# APPENDIX E-10 Dissolved Oxygen Mitigation Plan

*Pensacola Adaptive Mitigation Plan*

OWRB

the water agency

## Introduction

In an effort to mitigate for low dissolved oxygen (DO) in the tailraces of the Pensacola Dam, the GRDA has adopted an adaptive mitigation plan in conjunction with the OWRB. This plan was adapted after multi-year studies into the causes and extent of low DO in this area, as well as the effectiveness of mitigation scenarios. The following is the plan that has been accepted as a result of these studies and review by interested governmental and environmental agencies.

## Pensacola Adaptive Mitigation Plan (AMP)

Three multi-parameter instruments with dissolved oxygen (DO) probes will be installed on the county road bridge, aka Langley Bridge, approximately 1000 meters downstream of the Pensacola Dam. The probes are located near the right and left edges of water as well as midstream. These probes will be used to manage the Pensacola AMP, with any individual probe on the bridge capable of activating a mitigation response. In an effort to facilitate the response process, an e-mail alert system is set up to notify both operators and other interested parties. When any individual probe indicates a DO mg/L reading below any of the action limits listed below, the NexSens iChart 6.0 software housed at the Oklahoma Water Resources Board (OWRB) offices sends out an alarm email to all necessary personnel at Grand River Dam Authority (GRDA), Federal Energy Regulatory Commission (FERC), Oklahoma Department of Wildlife Conservation (ODWC), United States Fish and Wildlife (USFW), and the OWRB. This email indicates the most recently measured DO concentration and states the appropriate response according to the Pensacola AMP. Once measurements rise above the action limit, the system sends out an alert notification[3] indicating that target values have been achieved.

The action limit will be set at the Oklahoma Water Quality Standards (OWQS) criterion of 6 mg/L from 10/16 though 6/15 and at 5 mg/L from 6/16 through 10/15. Once the action limit is reached[1], according to any one of the Langley Bridge DO probes, one turbine will begin running at 20% wicket gate (~320 cfs) with full aeration. Once a release is started, it will continue until the average DO value exceeds the criterion, but, depending on lake level conditions in Grand Lake and Lake Hudson, will continue for three to eight hours. A second action limit will be set at 4.0 mg/L. If the second action limit is reached[2], the first turbine will be upped to 25% wicket gate (~ 430 cfs) and will continue for a minimum of 2 hours. This operational plan will run year round.

Example Email Alarm and Alert Notifications:

*First Action Limit Email:*
*[1]ODO (mg/L) at Langley bridge is at 4.29. Open one turbine to a 20% wicket gate position and run for a minimum of 6 hours. If after 6 hours no additional alarms have been received, the turbine may be closed. Note: it is likely you will receive emails from the other probes below Pensacola dam, Do Not open additional turbines. Only one turbine is used for the first stage of the mitigation plan. If you have any questions please call Lance Phillips (Work 405-xxx-xxxx Cell 405-530-xxxx) or Monty Porter (Work 405-530-xxxx Cell 405-xxx-xxxx)*

*Second Action Limit Email:*

*[2]ODO (mg/L) at Langley bridge is at 3.65. Open the turbine from 20% wicket gate to a 25% wicket gate position and run for a minimum of 2 hours. If after 2 hours, no additional alarms have been received, the turbine may be reset to 20% wicket gate position. Note: it is likely you will receive emails from the other probes below Pensacola dam, Do Not open additional turbines. Only one turbine is used for the first stage of the mitigation plan. If you have any questions please call Lance Phillips (Work 405-530-xxxx Cell 405-xxx-xxxx) or Monty Porter (Work 405-530-xxxx Cell 405-xxx-xxxx)*

*Resolution Email:*
*[3]ODO (mg/L) at Langley bridge is at 5.39. This value indicates that dissolved oxygen (DO) is currently meeting WQ standards. Continue mitigation plan outlined in the last alarm email.*

References

Dennis, A. Floodplain Analysis of the Neosho River Associated with Proposed Rule Curve Modifications for Grand Lake O' the Cherokees. Master's thesis, University of Oklahoma, 2014.

Oklahoma Water Resource Board. 2012. Sample Years 2006-2011 Reports: "Dissolved Oxygen Monitoring Below Pensacola Dam (Grand Lake) and Kerr Dam (Hudson Lake) for the Grand River Dam Authority (GRDA) Federal Energy Regulatory Commission (FERC) Permit". Oklahoma City, OK.

Oklahoma Water Resources Board. 2015. Pensacola Mitigation Testing Report 2014. Oklahoma City, OK.

**APPENDIX E-11 Wetland and Riparian Habitat Study Report**

# Wetlands and Riparian Habitat Study for the Pensacola Hydroelectric Project (FERC Project No. 1494) Craig, Delaware, Mayes, and Ottawa Counties, Oklahoma

**Prepared for:**

**Grand River Dam Authority**

**Prepared by:**

**Horizon Environmental Services, Inc.**

# TABLE OF CONTENTS



# LIST OF TABLES



# ATTACHMENTS

# 1.0 INTRODUCTION

Horizon conducted an updated Wetlands and Riparian Habitat Study (Study) for the Grand River Dam Authority (GRDA) on the Grand Lake O' the Cherokees (Grand Lake) located in Craig, Delaware, Mayes, and Ottawa counties, Oklahoma, to evaluate the effects of anticipated operations of the Pensacola Hydroelectric Project (Project) operations to wetlands and riparian habitat areas based on the inundation maps generated by the Comprehensive Hydraulic Model (CHM).

Inundation maps generated by the CHM were overlaid onto preliminary base maps that were developed using National Wetlands Inventory and other existing wetlands information and information related to the riparian habitat areas and Wildlife Management Areas (WMAs). The maps delineated the median areas inundated under baseline operations and the median areas to be inundated under anticipated operations during the growing season along with the current Project boundary. Horizon assessed the potential impacts to wetlands, riparian areas, and WMAs by identifying the extent, duration, and seasonality (timing) of inundation occurring in the Project boundary.

# 2.0 STUDY YEAR TWO ACTIVITIES

## 2.1 DATABASE CONTENTS

Project operations influence water levels of Grand Lake. These water level fluctuations have the potential to affect aquatic vegetation, wetlands, and riparian habitat, which can be important habitats for fish and wildlife. As such, Horizon was contracted to conduct a wetlands and riparian habitat study to quantify and refine the potential impacts associated with the anticipated change in Project operations under the new Federal Energy Regulatory Commission (FERC) license for the Project. Horizon used the National Wetlands Inventory (NWI) and CHM data to identify, display, and describe the composition of wetland and riparian communities (within the study area) in a geographic information systems (GIS) database. For this study, CHM data were utilized to determine the median elevation for the baseline operation and the anticipated operation of the project during the growing season (March 30 to November 2) to develop wetland and riparian inundation areas.

GRDA currently operates the Project's conservation pool to target reservoir surface elevations to serve multiple purposes, including hydropower generation, water supply, public recreation, and wildlife enhancement. This operational scheme, referred to as the Project's rule curve, is required by Article 401 of the license. Over the years, the rule curve has been adjusted several times by the FERC. Even during the existing license term, the Article 401 rule curve requirements have been amended several times. As recently as 2015, GRDA was required by the FERC to target a low elevation of 741 feet Pensacola Datum (PD) during the latter part of the growing season beginning September 1 through mid-October of each year. The recent operations of the Project as modified by the FERC from time to time are generally considered in the established baseline operation. Under baseline Project operations, the median elevation as determined by the CHM has been 742.92 feet PD.

Under the Project's new license, GRDA does not anticipate Project operations in accordance with a rule curve. In 2019, Congress enacted the National Defense Authorization Act for Fiscal Year 2020 (NDAA 2020), which, among other things, granted GRDA autonomy in establishing reservoir levels within Grand Lake:

> "(A) IN GENERAL.—Except as may be required by the Secretary [of the Army] to carry out responsibilities under section 7 of the Flood Control Act of 1944 (33 U.S.C. 709),

the Commission or any other Federal or State agency shall not include in any license for the project any condition or other requirement relating to—

(i) surface elevations of the conservation pool; or

(ii) the flood pool (except to the extent it references flood control requirements prescribed by the Secretary).

(B) EXCEPTION.—Notwithstanding subparagraph (A), the project shall remain subject to the Commission's rules and regulations for project safety and protection of human health."

Pub. L. No. 116-92, § 7612(b)(2), 133 Stat. 1198, 2312 (2019).

Based on authority granted to GRDA under NDAA 2020 and informed by the first season of relicensing studies, GRDA has determined that the following anticipated operational parameters will apply during the new license term:

1. GRDA will no longer utilize a rule curve with seasonal target elevations.

2. GRDA will maintain the conservation pool between elevations 742 and 745 feet PD for purposes of normal hydropower operations. While hydropower operations may occur when water surface elevations are outside this range (e.g., maintenance drawdowns and high-flow events), GRDA expects to generally maintain water surface elevations between 742 and 745 feet PD during normal Project operations.

3. Instead of managing the Project to target a specified seasonal elevation, GRDA's new operations may fluctuate reservoir levels within the elevational range of 742 and 745 feet PD, for purposes of responding to grid demands, market conditions, and the public interest, such as environmental and recreational considerations.

4. GRDA will continue to adhere to the Corps' direction on flood control operations in accordance with the Water Control Manual, with no changes to existing operations.

These anticipated Project operations under the new FERC license will result in a water level fluctuation between 742 to 745 feet PD, with a CHM predicted median elevation of 743.46 ft PD during the growing season.

To meet the objectives of this study, median wetland and riparian inundation levels during baseline operations and anticipated operations were compared to the wetland and habitat types from the NWI database. The NWI database was clipped below the baseline median elevation to remove erroneous areas of open water. The analysis of the wetland acres that may be affected was then assessed between the baseline median and anticipated median inundation levels during the growing season.

To determine the net change (increase) in wetland, riparian habitats, and WMAs between the baseline and anticipated median operational levels, Horizon assessed 160.78 acres of wetland habitat types as defined by the NWI map layer and as reported in Table 1. As provided in Table 2, the study area contains 2.70 acres of riparian habitat types. As reported in Table 3, the study area contains 28.54 acres of WMAs. These data are also displayed graphically in a map set that is included in Attachment A. It should be noted that the wetland and riparian areas that are listed in the tables below and illustrated in Attachment A are difficult to display due to the large geographical scope of the study and the narrow area between the baseline and anticipated operation water line. The majority of the water line difference, in a horizontal direction, between the baseline and anticipated operation ranges between a few to several feet wide along the lake shoreline.

**Table 1. Wetland Composition within Study Area**

| Wetland Habitat Type | Acres Within Study Area |
|---|---|
| **Freshwater Emergent Wetlands** | |
| Palustrine, Emergent, Persistent, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PEM1/SS1Ch) | 0.23 |
| Palustrine, Emergent, Persistent, Temporary Flooded (PEM1A) | 0.02 |
| Palustrine, Emergent, Persistent, Seasonally Flooded (PEM1C) | 3.61 |
| Palustrine, Emergent, Persistent, Seasonally Flooded, Diked/Impounded (PEM1Ch) | 2.02 |
| **Total Freshwater Emergent Wetlands Acres** | **5.88** |
| **Freshwater Forested Wetland** | |
| Palustrine, Forested, Broad-Leaved Deciduous, Emergent, Persistent, Seasonally Flooded, Diked/Impounded (PFO1/EM1Ch) | 0.80 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded (PFO1/SS1A) | 0.55 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded, Diked/Impounded (PFO1/SS1Ah) | 3.33 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded (PFO1/SS1C) | 0.36 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PFO1/SS1Ch) | 22.12 |
| Palustrine, Forested, Broad-Leaved Deciduous, Unconsolidated Bottom, Semi-permanently Flooded, Diked/Impounded (PFO1/UBFh) | 3.28 |
| Palustrine, Forested, Broad-Leaved Deciduous, Temporary Flooded (PFO1A) | 11.32 |
| Palustrine, Forested, Broad-Leaved Deciduous, Temporary Flooded, Diked/Impounded (PFO1Ah) | 7.84 |
| Palustrine, Forested, Broad-Leaved Deciduous, Seasonally Flooded (PFO1C) | 9.52 |

| Wetland Habitat Type | Acres Within Study Area |
|---|---|
| Palustrine, Forested, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PFO1Ch) | 51.31 |
| Palustrine, Forested, Broad-Leaved Deciduous, Semi-permanently Flooded, Diked/Impounded (PFO1Fh) | 7.98 |
| Palustrine, Forested, Dead, Broad-Leaved Deciduous, Semi-permanently Flooded, Diked/Impounded (PFO5/1Fh) | 0.83 |
| **Total Freshwater Forested Wetland Acres** | **119.24** |
| **Freshwater Scrub-Shrub Wetlands** | |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Emergent, Persistent, Temporary Flooded, Ditched (PSS1/EM1Ad) | 0.37 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Emergent, Persistent, Seasonally Flooded (PSS1/EM1C) | 0.73 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Emergent, Persistent, Seasonally Flooded, Diked/Impounded (PSS1/EM1Ch) | 6.13 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Unconsolidated Bottom, Semi-permanently Flooded, Diked/Impounded (PSS1/UBFh) | 0.13 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded (PSS1A) | 0.59 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded, Diked/Impounded (PSS1Ah) | 0.11 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded (PSS1C) | 1.22 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PSS1Ch) | 15.13 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Semi-permanently Flooded (PSS1F) | 0.07 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Semi-permanently Flooded, Diked/Impounded (PSS1Fh) | 9.21 |
| **Total Freshwater Scrub-Shrub Wetlands Acres** | **33.69** |
| **Freshwater Open Water** | |
| Palustrine, Unconsolidated Bottom, Permanently Flooded, Diked/Impounded (PUBHh) | 1.84 |
| Palustrine, Unconsolidated Bottom, Permanently Flooded, Excavated (PUBHx) | 0.13 |
| **Total Freshwater Open Water Acres** | **1.97** |
| **Total Wetland Acres Within Study Area** | **160.78** |

**Table 2. Riparian Composition within Study Area**

| Riparian Habitat Type | Acres Within Study Area |
|---|---|
| Riparian, Lotic, Forested, Deciduous (Rp1FO6) | 2.49 |
| Riparian, Lentic, Forested, Deciduous (Rp2FO6) | 0.21 |
| **Total Riparian Habitat Acres** | **2.70** |

**Table 3. Wildlife Management Areas within Study Area**

| WMA Name | Acres Within Study Area |
|---|---|
| Connors Bridge | 0.22 |
| Mallard Point | 13.4 |
| West Spring River | 14.92 |
| **Total WMA Acres** | **28.54** |

After the updated wetland and riparian habitat study was submitted and presented, FERC staff provided comments for the study. Below are the wetland and riparian habitat study comments and requested information:

> *"(a) existing wetland acreage by habitat type within elevation bands 741 feet to 742 feet PD, 742 feet to 743 feet PD, 743 feet to 744 feet PD, and 744 feet to 745 feet PD;"*

**Table 4. Wetland Habitat Types within Elevation Bands**

| Wetland Habitat Type | Acres Within Elevation Bands |
|---|---|
| **Elevation Band 741 feet to 742 feet PD** | |
| Freshwater Emergent Wetland | 38.99 |
| Freshwater Forested Wetland | 115.88 |
| Freshwater Scrub-Shrub Wetland | 39.51 |
| Freshwater Open Water | 0.07 |
| **Total Wetlands Acres (between 741 feet – 742 feet PD)** | **194.45** |
| | |
| **Elevation Band 742 feet – 743 feet PD** | |
| Freshwater Emergent Wetland | 12.28 |
| Freshwater Forested Wetland | 134.02 |
| Freshwater Scrub-Shrub Wetland | 41.60 |
| Freshwater Open Water | 0.45 |
| **Total Wetlands Acres (between 742 feet – 743 feet PD)** | **188.35** |
| | |
| **Elevation Band 743 feet – 744 feet PD** | |
| Freshwater Emergent Wetland | 11.54 |
| Freshwater Forested Wetland | 214.81 |
| Freshwater Scrub-Shrub Wetland | 72.46 |
| Freshwater Open Water | 0.47 |
| **Total Wetlands Acres (between 743 feet – 744 feet PD)** | **299.28** |
| | |
| **Elevation Band 744 feet – 745 feet PD** | |
| Freshwater Emergent Wetland | 15.37 |

| | |
|---|---:|
| Freshwater Forested Wetland | 358.87 |
| Freshwater Scrub-Shrub Wetland | 89.73 |
| Freshwater Open Water | 7.56 |
| **Total Wetlands Acres (between 744 feet – 745 feet PD)** | **471.53** |

A detailed table of the wetland habitat types that were derived from the NWI data for each of the individual elevation bands is provided in Attachment B.

> *"(b) daily average low water elevation during the growing season for baseline (i.e., pre-2015 operating rules) and proposed conditions;"*

The daily average low water elevation during the growing season for the baseline operation is 742.78 feet PD and the anticipated operation is 743.33 feet PD. These values were calculated from the hourly model output as the median of the daily (midnight to midnight) minimum values for each day within the growing season (March 30 to November 2) between November 1, 2004 and November 1, 2019.

*"and (c) average total days of inundation, during the growing season by the elevation bands identified for baseline and proposed conditions."*

**Table 5. Average Total Days of Inundation During the Growing Season by Elevation Bands**

| Elevation Bands | Baseline Operation | Anticipated Operation |
|---|---|---|
| Elevation Band 741 to 742 feet PD | 53 | 7 |
| Elevation Band 742 to 743 feet PD | 36 | 84 |
| Elevation Band 743 to 744 feet PD | 49 | 43 |
| Elevation Band 744 to 745 feet PD | 31 | 34 |

## 2.2 Discussion and Conclusion

According to NWI and GRDA data, 160.78 acres of wetlands, 2.70 acres of riparian habitat, and 28.54 acres of WMAs were identified in the study area and will be periodically inundated more often under the anticipated operations than under the baseline operations (i.e, the median elevation is expected to be slightly higher under the anticipated operations than it is under current, baseline operations).

In some areas of the reservoir far upstream, the stream channel had migrated to one side or the other from the location mapped in the original NWI data. The majority of these areas occur in portions of the reservoir where the median elevation differences are indistinguishable between the baseline and anticipated operations. Therefore, no major deviations from the preliminary wetland cover types required ground-truthing.

Overall, GRDA's anticipated operations under the new license will result in water level fluctuations ranging from 742 to 745 feet PD (or 3 feet), whereas baseline operations have resulted in frequent water level fluctuations ranging from 741 to 745 feet PD (or 4 feet). As a result, fewer overall impacts to wetlands, riparian areas, and WMAs are expected under the anticipated operations than under baseline operations. Additional wetlands will experience permanent inundation between 741 and 742 feet PD under the anticipated operations.

Historically, baseline operations enforced by the rule curve frequently resulted in an operational range between 741 and 745 feet PD (4 feet). In comparison, the median baseline and anticipated reservoir elevations during the growing season (March 30 to November 2) yield elevations of 742.92 feet PD and 743.46 feet PD, respectively. This increase of 0.54 feet is not likely to yield significant changes to wetlands in the affected areas. Furthermore, the comparisons between the baseline and anticipated operations also include the historical and now-abandoned fall drawdown of the reservoir to 741 feet PD to expose mudflats.

Using historical data to represent normal events, including 1-year flood events, the output of the CHM produced a comparison of the median water surface elevation (WSEL) under baseline operations versus the median WSEL under anticipated operations for the growing season (March 30 to November 2). The mapped output when overlaid on other sources of data, including the NWI data, showed very small differences along shorelines that could result in a net increase or conversion to other types of wetlands, because the anticipated operations have a higher median elevation during the growing season than do the baseline operations.

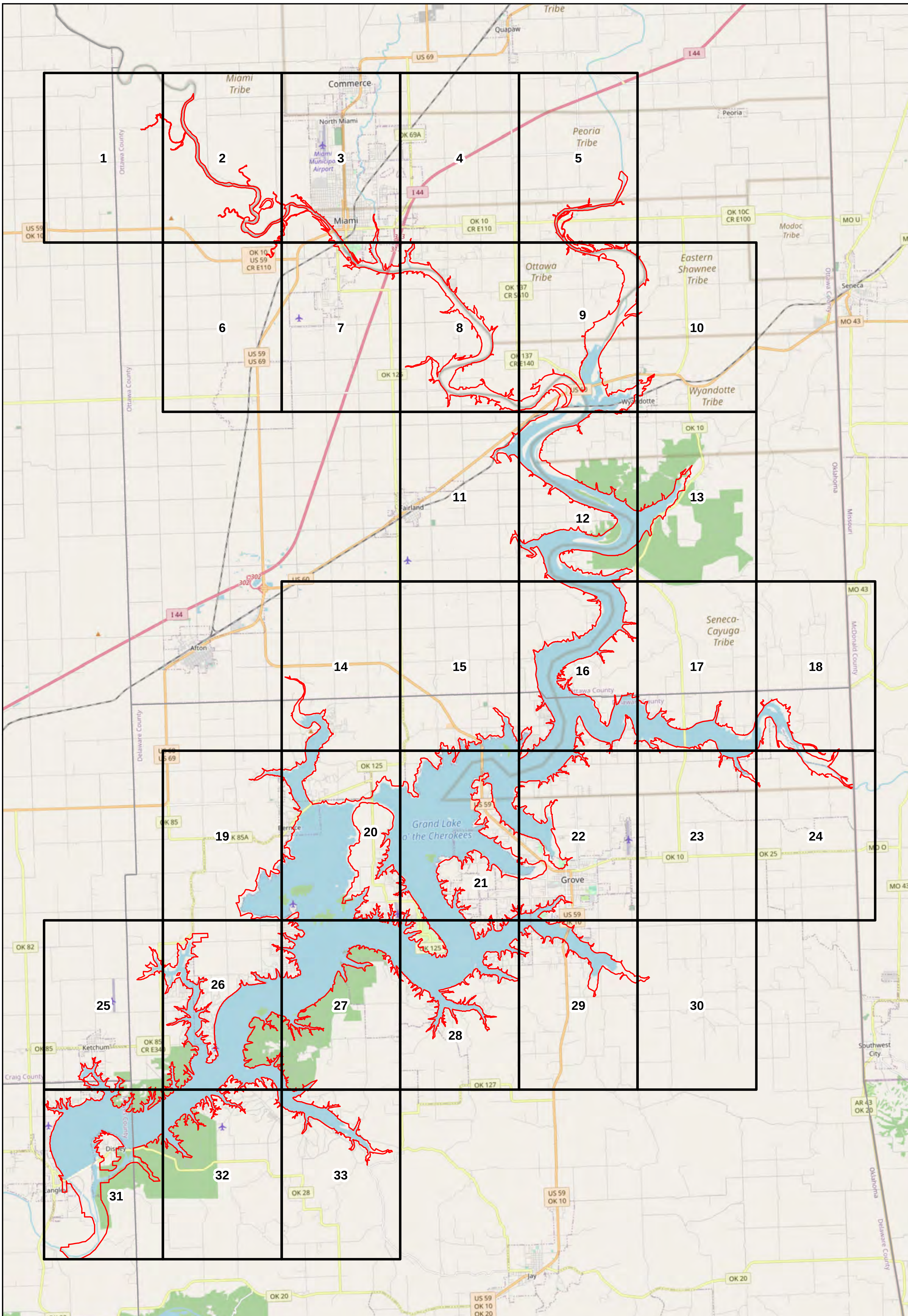
# 3.0 REFERENCES CITED

Cowardin, L., V. Carter, and E. LaRoe. Classification of Wetlands and Deepwater Habitats of the United States. US Fish and Wildlife Service publication. Published 1979.

(Esri) Environmental Systems Research Institute. World Imagery, <https://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9>. Imagery date 29 March 2021.

# ATTACHMENT A

Wetland and Riparian Inundation Changes Map Set

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| Source: | OSM, 2022 |

Wetland & Riparian
Inundation Changes
Overall Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

**Legend**

- County Boundary
- Project Boundary
- 1:24,000-scale Map Sheet

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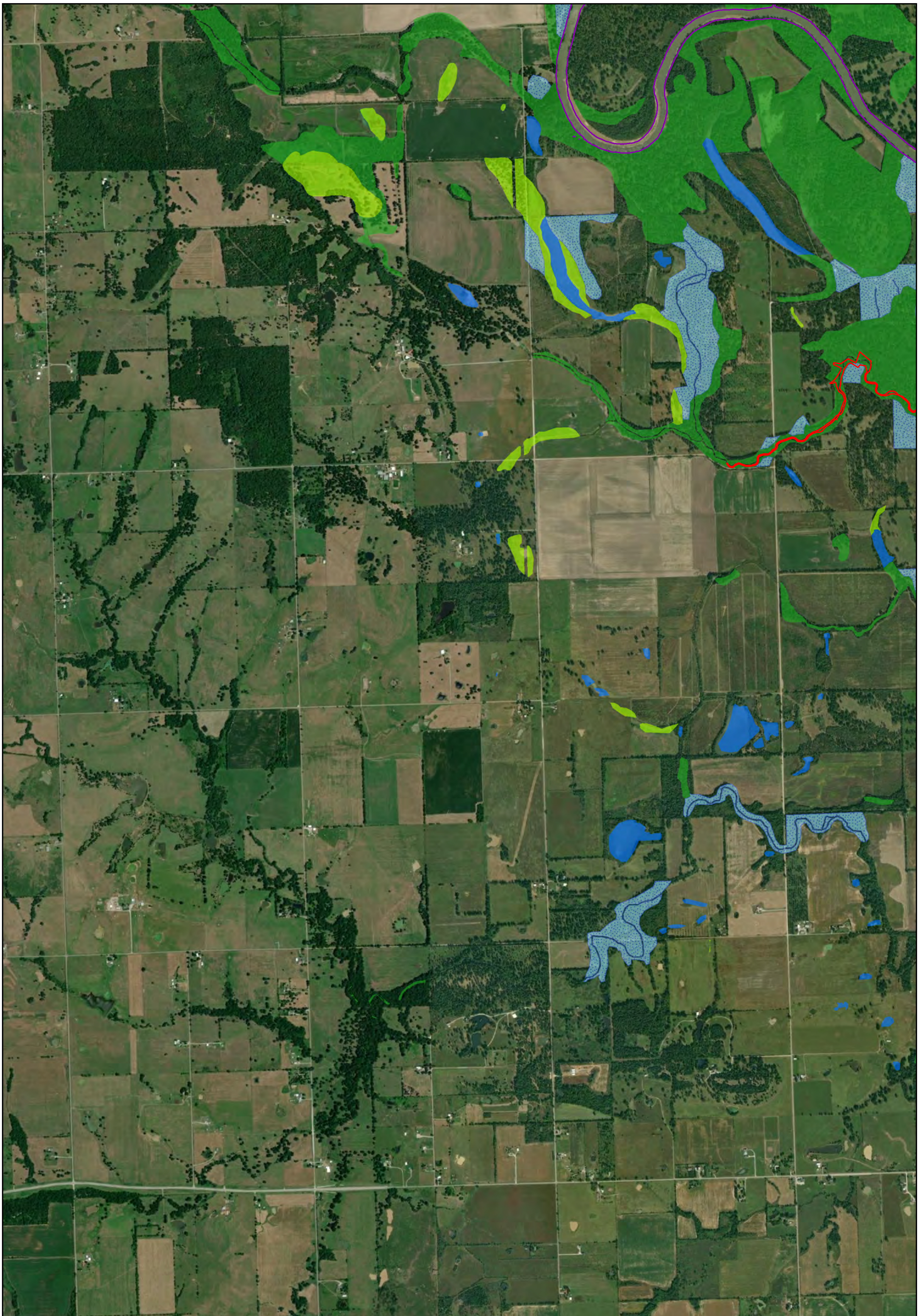

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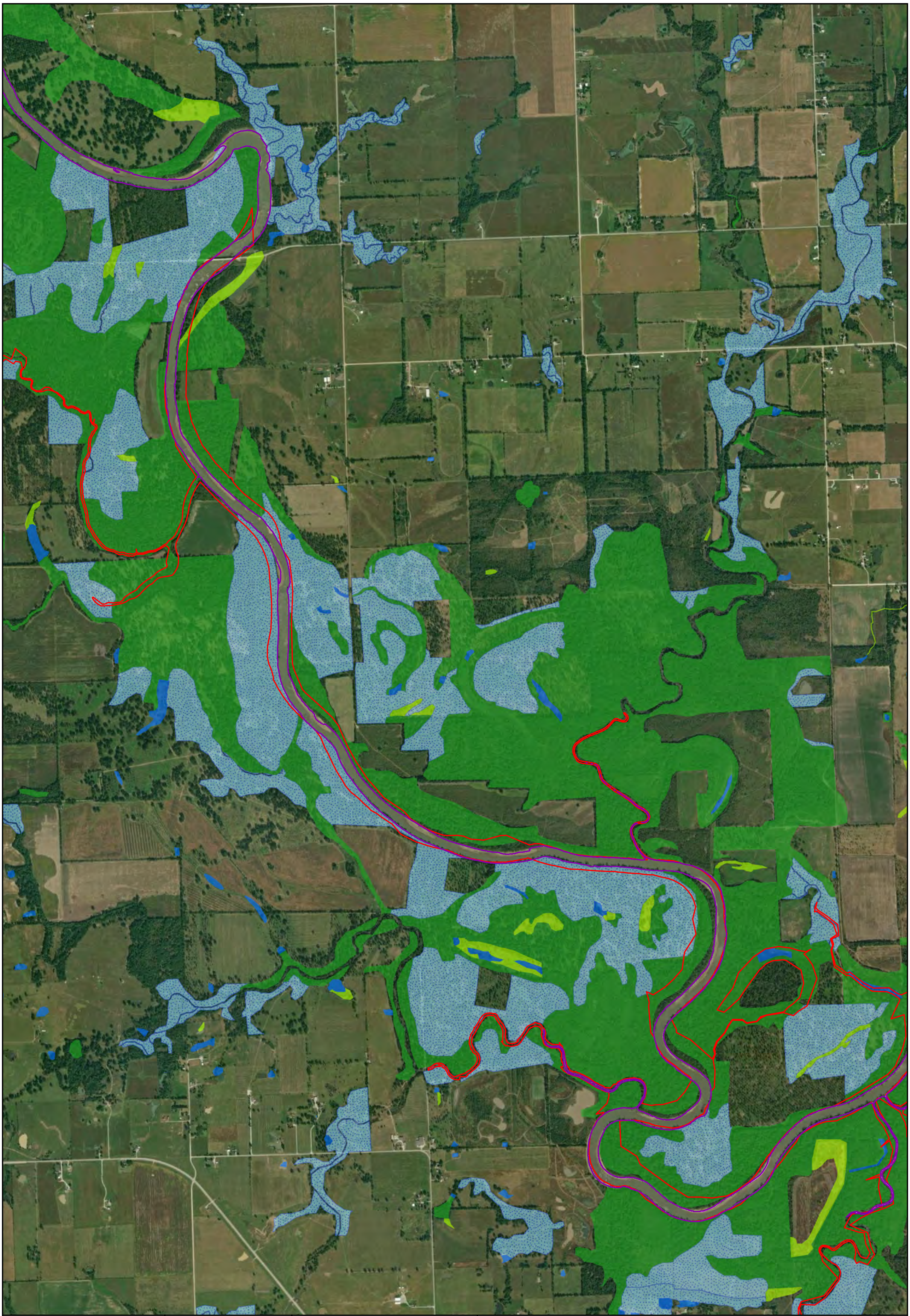

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**Figure 2**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- USFWS Riparian Habitat
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

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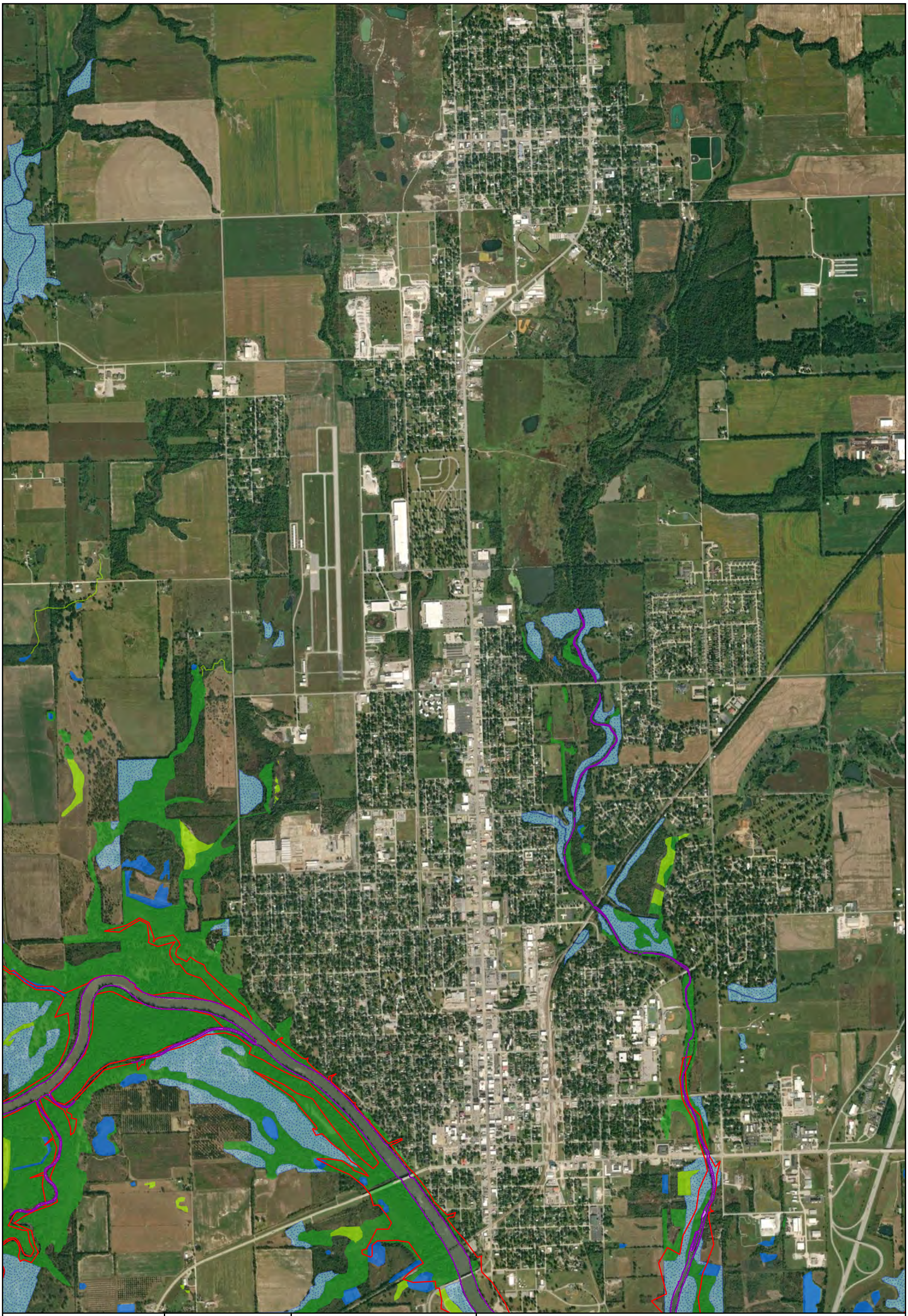

**Figure 3**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

Horizon™ Environmental Services, Inc.

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| Date: | 09/14/2022 |
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| Source: | Esri, 2021 |

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**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- USFWS Riparian Habitat
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

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Horizon Environmental Services, Inc.

**Figure 4**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- USFWS Riparian Habitat
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

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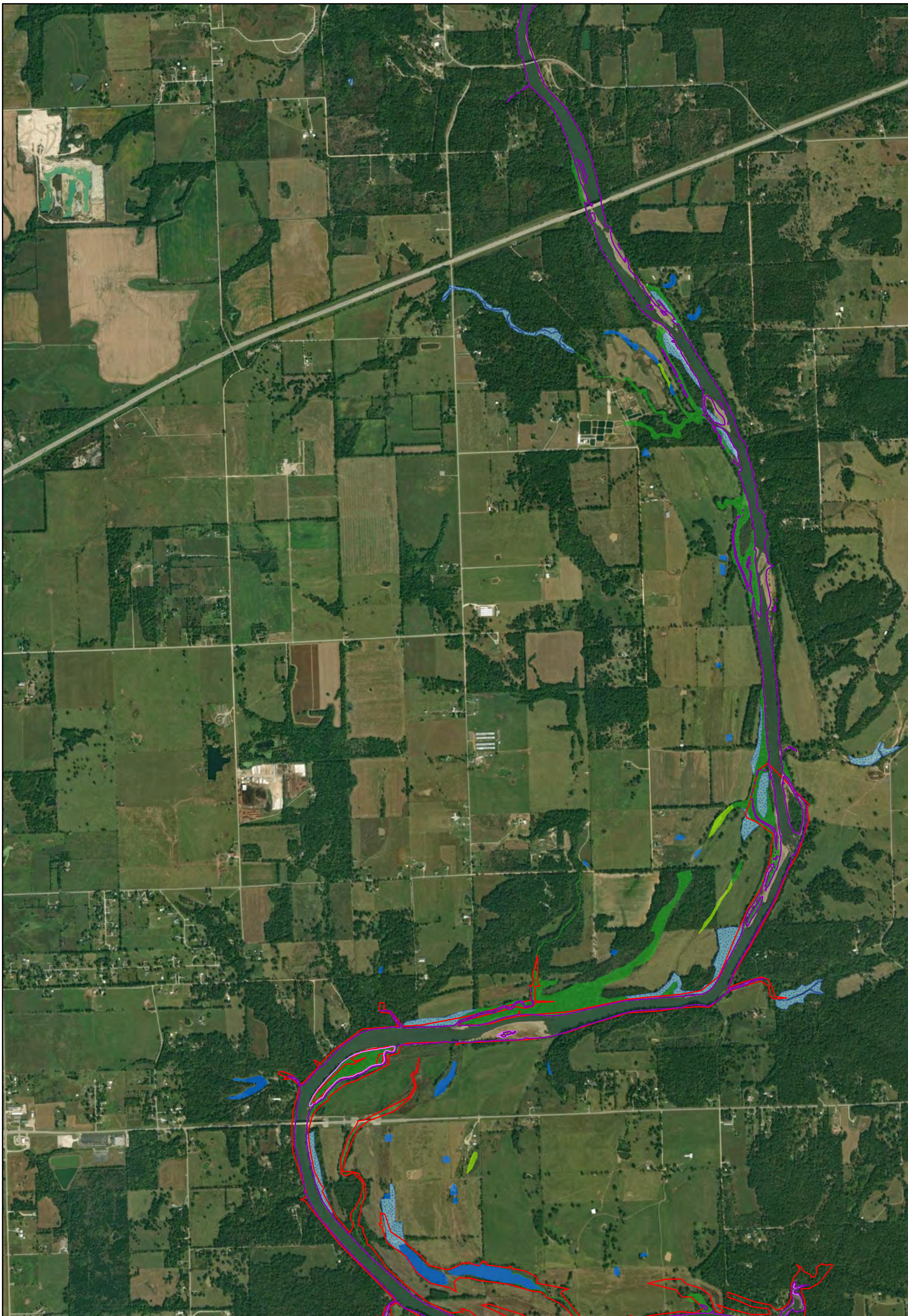

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Environmental Services, Inc.

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Feet

**Figure 5**

Wetland & Riparian
Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- USFWS Riparian Habitat
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

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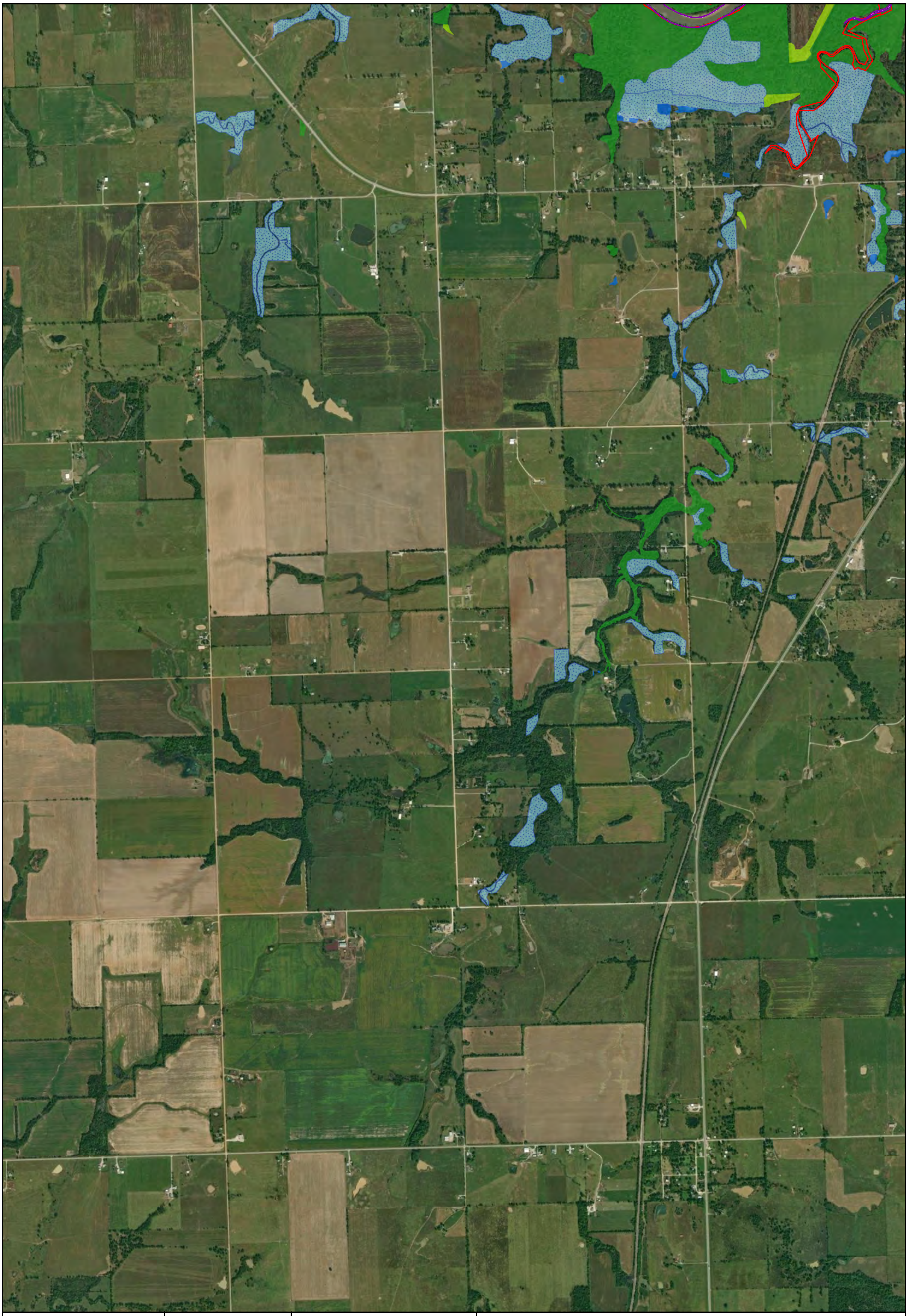



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| Source: | Esri, 2021 |

**Figure 6**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- USFWS Riparian Habitat
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

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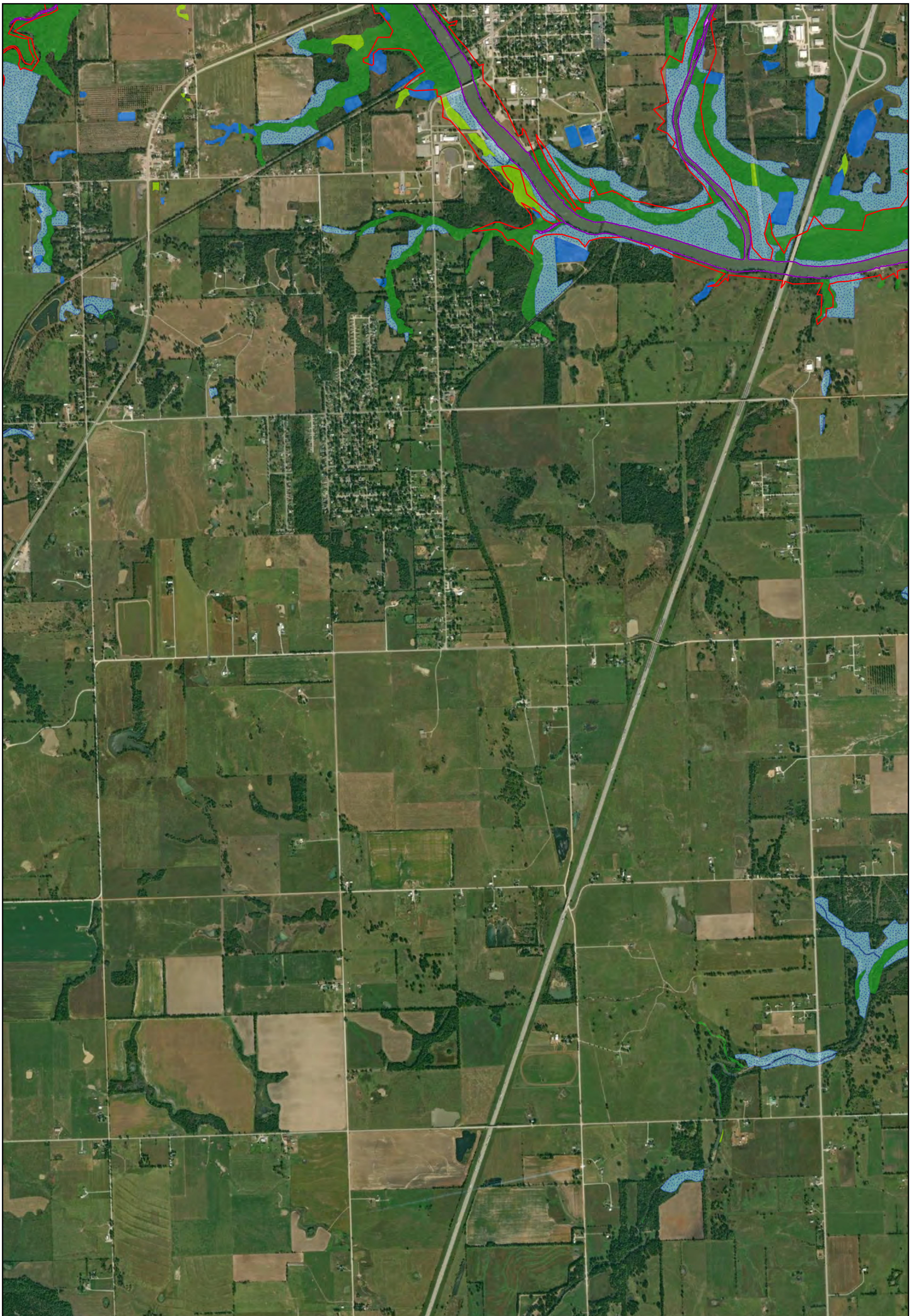

Horizon Environmental Services, Inc.

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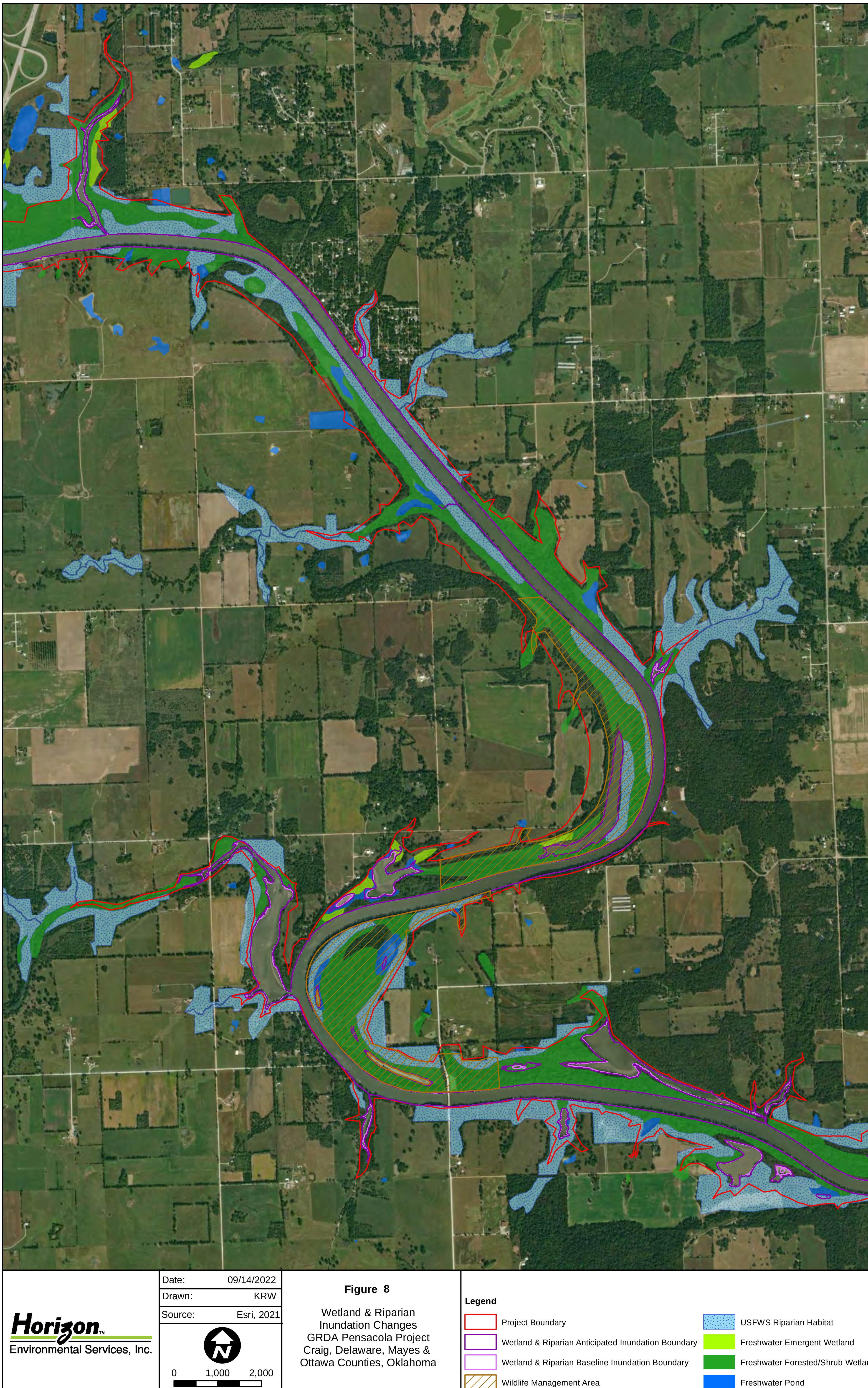
**Figure 7**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- USFWS Riparian Habitat
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian





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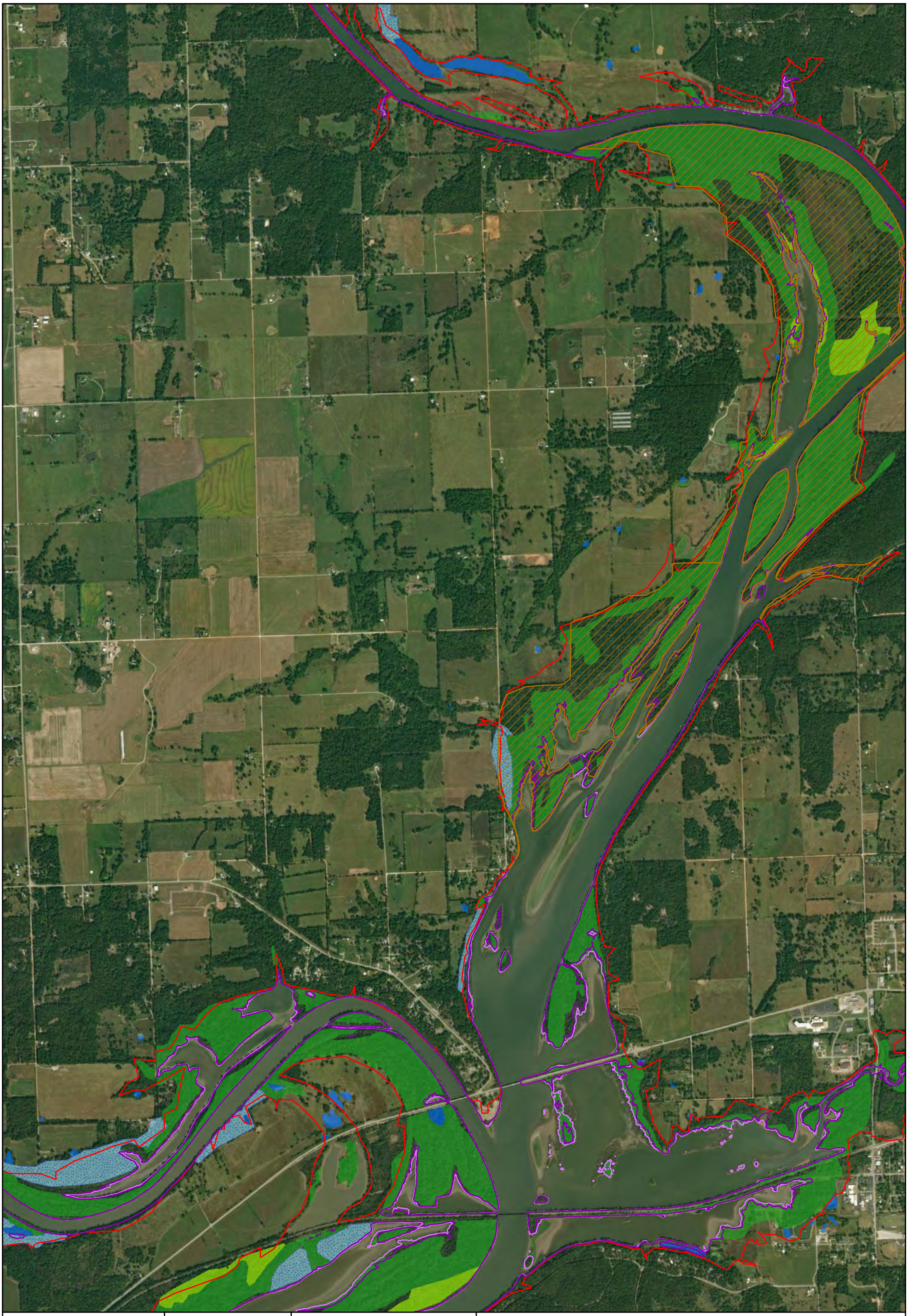
| Source: | Esri, 2021 |

**Figure 8**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian



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Horizon Environmental Services, Inc.

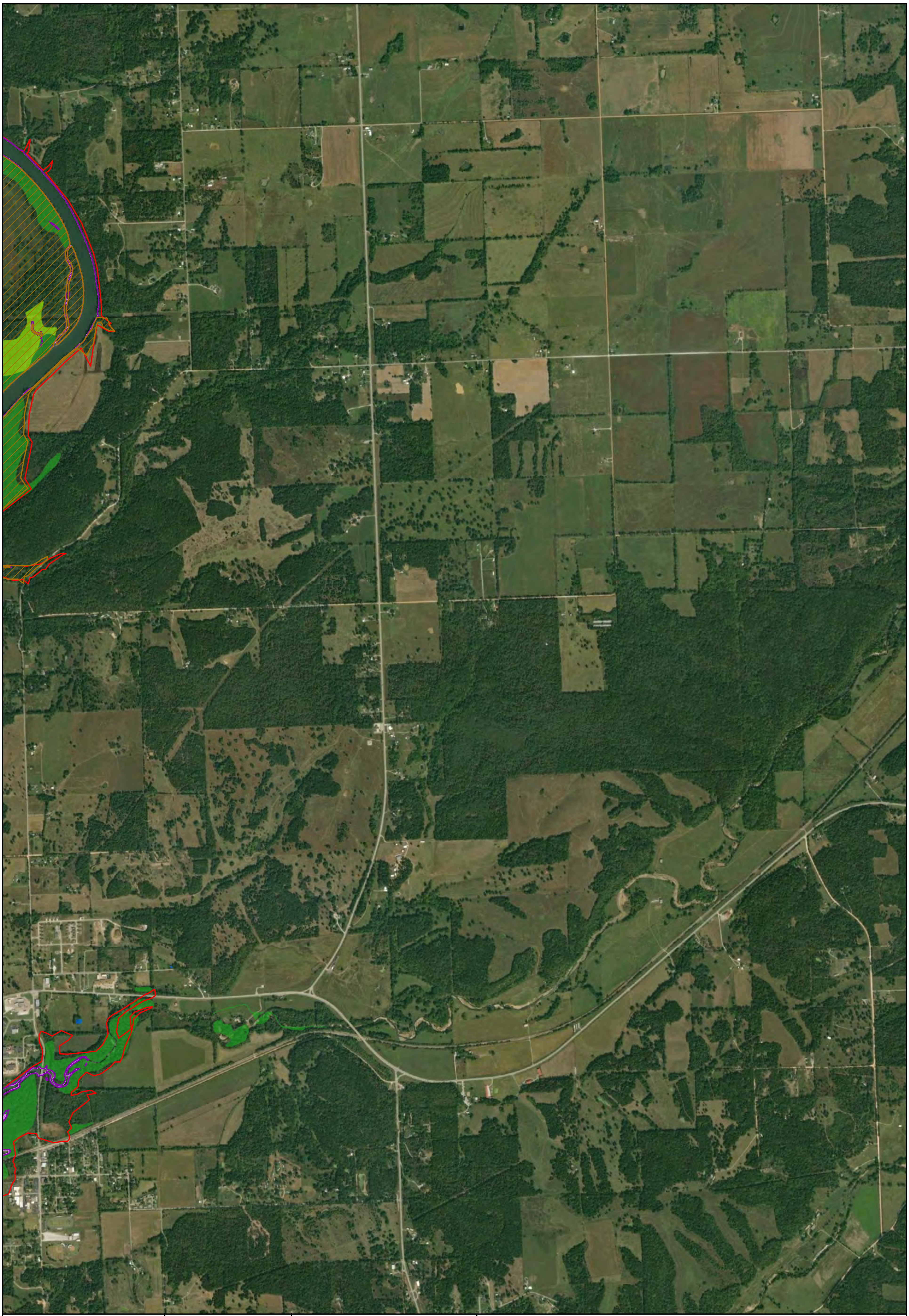
**Figure 9**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Wildlife Management Area
- USFWS Riparian Habitat
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian



Date: 09/14/2022
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Source: Esri, 2021

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**Horizon** Environmental Services, Inc.

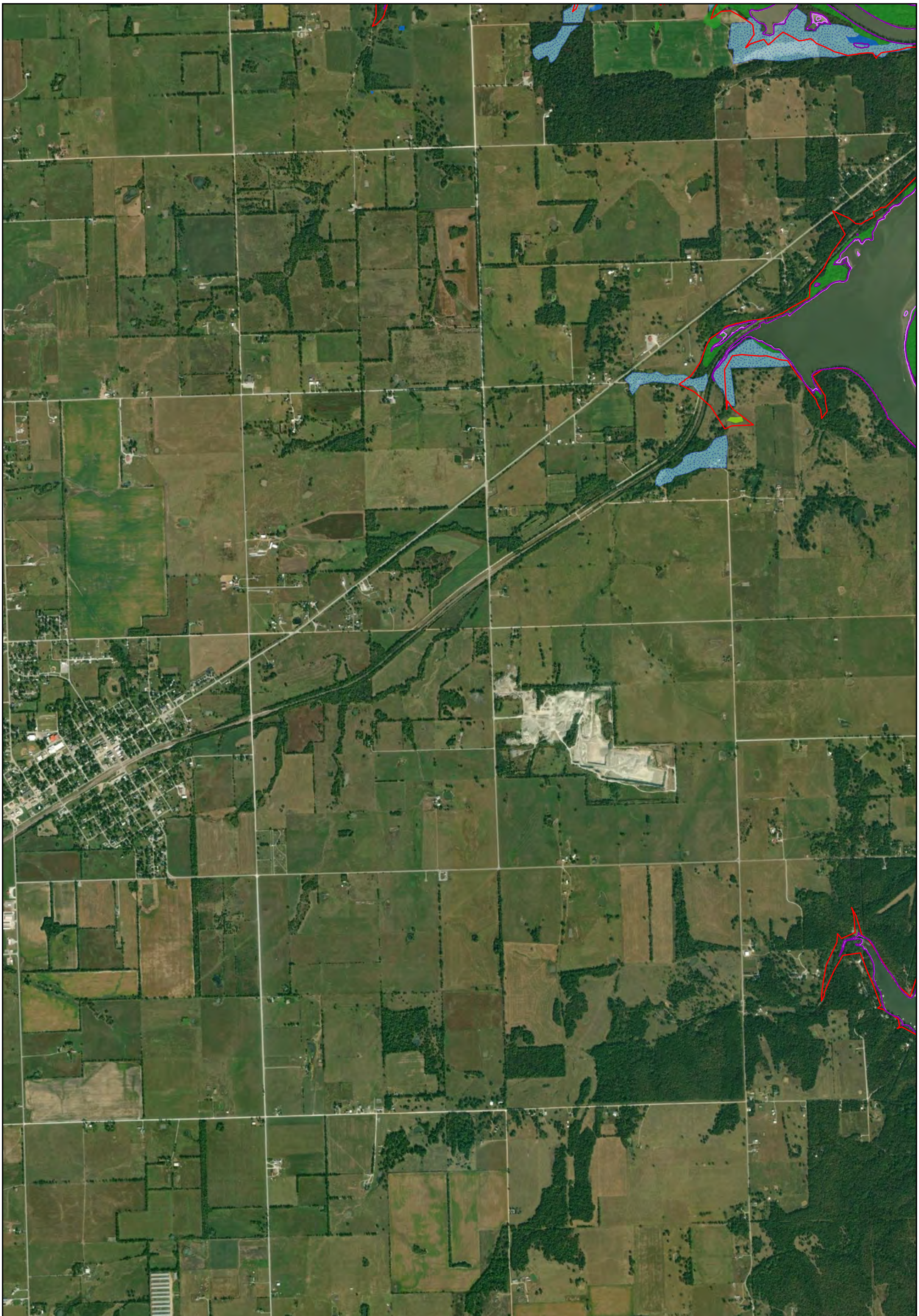
**Figure 10**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Wildlife Management Area
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian



Horizon Environmental Services, Inc.

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**Figure 11**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- USFWS Riparian Habitat
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian

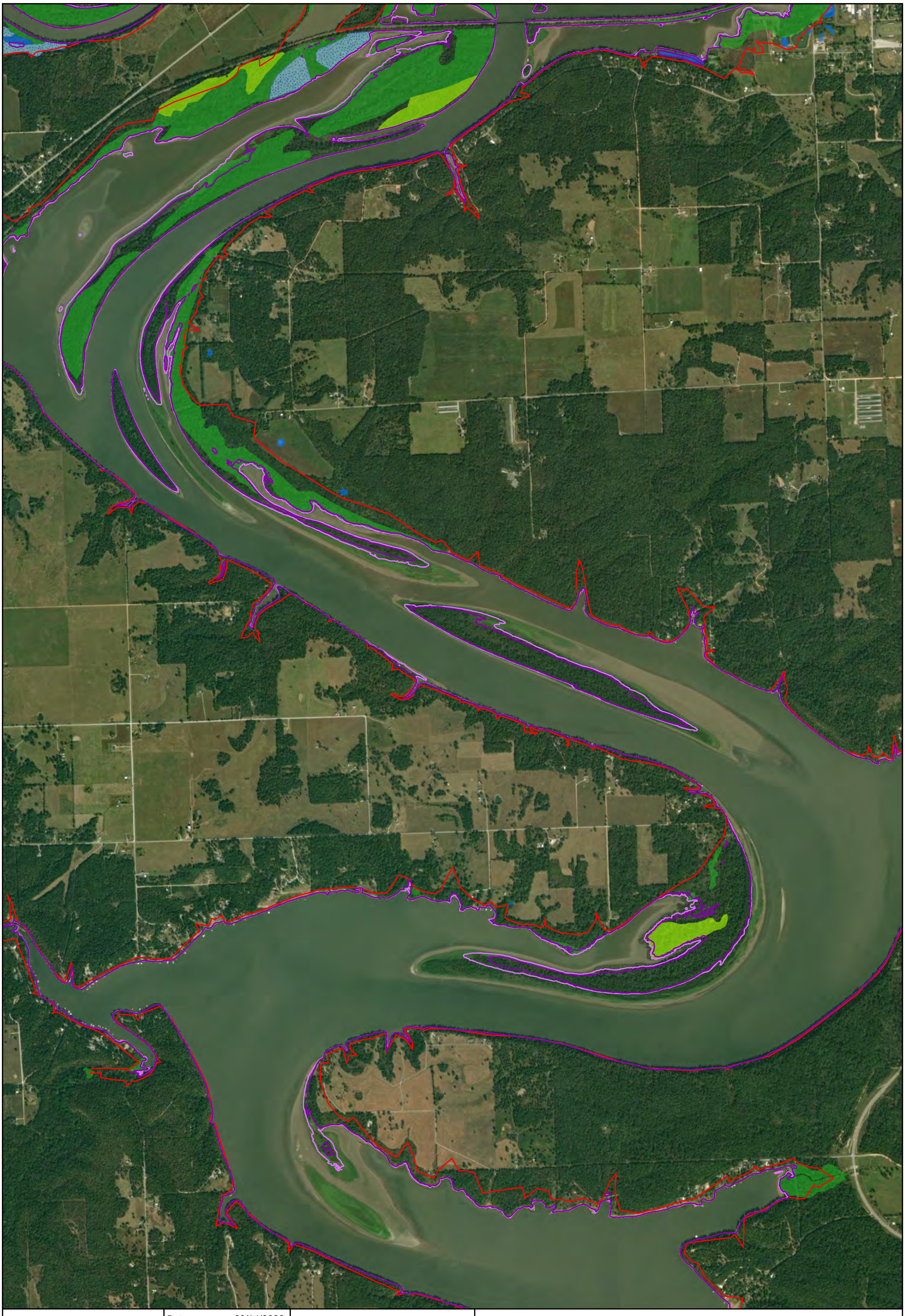

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**Figure 12**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- USFWS Riparian Habitat
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian

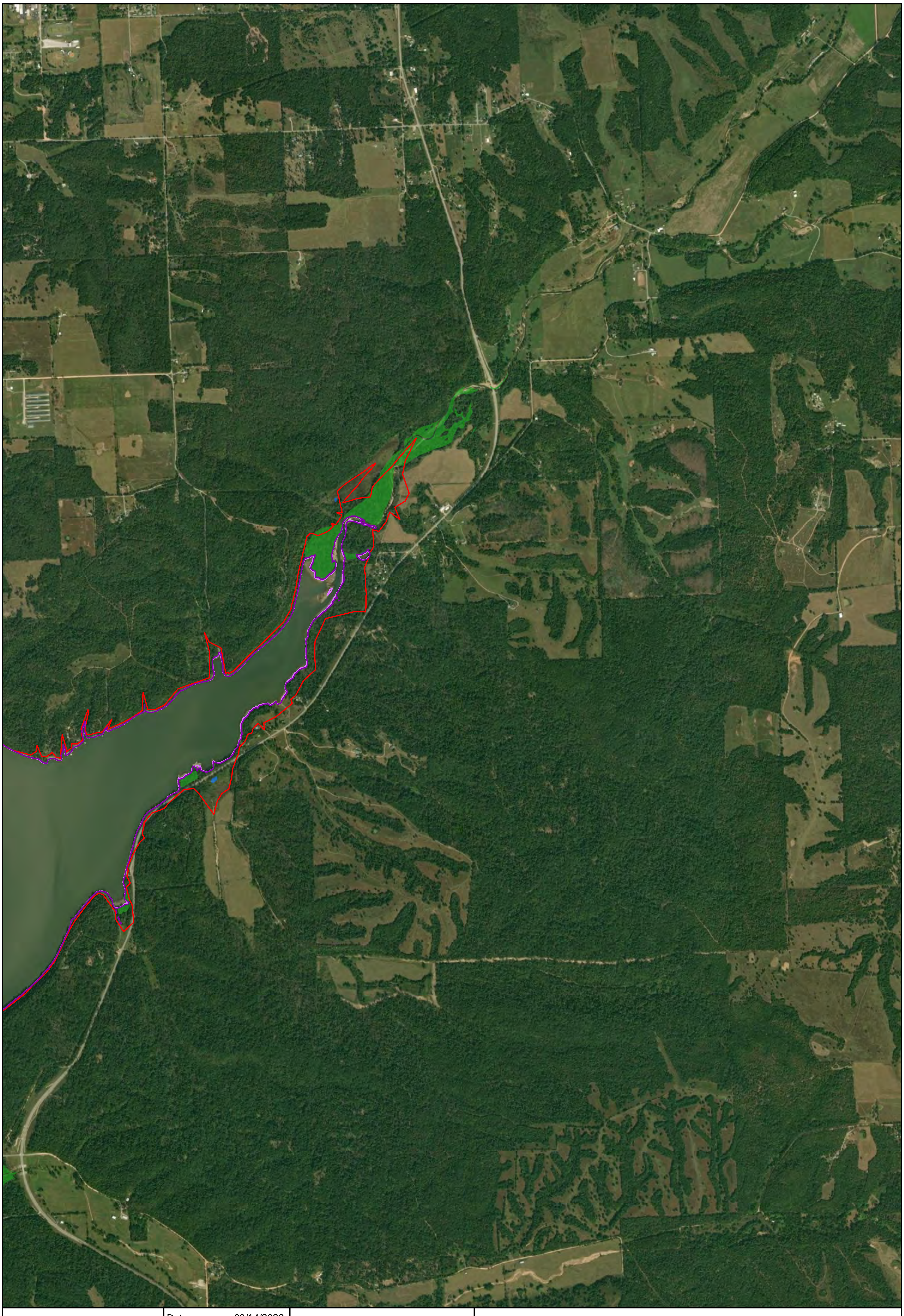

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**Figure 13**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian

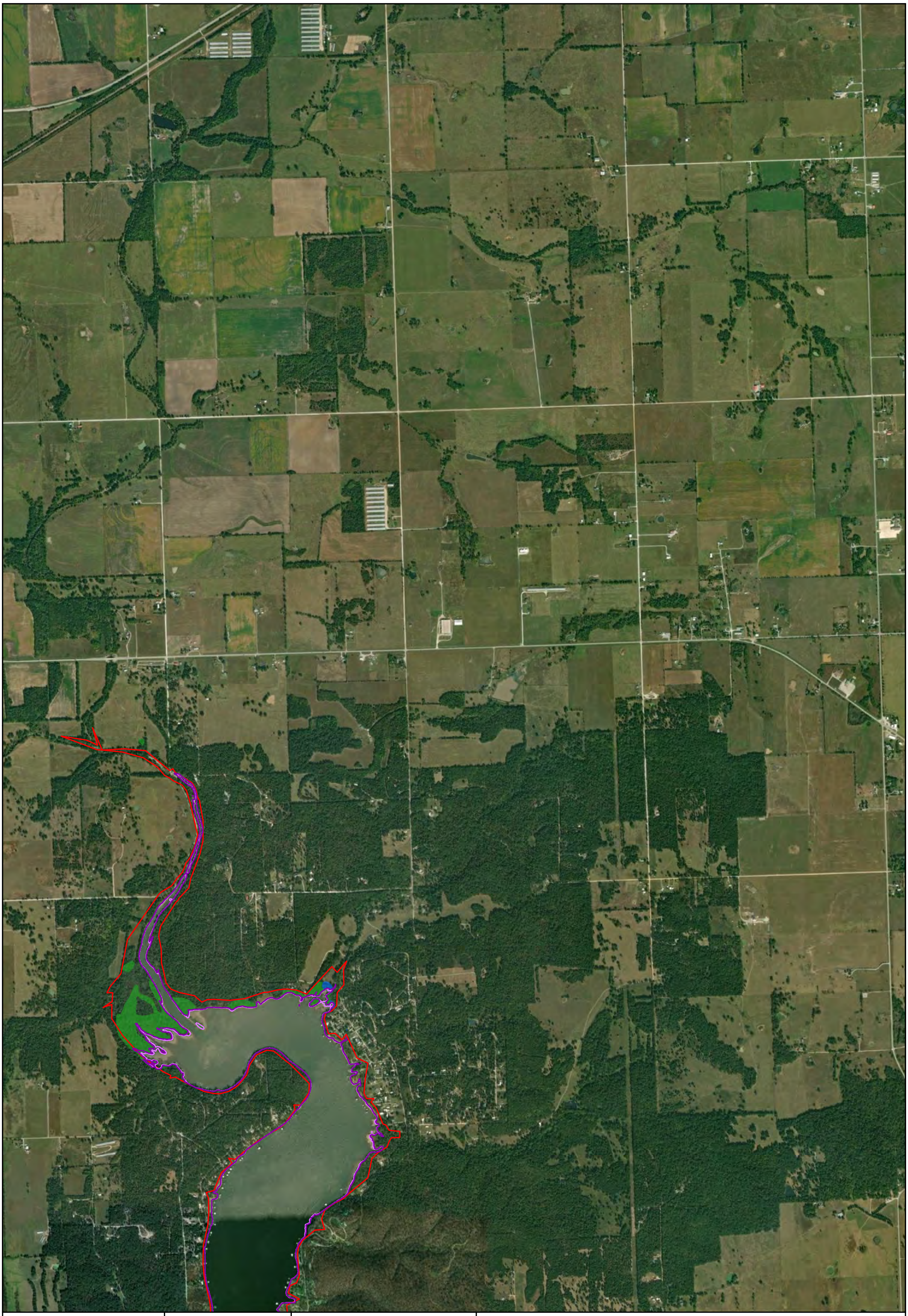

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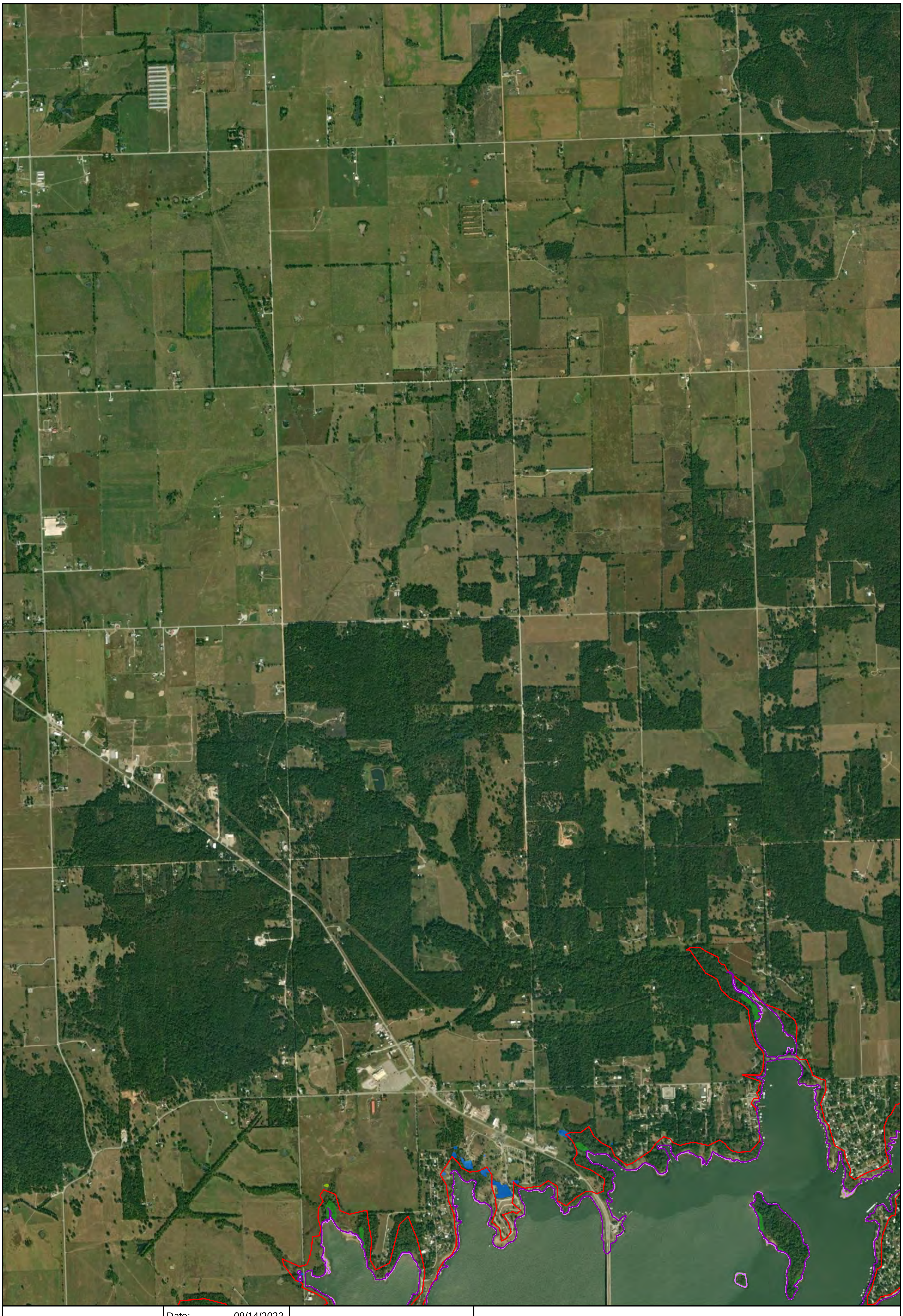
**Figure 14**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian



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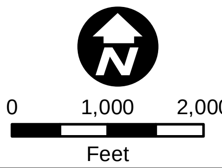


