-dimensional model because the reservoir would have sufficient storage capacity to contain a 5-year flood event. Based on water availability modeling, the median reservoir elevation is 529.6 feet-msl, corresponding to a storage volume of approximately 297,700 acre-feet. The spillway crest is set at a conservation pool elevation of 534.0 feet-msl, corresponding to a volume of 367,600 acre-feet. Therefore, the incremental storage volume is approximately 69,900 acre-feet. The total runoff volume produced by the 5-year flood hydrograph is approximately 53,700 acre-feet, which would not engage the spillway. By linear interpolation, any flood event that could produce spillway discharges when starting at the median pool level would have to exceed an approximately 12-year return period. The *Median Conditions* scenario produces the same inundation mapping as the *With Dam–No Spills* scenario.

With Dam–Spilling

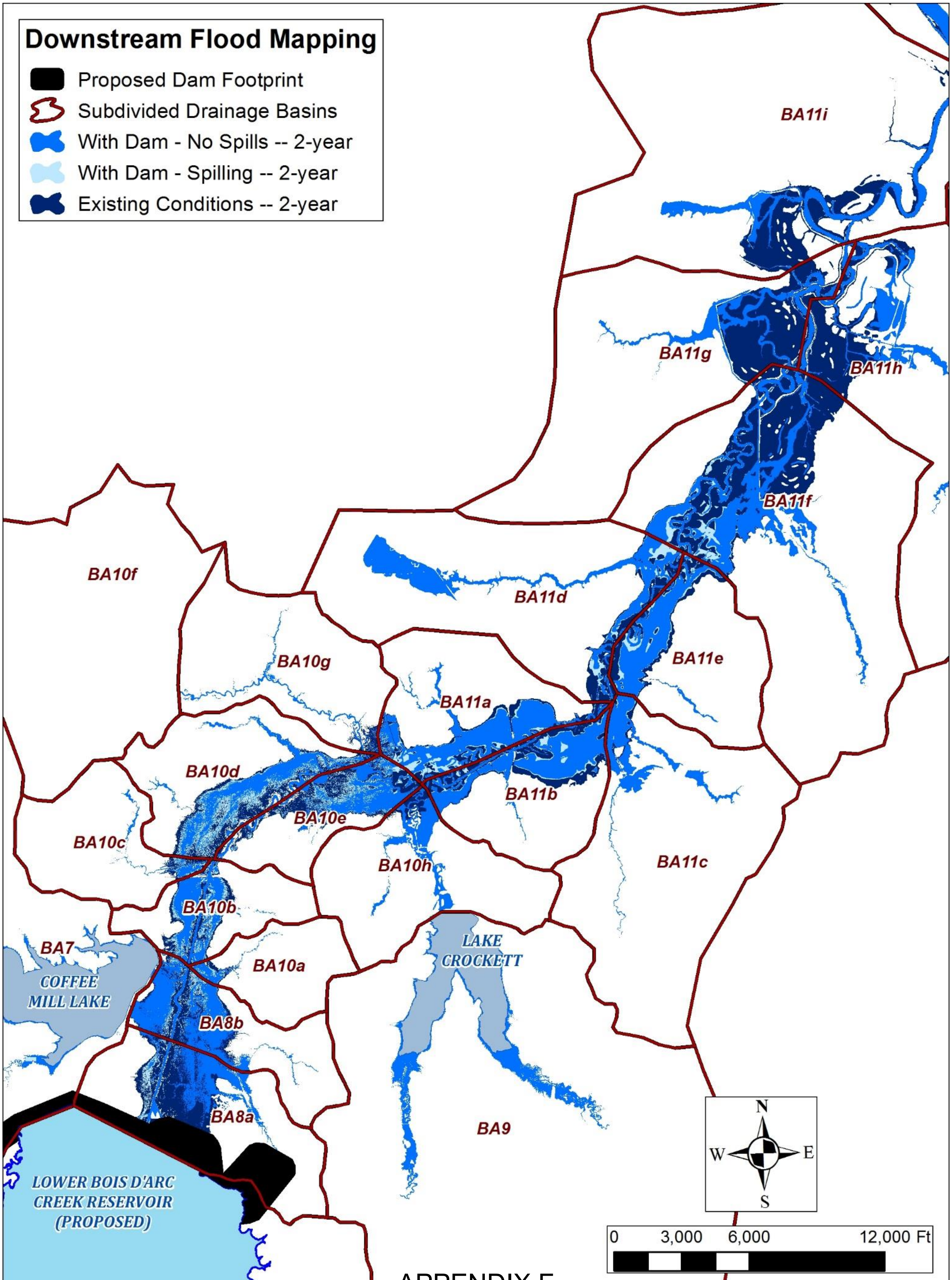
This scenario assumes the reservoir is at the conservation pool elevation of 534.0 feet-msl and any runoff event will produce discharges through the spillway. The minimum flow was also set to the same 3 cfs to represent minimum environmental base flows.

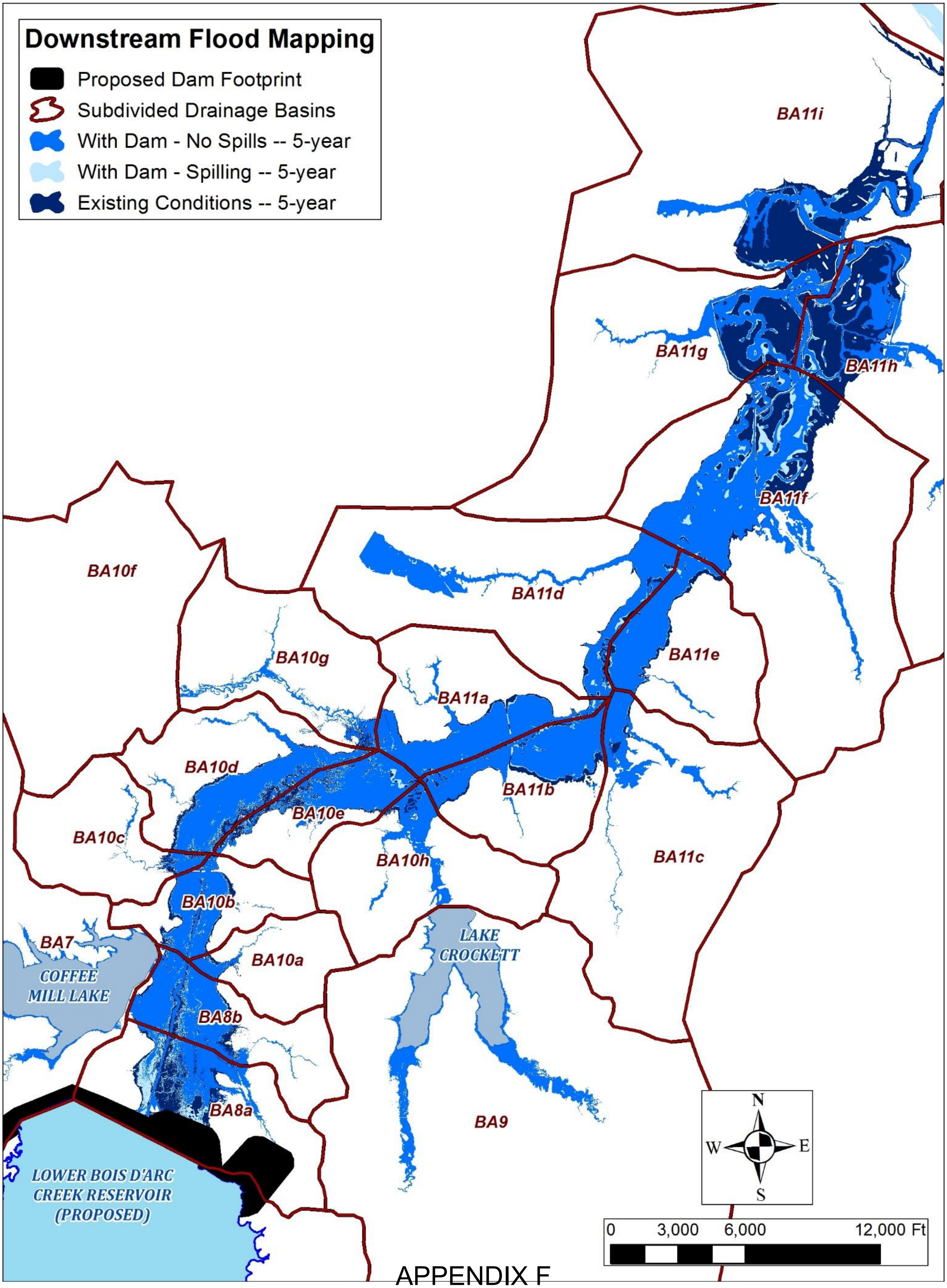
Downstream Flood Mapping Results

Each of these scenarios was computed for the 2-year and 5-year events. The flood mapping extents shown in the figures attached with this memorandum are being utilized in the assessment of impacts to downstream wetlands. For comparison purposes, discharge hydrographs calculated immediately downstream from the dam site are provided below, representing the *Existing Conditions* and *With Dam–Spilling* scenarios. Note the extended duration of flows in the *With Dam* condition, which is caused by the storage attenuation effects of the reservoir and labyrinth spillway. While the peak discharge decreases substantially, flows from the spillway remain in the system for a longer period of time.



The double peak shown in the *Existing Conditions* hydrographs simply represents timing delay as flows from the upper portions of the watershed are routed downstream. There is not a second peak in the rainfall applied to the model. The nature of the slow reservoir rise and gradual spillway discharges results in significant hydrograph dampening, such that the double peak is not apparent for the *With Dam–Spilling* scenario.


Downstream Flood Mapping
Proposed Dam Footprint
Subdivided Drainage Basins
With Dam - No Spills -- 2-year
With Dam - Spilling -- 2-year
Existing Conditions -- 2-year
BA11i
BA11g
BA11h
BA11f
BA10f
BA11d
BA10g
BA11e
BA11a
BA10d
BA11b
BA10e
BA10c
BA10h
BA11c
BA10b
BA7
BA10a
LAKE CROCKETT
COFFEE MILL LAKE
BA8b
BA8a
BA9
LOWER BOIS D'ARC CREEK RESERVOIR (PROPOSED)
N
W
E
S
0 3,000 6,000 12,000 Ft


Downstream Flood Mapping
Proposed Dam Footprint
Subdivided Drainage Basins
With Dam - No Spills -- 5-year
With Dam - Spilling -- 5-year
Existing Conditions -- 5-year
BA11i
BA11g
BA11h
BA11f
BA10f
BA11d
BA10g
BA11e
BA11a
BA10d
BA11b
BA10e
BA10c
BA10h
BA11c
BA10b
BA7
LAKE CROCKETT
BA10a
COFFEE MILL LAKE
BA8b
BA8a
BA9
LOWER BOIS D'ARC CREEK RESERVOIR (PROPOSED)
N
W
E
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0
3,000
6,000
12,000 Ft

Technical Memorandum on Functional Assessment of Downstream Wetlands

MEMORANDUM

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TO: Robert McCarthy, NTMWD

CC: File, NTD06128

FROM: Stephen Novair, Simone Kiel

SUBJECT: Functional Assessment of Downstream Wetlands

DATE: October 27, 2016

PROJECT: Lower Bois d'Arc Creek Reservoir, NTD06128

Objective

The purpose of this memo is to discuss expected HGM subindex variable changes for the forested wetlands downstream of the proposed Lower Bois d'Arc Creek Reservoir (LBCR) after dam construction. This report draws on existing information to populate and implement the Hydrogeomorphic (HGM) Approach to assess potential changes in wetland functions downstream of the LBCR due solely to expected changes associated with the construction of the LBCR (FNI_1, 2016). It is assumed that changes associated with natural maturation of the wetlands would continue to occur for conditions with and without the dam in place.

Method

This study assumes that the forested wetlands downstream of the LBCR dam are analogous to the present conditions of the forested wetlands within the footprint of the reservoir because they are contiguous, part of the same drainage network, and have similar plant communities. Each subindex variable score (Table 1) used in the HGM model was estimated based on potential system changes to the assumed current conditions after 20 years that may be associated with the construction of the LBCR. Subindex variables that are not expected to be affected by the construction of the dam were not changed. These values were then used to compute the Functional Capacity Index (FCI) values (Table 2), and ultimately the potential functional impacts that may be attributed to the proposed LBCR project.

APPENDIX F

General System Changes

The change from a natural flow regime to a regulated flow regime on Bois d'Arc Creek is expected to create lower peak-flood discharges and less overbank flooding with longer flood durations. Flow regimes, including overbanking flows, along downstream tributaries will not change. With the proposed instream flow regime, the flow in Bois d'Arc Creek would also be more consistent. This means extended periods of no flow are expected to be fewer and the system will be less flashy. As discussed in the FNI downstream memorandum (FNI_2, 2016), there are multiple sources of hydrology to sustain wetland communities consisting of precipitation (which is not expected to change), overland flow (which is not expected to change), and subsurface groundwater (which may be enhanced). In general, land degradation from large flood events will become less frequent and water will be more readily available and consistent for use by the plant community. Lastly, the stream channel, which has been in a continuous state of degradation (average bank erosion rate of ~0.5 feet per year), is predicted to stop eroding and begin to aggrade. Over time this will reconnect the channel with the flood plain and raise the groundwater table. While this process will take longer than 20 years, previous studies show that this will lead to an enriched and more stable ecosystem.

Hydrologic and hydraulic modeling indicate that there will be changes in the aerial extent of the 5-year flood events. These changes are discussed in the FNI downstream memorandum (FNI_2, 2016). While it is expected that the hydrology to sustain the wetlands downstream of the dam will continue after construction, the sources of hydrology may shift for some areas. It is this shift in hydrology source and changes associated with specific subindex variables that were evaluated.

Results and Discussion

Subindex variables

Due to the different changes in hydrology across the study area after construction of the dam, the subindex variables were evaluated separately for following subareas: 1) area that will remain inundated under the 2-year flood, 2) area inundated under the 5-year flood but not under the 2-year flood, and 3) area not inundated under the 5-year flood. These subareas are based on the HEC-RAS (2-D) modeling with no spills from the reservoir. Many of the subindex variables remained the same for conditions with and without the dam. The following are brief descriptions of each subindex variables that changed and the reasoning for each chosen score.

Change in Frequency of Flooding (VFREQ) – The frequency of flooding during the growing season was evaluated by subareas. For the area that remains flooded under a 2-year flood event, it was assumed that there will be no changes in flood frequency, resulting in a subindex score of 1.0. For the subarea that is not flooded under a 2-year event, but is flooded under a 5-year event, the VFREQ has a subindex score of 0.40, which reflects a change in frequency of 3 years. For the area that is not flooded under a 5-year flood, VFREQ was assumed to be not applicable.

Change in Growing Season Flood Duration (VDUR) – This variable was also evaluated by subarea. Flood duration in the Bois d'Arc Creek watershed for a single event typically is 2 to 3 days (based on HEC-RAS modeling). This is characteristic of the flashy nature of the existing system. Therefore, while there is expected to be changes in some areas for flood frequency, the duration of a single flood event is expected to remain the same. For the area with no change in flood frequency and the incremental area flooded under the 5-year event, it was assumed that the flood duration would be the same and the VDUR would be 1.0. For the area that is not flooded under a 5-year flood, VDUR was assumed to be not applicable.

O-Horizon Organic Accumulation (VOHOR) – The current VOHOR is assumed to be 0 cm (score of 0.20). The East Texas HGM Guidebook indicates 1 cm O-horizon is generated in 20 years for typical hardwood forests. In addition to continual deadwood decomposition and less frequent erosive flood events, O-horizon soils should increase after reservoir construction. The O-horizon was assumed to be the same for wetlands within the 2-year flood. For those inundated every 5 years, it was increased to 0.5 cm, and 0.8 cm for the areas no longer inundated from overbanking flows.

Litter Cover (VLITTER) – The current VLITTER is 57% (score of 0.92). The HGM Guidebook indicates approximately 80% litter cover for typical hardwood forests. It is expected that with reduced scouring of high flow events downstream, the litter cover would increase. VLITTER was assumed to be the same for wetlands within the 2-year flood. For those inundated every 5 years, it was increased to 65% (score of 1.00), and 80% (score of 1.00) for the areas no longer inundated from overbanking flows.

Table 1. Assumed Current and Projected HGM Subindex Scores

Subindex Variables in the Modified East TX HGM Model	Assumed Current Score	20 Year Projection Score by Subarea with LBCR		
		2-yr Flood	*5-yr Flood*	*>5-yr Flood*
Change in Growing Season Flood Duration (VDUR)	1.00	1.00	1.0	NA
Change in Frequency of Flooding (VFREQ)	1.00	1.00	0.40	NA
Total Ponded Area (VPOND)	1.00	1.00	1.00	1.00
Composition of Overstory Vegetation (VTCOMP)	0.70	0.70	0.70	0.70
Number of Vegetation Strata (VSTRATA)	1.00	1.00	1.00	1.00
Snag Density (VSNAG)	1.00	1.00	1.00	1.00
Tree Basal Area (VTBA)	1.00	1.00	1.00	1.00
Log Volume (VLOG)	1.00	1.00	1.00	1.00
Forest Patch Size (VPATCH)	1.00	1.00	1.00	1.00
Ground Vegetation Cover (VGVC)	1.00	1.00	1.00	1.00
Shrub-Sapling Density (VSSD)	0.88	0.88	0.88	0.88
Tree Density (VTDEN)	0.81	0.81	0.81	0.81
O-Horizon Organic Accumulation (VOHOR)	0.20	0.20	0.52	0.71
Litter Cover (VLITTER)	0.92	0.92	1.00	1.00
Woody Debris Biomass (VWD)	1.00	1.00	1.00	1.00
Composition of Tallest Woody Stratum (VCOMP)	0.70	0.70	0.70	0.70
Soil Integrity (VSOIL)	1.00	1.00	1.00	1.00

Table 2. Expected Future Functional Capacity Indices (FCI) for Downstream Wetlands

		Expected Future FCI		
Function	**Existing FCI**	**2-Yr Flood**	**5-Yr Flood**	**>5-Yr Flood**
Area (Acres)	*1,852*	*954*	*541*	*357*
Detain Floodwater	0.92	0.92	0.37	Not Assessed
Detain Precipitation	0.78	0.78	0.88	0.93
Cycle Nutrients	0.85	0.85	0.90	0.93
Export Organic Carbon	0.87	0.87	0.37	Not Assessed
Maintain Plant Communities	0.90	0.90	0.90	0.90
Provide Habitat for Fish/Wildlife	0.86	0.86	0.87	0.94
Average	**0.86**	**0.86**	**0.715**	**0.925**
Functional Capacity Reduction (FCU)	**-**	**0**	**78.4**	**0**

References

Votaw, M. (2016, June 22). Functional Assessment of Forested Wetlands at the Lower Bois d'Arc Creek Reservoir Site using the Modified East Texas HGM. *Freese and Nichols, Inc.*

Waters, S., & Kiel, S. (2016, June 3). Assessment of Potential Impacts of Wetlands Downstream of LBCR. *Freese and Nichols, Inc.*

Appendix G

May 27, 2014, Lower Bois d'Arc Creek Littoral Zone/Fringe Wetland Development Technical Memorandum

Technical Memorandum on Lower Bois d'Arc Creek Littoral Zone/Fringe Wetland Development

MEMORANDUM

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TO: Simone Kiel, P.E.

CC: Steve Watters, PWS; Randall Howard

FROM: Michael Votaw, CWB, PWS

SUBJECT: Lower Bois d'Arc Creek Littoral Zone/Fringe Wetland Development

DATE: 5/27/2014

PROJECT: NTD06128 – Lower Bois d'Arc Creek Reservoir

Introduction

On May 14-15, 2014, environmental scientists with Freese and Nichols, Inc. (FNI) conducted pedestrian surveys along the lake margins of five reservoirs located in Northeast Texas. Reservoirs surveyed were Cooper Reservoir, Pat Mayse Reservoir, Lake Bonham, Coffee Mill Lake, and Davy Crockett Reservoir (Figure 1). These reservoirs were selected based on their proximity to the proposed Lower Bois d'Arc Creek reservoir site. The purpose of the survey was to identify plant species that occur within the littoral zone/fringe wetlands along the margins of these reservoirs in order to better predict the species expected to develop within the littoral zone/fringe wetland areas of the proposed Lower Bois d'Arc Creek Reservoir. An additional purpose of this investigation was to evaluate the expected plant response during extended periods of low water elevations within the reservoir (i.e., below 530 ft. msl).

Results

All five of the reservoirs that were surveyed had developed functioning littoral zone/fringe wetlands along their shorelines that extended for some distance into the reservoir pool. These littoral zone/fringe wetlands showed high plant diversity with over 49 different species of plants being observed. Species observed at each reservoir during the survey are listed in Table 1. This list is not meant to be comprehensive and it is only representative of the species that were readily observable/identifiable at the locations that were surveyed. Photographs of the littoral zone/fringe wetlands observed at each of these reservoirs are located in Attachment 1. Species that were observed most frequently at the reservoirs that were surveyed include soft rush and other rush species, obedient plant, frog fruit, cattail, goldenrod, several species of smartweed, winter bentgrass, black willow, buttonbush, and a variety of different sedge and dock species.

Based on the results of the pedestrian survey, it is likely that a wide variety of plant species would develop within the littoral zone/fringe wetland areas of the proposed Lower Bois d'Arc Creek Reservoir. Although it is not possible to predict exactly which species will establish within the littoral zone/fringe wetland areas around the proposed Lower Bois d'Arc Creek Reservoir, many of the species identified above and within Table 1 would likely be present.

Table 1. Plant Species Identified within the Littoral Zone/Fringe Wetlands of Five Reservoirs in Northeast Texas.

Reservoir	Cooper	Pat Mayse	Bonham	Coffee Mill	Davy Crockett
Species					
Ravenfoot sedge (*Carex crus-corvi*)	●				
Sedge (*Carex* spp.)	●		●	●	
Buttonbush (*Cephalanthus occidentalis*)	●	●	●	●	●
Curly dock (*Rumex crispus*)	●	●	●		
Winter bentgrass (*Agrostis hyemalis*)	●	●	●		
Goldenrod (*Solidago* spp.)	●	●	●		●
Rush (*Juncus* spp.)	●	●	●	●	●
Blackberry (*Rubus* sp.)	●				
Smartweed (*Polygonum* spp.)	●	●	●		●
Balloonvine (*Cardiospermum halicacabum*)	●				
Loosestrife (*Lythrum* sp.)	●				
Eastern baccharis (*Baccharis halimifolia*)	●	●			
Black willow (*Salix nigra*)	●	●	●	●	●
Spiny aster (*Chloracantha spinosa*)	●				
Stickywilly (*Galium aparine*)	●				
Cattail (*Typha* sp.)		●	●		●
California Bulrush (*Schoenoplectus californicus*)			●		●
Water primrose (*Ludwigia peploides*)			●		
Frog fruit (*Phyla nodiflora*)		●	●		●
Ovate false fiddleleaf (*Hydrolea ovata*)			●		
Mock bishopweed (*Ptilimnium nuttallii*)			●		

Reservoir	Cooper	Pat Mayse	Bonham	Coffee Mill	Davy Crockett
Golden alexanders (*Zizia aurea*)			●	●	
Vine mesquite (*Panicum obtusum*)		●	●		
Obedient plant (*Physostegia virginiana*)		●	●	●	●
Beaksedge (*Rhynchospora* spp.)			●		
Texas toadflax (*Nuttallanthus texanus*)			●		
Rabbitsfoot grass (*Polypogon* sp.)			●		
Barnyardgrass (*Echinochloa crus-galli*)					●
Lotus (*Nelumbo lutea*)				●	●
Soft rush (*Juncus effuses*)	●	●		●	●
Buttercup (*Ranunculus* sp.)					●
Morning-glory (*Ipomoea* sp.)			●		●
Bald cypress (*Taxodium distichum*)					●
Spikerush (*Eleocharis* spp.)		●			●
False indigo bush (*Amorpha fruticosa*)					●
Water willow (*Justicia americana*)				●	●
Common selfheal (*Prunella vulgaris*)				●	
American pondweed (*Potamogeton nodosus*)				●	
Water hemlock (*Cicuta maculata*)				●	
Florida paspalum (*Paspalum floridanum*)				●	
Arrowhead (*Sagittaria* sp.)				●	
Green ash (*Fraxinus pennsylvanica*)		●		●	
Common duckweed (*Lemna minor*)				●	

Reservoir	Cooper	Pat Mayse	Bonham	Coffee Mill	Davy Crockett
Giant cutgrass (*Zizaniopsis miliacea*)		●			
Maidencane (*Panicum hemitomon*)		●			●
Ironweed (*Vernonia* sp.)		●	●		
Common marshmallow (*Althaea officinalis*)		●			
River birch (*Betula nigra*)		●			
Pennywort (*Hydrocotyle* sp.)		●			

Plant Response to Extended Periods of Low Water Levels

As described in the Mitigation Plan for the proposed Lower Bois d'Arc Creek Reservoir, littoral zone/fringe wetlands are expected to develop in locations three feet deep or less (between elevations 531-534 ft. msl) within the reservoir. The time it will take for these wetlands to develop is unknown, but it is estimated to take two to three years following inundation. These wetlands would most likely develop in broad, shallow areas and in coves where tributaries flow into the reservoir. It is estimated that approximately 1,402 acres of these littoral zone/fringe wetlands would develop and provide on-site mitigation.