**Figure 15**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian

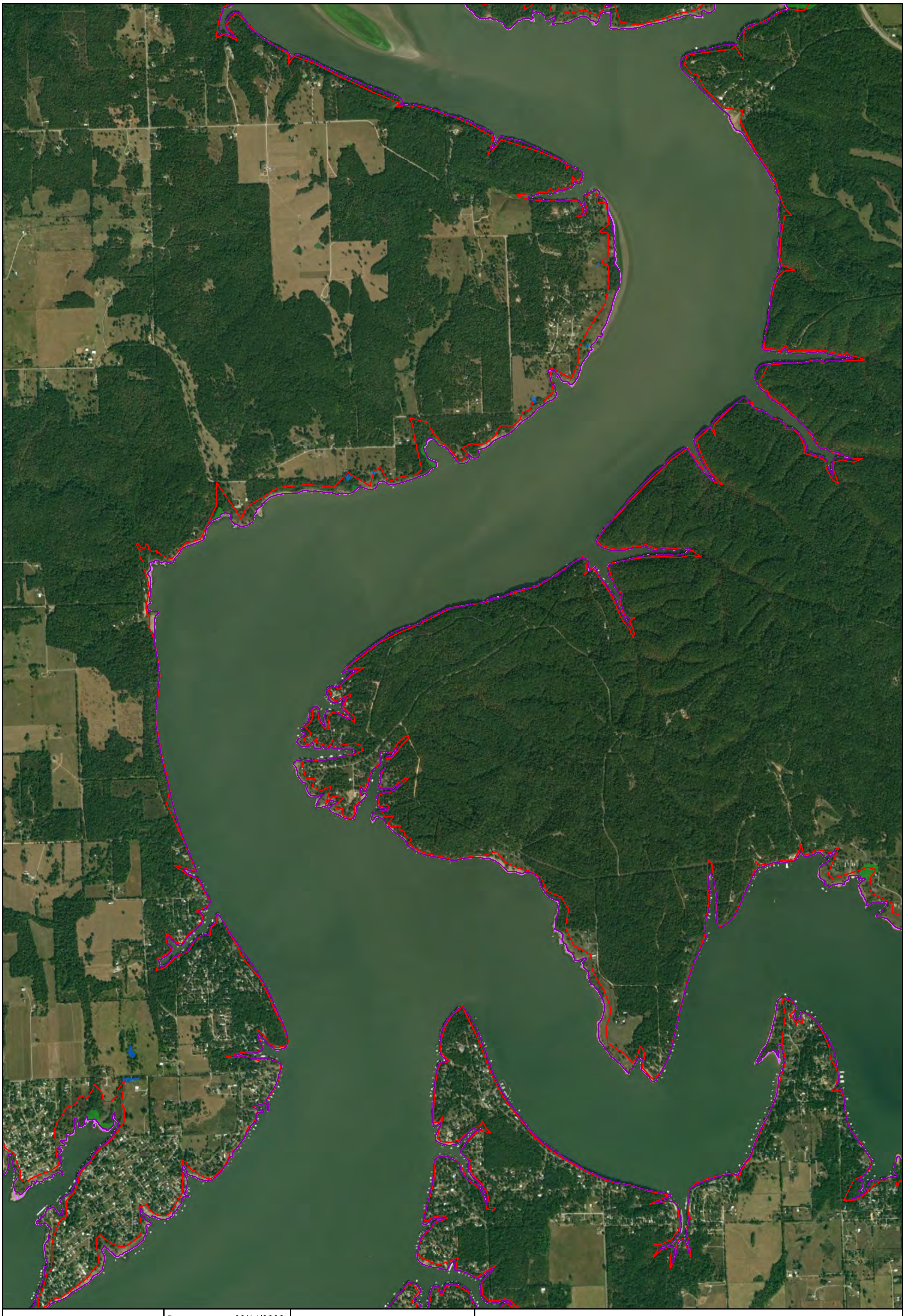



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**Figure 16**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian

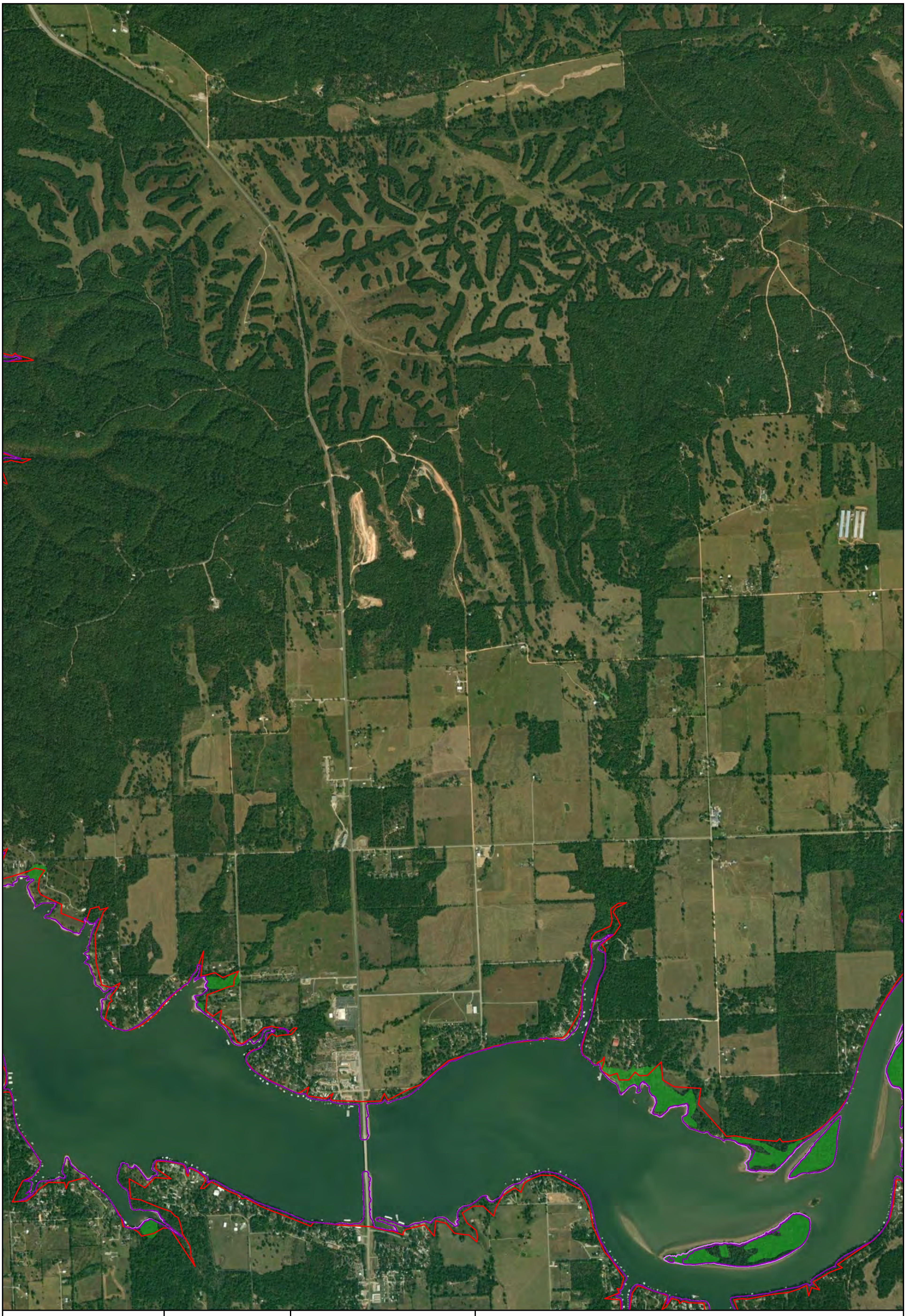

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**Figure 17**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian

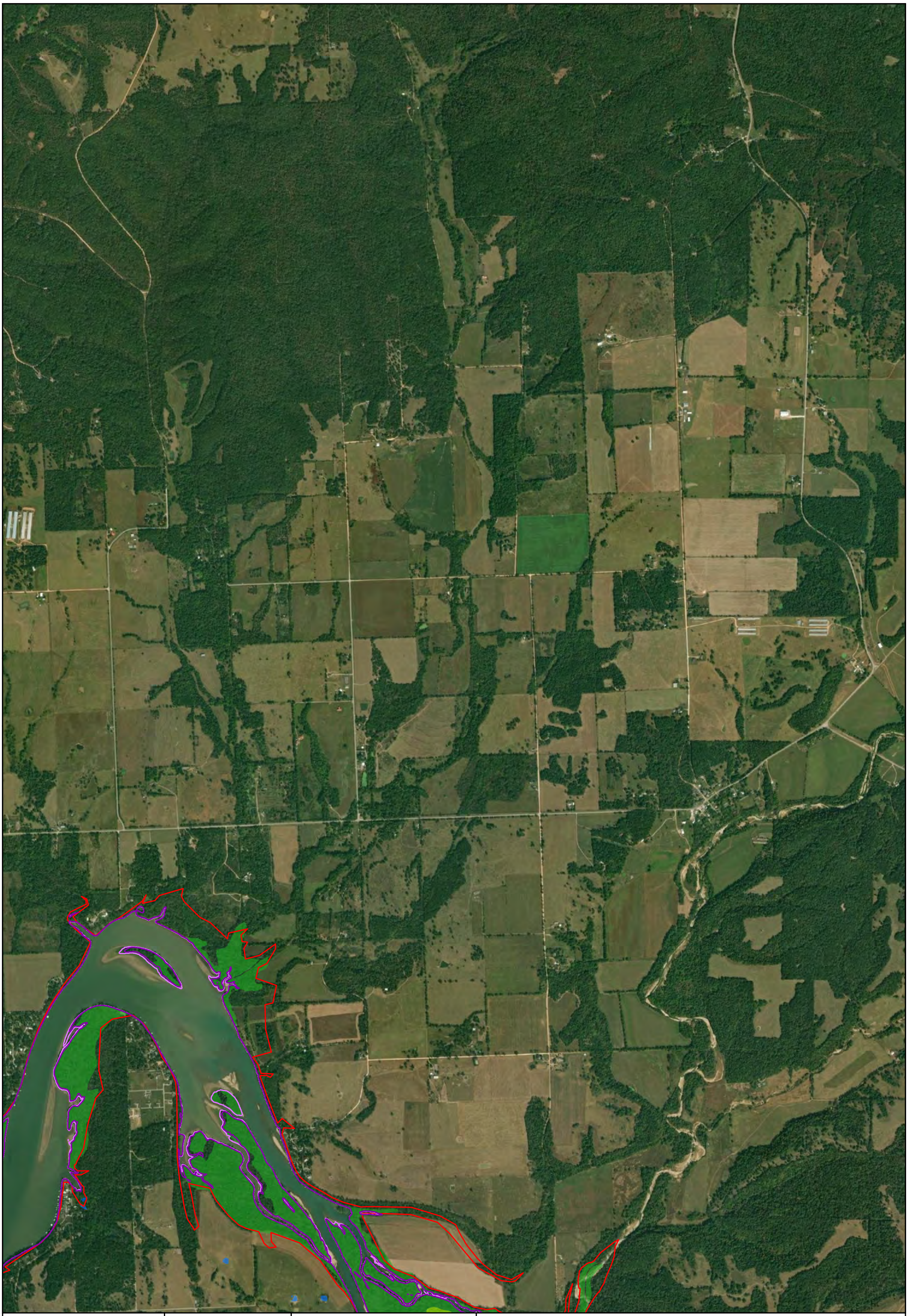

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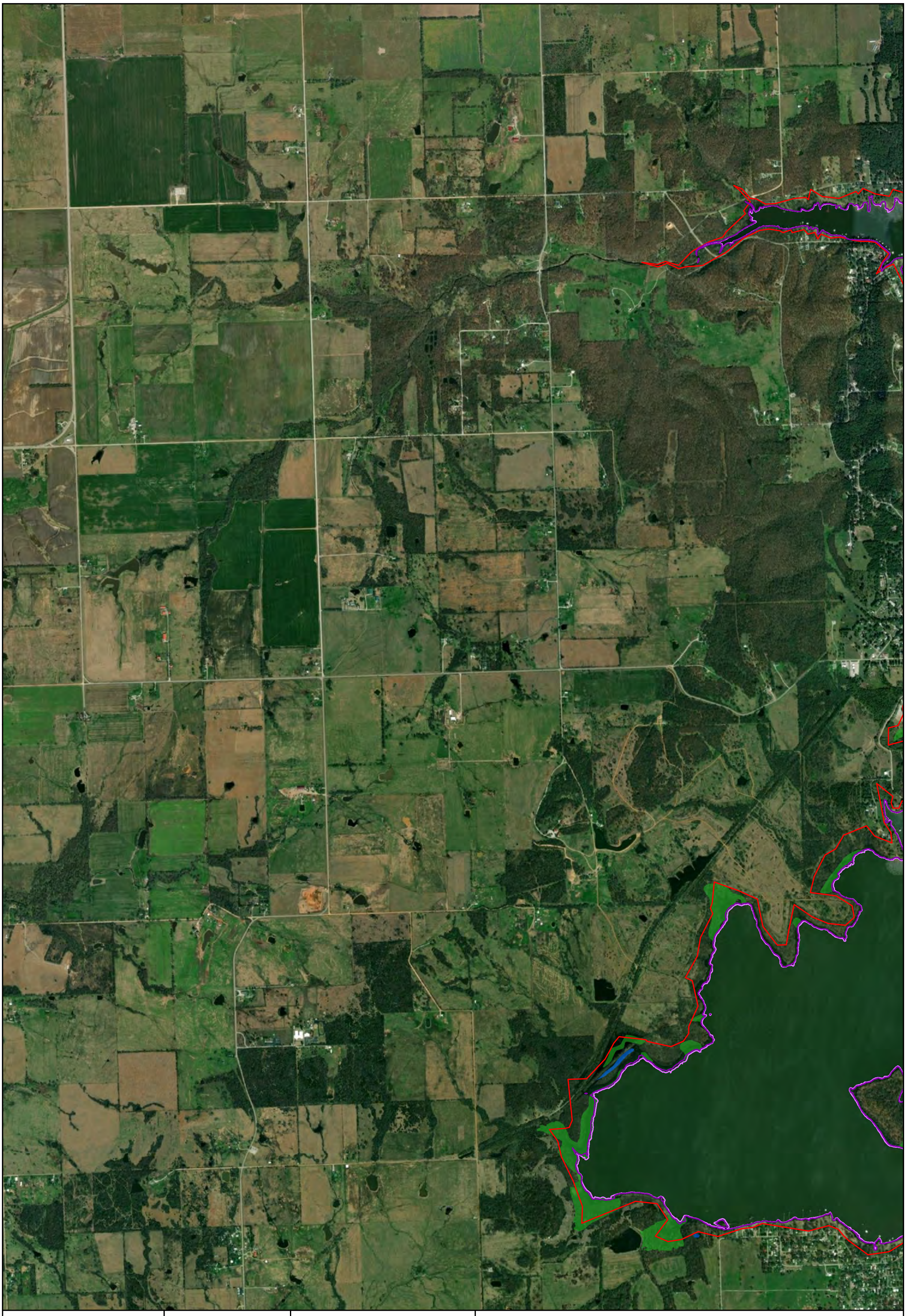
**Figure 18**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian



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| Horizon™ Environmental Services, Inc. | Date: 09/14/2022<br>Drawn: KRW<br>Source: Esri, 2021<br>0 1,000 2,000<br>Feet | **Figure 19**<br><br>Wetland & Riparian Inundation Changes<br>GRDA Pensacola Project<br>Craig, Delaware, Mayes & Ottawa Counties, Oklahoma | **Legend**<br>Project Boundary<br>Wetland & Riparian Anticipated Inundation Boundary<br>Wetland & Riparian Baseline Inundation Boundary<br>Freshwater Forested/Shrub Wetland<br>Freshwater Pond |

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian

Horizon Environmental Services, Inc.

Date: 09/14/2022
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**Figure 20**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian



Date: 09/14/2022
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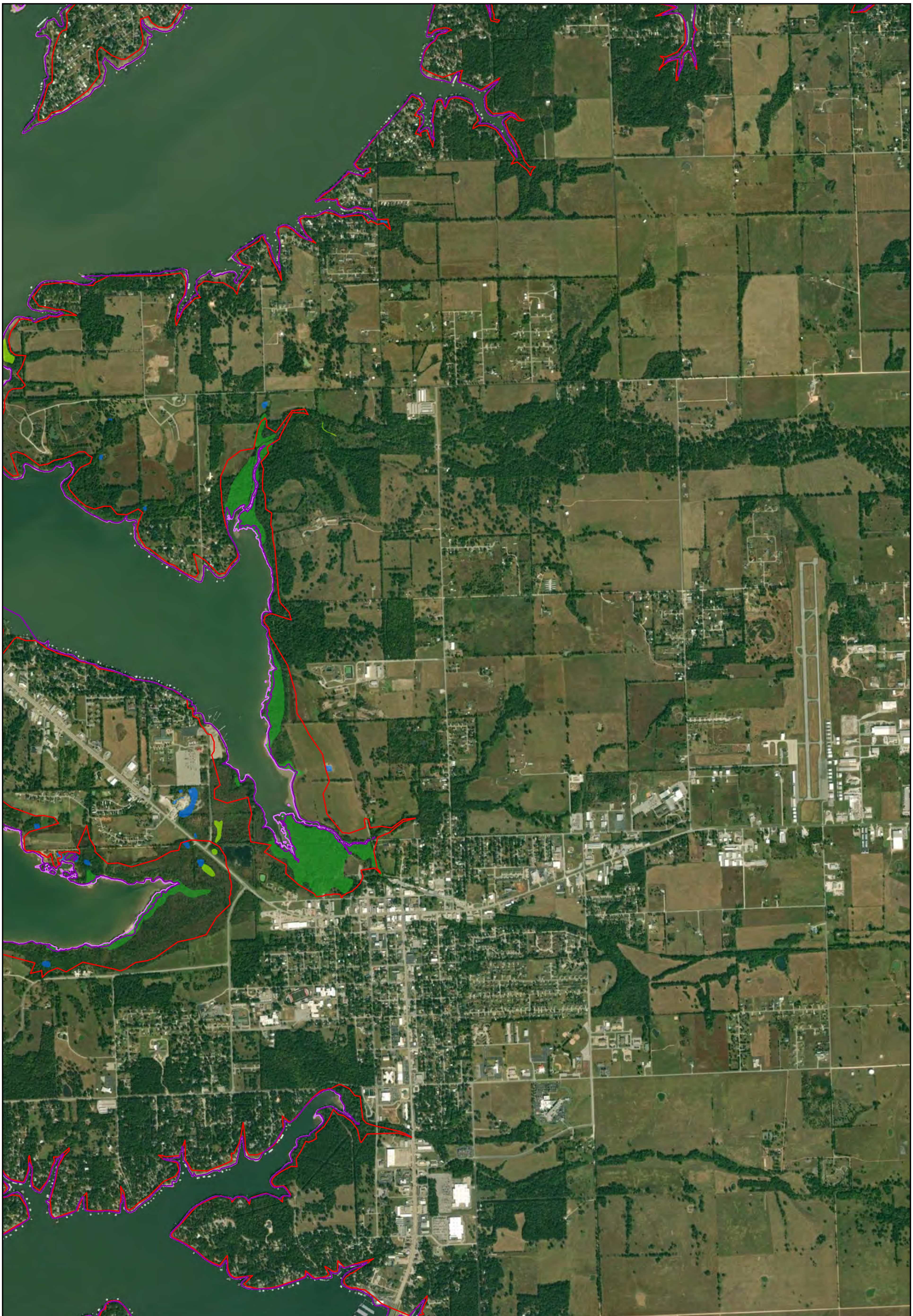
**Figure 21**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian



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Environmental Services, Inc.

**Figure 22**

Wetland & Riparian
Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian

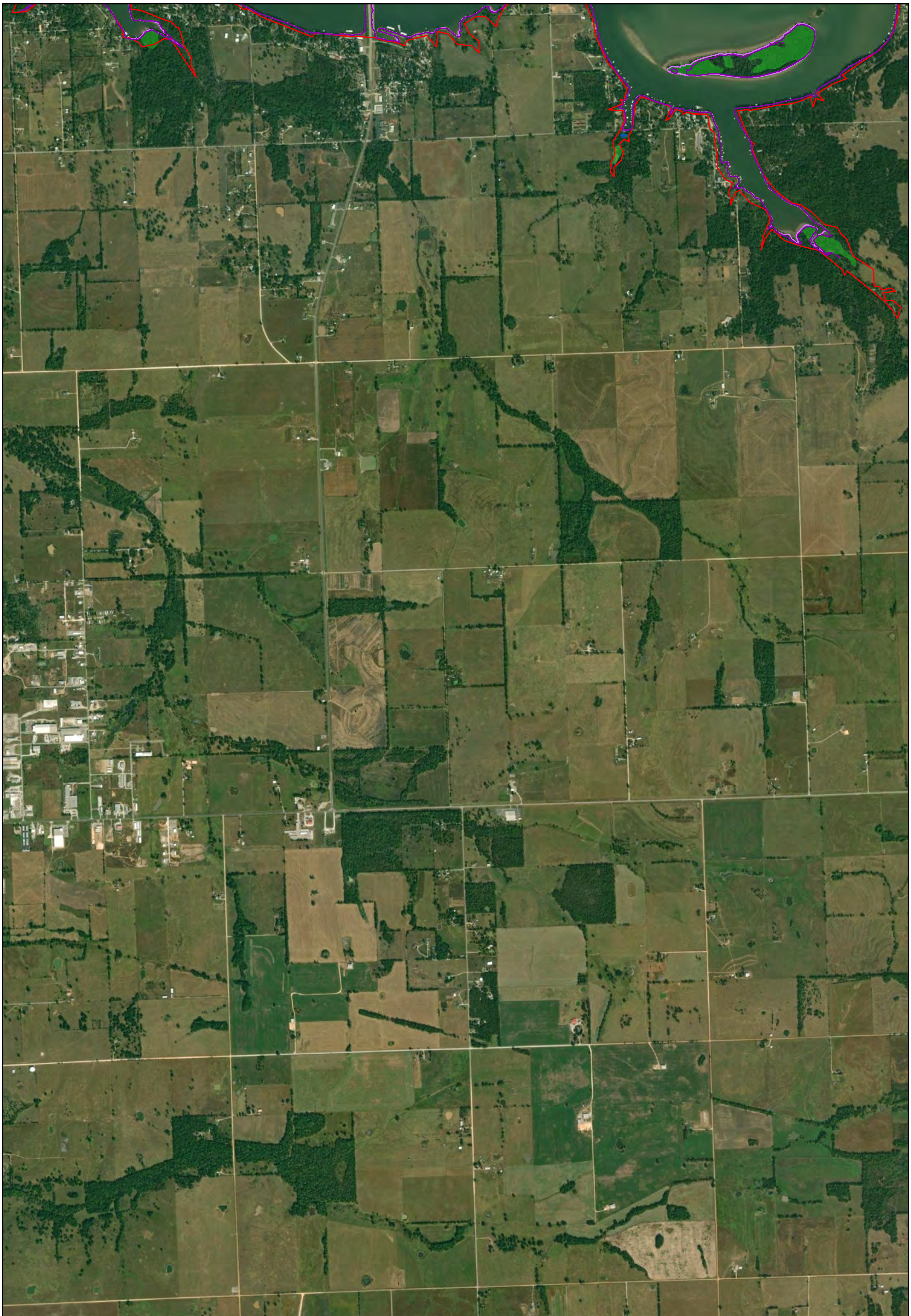

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**Figure 23**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian

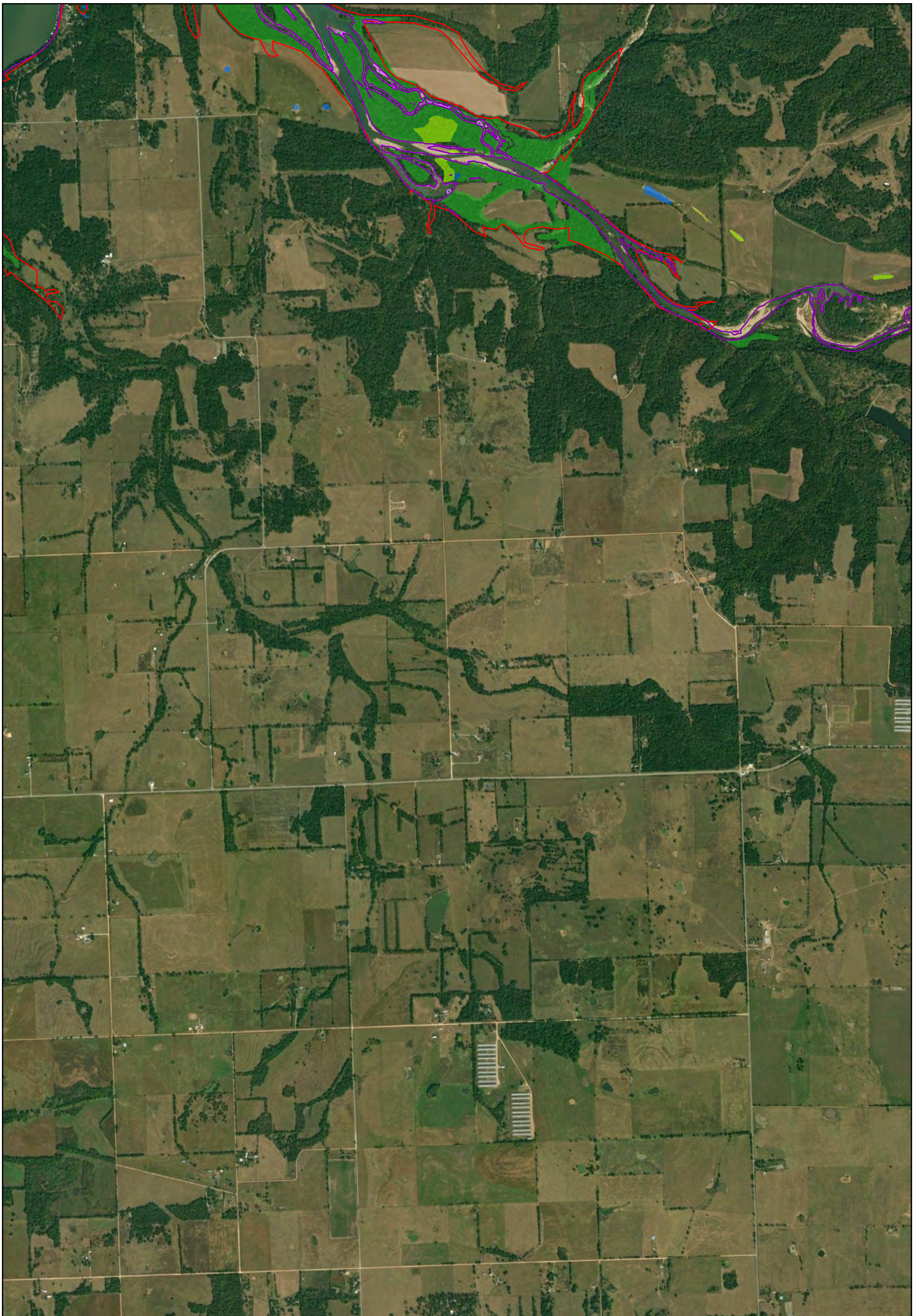

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**Figure 24**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian

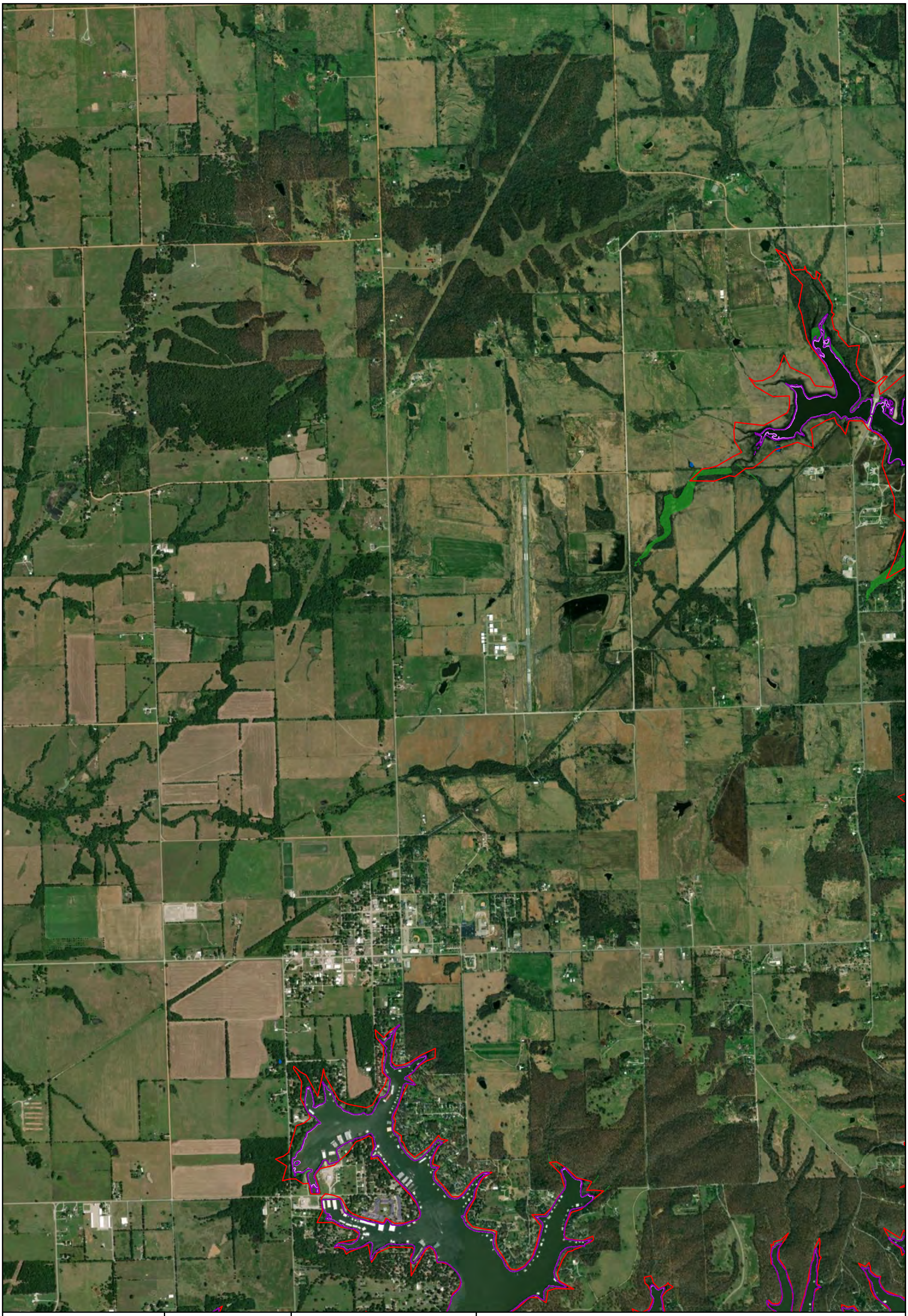



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**Figure 25**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian

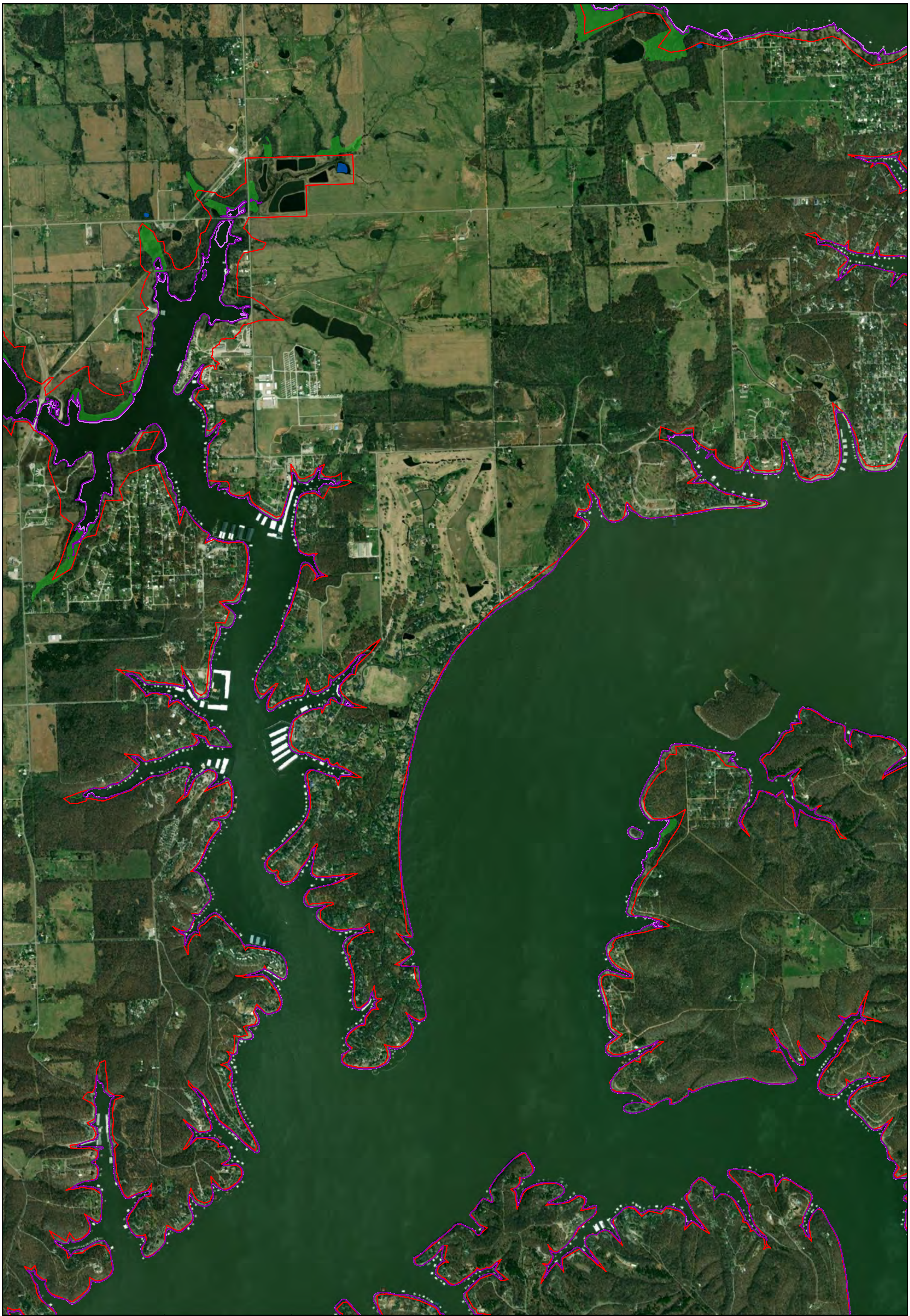

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**Figure 26**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian

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Horizon™
Environmental Services, Inc.

**Figure 27**

Wetland & Riparian
Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Forested/Shrub Wetland

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian

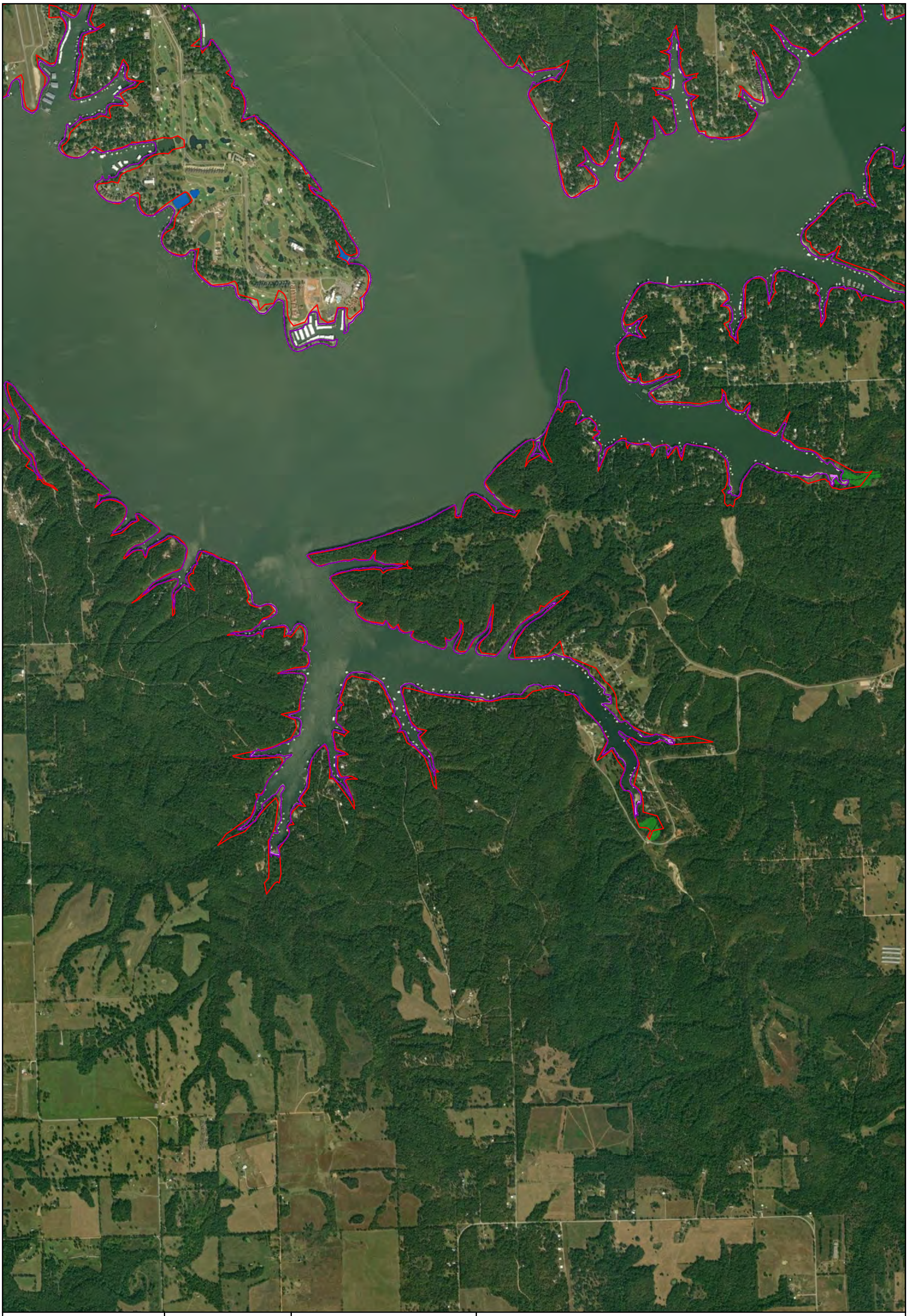

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**Figure 28**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian

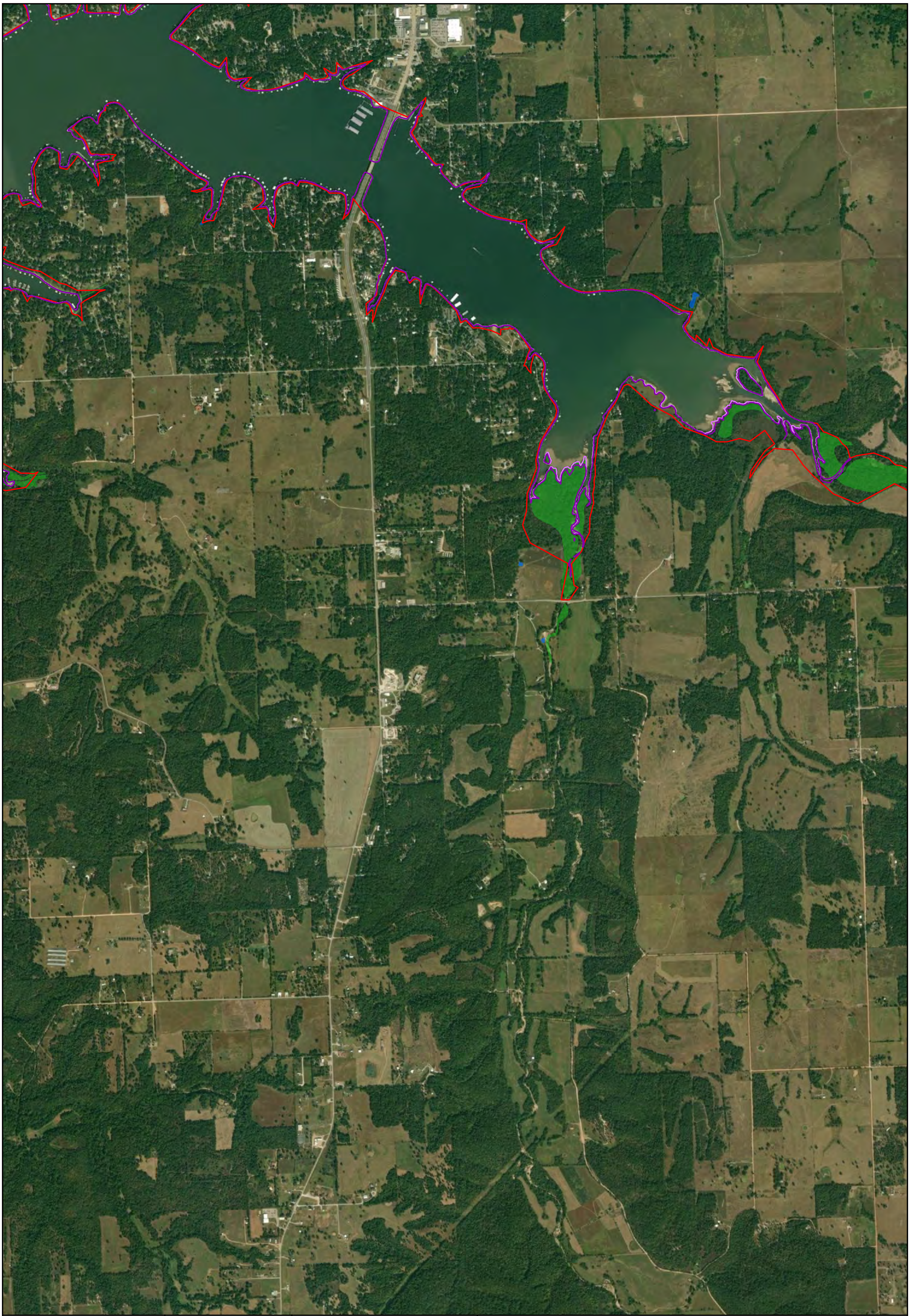

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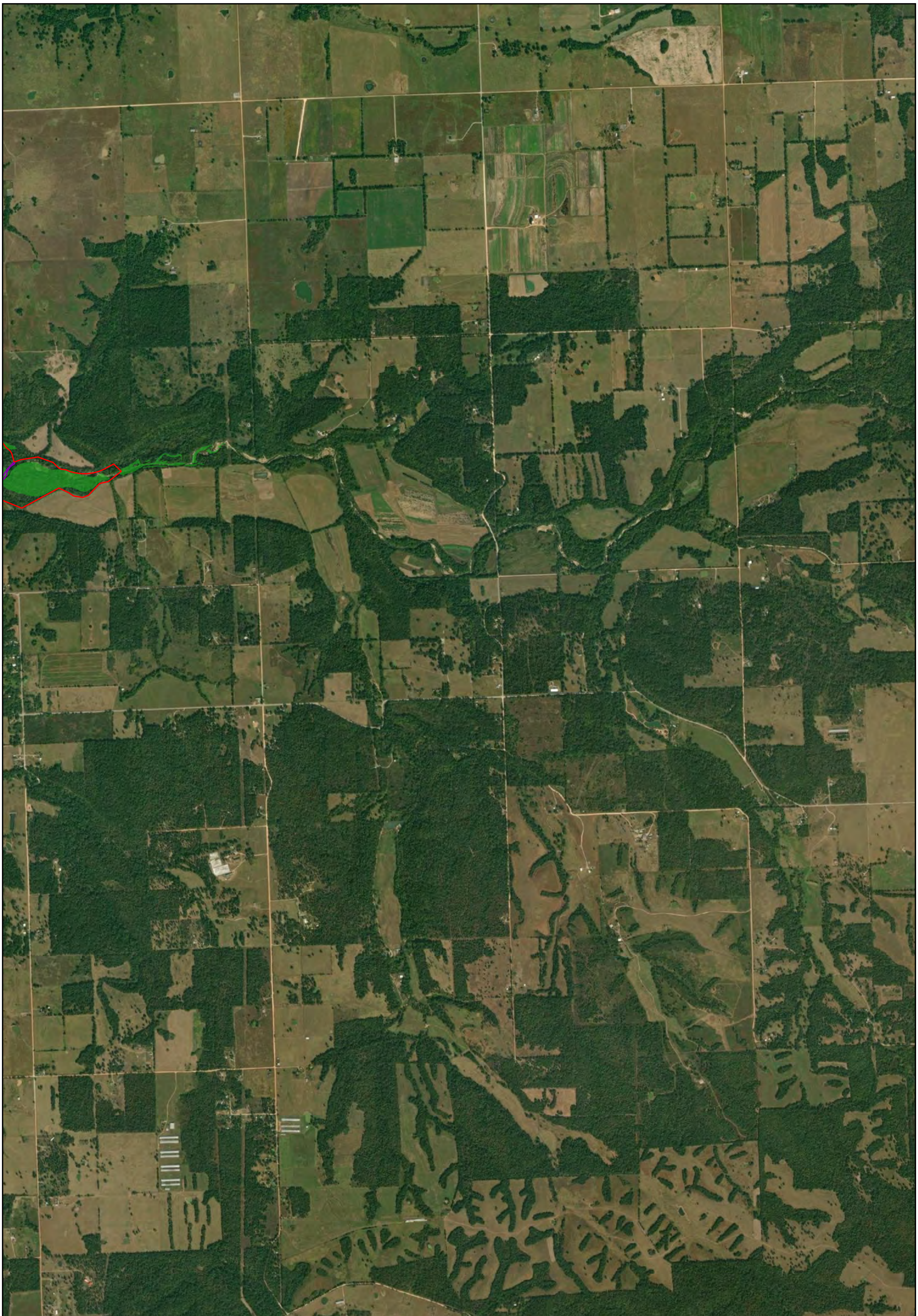
**Figure 29**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian



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| Source: | Esri, 2021 |

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**Figure 30**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Freshwater Forested/Shrub Wetland

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian

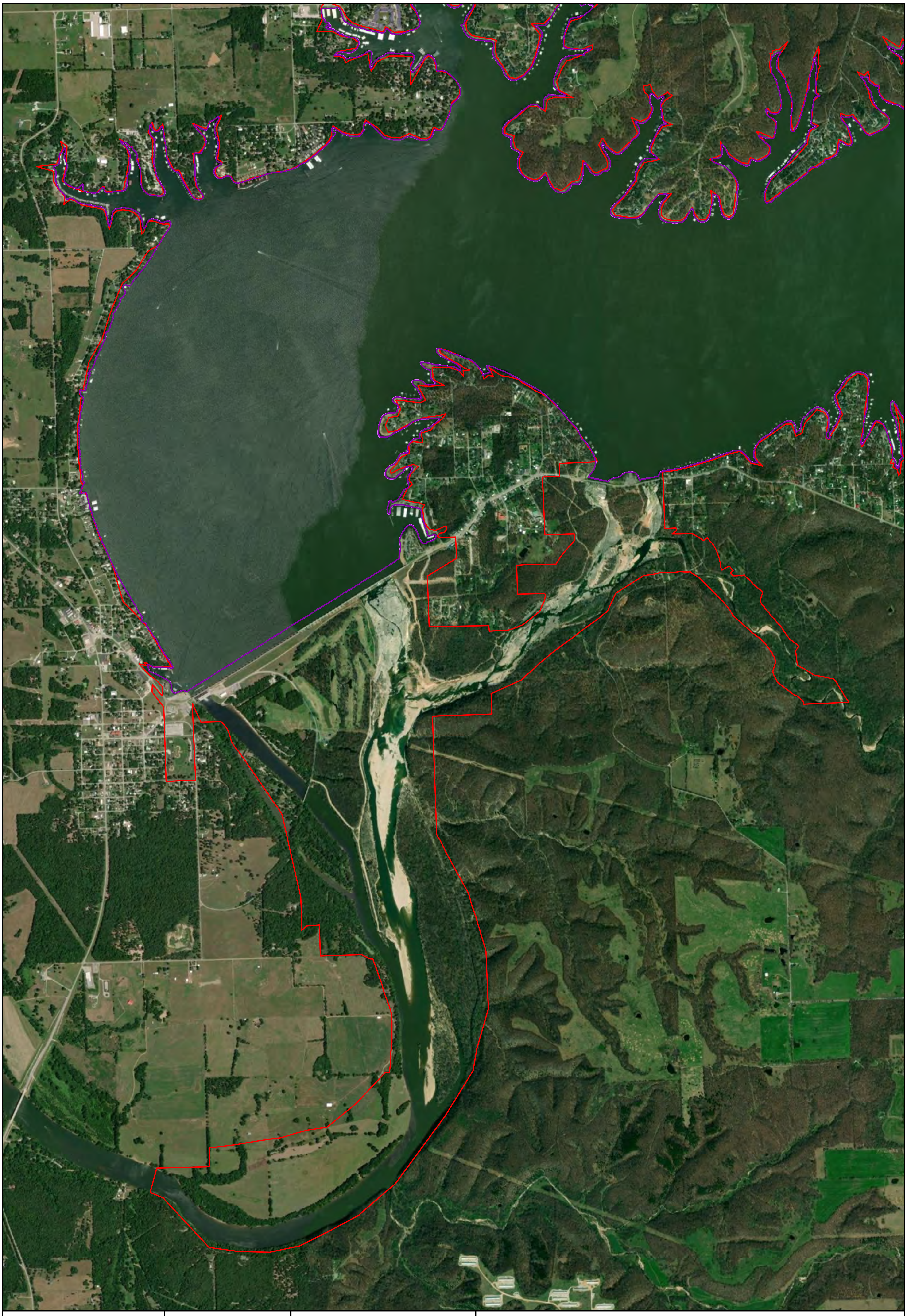

Figure 31

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

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| Drawn: | KRW |
| Source: | Esri, 2021 |

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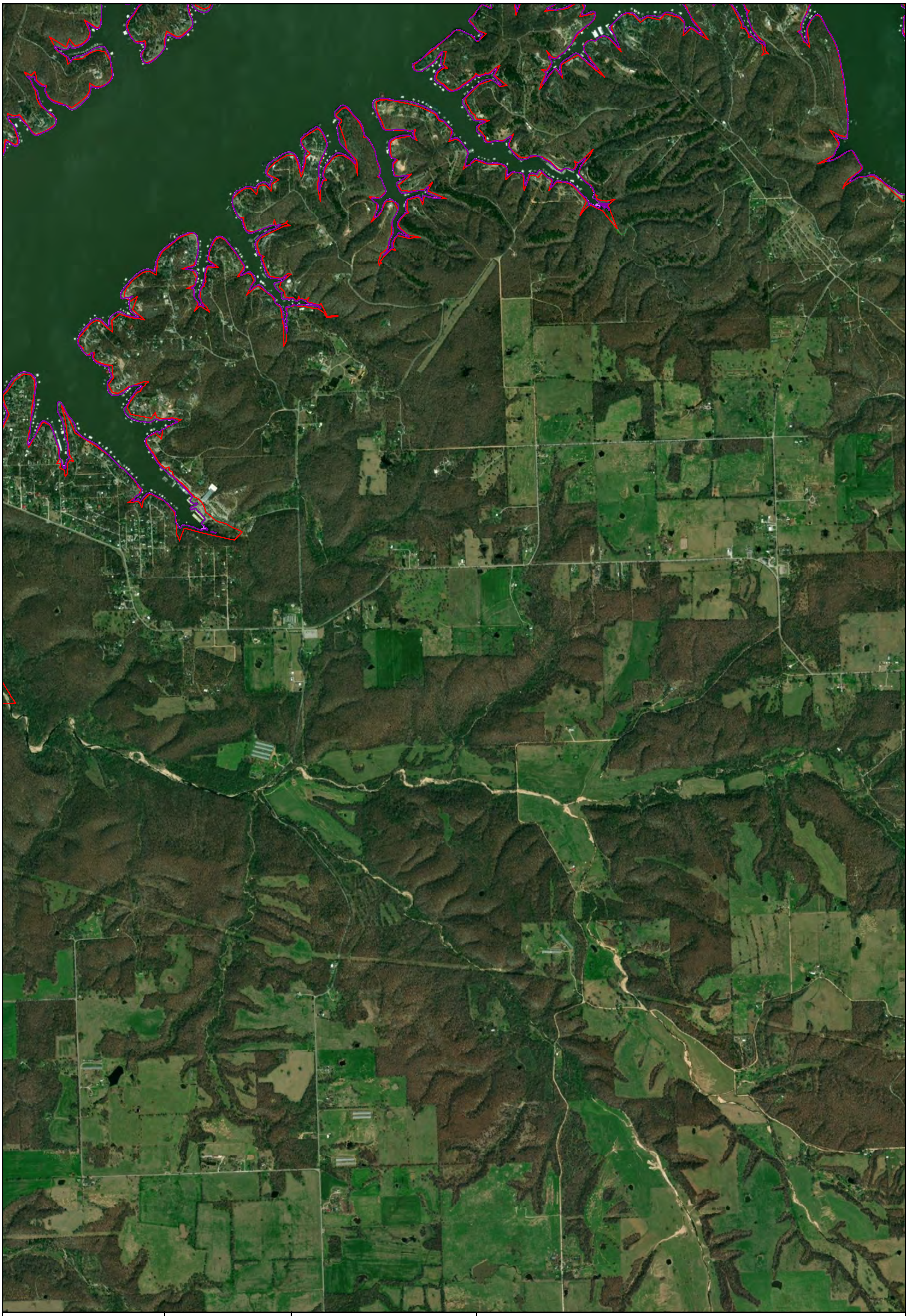
Horizon Environmental Services, Inc.

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian



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Horizon Environmental Services, Inc.

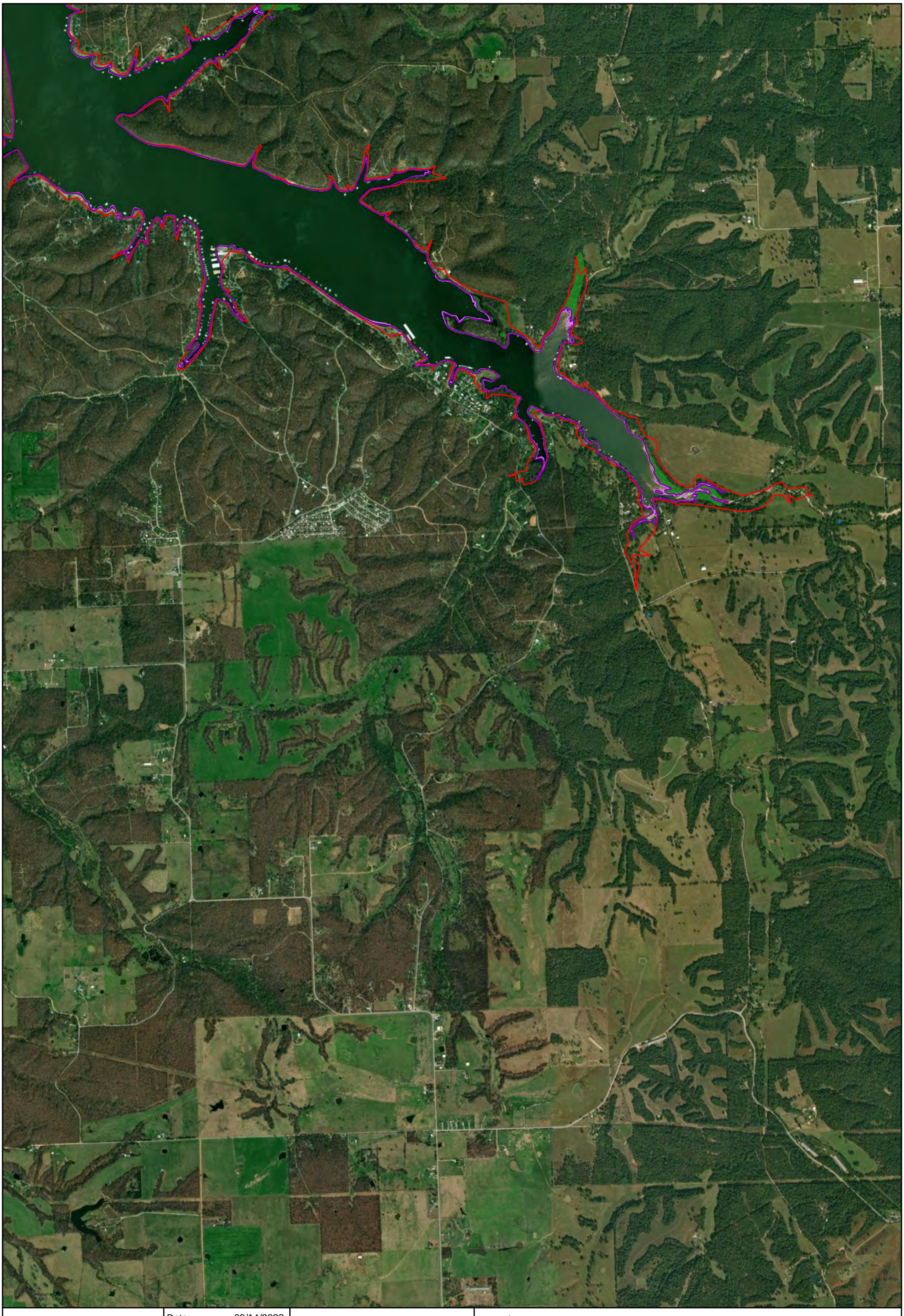
**Figure 32**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Forested/Shrub Wetland

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian



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Horizon™
Environmental Services, Inc.

**Figure 33**

Wetland & Riparian Inundation Changes
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

**Legend**

- Project Boundary
- Wetland & Riparian Anticipated Inundation Boundary
- Wetland & Riparian Baseline Inundation Boundary
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

21021--GRDA_Pensacola_Project_Relicensing\Graphics\WD_2022\21021-001WD_02A_Wetland_and_Riparian

# ATTACHMENT B

Wetland Contour Line Interval Tables

## Wetland Habitat Type within Elevation Bands 741 feet to 742 feet PD

| Wetland Habitat Type | Acres Within Study Area |
|---|---|
| **Freshwater Emergent Wetlands** | |
| Palustrine, Emergent, Persistent, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PEM1/SS1Ch) | 0.01 |
| Palustrine, Emergent, Persistent, Temporary Flooded (PEM1A) | 0.02 |
| Palustrine, Emergent, Persistent, Seasonally Flooded (PEM1C) | 32.20 |
| Palustrine, Emergent, Persistent, Seasonally Flooded, Diked/Impounded (PEM1Ch) | 6.71 |
| Palustrine, Emergent, Persistent, Semipermanently Flooded, Diked/Impounded (PEM1Ch) | 0.05 |
| **Total Freshwater Emergent Wetlands Acres** | **38.99** |
| **Freshwater Forested Wetland** | |
| Palustrine, Forested, Broad-Leaved Deciduous, Emergent, Persistent, Seasonally Flooded, Diked/Impounded (PFO1/EM1Ch) | 0.56 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded (PFO1/SS1A) | 0.55 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded, Diked/Impounded (PFO1/SS1Ah) | 2.34 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded (PFO1/SS1C) | 0.47 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PFO1/SS1Ch) | 22.42 |
| Palustrine, Forested, Broad-Leaved Deciduous, Unconsolidated Bottom, Semi-permanently Flooded, Diked/Impounded (PFO1/UBFh) | 15.84 |
| Palustrine, Forested, Broad-Leaved Deciduous, Temporary Flooded (PFO1A) | 5.04 |
| Palustrine, Forested, Broad-Leaved Deciduous, Temporary Flooded, Diked/Impounded (PFO1Ah) | 7.45 |
| Palustrine, Forested, Broad-Leaved Deciduous, Seasonally Flooded (PFO1C) | 1.87 |
| Palustrine, Forested, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PFO1Ch) | 44.35 |
| Palustrine, Forested, Broad-Leaved Deciduous, Semi-permanently Flooded, Diked/Impounded (PFO1Fh) | 13.87 |
| Palustrine, Forested, Dead, Broad-Leaved Deciduous, Semi-permanently Flooded, Diked/Impounded (PFO5/1Fh) | 0.95 |
| Palustrine, Forested, Dead, Unconsolidated Bottom, Permanently Flooded, Diked/Impounded (PFO5/UBHh) | 0.17 |
| **Total Freshwater Forested Wetland Acres** | **115.88** |
| **Freshwater Scrub-Shrub Wetlands** | |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Emergent, Persistent, Temporary Flooded, Ditched (PSS1/EM1Ad) | 0.002 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Emergent, Persistent, Seasonally Flooded, Diked/Impounded (PSS1/EM1Ch) | 8.24 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Unconsolidated Bottom, Semi-permanently Flooded, Diked/Impounded (PSS1/UBFh) | 0.21 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Unconsolidated Shore, Seasonally Flooded, Diked/Impounded (PSS1/USCh) | 0.66 |

| Wetland Habitat Type | Acres Within Study Area |
|---|---|
| **Freshwater Scrub-Shrub Wetlands (cont.)** | |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded (PSS1A) | 1.19 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded, Diked/Impounded (PSS1Ah) | 0.10 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded (PSS1C) | 1.59 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PSS1Ch) | 26.44 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Semi-permanently Flooded (PSS1F) | 0.01 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Semi-permanently Flooded, Diked/Impounded (PSS1Fh) | 1.07 |
| **Total Freshwater Scrub-Shrub Wetlands Acres** | **39.51** |
| **Freshwater Open Water** | |
| Palustrine, Unconsolidated Bottom, Permanently Flooded, Diked/Impounded (PUBHh) | 0.01 |
| Palustrine, Unconsolidated Bottom, Permanently Flooded, Excavated (PUBHx) | 0.06 |
| **Total Freshwater Open Water Acres** | **0.07** |
| **Total Wetland Acres Within Study Area** | **194.45** |

## Wetland Habitat Type within Elevation Bands 742 feet to 743 feet PD

| Wetland Habitat Type | Acres Within Study Area |
|---|---|
| **Freshwater Emergent Wetlands** | |
| Palustrine, Emergent, Persistent, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PEM1/SS1Ch) | 0.01 |
| Palustrine, Emergent, Persistent, Temporary Flooded (PEM1A) | 0.03 |
| Palustrine, Emergent, Persistent, Seasonally Flooded (PEM1C) | 9.72 |
| Palustrine, Emergent, Persistent, Seasonally Flooded, Diked/Impounded (PEM1Ch) | 2.49 |
| Palustrine, Emergent, Persistent, Semipermanently Flooded, Diked/Impounded (PEM1Fh) | 0.03 |
| **Total Freshwater Emergent Wetlands Acres** | **12.28** |
| **Freshwater Forested Wetland** | |
| Palustrine, Forested, Broad-Leaved Deciduous, Emergent, Persistent, Seasonally Flooded, Diked/Impounded (PFO1/EM1Ch) | 0.76 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded (PFO1/SS1A) | 1.12 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded, Diked/Impounded (PFO1/SS1Ah) | 4.84 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded (PFO1/SS1C) | 0.89 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PFO1/SS1Ch) | 26.79 |
| Palustrine, Forested, Broad-Leaved Deciduous, Unconsolidated Bottom, Semi-permanently Flooded, Diked/Impounded (PFO1/UBFh) | 6.97 |
| Palustrine, Forested, Broad-Leaved Deciduous, Temporary Flooded (PFO1A) | 10.40 |
| Palustrine, Forested, Broad-Leaved Deciduous, Temporary Flooded, Diked/Impounded (PFO1Ah) | 11.15 |
| Palustrine, Forested, Broad-Leaved Deciduous, Seasonally Flooded (PFO1C) | 3.81 |
| Palustrine, Forested, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PFO1Ch) | 57.17 |
| Palustrine, Forested, Broad-Leaved Deciduous, Semi-permanently Flooded, Diked/Impounded (PFO1Fh) | 8.12 |
| Palustrine, Forested, Dead, Broad-Leaved Deciduous, Semi-permanently Flooded, Diked/Impounded (PFO5/1Fh) | 2.00 |
| Palustrine, Forested, Dead, Unconsolidated Bottom, Permanently Flooded, Diked/Impounded (PFO5/UBHh) | 0.000002 |
| **Total Freshwater Forested Wetland Acres** | **134.02** |
| **Freshwater Scrub-Shrub Wetlands** | |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Emergent, Persistent, Temporary Flooded, Ditched (PSS1/EM1Ad) | 0.62 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Emergent, Persistent, Seasonally Flooded (PSS1/EM1C) | 0.08 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Emergent, Persistent, Seasonally Flooded, Diked/Impounded (PSS1/EM1Ch) | 10.09 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Unconsolidated Bottom, Semi-permanently Flooded, Diked/Impounded (PSS1/UBFh) | 0.35 |

| Wetland Habitat Type | Acres Within Study Area |
|---|---|
| **Freshwater Scrub-Shrub Wetlands (cont.)** | |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Unconsolidated Shore, Seasonally Flooded, Diked/Impounded (PSS1/USCh) | 0.24 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded (PSS1A) | 1.13 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded, Diked/Impounded (PSS1Ah) | 0.20 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded (PSS1C) | 2.10 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PSS1Ch) | 21.34 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Semi-permanently Flooded (PSS1F) | 0.01 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Semi-permanently Flooded, Diked/Impounded (PSS1Fh) | 5.44 |
| **Total Freshwater Scrub-Shrub Wetlands Acres** | **41.60** |
| **Freshwater Open Water** | |
| Palustrine, Unconsolidated Bottom, Permanently Flooded, Diked/Impounded (PUBHh) | 0.42 |
| Palustrine, Unconsolidated Bottom, Permanently Flooded, Excavated (PUBHx) | 0.03 |
| **Total Freshwater Open Water Acres** | **0.45** |
| **Total Wetland Acres Within Study Area** | **188.35** |

**Wetland Habitat Type within Elevation Bands 743 feet to 744 feet PD**

| Wetland Habitat Type | Acres Within Study Area |
|---|---|
| **Freshwater Emergent Wetlands** | |
| Palustrine, Emergent, Persistent, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PEM1/SS1Ch) | 0.01 |
| Palustrine, Emergent, Persistent, Temporary Flooded (PEM1A) | 0.05 |
| Palustrine, Emergent, Persistent, Seasonally Flooded (PEM1C) | 6.76 |
| Palustrine, Emergent, Persistent, Seasonally Flooded, Diked/Impounded (PEM1Ch) | 4.72 |
| **Total Freshwater Emergent Wetlands Acres** | **11.54** |
| **Freshwater Forested Wetland** | |
| Palustrine, Forested, Broad-Leaved Deciduous, Emergent, Persistent, Seasonally Flooded, Diked/Impounded (PFO1/EM1Ch) | 1.40 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded (PFO1/SS1A) | 1.08 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded, Diked/Impounded (PFO1/SS1Ah) | 7.34 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded (PFO1/SS1C) | 0.56 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PFO1/SS1Ch) | 39.95 |
| Palustrine, Forested, Broad-Leaved Deciduous, Unconsolidated Bottom, Semi-permanently Flooded, Diked/Impounded (PFO1/UBFh) | 4.38 |
| Palustrine, Forested, Broad-Leaved Deciduous, Temporary Flooded (PFO1A) | 15.06 |
| Palustrine, Forested, Broad-Leaved Deciduous, Temporary Flooded, Diked/Impounded (PFO1Ah) | 17.89 |
| Palustrine, Forested, Broad-Leaved Deciduous, Seasonally Flooded (PFO1C) | 4.53 |
| Palustrine, Forested, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PFO1Ch) | 104.31 |
| Palustrine, Forested, Broad-Leaved Deciduous, Semi-permanently Flooded, Diked/Impounded (PFO1Fh) | 16.86 |
| Palustrine, Forested, Dead, Broad-Leaved Deciduous, Semi-permanently Flooded, Diked/Impounded (PFO5/1Fh) | 1.40 |
| Palustrine, Forested, Deciduous, Semipermanently Flooded, (PFO6F) | 0.05 |
| **Total Freshwater Forested Wetland Acres** | **214.81** |
| **Freshwater Scrub-Shrub Wetlands** | |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Emergent, Persistent, Temporary Flooded, Ditched (PSS1/EM1Ad) | 1.02 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Emergent, Persistent, Seasonally Flooded (PSS1/EM1C) | 0.54 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Emergent, Persistent, Seasonally Flooded, Diked/Impounded (PSS1/EM1Ch) | 11.95 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Unconsolidated Bottom, Semi-permanently Flooded, Diked/Impounded (PSS1/UBFh) | 0.15 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded (PSS1A) | 1.03 |

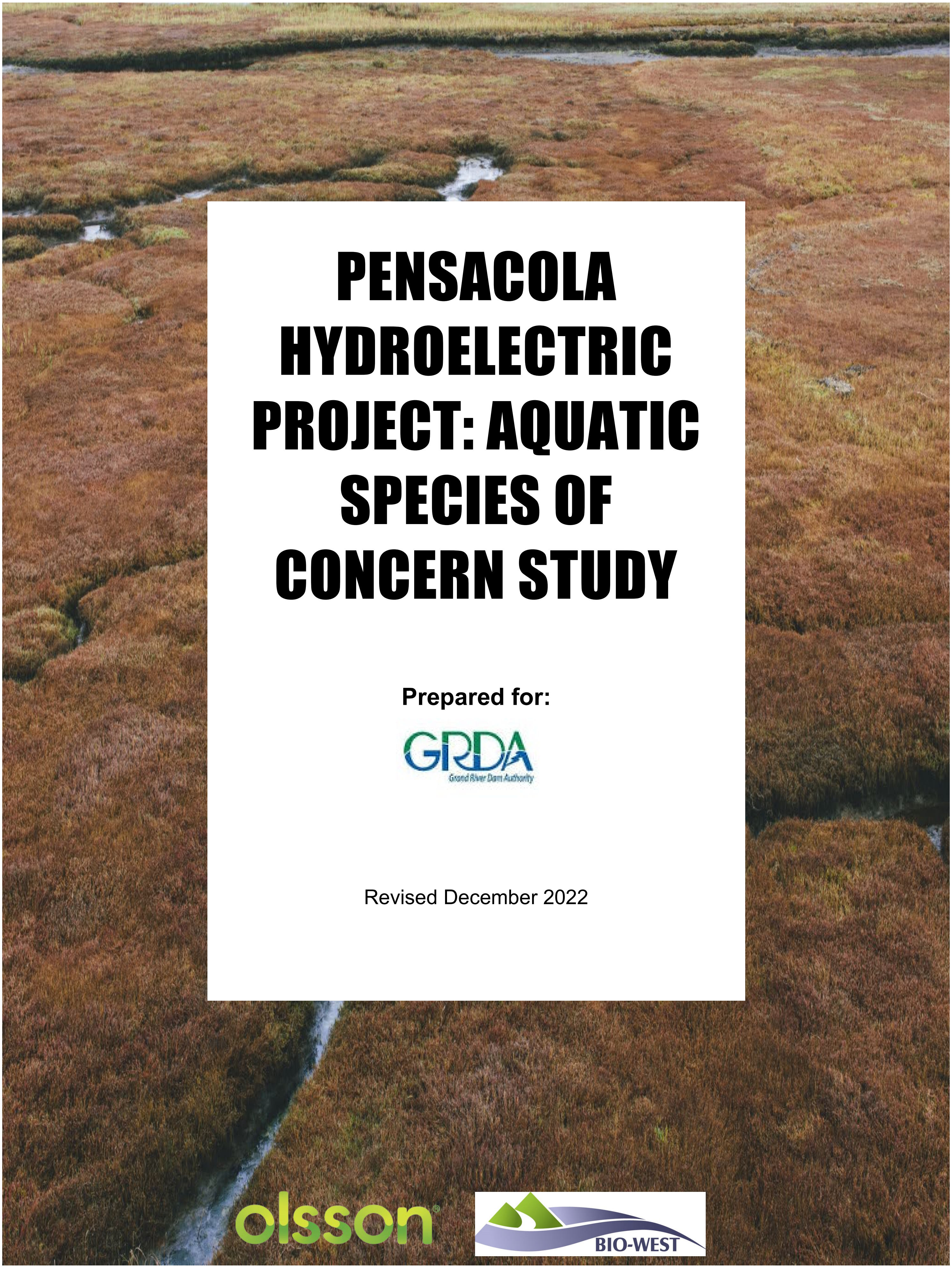
| Wetland Habitat Type | Acres Within Study Area |
|---|---|
| **Freshwater Scrub-Shrub Wetlands (cont.)** | |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded, Diked/Impounded (PSS1Ah) | 0.17 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded (PSS1C) | 2.66 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PSS1Ch) | 35.64 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Semi-permanently Flooded (PSS1F) | 0.25 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Semi-permanently Flooded, Diked/Impounded (PSS1Fh) | 19.05 |
| **Total Freshwater Scrub-Shrub Wetlands Acres** | **72.46** |
| **Freshwater Open Water** | |
| Palustrine, Unconsolidated Bottom, Permanently Flooded, Diked/Impounded (PUBHh) | 0.42 |
| Palustrine, Unconsolidated Bottom, Permanently Flooded, Excavated (PUBHx) | 0.05 |
| **Total Freshwater Open Water Acres** | **0.47** |
| **Total Wetland Acres Within Study Area** | **299.28** |

## Wetland Habitat Type within Elevation Bands 744 feet to 745 feet PD

| Wetland Habitat Type | Acres Within Study Area |
|---|---|
| **Freshwater Emergent Wetlands** | |
| Palustrine, Emergent, Persistent, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PEM1/SS1Ch) | 0.95 |
| Palustrine, Emergent, Persistent, Temporary Flooded (PEM1A) | 0.07 |
| Palustrine, Emergent, Persistent, Seasonally Flooded (PEM1C) | 4.08 |
| Palustrine, Emergent, Persistent, Seasonally Flooded, Diked/Impounded (PEM1Ch) | 10.27 |
| **Total Freshwater Emergent Wetlands Acres** | **15.37** |
| **Freshwater Forested Wetland** | |
| Palustrine, Forested, Broad-Leaved Deciduous, Emergent, Persistent, Seasonally Flooded, Diked/Impounded (PFO1/EM1Ch) | 1.44 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded (PFO1/SS1A) | 1.10 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded, Diked/Impounded (PFO1/SS1Ah) | 14.81 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded (PFO1/SS1C) | 0.24 |
| Palustrine, Forested, Broad-Leaved Deciduous, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PFO1/SS1Ch) | 34.44 |
| Palustrine, Forested, Broad-Leaved Deciduous, Unconsolidated Bottom, Semi-permanently Flooded, Diked/Impounded (PFO1/UBFh) | 1.25 |
| Palustrine, Forested, Broad-Leaved Deciduous, Temporary Flooded (PFO1A) | 24.56 |
| Palustrine, Forested, Broad-Leaved Deciduous, Temporary Flooded, Diked/Impounded (PFO1Ah) | 47.34 |
| Palustrine, Forested, Broad-Leaved Deciduous, Seasonally Flooded (PFO1C) | 18.19 |
| Palustrine, Forested, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PFO1Ch) | 205.35 |
| Palustrine, Forested, Broad-Leaved Deciduous, Semi-permanently Flooded, Diked/Impounded (PFO1Fh) | 9.82 |
| Palustrine, Forested, Dead, Broad-Leaved Deciduous, Semi-permanently Flooded, Diked/Impounded (PFO5/1Fh) | 0.26 |
| Palustrine, Forested, Deciduous, Semipermanently Flooded, (PFO6F) | 0.07 |
| **Total Freshwater Forested Wetland Acres** | **358.87** |
| **Freshwater Scrub-Shrub Wetlands** | |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Emergent, Persistent, Temporary Flooded, Ditched (PSS1/EM1Ad) | 4.92 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Emergent, Persistent, Seasonally Flooded (PSS1/EM1C) | 0.83 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Emergent, Persistent, Seasonally Flooded, Diked/Impounded (PSS1/EM1Ch) | 10.38 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Unconsolidated Bottom, Semi-permanently Flooded, Diked/Impounded (PSS1/UBFh) | 0.01 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded (PSS1A) | 0.66 |

| Wetland Habitat Type | Acres Within Study Area |
|---|---|
| **Freshwater Scrub-Shrub Wetlands (cont.)** | |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Temporary Flooded, Diked/Impounded (PSS1Ah) | 1.16 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded (PSS1C) | 3.59 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PSS1Ch) | 36.93 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Semi-permanently Flooded (PSS1F) | 10.11 |
| Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Semi-permanently Flooded, Diked/Impounded (PSS1Fh) | 21.14 |
| **Total Freshwater Scrub-Shrub Wetlands Acres** | **89.73** |
| **Freshwater Open Water** | |
| Palustrine, Unconsolidated Bottom, Permanently Flooded (PUBHh) | 2.99 |
| Palustrine, Unconsolidated Bottom, Permanently Flooded, Diked/Impounded (PUBHh) | 4.26 |
| Palustrine, Unconsolidated Bottom, Permanently Flooded, Excavated (PUBHx) | 0.31 |
| **Total Freshwater Open Water Acres** | **7.56** |
| **Total Wetland Acres Within Study Area** | **471.53** |

## APPENDIX E-12 Aquatic Species of Concern Study Report



# PENSACOLA HYDROELECTRIC PROJECT: AQUATIC SPECIES OF CONCERN STUDY

**Prepared for:**

GRDA
Grand River Dam Authority

Revised December 2022

olsson

BIO-WEST

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| CHM | Comprehensive Hydraulic Model |
| CFR | Code of Federal Regulations |
| ESA | Endangered Species Act |
| FERC | Federal Energy Regulatory Commission |
| GIS | Geographic Information System |
| GRDA | Grand River Dam Authority |
| H&H | Hydrologic and Hydraulic Study |
| ISR | Initial Study Report |
| kW | kilowatts |
| NDAA | National Defense Authorization Act for Fiscal Year 2020 |
| ODWC | Oklahoma Department of Wildlife Conservation |
| OSU | Oklahoma State University |
| OWRB | Oklahoma Water Resource Board |
| PAD | Pre-Application Document |
| PD | Pensacola Datum |
| PSP | Proposed Study Plan |
| RSP | Revised Study Plan |
| SMP | Shoreline Management Plan |
| TCTC | Tar Creek Trustee Council |
| TSMD | Tri-state Mining District |
| USACE | U.S. Army Corps of Engineers |
| USFWS | U. S. Fish and Wildlife Service |
| USGS | U. S. Geological Survey |
| USR | Updated Study Report |

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# APPENDICES

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# 1. INTRODUCTION

As part of the relicensing of the Pensacola Hydroelectric Project (Project; FERC [Federal Energy Regulatory Commission] No. 1494), the Grand River Dam Authority (GRDA) filed a Pre-Application Document (PAD) with FERC on February 1, 2017 (GRDA 2017). The GRDA filed its Proposed Study Plan (PSP) for the relicensing on April 27, 2018 (GRDA 2018a). Also, on April 27, 2018, FERC released its Scoping Document 2 for the relicensing of the Project (FERC 2018). In its PSP, GRDA did not include a specific study to investigate potential Project effects on aquatic resources. Based on comments received from federal and state resource agencies and other stakeholders, GRDA's Revised Study Plan (RSP), filed on September 24, 2018, proposed an Aquatic Species of Concern Study to provide further details regarding how potential impacts to aquatic resources related to changing water levels due to Project operations will be assessed during the relicensing process.

GRDA's Aquatic Species of Concern Study proposed a phased approach to identify and analyze potential Project effects on aquatic species in the study area and focused on six species: Neosho Mucket (*Lampsilis rafinesqueana*); Rabbitsfoot mussel (*Quadrula cylindrical cylindrical*); Winged Mapleleaf mussel (*Quadrula fragosa)*; Neosho Madtom (*Noturus placidus*); Neosho Smallmouth Bass (*Micropterus dolomieu velox*); and Paddlefish (*Polyodon spathula*). In the RSP, GRDA's Aquatic Species of Concern Study Plan generally proposed to use existing information and output from the Comprehensive Hydraulic Model (CHM) to assess potential impacts to these aquatic resources. For three species (Neosho Mucket, Neosho Madtom, and Neosho Smallmouth Bass), GRDA also proposed to conduct field surveys in the second study season to develop rough estimates of species' distribution in relevant reaches, if determined necessary.

FERC issued its Study Plan Determination on November 8, 2018, which recommended the following refinements to GRDA's proposed Aquatic Species of Concern Study:

- For Paddlefish, FERC recommended that GRDA include estimating the proportion of Paddlefish spawning habitat affected by increasing the reservoir elevation, relative to available spawning habitat in the Project vicinity. FERC explained that estimating the proportion of spawning habitat affected by increasing the reservoir elevation could be accomplished using GRDA's proposed data gathering methodology.

- For the three Neosho species, FERC recommended that GRDA address the need for species density information by: (1) including a review of existing density estimates in the Project vicinity for each species (for the first season of studies); and (2) including surveys designed to estimate each species' density (in the second season of studies).

The review of existing information required by the FERC-approved Aquatic Species of Concern Study during the first season was summarized in an Initial Study Report (ISR) submitted in September 2021. Following agency comments and GRDA responses on this report, FERC issued a Year 2 Study Plan Determination in February 2022. This determination identified areas to be surveyed for Neosho Mucket and Neosho Madtom during Phase 2 studies in 2022, and directed GRDA to consult with EcoAnalysts, Tar Creek Trustee Council (TCTC), and U.S. Fish and Wildlife Service (USFWS) on mussel survey design. A proposed mussel survey design was developed, shared with the above entities during spring 2022, and completed during the summer of 2022 (see Appendix B).

As part of the relicensing process, an Updated Study Report (USR) was provided for stakeholder comment. Several comments were received on the updated study report from FERC staff and the USFWS. FERC staff requested maps delineating the riverine reaches that would be converted to lentic habitat during the Paddlefish spawning season (March-April) and an estimate of the acreage of habitat in the Spring and Neosho Rivers that would be converted to lentic habitat under anticipated operations (See Section 4.6.3 and Appendix E).

FERC also requested the following for the Neosho Madtom and Neosho Mucket:

> (1) a table that reports the numerical difference in water level in feet between baseline and anticipated operation at each survey site in the Spring and Neosho Rivers where GRDA conducted Neosho Madtom surveys during July and August 2022 and at any other sites where Neosho Madtom have been observed within the Project boundary. The estimated differences in water level between baseline and anticipated operations should be based on the data used to generate the aquatic habitat maps in Appendix I of the Hydrologic and Hydraulic Modeling: Upstream Hydraulic Model Updated Study Report (See Table D3 in Appendix D);
>
> (2) use the upstream hydraulic model to estimate the water level under baseline operations and anticipated operations using the median reservoir elevations and inflows during the Neosho Mucket spawning period (April through May) and separately during the brooding period (May through August) (See Tables D1 and D2 in Appendix D); and
>
> (3) use the model output to estimate the numerical difference in water level in feet between baseline and anticipated operations at each of the locations in the Spring, Neosho, and Elk Rivers where suitable Neosho Mucket habitat was identified during the July 2022 freshwater mussel surveys. Please report the above requested water level differences in two tables (one for the spawning season and one for the brooding season) (See Tables D1 and D2 in Appendix D).

This comprehensive Aquatic Species of Concern Study Report summarizes results of the initial review of existing information, subsequent survey efforts, the FERC information requested on

November 29, 2022, changes necessary as a result of USFWS comments, and provides an analysis of the effects of anticipated Project operations on each of the aquatic species of concern.

## 1.1 Purpose of the Study

The purpose of this study is to determine if GRDA's anticipated operation has the potential to affect aquatic species of concern in Grand Lake O' the Cherokees (Grand Lake) and the lower reaches of its tributaries. This study reports on information needed to assess the effects of the Project, if any, on these relevant species (identified in the following section) as part of FERC's analysis for the relicensing of the Project. Specifically, Section 3 summarizes existing and recently collected information on each of the six species identified above and based on that existing information, discusses the potential effects of baseline Project operations versus anticipated Project operations (if any) using hydraulic conditions predicted by the CHM during sensitive life stages.

### 1.1.1 Species of Concern

The Neosho Mucket, Rabbitsfoot, Winged Mapleleaf, Neosho Madtom, and Neosho Smallmouth Bass have been identified as species of concern that inhabit or have the potential to inhabit the areas affected by the anticipated Project operations. While Paddlefish is not a species of concern, it is an important resource in Grand Lake. Project operations may influence water levels of the surrounding tributaries of the Pensacola Dam. These water level fluctuations have the potential to alter the habitat of the species of concern and Paddlefish. Understanding the spatial and temporal effects, if any, caused by anticipated Project operations on the study area will allow for characterization of potential impacts to these species.

The following list details the dates when the above species were listed by the USFWS as threatened or endangered under the federal Endangered Species Act (ESA):

- Neosho Mucket was listed as endangered effective October 17, 2013 – listed wherever found (ECOS 2021a).
- Rabbitsfoot mussel was listed as threatened effective October 17, 2013 – listed wherever found (ECOS 2021b).
- Winged Mapleleaf mussel was listed as endangered effective June 20, 1991, and experimental population, nonessential effective June 14, 2001– Endangered wherever found, except where listed as an experimental population (ECOS 2021c).
- Neosho Madtom was listed as threatened effective June 22, 1990 – listed wherever found (ECOS 2021d).

Neosho Smallmouth Bass is not listed under the federal ESA. However, it was identified by Oklahoma Department of Wildlife Conservation (ODWC) in its July 24, 2018, PSP comment letter to FERC as a species of concern in the context of anticipated changes to water level management in Grand Lake.

Paddlefish is not listed under the federal ESA, nor has it been identified by ODWC as a species of concern. Paddlefish use Grand Lake's two primary headwaters (the Neosho River and Spring River) for spawning. However, stocks in Grand Lake and the Neosho and Spring Rivers support a prominent snag fishery, attracting anglers from throughout the United States during the spring spawning run (Jager and Schooley 2016). Although annual catch rates are variable depending on hydrologic conditions, thousands of mature Paddlefish are harvested from Grand Lake stocks during some years (Scarnecchia et al. 2013). Trip expenditures from Paddlefish angling in Oklahoma have an estimated economic impact of $18.2 million (Melstrom and Shideler 2017), much of which is focused on the Grand Lake fishery.

## 1.2 Project Background

Based on the information in the Shoreline Management Plan (SMP; GRDA 2008) the existing Project consists of the following:

1. A main dam, which has a maximum height of 147 feet (ft) and is comprised of (a) a 53.5-ft-long non-overflow abutment section on the western end, (b) a 4,284-ft long multiple-arch section with a crest elevation of 757-ft Pensacola Datum (PD), (c) an 861-ft long main spillway section, which has a crest elevation of 730-ft PD and is controlled by 21 Taintor gates, each of which is 36-ft long by 25-ft high, (d) a 451-ft long non overflow gravity section on the eastern end, and (e) a 300-ft long non overflow abutment section consisting of a concrete core wall;
2. Two auxiliary spillways with approximate lengths of 464-ft and 422-ft about 1.0 mile east of the main dam, which consist of concrete gravity overflow type spillways with crest elevations of 740-ft PD controlled by a total of 21 Taintor gates, each of which is 37-ft long by 15-ft high;
3. Grand Lake, which has a surface area of 46,500 acres (ac) and a storage volume of 1,680,000 acre-feet at the maximum power pool of 745-ft PD;
4. A 27-ft by 246-ft intake structure;
5. A powerhouse with dimensions of 87.75-ft by 279.0-ft located immediately downstream of the western end of the dam, which contains seven turbine generator units with a total nameplate capacity of 86,900 kilowatts (kW); and
6. Other pertinent equipment and facilities.

Under the Flood Control Act of 1944, the NDAA (National Defense Authorization Act for Fiscal Year 2020), and other federal legislation and regulations, the U.S. Army Corps of Engineers (USACE) has control of the basin wide system of flood control and navigation projects. Flood storage at the Project is when the elevation is expected rise above 745--ft PD.

## 1.3 Study Area

Grand Lake is located in portions of Craig, Mayes, Delaware, and Ottawa counties, Oklahoma. The study area for the Aquatics Species of Concern Report can be broken into three categories:

1. Project Vicinity: The associated tributaries outside of the project boundary. These include the Spring River into Kansas and Missouri, Neosho River into Kansas, and Elk River in Missouri.
2. Model Extent: The Model extent area for the Aquatic Species of Concern review corresponds to those counties associated with the Hydrologic and Hydraulic (H&H) Study (see Section 3 Methodology of the H&H Study Plan: GRDA 2018b). The study area extends upstream from Pensacola Dam along the Neosho River to within approximately 3 miles of the Kansas state line, upstream along the Spring River to within 6.5 miles of the Kansas state line, upstream along the Elk River to the extent dictated by the H&H model, and along Tar Creek to just upstream of the U.S. Geological Survey (USGS) gage at 22$^{nd}$ Avenue Bridge (Figure 1). The model extent encompasses space between the Project Vicinity and project boundary.
3. Project Boundary: The project boundary is an administrative marker to clearly delineate those lands necessary for operation and maintenance of the project and for other project purposes, such as recreation, shoreline control, or protection of environmental resources (Figure 1). The boundary does not affect existing property rights.

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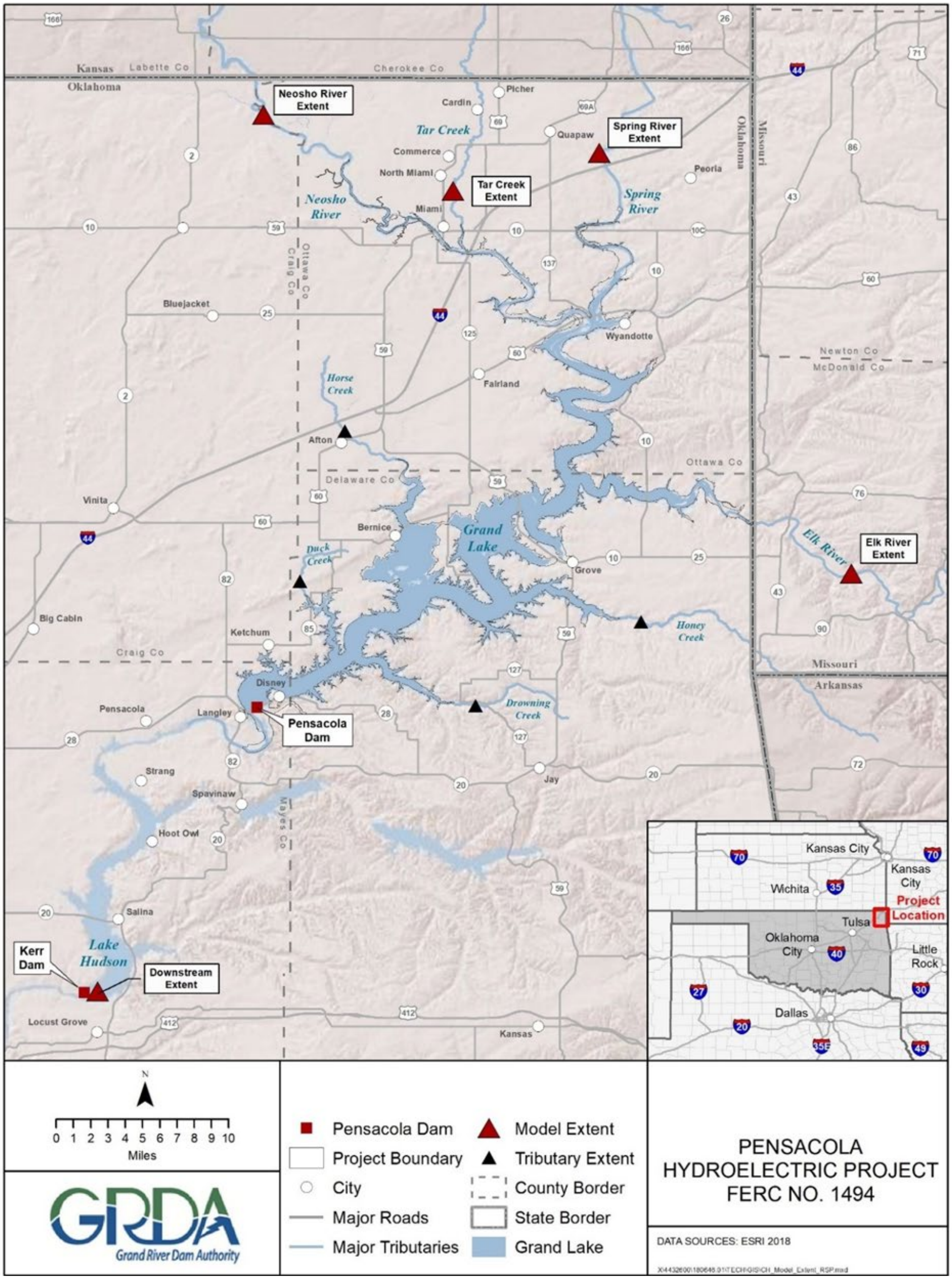


**Figure 1. Study area for the Aquatic Species of Concern Study.**

# 2. PHASES OF STUDY

## 2.1 Phase I: Review of Existing information

Phase I of this study involved a detailed exploration of existing information, including ODWC reports, peer-reviewed scientific publications, and, to the extent possible, unpublished information gathered by researchers from ODWC, Sam Nobel Museum, Oklahoma State University (OSU) invertebrate collection, Oklahoma Water Resource Board (OWRB), academic institutions, and other entities. As part of the Phase I activities, Olsson coordinated with ODWC to obtain verbal feedback (i.e., documented personal communications) regarding the distributions of the species of interest in the Project vicinity that have the potential to be affected by Project operations (Project Boundary). Reaches of reservoir inundation within the study area were identified based on maps generated by the CHM as part of the H&H Study. Habitat preferences for each life-history stage of the species of concern identified in this study report are based on literature review and professional judgment.

## 2.2 Phase II and Phase III: Field Studies to Document Distribution of the Species of Concern and Anticipated Project Effects Discussion

Under GRDA's RSP for the Aquatic Species of Concern Study, if the information gathered during Phase I for any species is of sufficient quality to conduct an effects analysis, then Phase II actions (e.g., fieldwork) were not undertaken for that species. If existing records were inadequate for estimating a species' distribution, the FERC-approved study plan provided for targeted field surveys to be conducted to develop a rough estimate of the species' distribution in the reaches of concern (i.e., reaches of reservoir inundation identified by the CHM). Phase II fieldwork included the following:

1) A review of existing density estimates in the study area for each species, and
2) Surveys designed to estimate each species' distribution and density for select species based on the results of the Phase I study.

As stated in the previous section, habitat preferences have been based on information taken from the scientific literature and collaboration with agency experts; no field data was collected during Phase II to characterize habitat use. Phase II data has been analyzed and Phase III incorporated Project effects in the discussion sections of this report.

# 3. EXISTING AND RECENTLY COLLECTED INFORMATION

The following section reviews the habitat preference, distribution, and occurrence of all six species, listed above, that are the subject of this Aquatic Species of Concern Study.

## 3.1 Neosho Mucket (*Lampsilis rafinesqueana*)

### 3.1.1 Habitat and Conservation Status

The life history for the Neosho Mucket, similar to most freshwater mussels in North America, is not fully understood. In general, freshwater mussels siphon water across gills for respiration and food collection. Mussels are known to forage on detritus, algae, dissolved organic carbon, and other microscopic organisms (Strayer et al. 2004). Adult mussels tend to orient themselves on the surfaces of substrate to take in food and oxygen from the water column (The Neosho Mucket Recovery Team 2018). The Neosho Mucket reproduces with the release of sperm from male mussels into the water column where females can draw it in through their siphon (Barnhart 2003). Reproductive success is often a function of water flow conditions and species density. Neosho Muckets spawn in late April and May and female brooding of glochidia occurs through the month of August (Barnhart 2003). It has been demonstrated that Neosho Mucket glochidia are obligate parasites of black bass species, including the Largemouth Bass (*Micropterus salmoides*), Smallmouth Bass (*Micropterus dolomieu*), and Spotted Bass (*Micropterus punctulatus*) (Barnhart and Roberts 1997).

Habitat requirements for the Neosho Mucket are not adequately understood and sometimes contradictory depending on the reporting survey and the drainage where found. Previous research has demonstrated an association of Neosho Muckets with shallow riffles and runs with moderate to swift-moving water. In Shoal Creek and the Illinois River, Oklahoma, it prefers nearshore areas or areas out of the main current (Oesch 1984; Obermeyer 2000). It is believed the Neosho Mucket does not occur in reservoirs lacking riverine characteristics (Obermeyer et al. 1997). In the Illinois River, Neosho Muckets seem to concentrate in areas outside of the main river channel near the shore (ODWC 2021b), often in mucky and/or slack-water habitats (Olsson 2019).

As of its 5-year status review conducted by USFWS in 2020, the conservation status of the Neosho Mucket remains unchanged and exists in isolated populations with low abundance except in the Spring River critical habitat locations (USFWS 2020a). Threats to conservation vary by river system within the Project vicinity. In the Neosho River upstream of Grand Lake, 12 low head dams and 3 federal dams exist, which alter the hydrologic and water quality conditions along the Neosho River north of the Project boundary. Obermeyer (1996) found mussel richness and diversity negatively affected by the presence of low head dams both upstream and downstream on the Neosho River in Kansas. In the Spring River, the historic mining of lead and zinc within the Tri-state Mining District (TSMD) has caused contamination of waterways within the Project boundary at levels above TSMD sediment quality guidelines in the Spring River (Morrison et. al., 2019). Angelo et al (2007) noted that unionid mussel species richness declined with increasing sediment metals concentrations within the Spring River and TSMD. Overall, threats to the species include impoundment, sedimentation, chemical contaminants, mining, the inadequacy of existing regulatory mechanisms, population fragmentation and isolation, invasive nonindigenous species, and degradation of water quality. Climate change is also likely to have adverse effects on the species because of the alteration of hydrologic cycles of rivers that support Neosho Mucket, but the extent or magnitude of this threat has not been quantified at this time (USFWS 2018).

## 3.1.2 Distribution and Occurrence

The Neosho Mucket is an endemic and federally endangered freshwater mussel species with a distribution found in the Arkansas River System (Gordon 1981; Harris and Gordon 1987; Mather 1990; Obermeyer 1996). Historically, this species of mussel has been observed in seventeen streams within the Neosho, Illinois, and Verdigris River basins (USFWS 2018). With respect to this relicensing project and discrete Project vicinity, rivers within the Neosho River basin with known populations of Neosho Mucket include the Neosho River, Spring River, and Elk River. In a USFWS 5-year review (2020a) of the Neosho Mucket, the population status was found to be declining in the Neosho River (last observed 2014), and stable in the Spring and Elk Rivers (last observed 2017). While the species is considered endangered wherever found, critical habitat areas are summarized in Table 1 for the Neosho, Spring and Elk Rivers.

**Table 1. Critical habitat for Neosho Mucket.**

| Critical Habitat Unit Number | River | Within Project Boundary |
|---|---|---|
| **NM7** | Neosho | No |
| **NM5** | Spring | No |
| **NM4** | Spring | No |
| **NM3** | Spring | No |
| **NM2** | Elk | Yes |

Critical Habitat found within Project boundary and model extent is located on the Elk River with the general description as follows:

Unit NM2 includes 12.6 mi of the Elk River from Missouri Highway 59 at Noel, McDonald County, Missouri, to the confluence of Buffalo Creek immediately downstream of the Oklahoma and Missouri State line, Delaware County, Oklahoma (USFWS 2021).

The occurrence of the Neosho Mucket within the Project vicinity has been described as extremely rare in the Oklahoma portions of the Spring and Neosho Rivers (USFWS 2015). On the Elk River, species occurrences have been documented primarily on the Missouri side of the state line (USFWS 2018), outside Project boundary. However, some of these locations appear to fall within the model extent. While personal contacts with ODWC suggested no formal mussel surveys have been conducted within the Neosho, Spring, and Elk Rivers (Curtis Tacket; Personal Communication), data does exist in various agency reports, primary literature, and communications that is germane to this process. These data are summarized in Table 2.

**Table 2. Summary of Neosho Mucket locations within the Project Vicinity.**

| River | Date (Years) | Agency/Tribe/Entity | Location/Result | Citation(s) |
|---|---|---|---|---|
| **Neosho** | 1990 | ODWC | 4 Sites from Neosho River 3 Miles WNW of Miami to Kansas State Line/8 Relic Shells Found | Mater, C.M. 1990. Status Survey of the Western Fanshell and the Neosho Mucket. Report to the Oklahoma Department of Wildlife Conservation. |
| | 1994-1997 | ODWC/OU | Neosho River, State Line to Stepp's Ford Bridge (estimate)/No Live Neosho Muckets/29% of sites had Relic Neosho Mucket Shells | Vaughn CC. Determination of the status and habitat preference of the Neosho Mucket in Oklahoma. Oklahoma City, OK: Oklahoma Biological Survey; 1998. 17 pp. |
| | 2006-2007 | Peoria Tribe | Gravel Bars 4, 7, and 8/ Six Relict Shells | USFWS Neosho Mucket 5-year review: Summary and Evaluation. |
| | 2014 | Peoria Tribe | Stepp's Ford Bridge/ 1 Live and 1 Relict Shell | USFWS Neosho Mucket 5-year review: Summary and Evaluation USFWS Memorandum, Biological Opinion, May 12, 2015. |
| | 2018 | EcoAnaysts, Inc. | 19.5 km upstream to 1.5 km downstream of the Interstate 44 Bridge near Miami Oklahoma/No live or Relic Neosho Mucket Found | USFWS Neosho Mucket 5-year review: Summary and Evaluation. |
| **Spring** | 1990 | ODWC | 3 Sites North from Devils Promenade Bridge to the State Line/1 relict shell collected | Mater, C.M. 1990. Status Survey of the Western Fanshell and the Neosho Mucket. Report to the Oklahoma Department of Wildlife Conservation |
| | 1994-1997 | ODWC/OU | Spring River, E57 Rd Bridge to State Line, 10 Sites, 60% of sites had relic shells. Authors Note Fresh Shells found at 2 sites and may have come down the river from known/healthy populations in Kansas/Missouri. | Vaughn CC. Determination of the status and habitat preference of the Neosho Mucket in Oklahoma. Oklahoma City, OK: Oklahoma Biological Survey; 1998. 17 pp. |
| | 2003/11/05<br>2006/08/03 | KDHE | Spr7: 36.96145, -94.72203,<br>Dead Weathered Neosho Mucket Shell<br><br>Spr8: 36.93439, -94.74520,<br>Dead (Recent) Neosho Mucket Shell<br><br>Spr9: 36.87474, -94.76269<br>None Found | Angelo, R.T., M.S. Cringan, D. L. Chamberlain, A. J. Stahl, S. G. Haslouer, and C. A. Goodrich. 2007. Residual effects of lead and zinc mining on freshwater mussels in the Spring River basin (Kansas, Missouri, and Oklahoma, USA). Science of the Total Environment 384: 467-496. |

| River | Date (Years) | Agency/Tribe/Entity | Location/Result | Citation(s) |
|---|---|---|---|---|
| | 2018 | EcoAnaysts, Inc. | Found live Neosho Mucket from 8 of 15 sites in Missouri, Kansas, and Oklahoma. This included one of four sites in Oklahoma. Five live Neosho Muckets were located from site "Spring 19" (36.913964, -94.732117) in 2016. Subsequent quantitative surveys in 2017 were unable to locate Neosho Mucket at Spring 19. | EcoAnalysts, Inc., 2018 |
| **Elk** | 1978-1995 | | 23 Neosho Muckets collected in Missouri from two sites. (Location Undisclosed) | USFWS Neosho Mucket 5-year review: Summary and Evaluation. |
| | 1992 & 1998 | | Reports of Brooding Neosho Mucket Females and Juveniles present at two sites (Location Undisclosed) | USFWS Neosho Mucket 5-year review: Summary and Evaluation. |
| | 2016-2017 | | 45 Live Muckets collected from 4 locations near Noel and HWY DD, McDonald County, MO | USFWS Neosho Mucket 5-year review: Summary and Evaluation. |

# 4. PHASE II STUDY

## 4.1 Neosho Mucket (*Lampsilis rafinesqueana*)

### 4.1.1 Study Methodology

Based off historical mussel survey data from 1990-2017, and the 5 year species reviews compiled by USFWS for the Neosho Mucket, a data gap was identified in the records regarding the presence or absence of endangered mussel species within the Elk River portion of the GRDA Project boundary.

On the Neosho River, the most recent mussel survey completed by Eco Analysts Inc. (2018) in 2017 found no live or relic shells of Neosho Mucket within the Project boundary or model extent. While one live specimen of Neosho Mucket was found during a bridge construction project in 2014, the body of available data within the Neosho River arm of the Project suggests that the Neosho Mucket and other federally listed mussel species are unlikely to occur in the Project boundary of the Neosho River arm. On the Spring River, previous surveys from the Kansas/Oklahoma State line to the Project boundary have located Neosho Mucket at one site upstream of the Project boundary.

The Elk River portion for the GRDA Project boundary was listed in 2015 as critical habitat for the Neosho Mucket. The most recent survey data recounted in the 5 Year Review of the Neosho Mucket status suggests that a population of mussels may exist within the Project boundary of Grand Lake as evidenced by recent surveys that recovered live specimens only a few river miles upstream. Per the description in the Code of Federal Regulations (CFR) for critical habitat NM2, a roughly one mile stretch of critical habitat occurs within the current Project boundary and no data was identified during the Phase I Study regarding the presence or absence of the Neosho Mucket, or other federally listed unionid species in this area.

Based on the analysis of existing data from Phase 1 Aquatic Studies presented in the ISR along with the subsequent agency comment responses and FERC’s study plan determination, Phase 2 mussel surveys were conducted for Neosho Mucket in select portions of the Elk, Spring, and Neosho rivers. Specifically, these areas were:

- The portion of the Elk River from the Missouri/Oklahoma state line to the confluence with Buffalo Creek (approximately 1.0 river mile);
- The portion of the Spring River from Warren Branch to the confluence with the Neosho River (approximately 10.5 river miles); and
- The portion of the Neosho River from the City of Miami [Riverview Park] to the confluence with the Spring River (approximately 13 miles).

A three-phase mussel survey methodology was developed by the study team and reviewed by USFWS, EcoAnalysts, and the TCTC. Phase 1 of the methodology included identification and mapping of any potential Neosho Mucket habitat. Phase 2 included qualitative sampling to evaluate the presence of Neosho Mucket in any areas of potential habitat identified. Lastly, Phase 3 included quantitative quadrat sampling to estimate density of Neosho Mucket in any areas where the species was detected.

The initial Phase 1 habitat assessment identified potential habitat consistent with previous mussel survey efforts and habitat descriptions for Neosho Mucket. Freshwater mussels are typically most abundant and diverse within stable fluvial habitats (riffles/runs) of riverine environments (Haag 2012, EcoAnalysts 2018). Specifically, Neosho Muckets have been collected from a variety of habitats but are typically described to have an association with moderately flowing shallow water over gravel or intermixed gravel and sand substrates (McMurray et al. 2012; Oesch 1984) and are not thought to inhabit reservoirs (Obermeyer et al. 1997). Therefore, potential habitat for Neosho Mucket was considered to be flowing water riffles and runs over gravel or intermixed gravel and sand substrates. Limited amounts of potentially suitable Neosho Mucket habitat were identified within the study areas. Therefore, additional mussel survey sites (Community Assessment Sites) were added to characterize the mussel community within other portions of the study area.

Qualitative surveys via timed visual/tactile search methods (hand-grubbing into the top 1-4 inches of substrate to increase detection of more deeply buried mussels) were utilized to efficiently assess occurrence of Neosho Mucket. A qualitative survey approach is an efficient search method to establish a list of taxa, as well as increase the detection probability of rare species (Vaughn et al. 1997; Strayer and Smith 2003). To ensure suitable habitat was adequately sampled, following the same methodology, divers used surface-supplied air from a Brownies Third Lung Hookah Dive System to reach deeper areas. Surveyors conducted a minimum of three person-hours using mask and snorkel (or dive gear, where appropriate). All live mussels were placed in mesh bags and submerged in the stream. If no live mussels were collected by the end of the third person-hour, the site was considered complete. If live mussels were located, an additional two person-hours of search effort were conducted. Since Neosho Mucket (or other listed mussels) were not detected at any point during Phase 2 surveys, Phase 3 quantitative surveys were not necessary.

Upon completion of surveys at each site, all mussels were identified to species by federally permitted biologists, enumerated, and returned to the approximate location of collection. Voucher photographs were taken of each species collected. At each survey location substrate composition was recorded. Substrate categories included: bedrock, boulder, cobble, gravel, sand, silt, and clay.

## 4.1.2 Results

Surveys were conducted during the week of July 18th, 2022. Overall, 188 mussels representing 12 species were collected from 13 sites during 57 person-hours of total survey effort (Figure 2). Bluefer (*Potamilus purpuratus*) was the most abundant species, with 108 individuals collected. The next most abundant species was Fragile Papershell (*Potamilus fragilis*), with 23 individuals collected. Threehorn Wartyback (*Obliquaria reflexa*) and Pink Papershell (*Potamilus ohiensis*) were the next most abundant species overall, with nineteen (19) and seventeen (17) individuals collected, respectively. No Neosho Muckets were collected during this study (Table 3). Voucher photographs can be found in Appendix A.

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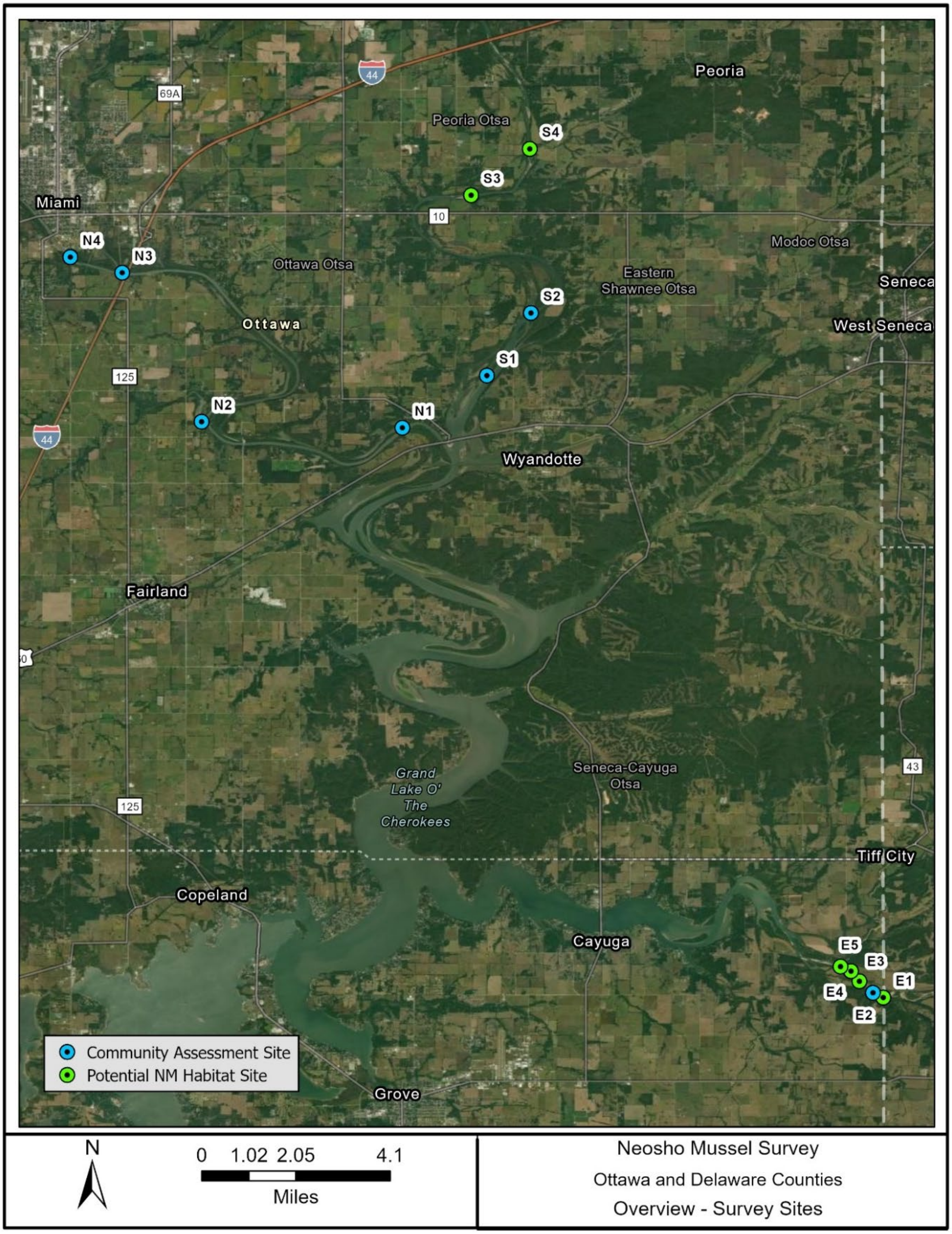


**Figure 2. Mussel survey sites on the Elk, Spring, and Neosho Rivers.**

**Table 3. Number of live individuals (#) and percent relative abundance (%) of live mussels in the Elk, Spring, and Neosho Rivers.**

| Species | Elk | | Spring | | Neosho | | Total | |
|---|---|---|---|---|---|---|---|---|
| | # | % | # | % | # | % | # | % |
| Plain Pocketbook (*Lampsilis cardium*) | 1 | 100.0 | 4 | 10.5 | 0 | 0.0 | 5 | 2.7 |
| Yellow Sandshell (*Lampsilis teres*) | 0 | 0.0 | 0 | 0.0 | 3 | 2.0 | 3 | 1.6 |
| White Heelsplitter *(Lasmigona complanata)* | 0 | 0.0 | 0 | 0.0 | 1 | 0.7 | 1 | 0.5 |
| Threehorn Wartyback *(Obliquaria reflexa)* | 0 | 0.0 | 5 | 13.2 | 14 | 9.4 | 19 | 10.1 |
| Fragile Papershell *(Potamilus fragilis)* | 0 | 0.0 | 2 | 5.3 | 21 | 14.1 | 23 | 12.2 |
| Pink Papershell *(Potamilus ohiensis)* | 0 | 0.0 | 9 | 23.7 | 8 | 5.4 | 17 | 9.0 |
| Bleufer *(Potamilus purpuratus)* | 0 | 0.0 | 11 | 28.9 | 91 | 61.1 | 102 | 54.3 |
| Mapleleaf *(Quadrula quadrula)* | 0 | 0.0 | 1 | 2.6 | 0 | 0.0 | 1 | 0.5 |
| Lilliput *(Toxolasma parvum)* | 0 | 0.0 | 0 | 0.0 | 1 | 0.7 | 1 | 0.5 |
| Pistolgrip *(Tritogonia verrucosa)* | 0 | 0.0 | 1 | 2.6 | 4 | 2.7 | 5 | 2.7 |
| Paper Pondshell *(Utterbackia imbecillis)* | 0 | 0.0 | 0 | 0.0 | 1 | 0.7 | 1 | 0.5 |
| Flat Floater *(Utterbackiana suborbiculata)* | 0 | 0.0 | 5 | 13.2 | 5 | 3.4 | 10 | 5.3 |
| **Species Richness** | 1 | | 8 | | 10 | | 12 | |
| **Total Abundance** | 1 | | 38 | | 149 | | 188 | |

## *Elk River Results*

On July 18th, three sites of potential Neosho Mucket habitat (E1, E3, and E5) and two additional community assessment sites (E2 and E4) were identified and surveyed on the Elk River for a total of 17 person-hours of effort (Figure 3). Habitats identified and sampled in the Elk River included shallow riffles and runs with a complex substrate mixture of gravel, sand, silt, cobble, and bedrock. The substrate observed at the Elk River sites varied from bedrock to silt. The substrate at sites E1 and E2 varied, ranging from bedrock to silt. The substrate at sites E3, E4, and E5 was predominantly gravel, sand, and silt. All sites were searched for at least three person-hours, except for E4 which was searched for five person-hours due to the presence of live mussels. Only one live mussel was collected in the Elk River, a Plain Pocketbook (*Lampsilis cardium*) at site E4 (Table 4).

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**Figure 3. Elk River survey sites.**

**Table 4. Number of live individuals (#) and percent relative abundance (%) of live mussels at five sites in the Elk River.**

| Species | Elk River 1 | | Elk River 2* | | Elk River 3 | | Elk River 4* | | Elk River 5 | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | # | % | # | % | # | % | # | % | # | % | # | % |
| Plain Pocketbook *(Lampsilis cardium)* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 100 | 0 | 0 | 1 | 100 |
| **Species Richness** | 0 | | 0 | | 0 | | 1 | | 0 | | 1 | |
| **Total Abundance** | 0 | | 0 | | 0 | | 1 | | 0 | | 1 | |

*Community Assessment Site

## Spring River Results

At the Spring River on July 19th, two sites of potential Neosho Mucket habitat were identified and sampled, and two additional community assessment sites were surveyed to evaluate the mussel community within lentic habitats of the study area (Figure 4). All sites on the Spring River were searched for five person-hours due to the presence of live mussels at each site. Habitat at the two most-upstream Spring River sites (S3 and S4) was characterized by shallow runs and riffles with complex substrates composed of gravel, sand, bedrock, and silt. Hence, these areas were identified as potential Neosho Mucket habitat. The remainder of the study area was characterized by deeper, slower moving water with silt and clay substrates. Two sites were conducted within these areas (S1 and S2) to characterize the mussel community present.

In the Spring River, 20 person-hours of total survey effort resulted in collection of 38 individuals belonging to 8 species. The most abundant species was the Bleufer, with 11 individuals. Pink Papershell was the next most abundant species collected, with 9 individuals (Table 5).

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**Figure 4. Spring River survey sites.**

**Table 5. Number of live individuals (#) and percent relative abundance (%) of live mussels at four sites in the Spring River.**

| Species | Spring River 1* | | Spring River 2* | | Spring River 3 | | Spring River 4 | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | # | % | # | % | # | % | # | % | # | % |
| Plain Pocketbook *(Lampsilis cardium)* | 0 | 0.0 | 0 | 0.0 | 1 | 7.1 | 3 | 42.9 | 4 | 10.5 |
| Threehorn Wartyback *(Obliquaria reflexa)* | 0 | 0.0 | 0 | 0.0 | 4 | 28.6 | 1 | 14.3 | 5 | 13.2 |
| Fragile Papershell *(Potamilus fragilis)* | 0 | 0.0 | 0 | 0.0 | 2 | 14.3 | 0 | 0.0 | 2 | 5.3 |
| Pink Papershell *(Potamilus ohiensis)* | 9 | 75.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 9 | 23.7 |
| Bleufer *(Potamilus purpuratus)* | 2 | 16.7 | 0 | 0.0 | 6 | 42.9 | 3 | 42.9 | 11 | 28.9 |
| Mapleleaf *(Quadrula quadrula)* | 1 | 8.3 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 2.6 |
| Pistolgrip *(Tritogonia verrucosa)* | 0 | 0.0 | 0 | 0.0 | 1 | 7.1 | 0 | 0.0 | 1 | 2.6 |
| Flat Floater *(Utterbackiana suborbiculata)* | 0 | 0.0 | 5 | 100.0 | 0 | 0.0 | 0 | 0.0 | 5 | 13.2 |
| **Species Richness** | 3 | | 1 | | 5 | | 3 | | 8 | |
| **Total Abundance** | 12 | | 5 | | 14 | | 7 | | 38 | |

*Community Assessment Site

## Neosho River Results

On July 20, the habitat assessment identified no potentially suitable habitat for Neosho Mucket within the Neosho River study area. No shallow riffles or runs were present within this area. Instead, the habitat was dominated by deep slow-moving waters. However, to characterize the mussel community present, four community assessment sites were surveyed within the Neosho River study area (Figure 5). All the sites were searched for five person-hours, as live mussels were detected at each site. Substrates at N1 and N2 were 100% silt. At N3, there was 10% cobble, 20% gravel, 50% silt, and 20% clay with rip-rap present associated with a bridge crossing. Finally, at N4, the substrate was 50% silt and 30% clay with minor amounts of gravel (15%) and cobble (5%).

During 20 person-hours of survey effort in the Neosho River, 149 individuals were collected belonging to 10 species. The most abundant species was the Bleufer, with 91 individuals. The next two most abundant species were the Fragile Papershell and the Threehorn Wartyback, represented by 21 and 14 individuals, respectively (Table 6).

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**Figure *5*. Neosho River survey sites.**

**Table 6. Number of live individuals (#) and percent relative abundance (%) of live mussels at four sites in the Neosho River.**

| Species | Neosho River 1* | | Neosho River 2* | | Neosho River 3* | | Neosho River 4* | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | # | % | # | % | # | % | # | % | # | % |
| Yellow Sandshell *(Lampsilis teres)* | 1 | 2.0 | 0 | 0.0 | 2 | 5.1 | 0 | 0.0 | 3 | 2.0 |
| White Heelsplitter *(Lasmigona complanata)* | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 1.8 | 1 | 0.7 |
| Threehorn Wartyback *(Obliquaria reflexa)* | 7 | 14.3 | 0 | 0.0 | 3 | 7.7 | 4 | 7.1 | 14 | 9.4 |
| Fragile Papershell *(Potamilus fragilis)* | 0 | 0.0 | 0 | 0.0 | 18 | 46.2 | 3 | 5.4 | 21 | 14.1 |
| Pink Papershell *(Potamilus ohiensis)* | 6 | 12.2 | 0 | 0.0 | 0 | 0.0 | 2 | 3.6 | 8 | 5.4 |
| Bleufer *(Potamilus purpuratus)* | 33 | 67.3 | 0 | 0.0 | 14 | 35.9 | 44 | 78.6 | 91 | 61.1 |
| Lilliput *(Toxolasma parvum)* | 1 | 2.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.7 |
| Pistolgrip *(Tritogonia verrucosa)* | 0 | 0.0 | 0 | 0.0 | 2 | 5.1 | 2 | 3.6 | 4 | 2.7 |
| Paper Pondshell *(Utterbackia imbecillis)* | 1 | 2.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.7 |
| Flat Floater *(Utterbackiana suborbiculata)* | 0 | 0.0 | 5 | 100.0 | 0 | 0.0 | 0 | 0.0 | 5 | 3.4 |
| **Species Richness** | 6 | | 1 | | 5 | | 6 | | 10 | |
| **Total Abundance** | 49 | | 5 | | 39 | | 56 | | 149 | |

*Community Assessment Site

## 4.1.3 Discussion

Overall, the habitat assessment identified potentially suitable Neosho Mucket habitat in the Elk River study area and upper portions of the Spring River study area. However, large portions of the Spring River study area and the entire Neosho River study area were dominated by deep lentic reservoir areas. Mussel surveys were targeted to areas identified as potential Neosho Mucket habitat but were also conducted in other portions of the study areas to document the community present and confirm suspected habitat associations. These targeted habitat-specific surveys and additional community assessment surveys within the study areas of the Elk, Spring, and Neosho Rivers documented 188 individual mussels of 12 species during 57 person-hours of total survey effort at 13 locations. Of these species collected, the majority were generalist or lentic-adapted species such as the Bleufer, Fragile Papershell, Threehorn Wartyback, Pink Papershell, and Flat Floater (*Utterbackiana suborbiculata*). Flat Floater was not documented by previous surveys which focused on riverine habitats upstream (EcoAnalysts 2018). No Neosho Muckets were observed.

Based on habitat descriptions for Neosho Mucket from the literature discussed in section 3.1.2, Phase 2 mussel surveys identified limited potentially suitable habitat within the study area. Three areas of potentially suitable habitat were identified and surveyed by the study team in the Elk River study area and two areas of potentially suitable habitat were identified and surveyed within the Spring River study area. No potentially suitable habitat was identified within the Neosho River study area. Despite the lack of potentially suitable Neosho Mucket habitat within the Neosho River study area and the lower Spring River study area (downstream of Hwy 10 bridge), additional surveys were conducted in these areas to provide a more complete characterization of the mussel community present.

Using hydraulic models developed as part of the Project, section-averaged velocities were calculated for cross-sections extracted at each mussel sampling location under both the baseline Project operations and anticipated Project operations scenarios (Table 7). The difference in section-averaged velocity at these cross-sections ranged from 0.00 to -0.22 ft/s (average = -0.06 ft/s).

Additionally, lentic/lotic maps were generated from the CHM to evaluate changes to inundation relative to Project operations (see Appendix C). These maps demonstrate a minor increase in inundation under the anticipated Project operations that is expected to have minimal, if any, impact to freshwater mussels in the Project boundary.

Updated Study Report (USR) comments from FERC staff requested additional tables reporting the difference in water level in feet between baseline and anticipated operation at each of the locations in the Elk, Spring, and Neosho Rivers where potentially suitable Neosho Mucket habitat was identified. Table D1 and D2 in Appendix D show these values for the Neosho Mucket spawning season (April through May) and brooding season (May through August), respectively. For the spawning season, differences in water level at potentially suitable areas ranged from -0.01 to 1.21 feet (Table D1). For the brooding season, differences in water level at potentially suitable sites ranged from -0.01 to -0.14 feet (Table D2).

Given that no Neosho Muckets were observed in the Project boundary, minor changes in inundation are expected, and the relatively minimal change in velocity and water surface elevation predicted to occur, no impacts to Neosho Mucket populations are expected to occur due to anticipated changes in Project operations.

**Table 7. Baseline and anticipated operation velocities at mussel survey locations.**

| Site | Latitude | Longitude | RM | Section-averaged velocity (ft/s) | | Difference in Velocity (ft/s) |
|---|---|---|---|---|---|---|
| | | | | Baseline Operations | Anticipated Operations | |
| Elk 1 | 36.624261 | -94.617709 | 12.03 | 1.06 | 1.05 | -0.01 |
| Elk 2 | 36.625842 | -94.621131 | 11.81 | 0.61 | 0.61 | 0.00 |
| Elk 3 | 36.629460 | -94.625396 | 11.41 | 0.53 | 0.52 | -0.01 |
| Elk 4 | 36.632643 | -94.628038 | 11.24 | 0.55 | 0.54 | -0.01 |
| Elk 5 | 36.634090 | -94.631331 | 11.01 | 1.22 | 1.00 | -0.22 |
| Neosho 1 | 36.803739 | -94.769177 | 123.46 | 0.62 | 0.58 | -0.04 |
| Neosho 2 | 36.805637 | -94.832343 | 127.47 | 1.14 | 1.10 | -0.04 |
| Neosho 3 | 36.852565 | -94.857317 | 133.88 | 1.77 | 1.72 | -0.05 |
| Neosho 4 | 36.857480 | -94.873648 | 134.92 | 2.07 | 1.98 | -0.09 |
| Spring 1 | 36.820170 | -94.742590 | 2.26 | 0.21 | 0.20 | -0.01 |
| Spring 2 | 36.839876 | -94.728731 | 3.79 | 0.26 | 0.26 | 0.00 |
| Spring 3 | 36.876963 | -94.747551 | 9.30 | 0.59 | 0.56 | -0.03 |
| Spring 4 | 36.891539 | -94.729085 | 10.94 | 1.65 | 1.43 | -0.22 |

## 4.2 Rabbitsfoot (*Theliderma cylindrica*)

### 4.2.1 Habitat and Conservation Status

The Rabbitsfoot is a freshwater mussel typically found in small-to-medium-sized rivers that have a moderate current and clear, relatively shallow water. It prefers river bottoms that are a mixture of sand and gravel substrates (Watters 1998). The Rabbitsfoot spawns from May to June (Yeager and Neves 1986). Several species of fishes have been determined to be suitable hosts for the Rabbitsfoot: Striped Shiner (*Luxilus chrysocephalus*), Emerald Shiner (*Notropis atherinoides*), Carmine Shiner (*Notropis percobromus*), Bullhead Minnow (*Pimephales vigilax*), Golden Redhorse (*Moxostoma erythrurum*), Blackstripe Topminnow (*Fundulus notatus*), Rainbow Darter (*Etheostoma caeruleum*), Blacktail Shiner (*Cyprinella venusta*), Red Shiner (*Cyprinella lutrensis*), Whitetail Shiner (*Cyprinella galactura*), Spotfin Shiner (*Cyprinella *spiloptera*), and Bigeye Chub (*Hybopsis amblops*) (INHS 2017). A number of these host species are known from the Project vicinity.

As with other headwater-inhabiting species of mussel, the combination of river impoundments and the ecological requirements of the Rabbitsfoot predict a series of isolated populations in the headwater streams throughout the species range. Because adults do not typically burrow into sediment but rather lie horizontally on the streambed surface (Watters 1998), flow refuges may decrease the likelihood of displacement into unsuitable habitat. The primary cause of population declines of the Rabbitsfoot is the construction of reservoirs and impoundments throughout its range (USFWS 2009). Direct disturbance by human recreational activities also can have a negative impact on the species. Metal pollution in the Spring River was the consequence of metal inputs from the Tri-State Mining District, where extensive mining for Pb and Zn occurred during the mid-1800s through the 1950s (Barks 1986; Wildhaber et al. 1999; 2000; Brumbaugh et al. 2005)

## 4.2.2 Distribution and Occurrence

The Rabbitsfoot was historically found in the Verdigris, Neosho, Spring, Illinois, Blue, and Little rivers in Oklahoma. Additionally, relic shells indicate that Rabbitsfoot formerly occurred extensively in the Verdigris, Fall, Cottonwood, Neosho, and Spring rivers in Kansas, and Spring River and Shoal Creek in Missouri. In Oklahoma, populations currently remain in the Verdigris, Illinois, and Little rivers. Though Rabbitsfoot still exist in the Spring and Neosho rivers, they are considered very rare or extirpated in the Oklahoma portion (Curtis Tacket; personal communication; USWFS 2020b). Recent records identify a few individuals from a handful of sites in the Spring and Neosho rivers outside of Oklahoma (EcoAnalysts 2018, Obermeyer et al. 1997). In 2016 and 2017, biologists surveyed 15 sites extending from 500 meters downstream of the confluence with the North Fork of the Spring River in Jasper County, Missouri, to 7.45 miles upstream of the confluence with the Neosho River in Ottawa County, Oklahoma (USFWS 2020b). Based on the five-year review (USFWC 2020b), two live specimens from two sites in Missouri and two live specimens from two sites in Kansas were reported but no specimens were found in Oklahoma during this survey period. This species is considered threatened wherever found with the closest critical habitat in Missouri 25 miles upstream (Table 8).

**Table 8. Critical habitat for Rabbitsfoot**

| Critical Habitat Unit Number | River | Within Project Boundary |
|---|---|---|
| **RF1** | Spring | No |

### 4.2.3 Discussion

Through personal contact and data received from the Sam Nobel Museum, OSU invertebrate collection department, and ODWC suggest that no Rabbitsfoot mussel surveys have been conducted within the drainages leading up to the reservoir. The closet critical habitat is located 25 miles upstream from the Project boundary in Jasper County Missouri on the Spring River. No live specimens have been found in Oklahoma segment of the river (EcoAnalysts 2018). The five-year review (USFWS 2020b) acknowledges the Oklahoma segment of the river as historic range with no extant population. Therefore, based on the literature and data available, it is not likely that a population would occur within the project boundary. Rabbitsfoot mussels have not been found in any surveys in Oklahoma, including the 2022 survey conducted for this study.

## 4.3 Winged Mapleleaf (*Quadrula fragosa*)

### 4.3.1 Habitat and Conservation Status

The Winged Mapleleaf is a freshwater mussel found in areas that have high water quality in stream beds varying from sand, cobble, or rubble (USFWS 2011, ODWC 2021c). The Winged Mapleleaf is often found in dense and diverse mussel beds where the large number of mussel species may stabilize the riverbed and improve the habitat for rare mussel species (Allen and Vaughn 2008). Confirmed host fishes include the Blue Catfish (*Ictalurus furcatus*) and the Channel Catfish (*Ictalurus punctatus*) (INHS 2017), both of which are known from the Project vicinity.

The Winged Mapleleaf has been found to be a fall tachytictic or short-term brooder (Heath et al. 2000). Habitat degradation is the primary cause of this species decline. Dams, channelization, and dredging increase siltation, physically alter habitat conditions, and block the movements of fish hosts (ODWC 2021c). Other factors could include narrow range, sparse population and low reproduction, and the probability of inbreeding, which could weaken the species genetically (Hornbach et al.1996). Of the five remaining populations, three are subject to threats from restricted populations and isolation from other populations. The low flows associated with droughts have been found to pose a high degree of threat to the Little River population (Hove et al. 2012).

### 4.3.2 Distribution and Occurrence

Historically, the Winged Mapleleaf is known to occur in the Boggy, Kiamichi, Neosho, and Little rivers of Oklahoma. Inclusion of the Neosho River in this list is based on records of the species in 1912 at Chetopa, Kansas (Isely 1924). The only known extant population in Oklahoma is found in the Little River, though its status in other river systems is generally unknown (USWFS 2011).

Winged Mapleleaf is known to exist in Missouri, Wisconsin, Arkansas, and Oklahoma. Known populations closest to the Project include those in the Bourbeuse River in Missouri, the Ouachita

River in Arkansas, the Saline River in Arkansas, and the Little River in Arkansas and Oklahoma. In the Little River, the Winged Mapleleaf has been found in 12 sites since 2005 (Galbraith et al. 2008). In 2008, Allen and Vaughn (2008) sampled six mussel beds and located Winged Mapleleaf in four of those beds. No critical habitat is currently designated for this species.

### 4.3.3 Discussion

Personal contact with the Sam Nobel Museum, OSU invertebrate collection department and ODWC indicate that no Winged Mapleleaf specimens have been previously found within the Neosho, Spring, and Elk Rivers or surrounding drainages in the Project vicinity. The only recognized population in Oklahoma is within the Little River which is 175 miles from the Project boundary. It is not likely that there is a population within the Project boundary. Winged Mapleleaf mussels have not been found in any surveys, including the 2022 surveys described above.

## 4.4 Neosho Madtom (*Noturus placidus*)

### 4.4.1 Habitat and Conservation Status

Neosho Madtoms have been found in the highest numbers during daylight in riffles in late summer and early fall, after young of the year are estimated to have recruited to the population (Moss 1981; Luttrell et al. 1992; Fuselier and Edds 1994). Neosho Madtoms prefer the interstitial spaces of unconsolidated pebbles and gravel, moderate-to-slow flows, and depths averaging 0.23 meter (Wildhaber et al. 2000). Adults hide in the interstices of loose gravel riffles during the day and feed nocturnally on the aquatic insects (Cross and Collins 1995). Young of the year are said to inhabit slower flowing waters downstream from riffles and use pools and backwaters as nursery areas (Fuselier and Edds 1994). Where contamination has occurred, Neosho Madtoms seem to be limited primarily by the presence of contaminants associated with the Spring River acting directly (via mortality or avoidance) or indirectly (by suppressing and/or contaminating) on the benthic invertebrate food base (Cross and Collins 1995).

### 4.4.2 Distribution and Occurrence

The Neosho Madtom is a small catfish commonly 1.75–2.75 inches long; the maximum is about 3 inches long (Wenke 1991). This species is native to the Illinois River in Oklahoma, the Neosho River (Kansas and Oklahoma), the Cottonwood River (Kansas), and the Spring River (Kansas, Oklahoma, and Missouri), where it inhabits riffles and bar habitats with loose pebble and gravel substrate, moderate to high water velocities, and relatively shallow depths (Ernsting et al. 1989; Wilkinson et al. 1996; Wilkinson and Fuselier 1997; Wildhaber et al. 2000). The density of Neosho Madtom populations is much greater in the Neosho system (i.e., the Neosho and Cottonwood rivers combined) than in the Spring River (Moss 1981; Wilkinson et al. 1996). The

Tar Creek superfund site is located with portions of the range of the Neosho Madtom within the Neosho and Spring rivers watersheds and the superfund site is a known source of heavy metal contamination (lead, cadmium, and zinc). Where metals contamination is minimal, Neosho Madtom densities seem to be limited primarily by physical and chemical habitat quality and availability. Extant Oklahoma populations of the Neosho Madtom are restricted to the Neosho River upstream from Grand Lake. A population documented in 1946 in the lower Illinois River is now presumed to be extirpated (Moss 1981).

### 4.4.3 Phase II and Phase III Recommendations

Neosho madtoms have been found in the drainages of the Project vicinity from 1969-2007; the last sampling attempts near the Project boundary occurred in 2016 and were conducted by the OWRB (Figure 6). Because of the five-year data gap, it is proposed that sampling efforts take place within the Neosho River branch of the Project boundary including sampling select locations upstream to determine habitat quality. Determining habitat quality outside of the Project boundary will allow for appropriate mitigation if management practices limit suitable habitat within. All previous madtom locations have been within this branch of the river and it is the most likely area to have a stable population.

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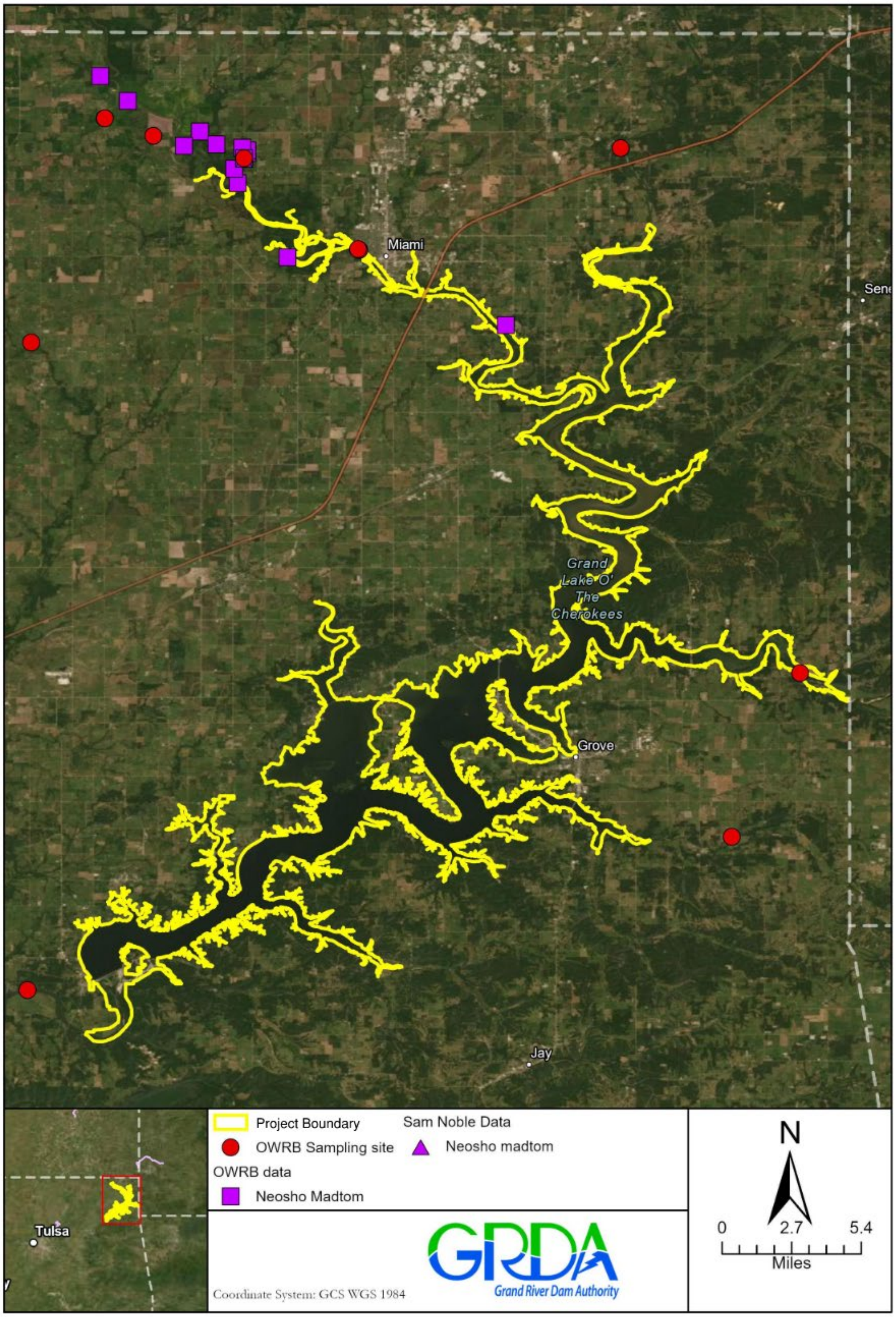


**Figure 6. Known Locations of Neosho Madtom – data provided by OWRB and Sam Noble Museum.**

Based on the Phase 1 literature review, agency comments, and the subsequent FERC Study Plan Determinations (2018 and 2022) the need for Phase 2 Neosho Madtom surveys were identified in select portions of the Spring and Neosho rivers. In the Neosho River, surveys were conducted from the Craig/Ottawa County border south to near the Hwy 60 bridge. In the Spring River, surveys were conducted from the I44 bridge downstream to the Hwy 10 bridge. Surveys were limited to areas with potential suitable habitat. Madtom sampling was conducted in July and August of 2022 at selected sites where riffles and gravel bars were identified during the time of surveys.

At each site, five points were surveyed by kick-seining (4.6 m x 1.8 m seine with 3.2 mm mesh) where at least two surveyors thoroughly disturbed the substrate beginning at least four meters upstream from a stationary seine and then kicked in a downstream direction to the seine's lead line. All fishes captured were identified to species, measured for total length (TL) to the nearest millimeter, and enumerated.

Lastly, substrate and mean water-column velocity were quantified to characterize habitat conditions at each site and were measured near the center of each sampling point. Substrate samples were collected and sieved using a series of sieves (38 mm, 19 mm, 9.5 mm, and 2 mm) to determine the particle size distribution. Sites where substrates were not compacted and contained over 50% of gravel 8-16 mm in diameter were considered high quality habitat for Neosho Madtom as defined by Moss (1981).

Spring River surveys were completed on July 19$^{th}$, 2022 at a discharge of 605 cubic feet per second (cfs) according to the USGS Spring River near Quapaw, Oklahoma gage. Median discharge for this date is about 725 cfs.

Neosho River surveys were initiated on July 20, 2022 at flows of 2,190 cfs according to the USGS Commerce, Oklahoma gage. Median flows for this time of year and location were expected to be about 1,100 cfs. These elevated flows inundated much of the appropriate Neosho Madtom habitat with swift flowing water and made sampling swift flowing riffles difficult. As a result, the study team made the decision to postpone sampling until flow conditions were more appropriate for sampling using the kick seining method. Surveys were completed on August 16, 2022, when flows reached 171 cfs at the Commerce gage.

### *4.4.3.1 Results*

Twenty-seven fish species were collected from 11 riffle/gravel bars in the Neosho and Spring Rivers (Figure 7). Neosho Madtoms were collected at five of the seven sites on the Neosho River and were not observed in the four sites sampled on the Spring River (Table 9).

#### 4.4.3.1.1 Neosho River

A total of twenty-one species of fish were collected at the Neosho River survey sites with the Red Shiner (*Cyprinella lutrensis*), Emerald Shiner (*Notropis atherinoides*), and Channel Catfish

(*Ictalurus punctatus*) being the most abundant species (209, 185, and 49 individuals, respectively) accounting for 77% of the individuals collected (Figure 8, Table 11). Neosho Madtoms were collected from five of nine sites surveyed, N1, N2, N3, N4, and N6 (Table 11) and were more abundant at sites within the upstream portions of the study area. Average velocity for all the survey sites in the Neosho River was 1.7 ft/s and ranged from 0.6 to 3.4 ft/s. Sites with Neosho Madtoms had an average flow of 1.9 ft/s (Table 10).

On the Neosho River, the substrate composition varied, exhibiting smaller average substrate size farther downstream. The largest particles sizes (38 mm and 19 mm) comprised greater than 40% in the upstream most sites (Neosho 1 and Neosho 2) and less than or equal to 5% in the remaining sites, being completely absent in the two farthest downstream sites (Neosho 6 and Neosho 7). (Table 10).

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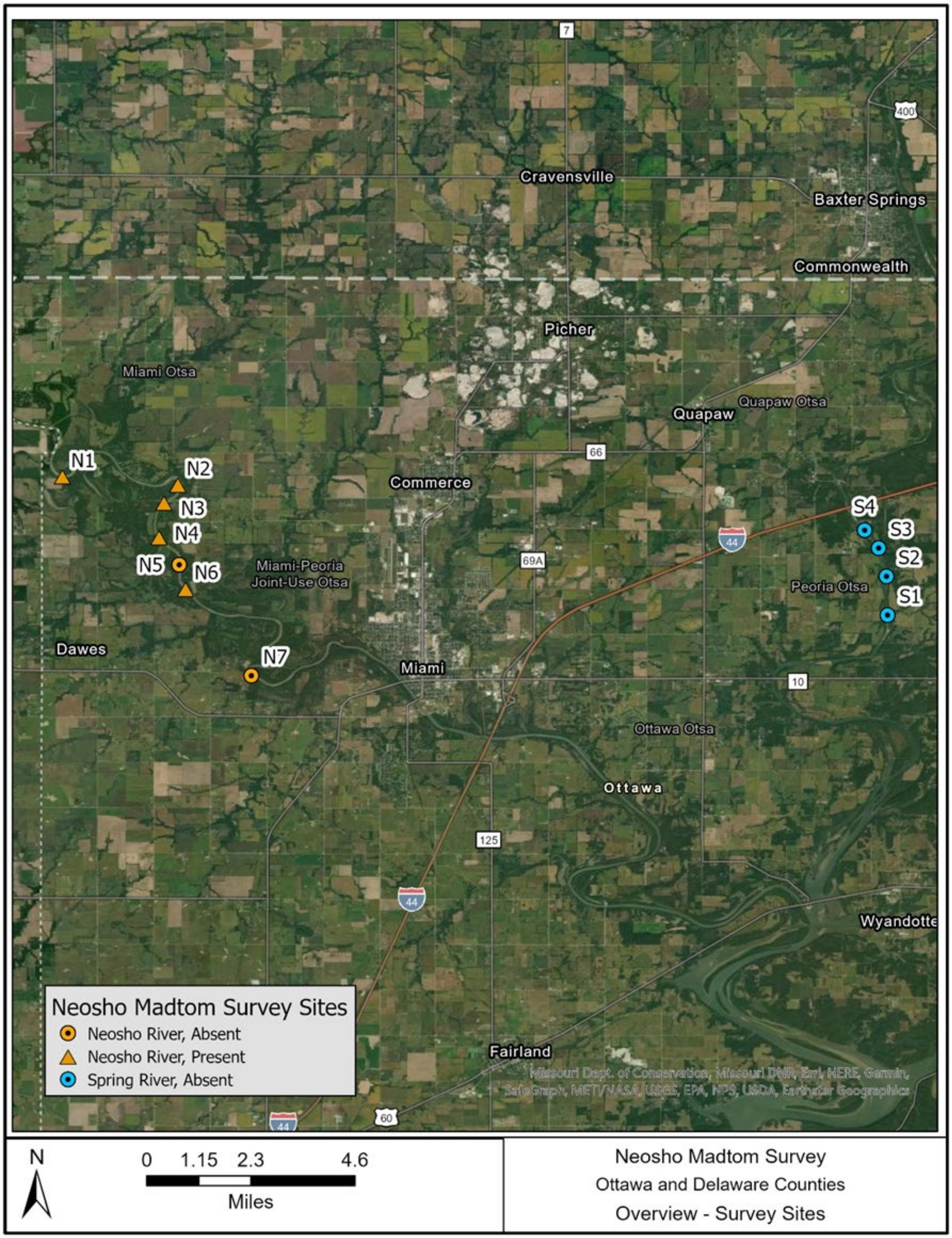


**Figure 7. Neosho Madtom survey sites on the Neosho and Spring rivers.**

**Table 9. Fishes captured at seven sites on the Neosho River and four sites on the Spring River.**

| Species | | Survey Sites | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scientific Name** | **Common Name** | **N1** | **N2** | **N3** | **N4** | **N5** | **N6** | **N7** | **S1** | **S2** | **S3** | **S4** | **Total** | **Relative Abundance** |
| *Dorosoma petense* | Threadfin Shad | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | <0.01 |
| *Campastoma anomalum* | Central Stoneroller | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 3 | <0.01 |
| *Cyprinella lutrensis* | Red Shiner | 50 | 11 | 34 | 8 | 32 | 46 | 28 | 27 | 47 | 12 | 7 | 302 | 0.33 |
| *Erimystax x-punctatus* | Gravel Chub | 2 | 0 | 1 | 3 | 0 | 0 | 0 | 4 | 19 | 1 | 6 | 36 | 0.04 |
| *Luxilus cardinalis* | Cardinal Shiner | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 4 | 4 | 1 | 16 | 0.02 |
| *Notropis athernoides* | Emerald Shiner | 20 | 52 | 30 | 9 | 12 | 18 | 44 | 35 | 13 | 2 | 1 | 236 | 0.26 |
| *Notropis buchanani* | Ghost Shiner | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | <0.01 |
| *Notropis percobromus* | Carmine Shiner | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 3 | 5 | <0.01 |
| *Notropis vollucellus* | Mimic Shiner | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | <0.01 |
| *Phenocobius mirabilis* | Suckermouth Minnow | 0 | 1 | 0 | 8 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 12 | 0.01 |
| *Pimephales notatus* | Bluntnose Minnow | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | <0.01 |
| *Ictalurus furcatus* | Blue Catfish | 0 | 0 | 33 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 34 | 0.04 |
| *Ictalurus punctatus* | Channel Catfish | 13 | 0 | 22 | 8 | 0 | 6 | 0 | 1 | 0 | 0 | 0 | 50 | 0.05 |
| *Noturus flavus* | Stonecat | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 5 | 0.01 |
| *Noturus miurus* | Brindled Madtom | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | <0.01 |
| *Noturus placidus* | Neosho Madtom | 4 | 1 | 3 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 13 | 0.01 |
| *Plyodictus olivaris* | Flathead Catfish | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | <0.01 |
| *Menidia audens* | Mississippi Silverside | 0 | 0 | 0 | 1 | 1 | 3 | 0 | 0 | 5 | 0 | 0 | 10 | 0.01 |
| *Morone chrysops* | White Bass | 0 | 2 | 1 | 5 | 0 | 1 | 0 | 1 | 27 | 15 | 64 | 116 | 0.13 |
| *Lepomis cyanellus* | Green Sunfish | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | <0.01 |
| *Lepomis macrochirus* | Bluegill | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | <0.01 |
| *Micropterus punctatus* | Spotted Bass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | <0.01 |
| *Etheostoma whipplei* | Redfin Darter | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | <0.01 |
| *Percina caprodes* | Logperch | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | <0.01 |
| *Percina phoxocephala* | Slenderhead Darter | 3 | 2 | 1 | 0 | 1 | 4 | 3 | 7 | 0 | 0 | 0 | 21 | 0.02 |
| *Percina shumardi* | River Darter | 0 | 0 | 2 | 2 | 0 | 6 | 9 | 10 | 3 | 0 | 7 | 39 | 0.04 |
| *Aplodinotus grunniens* | Freshwater Drum | 0 | 0 | 0 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 5 | 0.01 |
| **Species Richness** | | **10** | **8** | **10** | **12** | **6** | **13** | **5** | **10** | **9** | **6** | **10** | **27** | **-** |
| **Total Abundance** | | **97** | **71** | **128** | **53** | **48** | **92** | **86** | **95** | **121** | **35** | **92** | **918** | **-** |

**Table 10. Substrate composition (%) by mesh size and velocity (ft/s) at Neosho Madtom sampling sites.**

| | Site | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mesh size (mm)** | **Spring 1** | **Spring 2** | **Spring 3** | **Spring 4** | **Neosho 1** | **Neosho 2** | **Neosho 3** | **Neosho 4** | **Neosho 5** | **Neosho 6** | **Neosho 7** |
| 38 | 25 | 25 | 15 | 5 | 40 | 60 | 5 | 5 | 5 | 0 | 0 |
| 19 | 25 | 30 | 45 | 40 | 20 | 20 | 65 | 15 | 35 | 50 | 5 |
| 9.5 | 25 | 20 | 10 | 20 | 15 | 10 | 15 | 10 | 30 | 30 | 50 |
| 2 | 25 | 25 | 30 | 35 | 25 | 10 | 15 | 70 | 30 | 20 | 45 |
| **Velocity (ft/s)** | 2.0 | 3.2 | 3.1 | 2.6 | 1.8 | 1.9 | 1.5 | 1.3 | 0.6 | 3.4 | 1.4 |

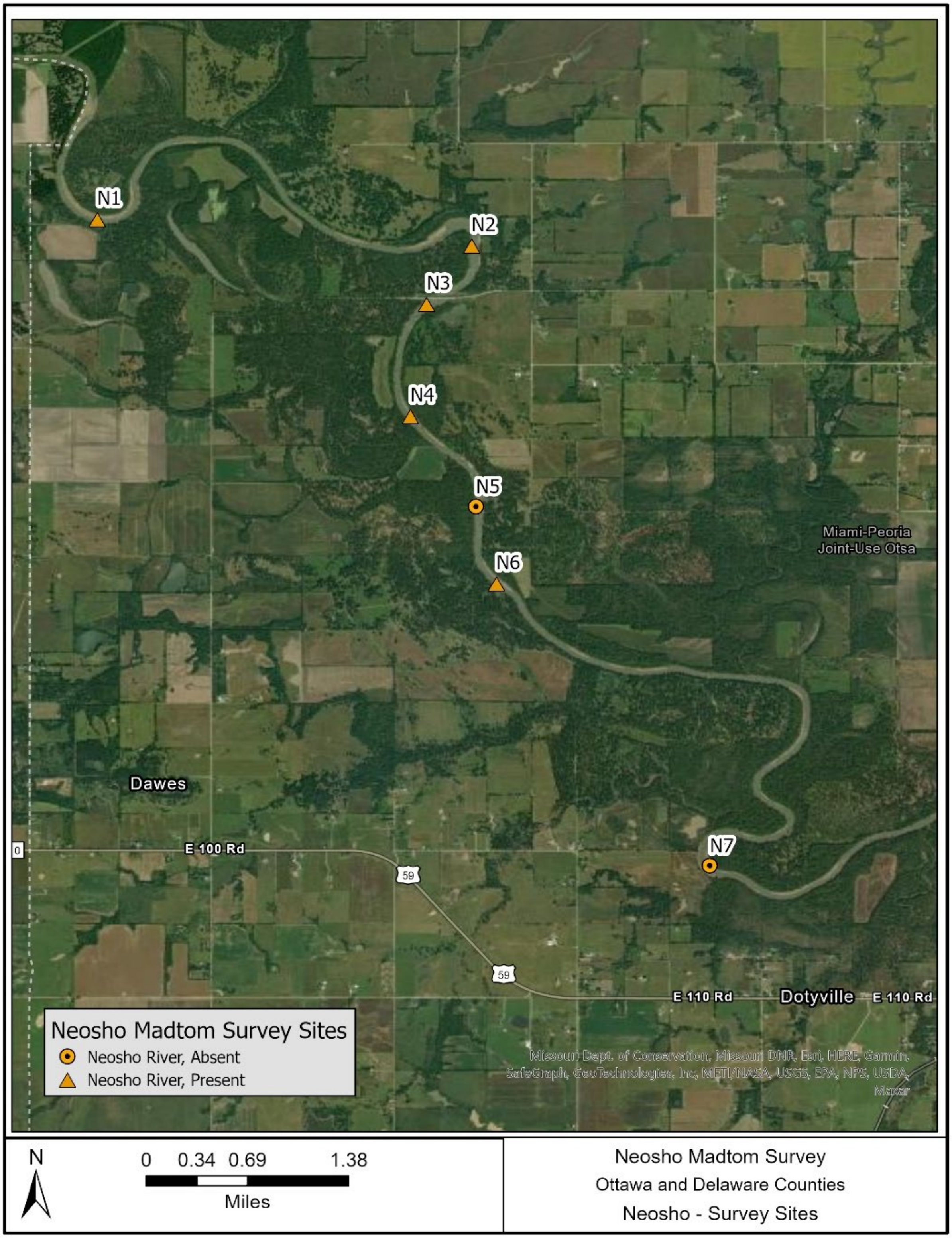


**Figure 8. Neosho Madtom survey sites on the Neosho River.**

**Table 11. Fishes captured at seven sites on the Neosho River.**

| Species | | Survey Sites | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scientific Name** | **Common Name** | **N1** | **N2** | **N3** | **N4** | **N5** | **N6** | **N7** | **Total** | **Relative Abundance** | **CPUE** |
| *Campastoma anomalum* | Central Stoneroller | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.00 | 0.02 |
| *Cyprinella lutrensis* | Red Shiner | 50 | 11 | 34 | 8 | 32 | 46 | 28 | 209 | 0.36 | 3.80 |
| *Erimystax x-punctatus* | Gravel Chub | 2 | 0 | 1 | 3 | 0 | 0 | 0 | 6 | 0.01 | 0.11 |
| *Notropis athernoides* | Emerald Shiner | 20 | 52 | 30 | 9 | 12 | 18 | 44 | 185 | 0.32 | 3.36 |
| *Notropis buchanani* | Ghost Shiner | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0.00 | 0.02 |
| *Phenocobius mirabilis* | Suckermouth Minnow | 0 | 1 | 0 | 8 | 0 | 1 | 2 | 12 | 0.02 | 0.22 |
| *Pimephales notatus* | Bluntnose Minnow | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 3 | 0.01 | 0.05 |
| *Ictalurus furcatus* | Blue Catfish | 0 | 0 | 33 | 0 | 1 | 0 | 0 | 34 | 0.06 | 0.62 |
| *Ictalurus punctatus* | Channel Catfish | 13 | 0 | 22 | 8 | 0 | 6 | 0 | 49 | 0.09 | 0.89 |
| *Noturus flavus* | Stonecat | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 4 | 0.01 | 0.07 |
| *Noturus miurus* | Brindled Madtom | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0.00 | 0.02 |
| *Noturus placidus* | Neosho Madtom | 4 | 1 | 3 | 2 | 0 | 3 | 0 | 13 | 0.02 | 0.24 |
| *Menidia audens* | Mississippi Silverside | 0 | 0 | 0 | 1 | 1 | 3 | 0 | 5 | 0.01 | 0.09 |
| *Morone chrysops* | White Bass | 0 | 2 | 1 | 5 | 0 | 1 | 0 | 9 | 0.02 | 0.16 |
| *Lepomis cyanellus* | Green Sunfish | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0.00 | 0.02 |
| *Lepomis macrochirus* | Bluegill | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0.00 | 0.02 |
| *Etheostoma whipplei* | Redfin Darter | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.00 | 0.02 |
| *Percina caprodes* | Logperch | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0.00 | 0.04 |
| *Percina phoxocephala* | Slenderhead Darter | 3 | 2 | 1 | 0 | 1 | 4 | 3 | 14 | 0.02 | 0.25 |
| *Percina shumardi* | River Darter | 0 | 0 | 2 | 2 | 0 | 6 | 9 | 19 | 0.03 | 0.35 |
| *Aplodinotus grunniens* | Freshwater Drum | 0 | 0 | 0 | 4 | 0 | 1 | 0 | 5 | 0.01 | 0.09 |
| **Species Richness** | | 10 | 8 | 10 | 12 | 6 | 13 | 5 | 21 | | |
| **Total Abundance** | | 97 | 71 | 128 | 53 | 48 | 92 | 86 | 575 | | |
| **Catch Per Unit Effort (CPUE)** | | 19.40 | 14.20 | 25.60 | 10.60 | 9.60 | 18.40 | 17.20 | 16.43 | | |

#### 4.4.3.1.2 Spring River Results

Seventeen species of fish were collected from four sites in the Spring River (Figure 9). Neosho Madtoms were not observed (Table 12). The average velocity at survey sites in the Spring River was 2.7 ft/s and ranged from 2 to 3.1 ft/s (Table 13). The substrate size distribution exhibited a trend of more even distribution of particle sizes in downstream sites (Table 10).