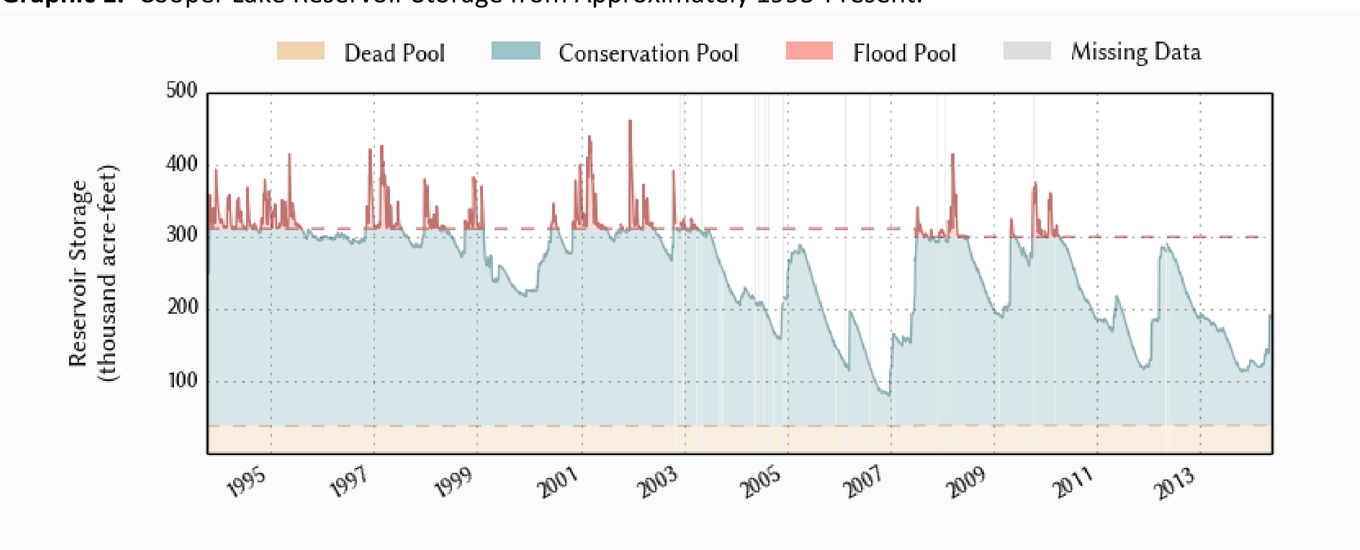
Wetlands, contrary to their name, do not always contain water. Many seasonal and temporary wetlands experience periods of drought at some point in time. Such wetlands tend to flood or recharge during winter months and will hold water into spring or early summer before drying out in the hot summer months (http://www.ducks.org/media/Conservation/GLARO/_documents/_library/_landowner/Landowner_Guide.pdf). This is a natural process that is frequently observed in wetlands in this area of Texas. These wet/dry cycles are beneficial as they discourage development of a monoculture of plant species such as cattail and bulrush. Another benefit of this wet/dry cycle is that it encourages seed production from many of the emergent wetland plant species. In fact, many wetlands that have capacity for water-level control are managed in such a way that they are drawn down during the spring, specifically to maximize seed production from native annual plants (http://www.ducks.org/conservation/habitat/conservation-private-marsh-management). This seed production not only establishes a seed bank in the wetland sediment, it also serves as a food source for many species of waterfowl and other seed-eating wildlife species.

If low water levels (i.e., below 530 ft. msl) within the proposed Lower Bois d'Arc Creek Reservoir persist for an extended period, it is likely that some of the plant species present in these wetlands might go dormant or possibly die, especially those species that are dependent on being submerged or inundated. However, other plant species that are not dependent on being submerged or inundated would likely survive and persist. This is expected as a result of Fannin County having a total annual precipitation of approximately 44 inches (http://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/texas/TX147/0/Fannin.pdf), which would likely provide ample moisture for many of the plant species listed in Table 1 to survive within the littoral zone/fringe wetland areas of the reservoir once they become established.

Such persistent low water conditions were observed at both Pat Mayse Reservoir and Cooper Lake during the current field survey. Both of these reservoirs have been below their conservation pool elevations for extended periods of time as a result of the ongoing drought in this area of Texas. Within the littoral zone/fringe wetlands observed at these reservoirs, species such as cattail and smartweed were dormant or dead, while other species such as button bush, ironweed, goldenrod, as well as a variety of different species of sedges and rushes were alive. It is expected that once water levels rise in these reservoirs (i.e., return to their conservation pool elevations) and these littoral zone/fringe wetlands become inundated again, the plants in these areas that have died or gone dormant would respond by breaking dormancy, re-sprouting from root systems, or developing from the seed bank in the wetland sediment.

This expected response is reinforced by looking at reservoir storage for Cooper Lake from 1995 to present (Graphic 1) and relating that back to what was observed at the reservoir during the current field survey. According to Graphic 1, persistent low water conditions have occurred at Cooper Lake several times, including recently. However, during the current field survey, many plants were observed within the littoral zone/fringe wetlands that were living, even though they were not submerged or inundated. The same, or similar conditions, are expected to occur within the proposed Lower Bois d'Arc Creek Reservoir.

Graphic 1. Cooper Lake Reservoir Storage from Approximately 1995-Present.



http://waterdatafortexas.org/reservoirs/individual/jim-chapman

In summary, it is expected that Lower Bois d'Arc Creek Reservoir will develop the same or similar conditions within the littoral zone/fringe wetlands that were observed at the five reservoirs surveyed in this study. It is likely that a wide variety of different plant species would establish within the littoral zone/fringe wetlands that would develop around the proposed Lower Bois d'Arc Creek Reservoir. It is also likely that there will be extended periods of low water levels within Lower Bois d'Arc Creek Reservoir that will preclude constant inundation of these wetlands. However, this "drying out" is expected to increase plant diversity by discouraging development of a monoculture of plant species such as cattail and bulrush.

ATTACHMENT A

PHOTOGRAPHS

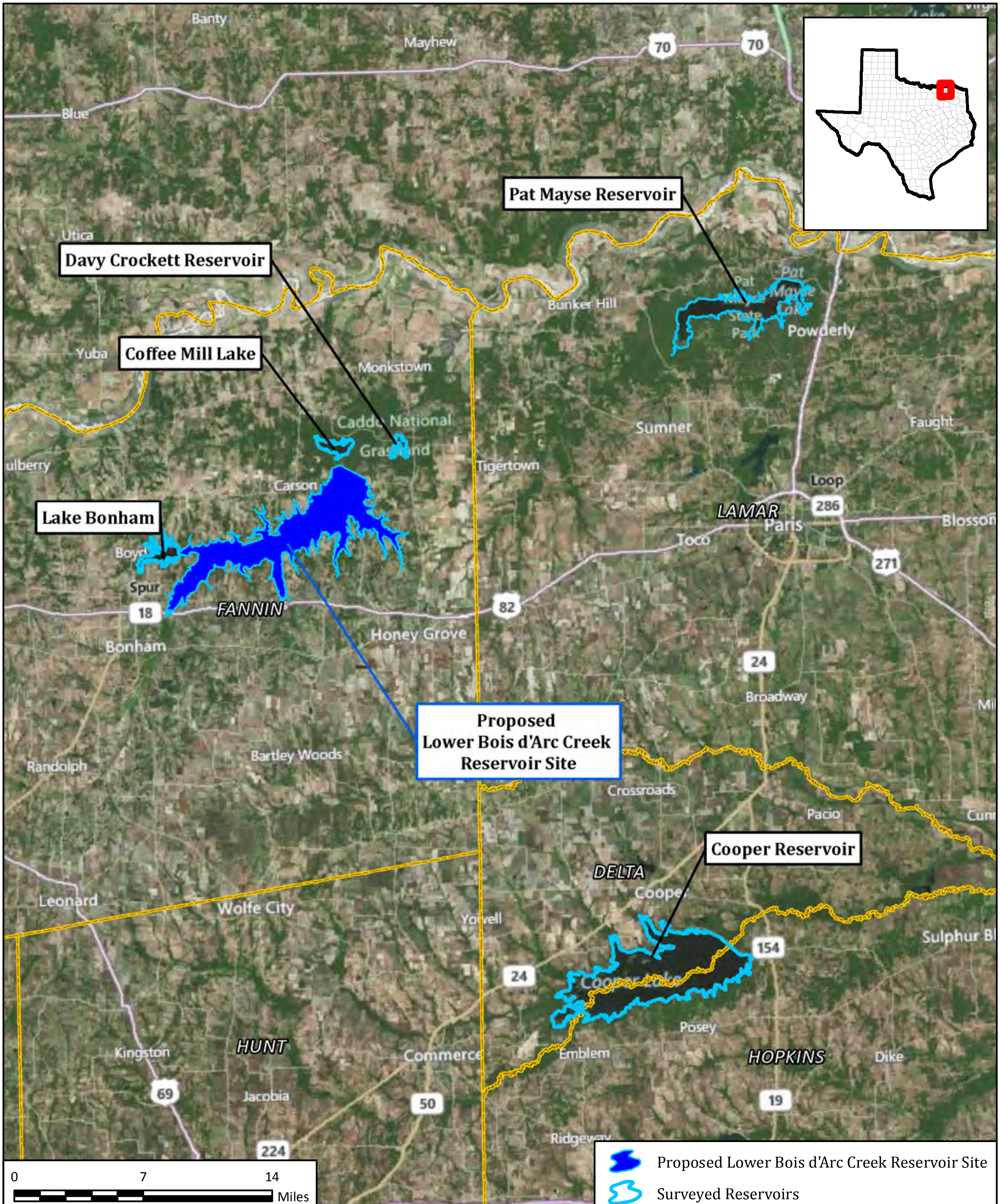

Photo 1. View of littoral zone/fringe wetland area at Pat Mayse Reservoir.


Photo 2. View of littoral zone/fringe wetland area at Lake Bonham.

Photo 3. View of littoral zone/fringe wetland area at Coffee Mill Lake.

Photo 4. View of littoral zone/fringe wetland area at Cooper Lake.

Photo 5. View of littoral zone/fringe wetland area at Davy Crockett Reservoir. Photograph shows fringe wetland regrowth after being dewatered and burned as part of the USFS's management program.



FREESE AND NICHOLS
4055 International Plaza, Suite 200
Fort Worth, TX 76109 - 4895
Phone - (817) 735 - 7300

N
W E
S

NTMWD
Lower Bois d'Arc Creek Reservoir

Littoral Zone/Fringe Wetland Reservoir Survey

FN JOB NO	NTD06128
FILE NAME	Regional_Reservoirs.mxd
DATE	5/27/2014
SCALE	1:450,000
DESIGNED	SSJ
DRAFTED	ssj

1
FIGURE

APPENDIX G

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NAD 1983 StatePlane Texas North Central FIPS 4202 Feet

Appendix H

May 13, 2011, Response to TCEQ Request for Information, Attachment F, *Impacts to Terrestrial and Riparian Habitats*

ATTACHMENT F

Impacts to Terrestrial and Riparian Habitats

The North Texas Municipal Water District has provided evaluations of the impacts of the proposed Lower Bois d'Arc Creek Reservoir to the Commission through supplemental reports to the water right application and supporting documents to the Section 404 permit application. A list of these reports and associated relevant sections is provided at the end of this attachment. The following discussions are compilations of data analyses and evaluations that have been previously reported. New and/or changed information in this attachment includes an updated list of threatened and endangered state-listed species in Fannin County and a comparative map of the 100-year floodplain with and without the proposed reservoir (Figure F-1).

DIRECT IMPACTS OF PROJECT

The proposed Lower Bois d'Arc Creek reservoir will impact approximately 17,068 acres which includes 16,641 acres for the lake and 427 acres for the construction of the dam and spillways. Much of the existing site has been altered over the past 100 years mainly due to agricultural practices and stream channelization. Currently, 38 percent of the project site is cropland and grassland, 37 percent is riparian woodland/bottomland hardwoods, and most of the remainder of the site is upland/ deciduous forests. Generally, the habitat quality is the highest for cropland, tree savanna (132 acres) and grassland. Riparian woodland/bottomland hardwood habitat is low quality, with a habitat suitability index of 0.25 (on a scale of 0 to 1). The habitat types and acreages found within the reservoir site are shown in Table F-1. The habitat suitability indices by cover type are shown in Table F-2.

Table F-1
Habitat Types and Acreage Found on Lower Bois d'Arc Reservoir Site

Habitat Type	Acreage
Evergreen Forest	228
Upland / Deciduous Forest	2,216
Riparian Woodland / Bottomland Hardwood / Forested Wetland (Total for HEP Purposes) *Riparian Woodland / Bottomland Hardwood* *Forested Wetland*	6,330 *1,728* *4,602*
Shrubland	63
Shrub Wetland	49
Grassland / Old Field	4,761
Emergent / Herbaceous Wetland	1,223
Cropland	1,757
Riverine	219
Lacustrine	87
Tree Savanna	132
Shrub Savanna	4
Grand Total	**17,068**

Source: Table 3-4, *Environmental Report Supporting an Application for a Section 404 Permit,* FNI, 2008.

Table F-2
Habitat Suitability Indices by Cover Type

Cover Type	Average HSI Values	Area (acres)	Habitat Units (HUs)
Upland Deciduous Forest	0.47	2,216	1,042
Evergreen Forest	0.35	228	80
Tree Savanna	0.73	132	96
Shrubland	0.57	63	36
Cropland	0.72	1,757	1,265
Grassland / Old Field	0.60	4,761	2,857
Riparian Woodland / Bottomland Hardwood	0.25	6,330	1,583
Shrub Wetland	0.46	49	23
Emergent / Herbaceous Wetland	0.42	1,223	514
		TOTAL HABITAT UNITS	**7,494**

Source: Table 12, Appendix D, "Habitat Evaluation procedure (HEP) Report for the Lower Bois d'Arc Creek Reservoir", *Environmental Report Supporting an Application for a Section 404 Permit*, FNI, 2008

Terrestrial Impacts:

Of the total 17,068 acres impacted by the construction of the proposed lake, approximately 16,762 acres are vegetated by terrestrial vegetation. This includes existing wetlands. Based on an inter-agency Habitat Evaluation Procedure study conducted at the reservoir site, these acreages represent 7,494 habitat units. With the construction of the reservoir, these habitat units will convert to aquatic habitats with approximately 2,150 acres of emergent wetlands created along the shores of the proposed reservoir (based on a 5-foot water level fluctuation). Terrestrial wildlife within the project area will likely relocate to nearby areas and new aquatic wildlife will develop within the project area.

The U.S. Fish and Wildlife Services lists one species occurring or potentially occurring in Fannin County as either threatened or endangered: least tern (endangered). The bald eagle, which was previously federally listed as threatened, has been recently delisted as recovered and being monitored for the first five years.

The Texas Parks and Wildlife Department (TPWD) also lists eleven additional terrestrial species as endangered or threatened with statewide extinction that are considered to potentially occur in Fannin County. Protections for state-listed species are limited to direct takings such as capture, trapping or killing. Incidental takings, such as destruction of habitats, are not prohibited. A list of the state listed species is shown on Table F-3. Based on the studies conducted at the site, no threatened or endangered terrestrial species are expected to be adversely affected by the proposed project.

Table F-3

State-Listed Threatened and Endangered Terrestrial Species in Fannin County

	Species	State Status	Description of Suitable Habitat
Birds	American Peregrine Falcon *Falco peregrinus anatum*	E	Found in open country habitats, including tundra, mountainous and coastal areas, and marshes; usually near water. Also in open forested areas. Cliffs are used for nest sites.
	Peregrine Falcon *Falco peregrinus*	T	Nests in tundra regions; migrates through Texas; winter inhabitant of coastlines. Subspecies *anatum* is a resident breeder in W. Texas. Open areas, usually near water.
	Bald Eagle *Haliaeetus leucocephalus*	T	Nests and winters near rivers, lakes and along coasts; nests in tall trees or on cliffs near large bodies of water.
	Eskimo Curlew *Numenius borealis*	E	Found in tundra habitats, and in grasslands, pastures, or plowed fields; may also frequent marshes or mudflats.
	Interior Least Tern *Sterna antillarum athalassos*	E	Nests along sand and gravel bars within braided streams and rivers; also known to nest on man-made structures.
	Piping Plover *Charadrius melodus*	T	Wintering migrant along Texas Gulf coast; nests near beaches and bayside mud or salt flats.
	Whooping Crane *Grus americana*	E	Potential migrant via plains throughout most of Texas to coast; winters in coastal marches of Aransas, Rufugio and Calhoun counties
	Wood Stork *Mycteria americana*	T	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds; breeds in Mexico and birds move into the Gulf states in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960.
Reptiles	Texas Horned Lizard *Phrynosoma cornutum*	T	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; sandy to rocky soil.
	Timber/Canebrake Rattlesnake *Crotalus horridus*	T	Swamps, floodplains, upland woodlands, riparian zones, abandoned farmland; prefers dense ground cover, i.e. grapevines or palmetto.
Mammals	Black Bear *Ursus americanus*	T	The Louisiana black bear is a habitat generalist and often overwinters in hollow cypress trees either in or along sloughs, lakes, or riverbanks in bottomland habitats. Constituent elements of black bear habitat include hard and soft mast, escape cover, denning sites, corridor habitats, and some freedom from disturbance by man.
	Red Wolf *Canis rufus* (extirpated)	E	Formerly known throughout eastern half of Texas in brushy and forested areas, as well as coastal prairies. It appears that in Texas, red wolves are now extinct.

T – State-Listed Threatened E – State-Listed Endangered

Riparian Impacts

For this discussion, direct impacts to riparian habitats include impacts to streams and channels within and adjacent to the project site. Within the proposed reservoir site boundaries, all perennial and intermittent streams will be lost due to inundation of the proposed site by waters forming the Lower Bois d’Arc Creek Reservoir. It is estimated that approximately 123.3 miles of perennial and intermittent streams will be inundated. (It should be noted that a segment of Bois d;Arc Creek is listed by TCEQ as perennial, but there are anecdotal records that show there is no flow in this stream segment for extended periods of time.) The riverine habitat (219 acres) will be converted to open water or deep water habitat. Biotic assemblages typical of small, fluvial (flowing water) environments will be replaced by those typical of large lacustrine environments. This includes changes in phytoplankton, zooplankton, benthic macroinvertebrates, and fish populations. Stream channels in and near the upper reaches and perimeter of the reservoir will experience increased silt deposition from sediments that drop out of the water column of these streams as water velocity drops upon approaching or entering the backwater of the lake. Tributary streams will become more stable as bank cutting and instability is reduced due to lower head differentials with impounded water in the lake.

The change from lotic (river) to lentic (lake) habitat will shift the present species composition toward more pool-associated species. Based on the fish assemblages found during the instream flow study, Lower Bois d'Arc Creek Reservoir would probably be characterized by combinations of red shiner, longear sunfish, bullhead minnow, logperch, and orange spotted sunfish as the dominant species. Other common fish expected in the proposed Lower Bois d’Arc Creek Reservoir would include gizzard shad, threadfish shad, bluegill, and redear sunfish. The few fluvial species identified during the instream flow study would likely relocate to the downstream corridor and be supported by instream flow releases.

The dominant fish populations found in Bois d’Arc Creek and surrounding water bodies are all adapted to lacustrine habitats and therefore most would be expected to continue to occur in the proposed reservoir. Although these species may occur in the reservoir, relative abundance may vary due to the introduction of predator and competing species over time, which may affect the survivability and population densities of some of the present species. In addition, vast expanses of new habitat for some of the resident species will be created, which will cause these species numbers to increase dramatically. Over time new species, such as flathead catfish, blue catfish, striped bass, white bass, or other fish suitable to large, open water bodies, even if not originally native, will likely be introduced either naturally or intentionally into the lake and will affect species abundance, diversity and distribution.

No detrimental impacts to mussel species resulting from the construction of the proposed Lower Bois d'Arc Creek Reservoir project are expected to occur. According to available literature, it appears that all species identified during site visits can and do adapt to life in a lake environment. (Howells et al, 1996 and Roe, 2002)

There are no federally listed threatened or endangered aquatic species within the Bois d'Arc Creek watershed. The state has listed five fish species and one aquatic reptile as threatened which are shown on Table F-4. No mollusks known to occur or potentially occur in Fannin County have been listed as threatened or endangered.

INDIRECT IMPACTS OF PROJECT

Indirect impacts include direct or associated actions of the project that potentially impact habitat upstream, adjoining, and downstream of the project site.

Terrestrial and Riparian Habitats

Losses to terrestrial habitats will result from secondary or indirect impacts as residential areas are constructed adjacent to and/or in proximity to the proposed reservoir. Over time, these residential areas, along with the associated infrastructure, such as schools, roads and utilities, and attendant commercial and recreational facilities would likely result in additional habitat loss to adjacent upland habitats. These developments would likely have occurred without the project, but may occur sooner with the reservoir in place. It is proposed that the development around the lake will be controlled and monitored by a county agency. The NTMWD is purchasing property to the spillway elevation of 541 ft msl and purchasing a flowage easement to elevation 545 ft. Restrictions on development in these zones will provide added protections to the terrestrial habitats around the lake.

Table F-4

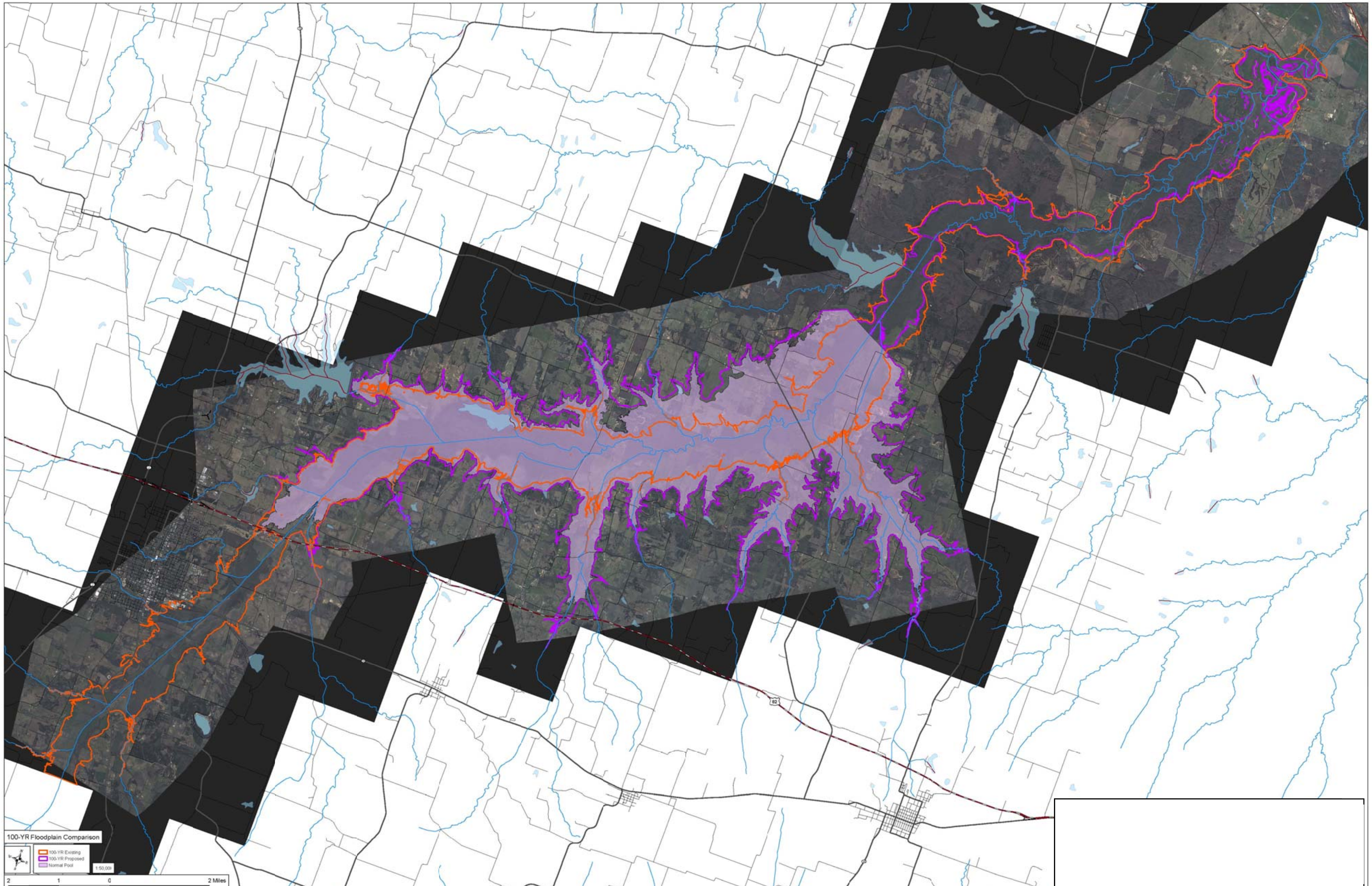
State-Listed Threatened and Endangered Aquatic Species in Fannin County

	Species	State Status	Description of Suitable Habitat
Reptiles	Alligator Snapping Turtle *Macrochelys temminckii*	T	Deep water of rivers, canals, lakes, and oxbows; also swamps, bayous, and ponds near deep running water; sometimes enters brackish coastal waters; usually in water with mud bottom and abundant aquatic vegetation; may migrate several miles along rivers; active March-October; breeds April-October.
Fishes	Blackside Darter *Percina maculata*	T	Clear, gravelly streams; prefers pools with some current, or even quiet pools, to swift riffles.
	Blue Sucker *Cycleptus elongatus*	T	Usually inhabits channels and flowing pools with a moderate current; bottom type usually consists of exposed bedrock, perhaps in combination with hard clay, sand, and gravel; adults winter in deep pools and move upstream in spring to spawn on riffles.
	Creek Chubsucker *Erimyzon oblongus*	T	Small rivers and creeks of various types; seldom in impoundments; prefers headwaters, but seldom occurs in springs; young typically in headwater rivulets or marshes; spawns in river mouths or pools, riffles, lake outlets, upstream creeks.
	Paddlefish *Polyodon spathula*	T	Prefers large, free-flowing rivers, but will frequent impoundments with access to spawning sites; spawns in fast, shallow water over gravel bars; larvae may drift from reservoir to reservoir.
	Shovelnose Sturgeon *Scaphirhynchus platorynchus*	T	Open, flowing channels with bottoms of sand or gravel; spawns over gravel or rocks in an area with a fast current; never more than a rare occurrence in Rio Grande.