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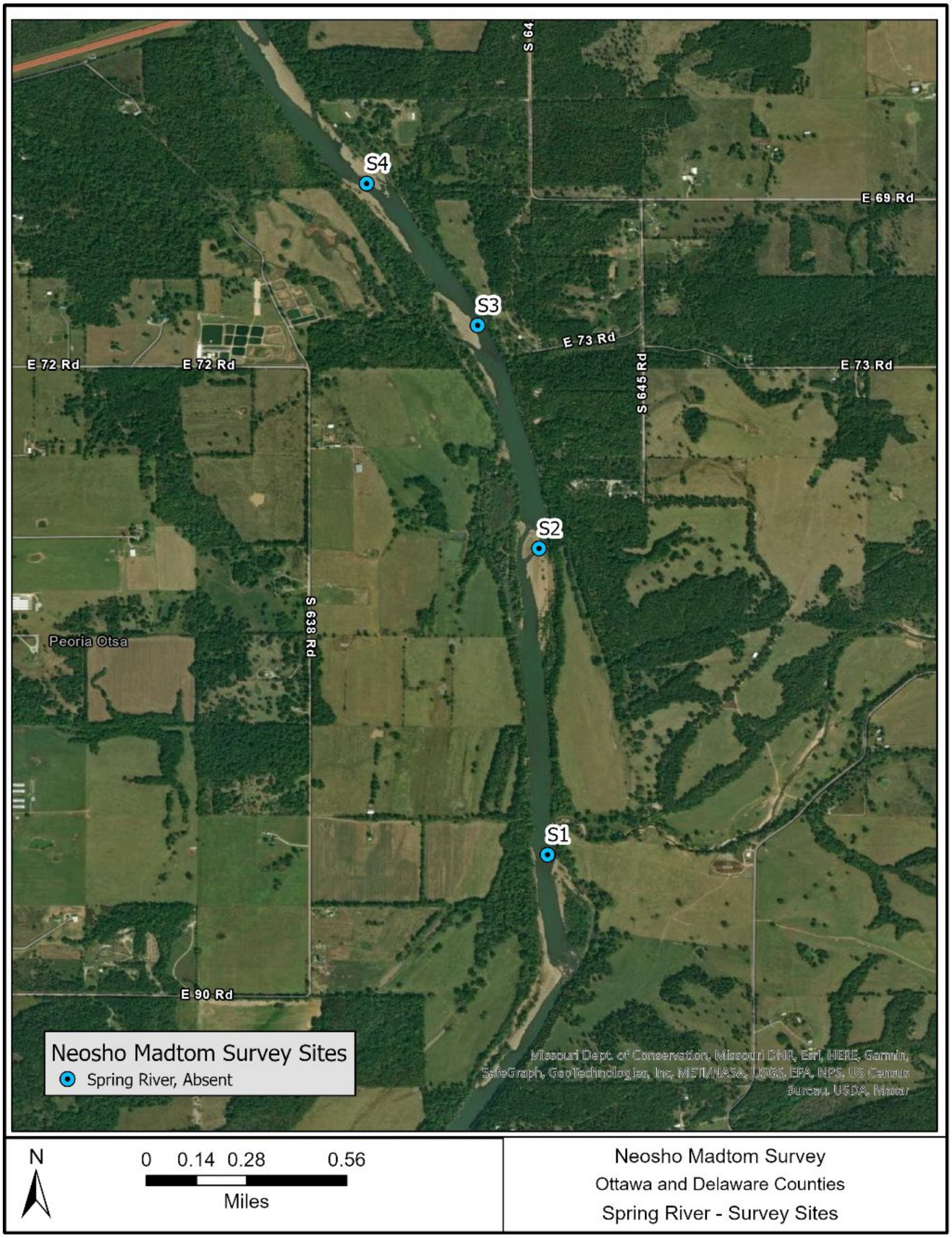


**Figure 9. Neosho Madtom survey sites on the Spring River.**

**Table 12. Fishes captured at four sites on the Spring River.**

| Species | | Survey Sites | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Scientific Name** | **Common Name** | **S1** | **S2** | **S3** | **S4** | **Total** | **Relative Abundance** | **CPUE** |
| *Dorosoma petense* | Threadfin Shad | 1 | 0 | 0 | 0 | 1 | 0.003 | 0.05 |
| *Campastoma anomalum* | Central Stoneroller | 2 | 0 | 0 | 0 | 2 | 0.006 | 0.10 |
| *Cyprinella lutrensis* | Red Shiner | 27 | 47 | 12 | 7 | 93 | 0.271 | 4.65 |
| *Erimystax x-punctatus* | Gravel Chub | 4 | 19 | 1 | 6 | 30 | 0.087 | 1.50 |
| *Luxilus cardinalis* | Cardinal Shiner | 7 | 4 | 4 | 1 | 16 | 0.047 | 0.80 |
| *Notropis athernoides* | Emerald Shiner | 35 | 13 | 2 | 1 | 51 | 0.149 | 2.55 |
| *Notropis percobromus* | Carmine Shiner | 0 | 2 | 0 | 3 | 5 | 0.015 | 0.25 |
| *Notropis vollucellus* | Mimic Shiner | 0 | 0 | 0 | 1 | 1 | 0.003 | 0.05 |
| *Ictalurus punctatus* | Channel Catfish | 1 | 0 | 0 | 0 | 1 | 0.003 | 0.05 |
| *Noturus flavus* | Stonecat | 0 | 0 | 0 | 1 | 1 | 0.003 | 0.05 |
| *Plyodictus olivaris* | Flathead Catfish | 0 | 0 | 1 | 0 | 1 | 0.003 | 0.05 |
| *Menidia audens* | Mississippi Silverside | 0 | 5 | 0 | 0 | 5 | 0.015 | 0.25 |
| *Morone chrysops* | White Bass | 1 | 27 | 15 | 64 | 107 | 0.312 | 5.35 |
| *Micropterus punctatus* | Spotted Bass | 0 | 0 | 0 | 1 | 1 | 0.003 | 0.05 |
| *Percina caprodes* | Logperch | 0 | 1 | 0 | 0 | 1 | 0.003 | 0.05 |
| *Percina phoxocephala* | Slenderhead Darter | 7 | 0 | 0 | 0 | 7 | 0.020 | 00.35 |
| *Percina shumardi* | River Darter | 10 | 3 | 0 | 7 | 20 | 0.058 | 1.00 |
| **Species Richness** | | **10** | **9** | **6** | **10** | **17** | | |
| **Total Abundance** | | **95** | **121** | **35** | **92** | **343** | | |
| **Catch Per Unit Effort (CPUE)** | | **19.00** | **24.20** | **7.00** | **18.40** | **17.15** | | |

#### 4.4.3.2 Discussion

As documented during previous surveys (see Section 3.4.1), Neosho Madtom were found within the Neosho River study area but were not located in the Spring River study area of Oklahoma. Within the Neosho River study area, they were most common at upstream sites near the Craig/Ottawa County line, and occurrence decreased at downstream sites. Substrate particle size also decreased from upstream to downstream, suggesting a potential relationship between larger particle sizes and Neosho Madtom occurrence.

Using hydraulic models developed as part of the Project, section-averaged velocities were calculated for cross-sections extracted at each madtom sampling location under both the baseline operations and anticipated operations scenarios (Table 13). The difference in section-averaged velocity at these cross-sections ranged from 0.01 to -0.22 ft/s (average = -0.05 ft/s). The average velocity changes at Neosho Madtoms sites were -0.02 ft/s and ranged from -0.01 to -0.04 ft/s (Table 13).

Updated Study Report (USR) comments from FERC staff requested additional tables reporting the difference in water surface elevation in feet between baseline and anticipated operation at Neosho Madtom sampling locations as well as areas where Neosho Madtom's have been historically observed within the Project boundary. Differences in WSE ranged from -0.02 to 0.54 feet at these locations (Table D3 of Appendix D).

Additionally, lentic/lotic maps were generated from the CHM to evaluate changes to inundation relative to Project operations (see Appendix C). These maps demonstrate a slight increase in inundation during the period of May 15 to July 8, with most of this change occurring in areas of close proximity to the reservoir. There is essentially no discernable change to inundation in the sections of the mainstem Neosho River occupied by Neosho Madtoms under the two scenarios.

While Neosho Madtoms were observed at five of the eleven survey sites, no material impacts to Neosho Madtoms populations are expected to occur due to changes in Project operations. Anticipated changes to inundation will have minimal, if any, influence on upstream areas of the Neosho River mainstem where Neosho Madtom were most common. Additionally, the change in the velocity predicted to occur is relatively minimal (-0.02 ft/s) compared to the range of velocities predicted at occupied sites (max:3.4 ft/s, min: 1.3, range: - 2.1 ft/s; Table 13).

**Table 13. Baseline and anticipated velocities at Neosho Madtom sampling locations (May 15-July 8).**

| Site | Latitude | Longitude | RM | Section-averaged velocity (ft/s) | | Difference in velocity (ft/s) |
|---|---|---|---|---|---|---|
| | | | | Baseline Operations | Anticipated Operations | |
| Spring 1 | 36.891539 | -94.729085 | 10.94 | 1.65 | 1.43 | -0.22 |
| Spring 2 | 36.903907 | -94.72943 | 11.83 | 1.46 | 1.40 | -0.06 |
| Spring 3 | 36.912914 | -94.731908 | 12.43 | 2.98 | 2.91 | -0.07 |
| Spring 4 | 36.918637 | -94.736391 | 12.82 | 1.98 | 1.99 | 0.01 |
| Neosho 1 | 36.93597 | -94.99258 | 148.72 | 3.87 | 3.86 | -0.01 |
| Neosho 2 | 36.93336 | -94.95569 | 145.79 | 4.47 | 4.46 | -0.01 |
| Neosho 3 | 36.92761 | -94.96014 | 145.26 | 3.65 | 3.63 | -0.02 |
| Neosho 4 | 36.91657 | -94.96173 | 144.45 | 3.65 | 3.63 | -0.02 |
| Neosho 5 | 36.90761 | -94.95527 | 143.69 | 3.43 | 3.41 | -0.02 |
| Neosho 6 | 36.90008 | -94.953251 | 143.13 | 3.02 | 2.99 | -0.04 |
| Neosho 7 | 36.87222 | -94.93223 | 139.47 | 3.92 | 3.81 | -0.10 |

# 4.5 Neosho Smallmouth Bass (*Micropterus dolomieu velox*)

## 4.5.1 Habitat and Conservation Status

The Neosho Smallmouth Bass is found in streams that have watersheds with coarse-textured soils (Brewer et al. 2007, Brewer and Long 2015, Dauwalter et al 2007) within the Ozark and Boston Mountain ecoregions. Generally, smallmouth bass are found in clear streams, but the Neosho Smallmouth Bass can persist in some streams that are often spring fed and have relatively high sediment loads (Nigh and Shroeder 2002; Brewer and Long 2015). Though Neosho Smallmouth Bass are found in pool habitats, larger streams that have various channel units, including runs and riffles, are necessary for abundant populations (Dauwalter et al. 2007, Brewer 2013).

Spawning habitat for the Neosho Smallmouth Bass consists of low-velocity, nearshore waters that are close to cover. The Neosho Smallmouth Bass also prefers to construct nests in areas that have fine sediment substrates and avoids areas that have thick layers or silts and clays (Dauwalter et al. 2007). In years that have low stream flows, low water velocity at the nest site was found to be important for nest success (Dauwalter et al. 2007). In years that have elevated discharge events, nest success was influenced by streamflow, temperature, and distance to shore (Dauwalter et al. 2007).

However, available data suggest that Neosho Smallmouth Bass possess local adaptations to warmer climates and intermittent stream flows (Brewer and Long 2015). Moreover, the Neosho Smallmouth Bass inhabits stream systems but are lacking from impoundment fisheries (Stark and Echelle 1998; Malloy 2001), underscoring the unique fluvial ecology of this subspecies compared with nonnative Smallmouth Bass that thrive in impoundments following stocking. Conservation of the Neosho Smallmouth Bass subspecies, and the population-level diversity within the subspecies, would thus provide a “diversified portfolio” that would contribute to maintaining the overall adaptability of Smallmouth Bass to future climate change or habitat-related stressors (Schindler et al. 2010). Nonnative black bass are typically stocked in impoundments to bolster sportfishing opportunities, and native congeners often experience introgression, widespread admixture, or complete replacement within impoundments (Avise et al. 1997; Barwick et al. 2006).

## 4.5.2 Distribution and Occurrence

The Neosho Smallmouth Bass is a genetically distinct subspecies of smallmouth bass (Stark and Echelle 1998, Taylor et al. 2018). The Neosho Smallmouth Bass is found in the western extent of the Ozark Highlands ecoregion (Nigh and Schroeder 2002) and is known to occur in the Spring River, the Elk River, the Neosho River, Spavinaw Creek, Spring Creek, the Illinois River, Baron Fork, Sallisaw Creek, Lee Creek, Clear Creek, the Mulberry River, Big Piney Creek, and the Illinois Bayou (Brewer and Long 2015). Taylor et al. (2018) identified Neosho

Smallmouth Bass in Sycamore Creek, the Elk River, and Honey Creek all which feed into Grand Lake.

### 4.5.3 Discussion

Several records show that a smallmouth bass population is present within the drainages of the Project vicinity (Figure 10), but during the sampling there was no determination that the Neosho subspecies was identified. It is likely that all records of smallmouth bass from OWRB and the Sam Nobel Museum are not of the Neosho strain (Curtis Tacket; personal communication) because the smallmouth bass that may occur within Grand Lake and the stretches of the Neosho, Spring, and Elk rivers in Oklahoma are likely to be reservoir-strain fish. ODWC sampling efforts (locations not disclosed), which looked for both the Neosho and reservoir subspecies, did not detect the Neosho subspecies of the smallmouth bass within the Project boundary or surrounding drainages. The latest surveys occurred in 2019 (Curtis Tacket; personal communication). Based on these data indicating that the Neosho Smallmouth Bass does not occur within the Project boundary, no additional surveys for Neosho Smallmouth Bass occurred in 2022. Furthermore, due to their absence within the Project boundary, Project Operations should not impact the Neosho Smallmouth Bass.

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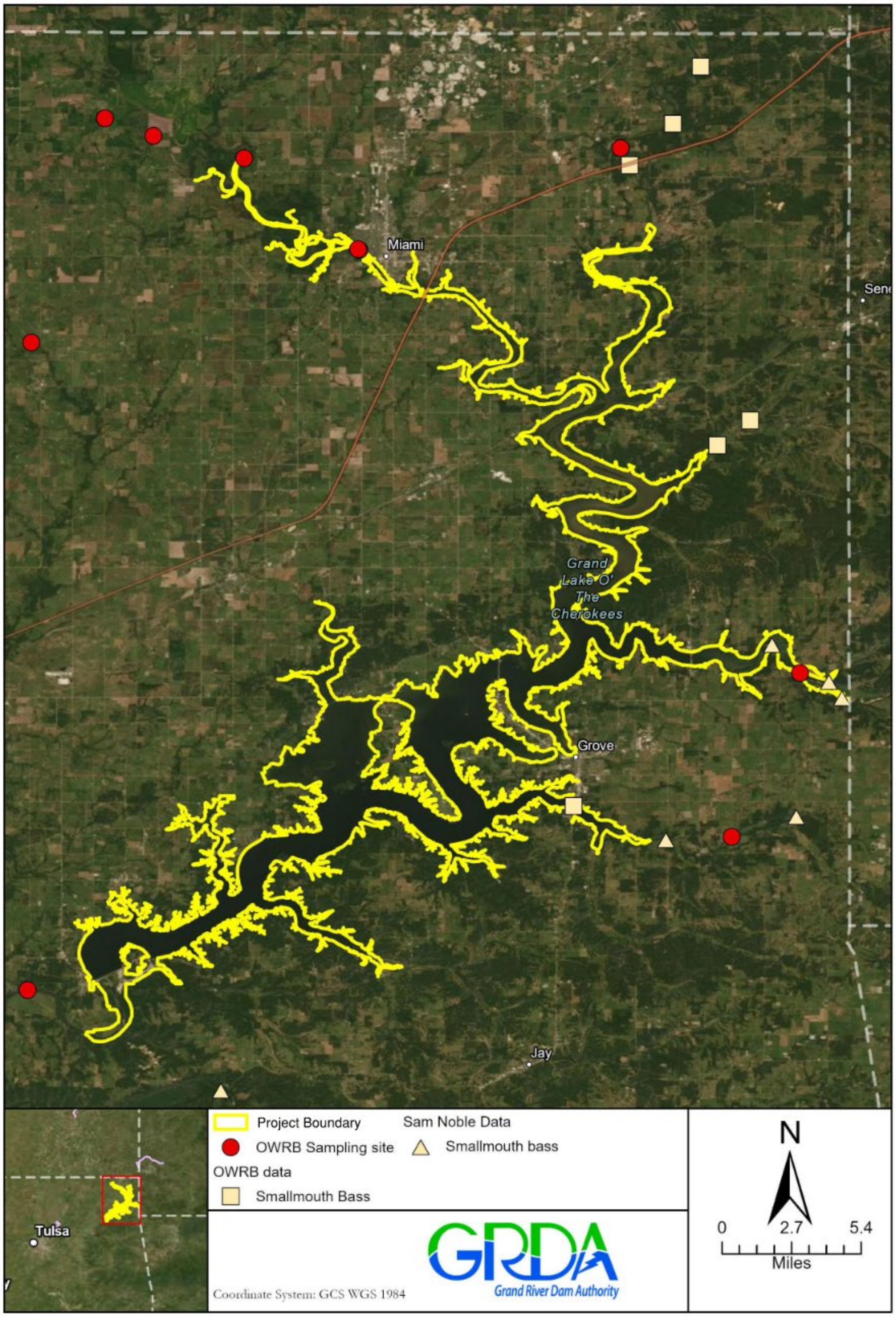


**Figure 10. Locations of sampling sites and Smallmouth Bass occurrence within the Project vicinity. Data provided by OWRB and Sam Noble Museum.**

# 4.6 Paddlefish (*Polyodon spathula*)

## 4.6.1 Habitat and Conservation Status

Adult Paddlefish inhabit deep slow-moving pools of large rivers and associated lakes and reservoirs, where they use special electrical receptors on their rostrum to detect zooplankton that are filtered from the water with specialized gill rakers (Jennings and Zigler 2009). They typically inhabit areas with depths greater than 9.8 ft and current velocities below 1.6 feet per second (ft/s) in reservoirs (Rosen et al. 1982; Zigler et al. 2003). Appropriate spawning habitats are more specific and require riverine habitats. Paddlefish spawning occurs in aggregations over hard substrates such as washed cobble within river environments during March – June, depending on latitude (Jennings and Zigler 2009; Schooley and O'Donnell 2016). In Oklahoma, spawning peaks in late March and early April (Scarnecchia et al. 2013). Spawning appears to be episodic, often initiated by rising water levels and occurring during periods of high flow, and year-class recruitment is often highest in years that have extended high flow conditions during the spring spawning period (O'Keefe et al. 2007; Jennings and Zigler 2009; Scarnecchia et al. 2013). Paddlefish spawn demersal eggs that become adhesive upon fertilization and stick to the substrate (Purkett 1961; Yeager and Wallus 1982). Hard substrates such as gravel and cobble are key to spawning success because eggs that fall on sand or silt may have reduced survival (Schooley and O'Donnell 2016).

Previous research by ODWC biologists has quantified the amount of hard spawning substrates within the Neosho and Spring rivers upstream of Grand Lake to the first migration barriers and evaluated how changes in flows influence the availability of spawning habitat in these rivers (Schooley and O'Donnnel 2016; Schooley and Neely 2018). Because changes to reservoir elevations could potentially influence the availability of spawning substrates, Phase I of this study included compilation of this data and development of maps to evaluate the amount and spatial distribution of Paddlefish spawning substrate within the Project boundary.

To perform this evaluation, spatially explicit depth and hardness data from the above studies provided by Jason Schooley (ODWC Senior Biologist, Paddlefish Research Center) and Ben Neely (Kansas Department of Wildlife, Parks, and Tourism) were compiled and formatted into a geographic information system (GIS) platform. Details on data collection and analysis used to generate this dataset and differentiate substrate types are provided in Schooley and O'Donnell (2016) and Schooley and Neely (2018). The study area for this dataset includes 38.5 miles of the Neosho River upstream to a dam at Chetopa, Kansas, and 22.4 miles of the Spring River upstream to a barrier at Baxter Springs, Kansas. Within this study area, the amount of usable spawning substrate changes with flow in each system because higher flows generally inundate more usable substrate. At the maximum flows evaluated, a total of approximately 2,647 ac of potential habitat occurs, of which 1,701 ac (64 percent) consist of hard substrates presumably suitable for Paddlefish spawning (Table 14). Specifically, 997 ac of Paddlefish spawning substrates (69 percent of available) were identified within the Neosho River and 704 ac (59 percent of available) were identified in the Spring River. The availability of hard substrates generally increases moving upstream from the river/reservoir interface. Within the Project boundary, approximately 696 ac of Paddlefish spawning substrate was identified within the Neosho River and 493 ac of spawning substrate was observed within the Spring River (Table 14; Figures 11-13). Therefore, 70 percent of the available spawning substrate within both the Neosho River and the Spring River falls within the Project boundary.

Due to hydrology differences between the two river systems, modeling of proportional habitat availability under varying flow rates suggests that the Neosho River has greater value for Paddlefish reproduction than the Spring River (Schooley and Neely 2018). Additionally, studies using dentary bone microchemistry to identify natal river found that 87% of fish analyzed were of Neosho River origin, whereas only 7% were of Spring River origin (Whitledge and Schooley 2019). Taken together, this demonstrates that the Neosho River has much greater value to Paddlefish reproduction than the Spring River.

**Table 14. Area of Paddlefish spawning substrate in acres (ac) as quantified by Schooley and O'Donnell (2016) in relation to their study area and the Project boundary.**

| | Neosho River | Spring River | Overall |
|---|---|---|---|
| **Study Area (ac)** | 1,444 | 1,203 | 2,647 |
| **Paddlefish Spawning Habitat (ac)** | 997 | 704 | 1,701 |
| **Paddlefish Spawning Habitat within Project (ac)** | 696 | 493 | 1,189 |
| **Percent of Paddlefish Spawning Habitat within Project** | 70% | 70% | 70% |

The area below the confluence of the two rivers, in the Grand River near the river/reservoir interface, was not evaluated for spawning habitat. Spawning activity in this section is unlikely because this area is a transitional zone used by staging Paddlefish in the late winter and early spring as they wait for high-flow pulses to move upriver into the Spring or Neosho rivers and begin spawning (Schooley and O'Donnell 2016). Occurrence of such high-flow pulses which stimulate upstream migration within the spring spawning period are the major determinant of Paddlefish spawning success, and likely have a much greater influence on Paddlefish recruitment than reservoir levels.

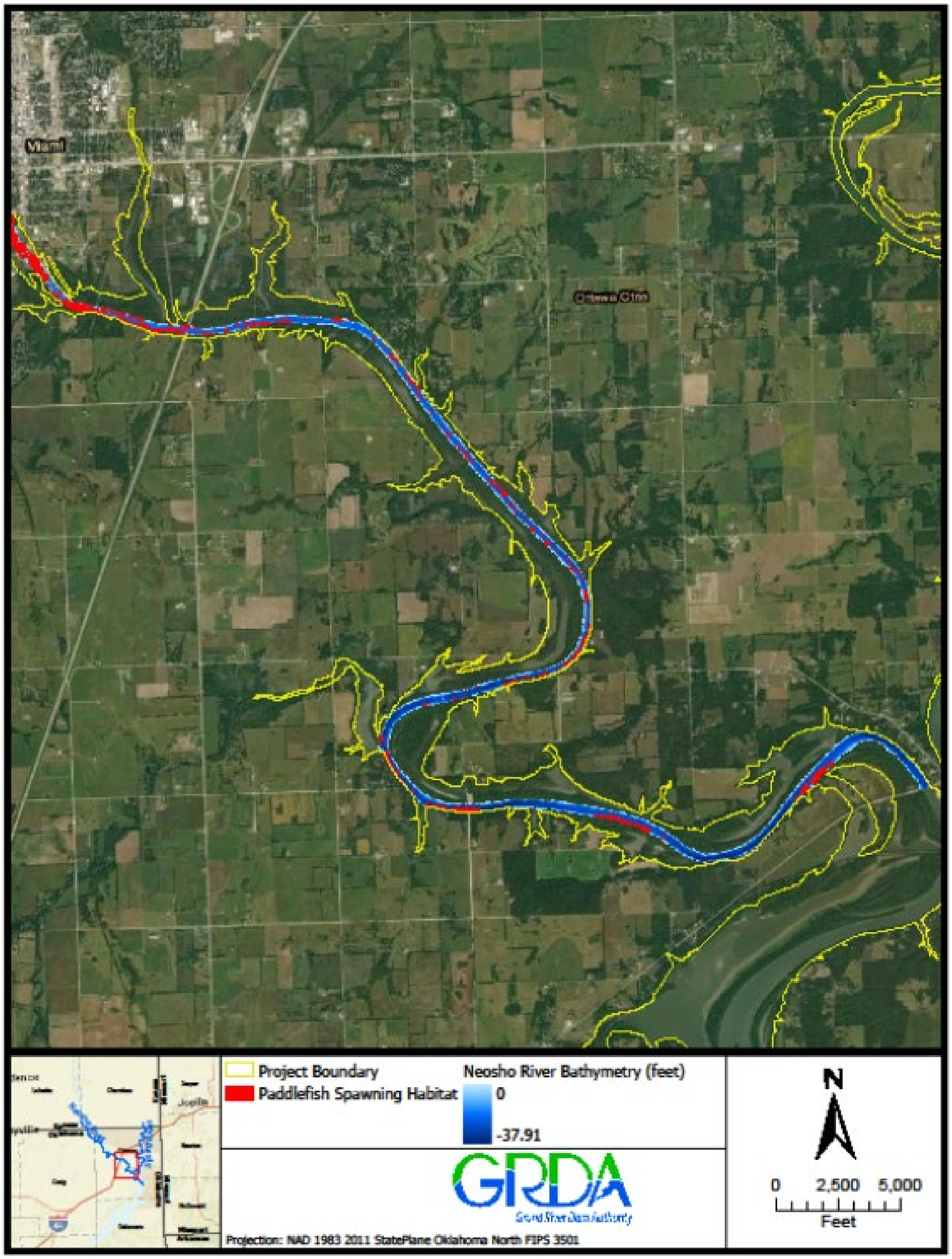


**Figure 11. Potential Paddlefish spawning substrate as defined by Schooley and O'Donnell (2016) within the Project boundary on the Neosho River downstream of Miami, OK.**

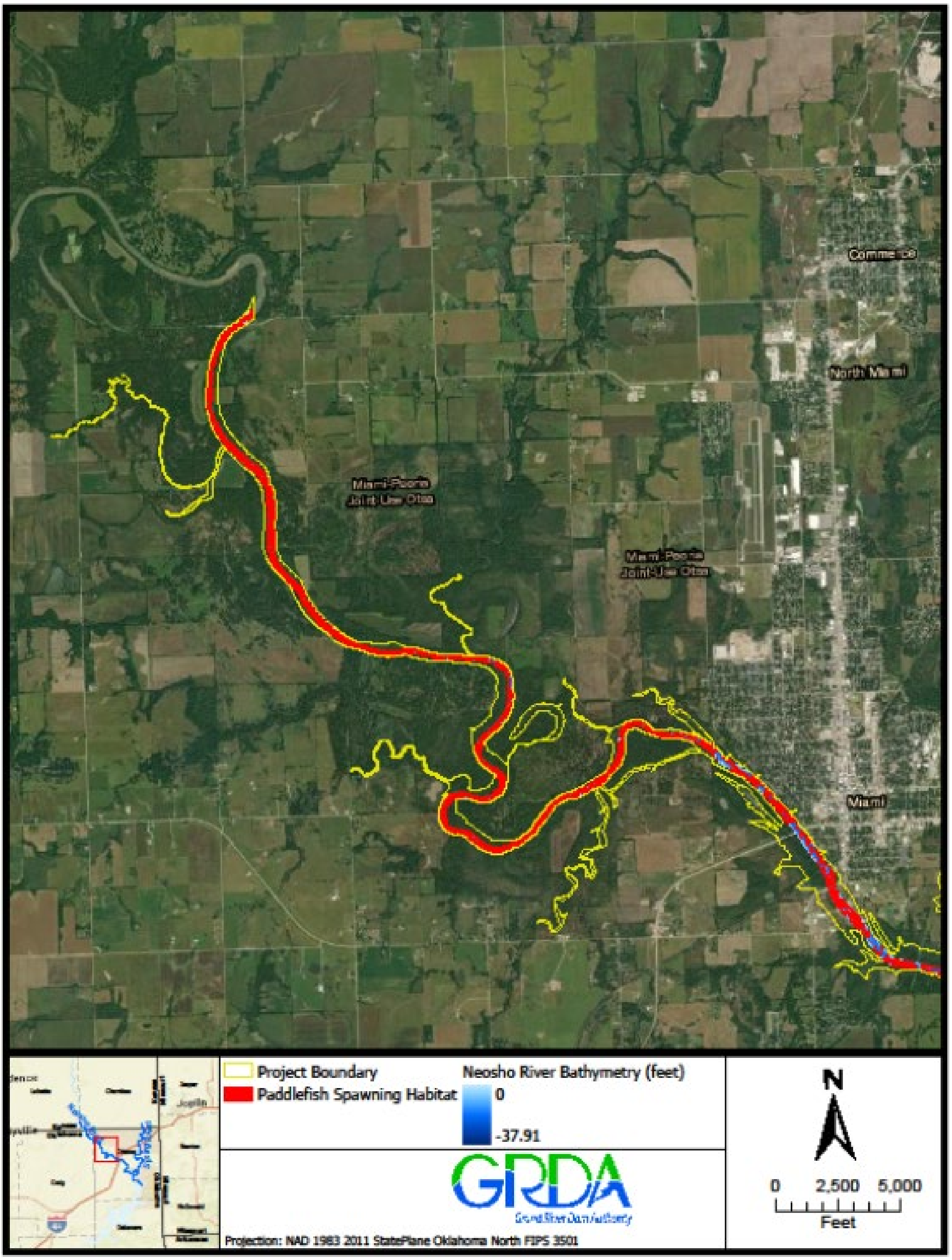


**Figure 12. Potential Paddlefish spawning substrate as defined by Schooley and O'Donnell (2016) within the Project boundary on the Neosho River upstream of Miami, Oklahoma.**

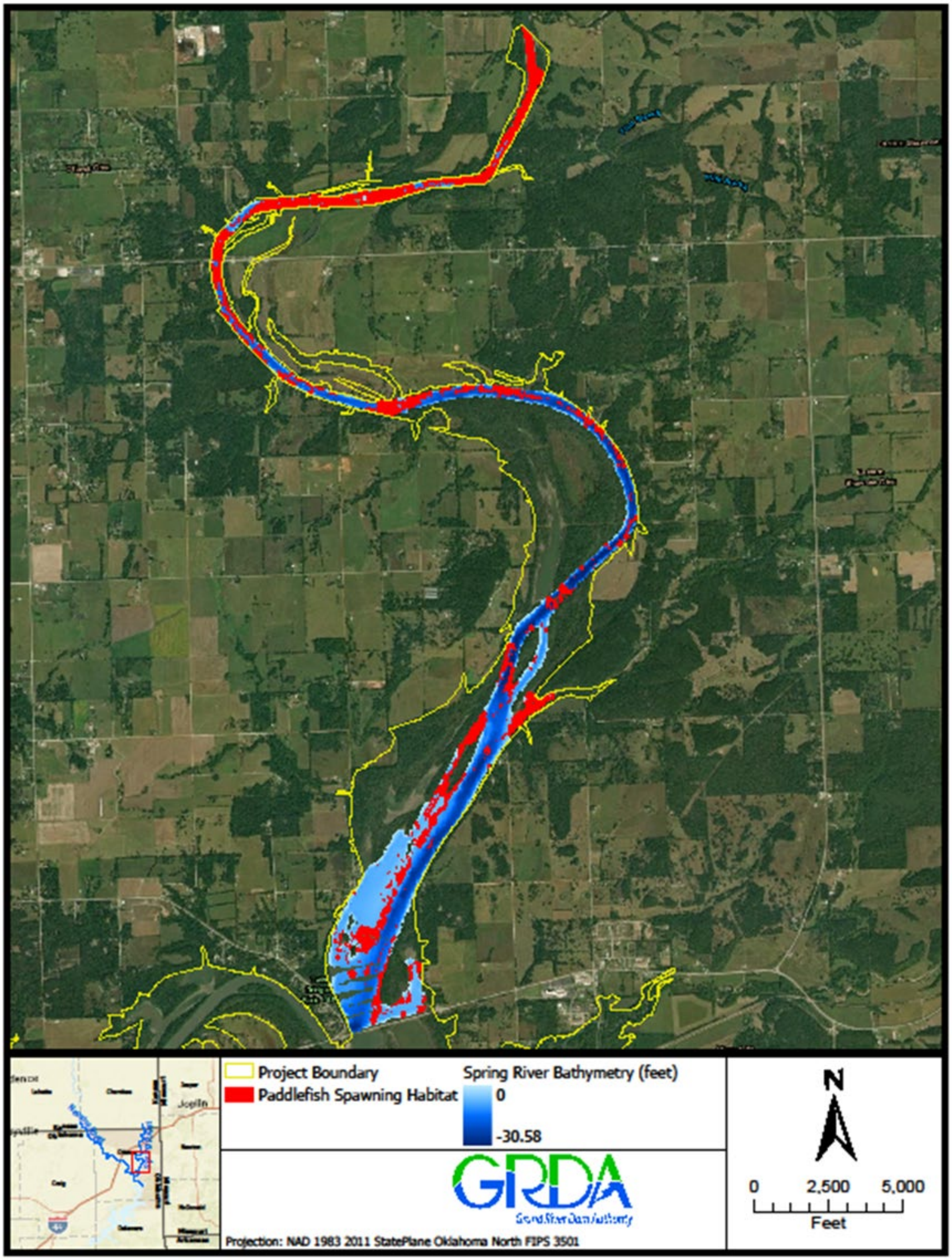


**Figure 13. Potential Paddlefish spawning substrate as defined by Schooley and O'Donnell (2016) within the Project boundary on the Spring River.**

## 4.6.2 Distribution and Occurrence

Paddlefish are native to large rivers and lakes of the Mississippi River drainage and nearby gulf slope drainages from the San Jacinto River in the southwest to the Tombigbee and Alabama rivers in the southeast. At the northern extent of their range, Paddlefish extend as far west as the Missouri and Yellowstone rivers of Montana to the Ohio and Allegheny rivers of the northeast (Jennings and Zigler 2009). In Oklahoma, Paddlefish were originally present in most large rivers of the Arkansas system including the Neosho and Grand rivers, the Little River, and the Red River (Miller and Robison 2004).

Paddlefish stocks in Grand Lake and the Neosho and Spring rivers support a prominent snag fishery, attracting anglers from throughout the United States during the spring spawning run (Jager and Schooley 2016). Although annual catch rates are variable depending on hydrologic conditions, thousands of mature Paddlefish are harvested from Grand Lake stocks during some years (Scarnecchia et al. 2013). Trip expenditures from Paddlefish angling in Oklahoma have an estimated economic impact of 18.2 million dollars (Melstrom and Shideler 2017), much of which is focused on the Grand Lake fishery. Since 2015, good water years (years with extended high springtime flows) have resulted in good Paddlefish recruitment in the Neosho watershed. The impacts of a large recruitment event in 2015 are now being realized as the males have reached sexual maturity and the females will in 2022-2023 (personal communication via email on Sep. 13, 2021, Jason Schooley, ODWC Paddlefish Research Center).

## 4.6.3 Discussion

As documented above, a large percentage of available Paddlefish spawning habitat occurs within upstream portions of the Project boundary in the Neosho and Spring Rivers. However, regardless of the anticipated future operation of the Project, the magnitude and timing of inflow events will continue to be the main determinant of hydraulic conditions necessary to facilitate successful Paddlefish spawning. Therefore, based on the abundance of potential spawning substrates available in upstream areas, the anticipated change in Project operations is not expected to adversely impact Paddlefish.

During the USR process, FERC staff requested maps delineating the riverine reaches that would be converted to lentic habitat during the Paddlefish spawning season (March-April), and an estimate of the acreage of habitat in the Spring and Neosho Rivers that would be converted to lentic habitat under anticipated operations. To do this, Figures 11-13 were examined to locate areas in which the substrate discernably changes from hard (gravel, cobble) to soft (silt) over a short distance, and this was used as a reference point for the lotic/lentic transition. In the Neosho River, a transect was selected just downstream of the I-44 Bridge (Neosho River Mile 133.35) (Figure 11, Appendix E). In the Spring River, a transect was selected south of the Highway 10 Bridge (Spring River Mile 7.32) (Figure 13, Appendix E). Water velocity was then calculated at these two locations under baseline operations to yield the average water velocity at this lotic/lentic transition. Then, the movement of this baseline velocity (i.e., lotic/lentic transition) was evaluated under model-simulated anticipated operations.

Using this method, 1.8 acres of wetted area on the Neosho River and 3.5 acres of wetted area on the Spring River may undergo a change in habitat quality. Under the median flow conditions analyzed, this would result in 0.5 acres of Paddlefish spawning substrate being influenced on the Neosho River, and 2.1 acres being influenced on the Spring River. Maps delineating these areas of potential lotic/lentic conversion are provided in Appendix E.

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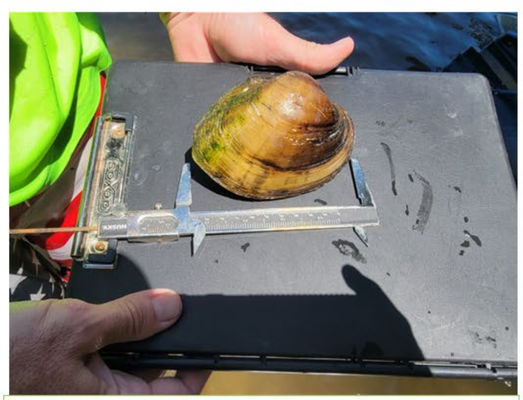
# APPENDIX A – PHOTO LOG

1. Elk 1 mussel site.

2. Elk 2 mussel site.

3.  Elk 3 mussel site.

4. Elk 4 mussel site.



5. Elk 4 mussels collected.

5. Elk 5 mussel site.

7. Spring 1 mussel site.

8. Spring 1 mussels collected.

9. Spring 2 mussel site.

10. Spring 2 mussels collected.

11. Spring 3 mussel site.

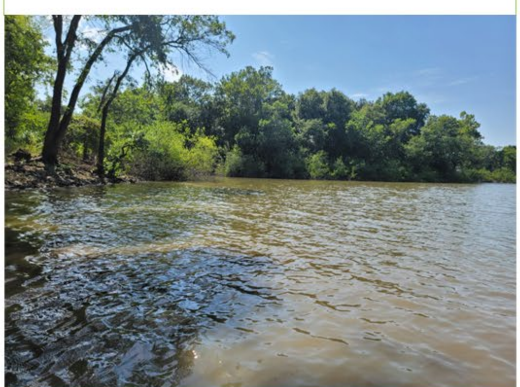
12. Spring 3 mussels collected.

13. Spring 4 mussel site.

14. Spring 4 mussels collected.

15. Neosho 1 mussel site.

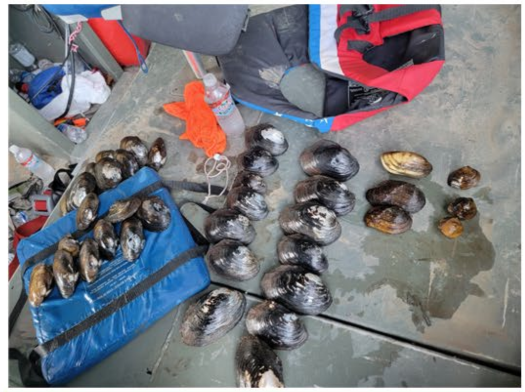
16. Neosho 1 mussels collected



17. Neosho 2 mussel site.

18. Neosho 2 results

19. Neosho 3 mussel site.



20. Neosho 3 mussels collected.

21. Neosho 4 mussel site.

22. Neosho 4 mussels collected.

23. Neosho 1 Madtom Site.

24. Neosho 2 Madtom Site.

25. Neosho 3 Madtom Site.

26. Neosho 4 Madtom Site.

27. Neosho 5 Madtom Site.

28. Neosho 6 Madtom Site.

29. Neosho 7 Madtom Site.

30. Spring 1 Madtom Site.

31. Spring 2  Madtom Site.

32.   Spring 3 Madtom Site.

33. Spring 4 Madtom Survey.

Bleufer (*Potamilus purpuratus*)

Threehorn Wartyback (*Obliquaria reflexa*)

Plain Pocketbook (*Lampsilis cardium*)

Yellow Sandshell (*Lampsilis teres*)

Fragile Papershell (*Potamilus fragilis*)

Pistolgrip (*Tritogonia verrucosa*)

Pink Papershell (*Potamilus ohiensis*)

Mapleleaf (*Quadrula quadrula*)

White Heelsplitter (*Lasmigona complanata*)

Flat Floater (*Utterbackiana suborbiculata*)

*No voucher photo available for Lilliput (*Toxolasma parvum*) and Paper Pondshell (*Utterbackia imbecillis*)

# APPENDIX B – MUSSEL SURVEY PLAN AND COMMENTS

# Aquatic Species of Concern Study

# Phase 2 Freshwater Mussel Sampling Protocols

## INTRODUCTION

The Grand River Dam Authority (GRDA) is relicensing the Pensacola Hydroelectric Project (Project) following the Integrated Licensing Process (ILP) as designated by the Federal Energy Regulatory Commission (FERC). One component of this process is an Aquatic Species of Concern Study to gather information on multiple potential aquatic species of concern and assess any potential effects of the Project on these species. As outlined in the Revised Study Plan, this study included three phases. Phase 1 (completed in 2021) consisted of a review of existing information to determine if further evaluation was needed; Phase 2 included potential field surveys to document distribution and density of the species of concern; and Phase 3 was an assessment of potential impacts of Project operation, if any, for relevant species. The Phase 1 review of existing information was summarized in the Initial Study Report (ISR) filed by GRDA on September 30, 2021 and proposed 2022 Phase 2 surveys for Neosho Mucket (*Lampsilis rafinesqueana*) in the Elk River portion of the study area, among other tasks. Both FERC and United States Fish and Wildlife Service (USFWS) provided comments on GRDA's proposed Phase 2 study plan related to Neosho Mucket and GRDA filed an official Response to Comments with FERC on December 29, 2021. On February 24, 2022, FERC released a Study Plan Determination on Study Year 2. This Study Plan Determination recommended that GRDA conduct targeted freshwater mussel surveys for Neosho Mucket in USFWS-recommended portions of the Spring River and Neosho River, after consultation with USFWS, EcoAnalysts, and the Tar Creek Trustee Council (TCTC) on survey design.

This document describes the proposed survey design for conducting Phase 2 targeted mussel surveys for Neosho Mucket in recommended portions of the Elk River, Spring River, and Neosho River. It aggregates survey locations and methods proposed by GRDA in the September 2021 ISR, modifications associated with the December 2021 Response to Comments, as well as FERC recommendations in the February 2022 Study Plan Determination. Goals of these surveys are to provide the information needed to determine whether Neosho Mucket are present and to provide habitat information to assess the potential effects of pProject operation on Neosho Mucket that are present within the targeted survey locations.

# SURVEY AREAS

As defined by the process described above, three areas have been identified for targeted mussel surveys to assess the distribution and site-specific density of Neosho Mucket in the Project vicinity. These areas are:

- the portion of the Elk River from the Missouri/Oklahoma state line to the confluence with Buffalo Creek[1] (approximately 1.0 river mile);
- the portion of the Spring River from Warren Branch to the confluence with the Neosho River[2] (approximately 10.5 river miles); and
- the portion of the Neosho River from the City of Miami [Riverview Park] to the confluence with the Spring River[3] (approximately 13 miles).

# SURVEY METHODOLOGY

Within each of the three survey reaches outlined above, the following three-phase survey methodology will be implemented. These surveys are planned for June-August 2022 with exact timing depending upon appropriate flow and weather conditions. The surveys will be conducted under the supervision of qualified personnel with appropriate permits and knowledge of mussel survey methods and procedures for handling endangered mussel species. Resumes of key team members are provided.

## Phase 1 – Identify and Map Any Potential Neosho Mucket Habitat

Surveys are intended to target Neosho Mucket. Phase 1 of surveys will involve identifying and mapping appropriate habitat for this species within the previously defined survey reaches. To do this, experienced malacologists will traverse the entire study area by boat and/or canoe/kayak to examine habitat conditions. Any areas of potential Neosho Mucket habitat will be georeferenced by creating polygons around areas of potential habitat with a GPS.

Potential habitat will be identified consistent with previous mussel survey efforts and habitat descriptions for Neosho Mucket. Freshwater mussels are typically most abundant and diverse within stable fluvial habitats (riffles/runs) of riverine environments (Haag 2012, EcoAnalysts 2018). Specifically, Neosho Muckets have been collected from a variety of habitats but are typically described to have an association with moderately flowing shallow water over gravel or intermixed gravel and sand substrates (McMurray et al. 2012; Oesch 1984) and are not thought to inhabit reservoirs (Obermeyer et al. 1997). Therefore, potential habitat for Neosho Mucket will be considered flowing water riffles and runs over gravel or intermixed gravel and sand

[1] As outlined in the Initial Study Report submitted September 30, 2021.
[2] Requested modification in FERC Study Plan Determination-Season II-02242022.
[3] Requested modification in FERC Study Plan Determination-Season II-02242022.

substrates[4]. Depth, benthic current velocity, and percent substrate composition (visually classified based on the modified Wentworth scale) will be recorded at each area of potential habitat delineated and reference photographs will be taken.

## Phase 2 – Qualitative Surveys

Within each delineated area of potential habitat, qualitative surveys via timed visual/tactile search methods (hand-grubbing into the top 1-4 inches of substrate to increase detection of more-deeply buried mussels) will be utilized to efficiently assess occurrence of Neosho Mucket. A qualitative survey approach is an efficient search method to establish a list of taxa, as well as increase the detection probability of rare species (Vaughn et al. 1997; Strayer and Smith 2003). Surveyors will select a shoreline and begin searching from downstream to upstream moving back and forth across the stream, ensuring that all the delineated search area of potential habitat is sufficiently covered. Surveyors will conduct a minimum of three one-person-hour searches using mask and snorkel. All live mussels and shell material will be collected, placed in mesh bags submerged in the stream, and aggregated by person-hour. If no live mussels are collected by the end of the third person-hour, the site will be considered complete. If live mussels are located, an additional two person-hours of search effort will be conducted. If a previously undetected mussel species is collected in the fifth person-hour, additional one-person-hour searches will be conducted until no new species are collected. If Neosho Mucket (or other listed mussels) are detected at any point during Phase 2 surveys, qualitative methods will immediately cease, and sampling will immediately transition to Phase 3 quantitative surveys.

Upon completion of qualitative surveys, all mussels will be identified to species by a qualified malacologist, enumerated, and returned to the approximate location of collection. Voucher photographs will be taken of each species collected. Shell material will also be collected, identified to species (when possible), and classified as fresh dead (FD; intact periostracum and lustrous nacre), weathered dead (WD; intact periostracum, weathered and chalky nacre); or subfossil (SF; shell chalky, no periostracum).

## Phase 3 – Quantitative Surveys

Phase 3 quantitative surveys will be conducted at all sites where Neosho Mucket are located during Phase 2 qualitative surveys. A single 100 $m^2$ quantitative sampling area will be delineated encompassing the area where Neosho Mucket were located. Within this 100 $m^2$ quantitative sampling area, systematic sampling will be incorporated using three random starts with a minimum of 10 0.25 $m^2$ quadrats conducted at each 100 $m^2$ site (Strayer and Smith 2003). Visual/tactile search methods will be used to remove larger mussels and each quadrat

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[4] In the initial study report, it was stated *"Additional, randomly selected quadrat points will be available to replace locations that do not provide mussel habitat (e.g., too close to shore, water depth, poor substrate)."* Such areas are now being excluded from the 100 $m^2$ sampling area. Therefore, additional randomly selected quadrat points are no longer necessary.

will then be excavated to a depth of 20 cm and sieved, as this increases the likelihood of detecting juvenile mussels. Data will be used to generate an estimate of Neosho Mucket density within each 100 $m^2$ site with each random start serving as an independent replicate.

Upon completion of quantitative surveys, all mussels will be identified to species by a qualified malacologist, enumerated, and returned to the approximate location of collection. All Neosho Mucket collected will also be measured to the nearest millimeter shell length. Shell material will also be collected, identified to species (when possible), and classified as fresh dead (FD; intact periostracum and lustrous nacre), weathered dead (WD; intact periostracum, weathered and chalky nacre); or subfossil (SF; shell chalky, no periostracum).

# SUMMARY

The above three-phase survey methodology addresses the goals of the project by identifying and mapping any potentially appropriate habitat for Neosho Mucket within the proposed survey areas, using qualitative timed searches to most-efficiently evaluate occurrence of the target species, and using quantitative surveys to provide an estimate of site-specific density of Neosho Mucket in the areas where it is detected.

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Vaughn, C.C., C.M. Taylor, and K.J. Eberhard. 1997. A comparison of the effectiveness of timed searches vs. quadrat sampling in mussel surveys. Conservation and Management of Freshwater Mussels II: Proceedings of a UMRCC Symposium.

Response Table:

| USFWS | Comment | Response |
|---|---|---|
| 1 | The Protocol identifies three principal areas for the surveys. These reflect prior input provided by the Service, which recommended making use of existing information collected on mussel resources of the Project area. We agree largely with the three identified areas, although we recommend expansion of the Elk River area. Presently, the Protocol proposes surveying a 1.0-mile portion of the Elk River between the Missouri/Oklahoma state line and the confluence with Buffalo Creek. Although sensitive mussel species such as the Neosho mucket are not likely to occur much farther downstream than Buffalo Creek, it is plausible that they could occur upstream of the state line. Future management actions that may be taken by the GRDA include scenarios in which lentic (pooled) waters would inundate presently flowing habitats, including extending pooled waters upstream of the state line. Such change may impact the Neosho mucket and other sensitive mussels. It creates a justification for expanding the Elk River survey area, minimally to include the extent of river habitat likely to be affected by future pool changes. | The project boundary extends to approximately the Oklahoma/Missouri state line, so the proposed survey area includes all habitats within the influence of the project. This proposed survey area was included in the ISR and received no comments in FERC's Study Plan Determination. |
| 2 | The qualitative survey procedure states that surveyors will conduct a minimum of three one-person-hour searches (of each survey area), using mask and snorkel. The quantitative survey procedure states that surveyors will sample a minimum of ten 0.25 m2 quadrats (within each survey area), without specifying surveyor gear. GRDA surveyors need to be prepared to dive using SCUBA or surface-supplied air to complete the surveys. While it is correct that typical Neosho mucket habitat is often described as flowing riffles and runs over gravel or gravel/sand substrates, Neosho muckets can occupy greater depths than cannot be surveyed efficiently by snorkeling. Potential habitats that will be encountered by the surveyors in the survey areas include extensive areas that are too deep to survey by snorkeling, even at base flows. We recommend that the Protocol state SCUBA or hookah diving will be employed in the surveys to sample deeper habitats. | We will add divers using surface-supplied-air to sample deeper habitats. |
| 3 | The qualitative survey procedure states that if Neosho muckets or other listed mussels are detected at any point of surveying, qualitative methods will immediately cease, and sampling will transition to quantitative methods. This provision disregards the greater effectiveness of qualitative searches for detecting the variety of species present, including rare species. Under the proposed Protocol, a random encounter with a listed mussel very early in qualitative sampling could result in under-detection of an area's mussel species. We recommend that the Protocol be revised to state that detection of a listed species will result in a transition to quantitative surveying, after which qualitative surveying will be completed. | As stated, the only reason to continue qualitative surveys is to document mussel assemblage composition, which is not the goal of this study. The goal of this study is to document if Neosho Mucket occur in the survey area, and if so, to estimate their densities in specific occupied habitats. The downside of additional qualitative sampling is that mussels collected/disturbed during qualitative surveys will influence density calculations from subsequent quantitative surveys. Given this, and the specific goals of the study, it is best to initiate quantitative |

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|---|---|---|
| | | sampling immediately upon detection of the target species. Other mussel protocols usually use a similar qualitative/quantitative transition. |
| 4 | The qualitative survey procedure states that voucher photographs will be taken of each species collected. The quantitative survey procedure does not address photo-documentation but does state that shell length of all Neosho muckets collected will be recorded in millimeters. We recommend that the Protocol be revised to state that voucher photographs/images shall be taken of all specimens of all listed mussel species collected and of at least one specimen of all other mussel species collected. The photographs/images must be of sufficient quality to support expert confirmation of species identifications. In addition, we recommend that the Protocol be revised to state that shell lengths of all listed mussel specimens collected shall be recorded in millimeters. We also recommend that for non-listed mussel species collected, the range of shell lengths be recorded and reported to demonstrate population recruitment. | We will take individual photos and length measurements of all listed mussels collected. For non-listed mussels, we will record min and max length and measure a subset of individuals. |
| 5 | The Protocol proposes to accomplish quantitative surveying using systematic sampling, as described by Strayer and Smith (2003). Sampling is to be performed within 100 m2 sampling areas using 3 random starts and a minimum of ten 0.25 m2 quadrats. The target minimum of ten sampling units would provide a relatively data-poor sample, especially with the use of 0.25 m2 quadrats. Length and width of the sampling area are not specified, and perhaps are to be varied to fit site habitats, but in most configurations will call for more than ten quadrats. We believe that setting/completing a higher target, such as a minimum of 15 sampling units, would result in better quantitative assessments. | We will revise protocols to include 15 0.25 m2 quadrats per quantitative sampling area. |
| 6 | The Protocol does not describe how the data collected are to be analyzed or presented, but we assume reports will be produced and made available to the Service, which include logical compilations and analyses of all pertinent data. Data on any occurrences of the Neosho mucket or other federally-listed species are most important, but data on other mussel species dependent on high quality lotic habitats also will be pertinent to assessing Project impacts. We recommend that plans for data analysis and reporting be described. | Data analysis will be presented in the USR. |
| 7 | Recommendations for sampling locations were based on assumptions that information from past surveys (the Service assisted in identifying this for the GRDA) will be used in composing an overall picture of mussel resources in the Project area. The Protocol does not describe if previously collected information was found to be sufficient for the relicensing analysis or would need to be supplemented in various respects. We recommend that this be addressed prior to conduct of the Phase 2 surveying. | Previous data was summarized and addressed in the ISR and this sampling plan was developed in response to that. |
| EcoAnalysts | Comment | Response |
| 1 | In Phase 1- working in this basin, we found many of the mussels in back channels or in outside bends of pools. So, I would suggest that although unionids are typically in shallow runs above and below riffles (not in riffles), they can also be in flowing parts of pools and secondary channels. In the Spring River in particular, we found the main part of the channel to be high energy and unstable. Most of the mussels we found were in secondary channels, along the edges | We will sample flowing-water areas in main-channel and side-channel areas and look for areas with the complex substrate (sand/gravel/cobble/clay mix) that is described here. |

| | | |
|---|---|---|
| | of islands. If substrate was "spongy" (sand/gravel/cobble over a clay base) there were typically mussels. In the Neosho in particular, more mussels were found in cracks in the bedrock or in silt/clay substrate along banks. | |
| 2 | Phase 2 mentions using mask and snorkel. Even during low water, we had to dive many of the areas with Neosho mucket. | We will add divers using surface-supplied-air to sample deeper habitats. |
| 3 | Phase 3- 10 quantitative samples may be insufficient if the objective is to obtain a density estimate of Neosho mucket. 10 samples can be used as a pilot to estimate density and standard deviation from which an adequate sample size can be calculated. An error objective should be established (+/- x% of the mean). I typically use a 25 to 30% precision unless this is a long-term monitoring that you want to compare over time, then you might want a more precise estimate. However, as precision increases, sample size increases substantially. | Based on input from USFWS, we will increase to 15 quadrat samples per quantitative sampling area. |
| TCTC | Comment | Response |
| 1 | In general, the Council recommends the sampling plan be revised to follow the U.S. Fish and WildHfe Service and Texas Parks and Wildlife Department, Texas Freshwater Mussel Sampling Protocol (October 2021) - https://www. fws.govllibrary/collections/texas-freshwater-mussel-sampling-protocol. | The Texas Freshwater Mussel Sampling Protocols referenced are designed for mussel relocation projects in Texas. Their goal is to collect mussels and relocate them from areas of direct impact related to instream construction projects. Our goals are different, and therefore, we should follow a protocol designed specifically to address these goals. Specifically, our goals are to identify if Neosho Mucket occur in the proposed sampling areas, and if so, at what approximate densities. Therefore, we should focus our efforts specifically in areas of potential Neosho Mucket habitat, initially use qualitative searches which are best at identifying the presence of rare species (Neosho Mucket) and follow with quantitative surveys in areas where the target species is detected. Others (Heidi Dunn with EcoAnalysts) have confirmed the appropriateness of this three-phase sampling approach. The protocols referenced in this comment are designed for construction projects in Texas and are not appropriate for the specific goals of our study. |
| 2 | Increase the amount of qualitative survey hours | A minimum of 5 person-hours of qualitative survey effort will be conducted |

| | | |
|---|---|---|
| | | at each sampling location. This will provide a thorough search effort which is comparable to or greater than most other previous survey efforts. Qualitative survey effort during previous surveys in the study area (EcoAnalyst 2018) ranged from 0.5 - 6.0 person-hours per site and averaged less than 1.5 person-hours per site. |
| 3 | Identify the maximum effort at a given location (minimum identified currently) | As described in the survey protocol, a minimum of 5 person-hours of qualitative survey will be conducted at each location. If new species are found on the last person-hour, additional 1 person-hr searches will be conducted until no new species are encountered. Although this leaves the maximum amount of effort somewhat undetermined, it ensures that the team samples until no new species are being collected. |
| 4 | Include dive teams to ensure that all habitats are surveys and reduce sampling bias | We will add divers using surface-supplied-air to sample deeper habitats. |
| 5 | Increase number of quadrats to increase statistical strength | Based on input from USFWS, we will increase to 15 quadrat samples per quantitative sampling area. |
| 6 | Take photos of all individual muckets that are found, and any other sensitive/rare species found | We will photograph each individual listed mussel encountered. |
| 7 | Include a description of how the data will be presented and how previous studies will be included | Data analysis will be presented in the USR. |
| 8 | In the final report, include sized classes of all mussels found to help determine reproduction at each location | We will include at least the minimum and maximum size of each species collected in the final report. We will include size class distributions for listed species. |

## USFWS COMMENTS:

The U. S. Fish and Wildlife Service (Service) has reviewed the proposed Phase 2, Freshwater Mussel Sampling Protocol (Protocol) prepared by the Grand River Dam Authority (GRDA) in regard to ongoing relicensing of the Pensacola Hydroelectric Project (Project). We submit the following comments for your consideration.

1. The Protocol identifies three principal areas for the surveys. These reflect prior input provided by the Service, which recommended making use of existing information collected on mussel resources of the Project area. We agree largely with the three identified areas, although we recommend expansion of the Elk River area. Presently, the Protocol proposes surveying a 1.0-mile portion of the Elk River between the Missouri/Oklahoma state line and the confluence with Buffalo Creek. Although sensitive mussel species such as the Neosho mucket are not likely to occur much farther downstream than Buffalo Creek, it is plausible that they could occur upstream of the state line. Future management actions that may be taken by the GRDA include scenarios in which lentic (pooled) waters would inundate presently flowing habitats, including extending pooled waters upstream of the state line. Such change may impact the Neosho mucket and other sensitive mussels. It creates a justification for expanding the Elk River survey area, minimally to include the extent of river habitat likely to be affected by future pool changes.
2. Response: Survey area expanded to include all suitable mussel habitat downstream of the Kansas State line.

   .
3. The qualitative survey procedure states that surveyors will conduct a minimum of three one-person-hour searches (of each survey area), using mask and snorkel. The quantitative survey procedure states that surveyors will sample a minimum of ten 0.25 $m^2$ quadrats (within each survey area), without specifying surveyor gear. GRDA surveyors need to be prepared to dive using SCUBA or surface-supplied air to complete the surveys. While it is correct that typical Neosho mucket habitat is often described as flowing riffles and runs over gravel or gravel/sand substrates, Neosho muckets can occupy greater depths than cannot be surveyed efficiently by snorkeling. Potential habitats that will be encountered by the surveyors in the survey areas include extensive areas that are too deep to survey by snorkeling, even at base flows. We recommend that the Protocol state SCUBA or hookah diving will be employed in the surveys to sample deeper habitats.
4. The qualitative survey procedure states that if Neosho muckets or other listed mussels are detected at any point of surveying, qualitative methods will immediately cease, and sampling will transition to quantitative methods. This provision disregards the greater effectiveness of qualitative searches for detecting the variety of species present, including rare species. Under the

proposed Protocol, a random encounter with a listed mussel very early in qualitative sampling could result in under-detection of an area's mussel species. We recommend that the Protocol be revised to state that detection of a listed species will result in a transition to quantitative surveying, after which qualitative surveying will be completed.

5. The qualitative survey procedure states that voucher photographs will be taken of each species collected. The quantitative survey procedure does not address photo-documentation but does state that shell length of all Neosho muckets collected will be recorded in millimeters. We recommend that the Protocol be revised to state that voucher photographs/images shall be taken of all specimens of all listed mussel species collected and of at least one specimen of all other mussel species collected. The photographs/images must be of sufficient quality to support expert confirmation of species identifications. In addition, we recommend that the Protocol be revised to state that shell lengths of all listed mussel specimens collected shall be recorded in millimeters. We also recommend that for non-listed mussel species collected, the range of shell lengths be recorded and reported to demonstrate population recruitment.
6. The Protocol proposes to accomplish quantitative surveying using systematic sampling, as described by Strayer and Smith (2003). Sampling is to be performed within 100 $m^2$ sampling areas using 3 random starts and a minimum of ten 0.25 $m^2$ quadrats. The target minimum of ten sampling units would provide a relatively data-poor sample, especially with the use of 0.25 $m^2$ quadrats. Length and width of the sampling area are not specified, and perhaps are to be varied to fit site habitats, but in most configurations will call for more than ten quadrats. We believe that setting/completing a higher target, such as a minimum of 15 sampling units, would result in better quantitative assessments.
7. The Protocol does not describe how the data collected are to be analyzed or presented, but we assume reports will be produced and made available to the Service, which include logical compilations and analyses of all pertinent data. Data on any occurrences of the Neosho mucket or other federally-listed species are most important, but data on other mussel species dependent on high quality lotic habitats also will be pertinent to assessing Project impacts. We recommend that plans for data analysis and reporting be described.
8. Recommendations for sampling locations were based on assumptions that information from past surveys (the Service assisted in identifying this for the GRDA) will be used in composing an overall picture of mussel resources in the Project area. The Protocol does not describe if previously collected information was found to be sufficient for the relicensing analysis or would need to be supplemented in various respects. We recommend that this be addressed prior to conduct of the Phase 2 surveying.

**Scott A. Thompson**
Executive Director

OKLAHOMA Environmental Quality

**Kevin Stitt**
Governor

May 6, 2022

Darrell E. Townsend II, Ph.D.
Vice President, Ecosystems & Watershed Management
Grand River Dam Authority
P.O. Box 70
Langley, OK 74350-0070

RE: Tar Creek Trustee Council's Comments on Proposed Phase 2, Freshwater Mussel Sampling Protocol

Dear Dr. Townsend:

As designated Tar Creek Trustee Council (Council) Lead Administrative Trustee, I received your certified letter requesting Council comment on the GRDA's proposed Phase 2, Freshwater Mussel Sampling Protocol on April 8, 2022. The request was circulated to the Council trustees and discussed during our April 12th meeting.

In general, the Council recommends the sampling plan be revised to follow the U.S. Fish and Wildlife Service and Texas Parks and Wildlife Department, *Texas Freshwater Mussel Sampling Protocol* (October 2021) - https://www.fws.gov/library/collections/texas-freshwater-mussel-sampling-protocol. More specific recommendations are:

a) increase the amount of qualitative survey hours,
b) identify the maximum effort at a given location (minimum identified currently),
c) include dive teams to ensure that all habitats are surveys and reduce sampling bias,
d) increase number of quadrats to increase statistical strength,
e) take photos of all individual muckets that are found and any other sensitive/rare species found,
f) include a description of how the data will be presented and how previous studies will be included, and
g) in the final report, include sized classes of all mussels found to help determine reproduction at each location.

The Council welcomes the opportunity to provide constructive feedback on this protocol as we prepare to implement selected restoration projects detailed in the Council's Phase 1 Restoration Plan and Environmental Assessment Plan.

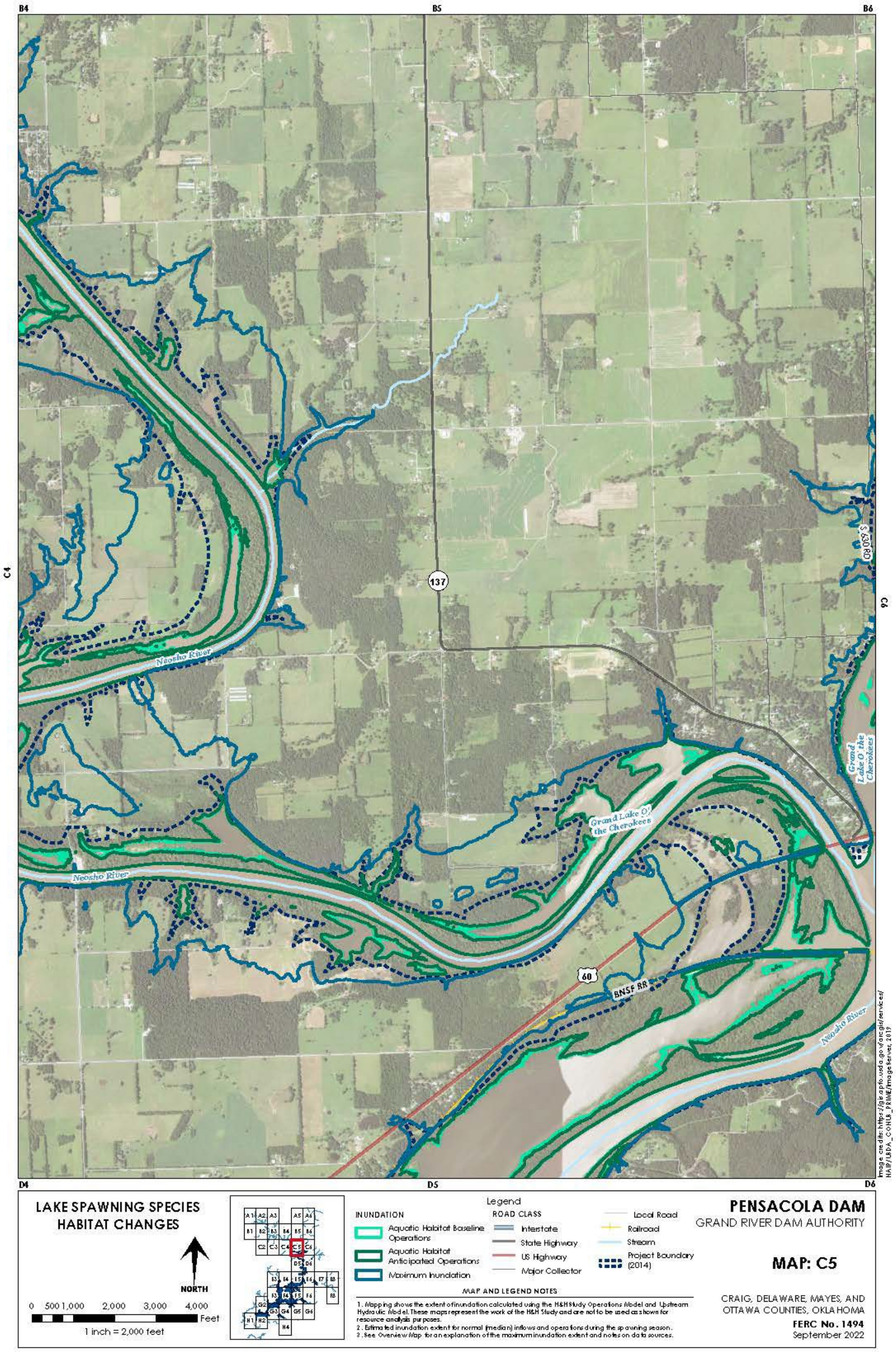
If you have any questions for the Council, you can contact me at susan.mensik@deq.ok.gov or at (405) 702-9145.

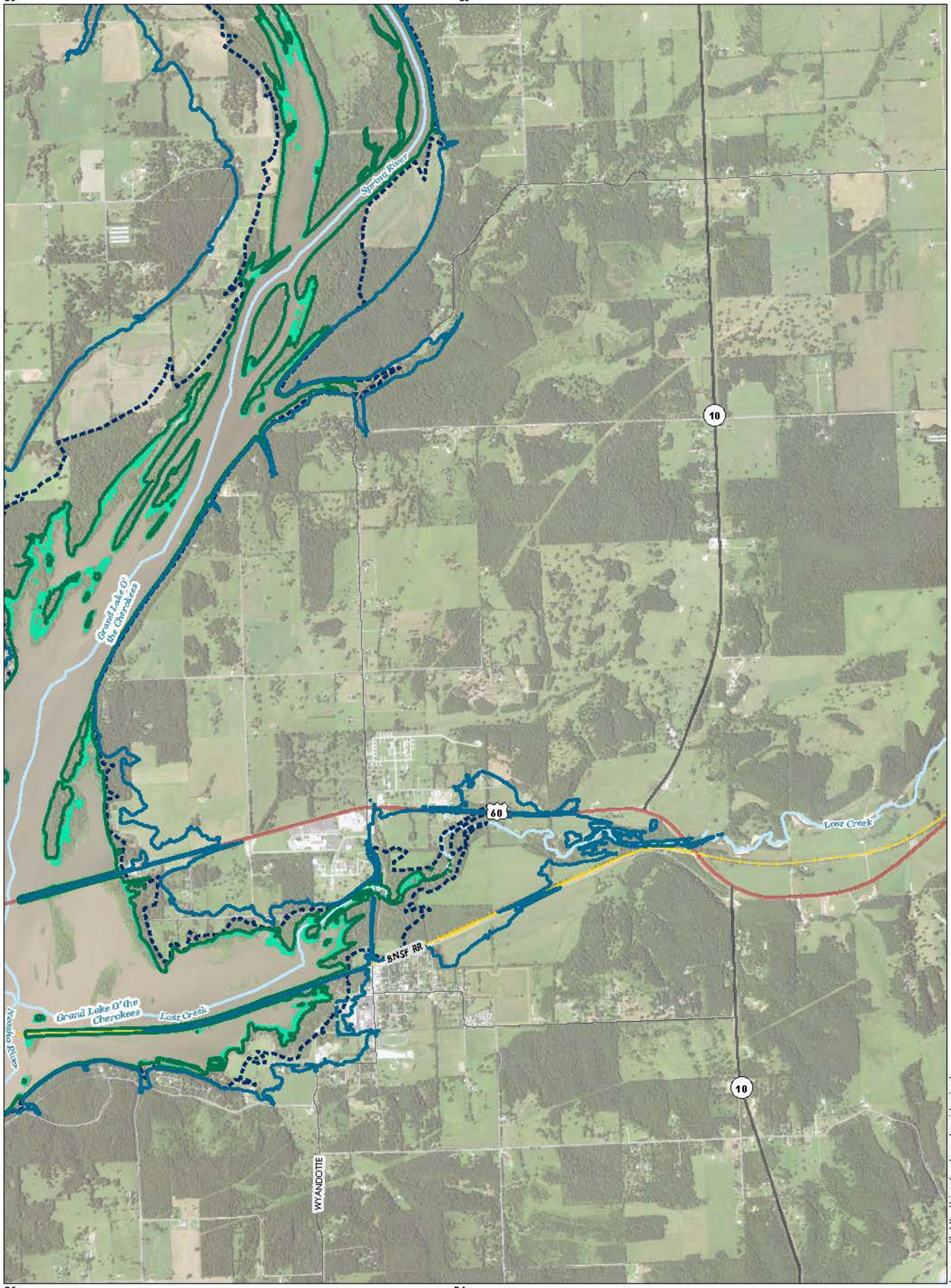
Sincerely,

Susan Mensik

Susan Mensik, Lead Administrative Trustee Representative
Tar Creek Trustee Council

# APPENDIX C – INUNDATION MAPS FROM COMPREHENSIVE HYDRAULIC MODEL



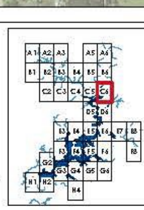



## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet



Legend

INUNDATION
- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

ROAD CLASS
- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

MAP AND LEGEND NOTES

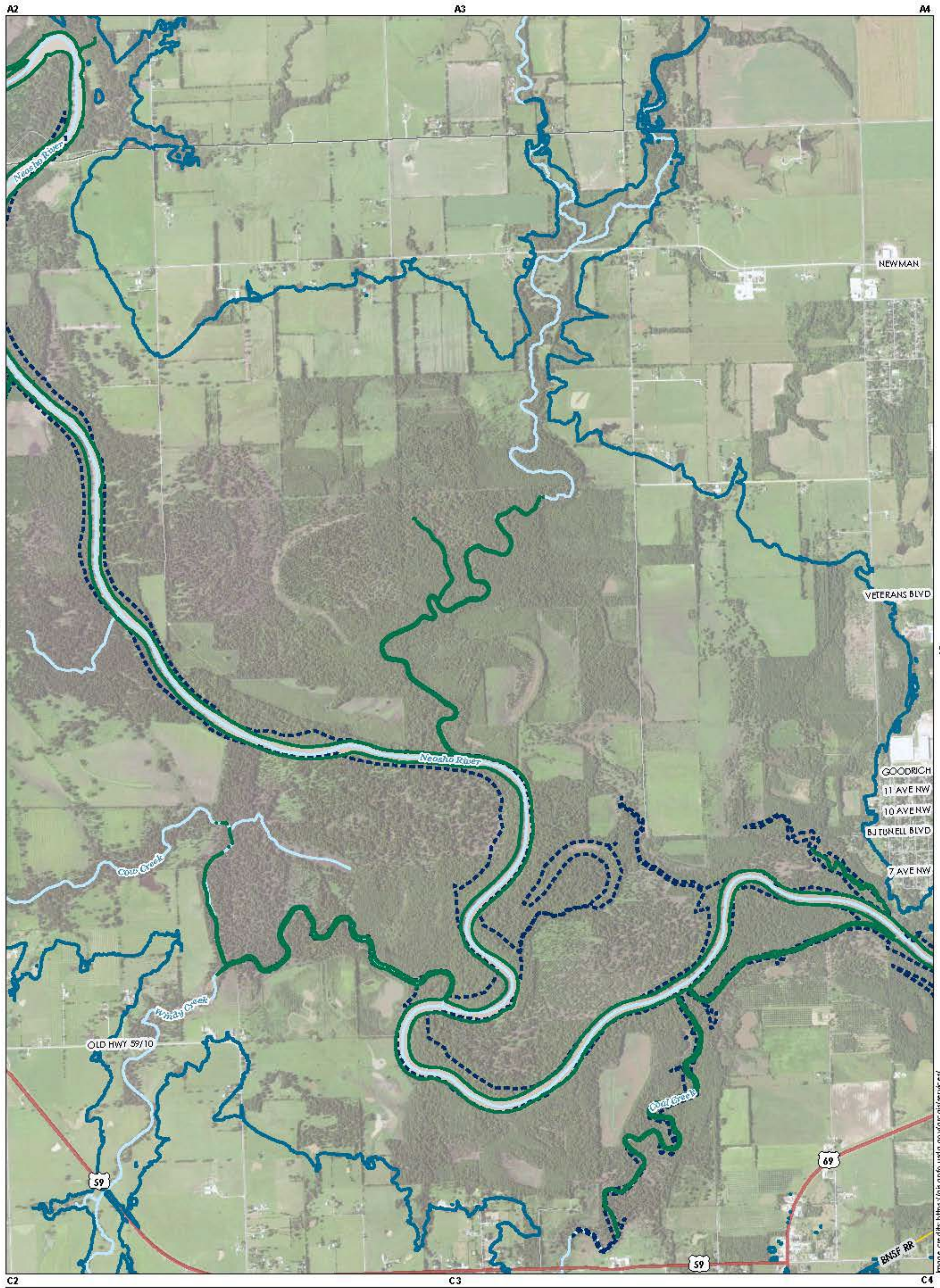
1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

**PENSACOLA DAM**
GRAND RIVER DAM AUTHORITY

**MAP: C6**

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**
September 2022




**LAKE SPAWNING SPECIES HABITAT CHANGES**

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet

Legend

INUNDATION
- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

ROAD CLASS
- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

MAP AND LEGEND NOTES

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

**PENSACOLA DAM**

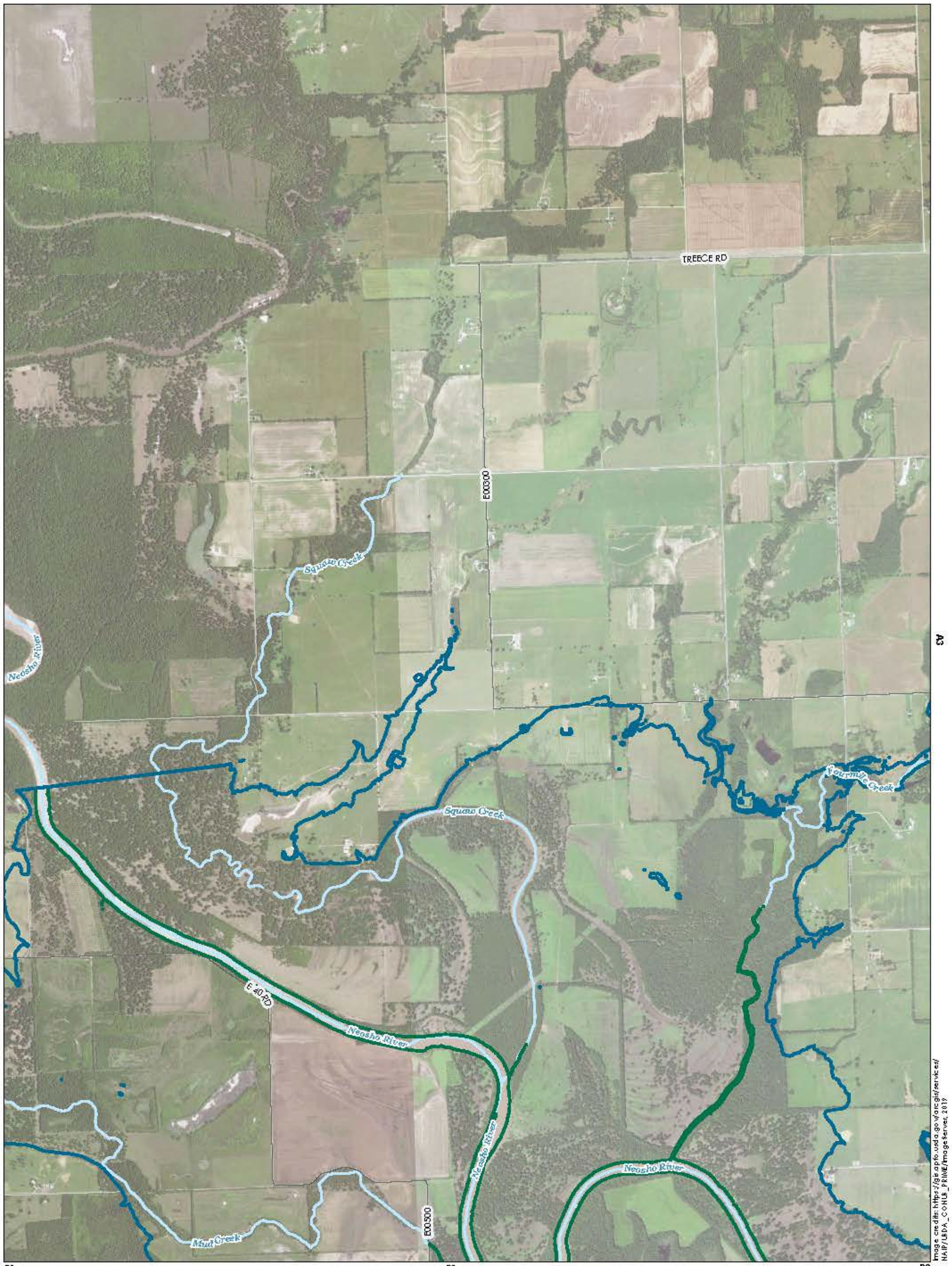
GRAND RIVER DAM AUTHORITY

**MAP: B3**

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022




# LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet

Legend

INUNDATION
- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

ROAD CLASS
- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

MAP AND LEGEND NOTES

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

## PENSACOLA DAM

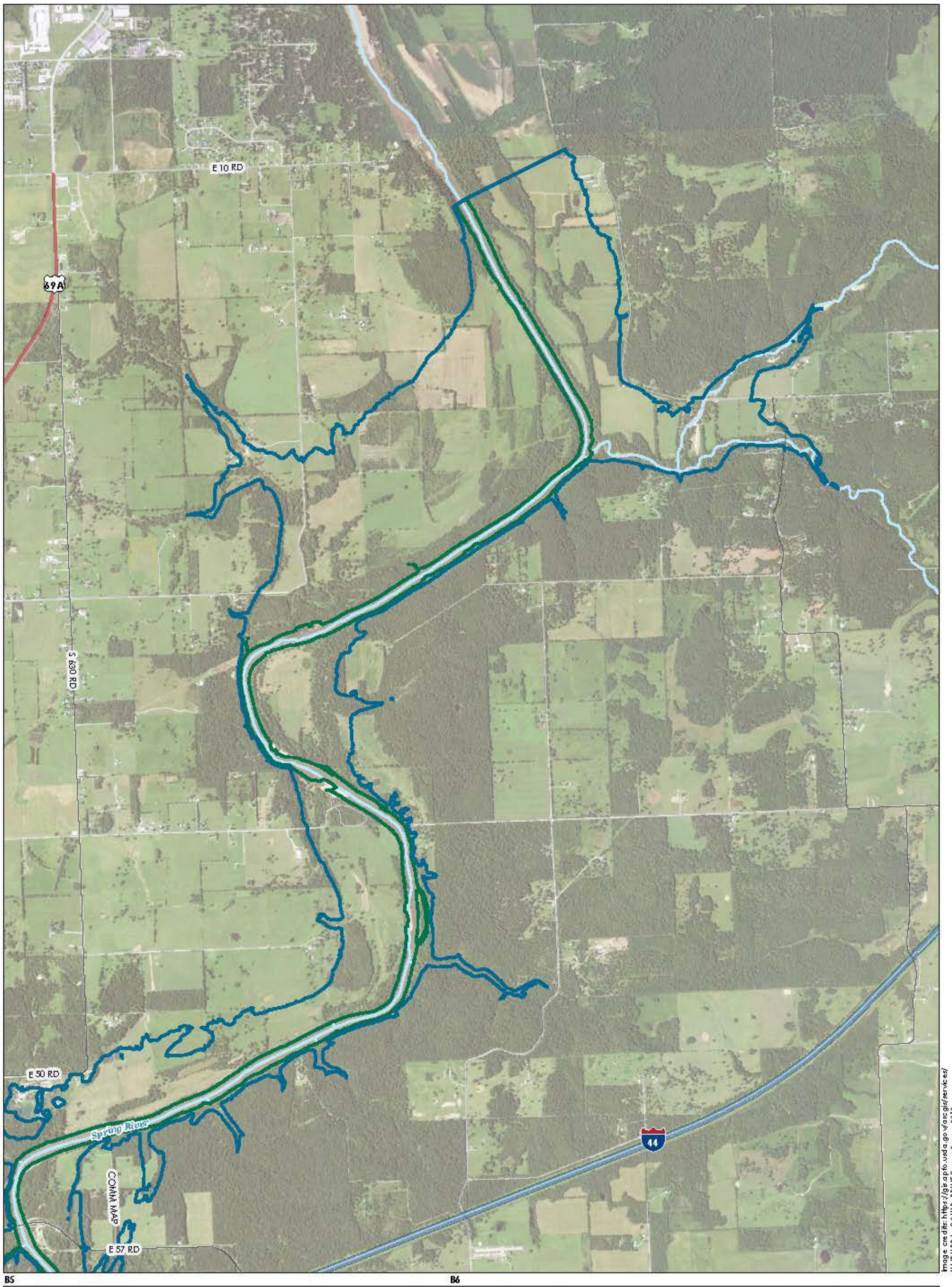
GRAND RIVER DAM AUTHORITY

## MAP: A2

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022




## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet

Legend

INUNDATION
- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

ROAD CLASS
- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

MAP AND LEGEND NOTES

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

**PENSACOLA DAM**

GRAND RIVER DAM AUTHORITY

**MAP: A6**

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

# APPENDIX D – ADDITIONAL TABLES REQUESTED IN FERC USR COMMENTS

Table D1. Water levels under baseline operations and anticipated operations using the median reservoir elevations and inflows and the numerical difference in water levels during the Neosho mucket spawning period (April through May) where potentially suitable habitat was identified during July 2022 freshwater mussel surveys.

| Site | Latitude | Longitude | RM | Water Level (ft, PD) | | Difference in water level (ft) |
|---|---|---|---|---|---|---|
| | | | | Baseline Operations | Anticipated Operations | |
| Elk 1 | 36.624261 | -94.617709 | 12.03 | 747.23 | 747.22 | -0.01 |
| Elk 3 | 36.629460 | -94.625396 | 11.41 | 746.59 | 746.58 | -0.01 |
| Elk 4 | 36.632643 | -94.628038 | 11.24 | 746.47 | 746.47 | 0.00 |
| Elk 5 | 36.634090 | -94.631332 | 11.01 | 745.44 | 745.53 | 0.09 |
| Spring 3 | 36.876963 | -94.747551 | 9.30 | 745.76 | 746.97 | 1.21 |
| Spring 4 | 36.891539 | -94.729085 | 10.94 | 747.20 | 747.78 | 0.58 |

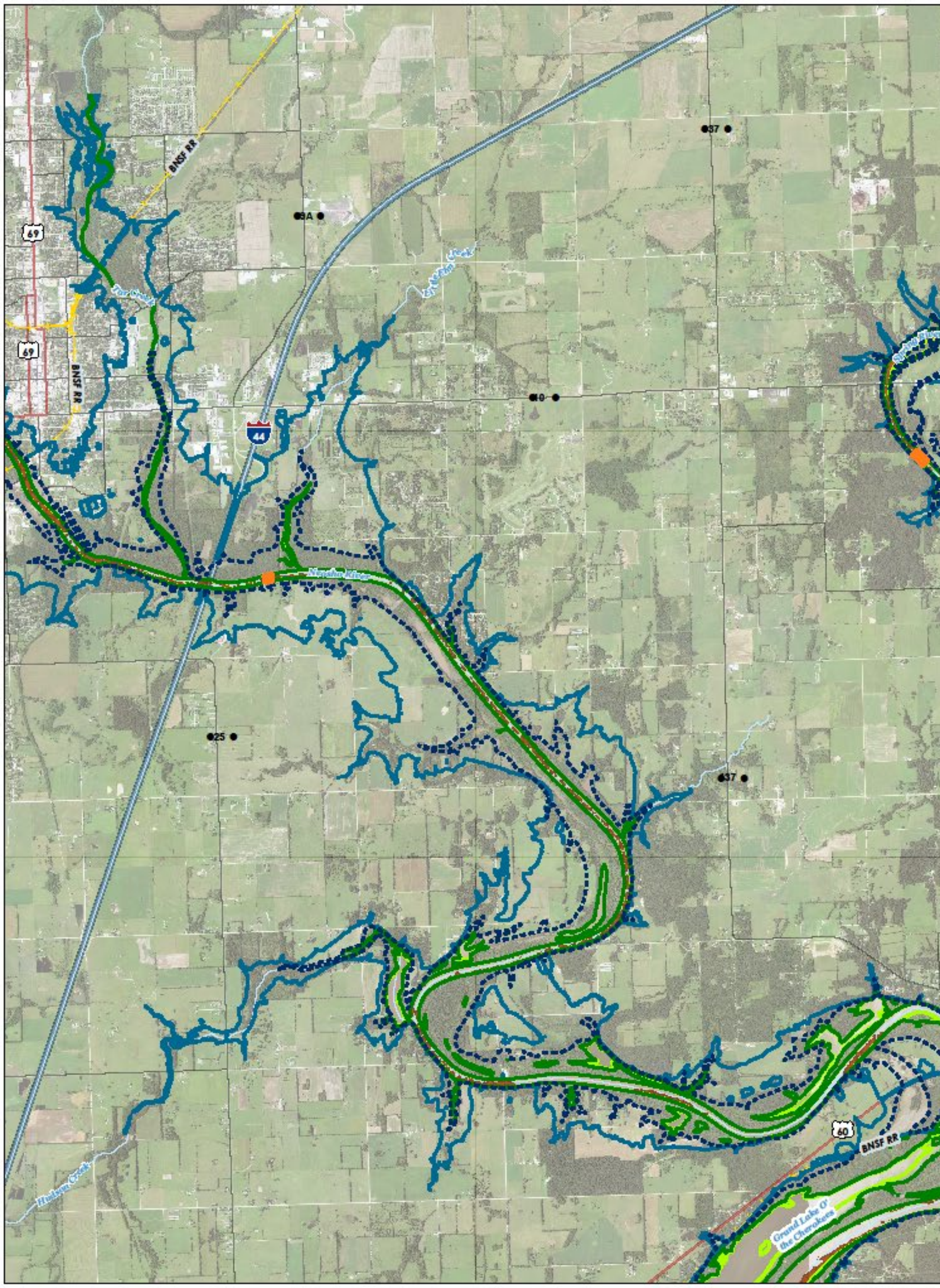
Table D2. Water levels under baseline operations and anticipated operations using the median reservoir elevations and inflows and the numerical difference in water levels during the Neosho mucket brooding period (May-August) where potentially suitable habitat was identified during July 2022 freshwater mussel surveys.

| Site | Latitude | Longitude | RM | Water Level (ft, PD) | | Difference in water level (ft) |
|---|---|---|---|---|---|---|
| | | | | Baseline Operations | Anticipated Operations | |
| Elk 1 | 36.624261 | -94.617709 | 12.03 | 745.45 | 745.44 | -0.01 |
| Elk 3 | 36.629460 | -94.625396 | 11.41 | 745.14 | 745.13 | -0.01 |
| Elk 4 | 36.632643 | -94.628038 | 11.24 | 745.08 | 745.07 | -0.01 |
| Elk 5 | 36.634090 | -94.631332 | 11.01 | 744.52 | 744.45 | -0.07 |
| Spring 3 | 36.876963 | -94.747551 | 9.30 | 746.12 | 745.98 | -0.14 |
| Spring 4 | 36.891539 | -94.729085 | 10.94 | 746.45 | 746.35 | -0.10 |

Table D3. Numerical difference between baseline and anticipated water surface elevations (May 15-July 8) at Neosho Madtom sampling locations (white) and at sites where Neosho Madtom have been historically observed within the Project Boundary (gray).

| Site | Latitude | Longitude | RM | WSE (ft, PD) | | Difference in WSE (ft) |
|---|---|---|---|---|---|---|
| | | | | Baseline Operations | Anticipated Operations | |
| Spring 1 | 36.891539 | -94.729085 | 10.94 | 747.03 | 747.44 | 0.41 |
| Spring 2 | 36.903907 | -94.72943 | 11.83 | 748.22 | 748.35 | 0.13 |
| Spring 3 | 36.912914 | -94.731908 | 12.43 | 749.44 | 749.48 | 0.04 |
| Spring 4 | 36.918637 | -94.736391 | 12.82 | 750.60 | 750.58 | -0.02 |
| Neosho 1 | 36.93597 | -94.99258 | 148.72 | 760.12 | 760.12 | 0.00 |
| Neosho 2 | 36.93336 | -94.95569 | 145.79 | 755.05 | 755.06 | 0.01 |
| Neosho 3 | 36.92761 | -94.96014 | 145.26 | 753.92 | 753.95 | 0.03 |
| Neosho 4 | 36.91657 | -94.96173 | 144.45 | 752.91 | 752.95 | 0.04 |
| Neosho 5 | 36.90761 | -94.95527 | 143.69 | 752.21 | 752.26 | 0.05 |
| Neosho 6 | 36.90008 | -94.953251 | 143.13 | 751.88 | 751.94 | 0.06 |
| Neosho 7 | 36.87222 | -94.93223 | 139.47 | 748.78 | 748.95 | 0.17 |
| NOPL - 79312,75490,67425 | 36.928600 | -94.957200 | 145.46 | 754.21 | 754.23 | 0.02 |
| NOPL - ONHI | 36.894996 | -94.948681 | 142.70 | 751.61 | 751.67 | 0.06 |
| OWRB | 36.834965 | -94.814289 | 130.87 | 744.73 | 745.27 | 0.54 |

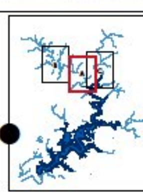
# APPENDIX E – MAPS EVALUATING CHANGES TO PADDLEFISH SPAWNING HABITAT




**PADDLEFISH SPAWNING SEASON LENTIC CONVERSION AREAS**

0 1,250 2,500 5,000 Feet

1 inch = 3,500 feet



Legend

**INUNDATION**

- Maximum Inundation
- Inundated Area During Paddlefish Spawning Season, Anticipated Operations
- Inundated Area During Paddlefish Spawning Season, Baseline Operations

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Railroad

- Stream
- Project Boundary (2014)
- Paddlefish Spawning Habitat
- Converted Spawning Habitat

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model.
2. Estimated inundation extent for normal (median) inflows and operations during the paddlefish spawning season (March 1 to April 30).

**PENSACOLA DAM**

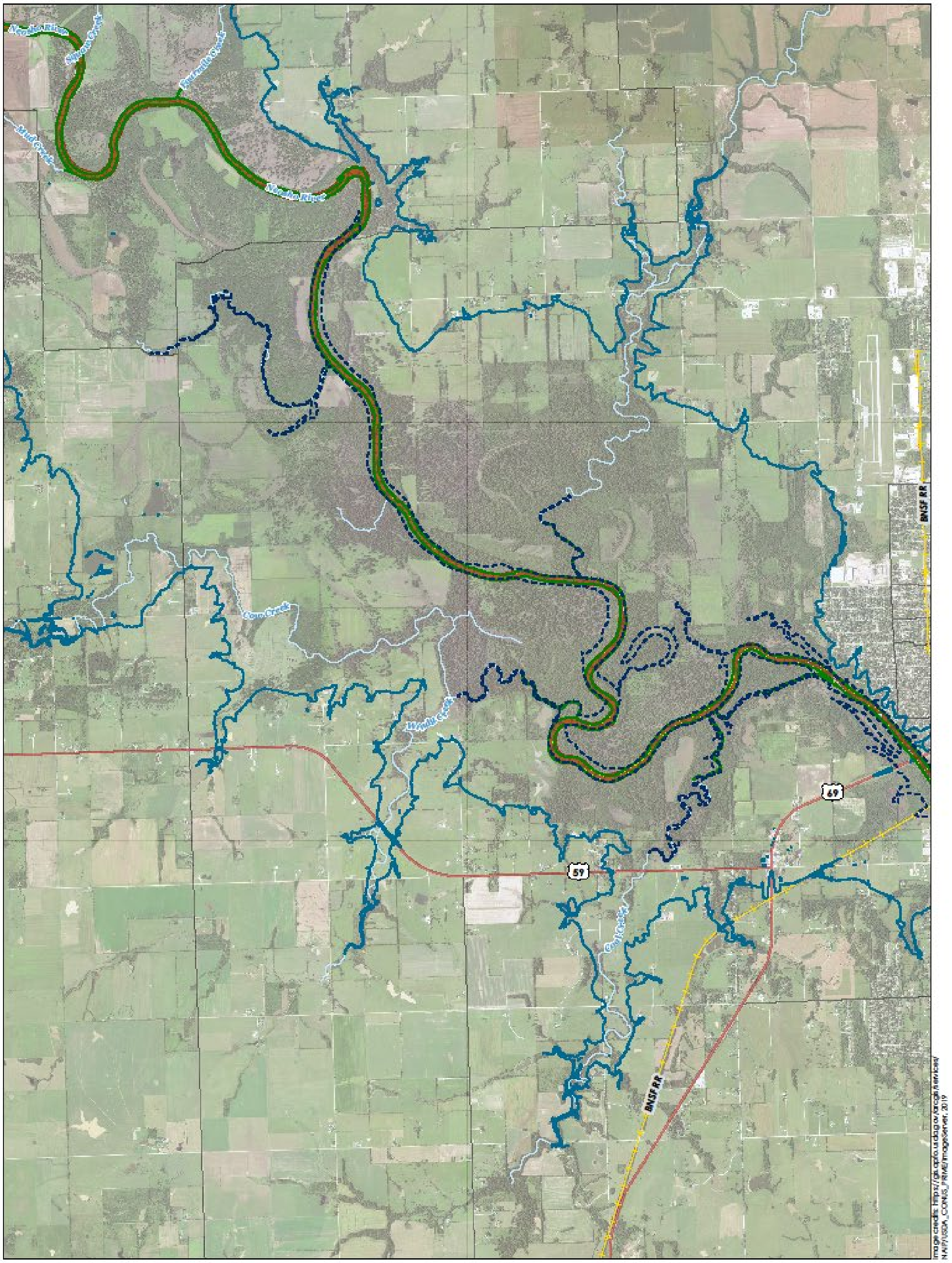
GRAND RIVER DAM AUTHORITY

**MAP A**

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

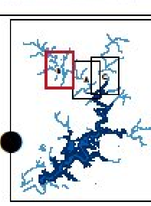
December 2022




## PADDLEFISH SPAWNING SEASON LENTIC CONVERSION AREAS

0 1,250 2,500 5,000 Feet

1 inch = 3,500 feet



**Legend**

**INUNDATION**
- Maximum Inundation
- Inundated Area During Paddlefish Spawning Season, Anticipated Operations
- Inundated Area During Paddlefish Spawning Season, Baseline Operations

**ROAD CLASS**
- Interstate
- State Highway
- US Highway
- Major Collector
- Railroad

- Stream
- Project Boundary (2014)
- Paddlefish Spawning Habitat
- Converted Spawning Habitat

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model.
2. Estimated inundation extent for normal (median) inflows and operations during the paddlefish spawning season (March 1 to April 30).

## PENSACOLA DAM

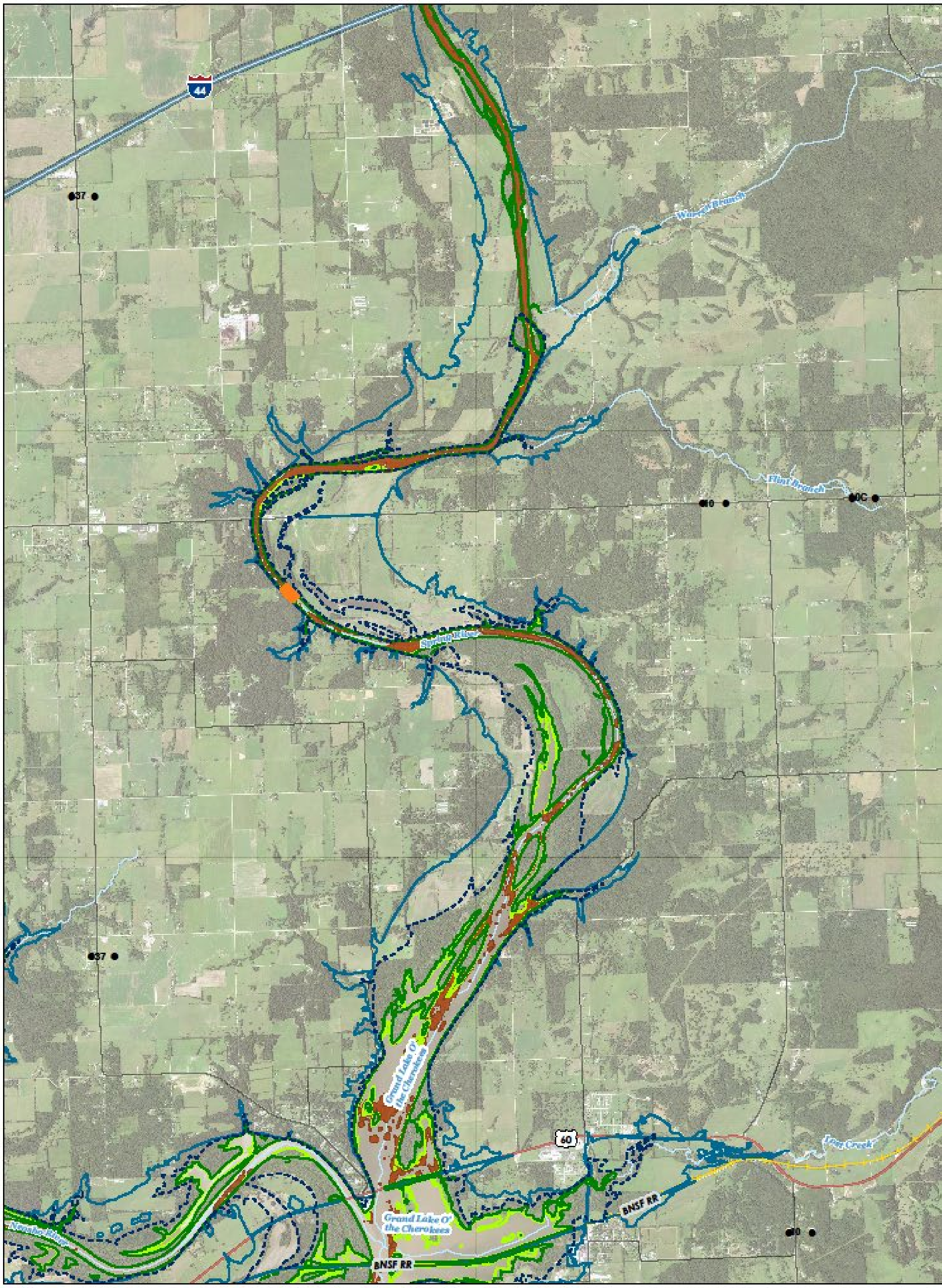
GRAND RIVER DAM AUTHORITY

## MAP B

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

FERC No. 1494

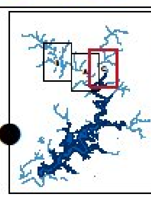
December 2022




**PADDLEFISH SPAWNING SEASON LENTIC CONVERSION AREAS**

0 1,250 2,500 5,000 Feet

1 inch = 3,500 feet



Legend

**INUNDATION**

- Maximum Inundation
- Inundated Area During Paddlefish Spawning Season, Anticipated Operations
- Inundated Area During Paddlefish Spawning Season, Baseline Operations

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Railroad

- Stream
- Project Boundary (2014)
- Paddlefish Spawning Habitat
- Converted Spawning Habitat

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model.
2. Estimated inundation extent for normal (median) inflows and operations during the paddlefish spawning season (March 1 to April 30).

**PENSACOLA DAM**

GRAND RIVER DAM AUTHORITY

**MAP C**

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

December 2022

# PENSACOLA HYDROELECTIC PROJECT: AQUATIC SPECIES OF CONCERN STUDY

Revised December 2022

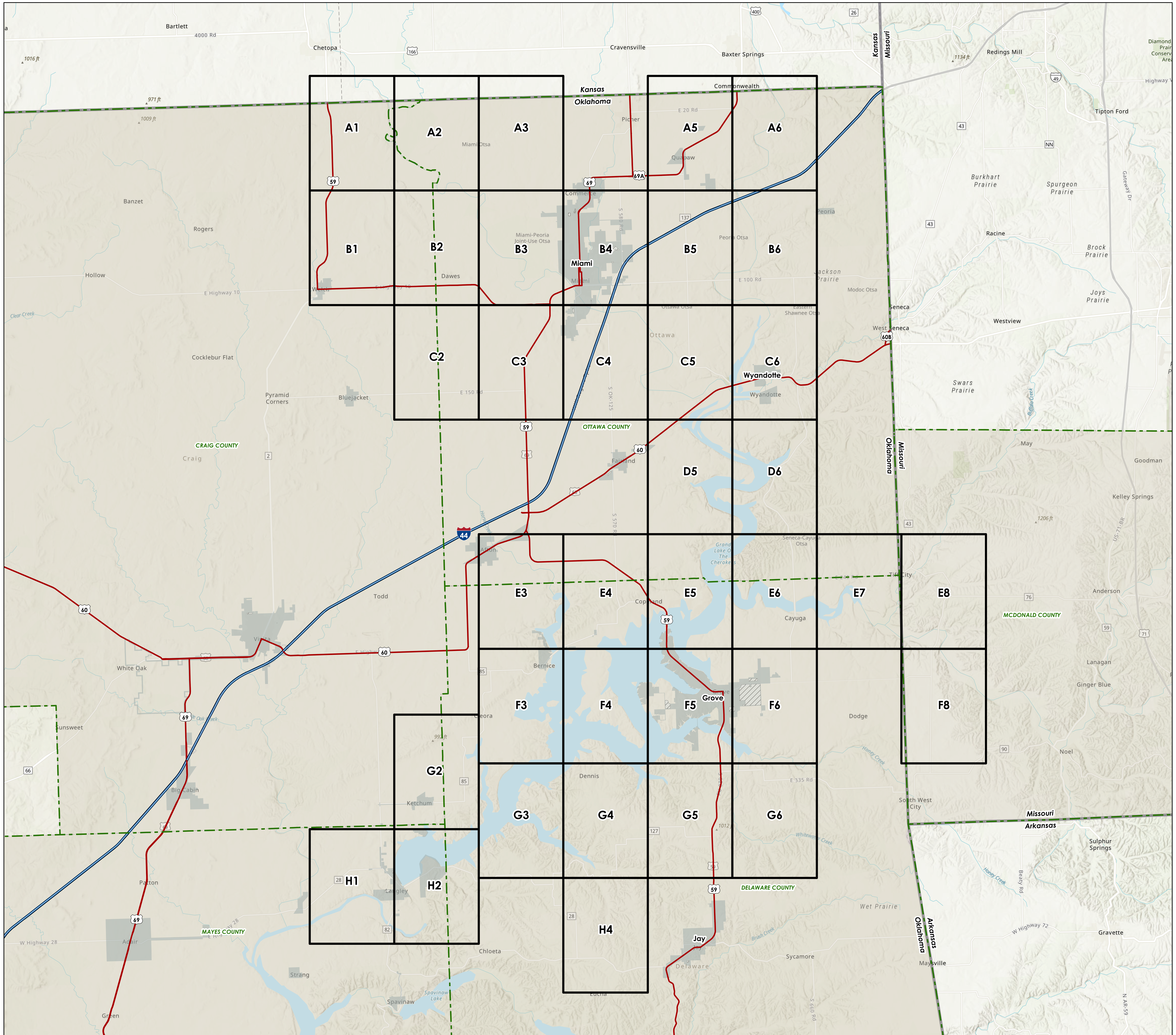
## APPENDIX E-13 Lake Spawning Habitat Changes Maps

# Lake Spawning Species Habitat Changes Overview Map

## Pensacola Dam

GRAND RIVER DAM AUTHORITY

September 2022




### Overview Map Legend

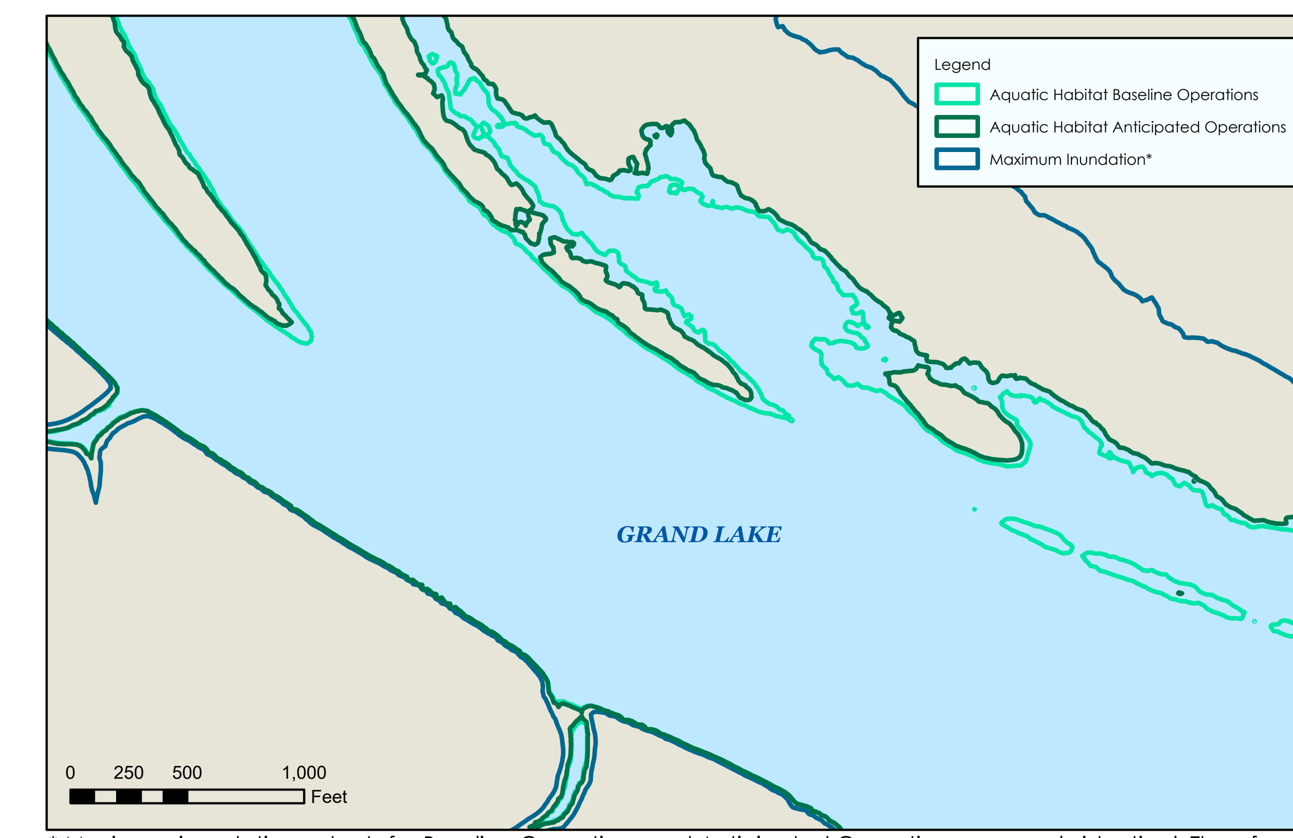
- 1:24,000-scale Map Sheet
- State Boundary
- County Boundary
- Municipality
- Unincorporated

**Road Class**

- Interstate
- US Highway

### Lake Spawning Habitat Mapping Explanation

Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. Estimated inundation extent for normal (median) inflows and operations during the spawning season.




* Maximum inundation extents for Baseline Operations and Anticipated Operations are nearly identical. Therefore, the Maximum inundation extent shown represents both conditions. Maximum inundation extent occurs when USACE is in flood control.

**Disclaimer: These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**

0 1.25 2.5 5 7.5 10 Miles

NORTH

**Map Notes**

Data Sources for Maps:

1. Base map images from https://gis.apfo.usda.gov/arcgis/services/NAIP/USDA_CONUS_PRIME/ImageServer, 2019
2. Transportation network (major roads, local roads, and railroads) and county boundaries obtained from the Oklahoma Office of Geographic Information (http://okmaps.org/ogi/search.aspx).

Map Source: Missouri Dept. of Conservation, Missouri DNR, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, NPS, USDA, Esri, NASA, NGA, USGS

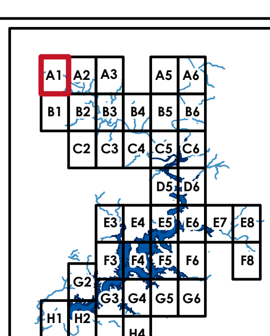

Image credits: https://gis.apfo.usda.gov/arcgis/services/NAIP/USDA_CONUS_PRIME/ImageServer, 2019

## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

GRAND RIVER DAM AUTHORITY

## MAP: A1

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

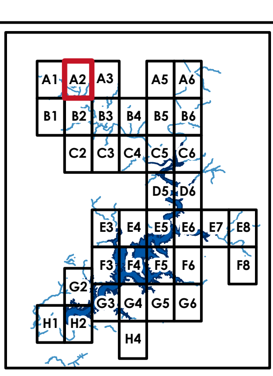
September 2022


## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

GRAND RIVER DAM AUTHORITY

## MAP: A2

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

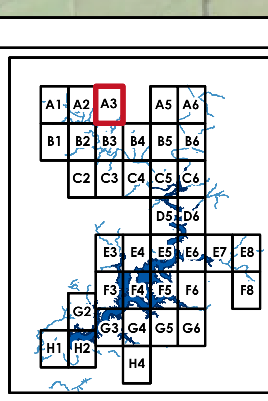
September 2022


## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

## PENSACOLA DAM

GRAND RIVER DAM AUTHORITY

## MAP: A3

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

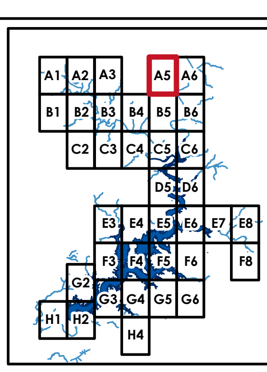
September 2022


## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

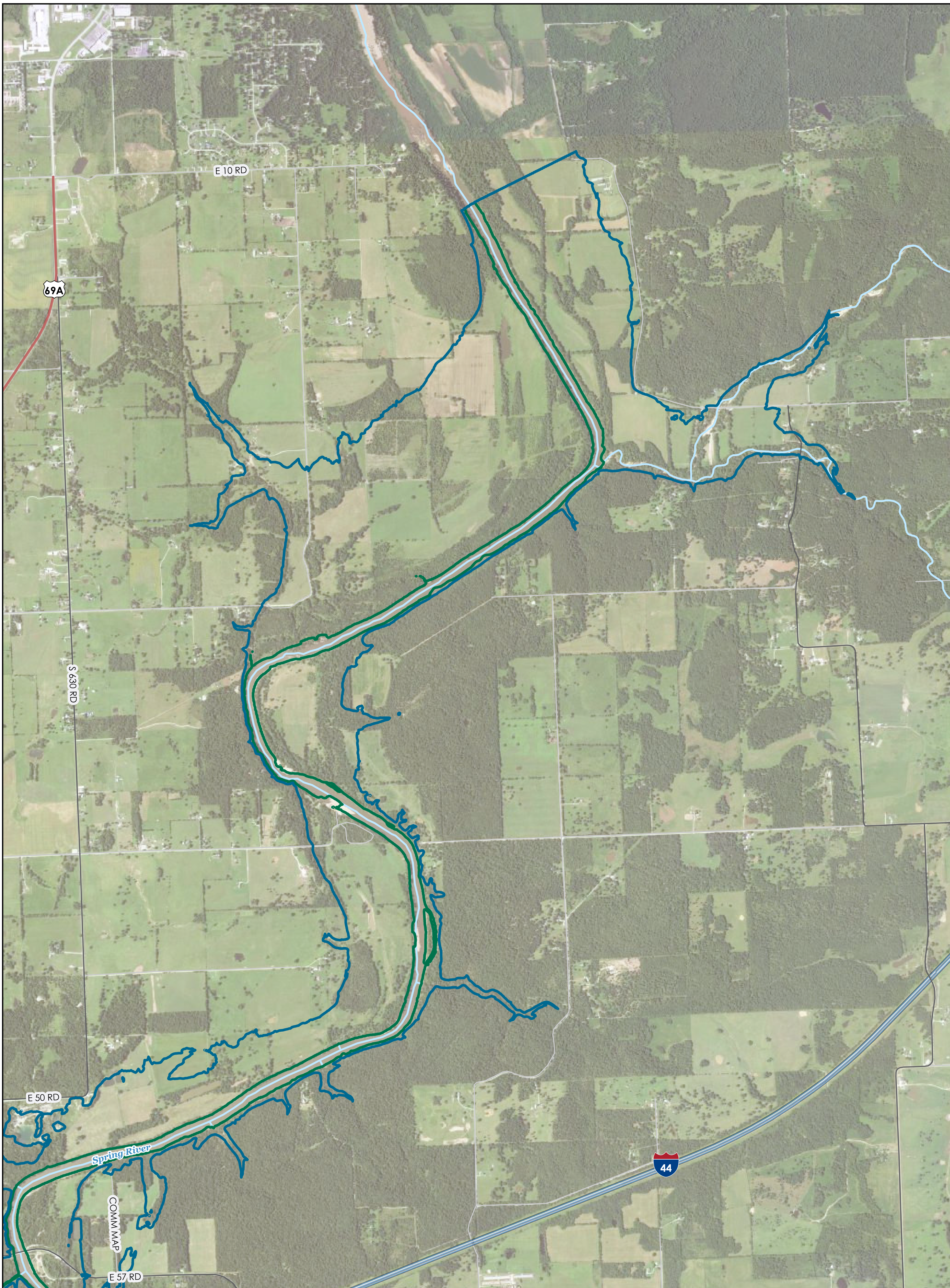
GRAND RIVER DAM AUTHORITY

## MAP: A5

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

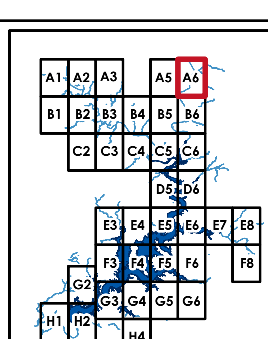



## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

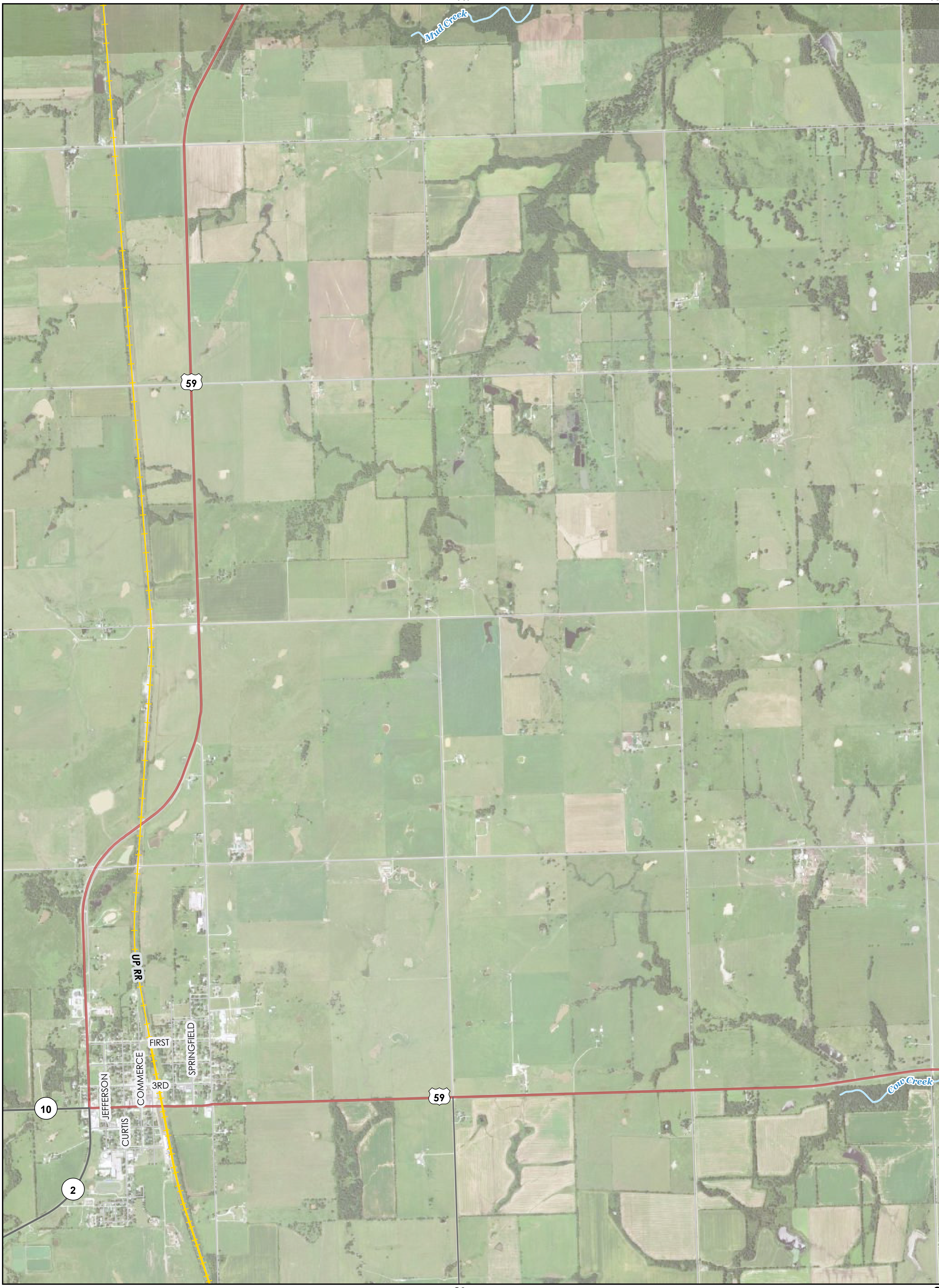
GRAND RIVER DAM AUTHORITY

## MAP: A6

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

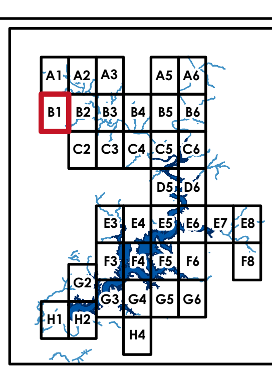



**LAKE SPAWNING SPECIES HABITAT CHANGES**

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

**PENSACOLA DAM**

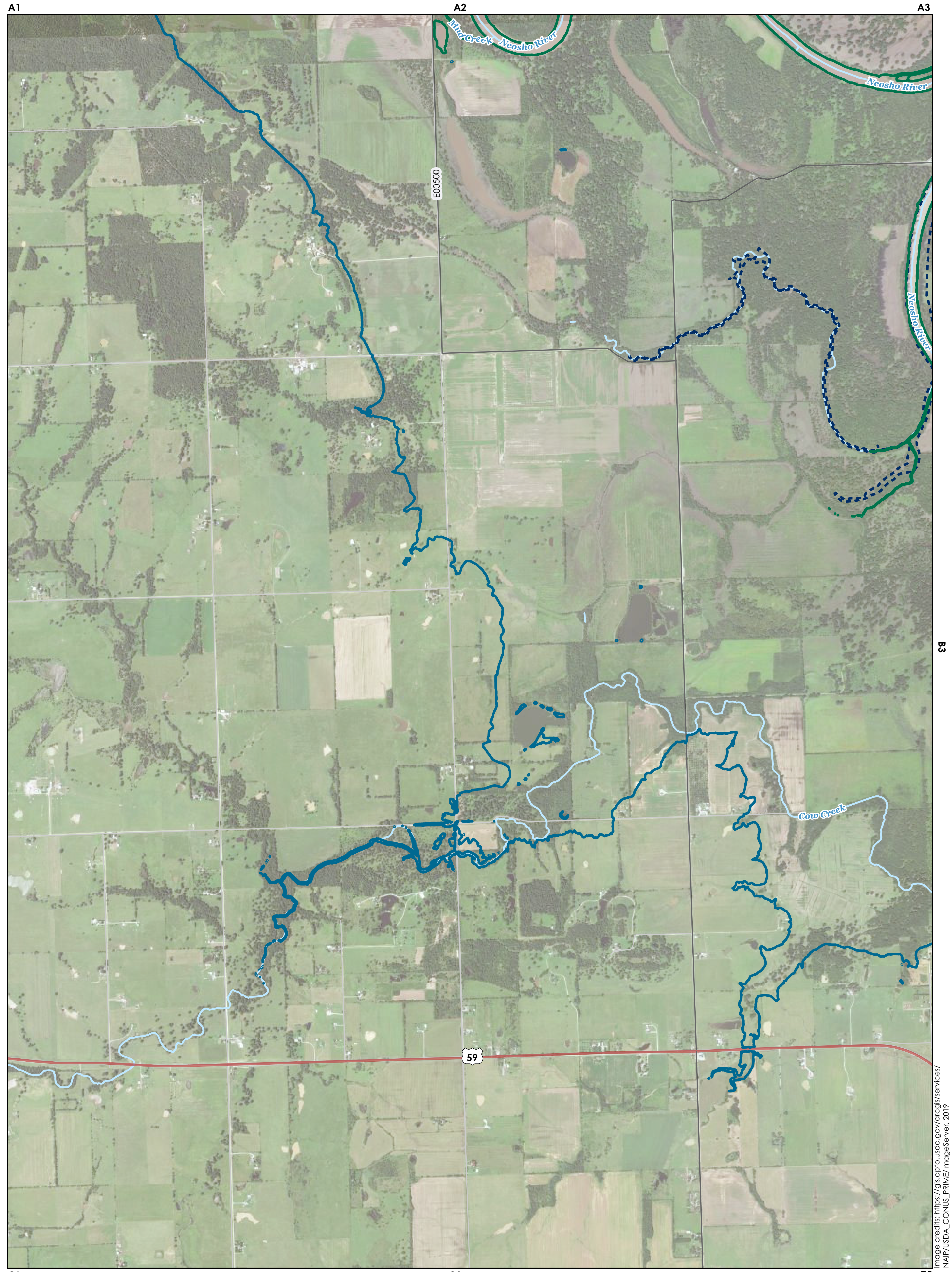
GRAND RIVER DAM AUTHORITY

**MAP: B1**

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

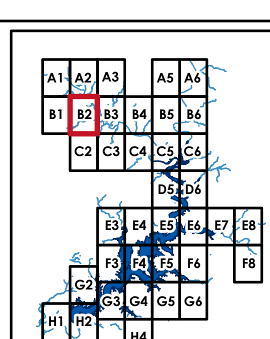



## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

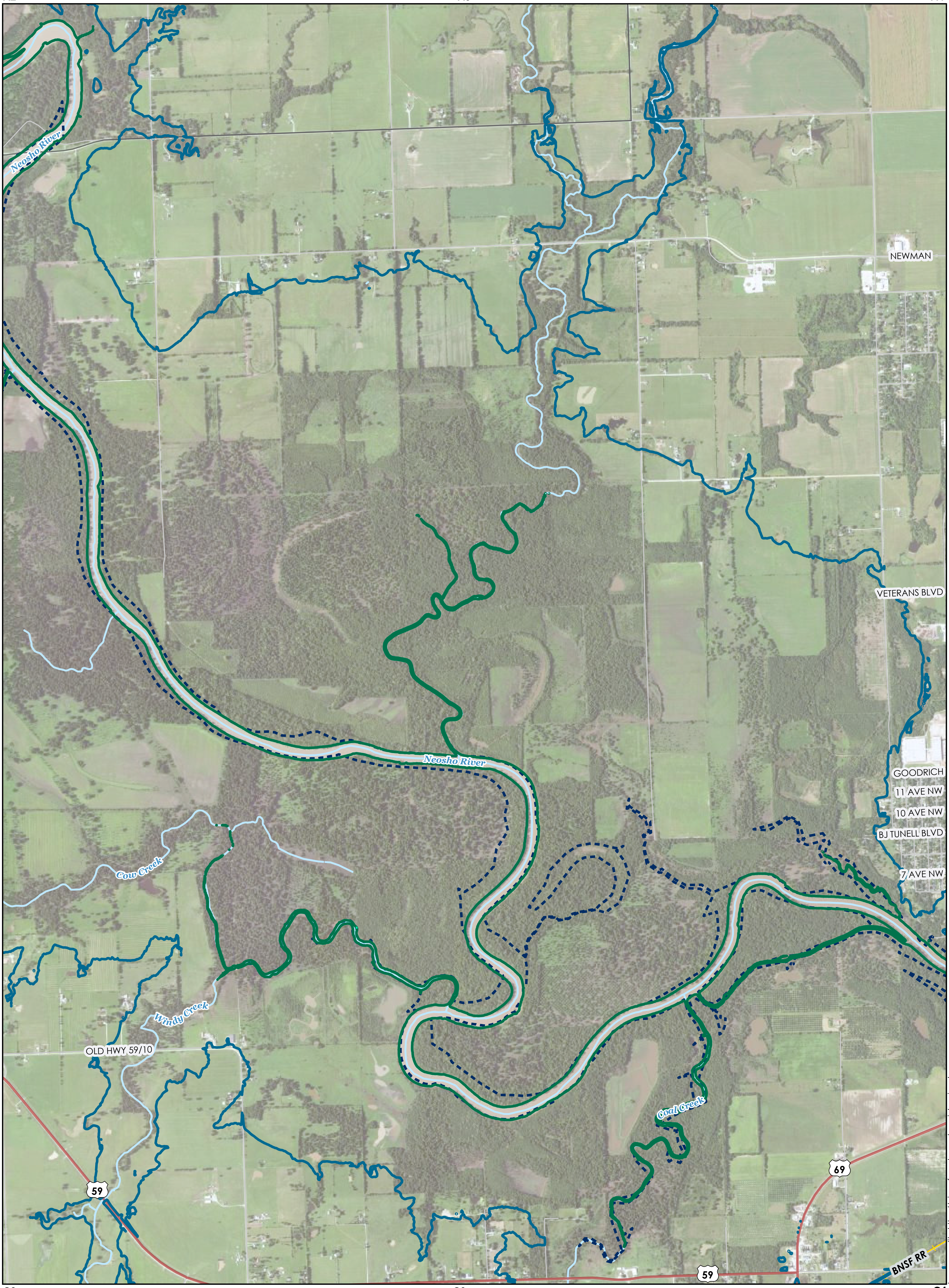
GRAND RIVER DAM AUTHORITY

## MAP: B2

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

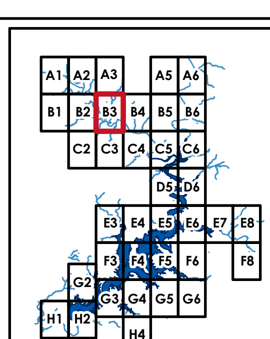



## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

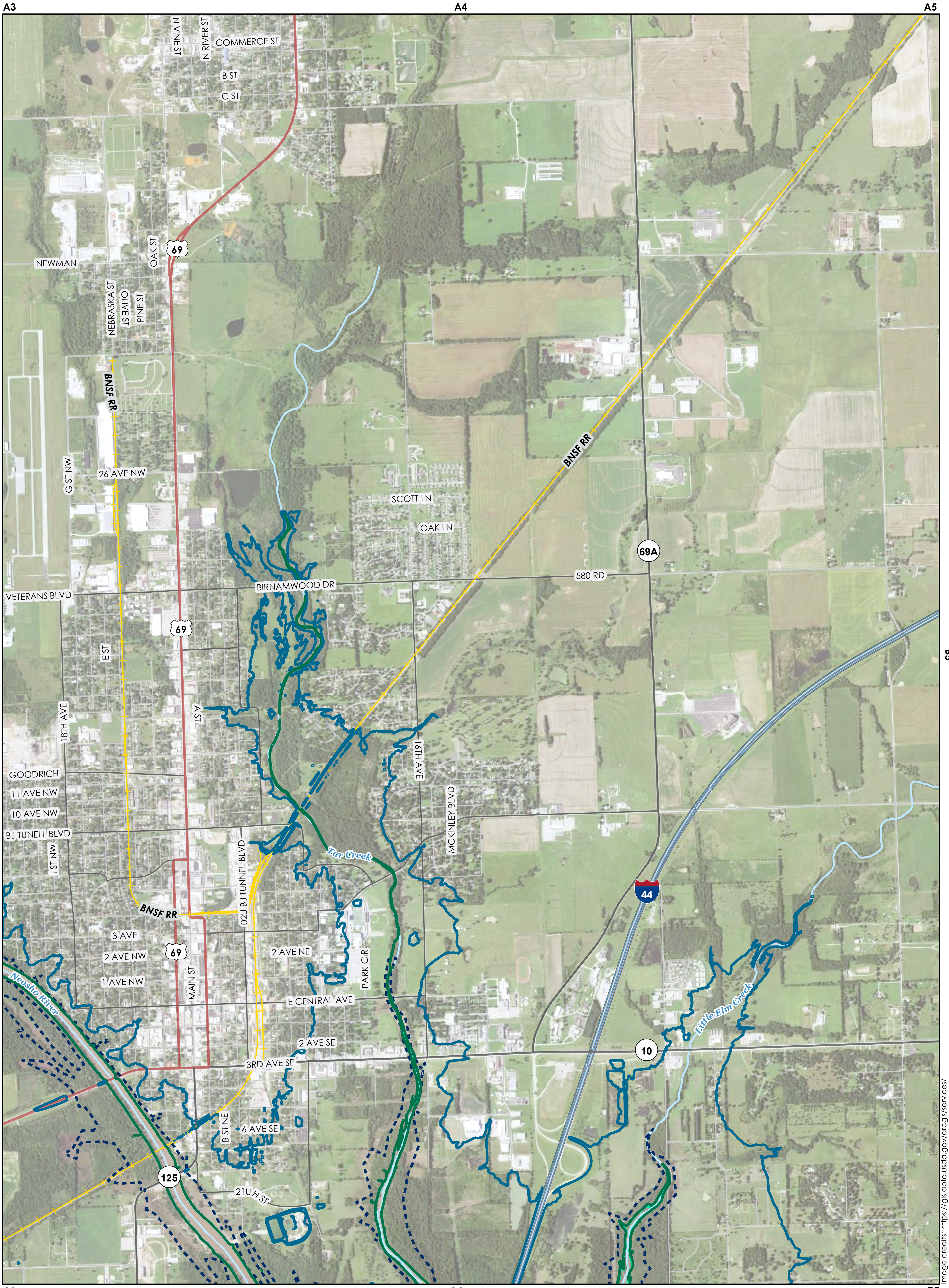
GRAND RIVER DAM AUTHORITY

## MAP: B3

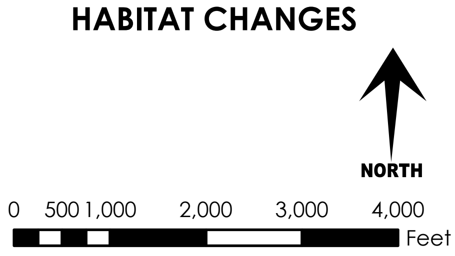
CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

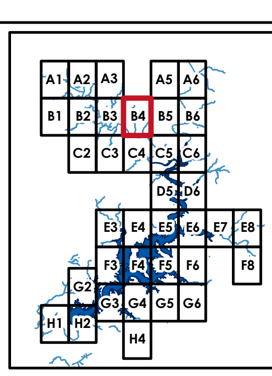
**FERC No. 1494**

September 2022




## LAKE SPAWNING SPECIES HABITAT CHANGES




Legend

**INUNDATION**
- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**
- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

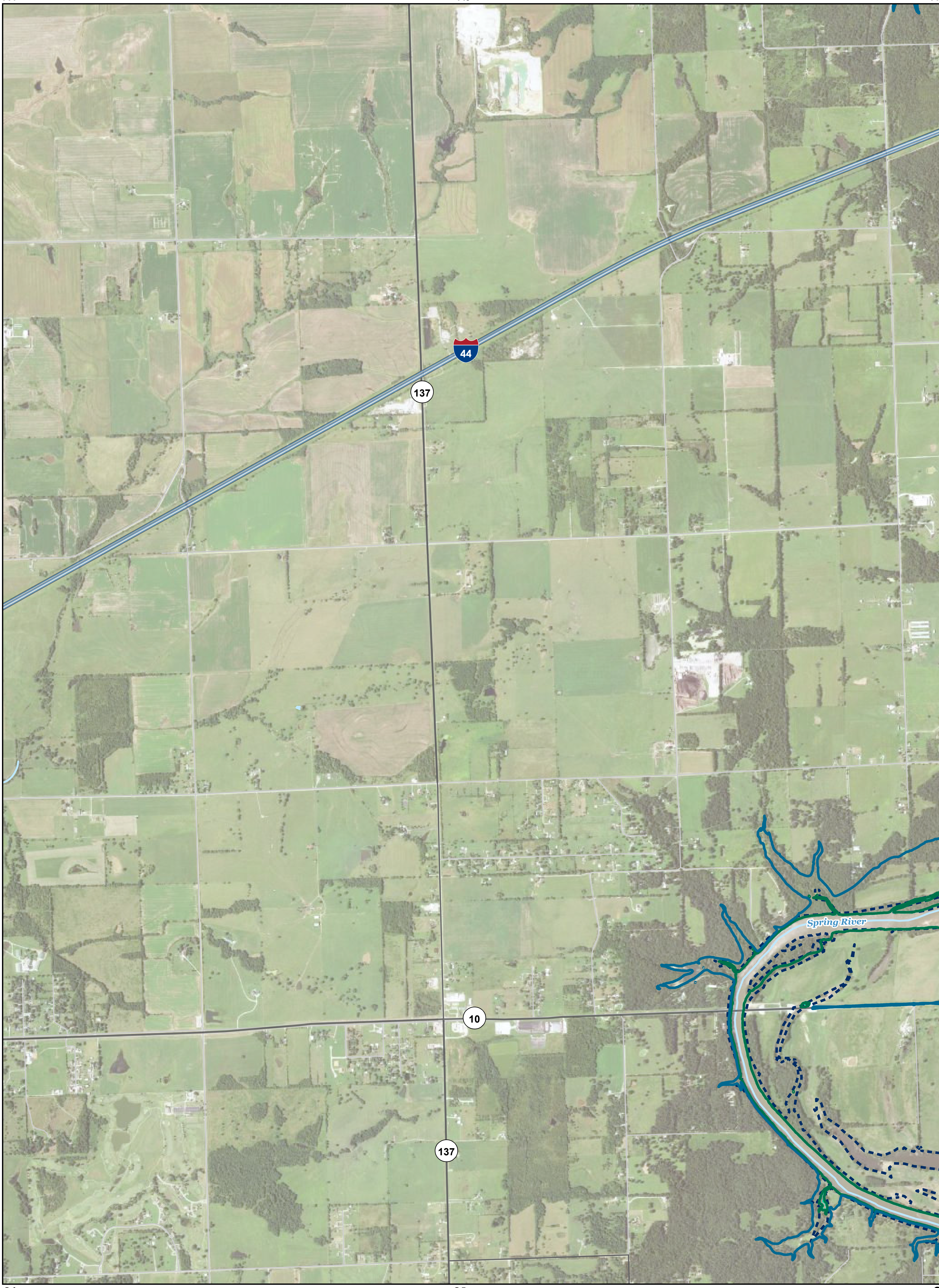
1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as stand-alone resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM
GRAND RIVER DAM AUTHORITY

## MAP: B4

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**
September 2022

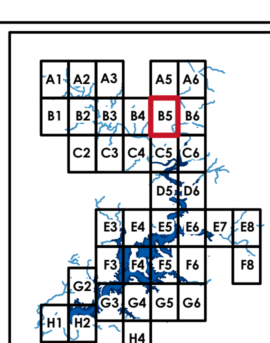



**LAKE SPAWNING SPECIES HABITAT CHANGES**

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**
- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**
- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

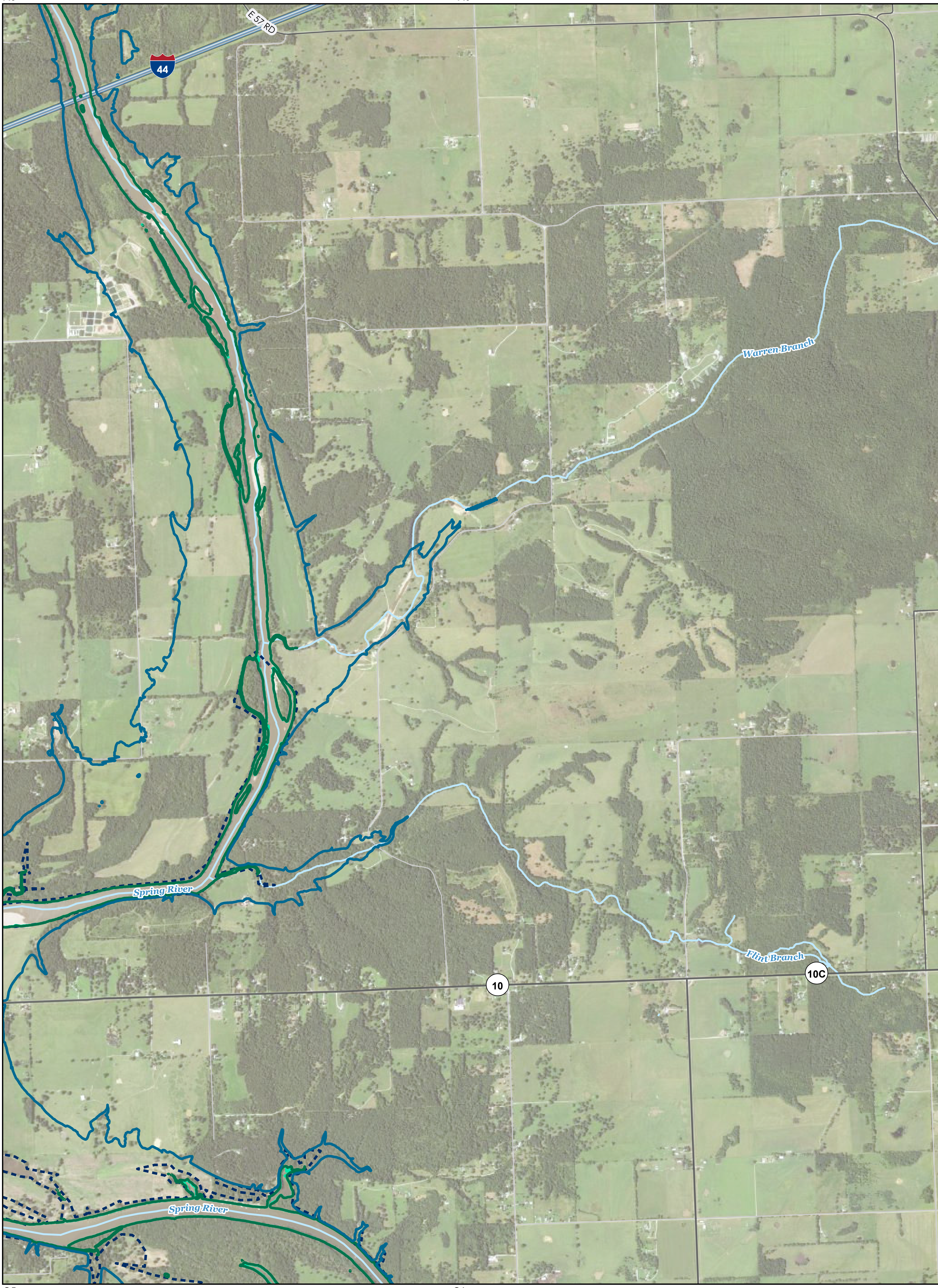
**PENSACOLA DAM**
GRAND RIVER DAM AUTHORITY

**MAP: B5**

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**
September 2022

A5 A6




B5

C5 C6

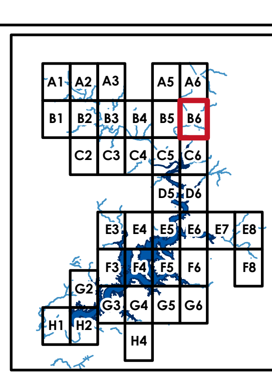
Image credits: https://gis.apfo.usda.gov/arcgis/services/NAIP/USDA_CONUS_PRIME/ImageServer, 2019

**LAKE SPAWNING SPECIES HABITAT CHANGES**

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

**PENSACOLA DAM**

GRAND RIVER DAM AUTHORITY

**MAP: B6**

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

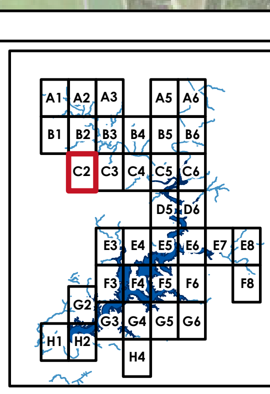
September 2022


## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

GRAND RIVER DAM AUTHORITY

## MAP: C2

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

B2 B3 B4

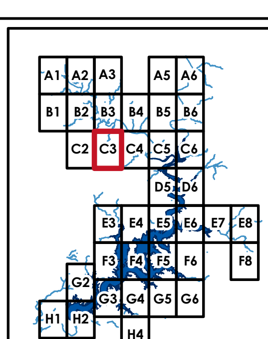

D2 D3 D4

## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

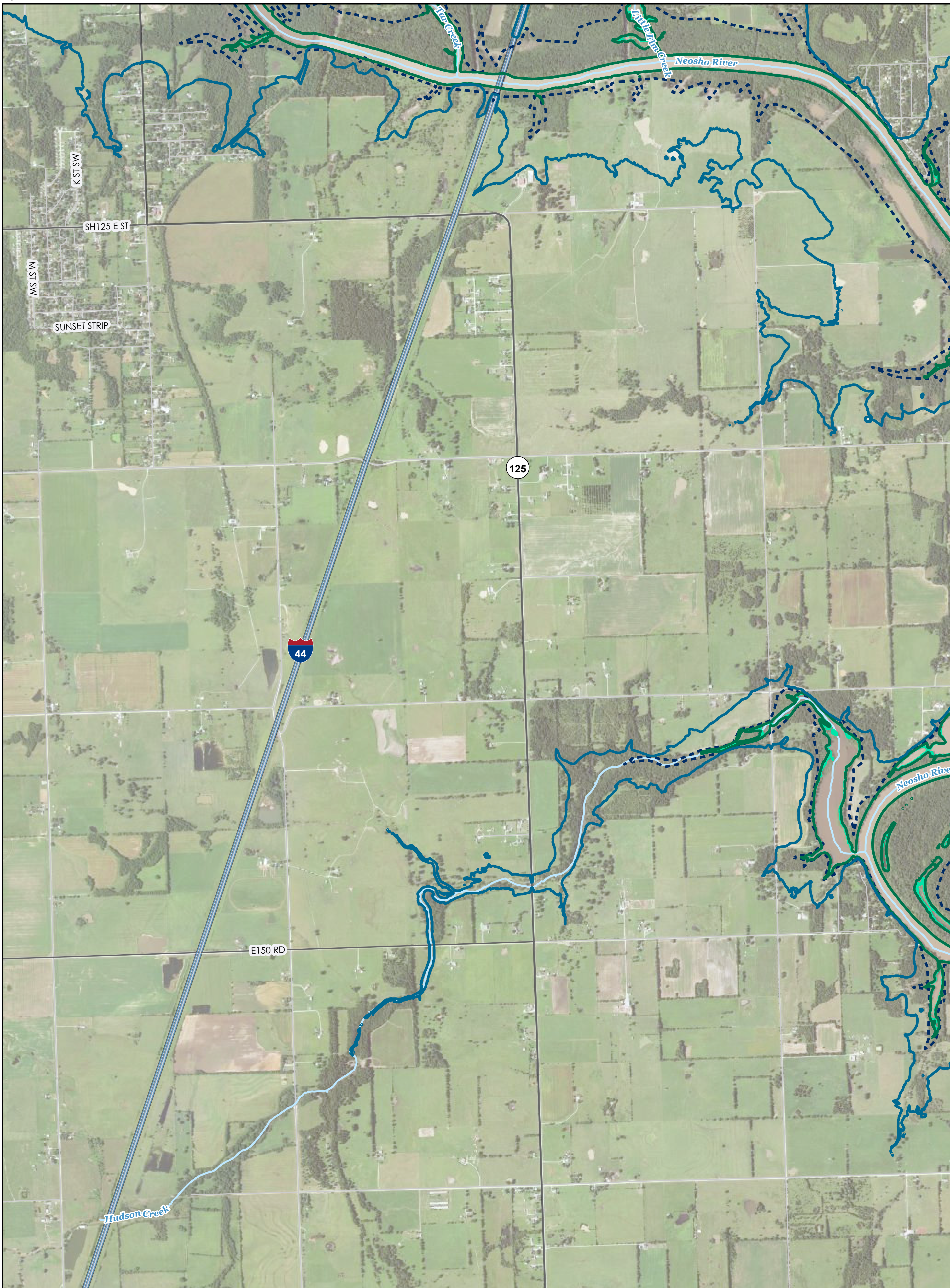
GRAND RIVER DAM AUTHORITY

## MAP: C3

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

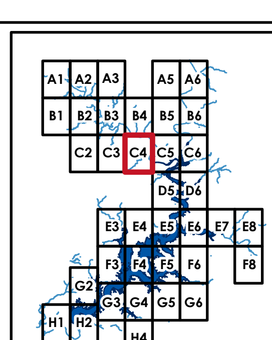



## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector

- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

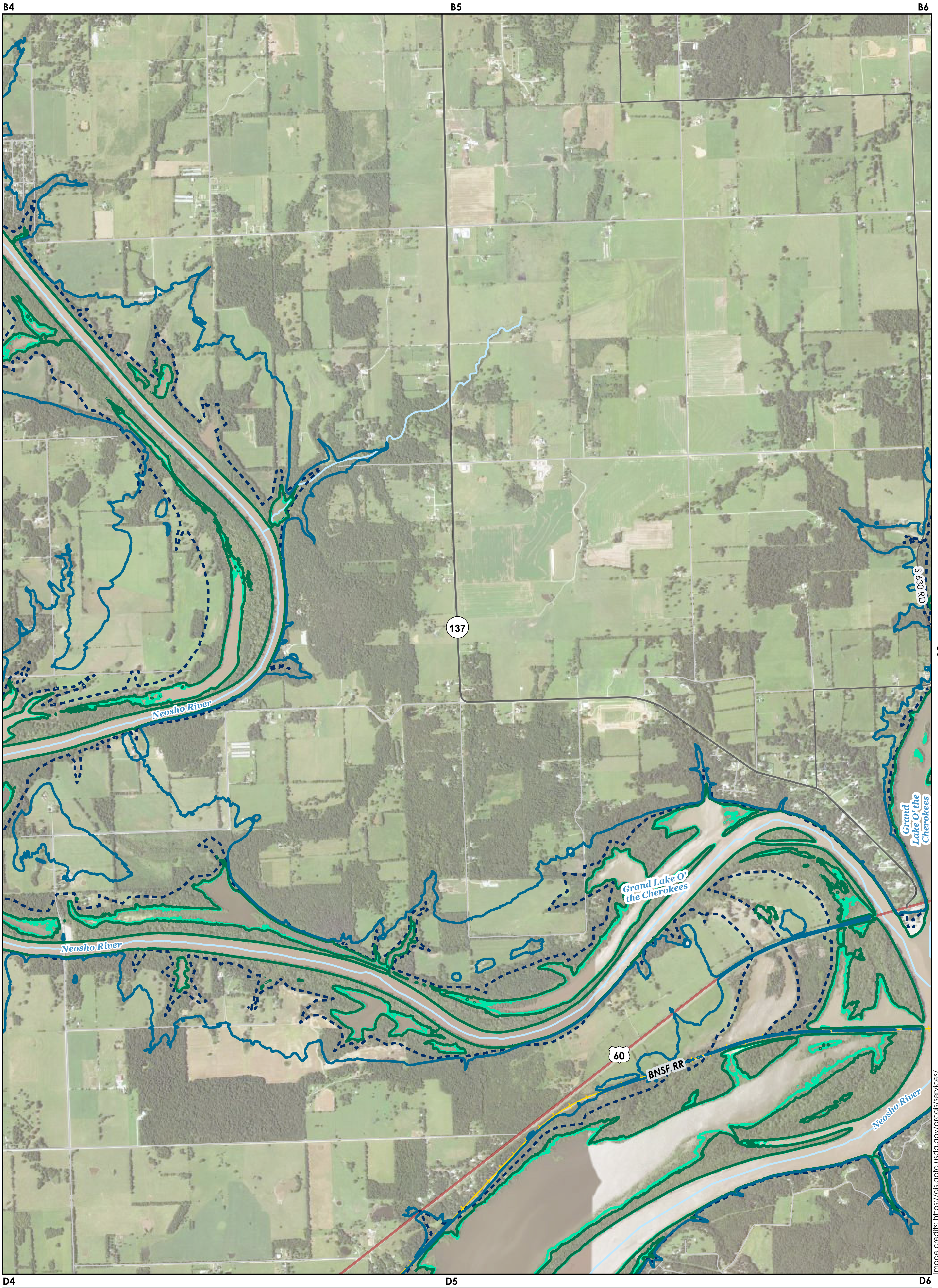
GRAND RIVER DAM AUTHORITY

## MAP: C4

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022




## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet

Legend

**INUNDATION**
- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**
- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