T – State-Listed Threatened

As part of the instream flow study, habitat evaluations of the downstream corridor were conducted. The discussion of these results and findings is included in Appendix C of the *Instream Flow Study Supplemental Data* (FNI, 2010). This study evaluated stream hydrology with the proposed instream flow regime, geomorphic processes, and fauna in the downstream riparian corridor and adjacent terrestrial habitats. Impacts to the habitats downstream of the reservoir are expected to be minimal due to several factors: (1) the existing community is not dependent upon overbank flow for reproduction and overall success. Many of the species along Bois d'Arc Creek riparian corridor are equally likely to occur in uplands; (2) the local site conditions (e.g., rainfall, soil type, and land cover) contribute to floodplain inundation; (3) the proposed release of continuous base flows should increase channel-groundwater connectivity and promote growth of streambank vegetation; (4) the reduction in highly erosive flows would allow the stream to aggrade over time increasing the potential for floodplain connectivity; and (5) downstream hydrology will continue to contribute to instream flow and supplement floodplain connectivity. Certain aspects of the riparian corridor may even be improved as a result of the dam, including increased streambank stabilization, vegetation growth, and gain of hardmast producing woody trees.

Flood studies conducted in support of this project found that the construction of the Lower Bois d'Arc Creek Reservoir will not increase flooding upstream or downstream of the project site. A study conducted in 2005 and updated in 2007 evaluated the potential impacts of the Lower Bois d'Arc Creek Reservoir for the 10-, 50-, 100- or 500-year flood events. The study results found that the reservoir did not increase water levels upstream of the Highway 82 bridge for the simulated 10-, 50-, 100- or 500-year flood events. The hydrologic modeling shows that flood levels decrease immediately downstream of the dam, and then return to existing levels without the project within about one mile downstream of the dam. Figure F-1 shows the comparison of the 100-year floodplain with and without the proposed reservoir.


100-YR Floodplain Comparison
100-YR Existing
100-YR Proposed
Normal Pool
1:50,000
2 1 0 2 Miles

APPENDIX H

PREVIOUS STUDIES SUBMITTED TO TCEQ

The direct and indirect impacts associated with the inundation of the proposed reservoir are discussed in more detail in the following reports:

Wtr Rt Report	*Report Supporting an Application for a Texas Water Right for Lower Bois d'Arc Creek Reservoir*, 2 volumes, submitted to TCEQ on December 29, 2006
404 Report	*Environmental Report, Supporting an Application for a 404 Permit for Lower Bois d'Arc Creek Reservoir*, submitted to TCEQ water rights permitting section on October 8, 2008
JD Report	*Section 404 Permit Application and Jurisdictional Determination Report*, submitted to TCEQ water rights permitting section on October 8, 2008
IFS	*Instream Flow Study Report for the Proposed Lower Bois d'Arc Creek Reservoir, May 2010.* Submitted to USACE and Cooperating agencies on May 27, 2010. Submitted to TCEQ on June 1, 2010.
Supplemental IFS	*Instream Flow Study Supplemental Data, September 2010,* Submitted to USACE and cooperating agencies on September 17, 2010. Submitted to TCEQ on September 23, 2010.

Topic of Interest Regarding Impacts to Terrestrial and Riparian Habitats:

Water Quality Study	Chapter 4.4 and Appendix H *Wtr Rt Report* *IFS*, Main Report and Appendix E
Wetlands Delineation	*JD Report, JD Pipeline Realignment, JD WTP*
(discussions)	Chapters 3.3.2, 5.3.2, *404 Report*
Baseline Habitat Evaluation	Chapter 3.4 and Appendix D, *404 Report,* *IFS, Supplemental IFS*
Geomorphic Assessment of Bois d'Arc Creek	*RGA*, Chapter 3.3.2, *404 Report;* *IFS, Supplemental IFS*
Flooding Studies	Chapters 3.3.1, 4.3.1 and 5.3.1 and Appendix A, *404 Report*
Instream Flow Assessment	*IFS, Supplemental IFS.*
Downstream Impacts	*Supplemental IFS*, Appendix C

References:

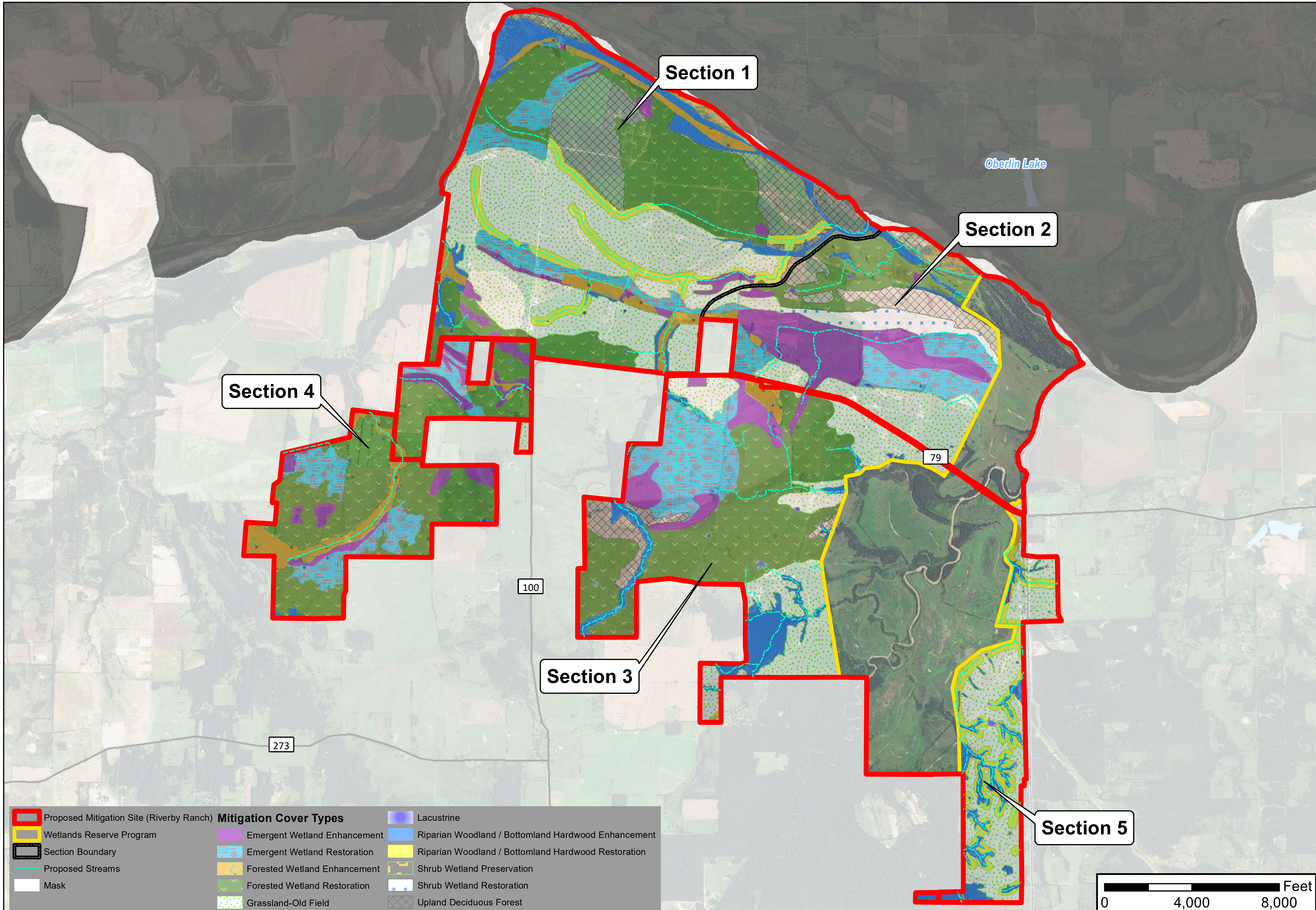
Howells, R.G., et al. 1996. Freshwater Mussels of Texas. Texas Parks and Wildlife Press. Austin, Texas.

Roe, Kevin J. 2002. Conservation Assessment for the Yellow Sandshell (*Lampsilis teres*). USDA Forest Service, Region 9. Saint Louis, MO.

Texas Parks and Wildlife Department, Annotated County Lists of Rare Species, downloaded from http://www.tpwd.state.tx.us/landwater/land/maps/gis/ris/endangered_species, May 2011.

Appendix I

Typical Plans and Details for Aquatic Mitigation



F&N JOB NO. NTD06128
DATE: Nov 2016
SCALE: 1:48,000
DESIGNED: HHM
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FILE: I1_RiverbyMitigation_11x17.mxd

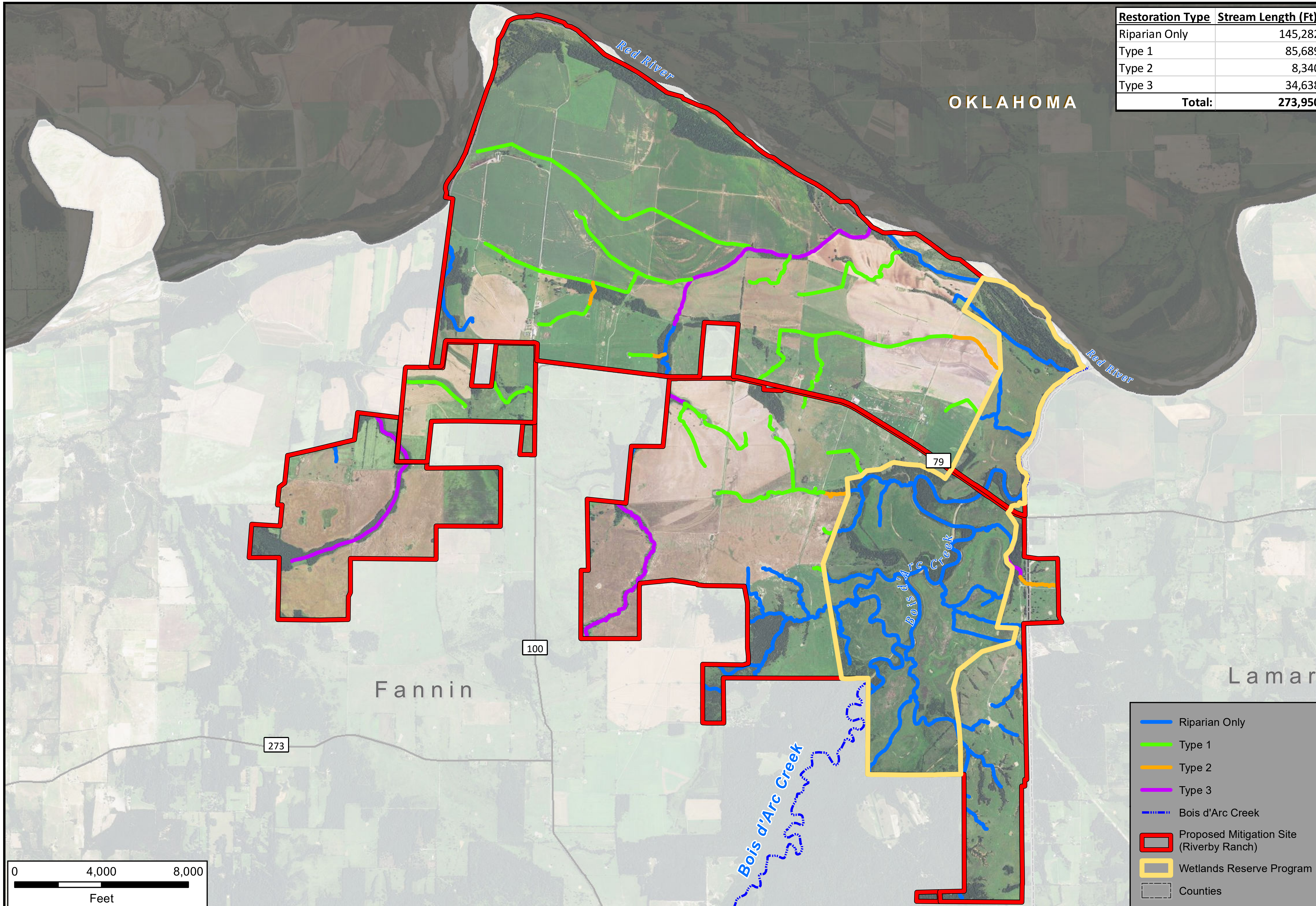
North Texas Municipal Water District

Riverby Ranch Mitigation Site Cover Type Map

N
W E
S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

I.1
FIGURE



Restoration Type	Stream Length (Ft)
Riparian Only	145,282
Type 1	85,689
Type 2	8,340
Type 3	34,638
Total:	**273,950**

F&N JOB NO. NTD06128
DATE: Nov 2016
SCALE: 1:48,000
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FILE: I2_RiverbyRestoration_11x17.mxd

North Texas Municipal Water District

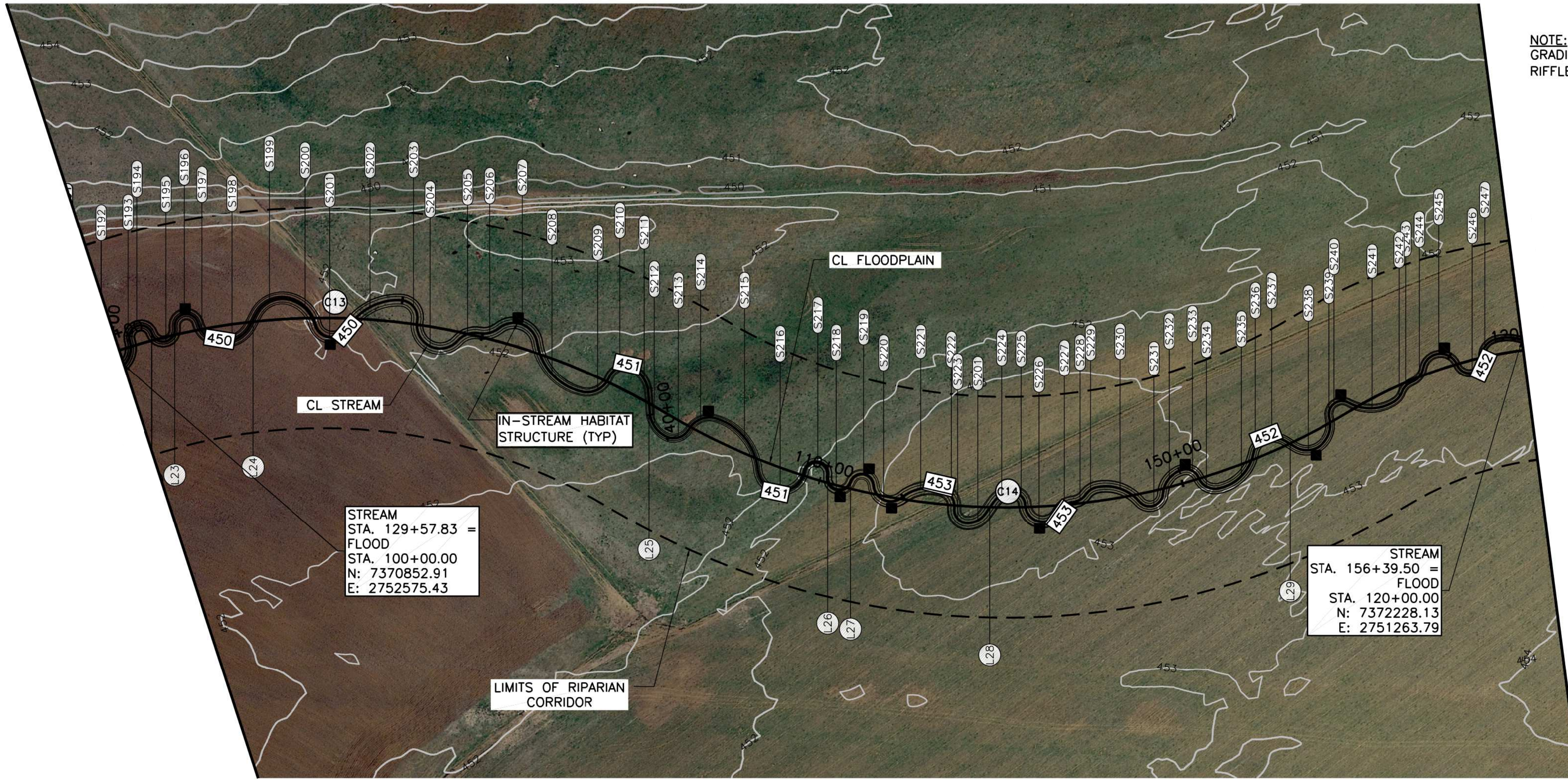
Riverby Ranch Stream Restoration Type

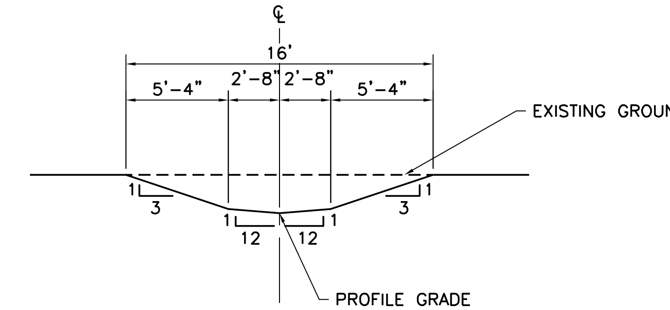
Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

I.2
FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Riverby_Design\I2_RiverbyRestoration_11x17.mxd

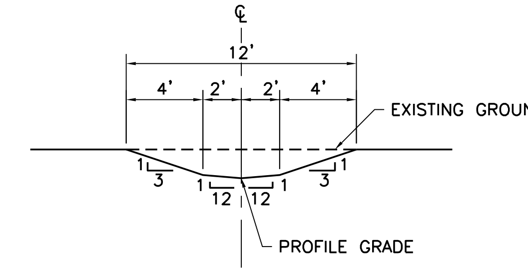
NOTE:
GRADING PLAN DOE NOT SHOW
RIFFLE/POOL GEOMETRY.





STREAM TYPICAL SECTION
STA 129+57.83 TO STA 143+00

0 5' 10'
SCALE IN FEET



STREAM TYPICAL SECTION
STA 143+00 TO STA 156+39.50

0 5' 10'
SCALE IN FEET

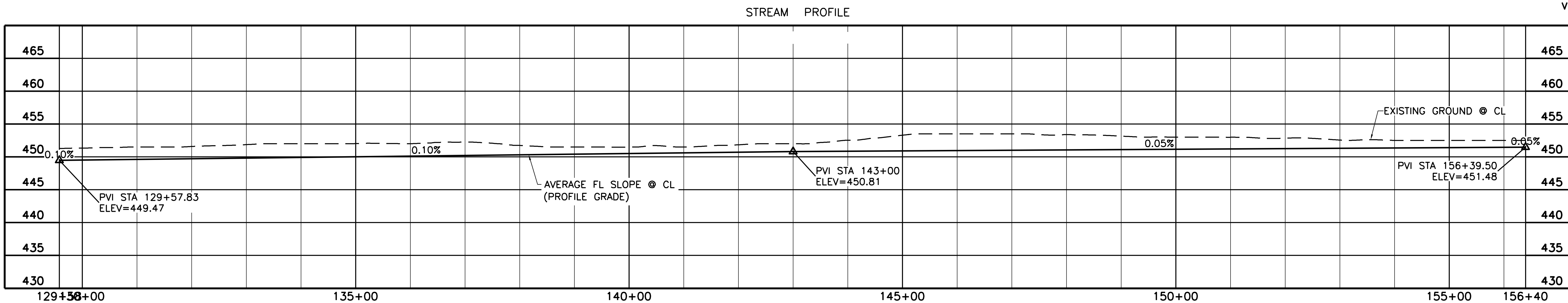
NORTH

NOTE:
BANKFULL STREAM CHANNEL
PROFILE DOES NOT SHOW
RIFFLE/POOL GEOMETRY.

0 100' 200'
SCALE IN FEET
HORIZONTAL

0 5' 10'
SCALE IN FEET
VERTICAL

STREAM PROFILE



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NORTH TEXAS MUNICIPAL WATER DISTRICT
LOWER BOIS D'ARC CREEK RESERVOIR PROGRAM
MITIGATION PROJECT

STREAMS
TYPICAL PLAN AND PROFILE
TYPE 1 STREAM

NO.	ISSUE	BY	DATE

F&N JOB NO. NTD15291
DATE JUNE 2016
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VERIFY SCALE 0 1
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I.3
FIGURE

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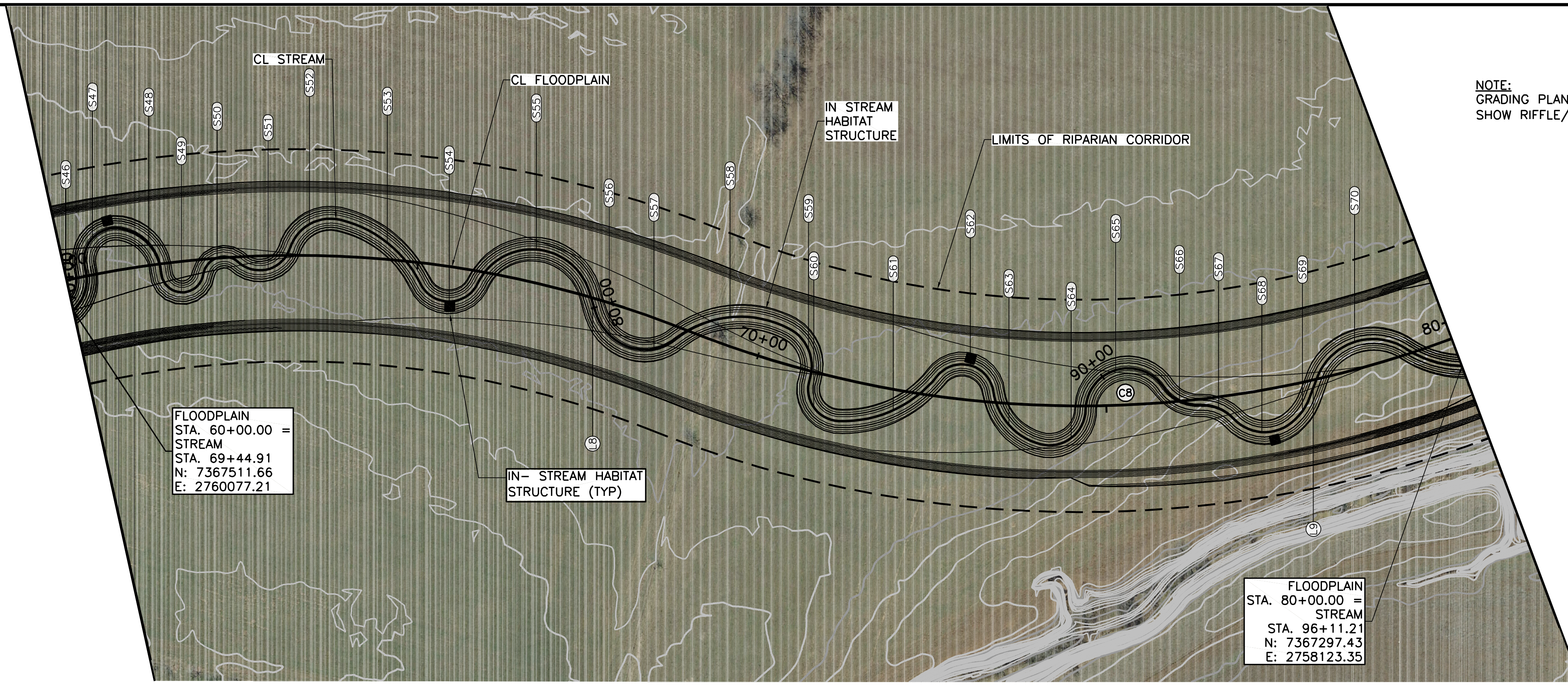
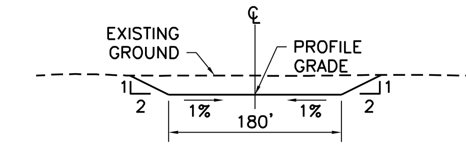
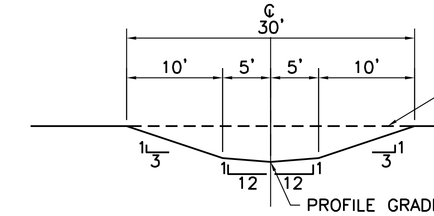


NOTE:
GRADING PLAN DOES NOT SHOW RIFFLE/POOL GEOMETRY.



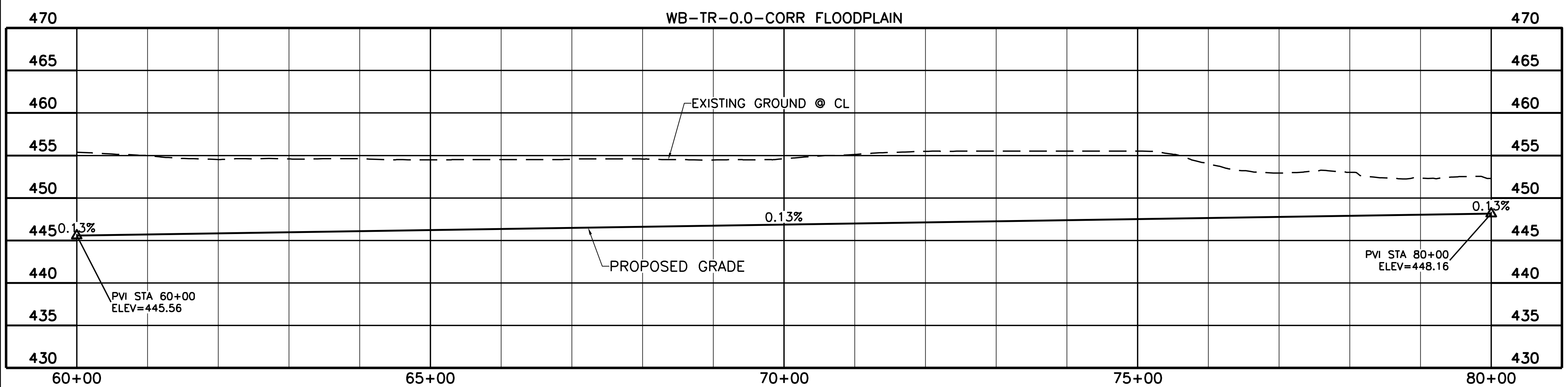
FLOODPLAIN TYPICAL SECTION
STA 60+00 TO STA 80+00

0 100' 200'
SCALE IN FEET



STREAM TYPICAL SECTION
STA 69+44.91 TO STA 96+11.21

0 10' 20'
SCALE IN FEET

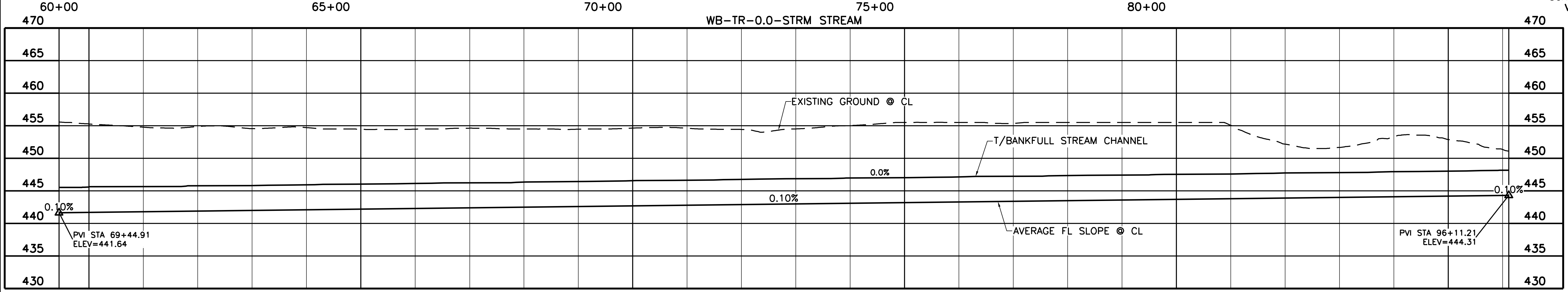


NOTE:
BANKFULL STREAM CHANNEL PROFILE DOES NOT SHOW RIFFLE/POOL GEOMETRY.

NORTH

0 100' 200'
SCALE IN FEET
HORIZONTAL

0 5' 10'
SCALE IN FEET
VERTICAL



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NORTH TEXAS MUNICIPAL WATER DISTRICT
LOWER BOIS D'ARC CREEK RESERVOIR PROGRAM
MITIGATION PROJECT
STREAMS
TYPICAL PLAN AND PROFILE
TYPE 2 STREAM

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FILE NAME CV-PP-SC1-STR01.dwg

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I.4
FIGURE

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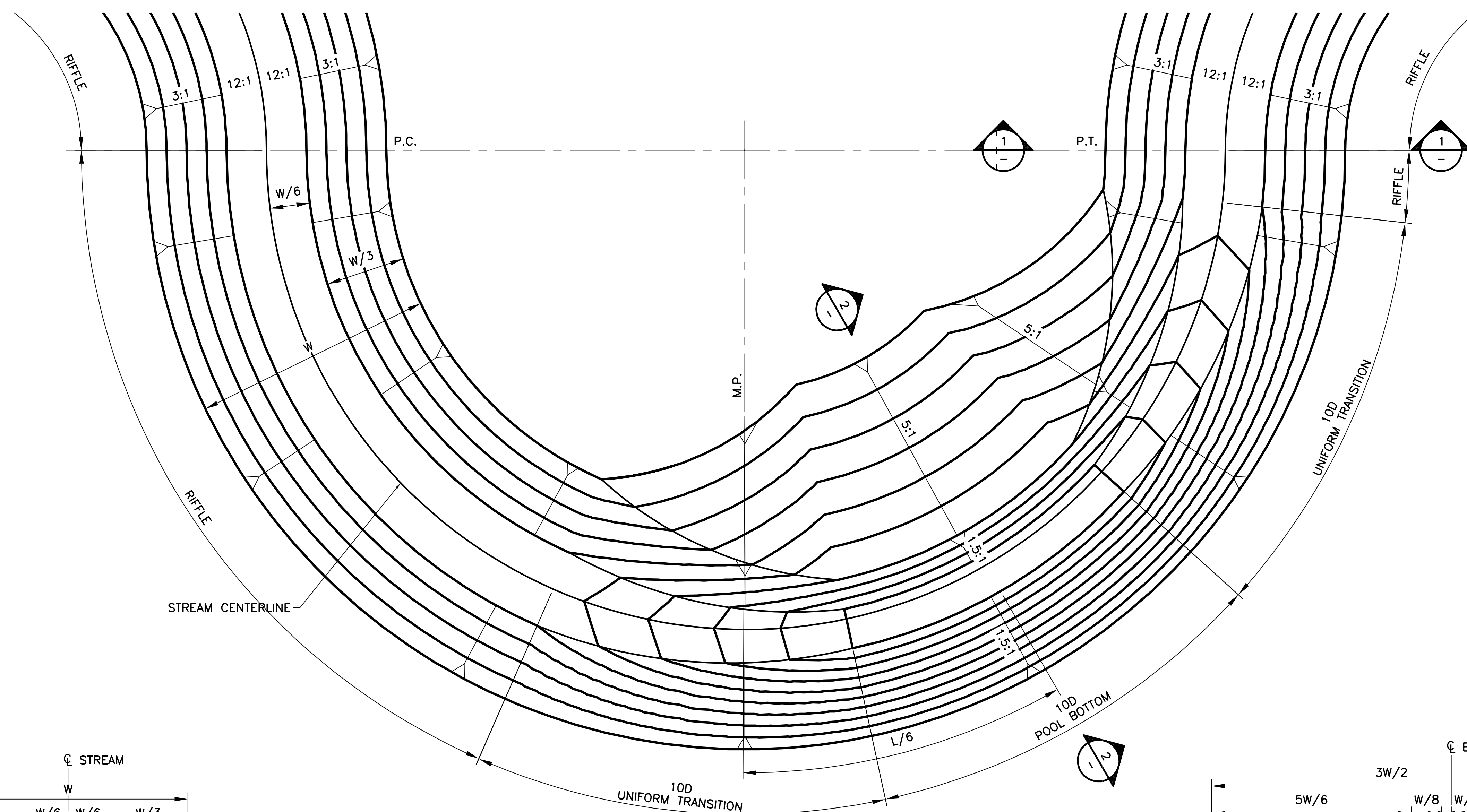
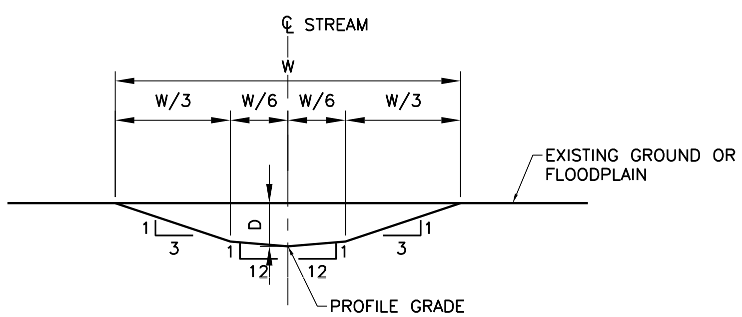
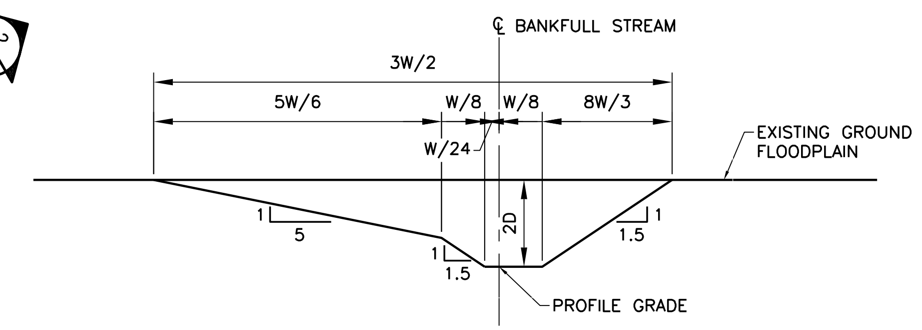


PLAN VIEW – POOL @ CURVATURE



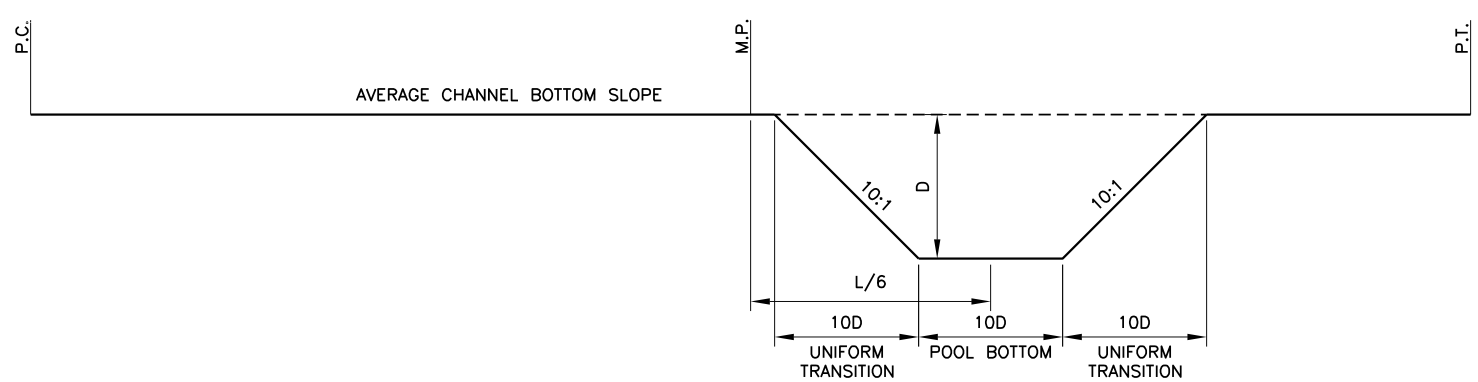
1 – TYPICAL SECTION RIFFLE

NOT TO SCALE



2 – TYPICAL SECTION POOL

NOT TO SCALE



3 – PROFILE VIEW – POOL

NOT TO SCALE

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NORTH TEXAS MUNICIPAL WATER DISTRICT

LOWER BOIS D'ARC CREEK RESERVOIR PROGRAM

MITIGATION PROJECT

STREAMS

POOL DETAILS

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				CHECKED .

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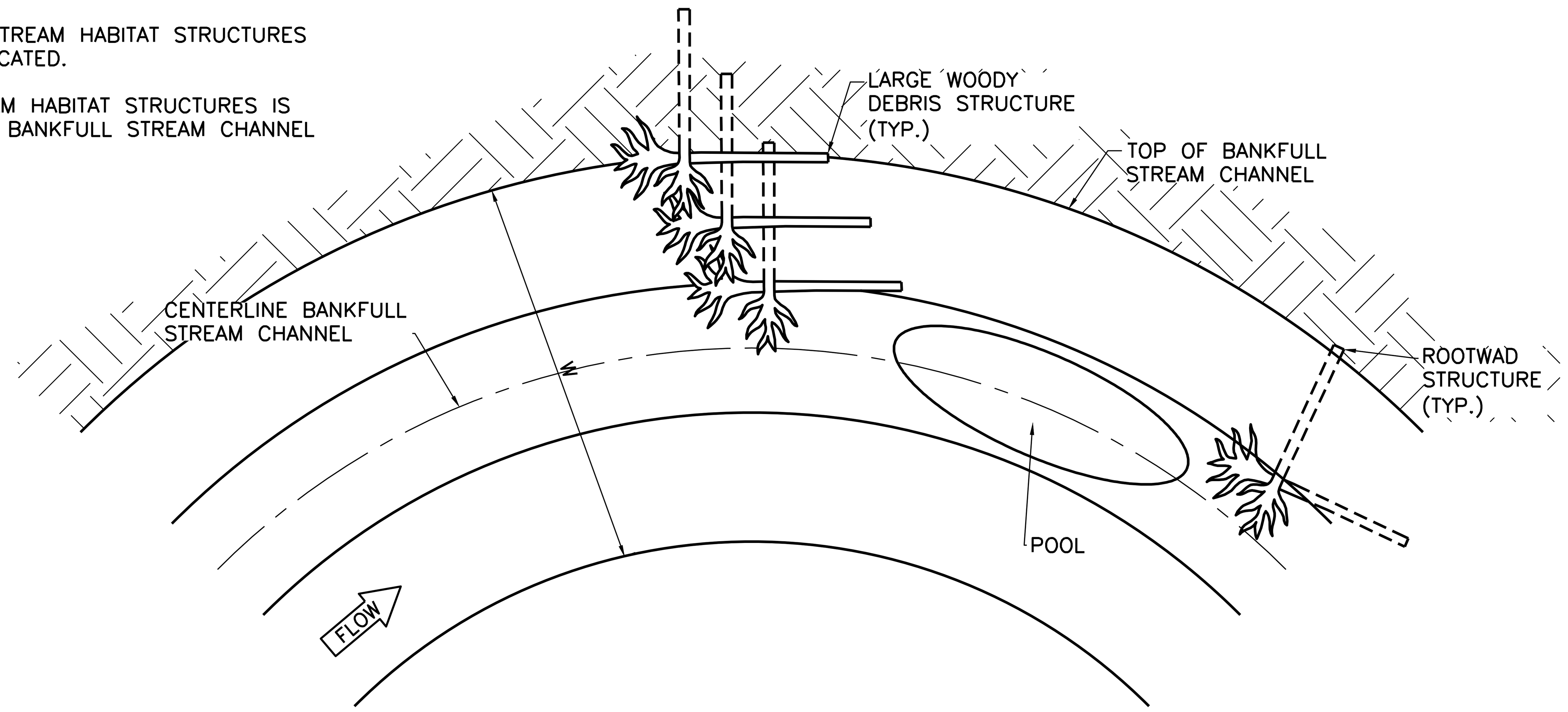
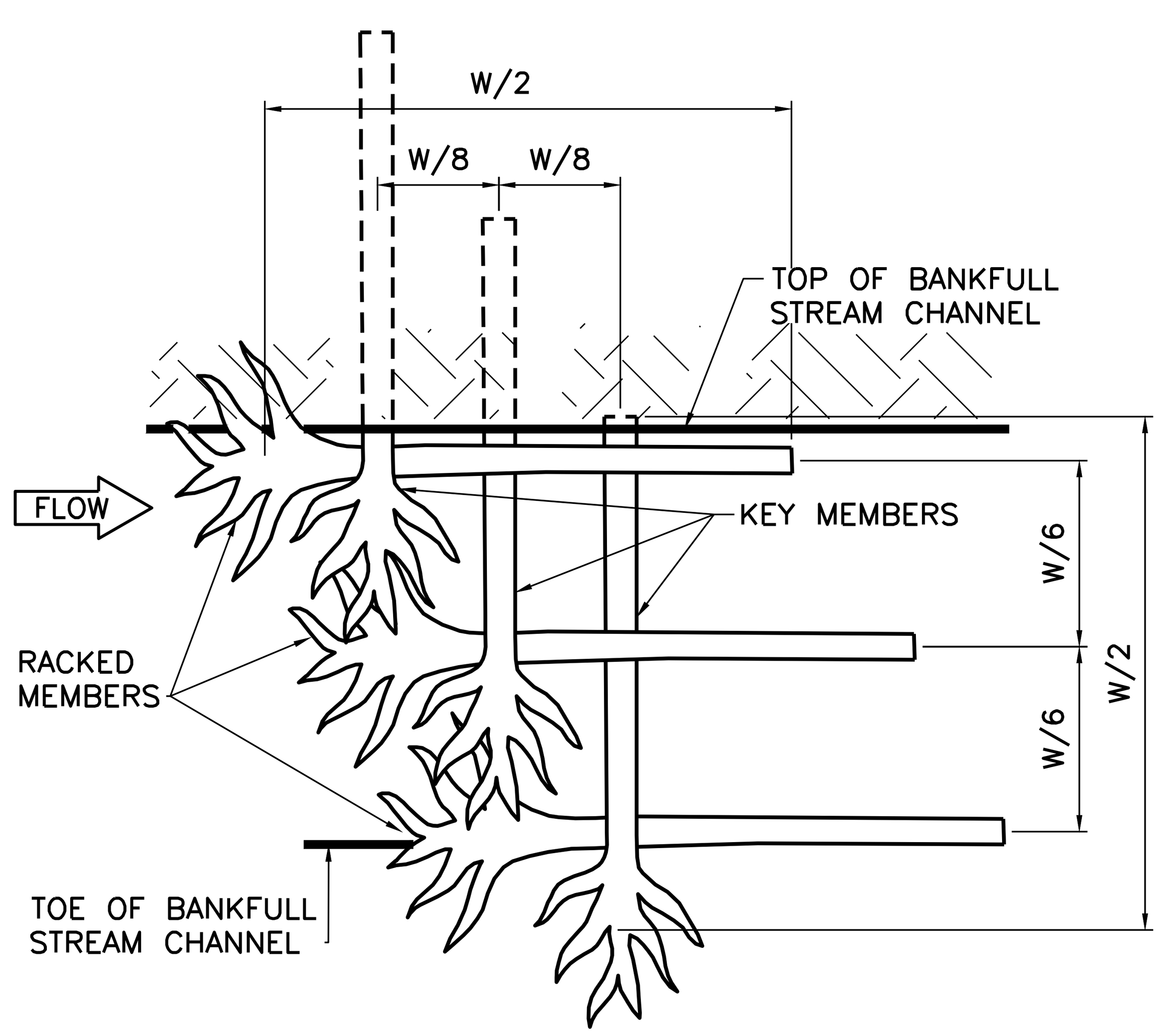
I.5
FIGURE

NOTES:

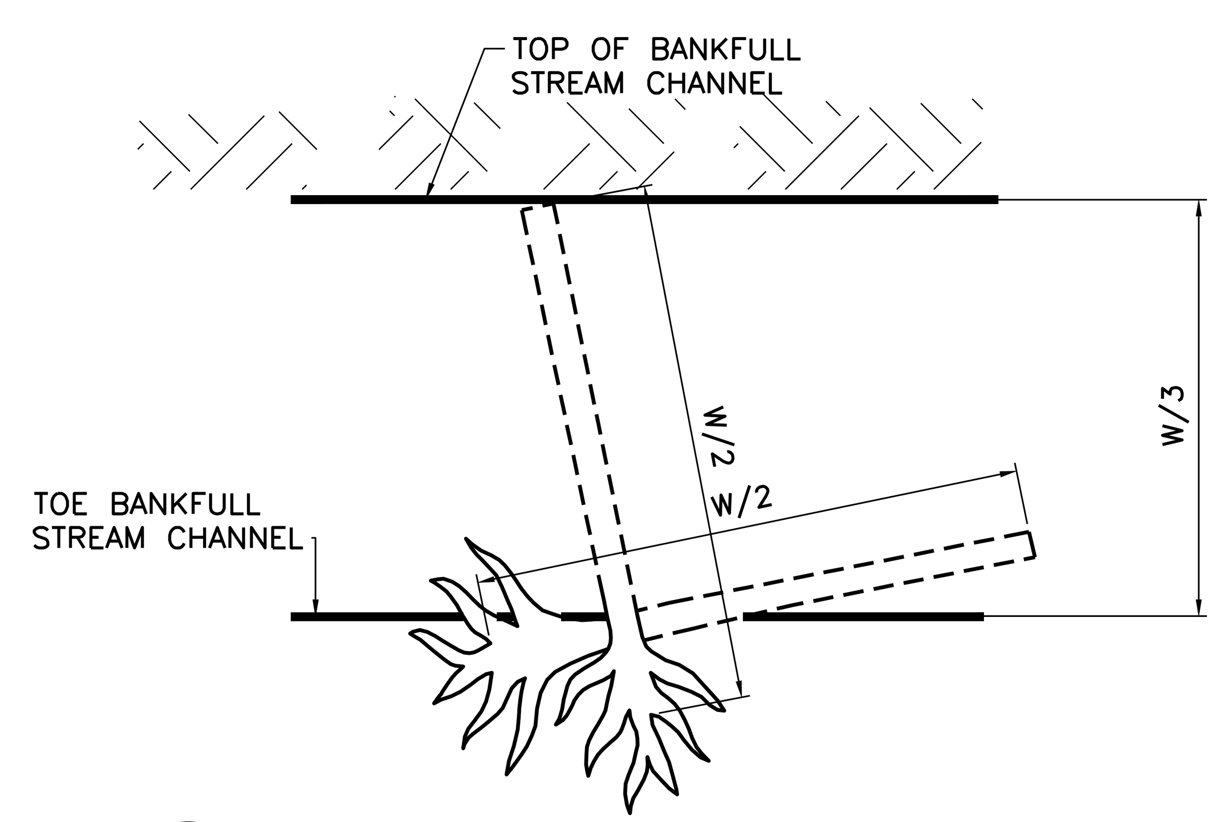
1. LOCATION OF IN STREAM HABITAT STRUCTURES SHALL BE AS INDICATED.
2. SIZE OF IN-STREAM HABITAT STRUCTURES IS PROPORTIONAL TO BANKFULL STREAM CHANNEL TOP WIDTH (W).