## PENSACOLA DAM

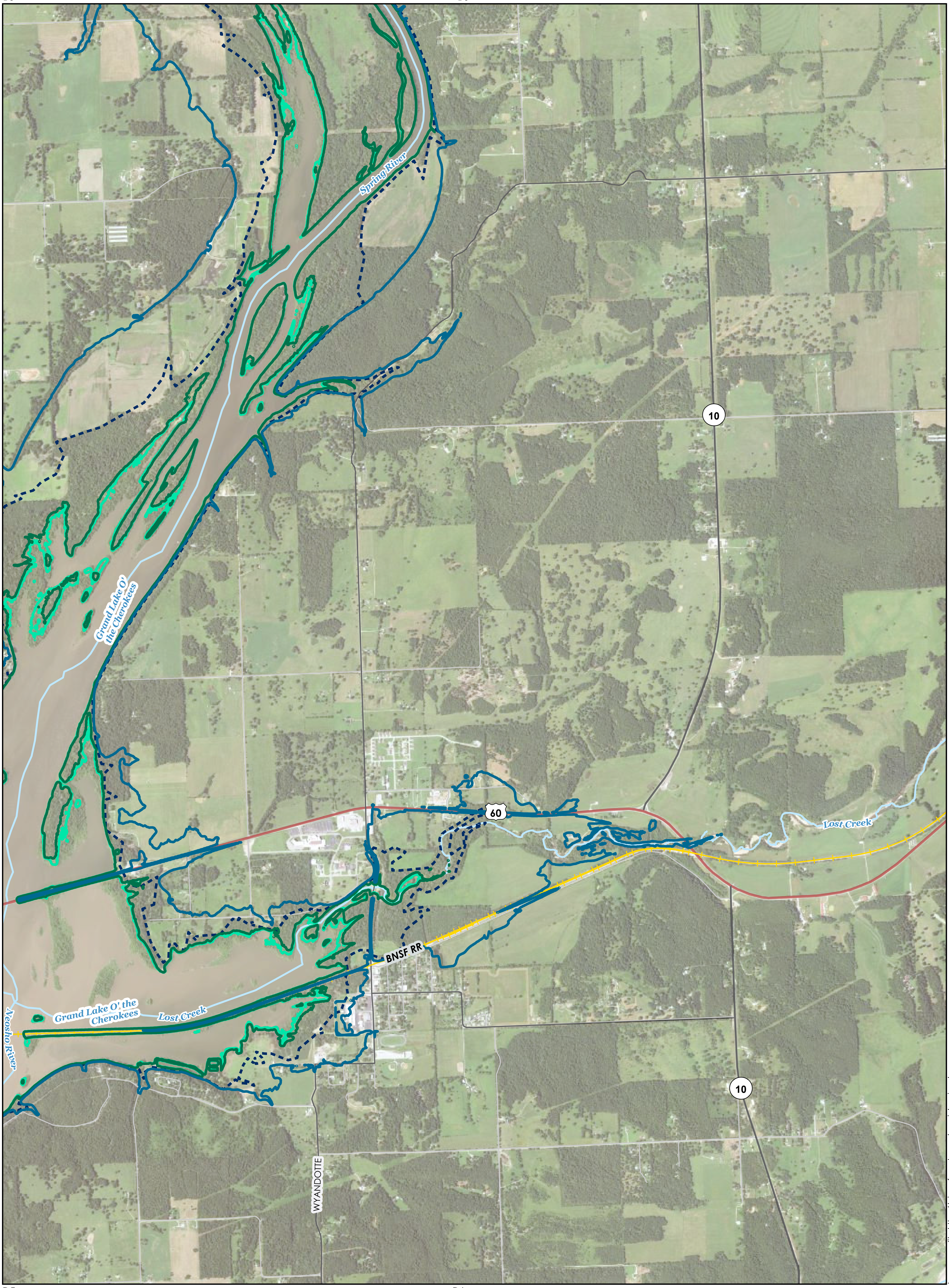
GRAND RIVER DAM AUTHORITY

## MAP: C5

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022




## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet

Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

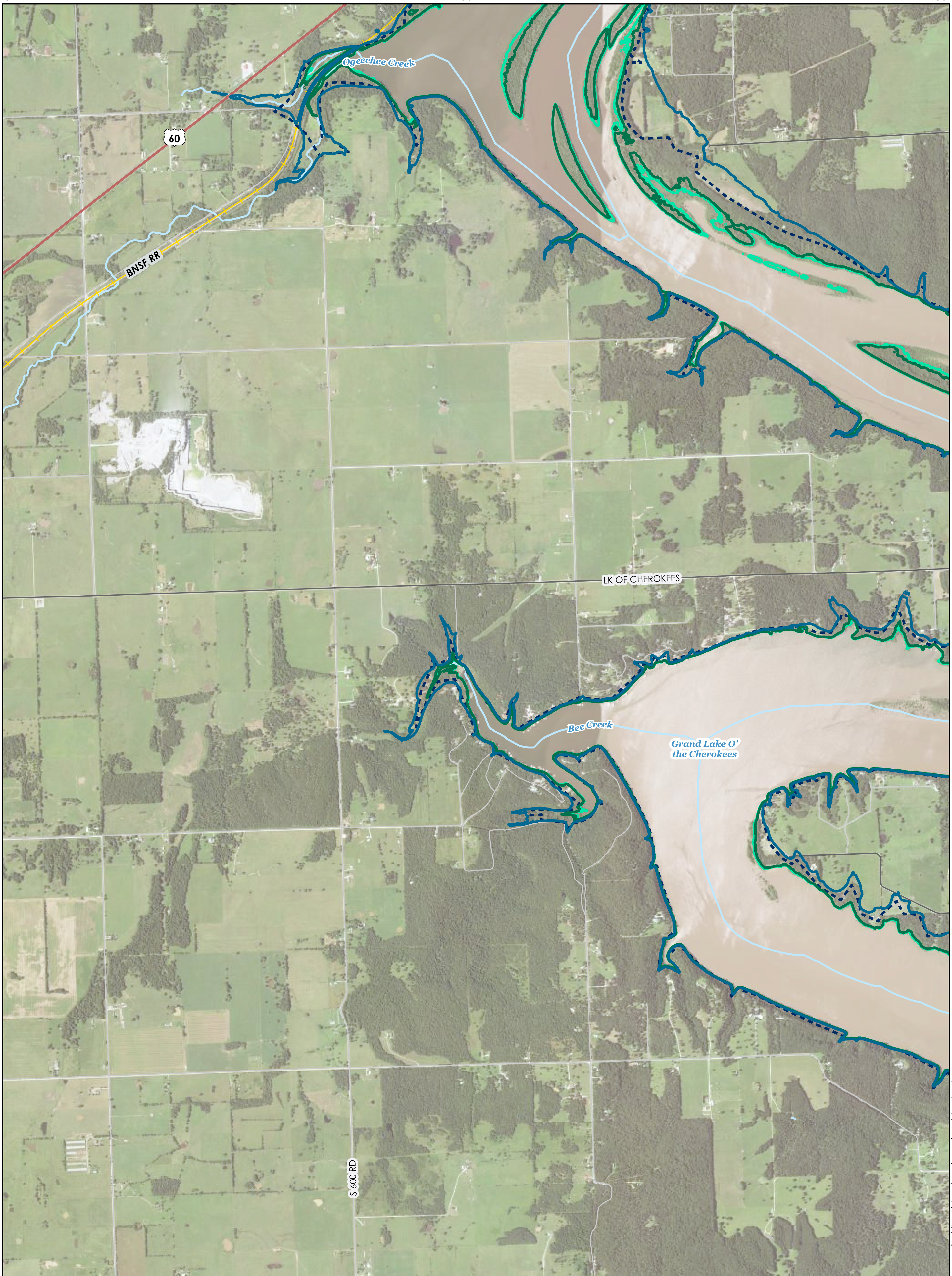
GRAND RIVER DAM AUTHORITY

## MAP: C6

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

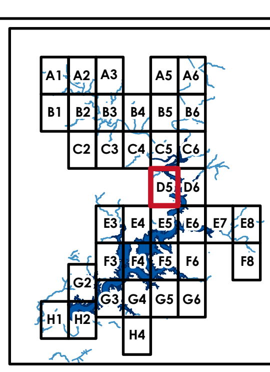



## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

## PENSACOLA DAM

GRAND RIVER DAM AUTHORITY

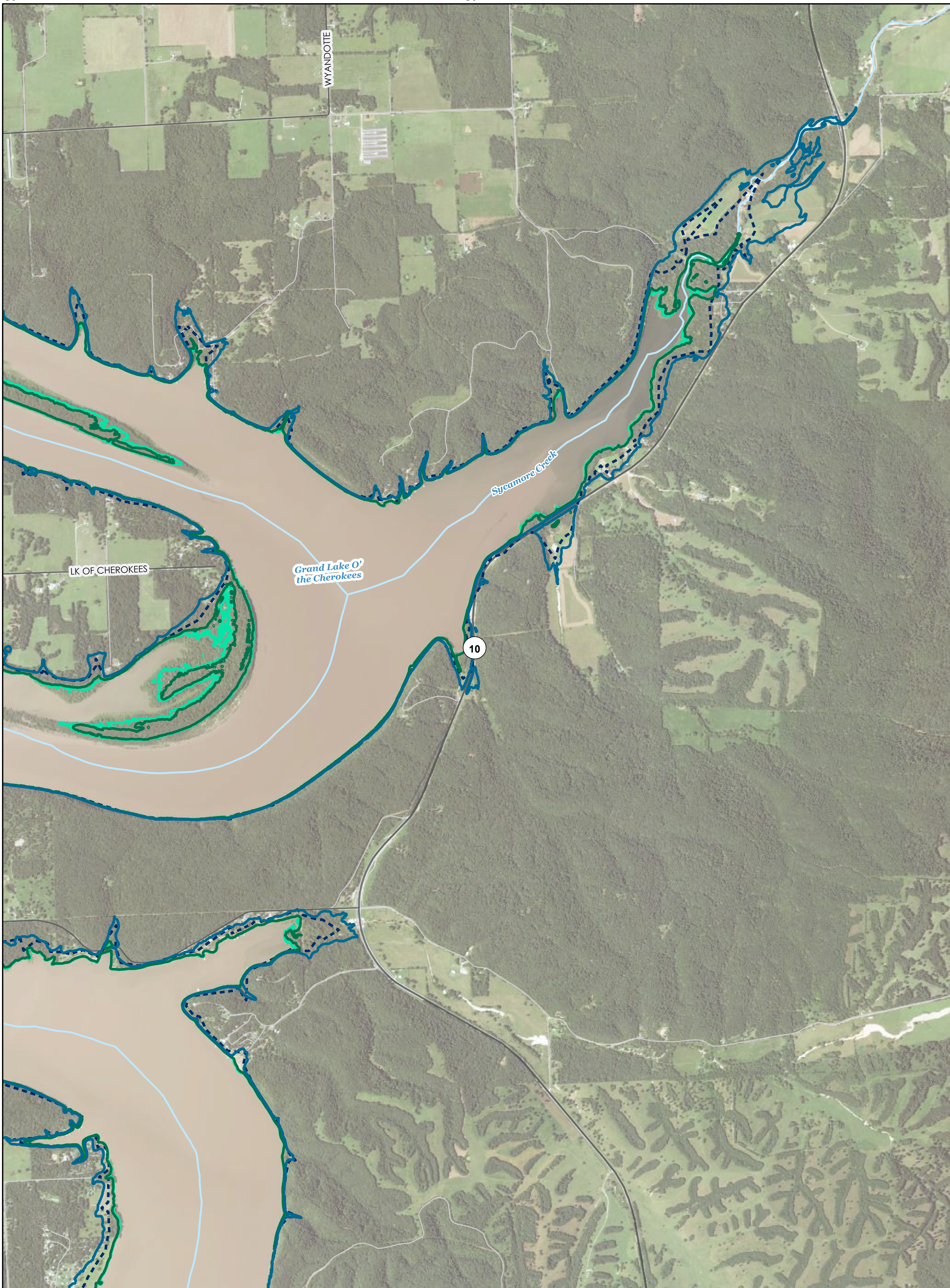
## MAP: D5

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

C5 C6




D5

E5 E6 E7

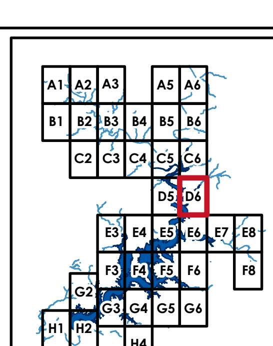
Image credits: https://gis.apfo.usda.gov/arcgis/services/NAIP/USDA_CONUS_PRIME/ImageServer, 2019

## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

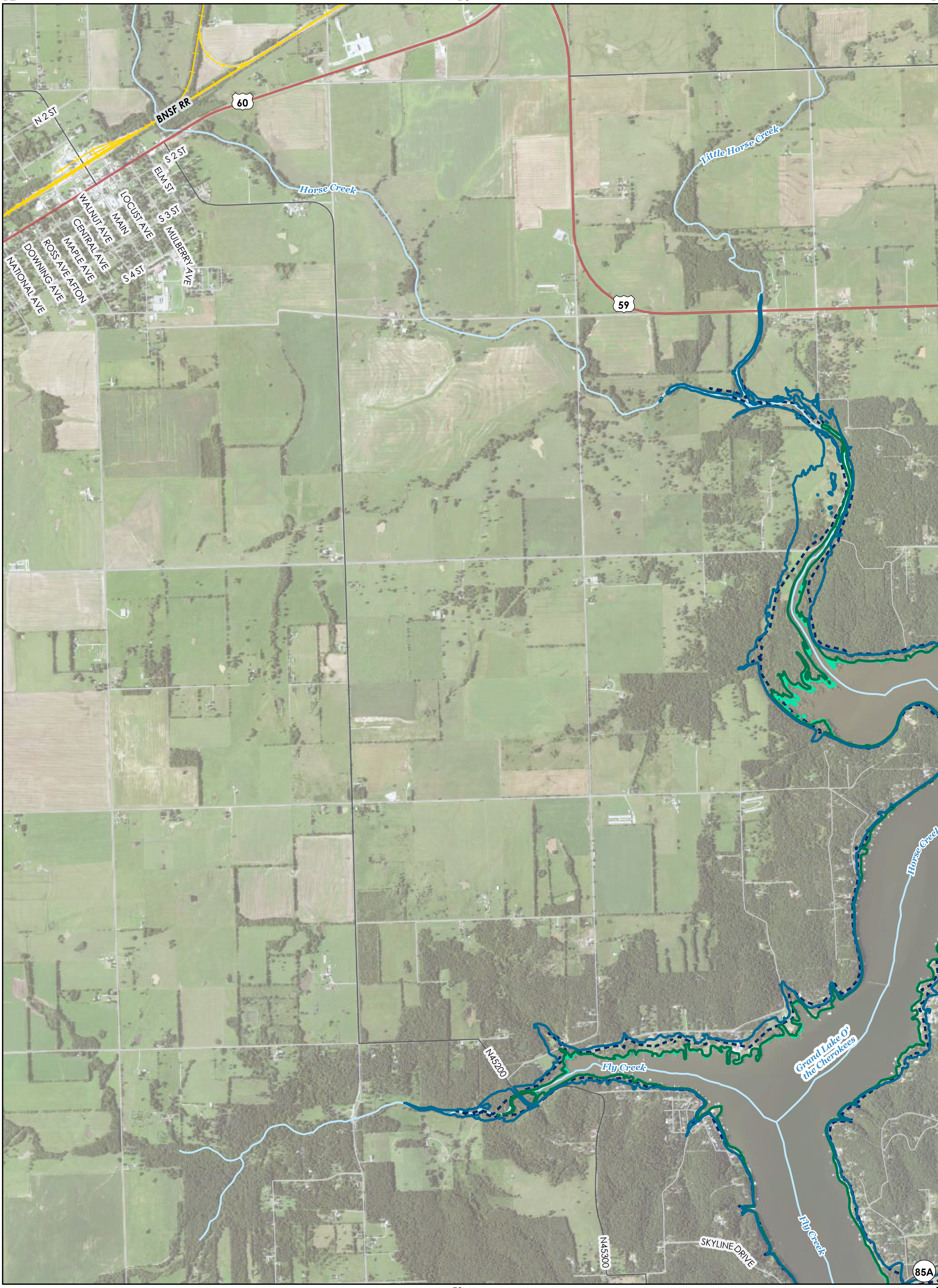
GRAND RIVER DAM AUTHORITY

## MAP: D6

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

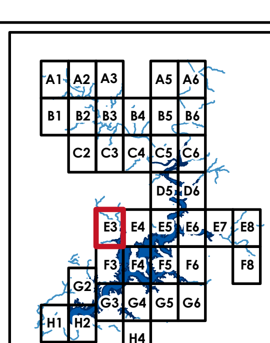



## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

## PENSACOLA DAM

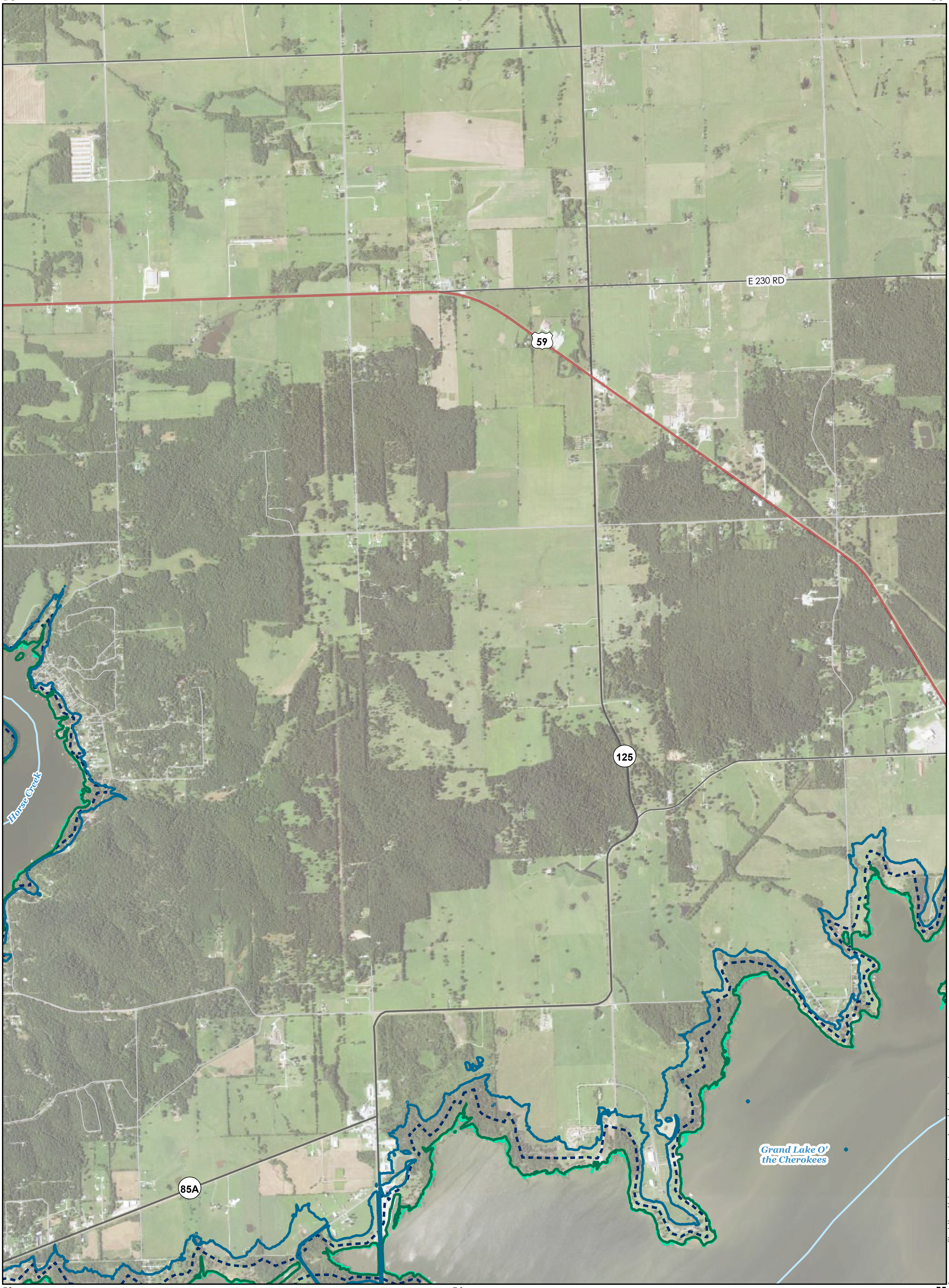
GRAND RIVER DAM AUTHORITY

## MAP: E3

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022




# LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet

Legend

**INUNDATION**
- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**
- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM
GRAND RIVER DAM AUTHORITY

## MAP: E4

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**
September 2022

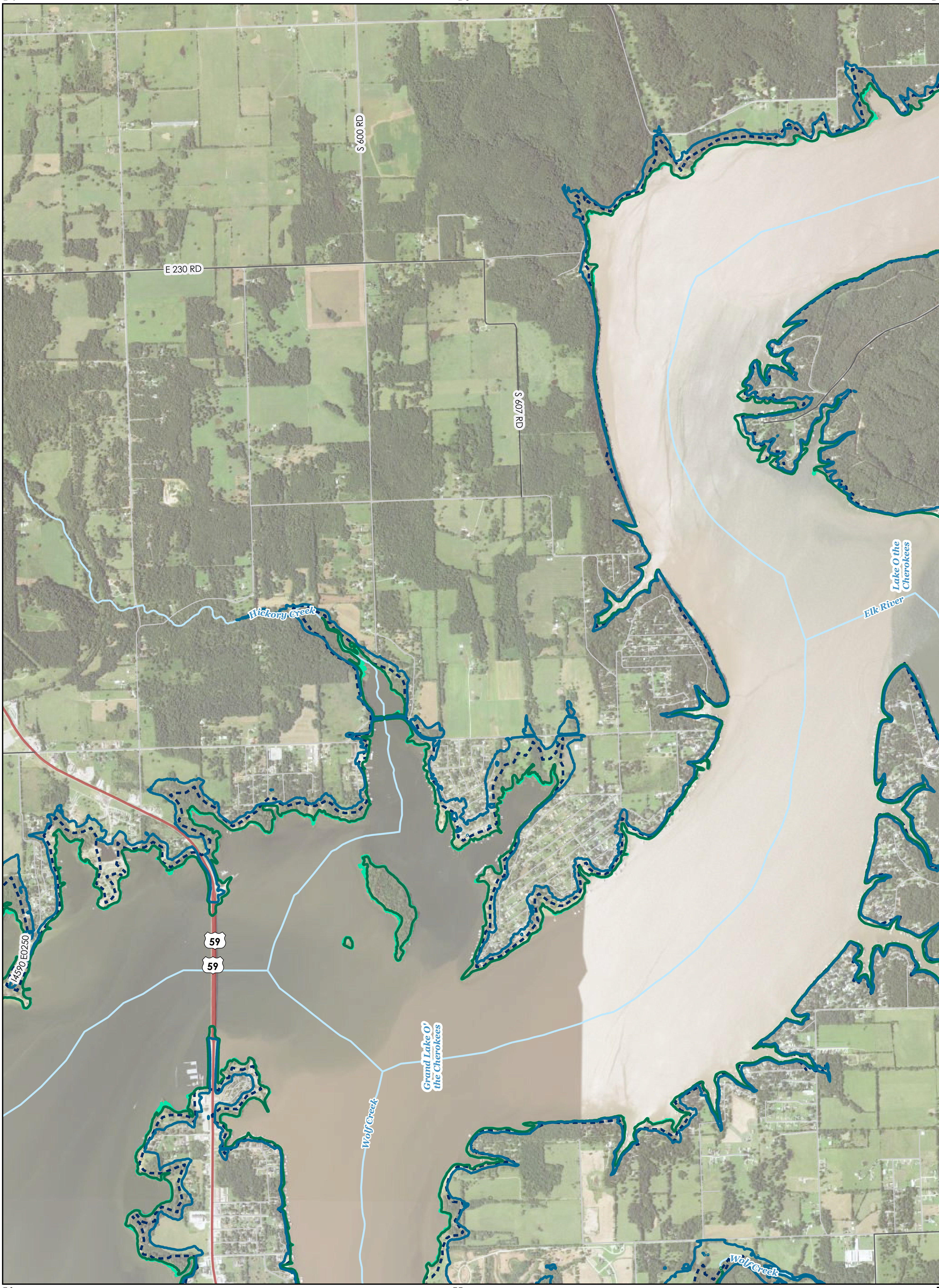


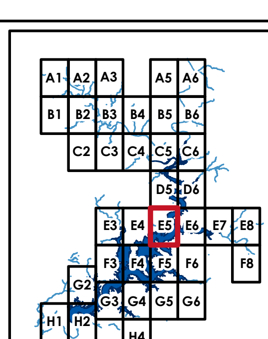

Image credits: https://gis.apfo.usda.gov/arcgis/services/NAIP/USDA_CONUS_PRIME/ImageServer, 2019

## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

**PENSACOLA DAM**

GRAND RIVER DAM AUTHORITY

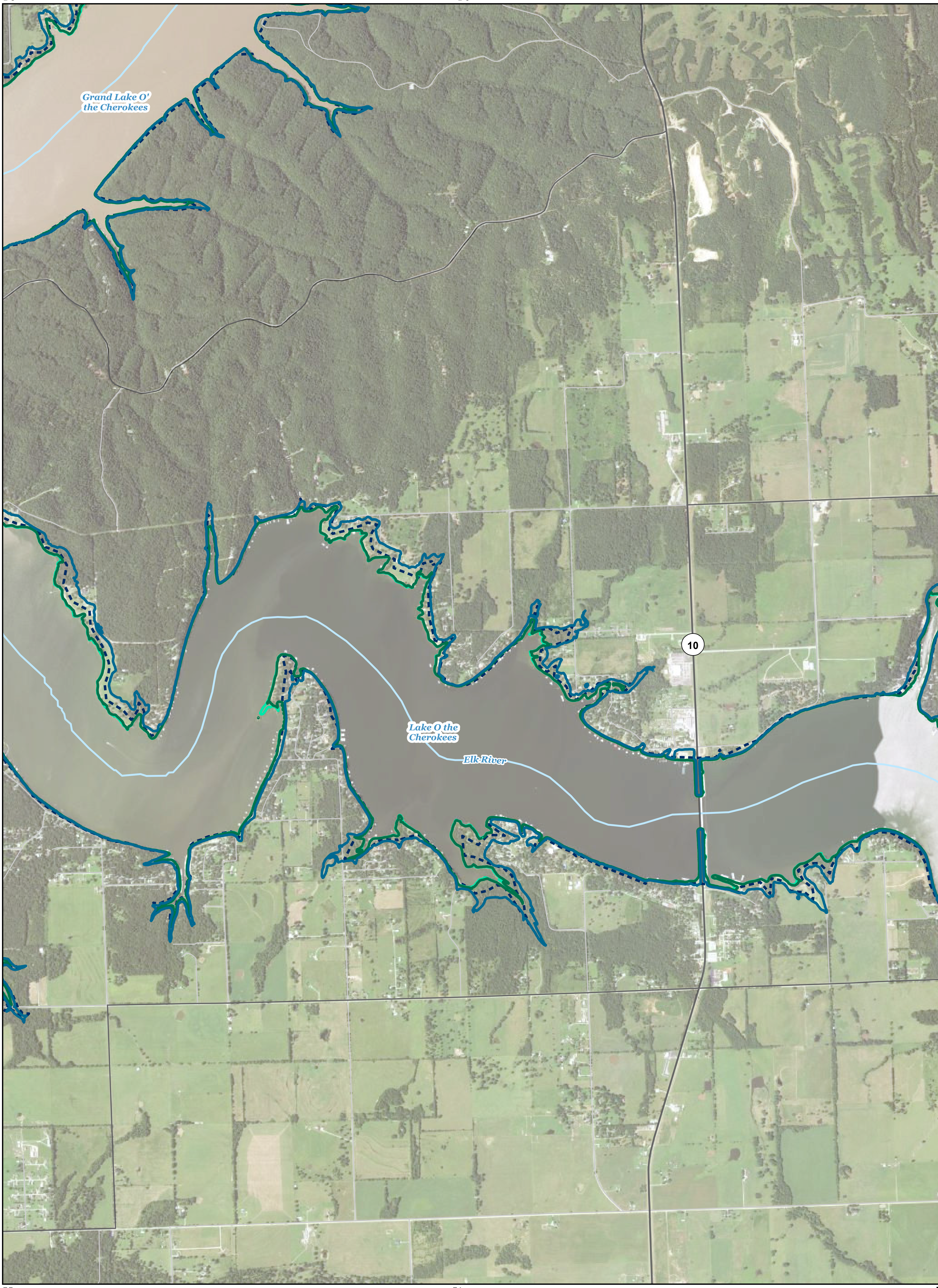
**MAP: E5**

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

D5 D6




E5 E7

F5 F6 F7

Image credits: https://gis.apfo.usda.gov/arcgis/services/NAIP/USDA_CONUS_PRIME/ImageServer, 2019

## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet

Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

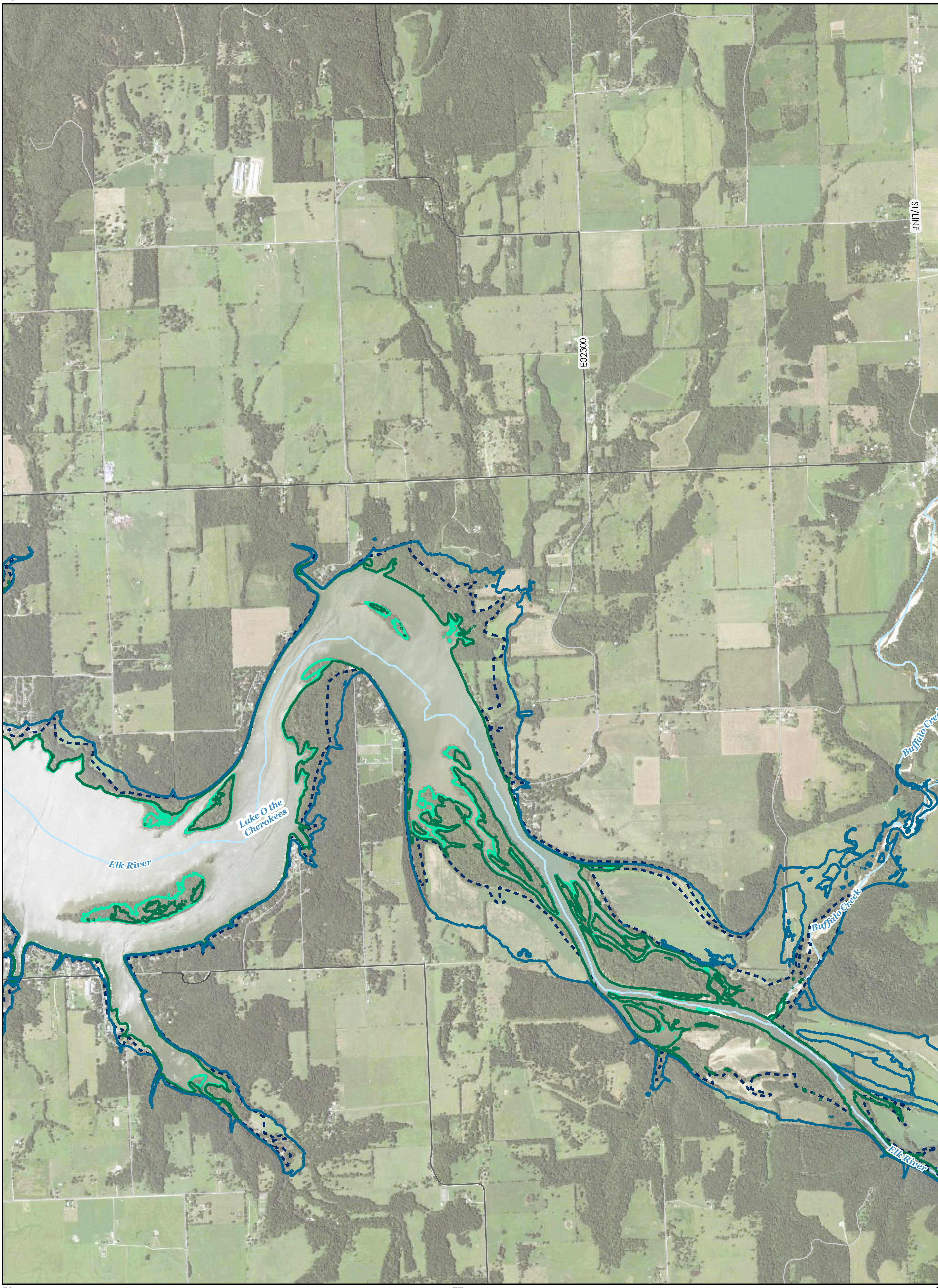
GRAND RIVER DAM AUTHORITY

## MAP: E6

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

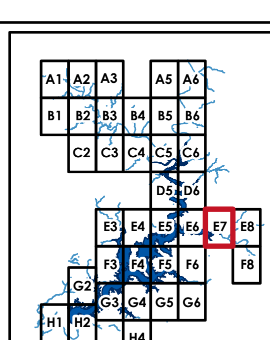



## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

GRAND RIVER DAM AUTHORITY

## MAP: E7

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

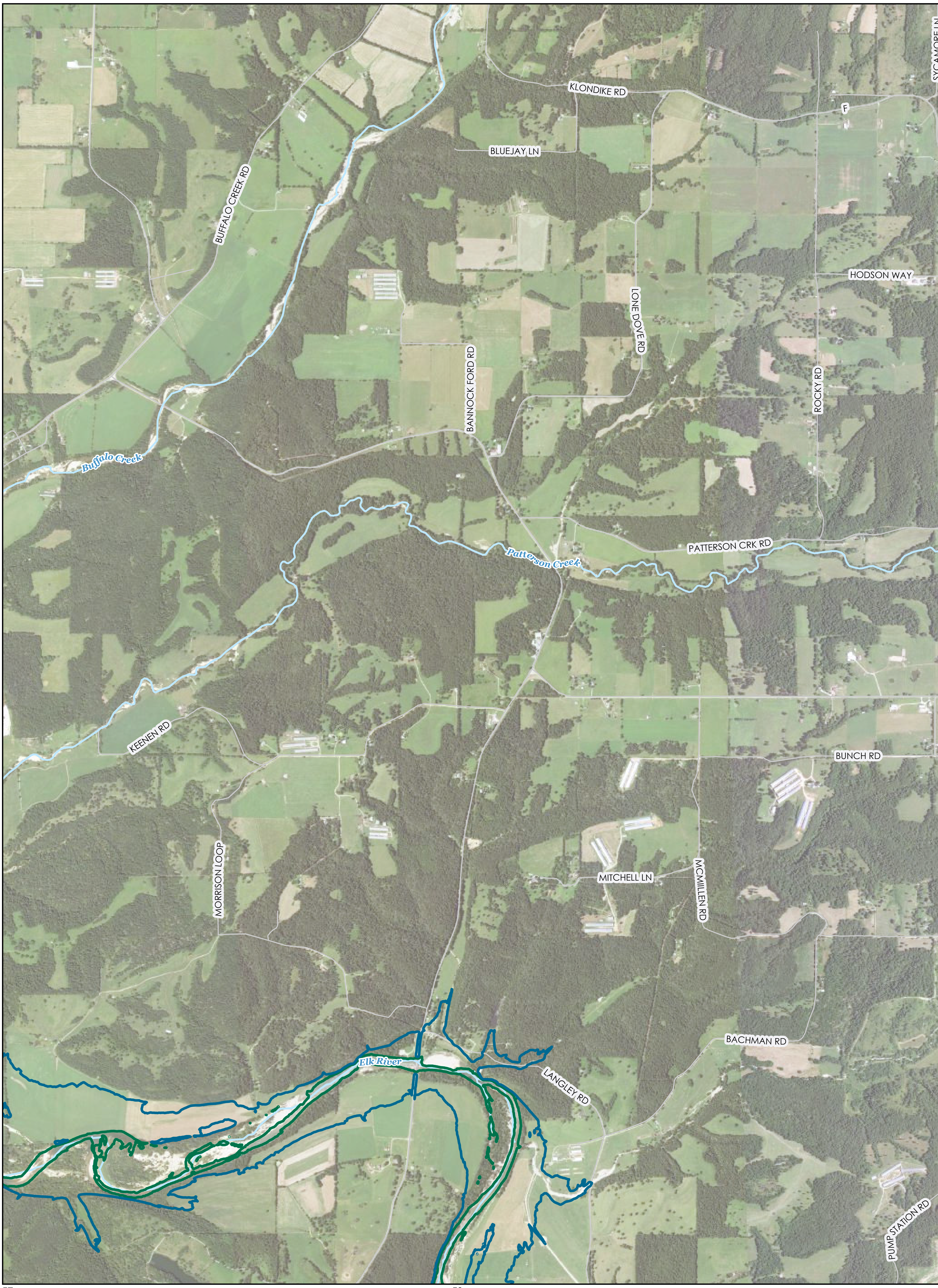



Image credits: https://gis.apfo.usda.gov/arcgis/services/NAIP/USDA_CONUS_PRIME/ImageServer, 2019

## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet

A1 A2 A3 A5 A6 B1 B2 B3 B4 B5 B6 C2 C3 C4 C5 C6 D5 D6 E3 E4 E5 E6 E7 E8 F3 F4 F5 F6 F8 G2 G3 G4 G5 G6 H1 H2 H4

Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

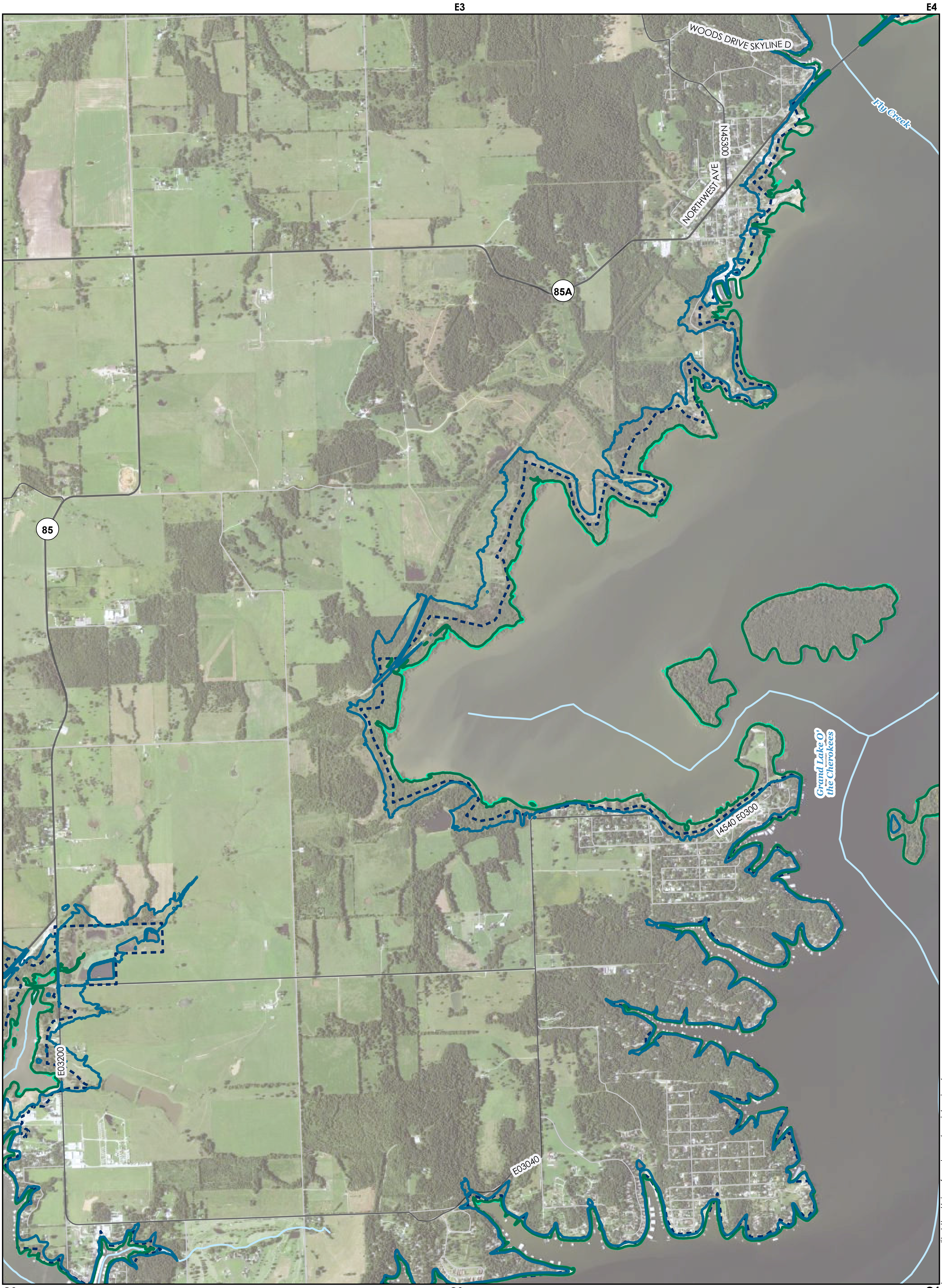
GRAND RIVER DAM AUTHORITY

## MAP: E8

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

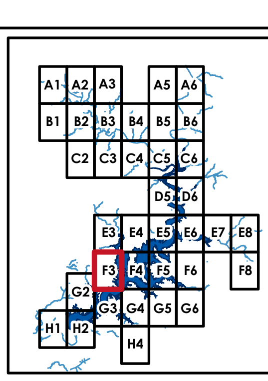



**LAKE SPAWNING SPECIES HABITAT CHANGES**

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet



Legend

**INUNDATION**
- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**
- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

**PENSACOLA DAM**

GRAND RIVER DAM AUTHORITY

**MAP: F3**

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

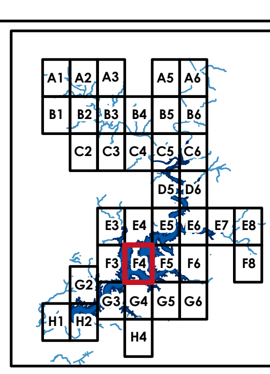

Image credits: https://gis.apfo.usda.gov/arcgis/services/NAIP/USDA_CONUS_PRIME/ImageServer, 2019

## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

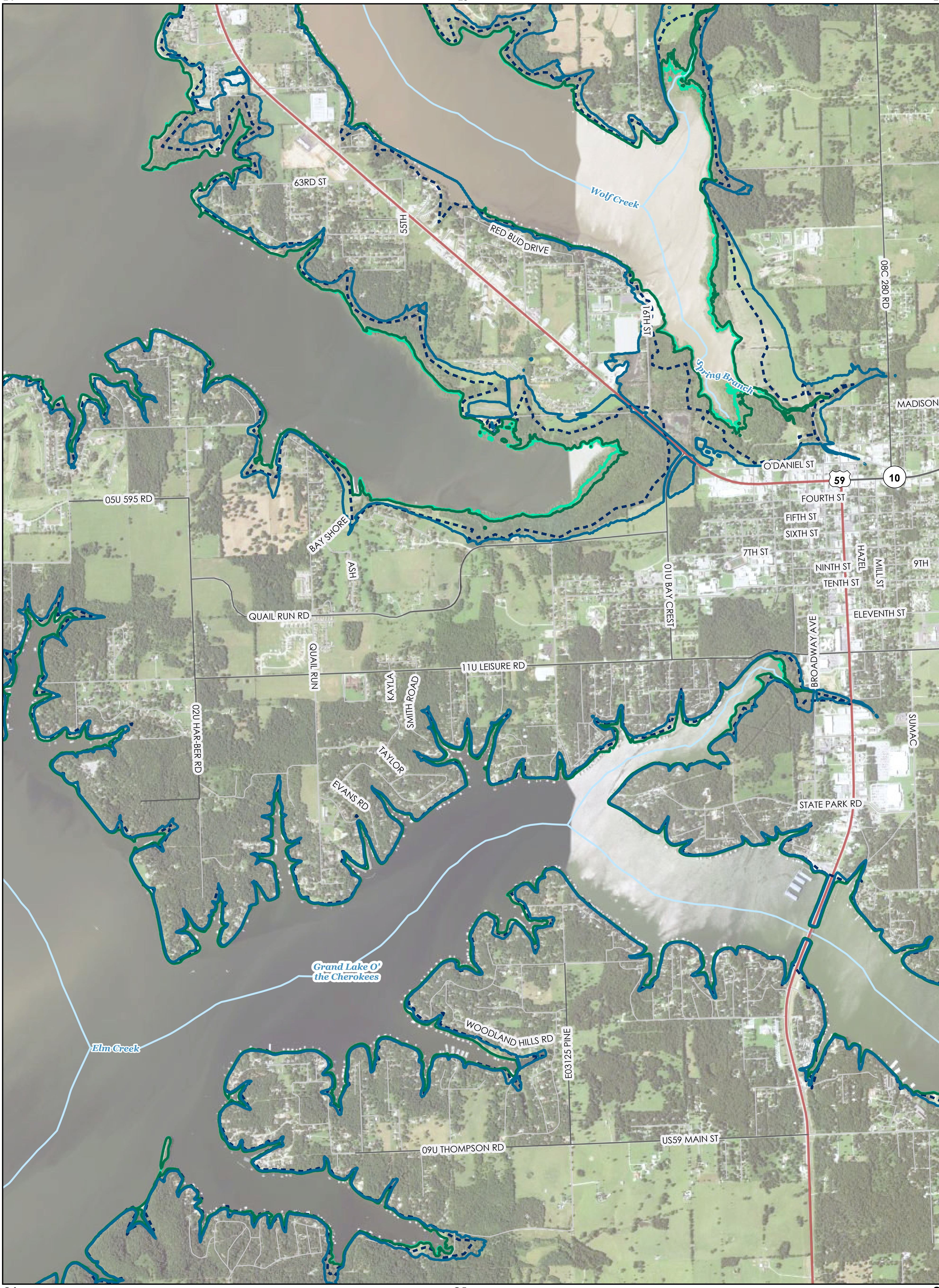
GRAND RIVER DAM AUTHORITY

## MAP: F4

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

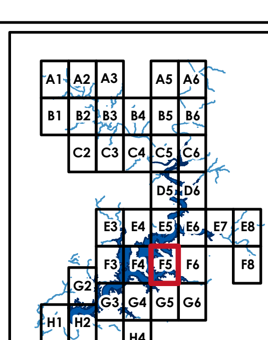



# LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

GRAND RIVER DAM AUTHORITY

## MAP: F5

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

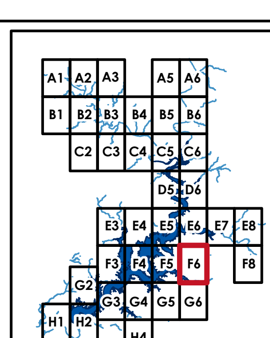
September 2022


## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

## PENSACOLA DAM

GRAND RIVER DAM AUTHORITY

## MAP: F6

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

E7

E8

F7

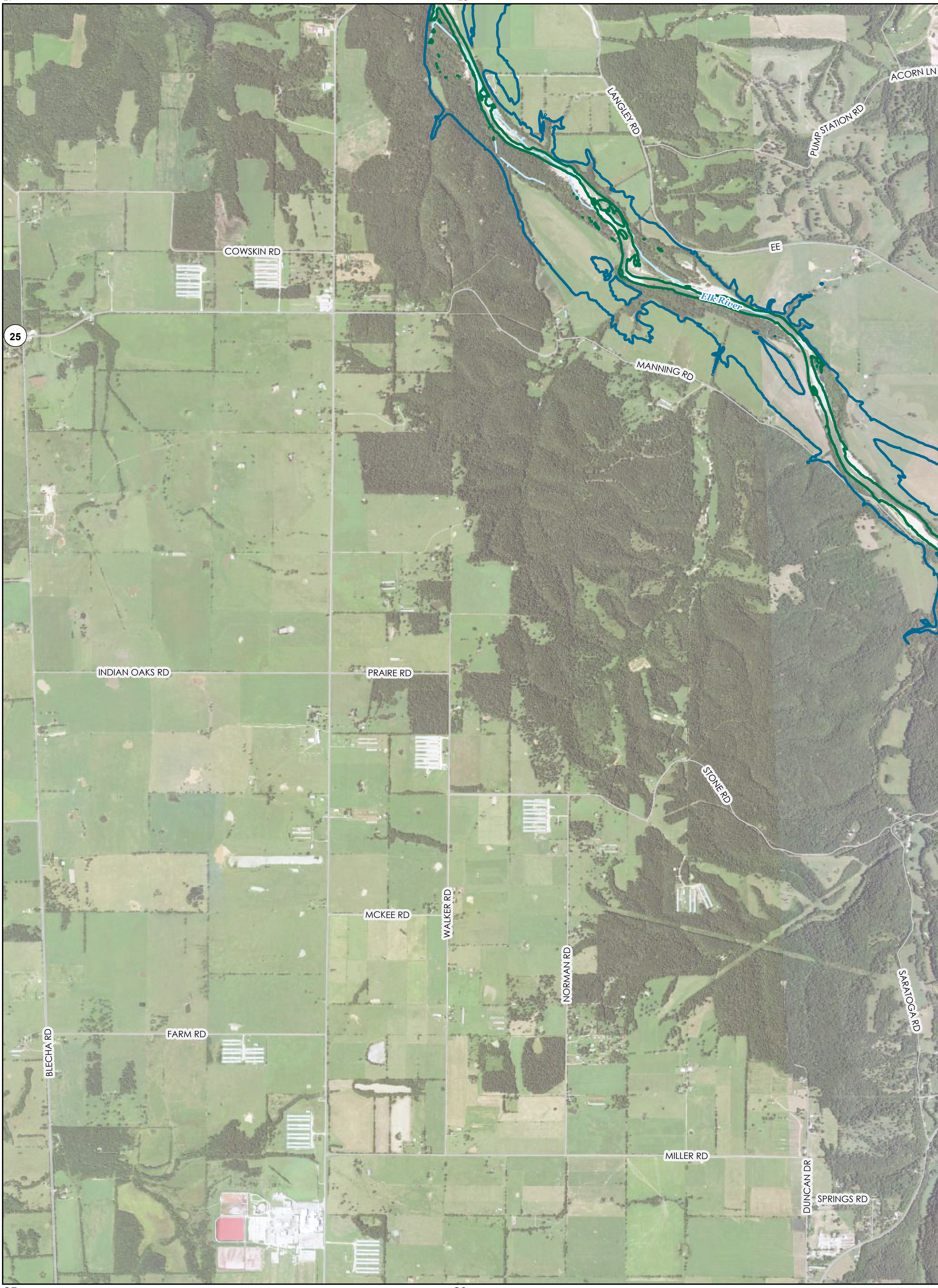



Image credits: https://gis.apfo.usda.gov/arcgis/services/NAIP/USDA_CONUS_PRIME/ImageServer, 2019

G7

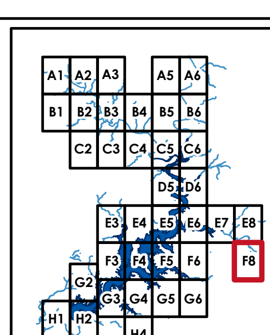
G8

## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

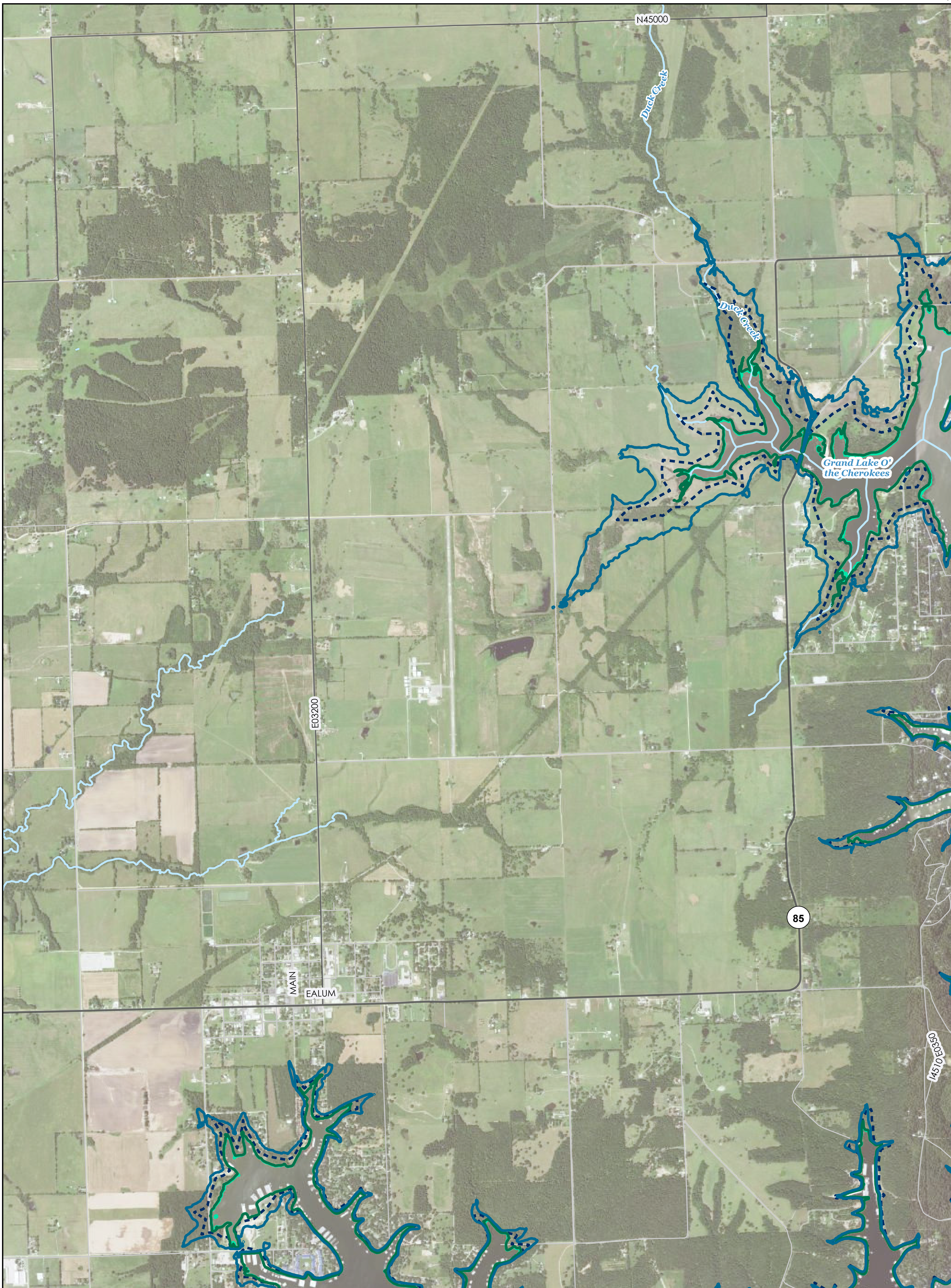
GRAND RIVER DAM AUTHORITY

## MAP: F8

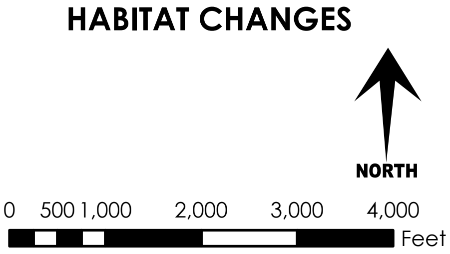
CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

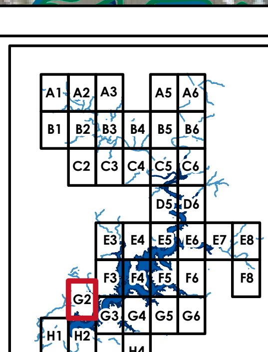
**FERC No. 1494**

September 2022




## LAKE SPAWNING SPECIES HABITAT CHANGES




Legend

**INUNDATION**
- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**
- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

## PENSACOLA DAM

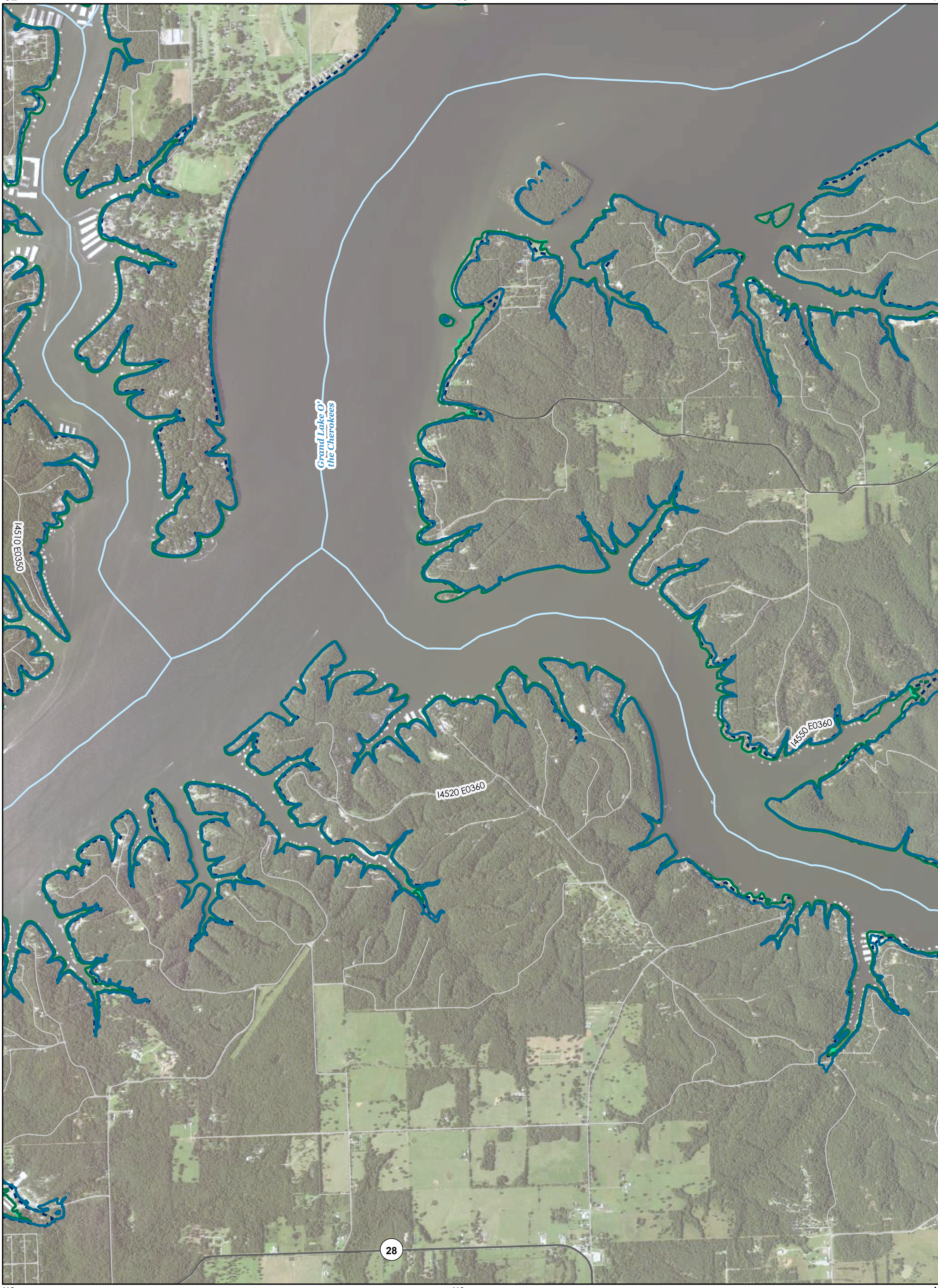
GRAND RIVER DAM AUTHORITY

## MAP: G2

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

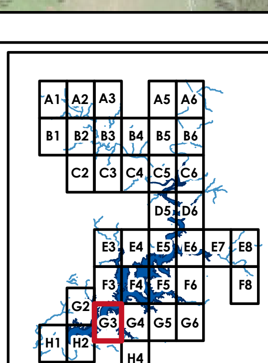



## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

**PENSACOLA DAM**

GRAND RIVER DAM AUTHORITY

**MAP: G3**

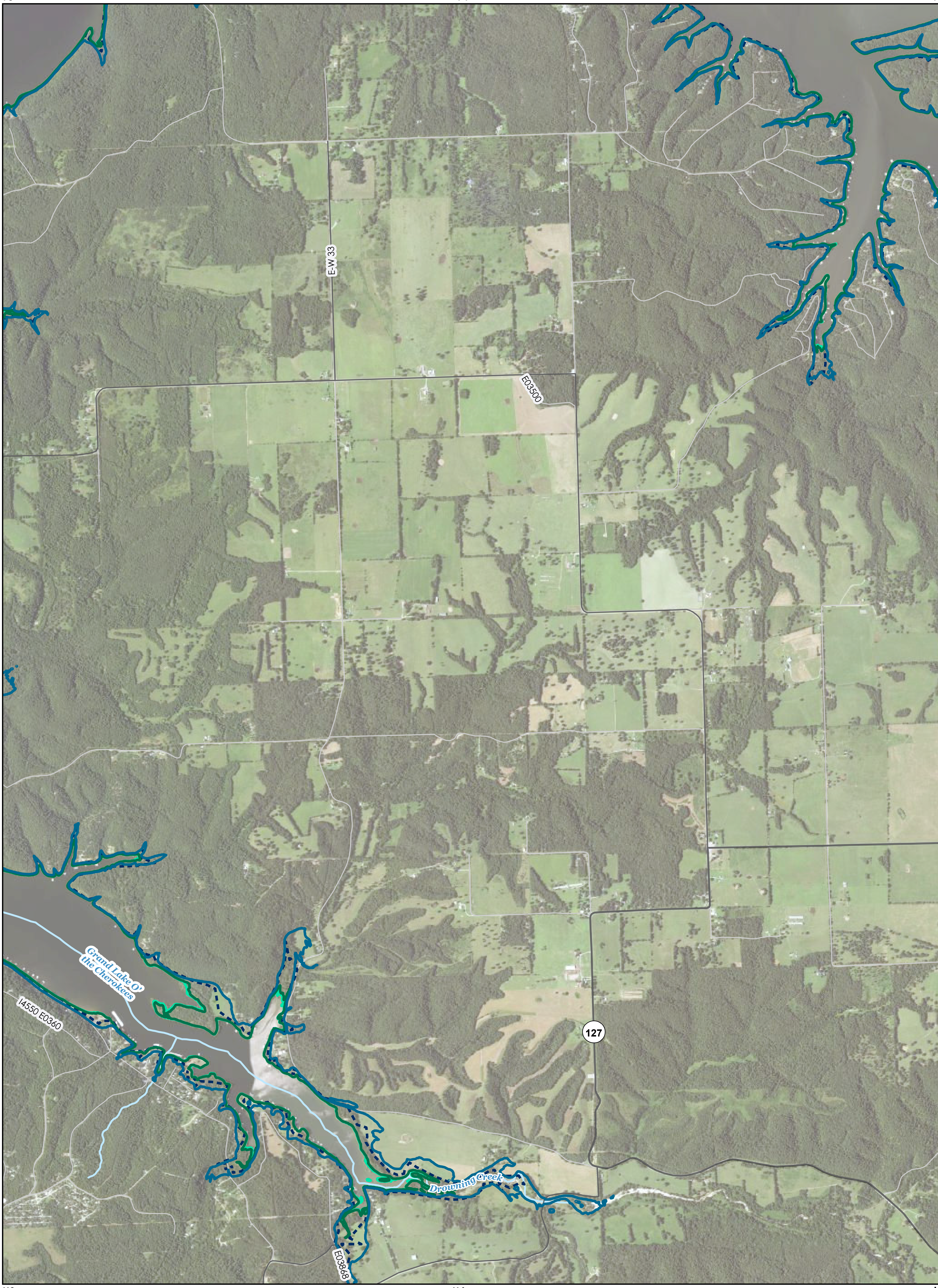
CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

F3 F4 F5

G3 G5



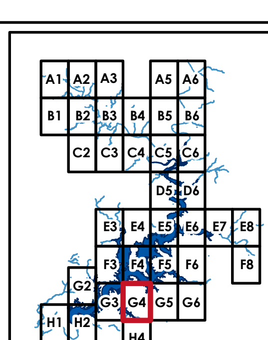

H3 H4 H5

## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

GRAND RIVER DAM AUTHORITY

## MAP: G4

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

F4 F5 F6

G4 G6

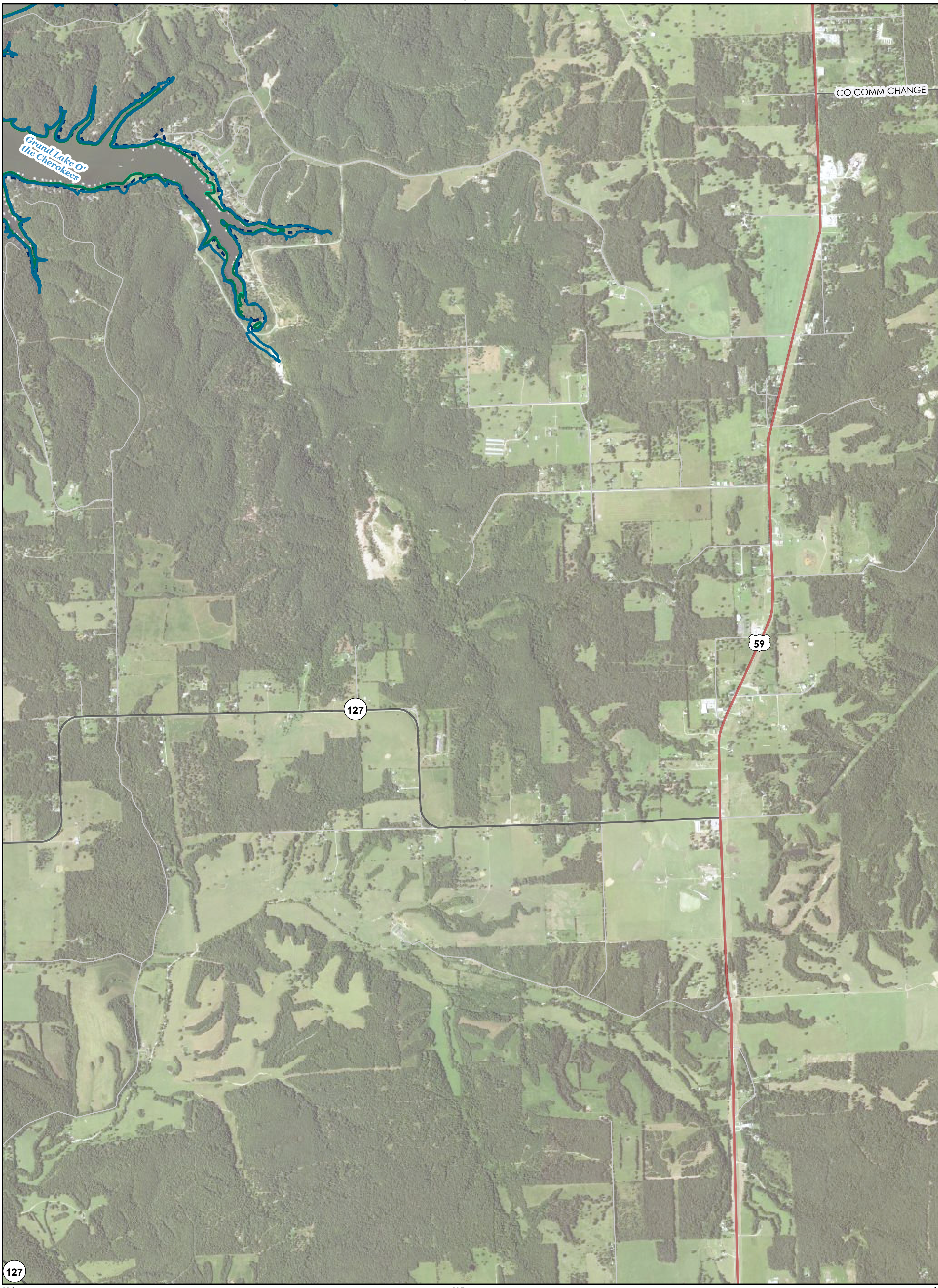



Image credits: https://gis.apfo.usda.gov/arcgis/services/NAIP/USDA_CONUS_PRIME/ImageServer, 2019

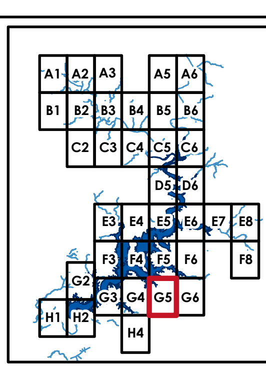
H4 H5 H6

## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

GRAND RIVER DAM AUTHORITY

## MAP: G5

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

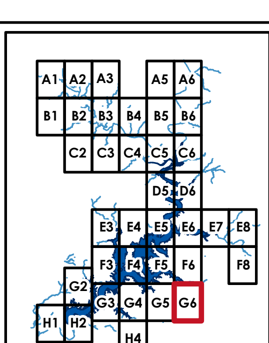

Image credits: https://gis.apfo.usda.gov/arcgis/services/NAIP/USDA_CONUS_PRIME/ImageServer, 2019

## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

GRAND RIVER DAM AUTHORITY

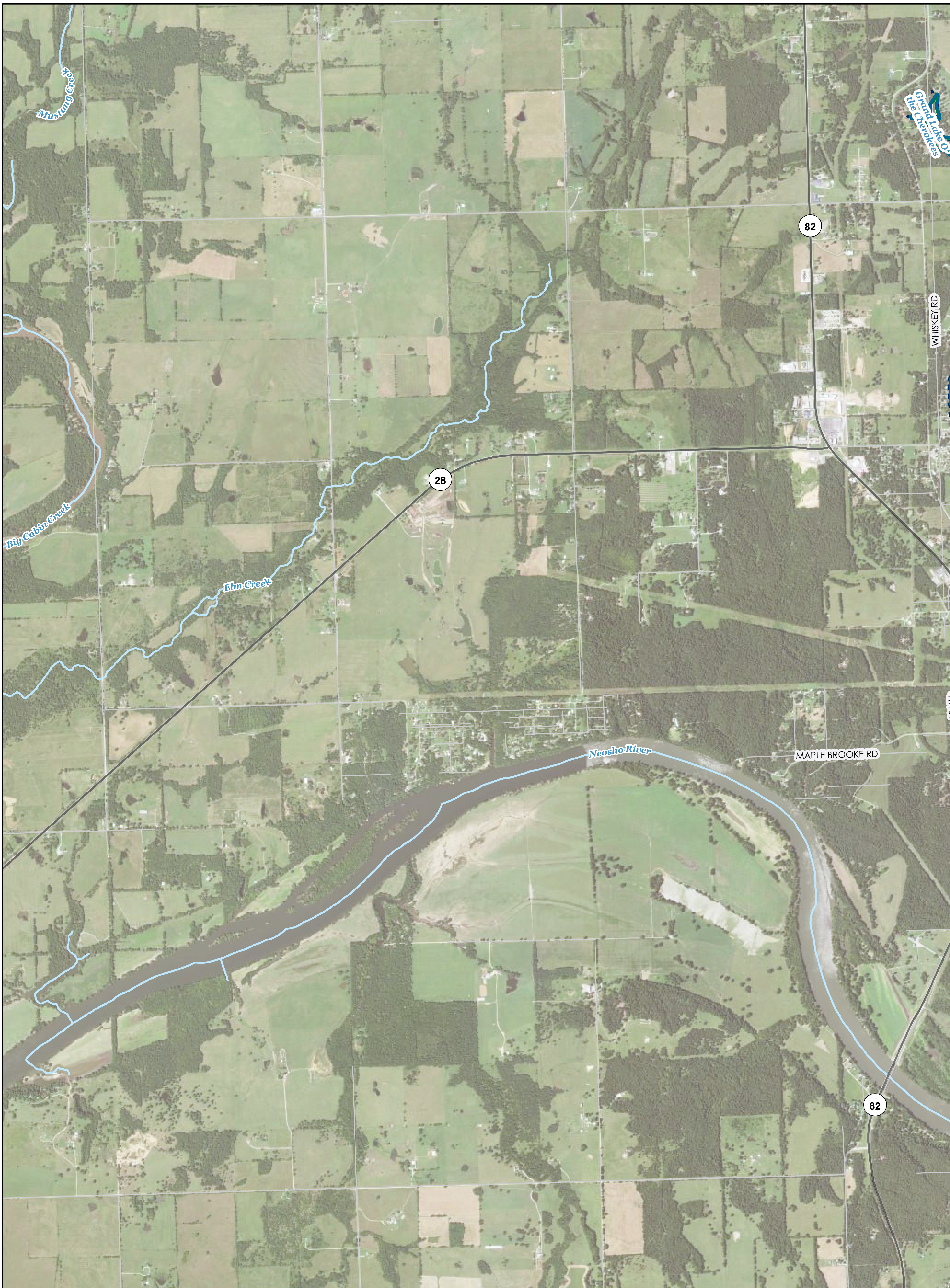
## MAP: G6

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

G1 G2




H2

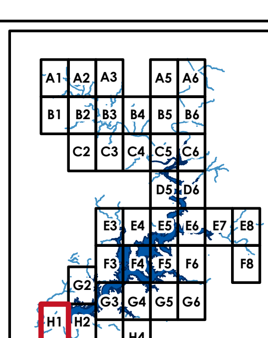
Image credits: https://gis.apfo.usda.gov/arcgis/services/NAIP/USDA_CONUS_PRIME/ImageServer, 2019

## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

GRAND RIVER DAM AUTHORITY

## MAP: H1

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

G1 G2 G3


H1 H3

Image credits: https://gis.apfo.usda.gov/arcgis/services/NAIP/USDA_CONUS_PRIME/ImageServer, 2019

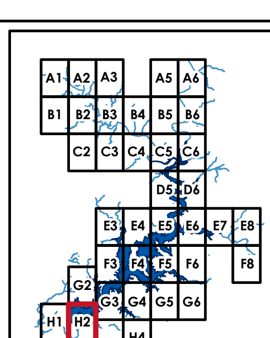
H3

## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

GRAND RIVER DAM AUTHORITY

## MAP: H2

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

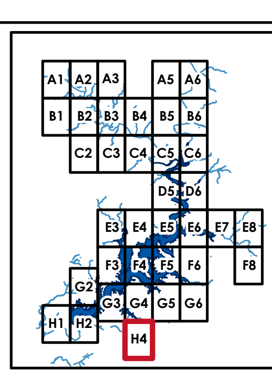

Image credits: https://gis.apfo.usda.gov/arcgis/services/NAIP/USDA_CONUS_PRIME/ImageServer, 2019

## LAKE SPAWNING SPECIES HABITAT CHANGES

NORTH

0 500 1,000 2,000 3,000 4,000 Feet

1 inch = 2,000 feet




Legend

**INUNDATION**

- Aquatic Habitat Baseline Operations
- Aquatic Habitat Anticipated Operations
- Maximum Inundation

**ROAD CLASS**

- Interstate
- State Highway
- US Highway
- Major Collector
- Local Road
- Railroad
- Stream
- Project Boundary (2014)

**MAP AND LEGEND NOTES**

1. Mapping shows the extent of inundation calculated using the H&H Study Operations Model and Upstream Hydraulic Model. **These maps represent the work of the H&H Study and are not to be used as shown for resource analysis purposes.**
2. Estimated inundation extent for normal (median) inflows and operations during the spawning season.
3. See Overview Map for an explanation of the maximum inundation extent and notes on data sources.