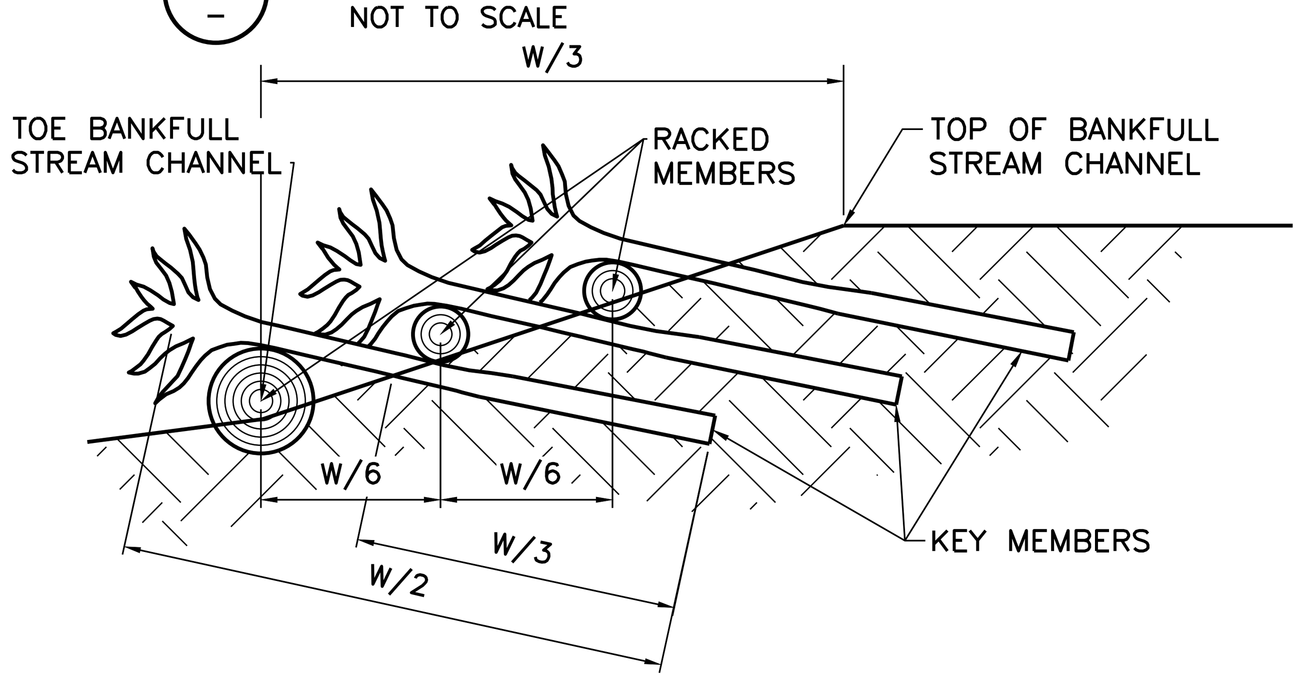
4 / – PLAN OF IN-STREAM HABITAT STRUCTURES
NOT TO SCALE



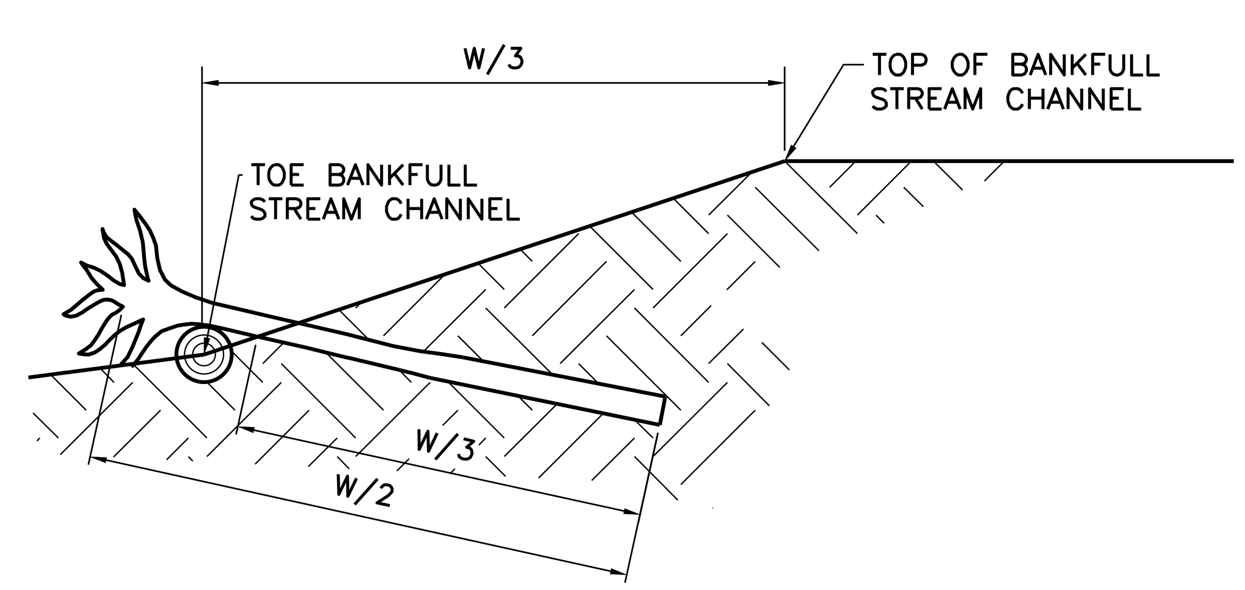
5 / – PLAN – LARGE WOODY DEBRIS STRUCTURE
NOT TO SCALE



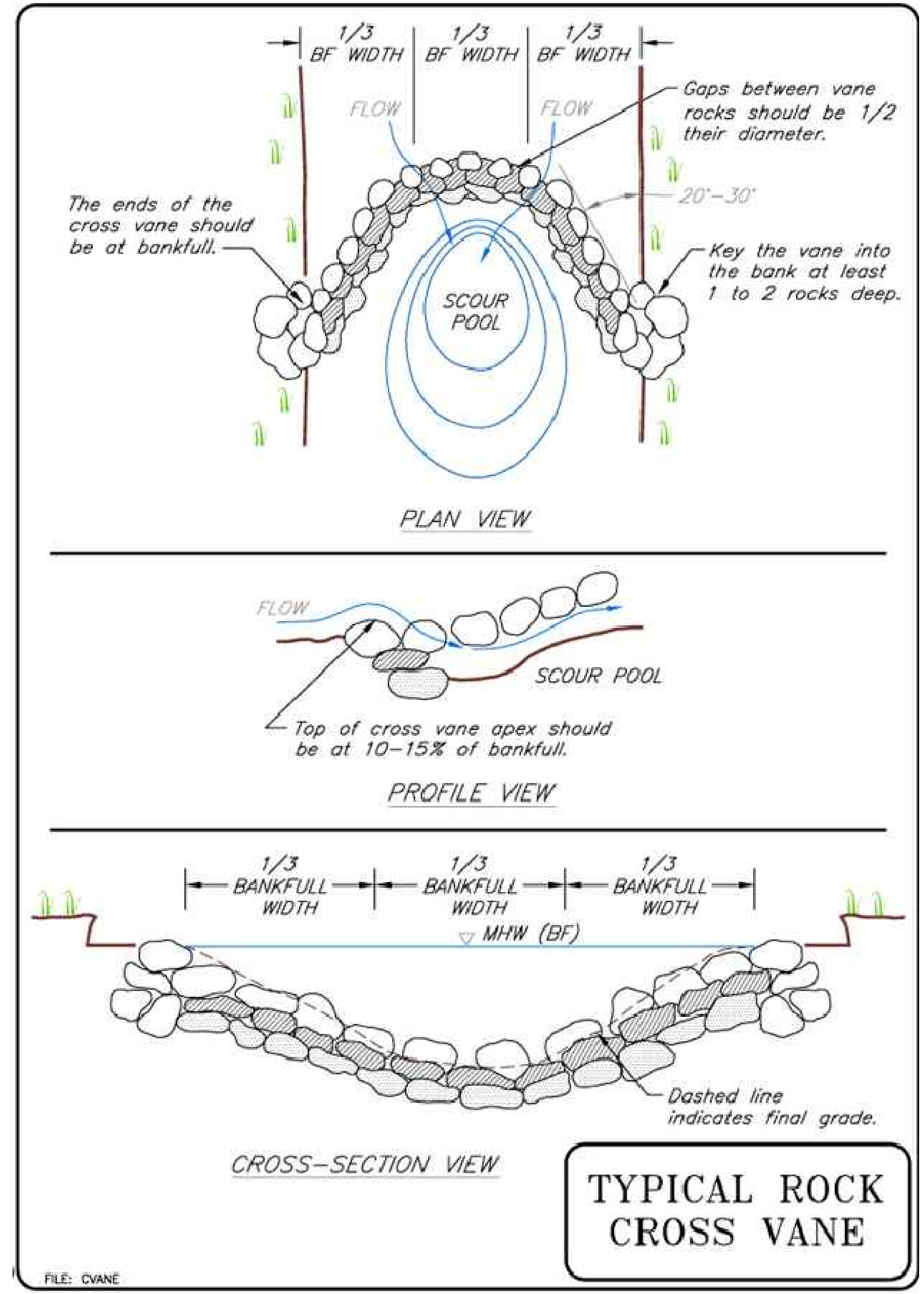
6 / – PLAN – ROOTWAD STRUCTURE
NOT TO SCALE



7 / – SECTION – LARGE WOODY DEBRIS STRUCTURE
NOT TO SCALE



8 / – SECTION – ROOTWAD STRUCTURE
NOT TO SCALE



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NORTH TEXAS MUNICIPAL WATER DISTRICT
LOWER BOIS D'ARC CREEK RESERVOIR PROGRAM
MITIGATION PROJECT
STREAMS
STREAM DETAILS

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I.6
FIGURE

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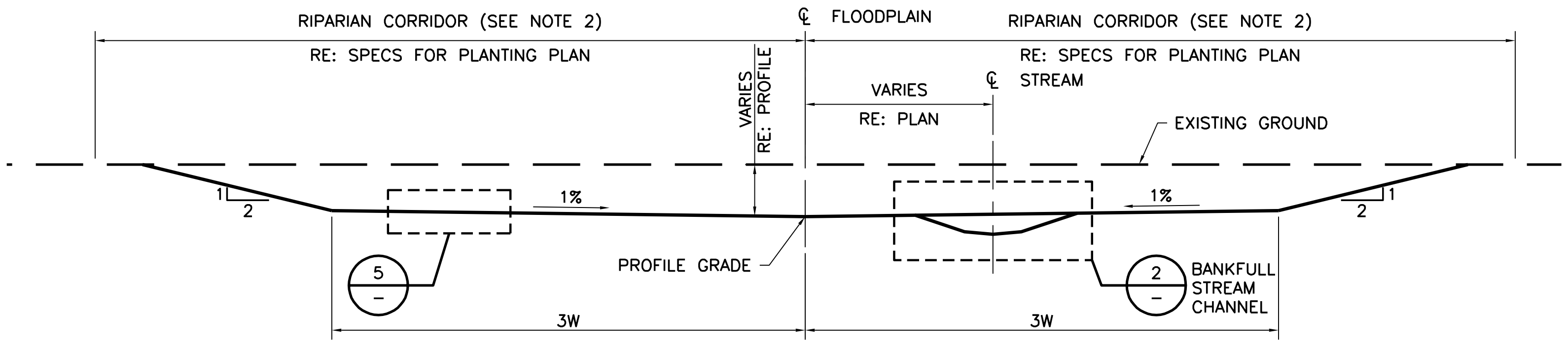


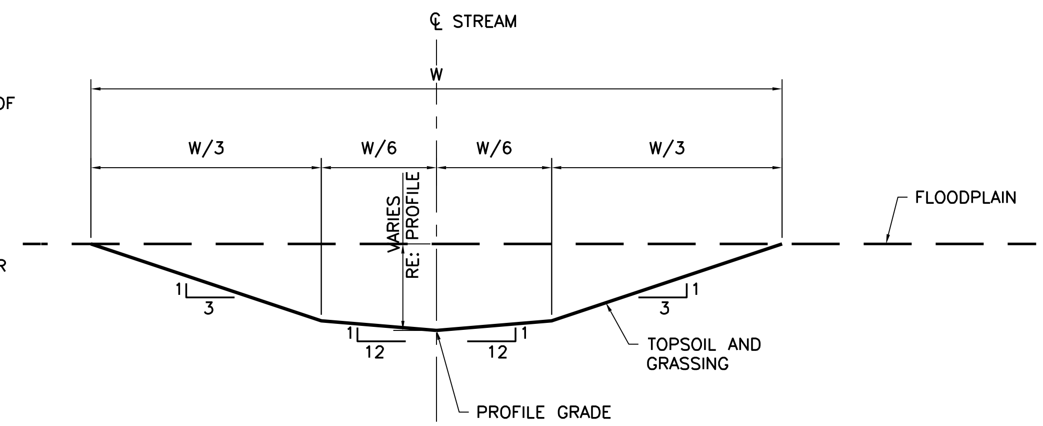
1 TYPICAL SECTION – TYPE 2 FLOODPLAIN

NOTES:

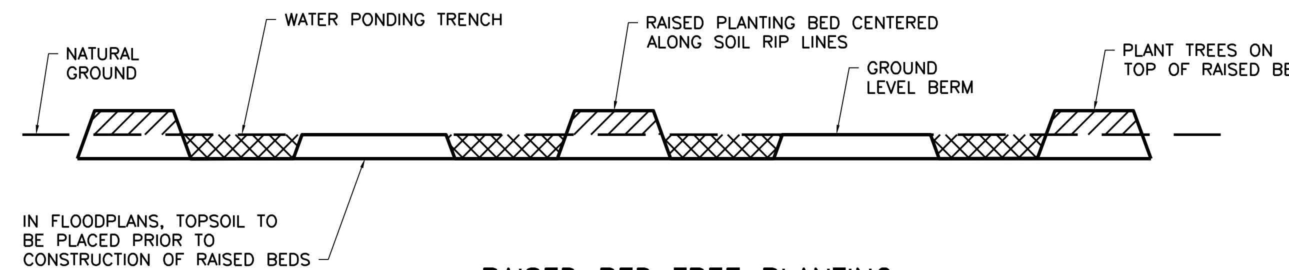
1. ALL STREAM DIMENSIONS ARE PROPORTIONAL TO THE BANKFULL STREAM CHANNEL TOPWIDTH (W), TYPICAL SECTIONS INCLUDED IN THIS SHEET ARE INTENDED TO ILLUSTRATE THIS PROPORTIONAL GEOMETRY. ACTUAL DIMENSIONS FOR EACH STREAM SEGMENT ARE INCLUDED IN THE PLAN AND PROFILE SHEETS.
2. RIPARIAN CORRIDOR WIDTH VARIES EITHER SIDE OF BANKFULL STREAM CHANNEL WITHIN FLOODPLAIN, BUT OVERALL RIPARIAN CORRIDOR WIDTH REMAIN CONSTANT 300 FEET.

NOMENCLATURE:

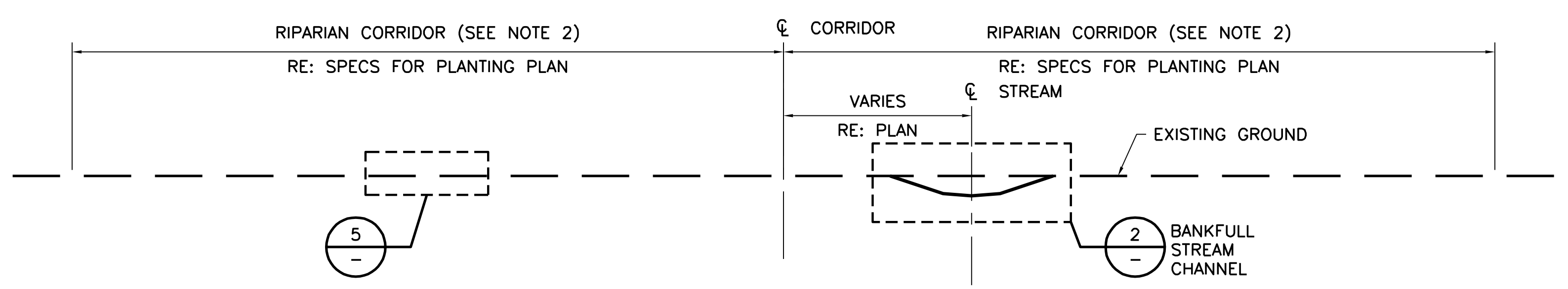
1. THE ALIGNMENTS AND PROFILES WHICH ARE USED TO ESTABLISH THE HORIZONTAL AND VERTICAL GEOMETRY OF THE STREAMS USE THE FOLLOWING NOMENCLATURE:
   a. "WB-TR-X.X" REFERS TO THE PARTICULAR STREAM NAME. (I.E. 0.0. REFERS TO THE MAIN STEM OF WILLOW BRANCH, 1.0 REFERS TO TRIBUTARY 1, ETC.)
   b. "_CORR" REFERS TO THE CORRIDOR OR FLOODPLAIN OF THE PARTICULAR STREAM, WHICH REPRESENTS THE GENERAL ORIENTATION OF THE STREAM.
   c. "_STRM" REFERS TO THE BANKFULL STREAM CHANNEL.
   d. EXAMPLE, AN OBJECT LABELED "WB-TR-2.1-STRM" WOULD PROVIDE GEOMETRY DATA FOR THE BANKFULL STREAM CHANNEL OF WILLOW BRANCH TRIBUTARY 2.1.



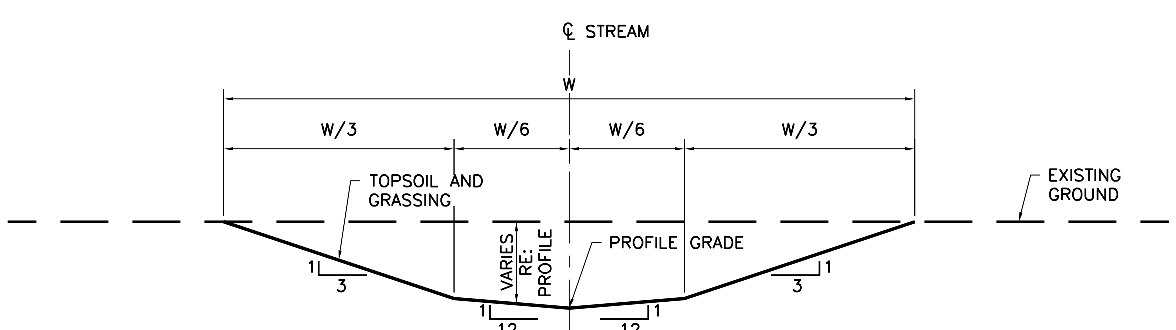
2 TYPICAL SECTION – TYPE 2 BANKFULL STREAM CHANNEL



5 RAISED BED TREE PLANTING ROW DETAIL CROSS SECTION



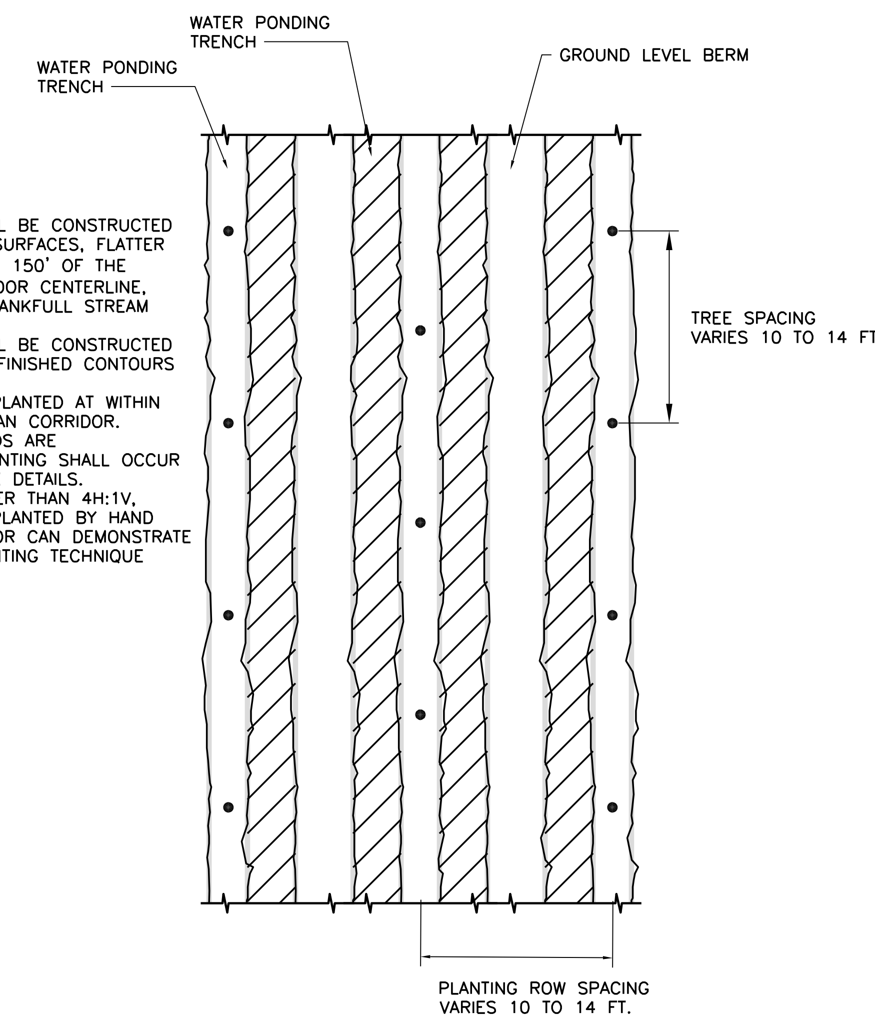
3 TYPICAL SECTION – TYPE 1 CORRIDOR



4 TYPICAL SECTION – TYPE 1 BANKFULL STREAM CHANNEL

NOTES:

1. RAISED BEDS SHALL BE CONSTRUCTED ON ALL FINISHED SURFACES, FLATTER THAN 4H:1V WITHIN 150' OF THE FLOODPLAIN/CORRIDOR CENTERLINE, OUTSIDE OF THE BANKFULL STREAM CHANNEL.
2. RAISED BEDS SHALL BE CONSTRUCTED PARALLEL TO THE FINISHED CONTOURS OF THE SURFACE.
3. TREES SHALL BE PLANTED AT WITHIN THE ENTIRE RIPARIAN CORRIDOR.
4. WHERE RAISED BEDS ARE CONSTRUCTED, PLANTING SHALL OCCUR ACCORDING TO THE DETAILS.
5. ON SLOPES STEEPER THAN 4H:1V, TREES SHALL BE PLANTED BY HAND UNLESS CONTRACTOR CAN DEMONSTRATE SATISFACTORY PLANTING TECHNIQUE OTHERWISE.



6 RAISED BED TREE PLANTING DETAIL FOR RIPARIAN CORRIDOR

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NORTH TEXAS MUNICIPAL WATER DISTRICT
LOWER BOIS D'ARC CREEK RESERVOIR PROGRAM
MITIGATION PROJECT
STREAMS
TYPICAL SECTIONS

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I.7
FIGURE

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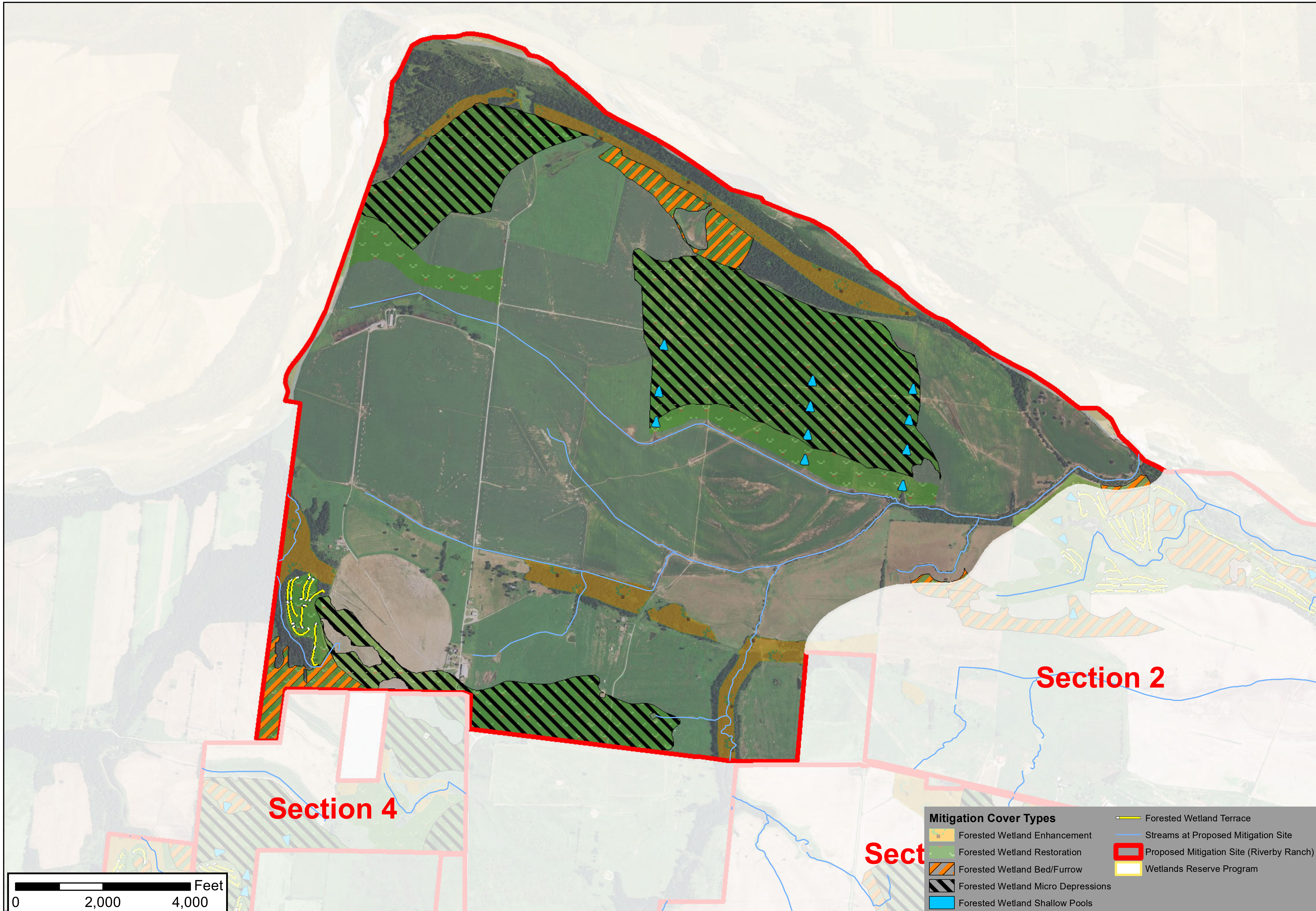

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FILE: I8_RiverbyFW_CoverTypes_11x17.mxd