# PENSACOLA DAM

GRAND RIVER DAM AUTHORITY

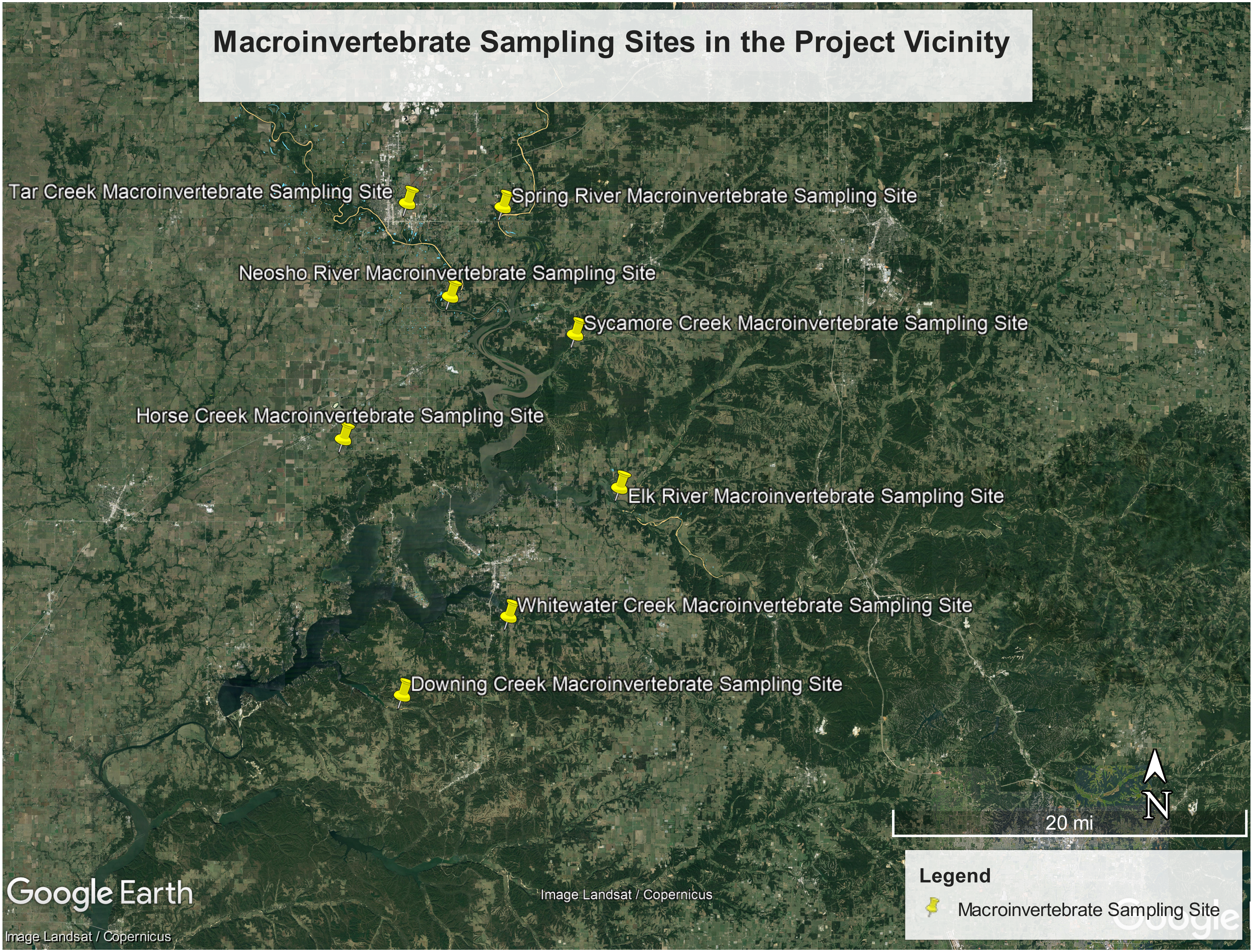
## MAP: H4

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

**FERC No. 1494**

September 2022

**APPENDIX E-14 Macroinvertebrate Sampling Site Map and Data**


Macroinvertebrate Sampling Sites in the Project Vicinity
Tar Creek Macroinvertebrate Sampling Site
Spring River Macroinvertebrate Sampling Site
Neosho River Macroinvertebrate Sampling Site
Sycamore Creek Macroinvertebrate Sampling Site
Horse Creek Macroinvertebrate Sampling Site
Elk River Macroinvertebrate Sampling Site
Whitewater Creek Macroinvertebrate Sampling Site
Downing Creek Macroinvertebrate Sampling Site
N
20 mi
Legend
Macroinvertebrate Sampling Site
Google Earth
Image Landsat / Copernicus
Image Landsat / Copernicus

# Macroinvertebrate Sampling Data

(Within Project Boundary)

| Site | Sample number | Date | Latitude | Longitude | Daphiniidae | Cyprididae | Coenagrionidae | Ceratopogonidae | Naididae |
|---|---|---|---|---|---|---|---|---|---|
| Spring | 105 | 9/9/2022 | 36.87163 | -94.7655 | 1 | 4 | 1 | 1 | 3 |
| Spring | 106 | 9/9/2022 | 36.87163 | -94.7655 | 1 | 0 | 0 | 0 | 11 |
| Neosho | 112 | 9/9/2022 | 36.79894 | -94.8188 | 0 | 0 | 0 | 0 | 20 |
| Neosho | 109 | 9/9/2022 | 36.79894 | -94.8188 | 0 | 0 | 0 | 0 | 25 |
| Neosho | 111 | 9/9/2022 | 36.79894 | -94.8188 | 0 | 0 | 0 | 0 | 5 |
| Spring | 104 | 9/9/2022 | 36.87163 | -94.7655 | 0 | 0 | 0 | 0 | 1 |
| Spring | 102 | 9/9/2022 | 36.87163 | -94.7655 | 0 | 0 | 0 | 0 | 4 |
| Spring | 101 | 9/9/2022 | 36.87163 | -94.7655 | 0 | 0 | 0 | 0 | 0 |
| Spring | 108 | 9/9/2022 | 36.87163 | -94.7655 | 2 | 5 | 0 | 2 | 10 |
| Spring | 103 | 9/9/2022 | 36.87163 | -94.7655 | 0 | 0 | 0 | 0 | 0 |
| Elk | 158 | 9/11/2022 | 36.64365 | -94.6474 | 1 | 1 | 0 | 0 | 18 |
| Elk | 156 | 9/11/2022 | 36.64365 | -94.6474 | 0 | 0 | 1 | 0 | 0 |
| Elk | 153 | 9/11/2022 | 36.64365 | -94.6474 | 0 | 0 | 0 | 0 | 1 |
| Elk | 154 | 9/11/2022 | 36.64365 | -94.6474 | 0 | 0 | 0 | 0 | 0 |
| Elk | 155 | 9/11/2022 | 36.64365 | -94.6474 | 0 | 0 | 2 | 0 | 0 |
| | | | | **Totals** | 5 | 10 | 4 | 3 | 98 |

| Site | Sample number | Date | Chironomidae | Ephemeridae | Caenidae | Prostigmata | Cyclopodia | Heptageniidae | Sphaeriidae |
|---|---|---|---|---|---|---|---|---|---|
| Spring | 105 | 9/9/2022 | 33 | 5 | 18 | 0 | 0 | 0 | 0 |
| Spring | 106 | 9/9/2022 | 38 | 2 | 7 | 1 | 1 | 2 | 0 |
| Neosho | 112 | 9/9/2022 | 9 | 3 | 0 | 0 | 0 | 0 | 1 |
| Neosho | 109 | 9/9/2022 | 18 | 8 | 0 | 0 | 0 | 0 | 0 |
| Neosho | 111 | 9/9/2022 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spring | 104 | 9/9/2022 | 21 | 0 | 0 | 0 | 0 | 1 | 0 |
| Spring | 102 | 9/9/2022 | 30 | 0 | 0 | 0 | 0 | 1 | 0 |
| Spring | 101 | 9/9/2022 | 25 | 0 | 0 | 0 | 0 | 2 | 0 |
| Spring | 108 | 9/9/2022 | 72 | 1 | 61 | 0 | 0 | 2 | 0 |
| Spring | 103 | 9/9/2022 | 16 | 0 | 0 | 0 | 0 | 1 | 0 |
| Elk | 158 | 9/11/2022 | 76 | 1 | 67 | 0 | 0 | 1 | 0 |
| Elk | 156 | 9/11/2022 | 14 | 2 | 0 | 0 | 0 | 0 | 0 |
| Elk | 153 | 9/11/2022 | 31 | 0 | 0 | 0 | 0 | 0 | 0 |
| Elk | 154 | 9/11/2022 | 84 | 0 | 71 | 1 | 0 | 5 | 0 |
| Elk | 155 | 9/11/2022 | 53 | 0 | 26 | 0 | 0 | 39 | 0 |
| | | **Totals** | 531 | 22 | 250 | 2 | 1 | 54 | 1 |

| Site | Sample Number | Date | Chaoboridae | Polycentropodidae | Leptophlebiidae | Hirudinea | Hydrophilidae | Baetidae | Corixidae |
|---|---|---|---|---|---|---|---|---|---|
| Spring | 105 | 9/9/2022 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spring | 106 | 9/9/2022 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Neosho | 112 | 9/9/2022 | 18 | 0 | 0 | 0 | 0 | 0 | 0 |
| Neosho | 109 | 9/9/2022 | 23 | 0 | 0 | 0 | 0 | 0 | 0 |
| Neosho | 111 | 9/9/2022 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spring | 104 | 9/9/2022 | 0 | 5 | 0 | 0 | 0 | 0 | 0 |
| Spring | 102 | 9/9/2022 | 0 | 7 | 1 | 0 | 0 | 0 | 0 |
| Spring | 101 | 9/9/2022 | 0 | 4 | 0 | 1 | 0 | 0 | 0 |
| Spring | 108 | 9/9/2022 | 0 | 0 | 0 | 0 | 11 | 9 | 2 |
| Spring | 103 | 9/9/2022 | 0 | 5 | 0 | 0 | 0 | 0 | 0 |
| Elk | 158 | 9/11/2022 | 0 | 0 | 0 | 0 | 1 | 9 | 0 |
| Elk | 156 | 9/11/2022 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Elk | 153 | 9/11/2022 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Elk | 154 | 9/11/2022 | 0 | 0 | 133 | 0 | 0 | 111 | 0 |
| Elk | 155 | 9/11/2022 | 0 | 0 | 171 | 0 | 1 | 60 | 0 |
| | | **Totals** | 42 | 21 | 306 | 1 | 13 | 190 | 2 |

| Site | Sample Number | Date | Hapilidae | Physidae | Culicidae | Poduridae | Gammaridae | Elmidae | Ephemerellidae | Gomphidae | Perlidae |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spring | 105 | 9/9/2022 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spring | 106 | 9/9/2022 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Neosho | 112 | 9/9/2022 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Neosho | 109 | 9/9/2022 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Neosho | 111 | 9/9/2022 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spring | 104 | 9/9/2022 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spring | 102 | 9/9/2022 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spring | 101 | 9/9/2022 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spring | 108 | 9/9/2022 | 7 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spring | 103 | 9/9/2022 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Elk | 158 | 9/11/2022 | 1 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| Elk | 156 | 9/11/2022 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Elk | 153 | 9/11/2022 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 |
| Elk | 154 | 9/11/2022 | 0 | 0 | 0 | 0 | 0 | 10 | 6 | 0 | 0 |
| Elk | 155 | 9/11/2022 | 0 | 1 | 0 | 0 | 0 | 38 | 28 | 1 | 1 |
| | | **Totals** | 8 | 14 | 1 | 2 | 14 | 48 | 34 | 1 | 1 |

# Macroinvertebrate Sampling Data

# (Within Project Vicinity But Outside Project Boundary)

| SiteName | Latitude | Longitude | Date | Index | SITEID | Elmidae | Psephenidae | Chironomidae | Empididae | Baetidae | Heptageniidae | Tricorythidae |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Horse Creek | 36.683 | -94.9273 | 8/3/2016 | Summer | OK121600( | 10 | 0 | 148 | 0 | 0 | 0 | 0 |
| Horse Creek | 36.683 | -94.9273 | 2/7/2017 | Winter | OK121600( | 6 | 0 | 128 | 0 | 0 | 12 | 0 |
| Horse Creek | 36.683 | -94.9273 | 6/26/2017 | Summer | OK121600( | 6 | 0 | 74 | 0 | 0 | 0 | 0 |
| Horse Creek | 36.683 | -94.9273 | 1/25/2018 | Winter | OK121600( | 0 | 0 | 86 | 0 | 0 | 2 | 0 |
| Drowning Creek | 36.4749 | -94.8672 | 1/29/2002 | Winter | OK121600( | 10 | 0 | 4 | 0 | 22 | 20 | 0 |
| Drowning Creek | 36.4749 | -94.8672 | 7/15/2002 | Summer | OK121600( | 2 | 0 | 6 | 0 | 46 | 2 | 0 |
| Drowning Creek | 36.4749 | -94.8672 | 1/27/2003 | Winter | OK121600( | 8 | 0 | 16 | 0 | 10 | 4 | 0 |
| Sycamore Creek | 36.76853 | -94.692 | 7/31/2001 | Summer | OK121600( | 10 | 74 | 36 | 0 | 20 | 24 | 10 |
| Sycamore Creek | 36.76853 | -94.692 | 1/29/2002 | Winter | OK121600( | 4 | 4 | 52 | 0 | 80 | 12 | 2 |
| Sycamore Creek | 36.76853 | -94.692 | 7/15/2002 | Summer | OK121600( | 8 | 28 | 22 | 0 | 50 | 32 | 8 |
| Sycamore Creek | 36.76853 | -94.692 | 1/13/2003 | Winter | OK121600( | 6 | 4 | 22 | 0 | 8 | 38 | 0 |
| Sycamore Creek | 36.76853 | -94.692 | 7/10/2006 | Summer | OK121600( | 34 | 8 | 52 | 0 | 20 | 30 | 0 |
| Sycamore Creek | 36.76853 | -94.692 | 1/11/2007 | Winter | OK121600( | 6 | 10 | 160 | 0 | 2 | 74 | 0 |
| Sycamore Creek | 36.76853 | -94.692 | 8/9/2007 | Summer | OK121600( | 8 | 6 | 162 | 0 | 0 | 6 | 4 |
| Sycamore Creek | 36.76853 | -94.692 | 1/7/2008 | Winter | OK121600( | 4 | 2 | 76 | 0 | 16 | 46 | 0 |
| Sycamore Creek | 36.76853 | -94.692 | 7/11/2011 | Summer | OK121600( | 0 | 6 | 82 | 0 | 30 | 22 | 2 |
| Sycamore Creek | 36.76853 | -94.692 | 1/3/2012 | Winter | OK121600( | 2 | 4 | 22 | 0 | 6 | 82 | 0 |
| Sycamore Creek | 36.76853 | -94.692 | 7/2/2012 | Summer | OK121600( | 8 | 116 | 16 | 0 | 2 | 34 | 4 |
| Sycamore Creek | 36.76853 | -94.692 | 2/5/2013 | Winter | OK121600( | 4 | 8 | 176 | 0 | 52 | 50 | 0 |
| Sycamore Creek | 36.76853 | -94.692 | 8/3/2016 | Summer | OK121600( | 10 | 4 | 14 | 2 | 26 | 74 | 0 |
| Sycamore Creek | 36.76853 | -94.692 | 2/1/2017 | Winter | OK121600( | 0 | 0 | 20 | 0 | 8 | 30 | 0 |
| Sycamore Creek | 36.76853 | -94.692 | 6/27/2017 | Summer | OK121600( | 16 | 8 | 72 | 0 | 64 | 10 | 4 |
| Sycamore Creek | 36.76853 | -94.692 | 1/26/2018 | Winter | OK121600( | 2 | 8 | 78 | 0 | 2 | 76 | 0 |
| Tar Creek | 36.87481 | -94.862 | 7/24/2001 | Summer | OK121600( | 0 | 0 | 42 | 10 | 0 | 0 | 0 |
| Tar Creek | 36.87481 | -94.862 | 1/28/2002 | Winter | OK121600( | 0 | 0 | 224 | 0 | 0 | 0 | 0 |
| Tar Creek | 36.87481 | -94.862 | 7/15/2002 | Summer | OK121600( | 0 | 0 | 192 | 38 | 0 | 0 | 0 |
| Tar Creek | 36.87481 | -94.862 | 1/13/2003 | Winter | OK121600( | 0 | 0 | 44 | 0 | 0 | 0 | 0 |
| Tar Creek | 36.87481 | -94.862 | 7/10/2006 | Summer | OK121600( | 0 | 0 | 10 | 2 | 0 | 0 | 0 |
| Tar Creek | 36.87481 | -94.862 | 8/9/2007 | Summer | OK121600( | 6 | 2 | 200 | 0 | 0 | 0 | 0 |
| Tar Creek | 36.87481 | -94.862 | 1/7/2008 | Winter | OK121600( | 0 | 0 | 42 | 2 | 0 | 0 | 0 |
| Tar Creek | 36.87481 | -94.862 | 7/11/2011 | Summer | OK121600( | 0 | 0 | 110 | 2 | 0 | 0 | 0 |
| Tar Creek | 36.87481 | -94.862 | 1/3/2012 | Winter | OK121600( | 0 | 0 | 28 | 0 | 2 | 2 | 0 |
| Tar Creek | 36.87481 | -94.862 | 7/2/2012 | Summer | OK121600( | 0 | 0 | 68 | 2 | 0 | 0 | 0 |
| Tar Creek | 36.87481 | -94.862 | 8/3/2016 | Summer | OK121600( | 0 | 0 | 306 | 0 | 0 | 0 | 0 |
| Tar Creek | 36.87481 | -94.862 | 2/7/2017 | Winter | OK121600( | 0 | 0 | 188 | 0 | 0 | 2 | 0 |
| Tar Creek | 36.87481 | -94.862 | 6/26/2017 | Summer | OK121600( | 2 | 0 | 336 | 0 | 0 | 2 | 0 |
| Tar Creek | 36.87481 | -94.862 | 1/25/2018 | Winter | OK121600( | 0 | 0 | 154 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 36.539 | -94.7596389 | 6/21/2016 | Summer | OK121600( | 6 | 4 | 38 | 2 | 46 | 2 | 0 |
| Whitewater Creek: | 36.539 | -94.7596389 | 2/6/2017 | Winter | OK121600( | 6 | 2 | 178 | 0 | 0 | 2 | 0 |
| Whitewater Creek: | 36.539 | -94.7596389 | 7/11/2017 | Summer | OK121600( | 8 | 0 | 74 | 0 | 56 | 10 | 8 |
| Whitewater Creek: | 36.539 | -94.7596389 | 3/13/2018 | Winter | OK121600( | 6 | 6 | 86 | 0 | 20 | 30 | 0 |

| SiteName | Date | Corydalidae | Perlidae | Hydropsychidae | Odontoceridae | Dugesiidae | Asellidae | Caenidae | Ephemerellidae | Isonychiidae | Perlodidae |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Horse Creek | 8/3/2016 | 0 | 0 | 24 | 0 | 0 | 0 | 32 | 0 | 0 | 0 |
| Horse Creek | 2/7/2017 | 0 | 0 | 20 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| Horse Creek | 6/26/2017 | 0 | 0 | 110 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| Horse Creek | 1/25/2018 | 0 | 0 | 20 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Drowning Creek | 1/29/2002 | 0 | 0 | 0 | 0 | 6 | 178 | 0 | 0 | 0 | 0 |
| Drowning Creek | 7/15/2002 | 0 | 0 | 0 | 0 | 0 | 108 | 0 | 0 | 0 | 0 |
| Drowning Creek | 1/27/2003 | 0 | 1 | 0 | 0 | 4 | 180 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 7/31/2001 | 12 | 2 | 2 | 0 | 0 | 20 | 18 | 0 | 4 | 0 |
| Sycamore Creek | 1/29/2002 | 2 | 8 | 4 | 0 | 0 | 40 | 0 | 0 | 22 | 8 |
| Sycamore Creek | 7/15/2002 | 8 | 0 | 10 | 0 | 5 | 2 | 4 | 0 | 58 | 0 |
| Sycamore Creek | 1/13/2003 | 4 | 2 | 6 | 0 | 0 | 134 | 0 | 0 | 102 | 0 |
| Sycamore Creek | 7/10/2006 | 2 | 0 | 6 | 0 | 2 | 30 | 16 | 0 | 6 | 0 |
| Sycamore Creek | 1/11/2007 | 2 | 8 | 2 | 0 | 3 | 94 | 0 | 0 | 18 | 0 |
| Sycamore Creek | 8/9/2007 | 12 | 4 | 18 | 2 | 0 | 0 | 0 | 0 | 4 | 0 |
| Sycamore Creek | 1/7/2008 | 0 | 0 | 20 | 0 | 1 | 176 | 0 | 2 | 52 | 0 |
| Sycamore Creek | 7/11/2011 | 12 | 2 | 16 | 0 | 0 | 0 | 2 | 0 | 16 | 0 |
| Sycamore Creek | 1/3/2012 | 0 | 10 | 14 | 0 | 0 | 12 | 0 | 0 | 56 | 0 |
| Sycamore Creek | 7/2/2012 | 8 | 2 | 36 | 0 | 0 | 2 | 0 | 0 | 12 | 0 |
| Sycamore Creek | 2/5/2013 | 0 | 4 | 20 | 0 | 0 | 32 | 4 | 2 | 34 | 0 |
| Sycamore Creek | 8/3/2016 | 14 | 6 | 34 | 0 | 1 | 24 | 10 | 0 | 20 | 0 |
| Sycamore Creek | 2/1/2017 | 2 | 16 | 34 | 0 | 0 | 2 | 0 | 0 | 76 | 2 |
| Sycamore Creek | 6/27/2017 | 0 | 8 | 0 | 0 | 0 | 6 | 8 | 0 | 0 | 0 |
| Sycamore Creek | 1/26/2018 | 0 | 42 | 8 | 0 | 2 | 0 | 0 | 6 | 10 | 0 |
| Tar Creek | 7/24/2001 | 4 | 0 | 164 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/28/2002 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/15/2002 | 2 | 0 | 54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/13/2003 | 2 | 0 | 198 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/10/2006 | 2 | 0 | 148 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 8/9/2007 | 8 | 2 | 36 | 0 | 0 | 0 | 14 | 0 | 0 | 0 |
| Tar Creek | 1/7/2008 | 0 | 0 | 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/11/2011 | 0 | 0 | 54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/3/2012 | 0 | 2 | 12 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| Tar Creek | 7/2/2012 | 2 | 0 | 112 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 8/3/2016 | 2 | 0 | 82 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| Tar Creek | 2/7/2017 | 2 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 6/26/2017 | 0 | 0 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/25/2018 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 6/21/2016 | 0 | 0 | 98 | 0 | 0 | 4 | 4 | 0 | 0 | 0 |
| Whitewater Creek: | 2/6/2017 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 7/11/2017 | 18 | 0 | 48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 3/13/2018 | 0 | 2 | 14 | 0 | 1 | 2 | 10 | 4 | 2 | 4 |

| SiteName | Date | Philopotamidae | Simuliidae | Tipulidae | Hyalellidae | Nemouridae | Limnephilidae | Helicopsychidae | Pleuroceridae | Hydroptilidae |
|---|---|---|---|---|---|---|---|---|---|---|
| Horse Creek | 8/3/2016 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 |
| Horse Creek | 2/7/2017 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Horse Creek | 6/26/2017 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Horse Creek | 1/25/2018 | 0 | 14 | 0 | 9 | 0 | 0 | 0 | 0 | 0 |
| Drowning Creek | 1/29/2002 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 |
| Drowning Creek | 7/15/2002 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 0 | 0 |
| Drowning Creek | 1/27/2003 | 0 | 0 | 0 | 28 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 7/31/2001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 1/29/2002 | 2 | 18 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Sycamore Creek | 7/15/2002 | 4 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Sycamore Creek | 1/13/2003 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 76 | 0 |
| Sycamore Creek | 7/10/2006 | 10 | 2 | 0 | 23 | 0 | 0 | 0 | 2 | 0 |
| Sycamore Creek | 1/11/2007 | 4 | 10 | 0 | 2 | 0 | 4 | 0 | 6 | 2 |
| Sycamore Creek | 8/9/2007 | 6 | 2 | 0 | 0 | 0 | 0 | 0 | 26 | 0 |
| Sycamore Creek | 1/7/2008 | 10 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| Sycamore Creek | 7/11/2011 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| Sycamore Creek | 1/3/2012 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 7/2/2012 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 2/5/2013 | 8 | 0 | 0 | 4 | 0 | 0 | 0 | 10 | 0 |
| Sycamore Creek | 8/3/2016 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 2/1/2017 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 6/27/2017 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 1/26/2018 | 2 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Tar Creek | 7/24/2001 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/28/2002 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/15/2002 | 0 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 2 |
| Tar Creek | 1/13/2003 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/10/2006 | 0 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 8/9/2007 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/7/2008 | 0 | 18 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/11/2011 | 2 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/3/2012 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| Tar Creek | 7/2/2012 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 8/3/2016 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 4 |
| Tar Creek | 2/7/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 6/26/2017 | 2 | 14 | 0 | 1 | 0 | 0 | 0 | 0 | 6 |
| Tar Creek | 1/25/2018 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 6/21/2016 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 2/6/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 7/11/2017 | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 3/13/2018 | 2 | 0 | 2 | 1 | 4 | 0 | 0 | 0 | 0 |

| SiteName | Date | Naididae | Sphaeriidae | Cambaridae | Coenagrionidae | Capniidae | Physidae | Glossiphoniidae | Erpobdellidae | Ephydridae | Leptophlebiidae |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Horse Creek | 8/3/2016 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Horse Creek | 2/7/2017 | 8 | 8 | 0 | 0 | 0 | 0 | 2 | 42 | 0 | 0 |
| Horse Creek | 6/26/2017 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 |
| Horse Creek | 1/25/2018 | 32 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Drowning Creek | 1/29/2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Drowning Creek | 7/15/2002 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Drowning Creek | 1/27/2003 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 7/31/2001 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 1/29/2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 7/15/2002 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 |
| Sycamore Creek | 1/13/2003 | 2 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 1 |
| Sycamore Creek | 7/10/2006 | 12 | 0 | 0 | 6 | 0 | 2 | 2 | 0 | 0 | 0 |
| Sycamore Creek | 1/11/2007 | 0 | 0 | 0 | 2 | 2 | 2 | 0 | 0 | 2 | 0 |
| Sycamore Creek | 8/9/2007 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Sycamore Creek | 1/7/2008 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 7/11/2011 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Sycamore Creek | 1/3/2012 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 7/2/2012 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 2/5/2013 | 0 | 2 | 0 | 0 | 2 | 12 | 0 | 0 | 0 | 6 |
| Sycamore Creek | 8/3/2016 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Sycamore Creek | 2/1/2017 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 6/27/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 1/26/2018 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/24/2001 | 2 | 0 | 0 | 10 | 0 | 2 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/28/2002 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/15/2002 | 2 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/13/2003 | 0 | 0 | 0 | 4 | 0 | 20 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/10/2006 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| Tar Creek | 8/9/2007 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/7/2008 | 5 | 0 | 0 | 4 | 0 | 8 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/11/2011 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/3/2012 | 2 | 0 | 0 | 6 | 0 | 4 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/2/2012 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 8/3/2016 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 2/7/2017 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 6/26/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/25/2018 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 6/21/2016 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Whitewater Creek: | 2/6/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 7/11/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 3/13/2018 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| SiteName | Date | Argulidae | Hydrophilidae | Leptoceridae | Polycentropodidae | Ceratopogonidae | Calopterygidae | Macromiidae | Planorbidae | |
|---|---|---|---|---|---|---|---|---|---|---|
| Horse Creek | 8/3/2016 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Horse Creek | 2/7/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| Horse Creek | 6/26/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| Horse Creek | 1/25/2018 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | |
| Drowning Creek | 1/29/2002 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | |
| Drowning Creek | 7/15/2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Drowning Creek | 1/27/2003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Sycamore Creek | 7/31/2001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Sycamore Creek | 1/29/2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Sycamore Creek | 7/15/2002 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | |
| Sycamore Creek | 1/13/2003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Sycamore Creek | 7/10/2006 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 2 | |
| Sycamore Creek | 1/11/2007 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | |
| Sycamore Creek | 8/9/2007 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Sycamore Creek | 1/7/2008 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | |
| Sycamore Creek | 7/11/2011 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Sycamore Creek | 1/3/2012 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Sycamore Creek | 7/2/2012 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Sycamore Creek | 2/5/2013 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | |
| Sycamore Creek | 8/3/2016 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | |
| Sycamore Creek | 2/1/2017 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | |
| Sycamore Creek | 6/27/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Sycamore Creek | 1/26/2018 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Tar Creek | 7/24/2001 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Tar Creek | 1/28/2002 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Tar Creek | 7/15/2002 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Tar Creek | 1/13/2003 | 0 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Tar Creek | 7/10/2006 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Tar Creek | 8/9/2007 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | |
| Tar Creek | 1/7/2008 | 1 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Tar Creek | 7/11/2011 | 0 | 0 | 8 | 6 | 0 | 0 | 0 | 0 | |
| Tar Creek | 1/3/2012 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Tar Creek | 7/2/2012 | 0 | 12 | 2 | 2 | 0 | 0 | 0 | 0 | |
| Tar Creek | 8/3/2016 | 0 | 10 | 0 | 2 | 0 | 0 | 0 | 0 | |
| Tar Creek | 2/7/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Tar Creek | 6/26/2017 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | |
| Tar Creek | 1/25/2018 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Whitewater Creek: | 6/21/2016 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Whitewater Creek: | 2/6/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Whitewater Creek: | 7/11/2017 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | |
| Whitewater Creek: | 3/13/2018 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

| SiteName | Date | Tetrastemmatidae | Tabanidae | Gomphidae | Glossosomatidae | Gammaridae | Psychomyiidae | Sialidae | Taeniopterygidae |
|---|---|---|---|---|---|---|---|---|---|
| Horse Creek | 8/3/2016 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Horse Creek | 2/7/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Horse Creek | 6/26/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Horse Creek | 1/25/2018 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Drowning Creek | 1/29/2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Drowning Creek | 7/15/2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Drowning Creek | 1/27/2003 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Sycamore Creek | 7/31/2001 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 1/29/2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 7/15/2002 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 1/13/2003 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 4 |
| Sycamore Creek | 7/10/2006 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 1/11/2007 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 8/9/2007 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 1/7/2008 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 7/11/2011 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 1/3/2012 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 7/2/2012 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 2/5/2013 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 8/3/2016 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 2/1/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 6/27/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 1/26/2018 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/24/2001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/28/2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/15/2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/13/2003 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/10/2006 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 8/9/2007 | 0 | 2 | 0 | 0 | 0 | 0 | 4 | 0 |
| Tar Creek | 1/7/2008 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/11/2011 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/3/2012 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/2/2012 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 8/3/2016 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 2/7/2017 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 6/26/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/25/2018 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 6/21/2016 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 2/6/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 7/11/2017 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 3/13/2018 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| SiteName | Date | Sparganophilidae | Sperchonidae | Ephemeridae | Muscidae | Viviparidae | Scirtidae | Hygrobatidae | Corixidae | Planariidae | Talitridae |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Horse Creek | 8/3/2016 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 |
| Horse Creek | 2/7/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Horse Creek | 6/26/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Horse Creek | 1/25/2018 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 9 |
| Drowning Creek | 1/29/2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 6 |
| Drowning Creek | 7/15/2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 18 |
| Drowning Creek | 1/27/2003 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 28 |
| Sycamore Creek | 7/31/2001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 1/29/2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 7/15/2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 |
| Sycamore Creek | 1/13/2003 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Sycamore Creek | 7/10/2006 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 23 |
| Sycamore Creek | 1/11/2007 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 |
| Sycamore Creek | 8/9/2007 | 3 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 1/7/2008 | 0 | 0 | 0 | 1 | 0 | 4 | 0 | 0 | 1 | 0 |
| Sycamore Creek | 7/11/2011 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 1/3/2012 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 7/2/2012 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 2/5/2013 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| Sycamore Creek | 8/3/2016 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Sycamore Creek | 2/1/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 6/27/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 1/26/2018 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| Tar Creek | 7/24/2001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/28/2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/15/2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/13/2003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/10/2006 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 8/9/2007 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/7/2008 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/11/2011 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/3/2012 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/2/2012 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 8/3/2016 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Tar Creek | 2/7/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 6/26/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Tar Creek | 1/25/2018 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 6/21/2016 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| Whitewater Creek: | 2/6/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 7/11/2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 3/13/2018 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |

| SiteName | Date | Lumbricidae | Ancylidae | Astacidae | Glossoscolecidae | Anthomyiidae |
|---|---|---|---|---|---|---|
| Horse Creek | 8/3/2016 | 0 | 0 | 0 | 0 | 0 |
| Horse Creek | 2/7/2017 | 0 | 1 | 0 | 0 | 0 |
| Horse Creek | 6/26/2017 | 0 | 1 | 0 | 0 | 0 |
| Horse Creek | 1/25/2018 | 0 | 2 | 0 | 0 | 0 |
| Drowning Creek | 1/29/2002 | 0 | 0 | 2 | 0 | 0 |
| Drowning Creek | 7/15/2002 | 0 | 0 | 2 | 0 | 0 |
| Drowning Creek | 1/27/2003 | 0 | 0 | 0 | 1 | 0 |
| Sycamore Creek | 7/31/2001 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 1/29/2002 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 7/15/2002 | 0 | 0 | 1 | 0 | 0 |
| Sycamore Creek | 1/13/2003 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 7/10/2006 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 1/11/2007 | 0 | 0 | 1 | 0 | 0 |
| Sycamore Creek | 8/9/2007 | 0 | 0 | 0 | 3 | 0 |
| Sycamore Creek | 1/7/2008 | 0 | 0 | 0 | 0 | 1 |
| Sycamore Creek | 7/11/2011 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 1/3/2012 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 7/2/2012 | 1 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 2/5/2013 | 3 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 8/3/2016 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 2/1/2017 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 6/27/2017 | 0 | 0 | 0 | 0 | 0 |
| Sycamore Creek | 1/26/2018 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/24/2001 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/28/2002 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/15/2002 | 2 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/13/2003 | 3 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/10/2006 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 8/9/2007 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/7/2008 | 22 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/11/2011 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/3/2012 | 0 | 0 | 0 | 0 | 0 |
| Tar Creek | 7/2/2012 | 1 | 0 | 0 | 0 | 0 |
| Tar Creek | 8/3/2016 | 1 | 0 | 0 | 0 | 0 |
| Tar Creek | 2/7/2017 | 4 | 0 | 0 | 0 | 0 |
| Tar Creek | 6/26/2017 | 1 | 0 | 0 | 0 | 0 |
| Tar Creek | 1/25/2018 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 6/21/2016 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 2/6/2017 | 0 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 7/11/2017 | 1 | 0 | 0 | 0 | 0 |
| Whitewater Creek: | 3/13/2018 | 1 | 0 | 0 | 0 | 0 |

**APPENDIX E-15 1990 Pensacola Project Entrainment Study Report**

# ENTRAINMENT SUSCEPTIBILITIES OF FISHES INHABITING THE LOWER PORTION OF GRAND LAKE, OKLAHOMA

By

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# Chapter I

## INTRODUCTION

This thesis is comprised of one manuscript written for submission to the Transactions of the American Fisheries Society. Chapter I is an introduction to the rest of the thesis. The manuscript is complete as written and does not require additional support material. The manuscript is contained in Chapter II and is titled 'Entrainment susceptibilities of fishes inhabiting the lower portion of Grand Lake, Oklahoma.'

# Chapter II

# ENTRAINMENT SUSCEPTIBILITIES OF FISHES INHABITING THE LOWER PORTION OF GRAND LAKE, OKLAHOMA

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Abstract.-I documented the seasonal dynamics of juvenile and adult fish in the vicinity of the Pensacola Dam hydropower facility on Grand Lake, Oklahoma, to determine species-specific entrainment susceptibilities. Fishes in Grand Lake were sampled monthly from August 1988 to July 1989 using gill nets, trap nets, and electrofishing gear. Water quality profiles were recorded concurrently. I used techniques typically used to quantify foraging preferences of selective predators to estimate the entrainment susceptibilities of individual species to non-selective "predation" by hydropower intakes. Relative abundances of fishes in Grand Lake were compared to relative abundances of fishes entrained (obtained from a concurrent study estimating entrainment rates) using Strauss' electivity index to determine species-specific entrainment susceptibilities. Wilcoxon's signed-rank test was used to incorporate sampling error and test statistical significance. Fishes were not entrained at rates reflecting their relative abundance in the lake. Only 8 of the 25 species collected in Grand Lake were entrained. Entrainment of gizzard shad exceeded expectations based on their relative abundance in the reservoir and it was the only species significantly susceptible to entrainment. Susceptibility to entrainment of all other species was negative or proportional to relative abundance. High midwinter entrainment of gizzard shad resulted from their

habitation of deep water proximal to the turbine intakes and cold-induced torpor. Entrainment was size-selective being skewed to enhance the selection of small fish. Occasional entrainment of white crappie and channel catfish was probably a result of the predilection of these species for structural cover in deep water as afforded by the forebay of the intake structure. Hypolimnetic anoxia associated with summer stratification precluded entrainment of all species during summer.

Extensive research on the effects of hydropower on adult and juvenile fish has been conducted in coldwater systems. These studies addressed upstream and downstream passage associated with the completion of life cycles of anadromous salmon and shad in the Pacific Northwest and New England (e.g., Schoeneman et al. 1961; Raymond 1979; Bell and Kynard 1985). Fish passing through hydropower plants may be subject to both immediate and delayed mortality. Common forms of immediate mortality include decapitation and crushing; delayed forms include deaths resulting from internal injuries, sudden pressure changes, and predation (Cramer and Oligher 1964; Cada 1988). Of no less importance are the fishes merely displaced downstream from the dam, because they are lost from the reservoir fishery.

Entrainment in warm-water reservoirs has not been studied because of the absence of obligatory migrants in these systems. However, many warmwater reservoirs contain populations of once-anadromous, now land-locked species (e.g., striped bass, *Morone saxatilis*; Scruggs 1955) which range widely (Pflieger 1975) and are subject to entrainment. In addition, many reservoir fishes are pelagic and nomadic (Pflieger 1975), rendering them vulnerable to entrainment. Grand Lake O' the Cherokees (Grand Lake) is an 18,818-hectare multi-purpose hydropower impoundment completed by the Grand River Dam Authority (GRDA) in 1940 by inundation of the Grand (Neosho) River by the Pensacola Dam. Grand

Lake was authorized by Congress to provide flood control, recreation, and hydropower, and the hydroelectric generating plant was granted a 50-year operating license. The license expired in 1988 and required renewal for the GRDA to continue hydropower generation. Relicensing required the GRDA to prepare an environmental impact assessment of the hydropower project. This assessment provided an opportunity to examine the effects of entrainment by the hydropower plant on adult and juvenile fishes in a warm-water reservoir.

The only previous study on entrainment of adult and juvenile warm-water fish was on the Ohio River (Greenup Dam, Vanceburg, Kentucky). Seasonal spatial and temporal distributions of fishes remained unchanged throughout the nine month duration of the study. At least 80 percent of the fish detected hydroacoustically immediately upstream of the forebay trashracks were entrained into the turbine gallery. Of those entrained, 93 percent were gizzard shad (Dorosoma cepedianum) and freshwater drum (Aplodinotus grunniens). Sport fish were entrained at a lower rate than expected as judged by their relative abundances upstream from the dam. However, no work was done during the winter months when streamflows peaked and entrainment potentials probably were greatest (Olson et al. 1988).

Simply documenting the presence of fishes in areas of potentially high entrainment risk does not allow estimation of entrainment because the assumption of equal species-specific entrainment susceptibility is likely erroneous (Helvey 1985). Entrainment susceptibility is regulated by attraction to intake structures, taxis to current, and body length due to the relationship between swimming speed and body length (Jones et al. 1974). Behavioral activities of a species may enhance or diminish entrainment potential, but species-specific entrainment susceptibilities have only been inferred by investigating behaviors and life histories (Helvey 1985).

Estimates of entrainment susceptibility can be made by comparing relative abundances of fishes subject to entrainment to the relative abundances of fishes entrained. My goal was to assess the possible effects of hydropower generation on fish populations in the lower portion of Grand Lake. Accordingly, my objectives were to: determine if relative abundances of fishes in the lower portion of Grand Lake were reflected by species-specific entrainment rates; determine if seasonal distribution of fishes contributed to the entrainment susceptibilities of fishes in the lower portion of Grand Lake; and determine if temporal differences in water quality affected entrainment rates of fishes in the lower portion of Grand Lake.

## STUDY SITE

Grand Lake is a monomictic reservoir in northeastern Oklahoma with a mean depth of 13 meters and a maximum depth of about 45 meters. It has a capacity of 1,672,000 acre-feet at the top of the power pool (elevation 745 feet MSL). It has a shoreline of of 998 km and is about 88 km long from the confluence of the Neosho and Spring rivers in the north to the dam in the south. It has an irregular shoreline with numerous bays and small coves and has a shoreline development index value of 43.1. The average discharge during 44 years of record (1939-1981) was 6809 cfs (Oklahoma Water Resources Board 1984). This equates to a flushing rate of about once every 100 days.

The hydropower intakes are housed in a structure about 20 meters off the face of the dam (Figure 1). Three 4.6-m diameter penstocks supply water to six-14,400-kw generators. Net generating head is about 120 ft. The top of the intake is at elevation 705 feet MSL and the bottom is at elevation 682 feet MSL. The intake structure is about 35 m long and distance between the upstream trashracks and the intakes is about 6 m.

# METHODS

## Field techniques

The fish assemblage inhabiting Grand Lake in the vicinity of Pensacola Dam was sampled at about monthly intervals from August 1988 to July 1989 using three gear types (gill nets, trap nets, and electrofishing). The study area encompassed the lower section of Grand Lake within about 3 km of the hydroelectric facility (Figure 2). The area was divided into 22 sampling blocks, each roughly 500-m square (Figure 2).

From August through December 1988, twelve monofilament-nylon experimental gill nets were set each month. The nets were 2.4 m deep, 91.4 m long, and included six 15.2-m panels with bar mesh sizes of 3.81, 5.08, 6.35, 7.62, 8.89, and 10.16 cm. A stratified-random sampling design was used to select net locations and depths, with emphasis placed on the four blocks in the vicinity of the hydropower intakes (blocks 1, 2, 5, and 6; Figure 2). Four nets were set at randomly selected locations in these blocks, and the remainder were set in randomly selected blocks throughout the study area. Four nets were set at the surface, four at mid-water, and four at the bottom. Nets were fished for 24 hours. All captured fish were removed, identified, weighed (g), measured (mm total length), and released. Each net set constituted one unit of effort. Effort was increased to 16 net sets per month from January through July 1989 by the addition of four nets in block 1.

Ten trap nets were set in the study area on each sampling date. Trap nets were set in coves in sampling blocks 1 (2 nets), 4 (4 nets), 8 (3 nets), and 13 (2 nets). The nets were constructed of tarred 1.3-cm nylon mesh stretched over two 1.8x0.9-m frames and four 0.76-m diameter hoops; a single 12.7-m lead extended perpendicularly from the mouth of each net. The trap nets were set perpendicular to shore with their leads extending towards shore and fished for 24 hours. All captured fish were removed, identified, weighed, measured, and released. Each net set constituted one unit of effort in the catch-rate analyses.

A commercially-produced 6.1-m aluminum electrofishing boat (Coffelt Manufacturing, Inc., Flagstaff, AZ) was used to complete 10 standardized electrofishing transects each month from August through December 1988. Pulsed direct current (300 volts, 6 to 8 amperes, 60% pulse width, 80 pulses per second) was applied in 500-m linear transects. Transects were completed at randomly selected stations stratified as follows: three along the east shoreline (blocks 4, 8, and 13), one along the west shoreline (blocks 1, 5, 9, 14, 19, 20, and 22), one along the face of the dam in block 1, one along the shoreline in block 1, and four in open-water blocks. Two of the open-water transects were in the vicinity of the hydropower intakes (blocks 1, 2, 5, and 6; Figure 1). All captured fish were identified, weighed, measured, and released. Total catches of each species in each transect will constitute catch-per-unit-effort rates (i.e., number per transect). Effort was increased to 12 electrofishing transects per month from January through July 1989 by the addition of two open water transects in block 1.

Water quality profiles of the water column about 150 m directly upstream from the hydroelectric facility were recorded in association with fish sampling. Water temperature, dissolved oxygen concentration, pH, and conductivity were measured with a Hydrolab Surveyor II at 1-m intervals from the surface to a depth of 20 m; additional measurements were taken at 5-m intervals to the bottom.

Analyses

Mean catch-per-unit-effort (CPUE) rates (by gear) of all species in aggregate and of species composing >1% of total catch were plotted over time to assess seasonal trends in abundance at the study sites. A catch index value combining the two most effective gear types for each species was calculated for each sampling date to facilitate evaluation of seasonal trends in abundance of major species; the index incorporated the relative magnitude of gear-specific catch rates by date and treated both gears equally. Monthly gear-specific CPUE rates were divided by the highest CPUE of that gear type obtained over the study duration to calculate a relative CPUE value ranging from 0 to 1. The catch index value was the mean of the two relative CPUE rates. For example: Monthly index value = [(Gear 1 monthly CPUE/Gear 1 highest observed CPUE)+(Gear 2 monthly CPUE/Gear 2 highest observed CPUE)]/2. All three gear types were used to calculate the index value for all species in aggregate. The index values were used only to facilitate evaluation of seasonal trends; they were not used in the quantitative analyses.

Analysis of variance was used to test whether significant differences existed in mean CPUE rates of all species among sampling dates. Duncan's multiple comparison procedure was used to identify months during which CPUE rates were significantly different (alpha = 0.05). Length-frequency distributions of fishes collected in Grand Lake were constructed for comparison with fishes collected in the entrainment samples.

A concurrent study conducted by the Oklahoma Cooperative Fish and Wildlife Research Unit estimated monthly entrainment of fishes at the Pensacola Dam hydropower facility (Fisher and Zale 1990). Entrained fish were collected in modified fyke nets positioned in the draft tubes. The densities of entrained fish were multiplied by monthly discharges to estimate total monthly entrainment. A total of nine species were entrained (gizzard shad, white crappie (Pomoxis annularis), channel catfish (Ictalurus punctatus), bluegill (Lepomis macrochirus), blue catfish (Ictalurus furcatus), green sunfish (Lepomis cyanellus), freshwater drum, white bass (Morone chrysops), and bigmouth buffalo (Ictiobus cyprinellus); Appendix A). Most entrained individuals were small (<200 mm), with the exception of a few catchable-sized channel catfish and one large bigmouth buffalo.

These entrainment estimates were compared to relative abundances of fishes in monthly collections from Grand Lake to estimate entrainment susceptibilities of species present. I used techniques typically used to quantify foraging preferences of selective predators to quantify susceptibilities of individual species to non-selective 'predation' by the turbine intakes. The linear electivity index (Strauss 1979) was used to determine relative susceptibilities of individual species to entrainment; the index is defined as

$$L=r-p$$

where r and p are the relative abundances of a species in entrainment samples and Grand Lake, respectively. Strauss' index was used mainly because of its simplicity, but its linear property gives the advantage of having symmetrical deviation of the index for all values where r does not equal p (Lechowicz 1982). Relative abundances of each species in pooled monthly collections (all three gear types) and in pooled monthly turbine-net samples were compared. L ranges from -1 to +1, with positive values indicating enhanced susceptibility to entrainment and negative values indicating lower susceptibility to entrainment. The expected value for a species entrained in proportion to its relative abundance (i.e., random susceptibility) is zero. Wilcoxon's signed-rank test (Hollander and Wolfe 1973; Kohler and Ney 1982) was used to determine if susceptibilities were significantly different from random. Relative abundances of each species in pooled monthly collections and in individual turbine-net samples collected in a month were compared using this nonparametric paired test (Appendix B).

## RESULTS

A total of 25 species composed of 3,726 individuals was collected in the lower Grand Lake study area with all three gear types from August 1988 to July 1989. Gizzard shad dominated the total catch (34.2%), followed by white crappie (14.3%), brook silverside (Labidesthes sicculus; 13.9%) and bluegill (13.8%); 10 species individually composed >1% of the total catch and 95.4% in aggregate (Figure 3).

The white bass was the most abundant (27.3%) of the 15 species in the gill net catch, followed by white crappie (23.8%), channel catfish (18.4%), and gizzard shad (10.2%). Ten species individually composed >1% of the gill-net catch and 97.6% in aggregate. White crappie (51.7%) and bluegill (37.5%) dominated the trap-net catch. Six of the 14 species collected with trap nets individually composed >1% of the catch and 98.2% in aggregate. The electrofishing catch was dominated by gizzard shad (51.6%). Brook silversides composed 22.3% of the electrofishing catch and 7 other species individually contributed at least 1%. In aggregate, these 9 species (out of 20) composed 97.7% of the electrofishing catch (Appendix C).

Gear-specific catch rates of all species in aggregate exhibited only modest seasonal fluctuations (Table 1). Catch rates of all species in aggregate for all gear types tended to be low and stable in autumn and winter and higher, yet variable, in spring and summer (Figure 4). Significant differences existed among monthly mean catch rates of all species in aggregate (Appendix D) only for trap nets (P=0.0012); no significant difference existed among monthly mean catch rates of all species in aggregate in gill nets (P=0.1320) or by electrofishing (P=0.1177).

Of the 11 major species present in lower Grand Lake (i.e., species that composed >1% of the total catch), significant differences existed among monthly mean catch rates of only three (bluegill, channel catfish, and gizzard shad) in the gear type most effective for each. Catch rates of bluegill in trap nets and channel catfish in gill nets were significantly elevated during July 1989 and June 1989, respectively. Catch rates of gizzard shad in electrofishing samples were significantly higher in November 1988 than during the remainder of the study period. Gill net catches of white bass peaked in April 1989, but the increased catch rate was not significant. Although elevated in summer, no significant differences existed among the monthly mean catch rates of the remaining abundant and entrained species in the gear type most effective for each (white crappie in trap nets, and green sunfish in electrofishing samples).

The length-frequency distribution of gizzard shad collected in lower Grand Lake was largely unimodal and primarily composed of adult sizes; the entrained gizzard shad consisted of mainly young-of-the-year individuals (Figure 5). The length frequency distribution of white crappie in Grand Lake consisted of unimodal adult-sized (>200 mm) individuals; entrained white crappie were represented by smaller (<200 mm) individuals. Channel catfish in Grand Lake were represented by wide size ranges of individuals including multiple age-classes and catchable-sized individuals. Entrained channel catfish were represented largely by sub-adult individuals, but catchable-sized fish were also collected.

Of 9 species entrained, 8 were collected in lower Grand Lake. A single bigmouth buffalo was taken in entrainment samples, but the species was absent in Grand Lake collections. Species that composed >1% of the Grand Lake assemblage but which were not entrained, included brook silversides, largemouth bass, smallmouth buffalo, and longear sunfish. Thirteen other species also collected in Grand Lake were absent from entrainment samples.

Susceptibility to entrainment of the 9 species entrained from August 1988 to July 1989 was positive (as judged by the linear electivity index) only for gizzard shad and bigmouth buffalo over the entire period (Table 2). However, susceptibility to entrainment was significantly positive only for gizzard shad over the entire August 1988 to July 1989 period; susceptibility was significantly negative for all other species (Table 2).

Entrainment susceptibilities of individual species varied among months as relative abundances in Grand Lake and in entrainment samples changed. However, significant positive susceptibility to entrainment was limited to gizzard shad and only from February through June 1989 (Figure 6). Entrainment of gizzard shad did not differ significantly from random during other months except during November 1988 when they were significantly negatively susceptible to entrainment. Monthly entrainment susceptibilities of all other species were either random or significantly negative over the entire period (Appendix B).

Seasonal trends in susceptibility to entrainment were evident only for gizzard shad, white crappie, and channel catfish. Entrainment susceptibilities of gizzard shad were depressed in autumn and enhanced in late winter, spring, and summer (Figure 6). The inverse, albeit less dramatic, was evident for white crappie and channel catfish (Figure 6). Entrainment susceptibilities of white bass, bluegill, blue catfish, green sunfish, and freshwater drum were typically random or slightly negative and showed no distinct seasonal trends.

Limnological characteristics of the water column in the immediate vicinity of Pensacola Dam (Figures 7 and 8) were largely dictated by seasonal reservoir stratification dynamics. Strong stratification was evident from August through October 1988 (Figure 7), but dissolved oxygen concentrations in 1988 were <2 mg/L over the entire range of depths encompassed by the intakes only during August (Figure 7). Stratification was absent from November 1988 through March 1989 (Figure 8), intermediate in May 1989 (Figure 8), and returned to patterns exhibited in October 1988 (Figure 7) and August 1988 (Figure 7) in June and July 1989, respectively. Dissolved oxygen concentrations were <2 mg/L over the entire range of depths encompassed by the intakes, similar to August 1988 profiles (Figure 7), again during July 1989. Only two fish were caught in gill nets set below the thermocline during periods when the reservoir was stratified; these may have become enmeshed during net retrieval.

## DISCUSSION

The relative abundances of individual fish species in the hydropower intake area of Grand Lake did not accurately reflect relative entrainment rates. Both lake and entrainment samples were dominated by gizzard shad, but entrainment of this species often exceeded its relative abundance, suggesting it was more susceptible to entrainment than other fishes present in lower reaches of Grand Lake. The gizzard shad accounted for over 99% of the total abundance in entrainment samples (Fisher and Zale 1990), but it composed about 34% of the collections in Grand Lake. The gizzard shad was also the most frequently entrained species at Greenup Dam, Kentucky (Olson et al., 1988).

Gizzard shad tend to travel in large schools (Miller and Robison 1973; Pflieger 1975) which may predispose them to additional entrainment risk. At an offshore cooling intake off the Karachi coast of Pakistan, schooling fishes were generally more vulnerable to entrainment, as they were often sluggish, weak swimmers, and were generally of small size (Moazzam and Rizvi 1980). Schooling fishes were entrained at an offshore cooling intake off the California coast more often than resident reef fishes (Helvey 1985). Whereas gizzard shad are not a physically hardy species (Miller 1960), I do not believe them to be weak swimmers. However, schooling behavior may tend to magnify the consequence of an encounter with the hydropower intakes because entrainment is the fate of many individuals simultaneously.

Entrainment susceptibilities of other entrained species in Grand Lake (white crappie, channel catfish, bluegill, blue catfish, green sunfish, bigmouth buffalo, freshwater drum, and white bass) were negative and many species present in lower Grand Lake were absent in entrainment samples. These were often species that, due to their behavior and habitat preferences were not present in the deeper waters near the intake structures. For example, the brook silverside was numerically the third most abundant fish present in Grand Lake but was absent from entrainment samples. It spends most of its life within a few centimeters of the surface and never goes deeper than a few meters (Pflieger 1975). The largemouth bass (Micropterus salmoides) was not collected in entrainment sampled despite being the seventh most abundant fish collected in Grand Lake. Largemouth bass prefer weedy littoral areas and when in deeper water are found near bottom (Pflieger 1975).

Pelagic species other than gizzard shad (i.e., white bass, hybrid striped bass, and freshwater drum) did not appear to be susceptible to entrainment. Hybrid striped bass are stocked at locations far upstream of the intakes (Jim Smith, Oklahoma Department of Wildlife Conservation, pers. com.). Stocking them far upstream allows them time to grow before encountering the intakes and renders them less apt to be entrained. White bass migrate to tributary streams to spawn (Pflieger 1975), and by the time the young encounter the intakes, they too are likely large enough to effectively resist intake velocities. Freshwater drum were not abundant in the lower portion of Grand Lake and were entrained at rates proportional to, or less than, their monthly relative abundances.

White crappie and channel catfish were the only species other than gizzard shad often entrained. Although never significantly susceptible to entrainment, these were the only other species to frequently exhibit enhanced likelihood of entrainment as indicated by Strauss' index. Because lower Grand Lake is largely devoid of cover, the entrainment of these species may have resulted from their attraction to the cover afforded by the intake structure. Inasmuch as the intake structure offered cover, it also caused local vertical velocity gradients having an unknown effect on orientation and behavior (Hocutt and Edinger 1980).

Fishes may become entrained because of behaviors that bring them into direct contact with the intake water currents at times when their vision is impaired or when intake hydraulics disorient their position in the flow (Helvey 1985). Confusion caused by these factors may prevent fishes from vacating areas where intake velocities make entrainment imminent. In addition, the Pensacola plant is a load-control facility exhibiting frequent start-ups during peak electrical demand. This method of operation may have promoted entrainment of white crappie and channel catfish that were inhabiting the forebay during periods of non-generation.

Entrainment was size-selective and consisted primarily of small, young-of-the-year individuals. Although the hydroelectric facility's trash racks precluded entrainment of exceptionally large individuals, it is likely that size-selective entrainment was a function of the positive relationship between swimming speed and body length (Jones et al. 1974). Large individuals could attain swimming speeds required to escape intake velocities whereas smaller fish were unable to escape and were entrained. High entrainment rates of young-of-the-year gizzard shad during winter were likely a product of their size-mediated swimming ability, sensitivity to low temperatures (Miller 1960; Heidinger 1983), and propensity to 'hibernate' in deep water during winter (Velasquez 1939; Jester and Jensen 1972).

Seasonal changes in relative abundance were not reflected by similar entrainment rate changes. In fact, relative abundances in the lake were most often opposite those in the entrainment samples. Gizzard shad entrainment peaked during late winter and early spring coincident with their lowest CPUE rates and relative abundances in Grand Lake. Similarly, entrainment rates of other species (white crappie and channel catfish) were highest in late summer, autumn, and early winter, corresponding temporally with their lowest CPUE rates and relative abundances. The apparent high susceptibility of gizzard shad to entrainment during winter may have been due, in part, to sampling gear limitations. Gill nets were the only gear used to sample the profundal areas inhabited by the gizzard shad in the winter. Cold water renders passive gears less effective by reducing the activity of fish, ultimately leading to underrepresentation in the abundance estimates in the lake. The enhanced electivity index values (i.e., high susceptibility) may be an artifact of inadequate sampling gear performance, which artifically lowered the relative abundance estimates of gizzard shad in the winter samples of lower Grand Lake.

Seasonal stratification of Grand Lake influenced vertical fish distributions and entrainment rates. Fish were absent from the hypolimnion, but the thermocline was typically present at depths below the upper edge of the turbine intakes. Accordingly, stratification capable of inhibiting entrainment was present only during mid-summer. The two lowest estimates of monthly turbine entrainment were recorded in August 1988 and July 1989 when dissolved oxygen concentrations were <2 mg/L over the entire range of depths encompassed by the intakes. Gizzard shad, white crappie, and channel catfish avoid waters with dissolved oxygen concentrations less than 2 mg/L (Gebhart and Summerfelt 1978). However, low rates of entrainment during these months suggested that stratification was destabilized by hydropower generation in the forebay of the intake structure and allowed habitation of the forebay structure at the depth of the intakes by fish.

To minimize the effects of entrainment at hydropower facilities, methods to divert fish away from areas of high risk and practices to increase survival of entrained fish have been used. Operation of hydropower facilities at peak efficiency minimizes the probability of encounter of excess stress during turbine passage. Operation at low efficiency subjects entrained fish to increased cavitation, excess turbulence, and shear forces. However, no single operational or design approach decreases mortality rates to <10% on a consistent basis (Cada 1988). Where operational or design alterations are not feasible, appreciable decreases in mortality are best obtained through exclusion from areas of high entrainment risk. Due to the low entrainment rates of game fish and the seasonality of gizzard shad entrainment, implementation of entrainment deterrance devices would probably not lead to a significant improvement in the fishery of Grand Lake.

In summary, entrainment of recreationally and commercially important sport and food fishes by the Pensacola Dam hydroelectric facility was limited because these species were not abundant in the vicinity of the dam and their relative susceptibilities to entrainment were low. Gizzard shad, especially young-of-the-year, were seasonally susceptible to entrainment, but dominance of the reservoir's fish assemblage by this species suggested that effects of entrainment were minimal or inconsequential. Because gizzard shad are often considered over-abundant in impoundments (Miller 1960; Jenkins 1957), it seems unlikely that selective entrainment of this species is deleterious to the ichthyofauna of Grand Lake.

My research may be applicable to many morphologically similar southern reservoirs built primarily for hydropower generation. Application to smaller reservoirs, those not stratifying, or those with faster flushing rates (i.e., more riverine in nature) may be limited. Relevance to pumped-storage facilities would only be incurred during generation periods and not to pump phases of operation.

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Table 1. Total catches (N), mean catch-per-unit-effort (CPUE) values, and standard deviations (SD) of CPUE of all fish species in aggregate, by gear type, collected in Grand Lake, August 1988 to July 1989.

| | Gill net | | | Trap net | | | Electrofishing | | |
|---|---|---|---|---|---|---|---|---|---|
| Month | N | CPUE | SD | N | CPUE | SD | N | CPUE | SD |
| AUG 88 | 59 | 4.92 | 7.14 | 70 | 7.00 | 9.24 | 26 | 2.60 | 3.72 |
| SEP 88 | 47 | 3.92 | 8.50 | 57 | 5.70 | 5.77 | 73 | 7.30 | 10.35 |
| OCT 88 | 29 | 2.50 | 4.46 | 15 | 1.50 | 2.17 | 245 | 24.50 | 48.31 |
| NOV 88 | 16 | 1.33 | 1.87 | 7 | 0.70 | 1.16 | 578 | 57.90 | 87.84 |
| DEC 88 | 38 | 3.17 | 6.64 | 32 | 3.20 | 2.10 | 115 | 12.10 | 21.55 |
| JAN 89 | 18 | 1.06 | 1.61 | 21 | 2.10 | 2.13 | 36 | 3.00 | 7.52 |
| FEB 89 | 39 | 2.44 | 6.90 | 5 | 0.50 | 0.71 | 161 | 13.42 | 32.22 |
| MAR 89 | 15 | 0.94 | 1.39 | 64 | 6.40 | 9.81 | 326 | 27.17 | 71.84 |
| APR 89 | 88 | 5.50 | 6.95 | 124 | 12.40 | 13.47 | 207 | 17.25 | 20.94 |
| MAY 89 | 169 | 7.22 | 9.98 | 52 | 5.20 | 5.29 | 165 | 13.75 | 19.97 |
| JUN 89 | 142 | 8.88 | 16.49 | 100 | 10.00 | 13.22 | 87 | 7.25 | 9.19 |
| JUL 89 | 47 | 2.94 | 7.70 | 146 | 14.60 | 14.49 | 307 | 25.58 | 33.63 |
| | 707 | 3.80 | 8.06 | 693 | 5.78 | 9.06 | 2326 | 17.40 | 40.03 |

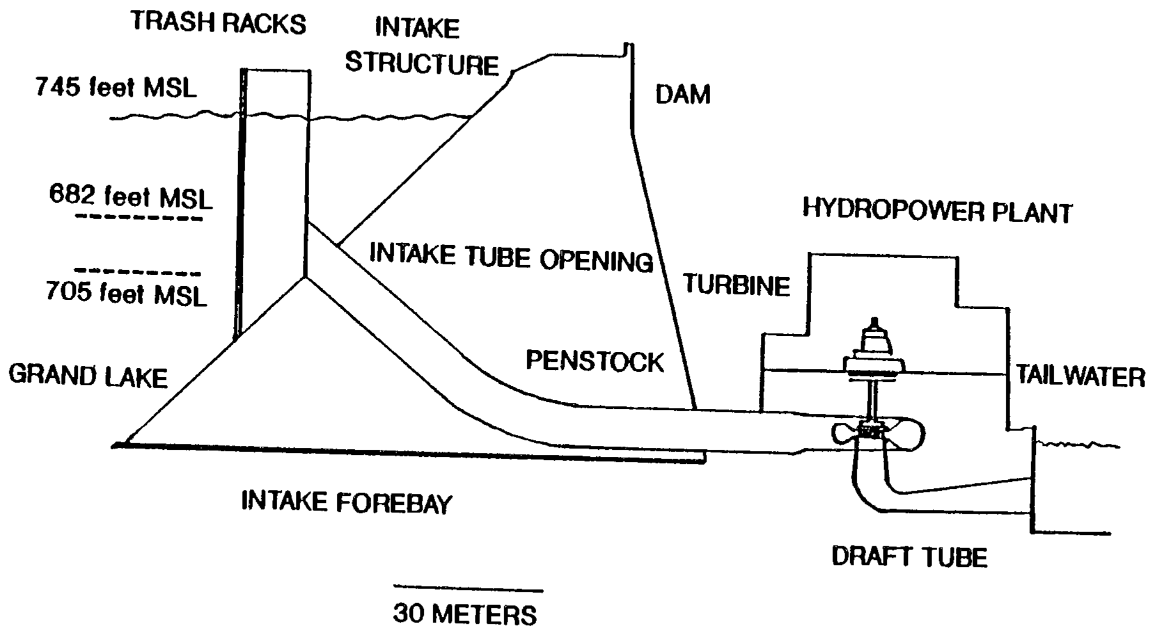
Table 2. Turbine-entrainment susceptibilities of fishes in Grand Lake, August 1988 to July 1989. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols + and - represent positive and negative susceptibility, respectively. Probability values are given in parentheses (Wilcoxon's signed rank test).

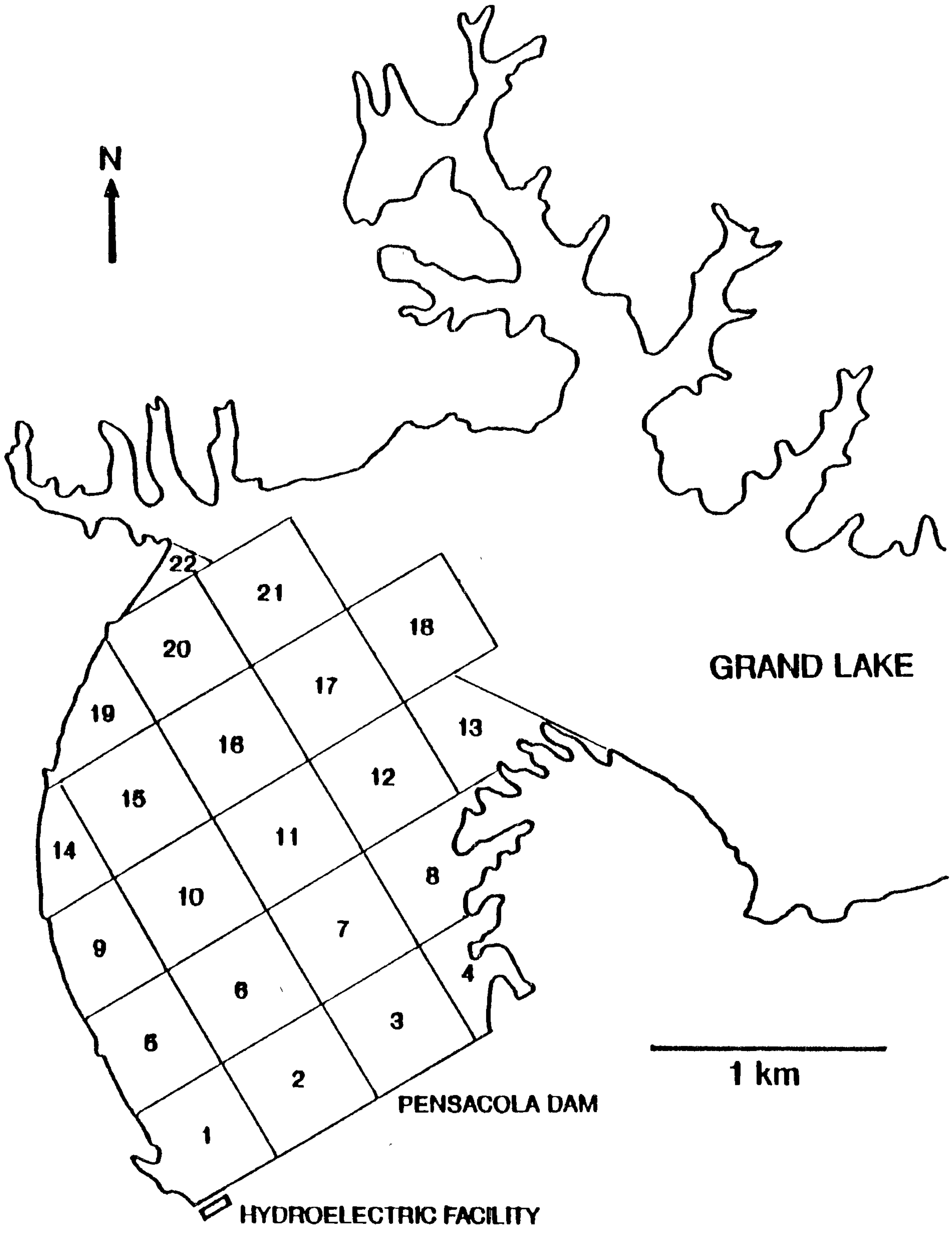
| Species | r | p | L | Susceptibility |
|---|---|---|---|---|
| Gizzard shad | 0.995 | 0.342 | +0.653 | + (0.0008) |
| White crappie | 0.002 | 0.143 | -0.141 | - (<0.0002) |
| Channel catfish | 0.002 | 0.036 | -0.034 | - (<0.0002) |
| Bluegill | <0.001 | 0.135 | -0.135 | - (<0.0002) |
| Blue catfish | <0.001 | 0.003 | -0.003 | - (<0.0002) |
| Green sunfish | <0.001 | 0.017 | -0.017 | - (<0.0002) |
| Bigmouth buffalo | <0.001 | 0.000 | +<0.001 | - (<0.0002) |
| Freshwater drum | <0.001 | 0.007 | -0.007 | - (<0.0002) |
| White bass | <0.001 | 0.074 | -0.074 | - (<0.0002) |

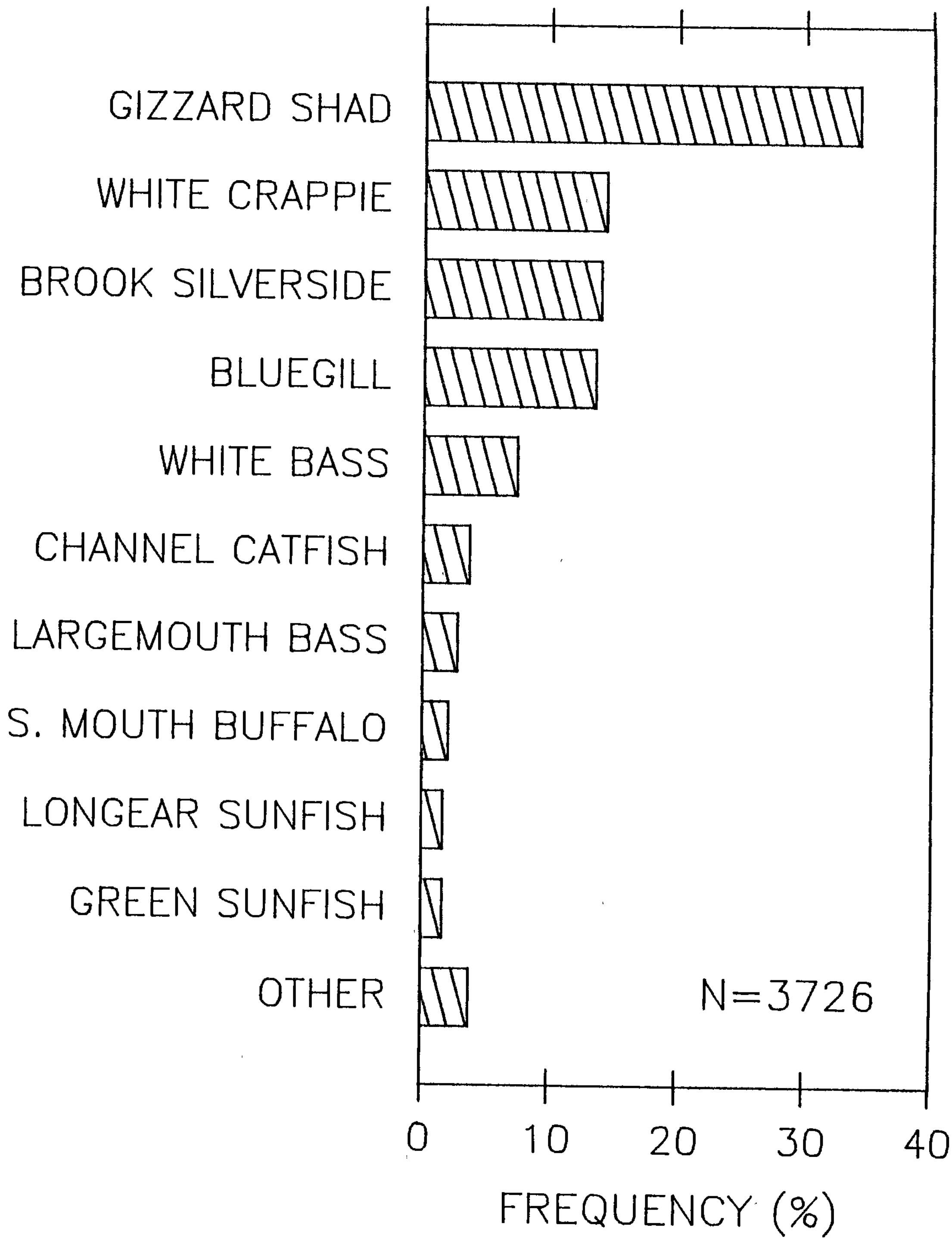
# FIGURE CAPTIONS

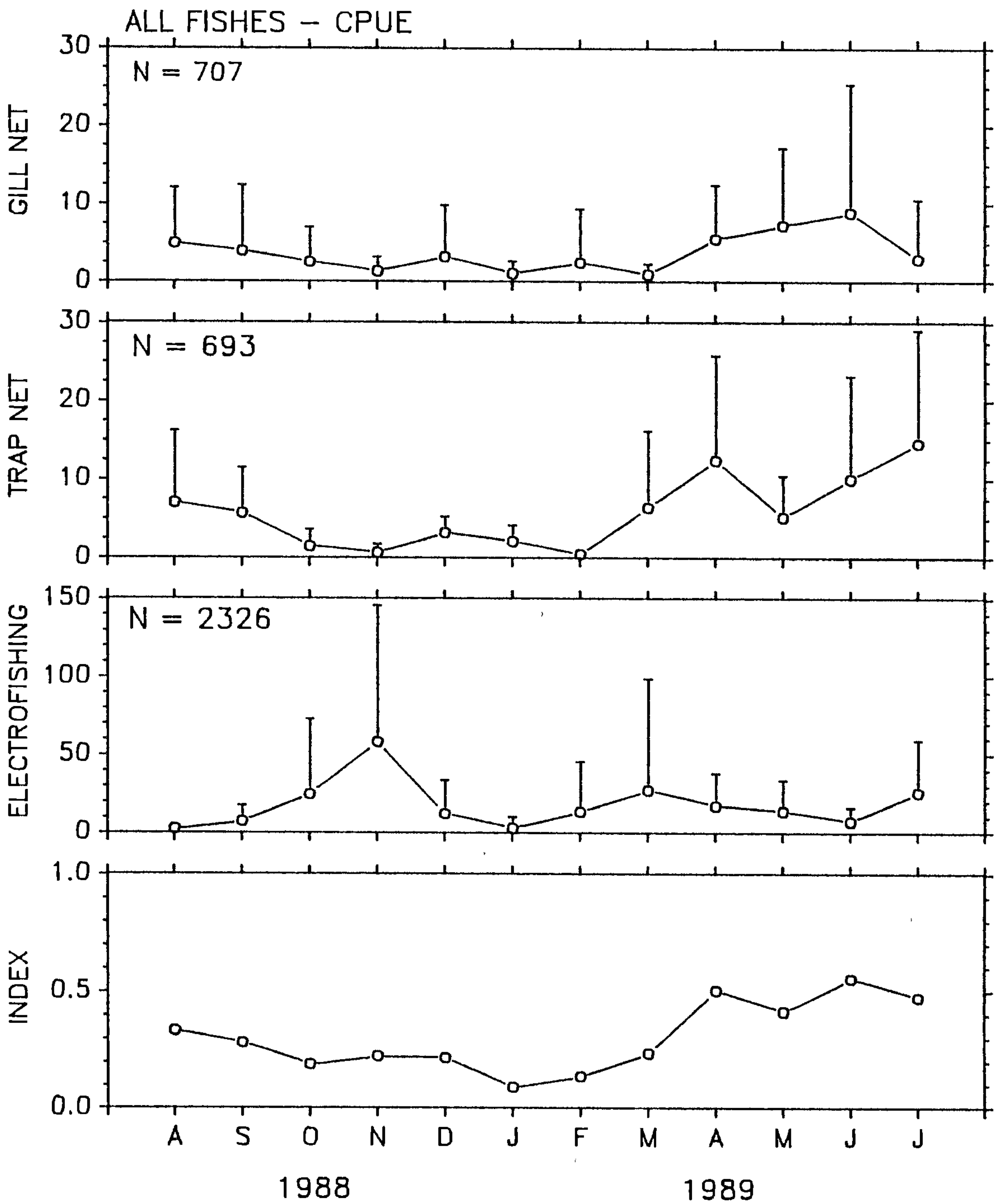
1. Diagrammatic Representation of Pensacola Dam Hydroelectric Facility Showing Structures Referred to in Text.
2. Fish Sampling Blocks in the Lower Grand Lake Study Area.
3. Relative Numeric Abundances (%) of Fishes Constituting >1% of the Total Catch Captured Using all Gear Types in Lower Grand Lake, August 1988 to July 1989.
4. Numeric Catch-Per-Unit-Effort Rates (+1 SD) by Gear and Combined-Gear Catch Index Values of all Fishes in Aggregate, Lower Grand Lake, August 1988 to July 1989.
5. Length-Frequency Distributions of Gizzard Shad Collected in Grand Lake Samples and Entrainment Samples August 1988 to July 1989.
6. Monthly Entrainment Susceptibility Trends for Gizzard Shad, White Crappie, and Channel Catfish Calculated as Electivity Indices from August 1988 to July 1989.