North Texas Municipal Water District

Proposed Mitigation - Forested Wetland Restoration Cover Types - Section 1

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I.8
FIGURE

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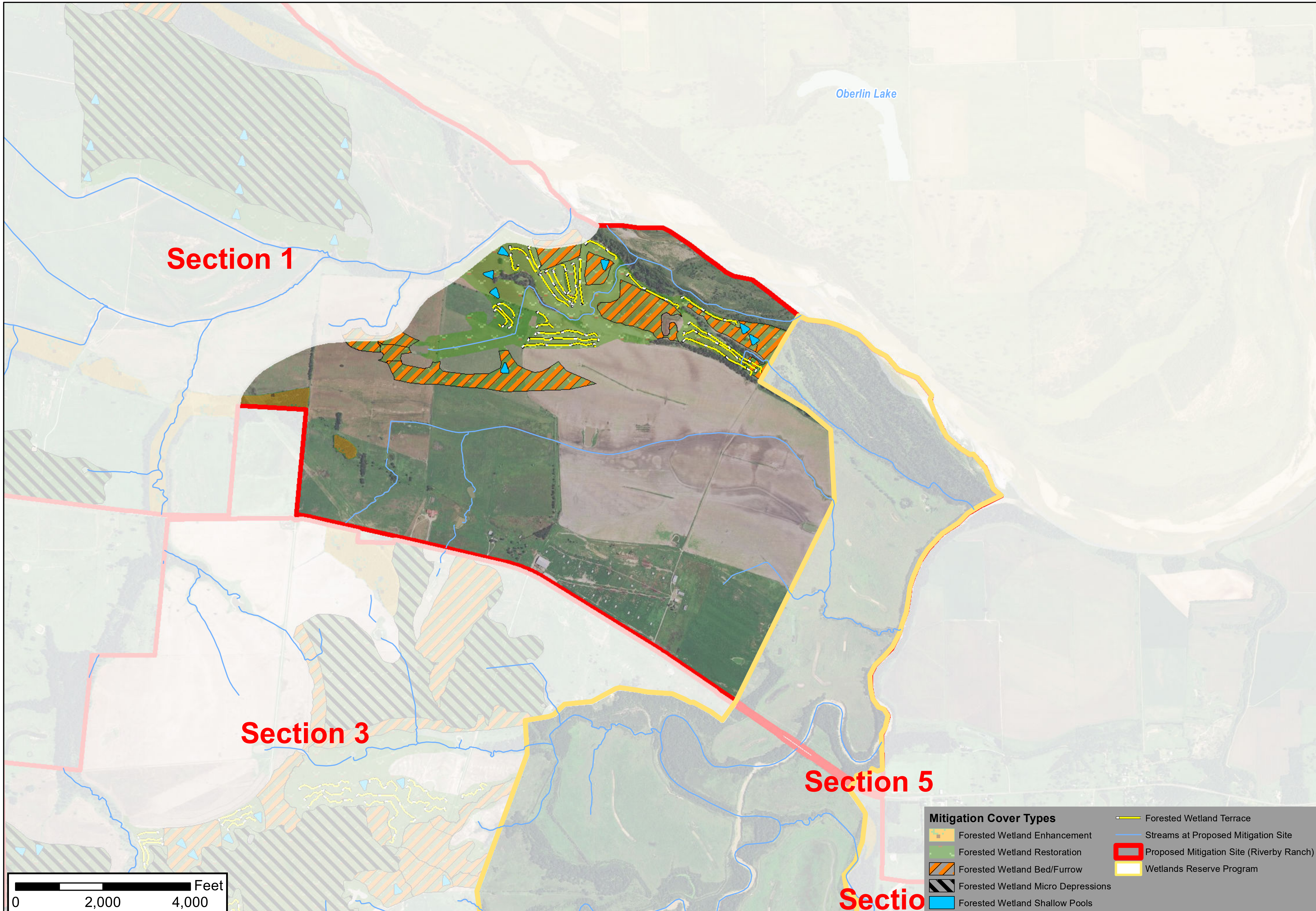

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DATE: Nov 2016
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FILE:

North Texas Municipal Water District

Proposed Mitigation -
Forested Wetland Restoration Cover Types - Section 2

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I.9

FIGURE

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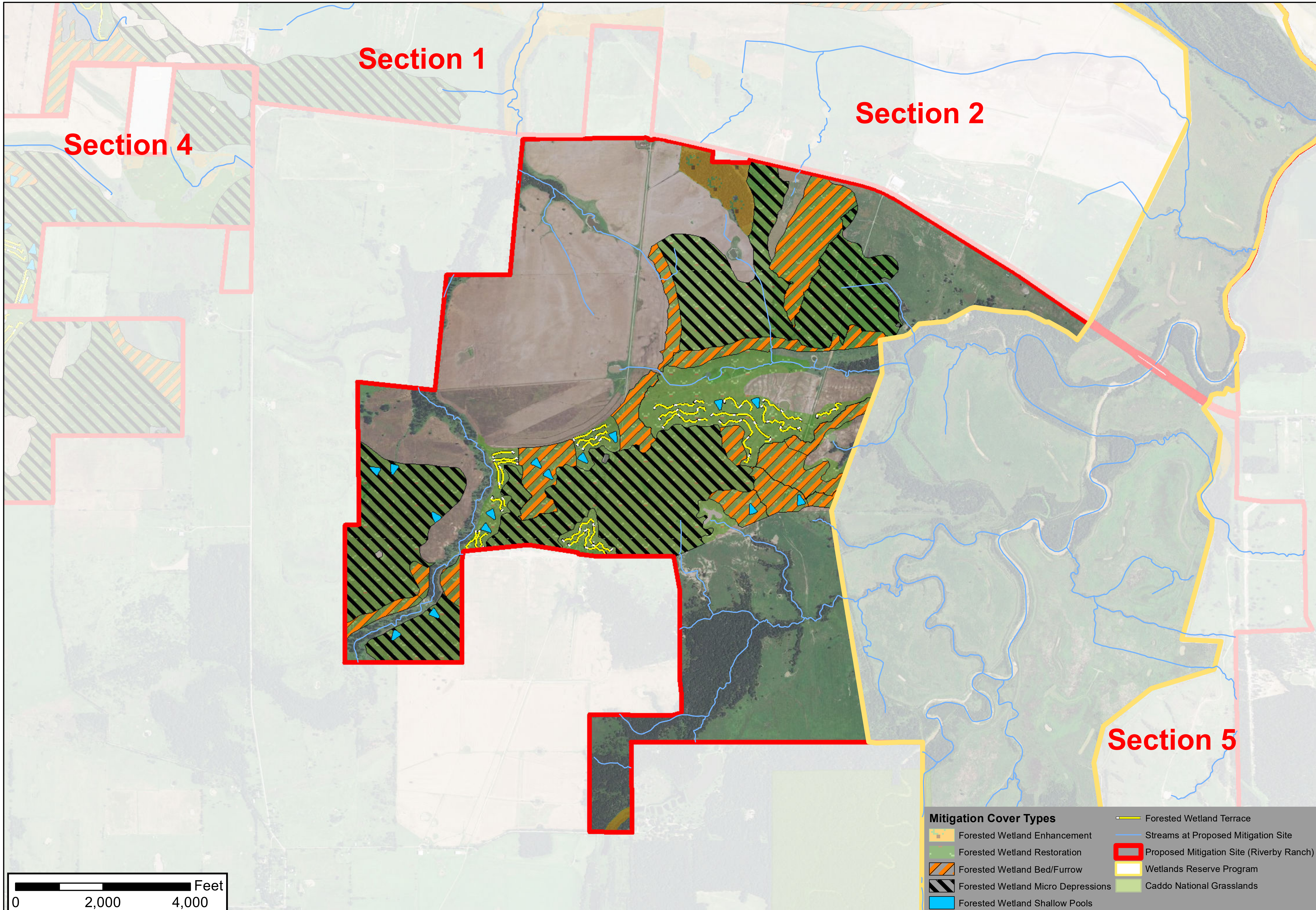

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North Texas Municipal Water District

Proposed Mitigation -
Forested Wetland Restoration Cover Types - Section 3

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817-735-7300

I.10
FIGURE

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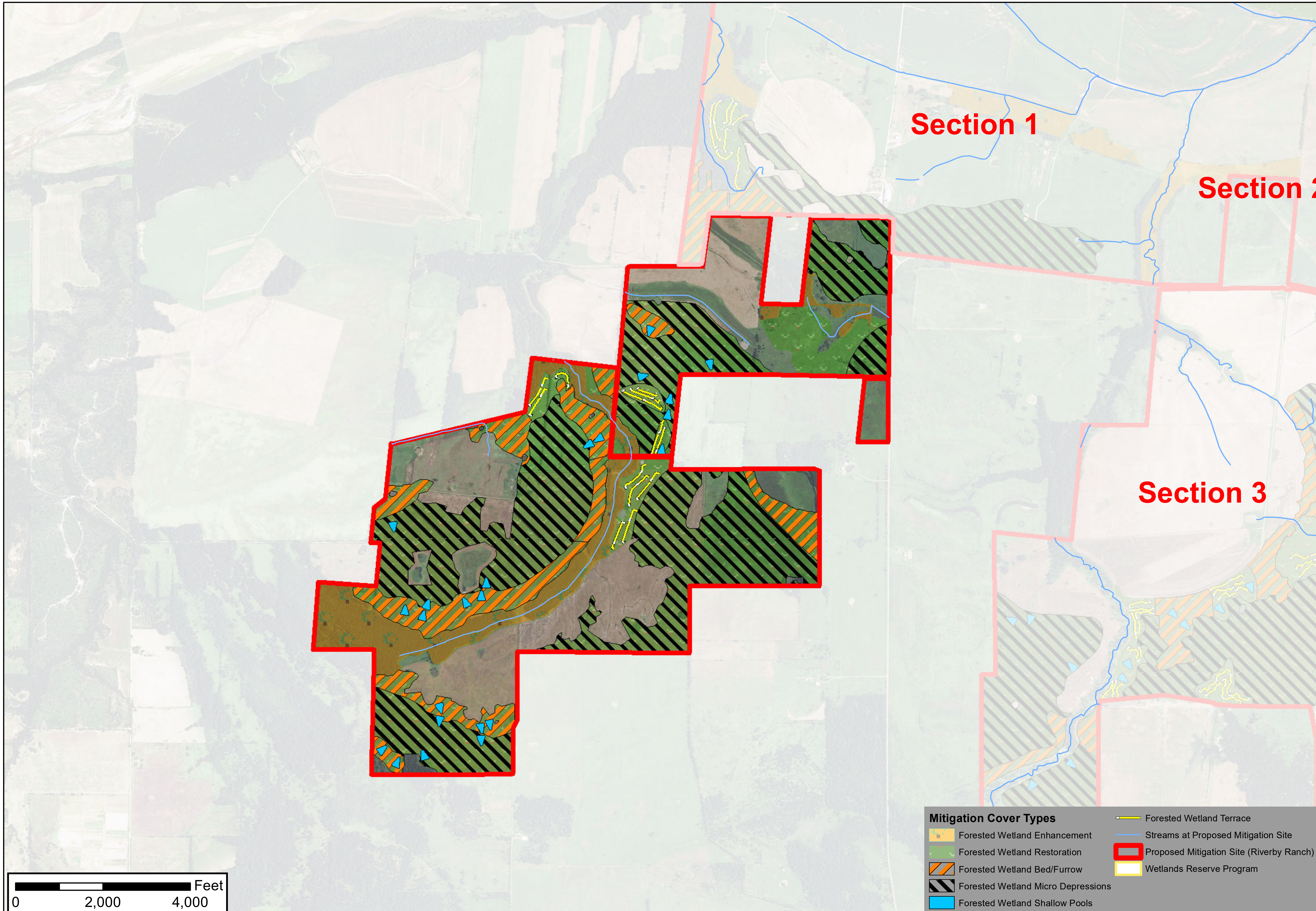

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North Texas Municipal Water District

Proposed Mitigation - Forested Wetland Restoration Cover Types - Section 4

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I.11

FIGURE

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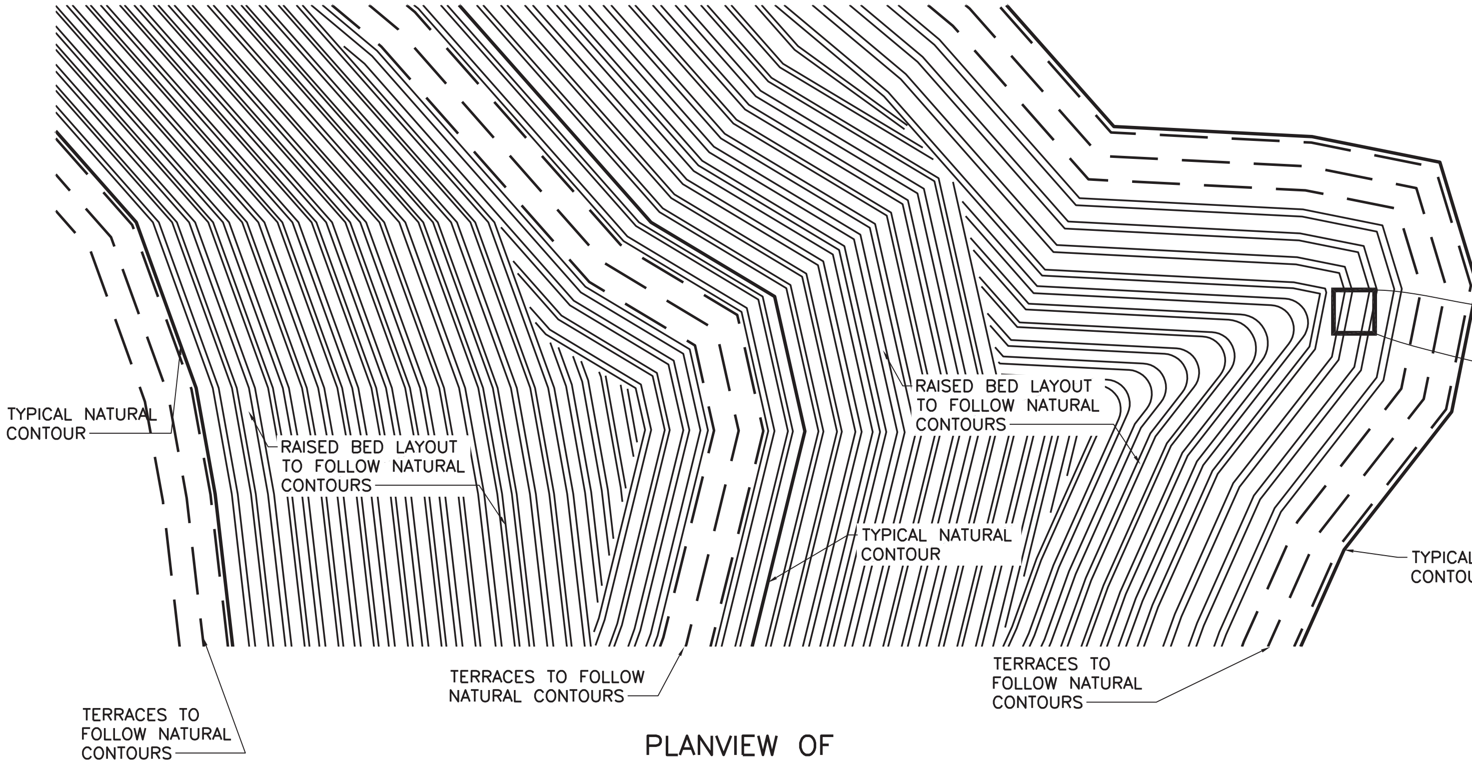
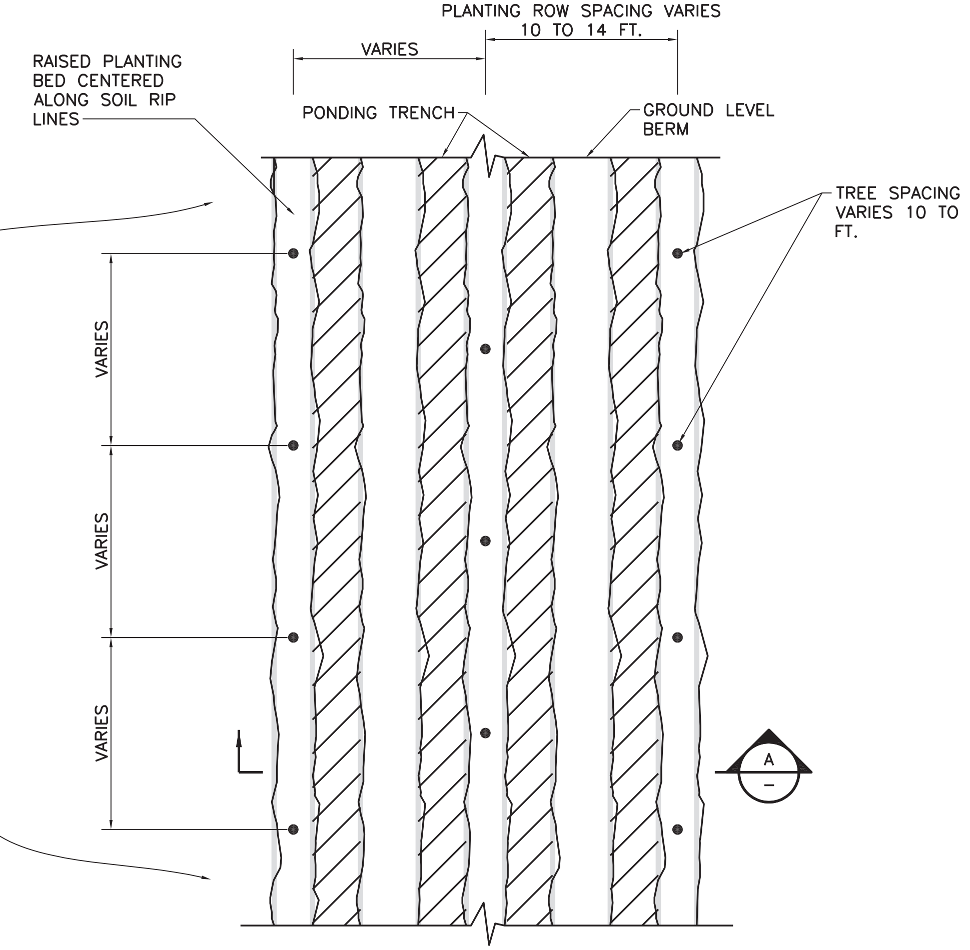
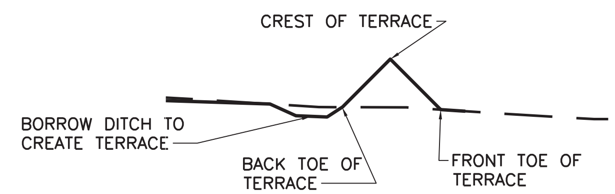


1 PLANVIEW OF TYPICAL FIELD LAYOUT
N.T.S.

NOTE: EARTHWORK ACTIVITIES– RIPPING, DISKING, RAISED BED FORMING, TERRACE FORMING, ARE INTENDED TO USE THE LAND'S NATURAL CONTOURS UNLESS SPECIFICIED ON PLAN SHEETS.



4 RAISED BED ROW STYLE 1 – PLAN VIEW



2 TERRACE DESCRIPTION
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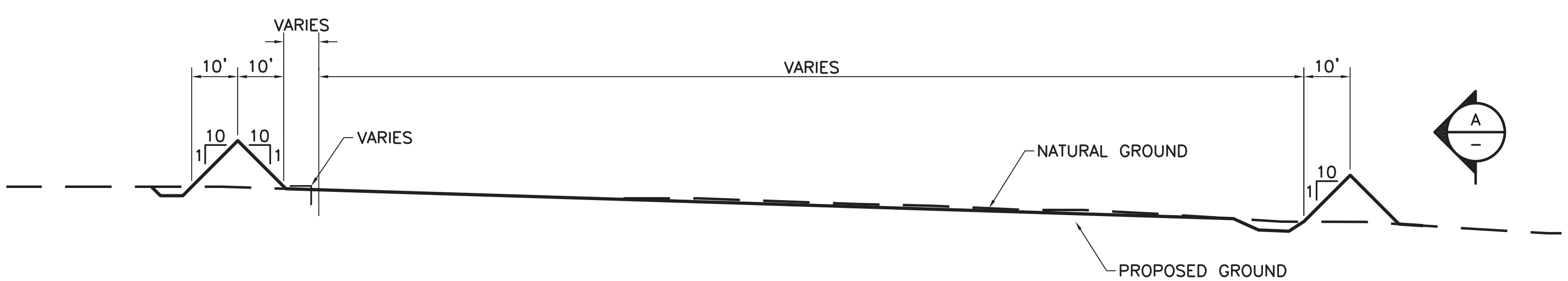
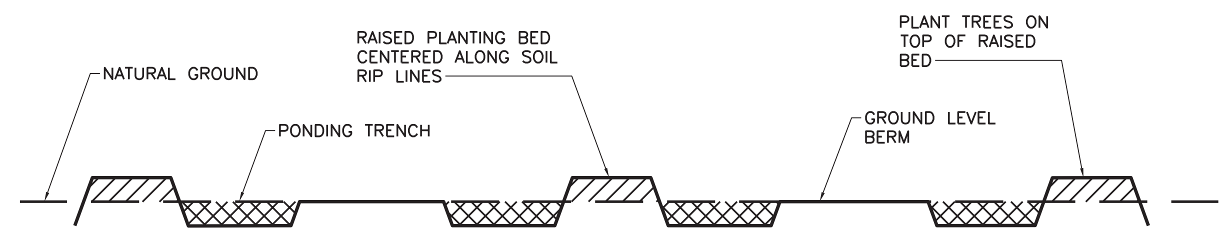


3 TERRACE CROSS SECTION PROFILE
N.T.S.



A RAISED BED ROW DETAIL STYLE 1 CROSS SECTION
N.T.S.

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NORTH TEXAS MUNICIPAL WATER DISTRICT
LOWER BOIS D'ARC CREEK RESERVOIR PROGRAM
MITIGATION PROJECT
FORESTED WETLANDS

TERRACE & RAISED BED ROW DETAILS

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SEQ.

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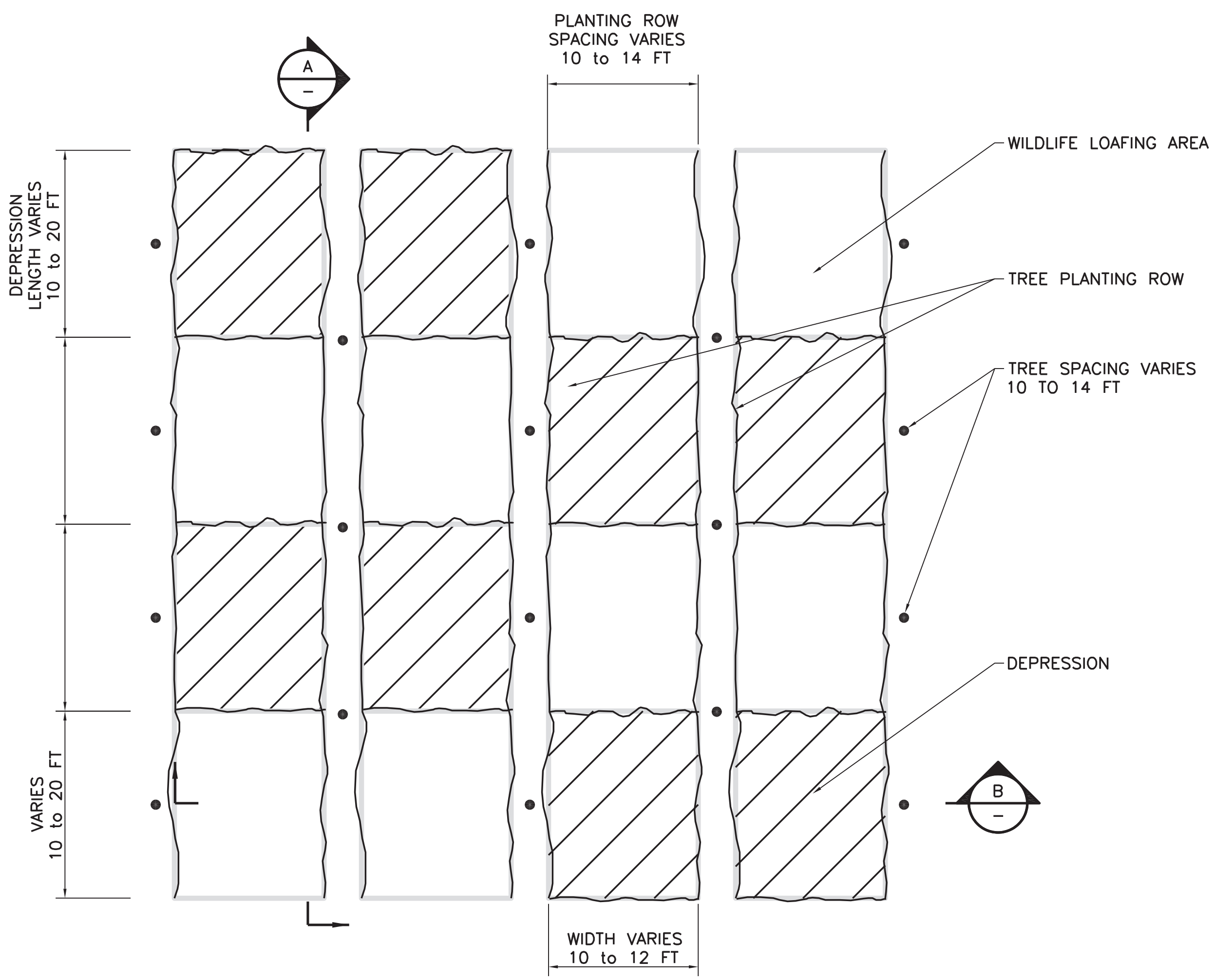
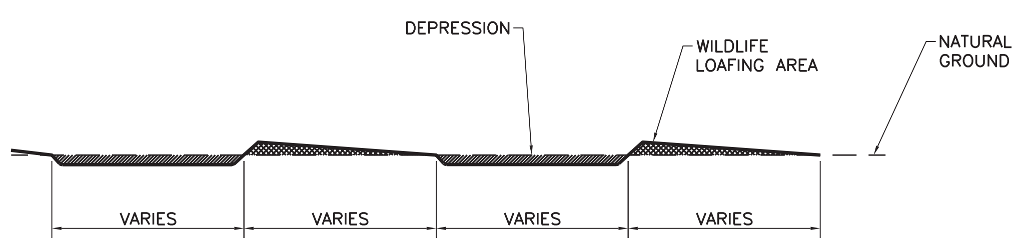
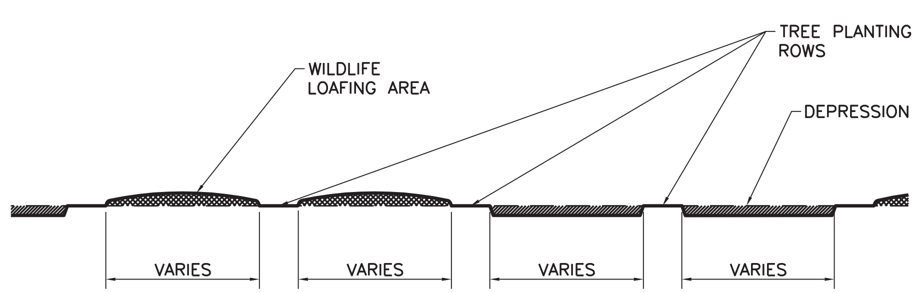


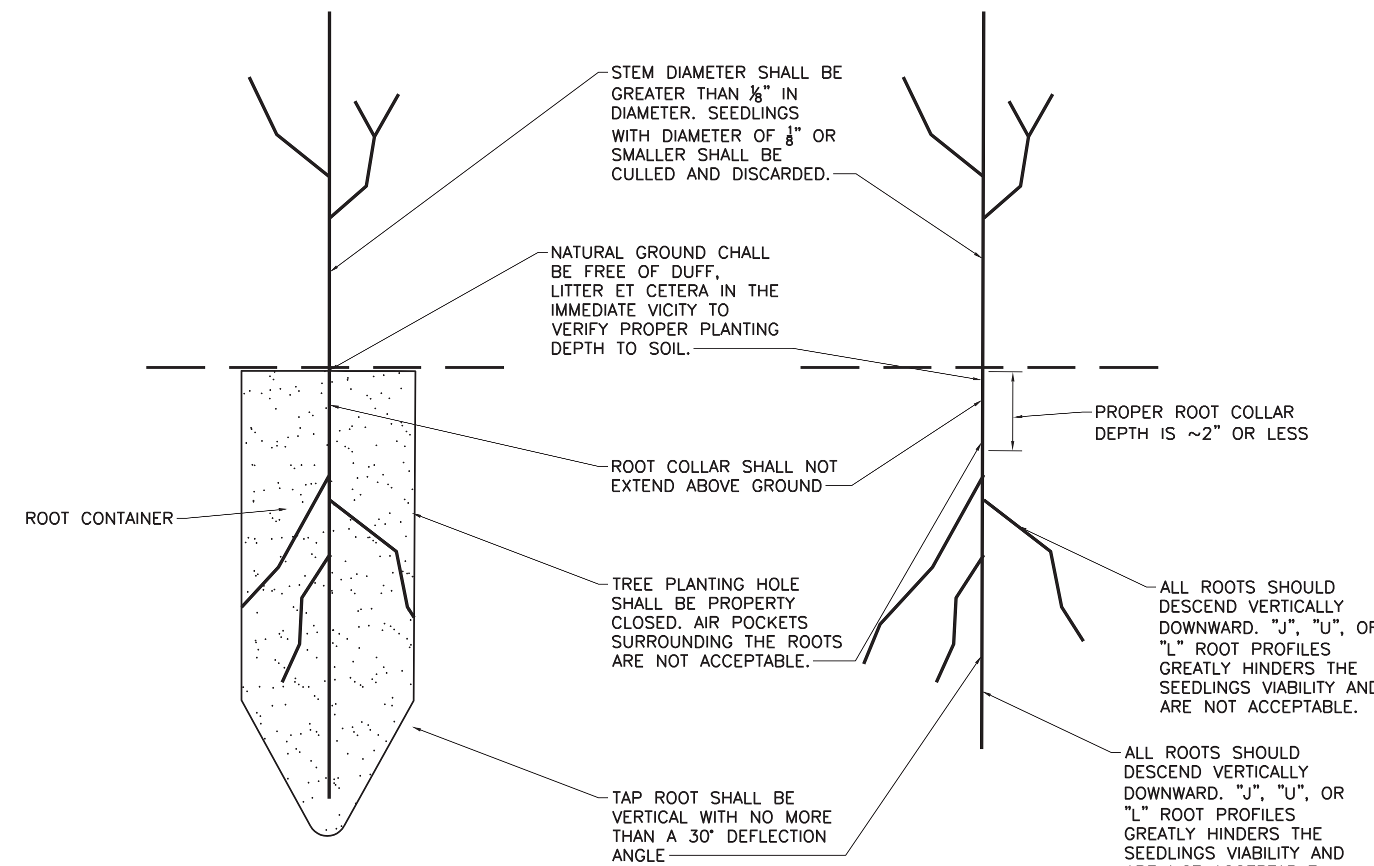
DEPRESSIONAL WETLAND PLAN VIEW



A DEPRESSIONAL WETLAND PROFILE VIEW



B DEPRESSIONAL WETLAND CROSS SECTION PROFILE



CONTAINERIZED ROOT SEEDLING

BARE ROOT SEEDLING

2 TREE PLANTING DETAIL
N.T.S.

0 5' 10'
SCALE IN FEET
HORIZONTAL

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NORTH TEXAS MUNICIPAL WATER DISTRICT
LOWER BOIS D'ARC CREEK RESERVOIR PROGRAM
MITIGATION PROJECT
FORESTED WETLANDS

FORESTED WETLAND DETAILS

NO.	ISSUE	BY	DATE

F&N JOB NO. NTD15291
DATE JUNE 2016
DESIGNED AMR
DRAWN TEF
REVISED
CHECKED MHP
FILE NAME WR-ALL-SC-XS01.dwg

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WORK TYPE/WORK PACKAGE
SEQ.

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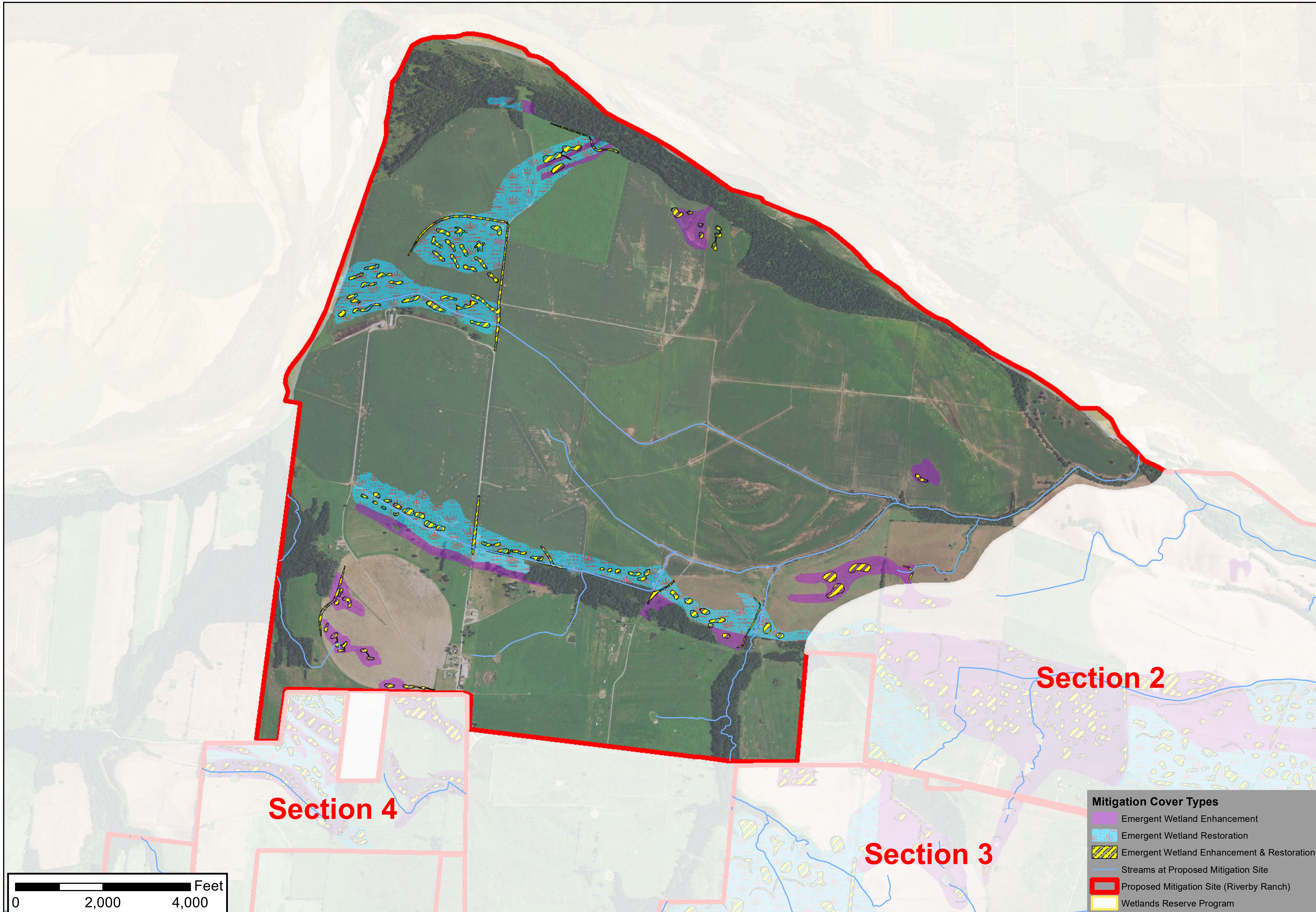

F&N JOB NO. NTD06128
DATE: Nov 2016
SCALE: 1:48,000
DESIGNED: HHM
DRAFTED: HHM
FILE: I14_RiverbyEW_CoverTypes_11x17.mxd

North Texas Municipal Water District

Proposed Mitigation - Emergent Wetland Cover Types - Section 1

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Fort Worth, Texas 76109-4895
817-735-7300

I.14

FIGURE

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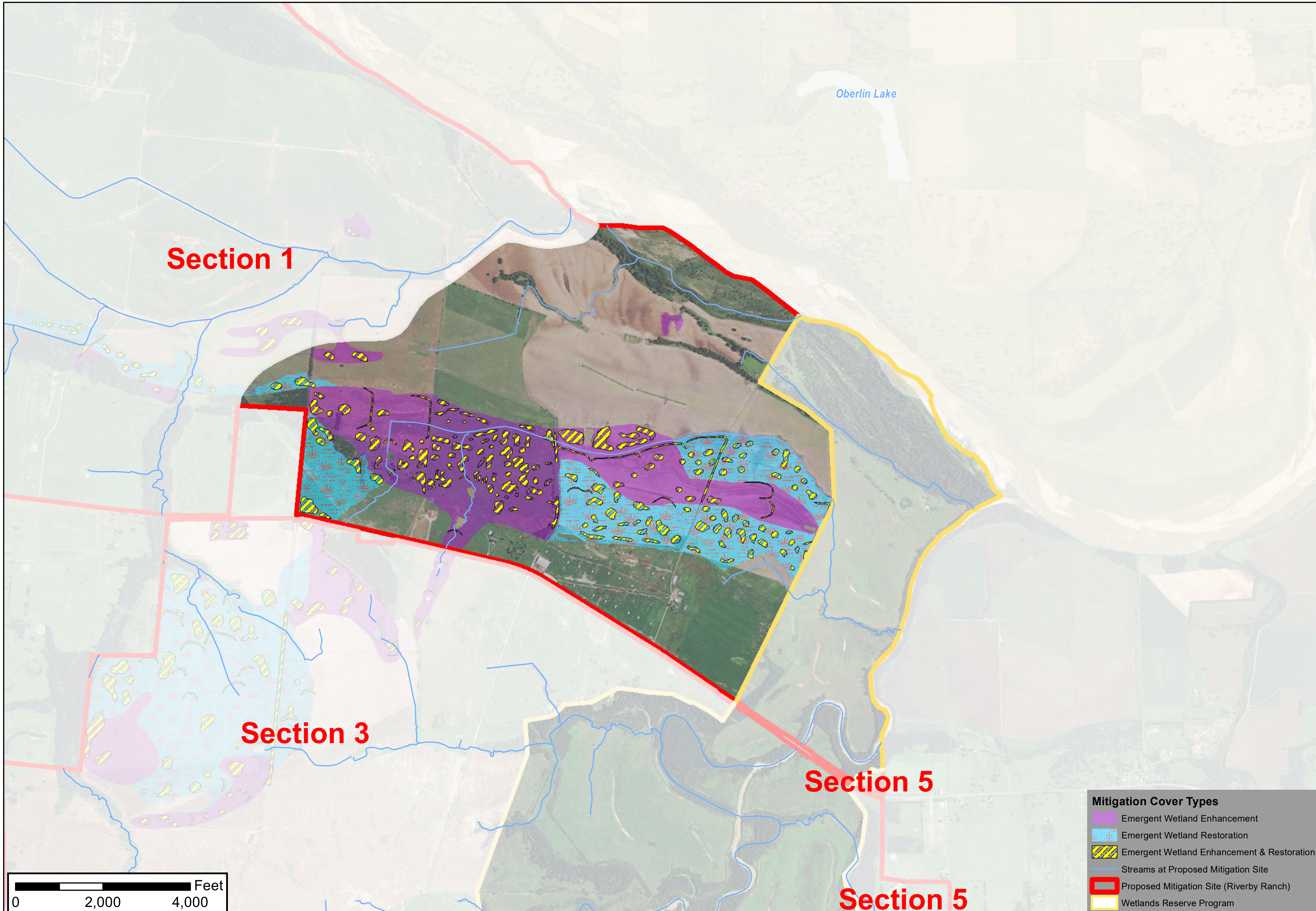

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DATE: Nov 2016
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North Texas Municipal Water District

Proposed Mitigation - Emergent Wetland Cover Types - Section 2

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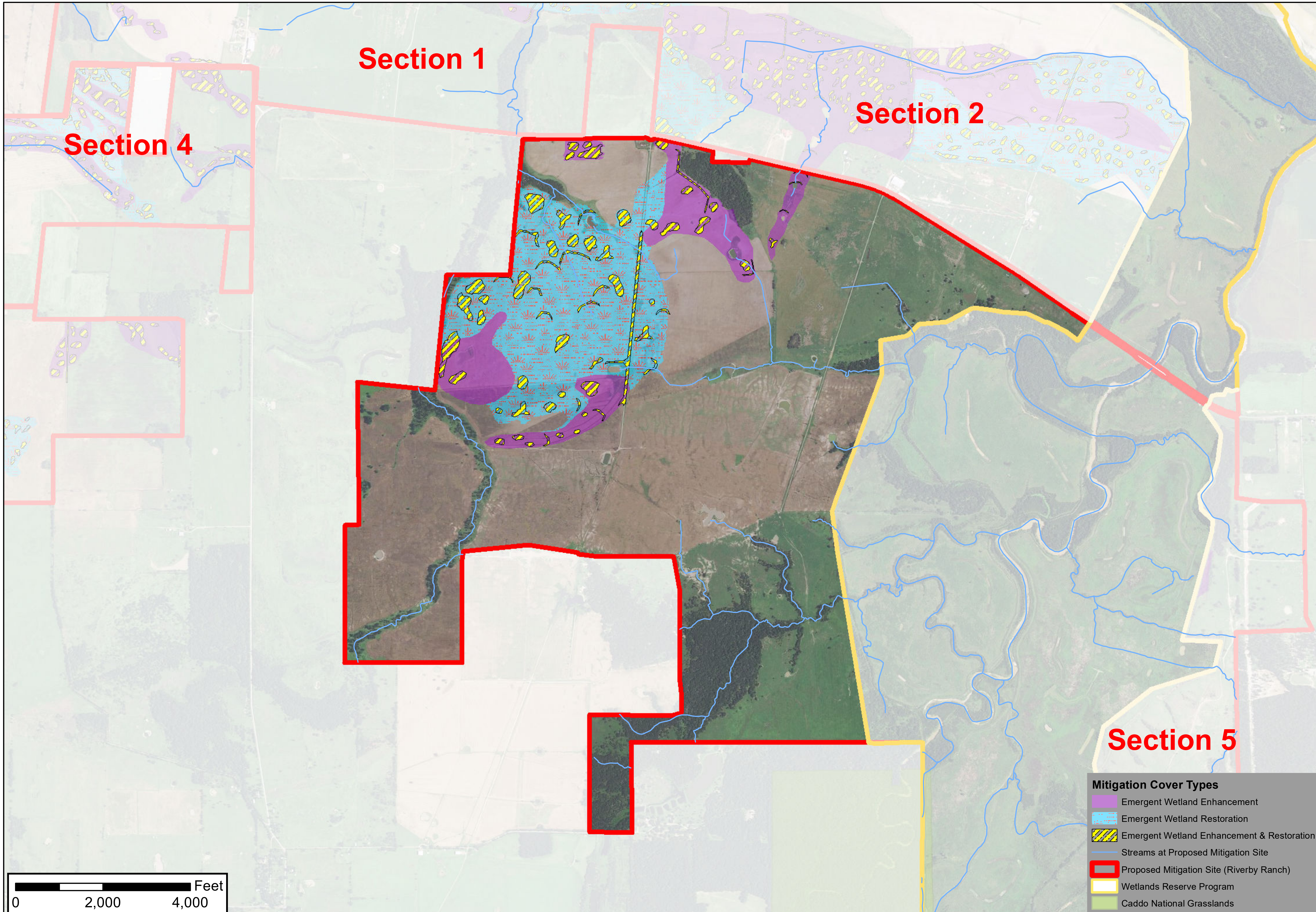
Fort Worth, Texas 76109-4895
817-735-7300

I.15

FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Riverby_Design\I14_RiverbyEW_CoverTypes_11x17.mxd



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North Texas Municipal Water District

Proposed Mitigation -
Emergent Wetland Cover Types - Section 3

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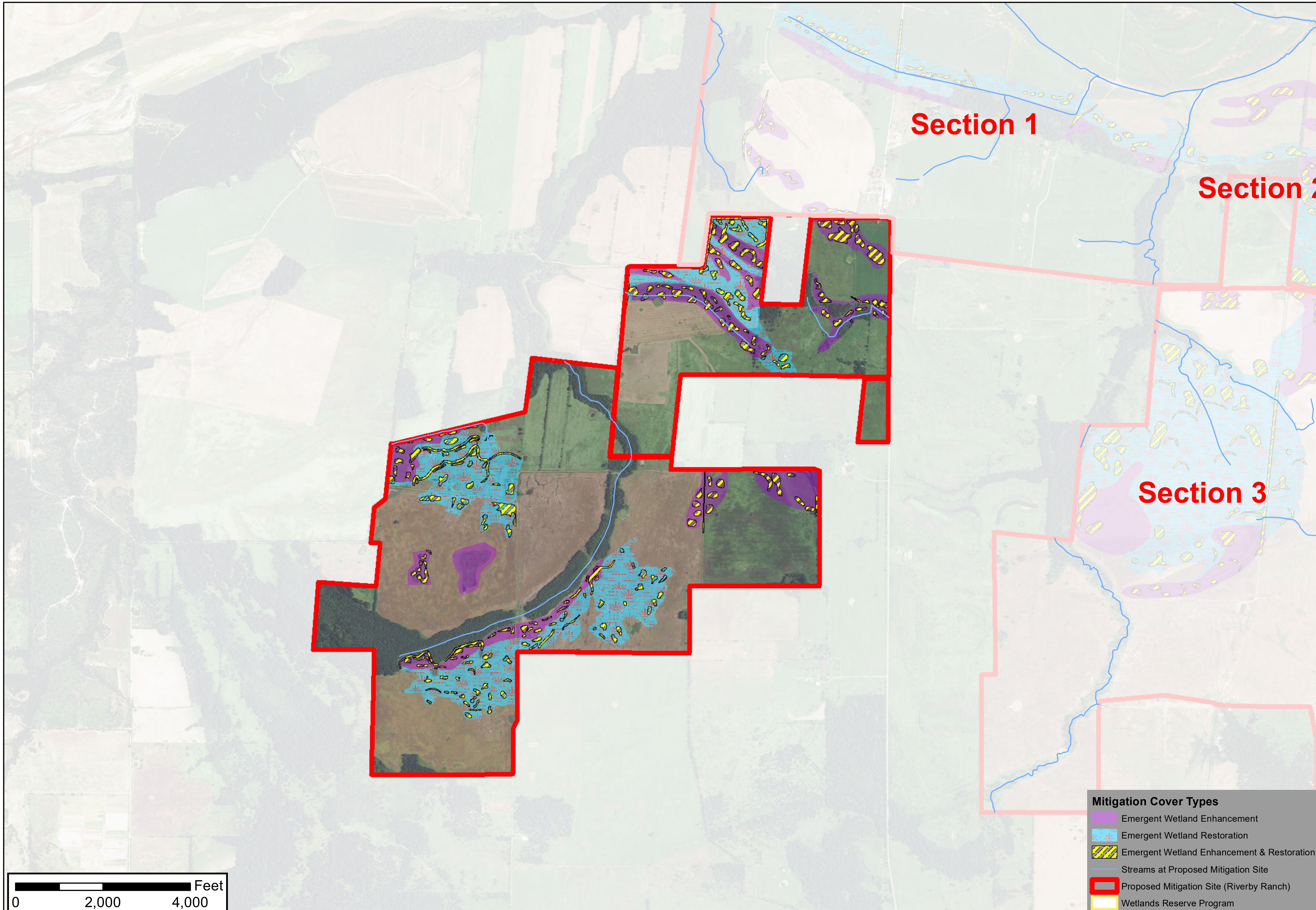
Fort Worth, Texas 76109-4895
817-735-7300

I.16
FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Riverby_Design\I14_RiverbyEW_CoverTypes_11x17.mxd



F&N JOB NO.	NTD06128
DATE:	Nov 2016
SCALE:	1:48,000
DESIGNED:	HHM
DRAFTED:	HHM
FILE:	I14_RiverbyEW_CoverTypes_11x17.mxd

North Texas Municipal Water District

Proposed Mitigation - Emergent Wetland Cover Types - Section 4

N
W E
S

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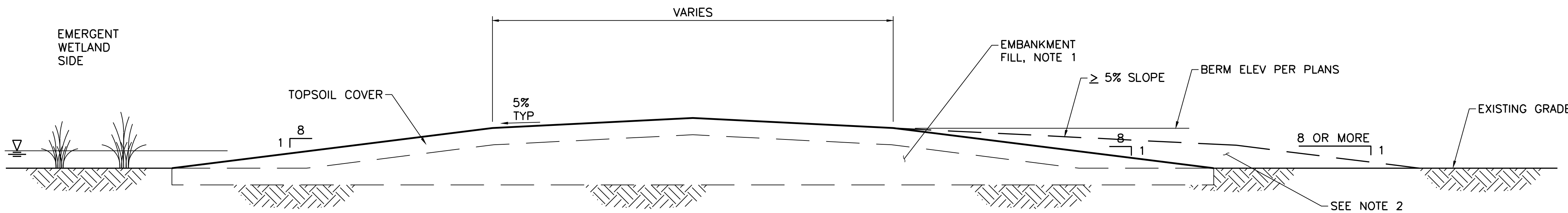
Fort Worth, Texas 76109-4895
817-735-7300

I.17

FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Riverby_Design\I14_RiverbyEW_CoverTypes_11x17.mxd

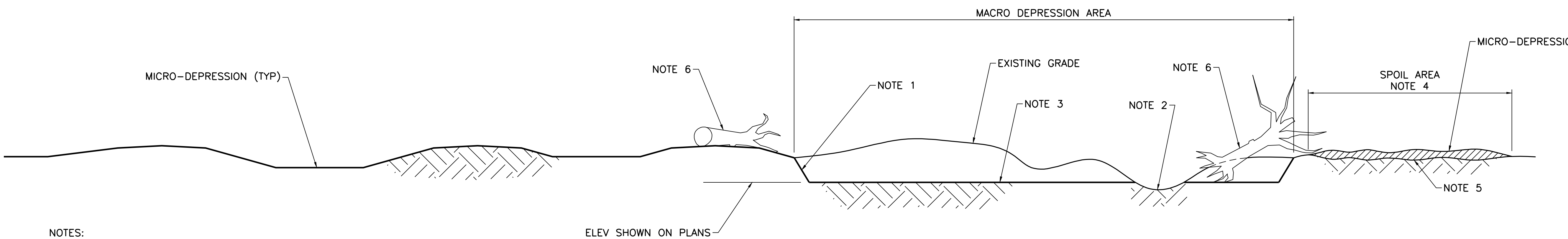


NOTES:

1. REFER TO PLANS FOR PLACEMENT OF EMBANKMENT FILL.
2. EXCESS SOIL MAY BE WASTED BY WIDENING THE BERM ON THE OPPOSITE SIDE OF THE EMERGENT WETLAND. WIDENED SECTIONS SHALL BE PARALLEL TO CENTERLINE OF BERM AND FINISHED BERM SHALL BE COVERED WITH TOPSOIL AND BE SLOPED AS SHOWN.
3. ESTABLISH VEGETATIVE COVER PER SPECIFICATIONS.

DETAIL 1 – BERM SECTION WITH TOPSOIL DRIVE SURFACE

NTS



NOTES:

1. NO SLOPE REQUIREMENT FOR EDGE OF EXCAVATED AREAS.
2. EXISTING GRADES LOWER THAN THE DESIGN BOTTOM ELEVATION SHOULD NOT BE FILLED.
3. TOPSOIL REPLACEMENT NOT REQUIRED IN EXCAVATED MACRO DEPRESSIONS EXCEPT IN THOSE NOTED ON THE CIVIL PLANS WHERE SEED BANK SOIL WILL BE PLACED.
4. REFER TO APPROVED SPOIL AREAS SHOWN ON CIVIL PLAN SHEETS.
5. TOPSOIL STRIPPING IS NOT REQUIRED IN SPOIL AREAS.
6. INSTALL WOODY DEBRIS PER SPECIFICATIONS.

DETAIL 2 – TYPICAL SECTION
EXCAVATED MACRO/MICRO DEPRESSION COMPLEX

NTS

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NORTH TEXAS MUNICIPAL WATER DISTRICT
LOWER BOIS D'ARC RESERVOIR PROGRAM
MITIGATION PROJECT
EMERGENT WETLANDS

STANDARD DETAILS I

NO.	ISSUE	BY	DATE		
				F&N JOB NO.	NTD15291
				DATE	APR 2016
				DESIGNED	RMP
				DRAWN	FJC
				REVISED	APAI
				CHECKED	TJN

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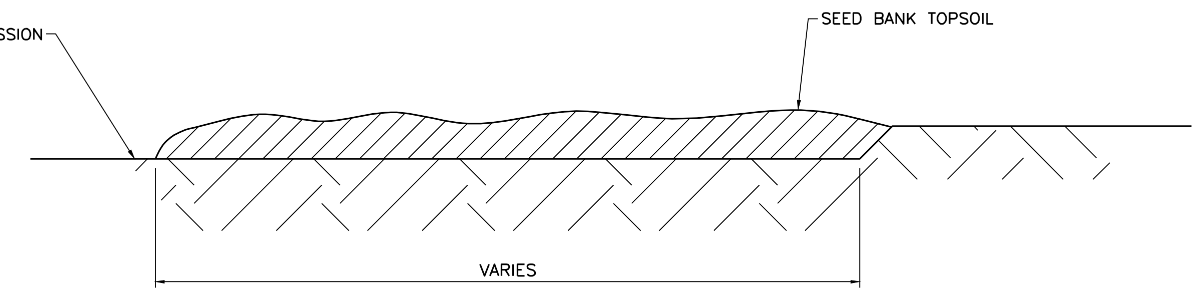
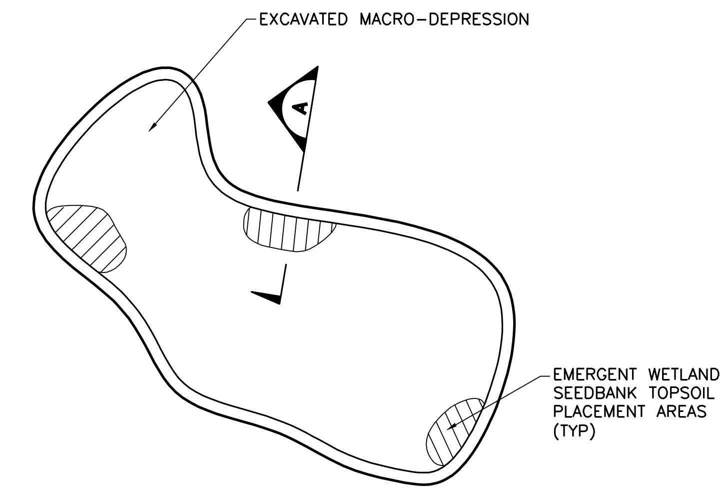
Plot Date: 10/31/2016 2:41 PM Plot By: rellis Filename: L:\Projects\0312\048-02\2-0 Wrk Prod\2-1 ACAD\SHEETFILES\GENERIC DETAILS\GN-DT-PL-01.dwg



SECTION A
NTS

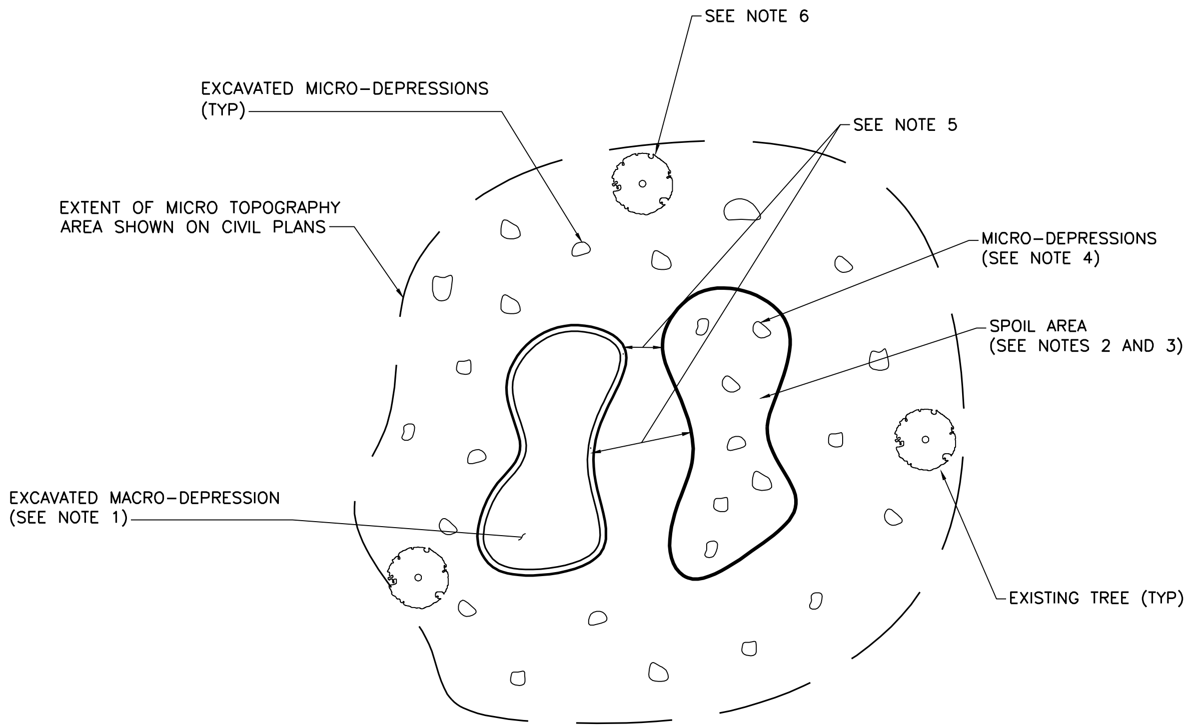


PLAN

NOTES:

1. FOR EXCAVATED MACRO DEPRESSIONS IDENTIFIED TO RECEIVE SEEDBANK TOPSOIL, PLACEMENT SHALL BE AS SHOWN. EACH AREA REPRESENTS ONE TRUCK LOAD. DUMP LOAD NEAR EDGE, THEN SPREAD OUT INTO DEPRESSION AWAY FROM THE EDGE. TRUCK LOADS SHOULD BE PLACED AT THE EXTREMITIES OF THE DEPRESSION AND ALSO NEAR THE CENTER. MACRO DEPRESSIONS IDENTIFIED FOR SEED BANK TOPSOIL ARE SHOWN IN SECTION 35 25 13.03.

DETAIL 4
SEED BANK TOPSOIL PLACEMENT
NTS



NOTES:

1. EXCAVATED MACRO DEPRESSIONS SHALL BE CONSTRUCTED PER CIVIL PLAN SHEETS.
2. SPOIL AREAS ARE TO BE LOCATED IMMEDIATELY ADJACENT TO EXCAVATED MACRO-DEPRESSIONS. REFER TO CIVIL PLAN SHEETS FOR APPROXIMATE LOCATIONS AND SHAPES.
3. FOOTPRINT OF SPOIL AREA SHALL BE APPROXIMATE SHAPES SHOWN IN CIVIL PLANS. HOWEVER EXTENT OF FOOTPRINT MAY BE FIELD ADJUSTED TO ACCOMMODATE ACTUAL VOLUME OF SPOIL WHILE MAINTAINING TOTAL SPREAD THICKNESS OF 0.5' TO 1.5', UNLESS A MINIMUM ELEV IS SHOWN ON THE CIVIL PLANS. SPOIL AREAS DO NOT NEED TO COMPLETELY DRAIN WATER AS SHALLOW PONDING IS ACCEPTABLE.
4. MICRO-DEPRESSIONS SHALL BE SHALLOW EXCAVATED DEPRESSIONS MEASURING APPROX 1 TO 2 EQUIPMENT WIDTHS BY 5' TO 20' LONG. SPOIL FROM MICRO DEPRESSIONS MAY BE DEPOSITED ADJACENT TO THE MICRO-DEPRESSION, SPREAD SPOIL TO NO MORE THAN 1' HIGH. MICRO-DEPRESSIONS SHALL BE PLACED IN RANDOM PATTERNS IN THE SPOIL AREA AND AROUND THE MACRO-DEPRESSION TO THE EXTENT LINE SHOWN ON THE PLANS. DO NOT PLACE MICRO-DEPRESSIONS WITHIN THE EXCAVATED MACRO-DEPRESSIONS.
5. DISTANCE BETWEEN SPOIL AREA AND EXCAVATION SHALL VARY.
6. AVOID PLACING MICRO-DEPRESSIONS WITHIN 10 FEET OF THE DRIP LINE OF EXISTING TREES GREATER THAN 6" DBH.

DETAIL 3
TYPICAL PLAN VIEW EXCAVATED MACRO/MICRO DEPRESSION COMPLEX
NTS

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NORTH TEXAS MUNICIPAL WATER DISTRICT
LOWER BOIS D'ARC RESERVOIR PROGRAM
MITIGATION PROJECT
EMERGENT WETLANDS

STANDARD DETAILS II

NO.	ISSUE	BY	DATE

F&N JOB NO.	NTD15291
DATE	APR 2016
DESIGNED	RMP
DRAWN	FJC
REVISED	APAI
CHECKED	TJN
FILE NAME	GN-DT-PL-02.dwg

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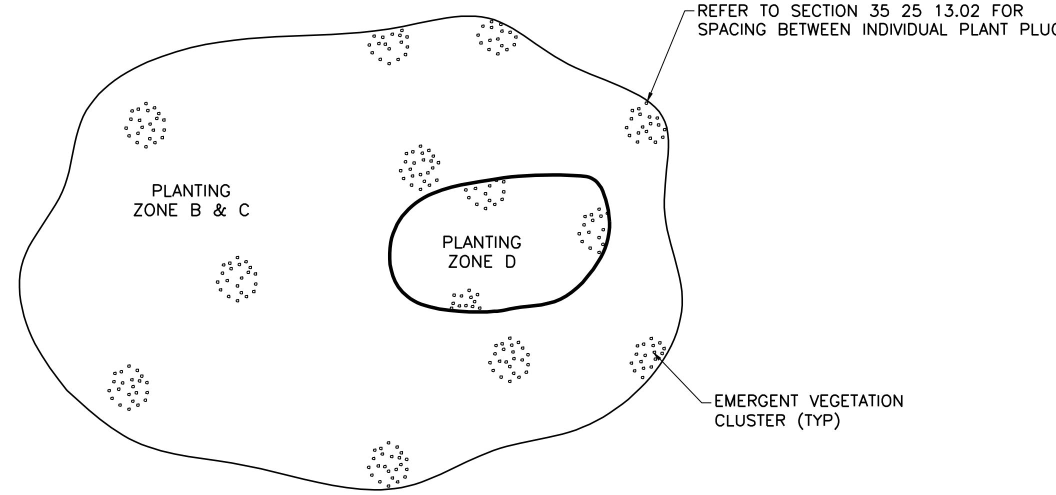
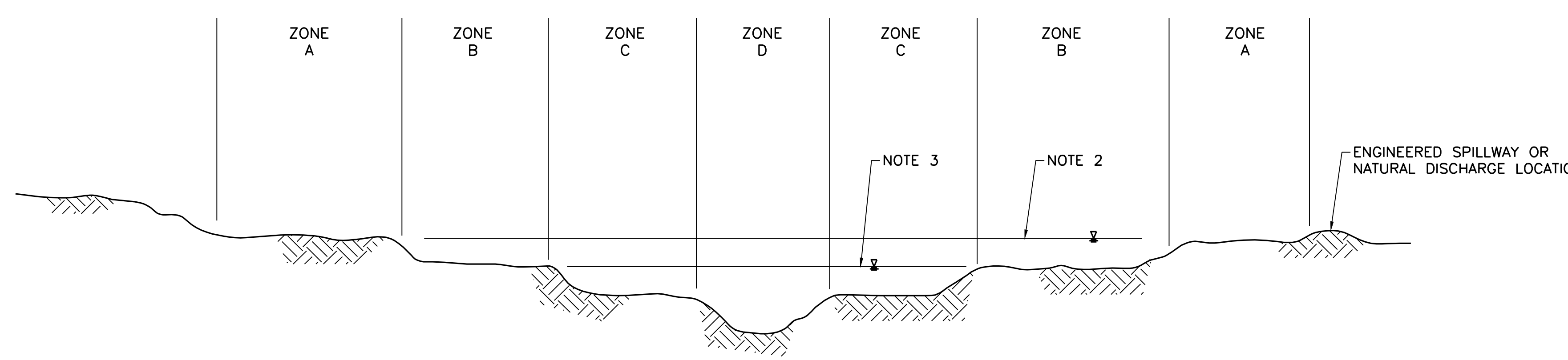
NOTES:

1. EACH CLUSTER TO CONTAIN ONE PLANT SPECIES WITH 8–20 PLANT PLUGS PER CLUSTER FOR PLANTING ZONES B AND C, AND 8–12 PLANT PLUGS FOR ZONE D.
2. RANDOMLY PLACE EACH CLUSTER WITHIN THE SPECIFIED PLANTING ZONE



EXAMPLE PLACEMENT OF EMERGENT WETLAND PLANT CLUSTERS

NTS



NOTES:

1. ZONE A = TEMPORARY FLOODED
   ZONE B = SEASONALLY FLOODED
   ZONE C = SEMI–PERMANENTLY FLOODED
   ZONE D = PERMANENTLY FLOODED
   SEE ALSO SECTION 31 25 13.02 FOR ADDITIONAL DETAILS.
2. COOL SEASON NORMAL WATER LEVEL.
3. WARM SEASON NORMAL WATER LEVEL.

AQUATIC VEGETATION PLANTING ZONES

NTS

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NORTH TEXAS MUNICIPAL WATER DISTRICT
LOWER BOIS D'ARC RESERVOIR PROGRAM
MITIGATION PROJECT
EMERGENT WETLANDS
STANDARD DETAILS IV

NO.	ISSUE	BY	DATE

F&N JOB NO. NTD15291
DATE APR 2016
DESIGNED RMP
DRAWN FJC
REVISED APAI
CHECKED TJN
FILE NAME GN-DT-PL-04.dwg

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Appendix J

Site Protection and Financial Assurance

DEED RESTRICTION

North Texas Municipal Water District ("NTMWD"), a conservation and reclamation district created under Article 16, Section 59, of the Texas Constitution, is the owner of the real property more particularly described and shown in Exhibit "A" (hereinafter the "Property") attached hereto and made a part hereof. The Property is approximately _____ acres and is also referenced in the "[Proposed] Lower Bois d'Arc Creek Reservoir Mitigation Plan." The Property is subject to the conditions of Department of the Army Section 404/Section 10 Permit Number _____, dated _____. One of the conditions of the referenced permit requires restrictions be placed on the deed for the Property for the purpose of providing appropriate compensatory mitigation for authorized adverse impacts to waters of the United States. The intent of this document is to assure that the Property will be retained, maintained, and protected in accordance with the "[Proposed] Lower Bois d'Arc Creek Reservoir Mitigation Plan. Activities, which may, in the future, be conducted within the Property that will affect the intended extent, condition and function of property for mitigation as provided in the "[Proposed] Lower Bois d'Arc Creek Reservoir Mitigation Plan.," must be coordinated with and approved by the United States Army Corps of Engineers ("USACE"), Tulsa District, Regulatory Branch, prior to initiation.

The parties to this agreement include the Property owner(s) who by their signature accept the third-party rights of enforcement herein and agree that the deed restrictions will be subject to the following conditions:

1) Use of Property

The Property, as more particularly described in "Exhibit A," is hereby dedicated for the purpose of compensatory mitigation for authorized adverse impacts to waters of the United States associated with the Lower Bois d'Arc Creek Reservoir project as authorized by Department of the Army Section 404/Section 10 Permit Number _____, dated _____. The Property shall not be disturbed except by those USACE-approved activities that would not adversely affect the intended extent, condition, and function of the mitigation area as provided in the "Proposed Lower Bois d'Arc Creek Reservoir Mitigation Plan." Any change, modification or disturbance of the dedicated Property not addressed in the "[Proposed] Lower Bois d'Arc Creek Reservoir Mitigation Plan," or a revision thereof, shall require prior written approval of the District Engineer, USACE, Tulsa District, or his/her duly authorized representative.

2) Term

These restrictions shall run with the land in perpetuity and be binding on all future owners, heirs, successors, administrators, assigns, lessees, or other occupiers and users. The owner must file this Deed Restriction of record with the County Clerks of Fannin County, Texas and Lamar County, Texas within 10 days of the date this document is signed and provide a copy of the recorded Deed Restriction to the USACE, Tulsa District within 30 days of filing.

3) Rights of Access and Entry

The USACE shall have the right to enter and go upon the Property for purposes of inspection, and to take actions including but not limited to scientific or educational observations and studies, and collection of samples.

4) Enforcement

In the event of a breach of the restrictions by the owner, or a third party working with the permission of or under the direction of the owner, the USACE must be notified immediately. If the USACE becomes aware of a breach of this Agreement, the USACE will notify the owner of the breach. The owner shall have thirty (30) days after receipt of such notice to undertake actions that are reasonably calculated to swiftly correct the conditions constituting the breach. If the owner corrects the conditions constituting the breach in a timely and reasonable manner, no further action is warranted or authorized. If the owner fails to initiate such corrective action within thirty (30) days or fails to complete the necessary corrective action, the USACE may undertake such actions, including legal proceedings, as are necessary to effect such corrective action. Any forbearance on the part of the USACE to exercise its rights in the event of a breach of the restrictions shall not be deemed or construed to be a waiver of their rights hereunder in the event of any subsequent failure of the Property owner to comply.

This notice of restriction does not grant any property rights or exclusive privileges.

EXECUTED this ________ day of ________, 20__.

NORTH TEXAS MUNICIPAL WATER DISTRICT

By: ___________________________________
___________, President

ATTEST:

____
___________, Secretary

STATE OF TEXAS §
§
COUNTY OF COLLIN §

This instrument was acknowledged before me on this ______ day of ____________, 201__, by ___________, President of North Texas Municipal Water District, a conservation and reclamation district and political subdivision of the State of Texas, on behalf of said conservation and reclamation district.

____
Notary Public, State of Texas
Printed Name of Notary:

____
My Commission Expires: _____________________

NORTH TEXAS MUNICIPAL WATER DISTRICT

Resolution No. ___-___

A RESOLUTION FOR SITE PROTECTION OF THE MITIGATION SITES ASSOCIATED WITH THE NORTH TEXAS MUNICIPAL WATER DISTRICT LOWER BOIS D'ARC CREEK RESERVOIR PROJECT

WHEREAS, NTMWD has proposed the Lower Bois D'Arc Creek Reservoir ("LBCR") Project, SWT Permit No. 14659, to the U.S. Army Corps of Engineers Tulsa District ("USACE") for a Clean Water Act Section 404 Permit ("404 Permit");

WHEREAS, pursuant to applicable regulatory guidance, USACE requires NTMWD to submit for approval a mitigation plan for the 404 Permit to compensate for authorized impacts to certain aquatic resources associated with the proposed LBCR Project;

WHEREAS, NTMWD submitted a mitigation plan to USACE for the LBCR Project ("Mitigation Plan") in November of 2016;

WHEREAS, NTMWD's proposed Mitigation Plan includes compensatory mitigation through a holistic, watershed and ecosystem approach to mitigation;

WHEREAS, to accomplish the mitigation approach, NTMWD has purchased property in Fannin and Lamar Counties to serve as the sites at which mitigation efforts will be concentrated to fulfill USACE-imposed mitigation requirements ("Mitigation Sites");

WHEREAS, following issuance of a 404 Permit for the LBCR that contains terms and conditions acceptable to NTMWD, and pursuant to the Mitigation Plan as finalized and approved by USACE ("Final Mitigation Plan"), NTMWD will own each Mitigation Site until the respective property has satisfied the performance standard requirements set forth in that Final Mitigation Plan;

WHEREAS, in accordance with the conditions of the issued 404 Permit, during NTMWD's ownership of the Mitigation Sites, USACE-approved deed restrictions will be imposed and enforced to allow for the implementation of the Final Mitigation Plan;

WHEREAS, in accordance with the conditions of the issued 404 Permit, NTMWD shall notify the USACE Tulsa District Engineer of any action affecting the Mitigation Sites, including a modification of the instrument, management plan, or long-term protection mechanism;

WHEREAS, once each Mitigation Site has satisfied the performance standard requirements set forth in that Final Mitigation Plan and in accordance with the issued 404 Permit for the LBCR, for long-term management of each Mitigation Site NTMWD will either: (1) enter into a conservation easement, or some other similar agreement approved by USACE, for the Mitigation Site with an USACE-approved third party easement holder/property manager; or (2) transfer title to that Mitigation Site to a federal or state management agency.

NOW, THEREFORE, THE BOARD OF DIRECTORS IN A REGULAR MEETING RESOLVES THAT:

1. Following issuance of a final 404 Permit for the LBCR that contains terms and conditions acceptable to NTMWD, NTMWD shall impose and enforce USACE-approved deed restrictions on the Mitigation Sites and any other land acquired by NTMWD to satisfy the compensatory mitigation requirements imposed for the LBCR Project.

2. The deed restrictions shall allow for the implementation of the compensatory mitigation proposed in the Final Mitigation Plan.

3. The deed restrictions shall contain a provision requiring 60-day advance notification to the USACE Tulsa District Engineer before any action is taken by NTMWD to void or modify Mitigation Site's instrument, management plan, or long-term protection mechanism, including transfer of title to, or establishment of any other legal claims over, the Mitigation Sites.

4. NTMWD shall record the USACE-approved deed restrictions with each of the Fannin and Lamar County clerks, as applicable, and provide a copy of the recorded deed restrictions to the USACE Tulsa District.

5. Once each Mitigation Site has satisfied the performance standard requirements set forth in that Final Mitigation Plan and in accordance with the final 404 Permit and Final Mitigation Plan, for long-term management of each Mitigation Site NTMWD will either: (1) enter into a conservation easement, or some other similar agreement approved by USACE, for the Mitigation Site with an USACE-approved third party easement holder/property manager; or (2) transfer title to that Mitigation Site to a federal or state management agency.

6. This Resolution shall take effect and be in full force and effect from and after the date of its adoption; provided, however, this Resolution shall terminate automatically and be of no further force or effect in the event a final 404 Permit for the LBCR that contains terms and conditions acceptable to NTMWD is not issued or, after issuance, in the event the final 404 Permit is modified or rescinded.

THIS RESOLUTION ADOPTED BY THE NTMWD BOARD OF DIRECTORS IN A REGULAR MEETING ON [MONTH AND DATE], 2017, IN THE ADMINISTRATIVE OFFICES OF THE NTMWD, WYLIE, TEXAS.

JOHN SWEEDEN, Secretary	TERRY SAM ANDERSON, President

(Seal)

NORTH TEXAS MUNICIPAL WATER DISTRICT

Resolution No. ___-___

A RESOLUTION FOR FINANCIAL ASSURANCES FOR COMPENSATORY MITIGATION ASSOCIATED WITH THE NORTH TEXAS MUNICIPAL WATER DISTRICT LOWER BOIS D'ARC CREEK RESERVOIR PROJECT

WHEREAS, NTMWD has proposed the Lower Bois D'Arc Creek Reservoir ("LBCR") Project, SWT Permit No. 14659, to the U.S. Army Corps of Engineers Tulsa District ("USACE") for a Clean Water Act Section 404 Permit ("404 Permit");

WHEREAS, applicable USACE regulatory guidance requires NTMWD to perform appropriate and practicable mitigation to compensate for authorized impacts to certain aquatic resources associated with the proposed LBCR Project;

WHEREAS, applicable USACE regulatory guidance allows USACE to require appropriate financial assurances to provide funding necessary to satisfy compensatory mitigation requirements and ensure mitigation success;

WHEREAS, USACE requires NTMWD to provide financial assurances for the mitigation proposed in the NTMWD mitigation plan for the LBCR Project ("Mitigation Plan");

WHEREAS, NTMWD has purchased property to serve as the site for mitigation activities as a financial assurance to USACE ("Mitigation Sites");

WHEREAS, USACE requires additional financial assurances to ensure the continuous protection of mitigation efforts on the Mitigation Sites for so long as such sites require funding; and

WHEREAS, NTMWD agrees to provide appropriate long-term financial assurances that NTMWD will fund the Mitigation Sites and mitigation activities performed thereon as long as a final 404 Permit is issued and effective for the LBCR Project as proposed or modified by NTMWD, including funding for any period after which NTMWD either: (1) enters into a conservation easement, or some other similar agreement approved by USACE, for each Mitigation Site with an USACE-approved third party easement holder/property manager; or (2) transfers title to each of the Mitigation Sites to a federal or state management agency.

NOW, THEREFORE, THE BOARD OF DIRECTORS IN A REGULAR MEETING RESOLVES THAT:

1. NTMWD shall provide funding in the amount necessary to satisfy compensatory mitigation requirements associated with the LBCR Project as outlined in the Mitigation Plan, as such plan is finalized and approved by the USACE ("Final Mitigation Plan"), and as required by the final issued 404 Permit.

2. NTMWD shall ensure compensatory mitigation funding for the LBCR Project is not withdrawn, reduced, delayed, or otherwise impaired or modified as a result of the transfer of title of the Mitigation Sites to a federal or state management agency or to a third party managing the Mitigation Sites under a conservation easement, or some other similar agreement approved by USACE.

3. This Resolution shall take effect and be in full force and effect from and after the date of its adoption; provided, however, this Resolution shall terminate automatically and be of no further force or effect in the event a final 404 Permit for the LBCR that contains terms and conditions acceptable to NTMWD is not issued or, after issuance, in the event the final 404 Permit is modified or rescinded.

THIS RESOLUTION ADOPTED BY THE NTMWD BOARD OF DIRECTORS IN A REGULAR MEETING ON [MONTH AND DATE], 2017, IN THE ADMINISTRATIVE OFFICES OF THE NTMWD, WYLIE, TEXAS.

JOHN SWEEDEN, Secretary	TERRY SAM ANDERSON, President

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