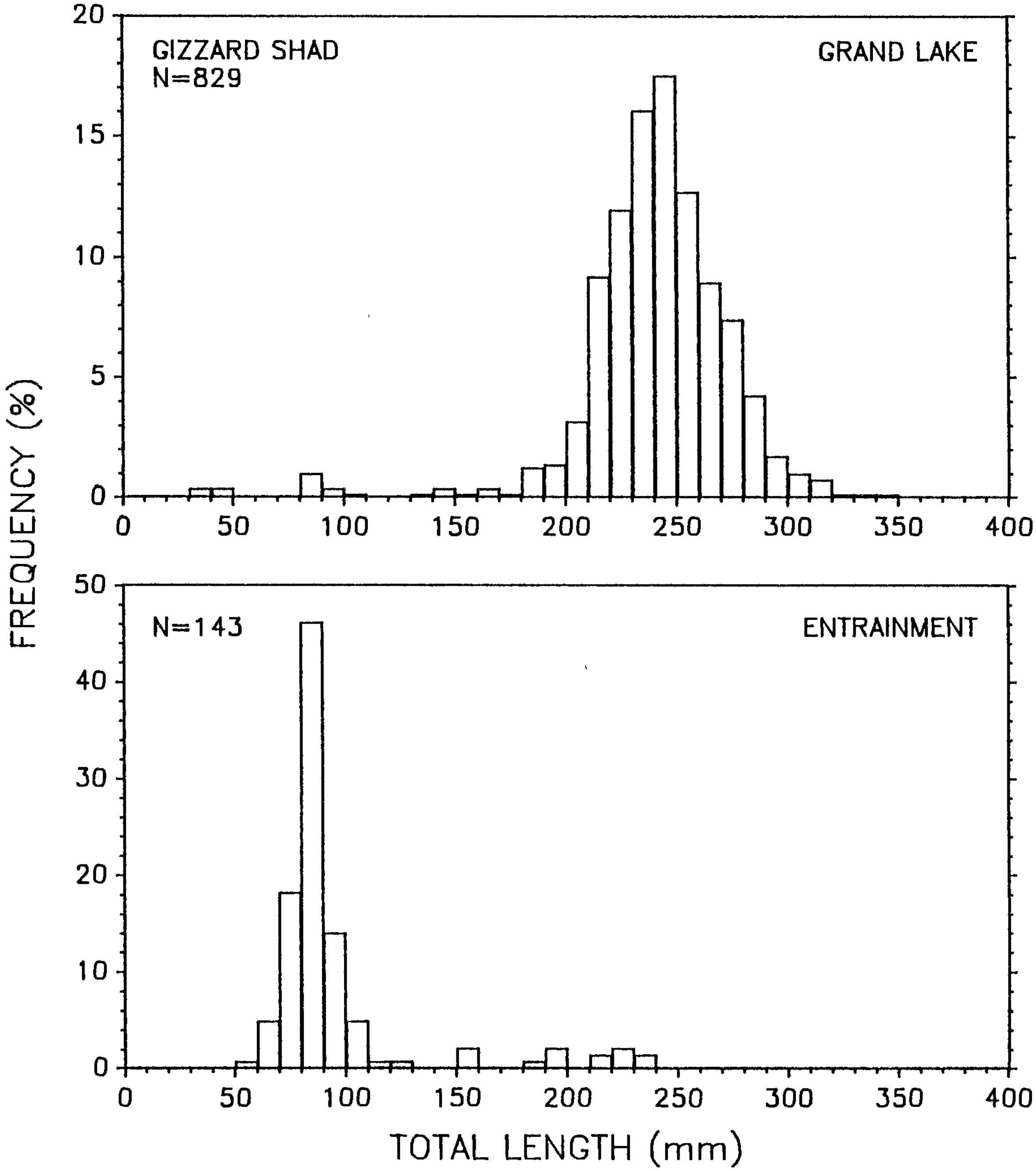
7. Water Temperature and Dissolved Oxygen Concentration Profiles Directly Upstream From the Pensacola Dam Hydroelectric Facility, August and October 1988. The bars along the right vertical axes indicate the depths of the turbine intakes.
8. Water Temperature and Dissolved Oxygen Concentration Profiles Directly Upstream From the Pensacola Dam Hydroelectric Facility, November 1988 and May 1989. The bars along the right vertical axes indicate the depths of the turbine intakes.

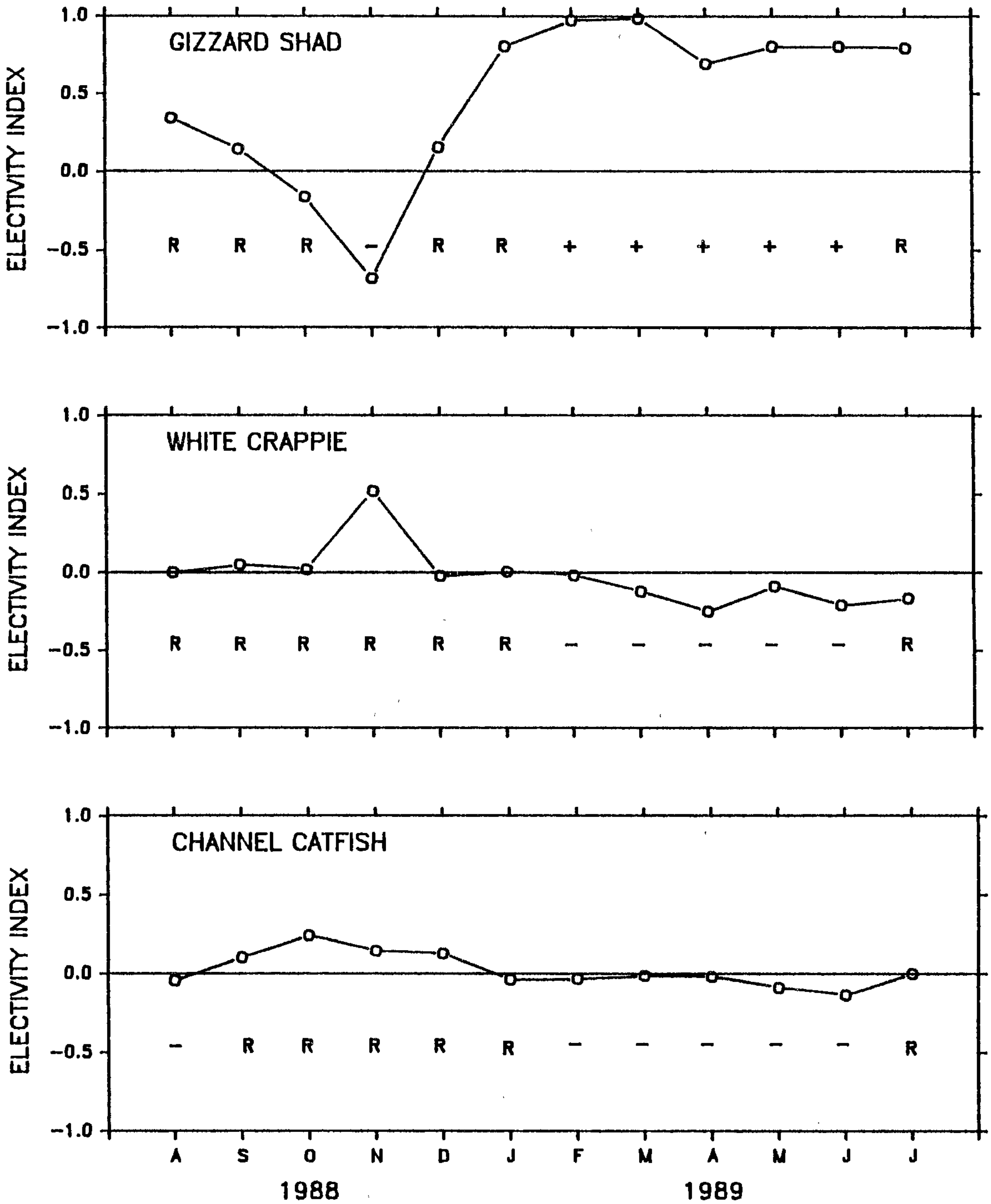

TRASH RACKS
INTAKE
STRUCTURE
745 feet MSL
DAM
682 feet MSL
705 feet MSL
HYDROPOWER PLANT
INTAKE TUBE OPENING
TURBINE
GRAND LAKE
PENSTOCK
TAILWATER
INTAKE FOREBAY
DRAFT TUBE
30 METERS

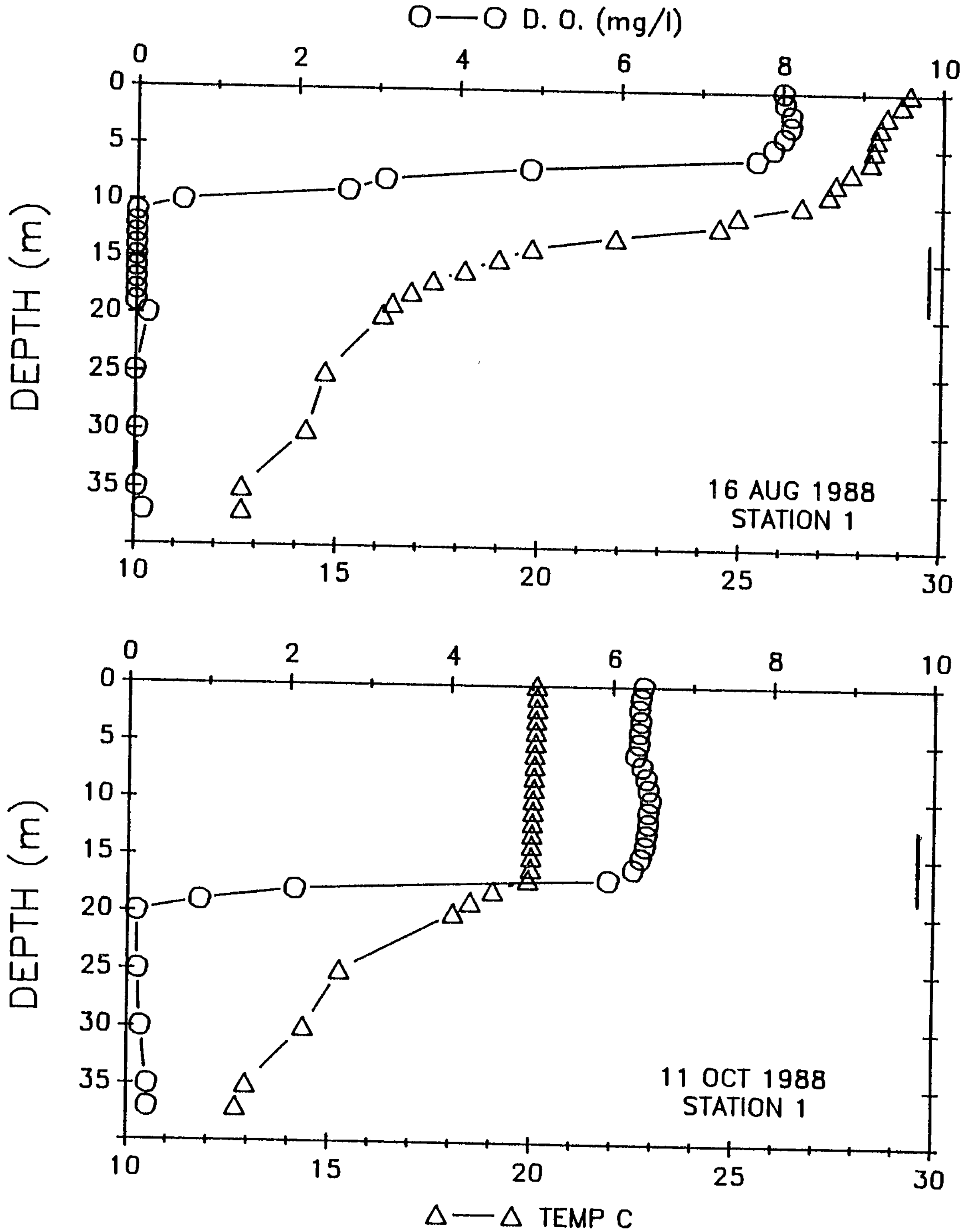

N
GRAND LAKE
22
21
20
18
17
19
16
13
12
15
11
14
10
8
7
9
6
4
3
5
2
1
1 km
PENSACOLA DAM
HYDROELECTRIC FACILITY

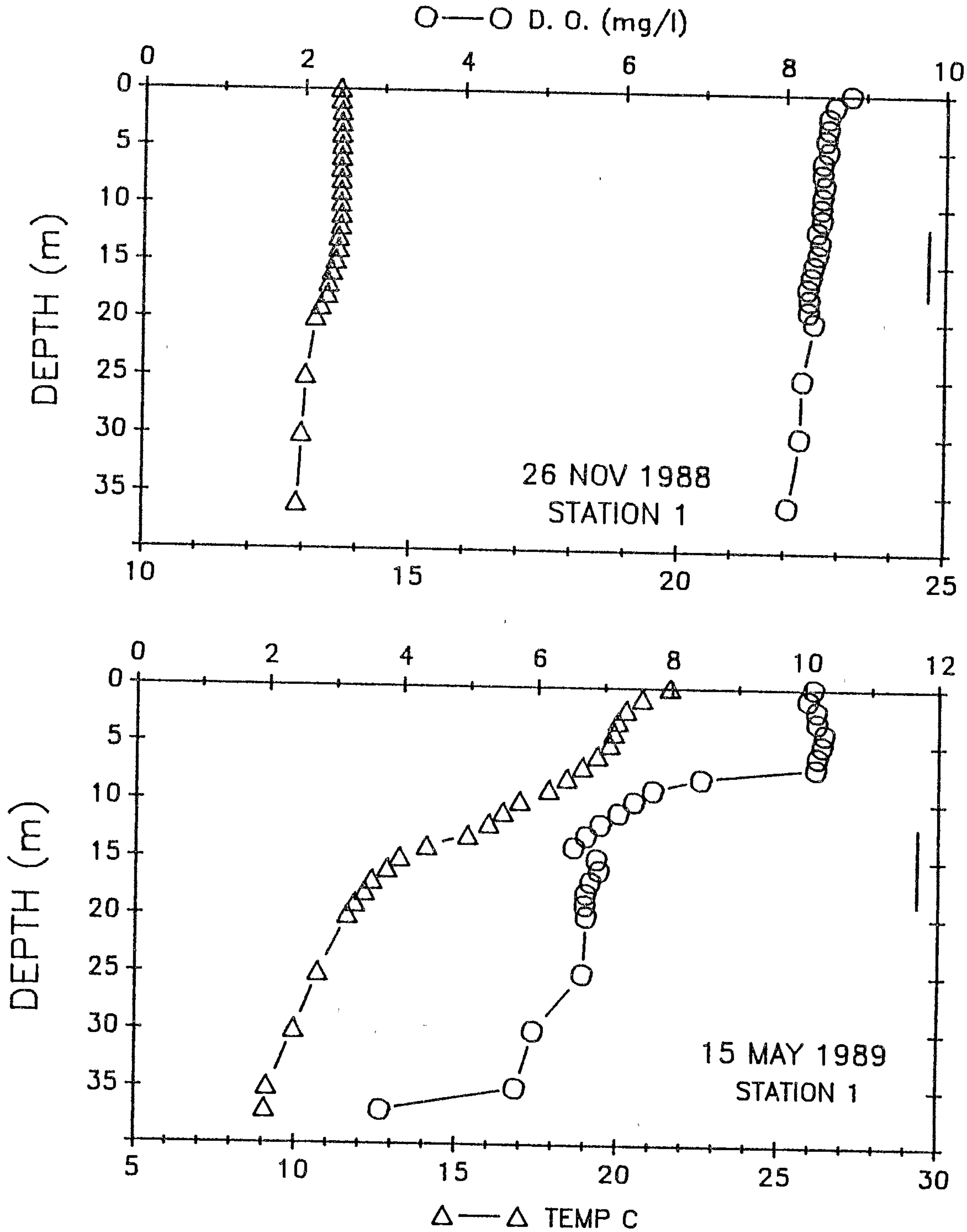

GIZZARD SHAD
WHITE CRAPPIE
BROOK SILVERSIDE
BLUEGILL
WHITE BASS
CHANNEL CATFISH
LARGEMOUTH BASS
S. MOUTH BUFFALO
LONGEAR SUNFISH
GREEN SUNFISH
OTHER
N=3726
0
10
20
30
40
FREQUENCY (%)


ALL FISHES - CPUE
N = 707
GILL NET
30
20
10
0
N = 693
TRAP NET
30
20
10
0
N = 2326
ELECTROFISHING
150
100
50
0
INDEX
1.0
0.5
0.0
A S O N D J F M A M J J
1988
1989


GIZZARD SHAD
N=829
GRAND LAKE
N=143
ENTRAINMENT
FREQUENCY (%)
TOTAL LENGTH (mm)
0
5
10
15
20
30
40
50
100
150
200
250
300
350
400


GIZZARD SHAD
WHITE CRAPPIE
CHANNEL CATFISH
ELECTIVITY INDEX
1.0
0.5
0.0
-0.5
-1.0
R R R – R R + + + + + R
R R R R R R – – – – – R
– R R R R R – – – – – R
A S O N D J F M A M J J
1988
1989


O—O D. O. (mg/l)
0 2 4 6 8 10
DEPTH (m)
0 5 10 15 20 25 30 35
10 15 20 25 30
16 AUG 1988
STATION 1
0 2 4 6 8 10
DEPTH (m)
0 5 10 15 20 25 30 35
11 OCT 1988
STATION 1
10 15 20 25 30
Δ—Δ TEMP C


O—O D. O. (mg/l)
0 2 4 6 8 10
DEPTH (m)
0 5 10 15 20 25 30 35
26 NOV 1988
STATION 1
10 15 20 25
0 2 4 6 8 10 12
DEPTH (m)
0 5 10 15 20 25 30 35
15 MAY 1989
STATION 1
5 10 15 20 25 30
Δ—Δ TEMP C

# APPENDIX A

# MONTHLY ENTRAINMENT RATES

Table A.1. Monthly entrainment rates of all fishes entrained at Pensacola Dam hydroelectric facility, August 1988 to July 1989 (Fisher and Zale 1990).

| Month | Total | Gizzard shad | White crappie | Channel catfish | Blue-gill | Blue cat-fish | Green sun-fish | Big-mouth buffalo | Fresh-water drum | White bass | Uniden-tified |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Aug 88 | 9150 | 4488 | 4026 | 0 | 0 | 0 | 0 | 0 | 636 | 0 | 0 |
| Sep 88 | 14706 | 6491 | 2047 | 1834 | 2744 | 722 | 0 | 0 | 0 | 816 | 0 |
| Oct 88 | 16272 | 7852 | 1035 | 3984 | 0 | 913 | 0 | 0 | 0 | 0 | 2488 |
| Nov 88 | 21563 | 4474 | 11454 | 3227 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dec 88 | 55144 | 37708 | 4104 | 9640 | 0 | 0 | 2408 | 0 | 0 | 0 | 0 |
| Jan 89 | 21500 | 17307 | 4193 | 0 | 0 | 0 | 0 | 2314 | 1377 | 0 | 0 |
| Feb 89 | 8949493 | 8949493 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mar 89 | 4270989 | 4266504 | 0 | 4449 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr 89 | 925433 | 920816 | 4623 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| May 89 | 998264 | 992382 | 0 | 1850 | 2190 | 1850 | 0 | 0 | 0 | 0 | 0 |
| Jun 89 | 44319 | 44319 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul 89 | 5950 | 5950 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 15257784 | 31482 | 2498 | 493 | 3535 | 2408 | 2314 | 2013 | 816 | 2488 |
| Percent | | 99.5 | 0.21 | 0.16 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 | <0.01 | 0.02 |

# APPENDIX B

# SUSCEPTIBILITY VALUES

Table B.1. Turbine-entrainment susceptibilities of fishes in Grand Lake, August 1988. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

| Species | r | p | L | Susceptibility |
|---|---|---|---|---|
| Gizzard shad | 0.490 | 0.148 | +0.342 | R (0.9680) |
| White crappie | 0.440 | 0.439 | +0.001 | R (0.6892) |
| Channel catfish | 0 | 0.045 | -0.045 | - (0.0434) |
| Bluegill | 0 | 0.084 | -0.084 | - (0.0434) |
| Blue catfish | 0 | 0.006 | -0.006 | - (0.0434) |
| Green sunfish | 0 | 0.026 | -0.026 | - (0.0434) |
| Bigmouth buffalo | 0 | 0 | -- | -- |
| Freshwater drum | 0.070 | 0.026 | +0.044 | R (0.5028) |
| White bass | 0 | 0.084 | -0.084 | - (0.0434) |

Table B.32. Turbine-entrainment susceptibilities of fishes in Grand Lake, September 1988. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

| Species | r | p | L | Susceptibility |
|---|---|---|---|---|
| Gizzard shad | 0.441 | 0.299 | +0.142 | R (0.9602) |
| White crappie | 0.139 | 0.090 | +0.049 | R (0.0075) |
| Channel catfish | 0.125 | 0.023 | +0.102 | R (0.3844) |
| Bluegill | 0.187 | 0.395 | -0.208 | R (0.3844) |
| Blue catfish | 0.052 | 0 | +0.052 | R (0.3174) |
| Green sunfish | 0 | 0.034 | -0.034 | - (0.0052) |
| Bigmouth buffalo | 0 | 0 | -- | -- |
| Freshwater drum | 0 | 0 | -- | -- |
| White bass | 0.055 | 0.028 | +0.027 | R (0.0750) |

Table B.3. Turbine-entrainment susceptibilities of fishes in Grand Lake, October 1988. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

| Species | r | p | L | Susceptibility | |
|---|---|---|---|---|---|
| Gizzard shad | 0.482 | 0.644 | -0.162 | R | (0.2628) |
| White crappie | 0.064 | 0.045 | +0.019 | R | (0.1616) |
| Channel catfis | 0.245 | 0.003 | +0.242 | R | (0.6744) |
| Bluegill | 0 | 0.080 | -0.080 | - | (0.0118) |
| Blue catfish | 0.056 | 0.010 | +0.046 | R | (0.1616) |
| Green sunfish | 0 | 0.017 | -0.017 | - | (0.0118) |
| Bigmouth buffalo | 0 | 0 | -- | | -- |
| Freshwater drum | 0 | 0.017 | -0.017 | - | (0.0118) |
| White bass | 0 | 0.017 | -0.017 | - | (0.0118) |

Table B.4. Turbine-entrainment susceptibilities of fishes in Grand Lake, November 1988. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

| Species | r | p | L | Susceptibility | |
|---|---|---|---|---|---|
| Gizzard shad | 0.207 | 0.890 | -0.683 | - | (0.0434) |
| White crappie | 0.531 | 0.012 | +0.519 | R | (0.0802) |
| Channel catfish | 0.150 | 0.007 | +0.143 | R | (0.5028) |
| Bluegill | 0 | 0.030 | -0.030 | - | (0.0434) |
| Blue catfish | 0 | 0.002 | -0.002 | - | (0.0434) |
| Green sunfish | 0.112 | 0.005 | +0.107 | R | (0.5028) |
| Bigmouth buffalo | 0 | 0 | -- | | -- |
| Freshwater drum | 0 | 0.002 | -0.002 | - | (0.0434) |
| White bass | 0 | 0.008 | -0.008 | - | (0.0434) |

Table B.5. Turbine-entrainment susceptibilities of fishes in Grand Lake, December 1988. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

| Species | r | p | L | Susceptibility | |
|---|---|---|---|---|---|
| Gizzard shad | 0.684 | 0.530 | +0.154 | R | (0.6600) |
| White crappie | 0.074 | 0.097 | -0.023 | R | (0.2846) |
| Channel catfish | 0.175 | 0.049 | +0.126 | R | (0.0512) |
| Bluegill | 0 | 0.108 | -0.108 | - | (0.0034) |
| Blue catfish | 0 | 0 | -- | | -- |
| Green sunfish | 0 | 0.016 | -0.016 | - | (0.0034) |
| Bigmouth buffalo | 0.042 | 0 | +0.042 | R | (0.3174) |
| Freshwater drum | 0.025 | 0 | +0.025 | R | (0.3174) |
| White bass | 0 | 0.070 | -0.070 | - | (0.0034) |

Table B.6. Turbine-entrainment susceptibilities of fishes in Grand Lake, January 1989. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

| Species | r | p | L | Susceptibility | |
|---|---|---|---|---|---|
| Gizzard shad | 0.805 | 0 | +0.805 | R | (1.0000) |
| White crappie | 0.195 | 0.200 | +0.005 | R | (1.0000) |
| Channel catfish | 0 | 0.040 | -0.040 | R | (0.1096) |
| Bluegill | 0 | 0.120 | -0.120 | R | (0.1096) |
| Blue catfish | 0 | 0.013 | -0.013 | R | (0.1096) |
| Green sunfish | 0 | 0 | -- | | -- |
| Bigmouth buffalo | 0 | 0 | -- | | -- |
| Freshwater drum | 0 | 0.013 | -0.013 | R | (0.1096) |
| White bass | 0 | 0.147 | -0.147 | R | (0.1096) |

Table B.7. Turbine-entrainment susceptibilities of fishes in Grand Lake, February 1989. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

| Species | r | p | L | Susceptibility |
|---|---|---|---|---|
| Gizzard shad | 1.000 | 0.029 | +0.971 | + (<0.0002) |
| White crappie | 0 | 0.020 | -0.020 | - (<0.0002) |
| Channel catfish | 0 | 0.034 | -0.034 | - (<0.0002) |
| Bluegill | 0 | 0.005 | -0.005 | - (<0.0002) |
| Blue catfish | 0 | 0.005 | -0.005 | - (<0.0002) |
| Green sunfish | 0 | 0.005 | -0.005 | - (<0.0002) |
| Bigmouth buffalo | 0 | 0 | -- | -- |
| Freshwater drum | 0 | 0 | -- | -- |
| White bass | 0 | 0.117 | -0.117 | - (<0.0002) |

Table B.8. Turbine-entrainment susceptibilities of fishes in Grand Lake, March 1989. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

| Species | r | p | L | Susceptibility |
|---|---|---|---|---|
| Gizzard shad | 0.999 | 0.017 | +0.982 | + (<0.0002) |
| White crappie | 0 | 0.123 | -0.123 | - (<0.0002) |
| Channel catfish | 0.001 | 0.015 | -0.014 | - (<0.0002) |
| Bluegill | 0 | 0.049 | -0.049 | - (<0.0002) |
| Blue catfish | 0 | 0 | -- | -- |
| Green sunfish | 0 | 0 | -- | -- |
| Bigmouth buffalo | 0 | 0 | -- | -- |
| Freshwater drum | 0 | 0 | -- | -- |
| White bass | 0 | 0.017 | -0.017 | - (<0.0002) |

Table B.9. Turbine-entrainment susceptibilities of fishes in Grand Lake, April 1989. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

| Species | r | p | L | Susceptibility |
|---|---|---|---|---|
| Gizzard shad | 0.995 | 0.303 | +0.692 | + (<0.0002) |
| White crappie | 0.005 | 0.255 | -0.250 | - (<0.0010) |
| Channel catfish | 0 | 0.021 | -0.021 | - (<0.0002) |
| Bluegill | 0 | 0.131 | -0.131 | - (<0.0002) |
| Blue catfish | 0 | 0 | -- | -- |
| Green sunfish | 0 | 0.021 | -0.021 | - (<0.0002) |
| Bigmouth buffalo | 0 | 0 | -- | -- |
| Freshwater drum | 0 | 0.005 | -0.005 | - (<0.0002) |
| White bass | 0 | 0.122 | -0.122 | - (<0.0002) |

Table B.10. Turbine-entrainment susceptibilities of fishes in Grand Lake, May 1989. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

| Species | r | p | L | Susceptibility |
|---|---|---|---|---|
| Gizzard shad | 0.994 | 0.189 | +0.805 | + (<0.0002) |
| White crappie | 0 | 0.212 | -0.212 | - (<0.0002) |
| Channel catfish | 0.002 | 0.093 | -0.091 | - (<0.0002) |
| Bluegill | 0.002 | 0.111 | -0.109 | - (0.0010) |
| Blue catfish | 0.002 | 0.010 | -0.008 | - (<0.0002) |
| Green sunfish | 0 | 0.036 | -0.036 | - (<0.0002) |
| Bigmouth buffalo | 0 | 0 | -- | -- |
| Freshwater drum | 0 | 0.008 | -0.008 | - (<0.0002) |
| White bass | 0 | 0.150 | -0.150 | - (<0.0002) |

Table B.11. Turbine-entrainment susceptibilities of fishes in Grand Lake, June 1989. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

| Species | r | p | L | Susceptibility |
|---|---|---|---|---|
| Gizzard shad | 1.000 | 0.195 | +0.805 | + (0.0434) |
| White crappie | 0 | 0.210 | -0.210 | - (0.0434) |
| Channel catfish | 0 | 0.137 | -0.137 | - (0.0434) |
| Bluegill | 0 | 0.222 | -0.222 | - (0.0434) |
| Blue catfish | 0 | 0 | -- | -- |
| Green sunfish | 0 | 0.021 | -0.021 | - (0.0434) |
| Bigmouth buffalo | 0 | 0 | -- | -- |
| Freshwater drum | 0 | 0 | -- | -- |
| White bass | 0 | 0.018 | -0.018 | - (0.0434) |

Table B.12. Turbine-entrainment susceptibilities of fishes in Grand Lake, July 1989. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

| Species | r | p | L | Susceptibility |
|---|---|---|---|---|
| Gizzard shad | 1.000 | 0.206 | +0.794 | R (0.6528) |
| White crappie | 0 | 0.166 | -0.166 | R (0.1802) |
| Channel catfish | 0 | 0.001 | -0.001 | R (0.1802) |
| Bluegill | 0 | 0.316 | -0.316 | R (0.1802) |
| Blue catfish | 0 | 0 | -- | -- |
| Green sunfish | 0 | 0.020 | -0.020 | R (0.1802) |
| Bigmouth buffalo | 0 | 0 | -- | -- |
| Freshwater drum | 0 | 0.014 | -0.014 | R (0.1802) |
| White bass | 0 | 0.154 | -0.154 | R (0.1802) |

# APPENDIX C

## TOTAL CATCHES AND RELATIVE ABUNDANCE BY GEAR

Table C.1. Total catches (N) and relative abundances (%) of fishes captured with gill nets, trap nets, and by electrofishing in Grand Lake, August 1988 to July 1989.

| Species | Gill net | | Trap net | | Electrofishing | | Combined | |
|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % |
| Blue catfish Ictalurus furcatus | 11 | 1.6 | 0 | 0.0 | 0 | 0.0 | 11 | 0.3 |
| Bluegill Lepomis macrochirus | 0 | 0.0 | 260 | 37.5 | 243 | 10.4 | 514 | 13.8 |
| Brook silverside Labidesthes sicculus | 0 | 0.0 | 0 | 0.0 | 518 | 22.3 | 518 | 27.7 |
| Channel catfish Ictalurus punctatus | 130 | 18.4 | 2 | 0.3 | 4 | 0.2 | 136 | 3.7 |
| Common carp Cyprinus carpio | 11 | 1.6 | 1 | 0.1 | 11 | 0.5 | 23 | 0.6 |
| Freshwater drum Aplodinotus grunniens | 13 | 1.8 | 3 | 0.4 | 10 | 0.4 | 26 | 0.7 |
| Flathead catfish Polyodictus olivaris | 2 | 0.3 | 0 | 0.0 | 0 | 0.0 | 2 | 0.1 |
| Green sunfish Lepomis cyanellus | 0 | 0.0 | 18 | 2.6 | 44 | 1.9 | 62 | 1.7 |
| Gizzard shad Dorosoma cepedianum | 72 | 10.2 | 1 | 0.1 | 1202 | 51.7 | 1275 | 34.2 |
| Hybrid striped bass Morone saxatilis x M. chrysops | 34 | 4.8 | 0 | 0.0 | 0 | 0.0 | 34 | 0.9 |
| Hybrid sunfish Lepomis sp. | 0 | 0.0 | 3 | 0.4 | 1 | <0.1 | 4 | 0.1 |
| Longear sunfish Lepomis megalotis | 0 | 0.0 | 17 | 2.5 | 46 | 2.0 | 63 | 1.7 |
| Logperch Percina caprodes | 0 | 0.0 | 0 | 0.0 | 8 | 0.3 | 8 | 0.2 |
| Largemouth bass Micropterus salmoides | 5 | 0.7 | 19 | 2.7 | 81 | 3.5 | 105 | 2.8 |
| Longnose gar Lepisosteus osseus | 0 | 0.0 | 0 | 0.0 | 2 | 0.1 | 2 | 0.1 |
| Paddlefish Polyodon spathula | 7 | 1.0 | 0 | 0.0 | 0 | 0.0 | 7 | 0.2 |
| Rainbow trout Oncorhynchus mykiss | 2 | 0.3 | 0 | 0.0 | 1 | <0.1 | 3 | 0.1 |
| River carpsucker Carpiodes carpio | 5 | 0.7 | 0 | 0.0 | 6 | 0.3 | 11 | 0.3 |
| Redear sunfish Lepomis microlophus | 0 | 0.0 | 1 | 0.1 | 0 | 0.0 | 1 | <0.1 |
| Smallmouth buffalo Ictiobus bubalus | 52 | 7.4 | 1 | 0.1 | 27 | 1.2 | 80 | 2.1 |
| Slender madtom Noturus exilis | 0 | 0.0 | 0 | 0.0 | 1 | <0.1 | 1 | <0.1 |
| Spotted bass Micropterus punctulatus | 3 | 0.4 | 2 | 0.3 | 30 | 1.3 | 35 | 0.9 |
| White bass Morone chrysops | 192 | 27.2 | 0 | 0.0 | 83 | 3.6 | 275 | 7.4 |
| White crappie Pomoxis annularis | 168 | 23.8 | 358 | 51.7 | 6 | 0.3 | 532 | 14.3 |
| Warmouth Lepomis gulosis | 0 | 0.0 | 7 | 1.0 | 2 | 0.1 | 9 | 0.2 |
| TOTAL | 707 | | 693 | | 2326 | | 3726 | |

# APPENDIX D

## ANOVA OF MONTHLY MEAN CPUE

Table D.1. Sums of squares (SS), F, and probability values (P) of analyses of variance testing whether differences existed among monthly mean numeric catch-per-unit-effort rates, by gear, of fishes collected in Grand Lake, August 1988 to July 1989. Asterisks denote significant differences (alpha = 0.05).

| Species | Gill net | | | Trap net | | | Electrofishing | | |
|---|---|---|---|---|---|---|---|---|---|
| | SS | F | P | SS | F | P | SS | F | P |
| Blue catfish | 1.34 | 1.15 | 0.3280 | -- | -- | -- | -- | -- | -- |
| Bluegill | -- | -- | -- | 845.07 | 3.10 | 0.0012* | 320.90 | 1.64 | 0.0956 |
| Brook silverside | -- | -- | -- | -- | -- | -- | 7642.59 | 1.30 | 0.2329 |
| Channel catfish | 108.61 | 1.85 | 0.0505 | 0.17 | 0.91 | 0.5344 | 0.40 | 0.80 | 0.6363 |
| Common carp | 0.59 | 0.73 | 0.7079 | 0.09 | 1.00 | 0.4513 | 1.08 | 0.80 | 0.6418 |
| Freshwater drum | 2.44 | 1.55 | 0.1186 | 0.27 | 0.73 | 0.7102 | 1.27 | 1.41 | 0.1761 |
| Flathead catfish | 0.23 | 1.88 | 0.0449* | -- | -- | -- | -- | -- | -- |
| Green sunfish | -- | -- | -- | 2.30 | 1.19 | 0.3036 | 10.05 | 0.53 | 0.8783 |
| Gizzard shad | 85.73 | 1.75 | 0.0665 | 0.09 | 1.00 | 0.4513 | 24836.80 | 3.30 | 0.0005* |
| Hybrid striped bass | 11.64 | 1.22 | 0.2755 | -- | -- | -- | -- | -- | -- |
| Hybrid sunfish | -- | -- | -- | 0.43 | 0.93 | 0.5173 | 0.09 | 1.14 | 0.3363 |
| Longear sunfish | -- | -- | -- | 7.49 | 0.84 | 0.5964 | 15.37 | 1.25 | 0.2642 |
| Logperch | -- | -- | -- | -- | -- | -- | 2.11 | 0.92 | 0.5247 |
| Largemouth bass | 0.42 | 0.94 | 0.5014 | 6.49 | 2.50 | 0.0077* | 37.55 | 1.20 | 0.2927 |
| Longnose gar | -- | -- | -- | -- | -- | -- | 0.14 | 0.83 | 0.6127 |
| Paddlefish | 0.37 | 1.11 | 0.3594 | -- | -- | -- | -- | -- | -- |
| Rainbow trout | 0.06 | 0.88 | 0.5617 | -- | -- | -- | 0.07 | 0.92 | 0.5255 |
| River carpsucker | 0.58 | 0.83 | 0.6134 | -- | -- | -- | 0.41 | 0.87 | 0.5762 |
| Redear sunfish | -- | -- | -- | 0.09 | 1.00 | 0.4513 | -- | -- | -- |
| Smallmouth buffalo | 24.09 | 1.30 | 0.2282 | 0.09 | 1.00 | 0.4513 | 15.99 | 2.55 | 0.0062* |
| Slender madtom | -- | -- | -- | -- | -- | -- | 0.07 | 0.92 | 0.5255 |
| Spotted bass | 0.51 | 1.67 | 0.0814 | 0.17 | 0.91 | 0.5344 | 8.05 | 1.37 | 0.1961 |
| White bass | 138.14 | 1.58 | 0.1081 | -- | -- | -- | 420.59 | 0.93 | 0.5169 |
| White crappie | 135.96 | 1.80 | 0.0572 | 795.57 | 1.80 | 0.0622 | 0.96 | 0.84 | 0.6025 |
| Warmouth | -- | -- | -- | 0.05 | 0.94 | 0.5017 | 0.30 | 0.92 | 0.5255 |
| TOTAL | 1045.76 | 1.51 | 0.1320 | 2338.43 | 3.09 | 0.0012* | 26340.49 | 1.56 | 0.1177 |

# VITA

Kent Michael Sorenson

Candidate for the Degree of

Master of Science

Thesis: ENTRAINMENT SUSCEPTIBILITIES OF FISHES INHABITING THE LOWER PORTION OF GRAND LAKE, OKLAHOMA

Major Field: Wildlife and Fisheries Ecology

Biographical:

Personal Data: Born in Westbrook, Minnesota, May 21, 1963, the son of John C. and Sheryl R. Sorenson.

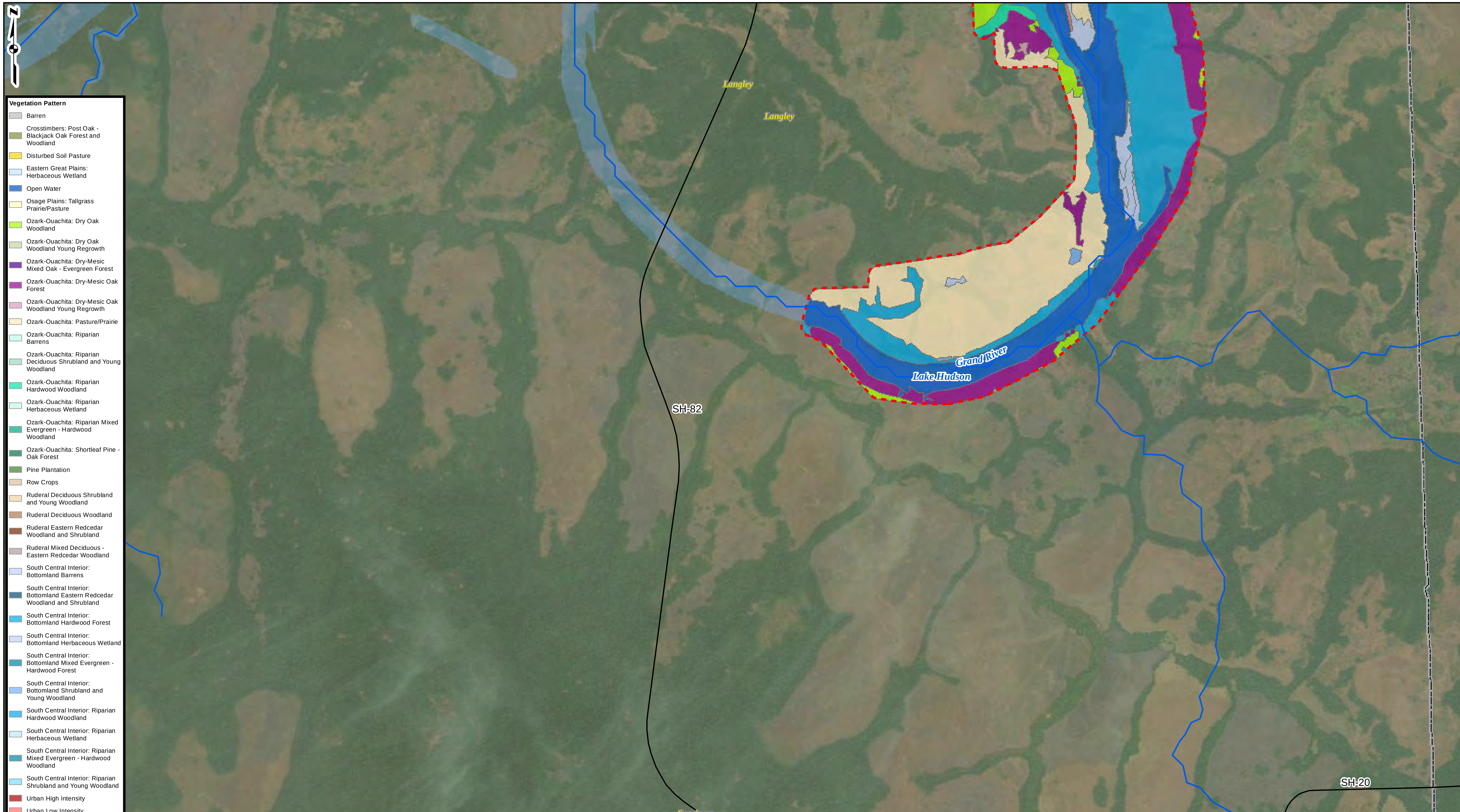
Education: Graduated from Storden-Jeffers High School, Jeffers, Minnesota, in May, 1981; received Bachelor of Science Degree in Wildlife and Fisheries Science from South Dakota State University in May, 1985; completed requirements for the Master of Science degree at Oklahoma State University in July, 1990.

Professional Experience: Professional Aide, South Dakota Department of Game, Fish, and Parks, Pierre, South Dakota, April 1986, to August, 1987; Graduate Research Assistant, Oklahoma Cooperative Fish and Wildlife Research Unit, Oklahoma State University, August, 1987, to June, 1990.

Organizational Memberships: American Fisheries Society, Oklahoma Academy of Science, Oklahoma Chapter of the American Fisheries Society.

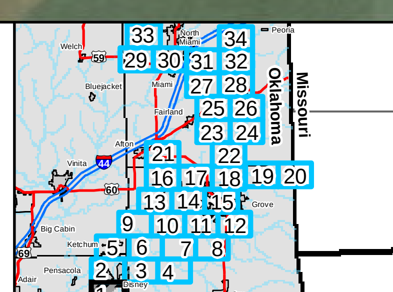
Document Content(s)

## APPENDIX E-16 Vegetative Communities in the Pensacola Project Vicinity




PROJECT LOCATION

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

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Vegetation and Landcover, MoRAP, 3/2015

**Legend**

- Major Roadway
- Waterway
- Waterbody
- 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 1 OF 34

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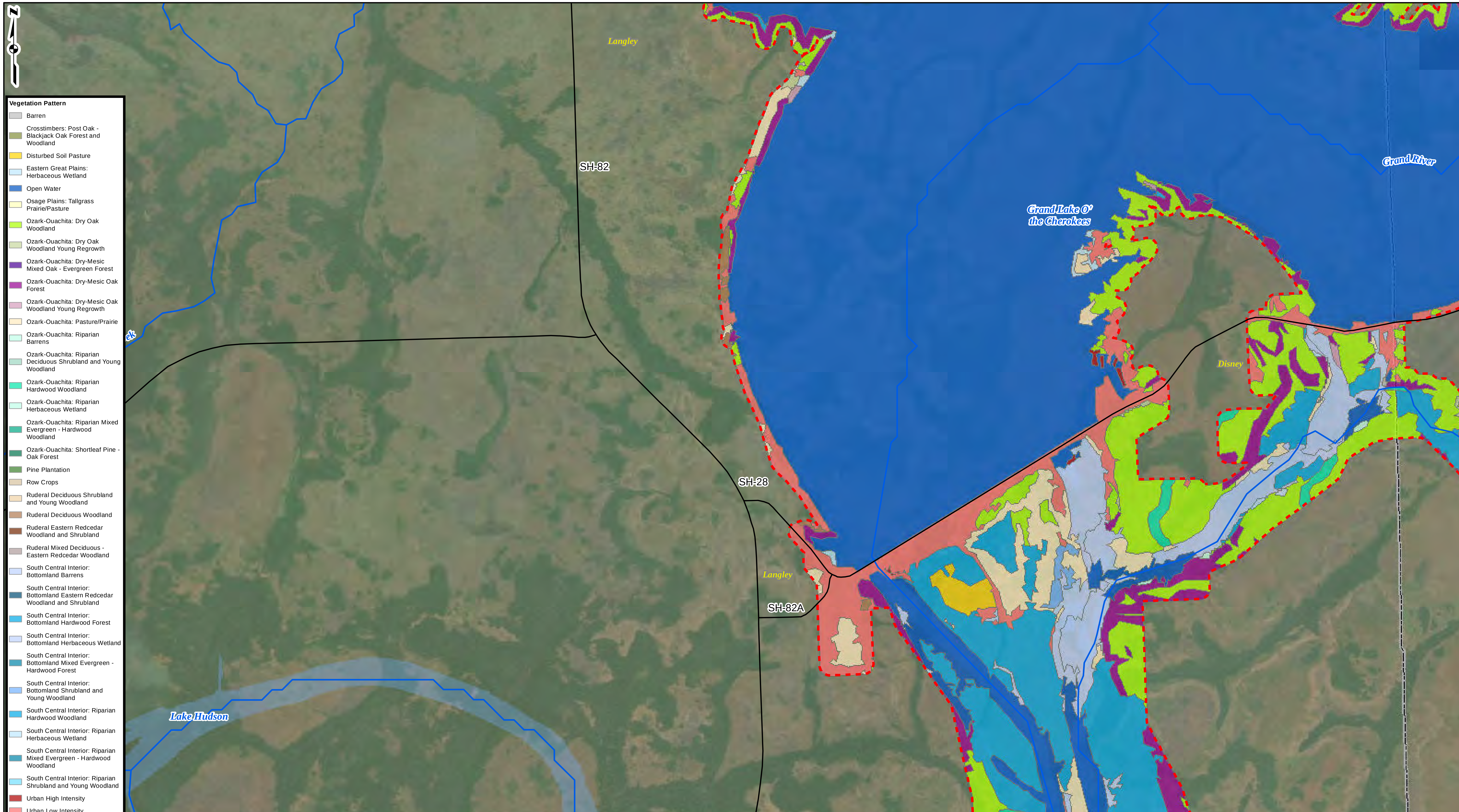


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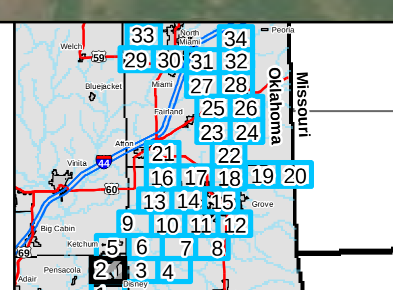


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**Legend**

- Major Roadway
- Waterway
- Waterbody
- 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

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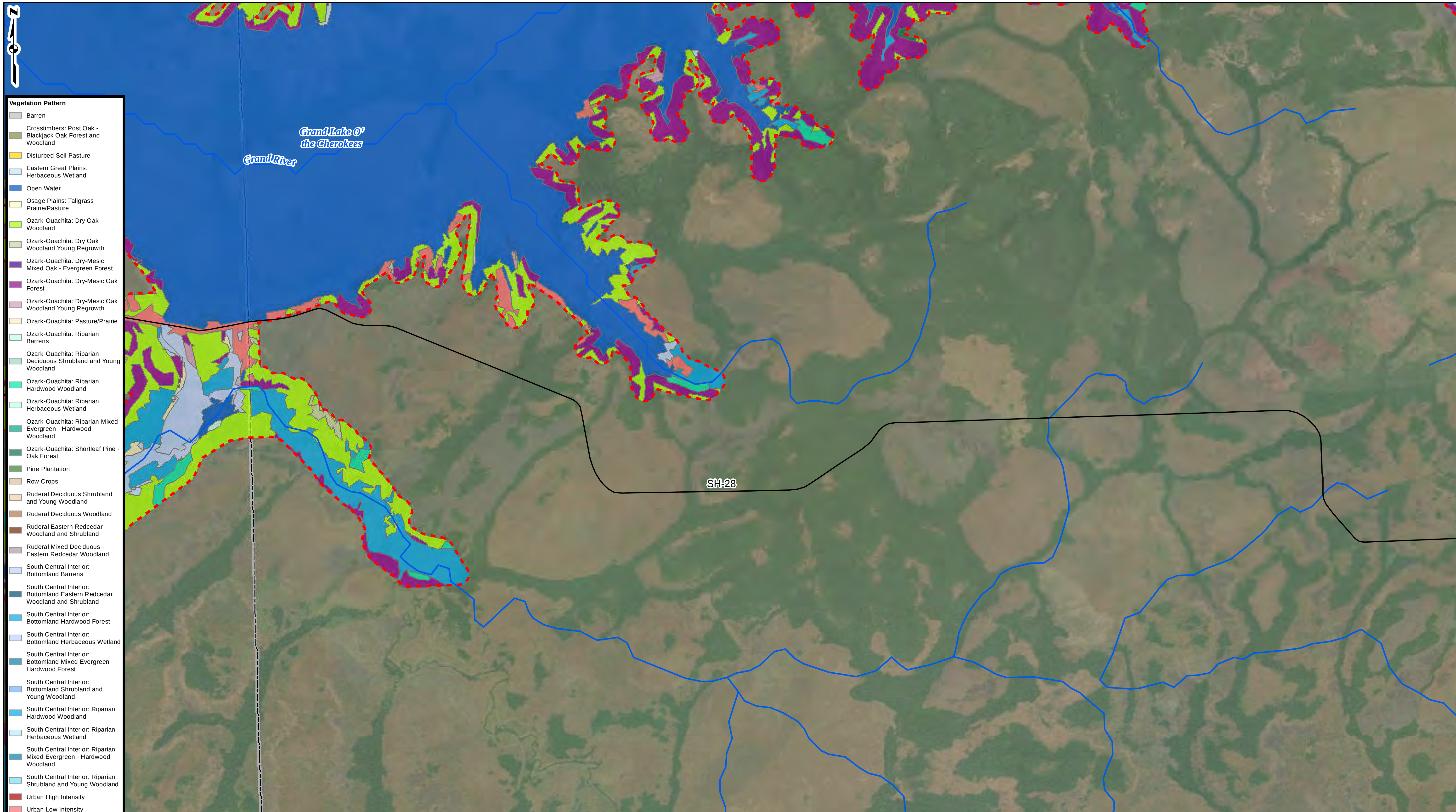


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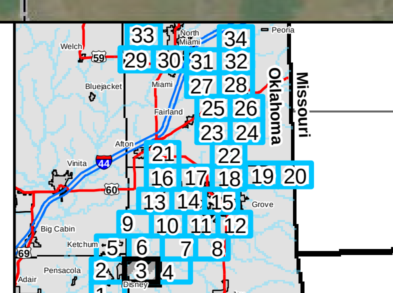


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**Legend**

- Major Roadway
- Waterway
- Waterbody
- 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
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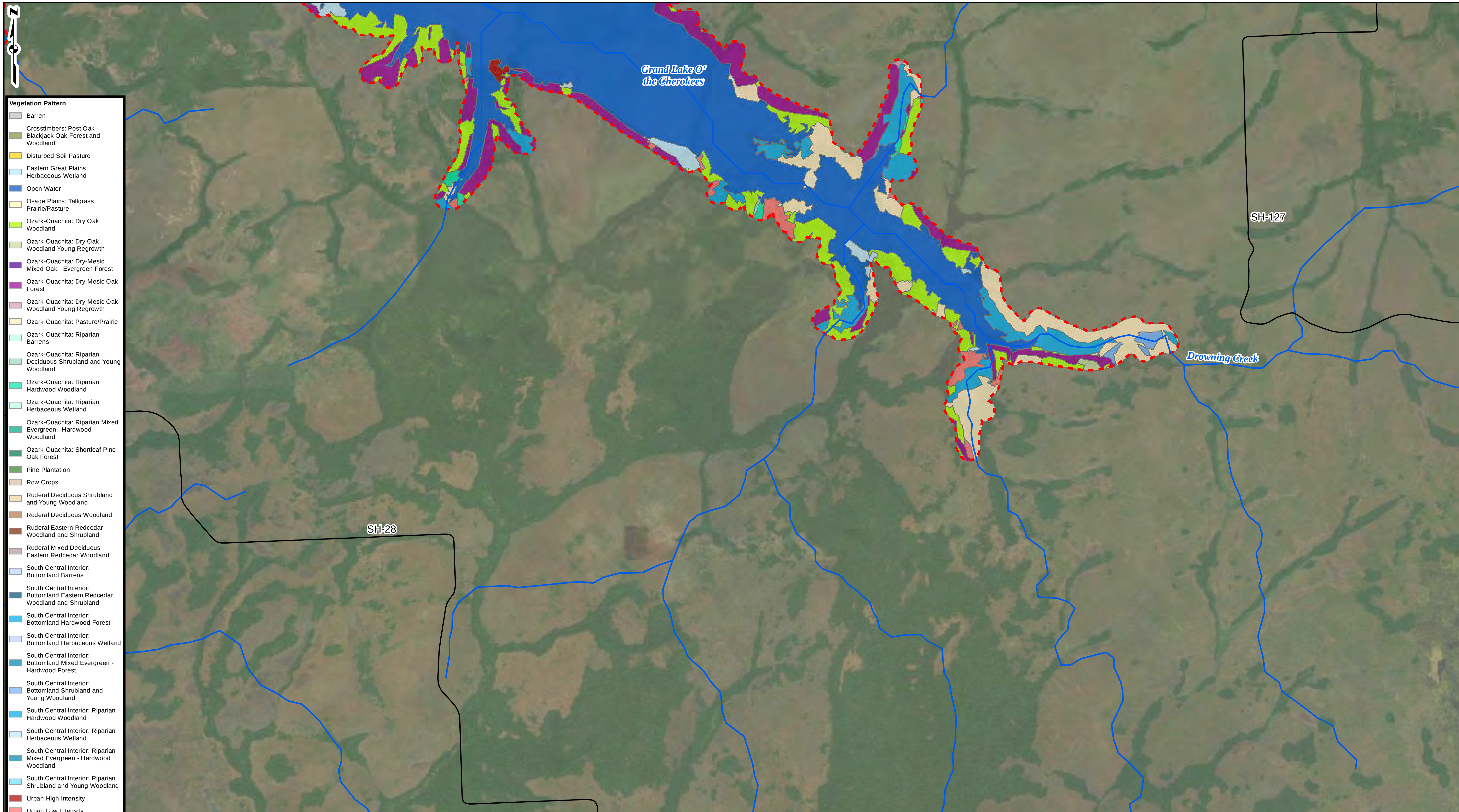


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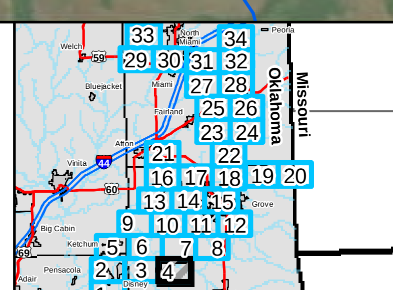


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**Legend**

Major Roadway
Waterway
Waterbody
200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
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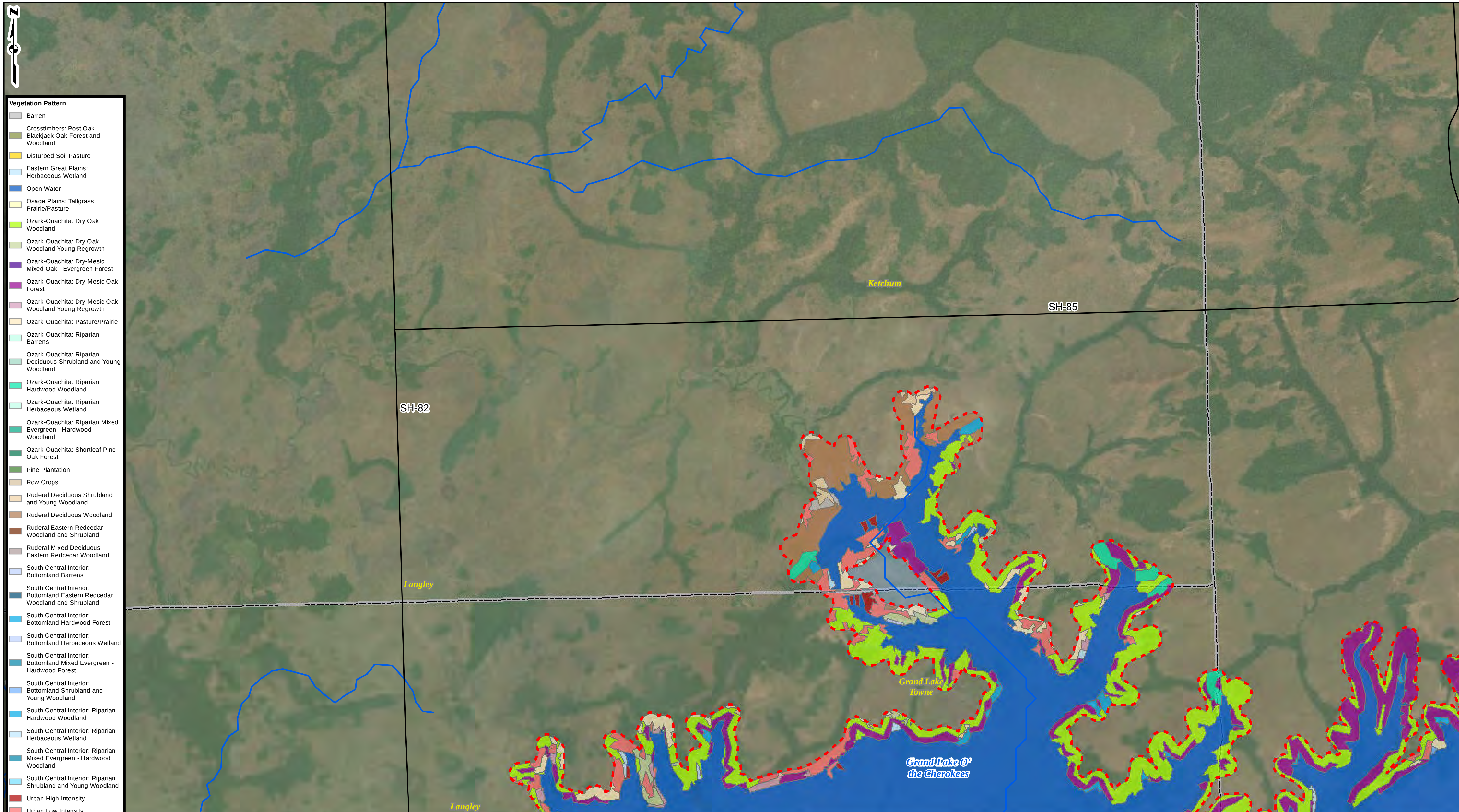


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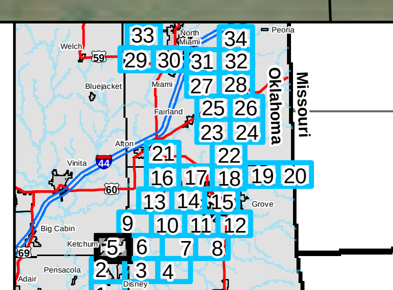


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## Legend

- Major Roadway
- Waterway
- Waterbody
- 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

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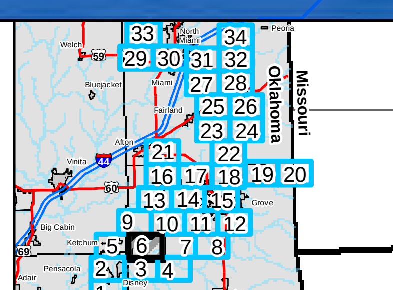


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**Legend**

- Major Roadway
- Waterbody
- Waterway
- 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
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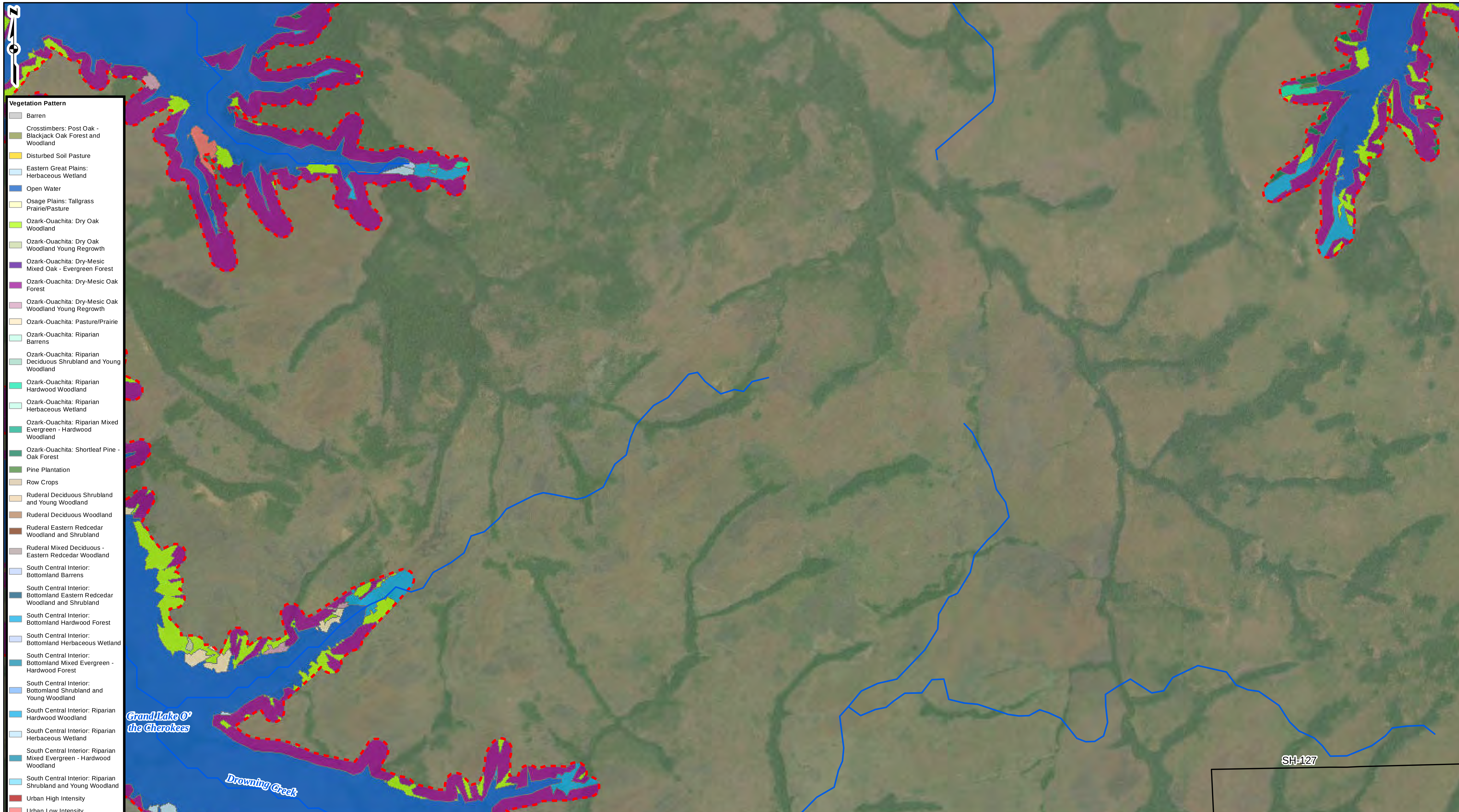


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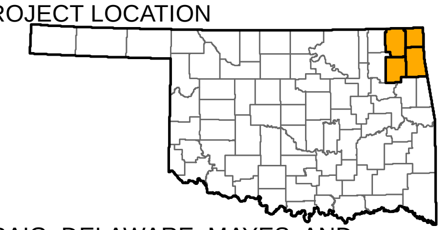
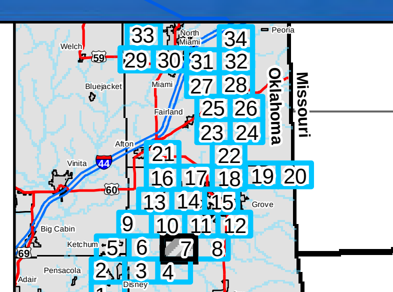


CRAIG, DELAWARE, MAYES, AND
OTTAWA COUNTIES, OKLAHOMA

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**Legend**

- Major Roadway
- Waterway
- Waterbody
- 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
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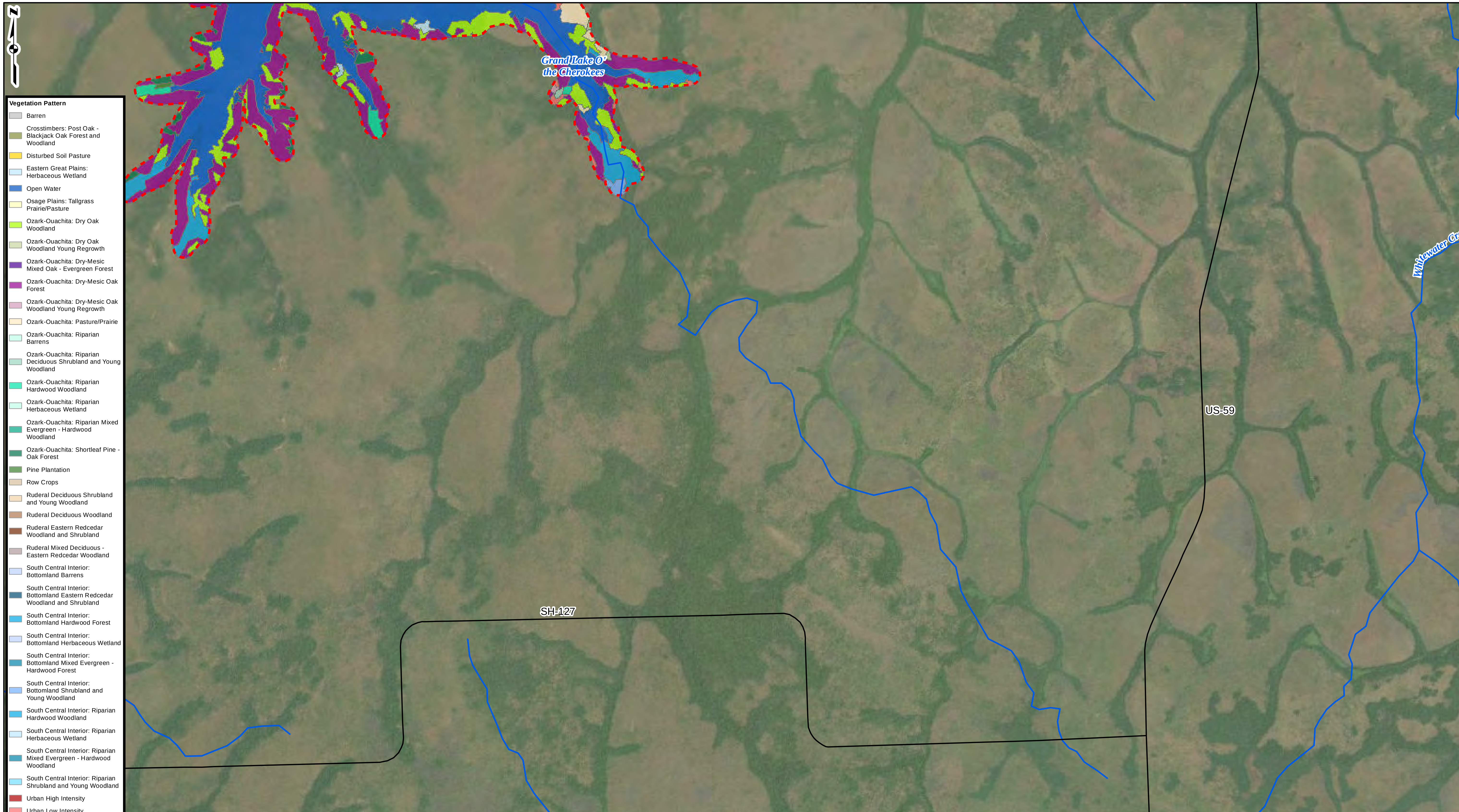


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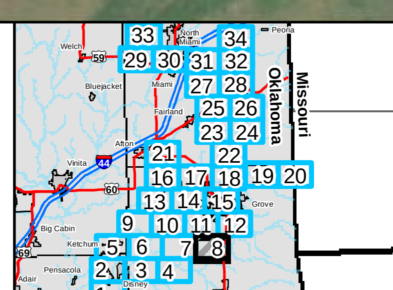


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**Legend**

Major Roadway — Waterbody
Waterway — 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

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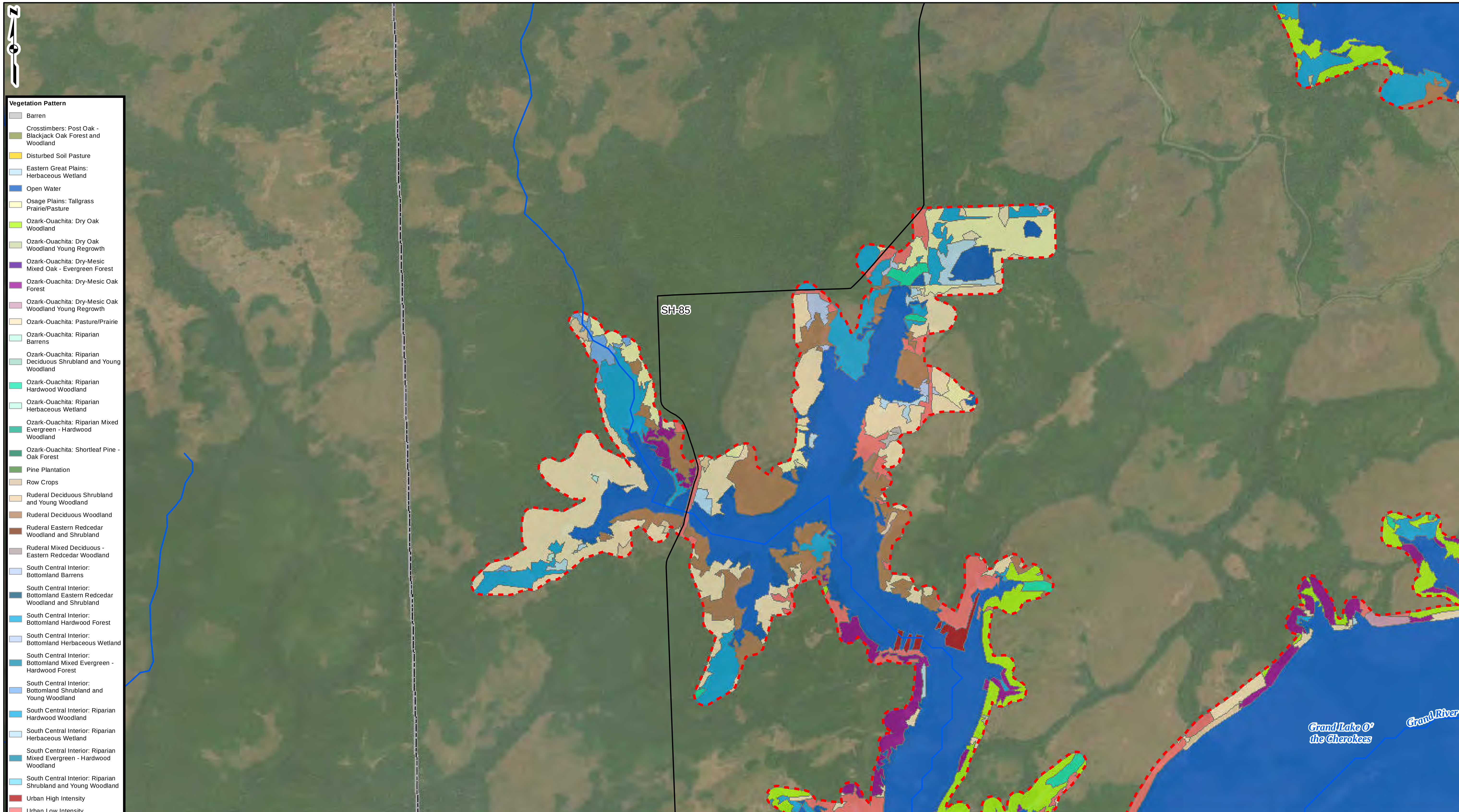
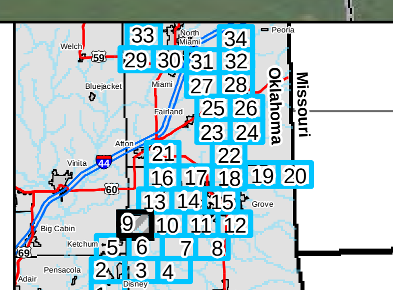



PROJECT LOCATION

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

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**Legend**

- Major Roadway
- Waterway
- Waterbody
- 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
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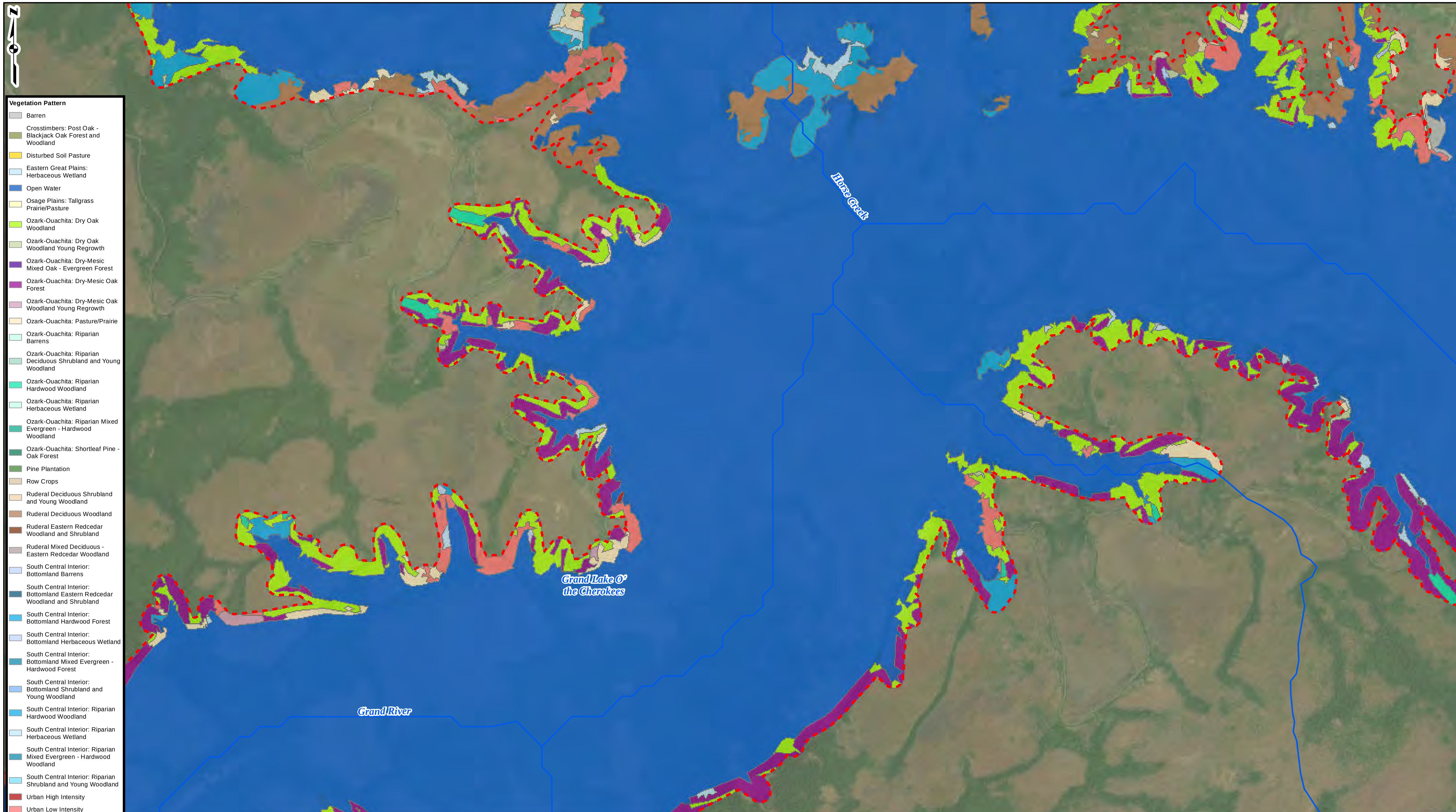
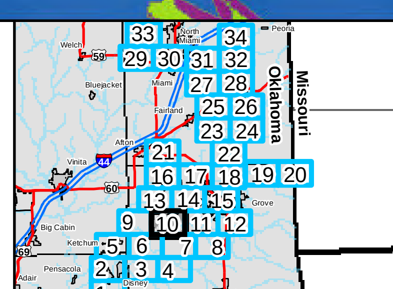



PROJECT LOCATION

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

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**Legend**

Major Roadway
Waterbody
Waterway
200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
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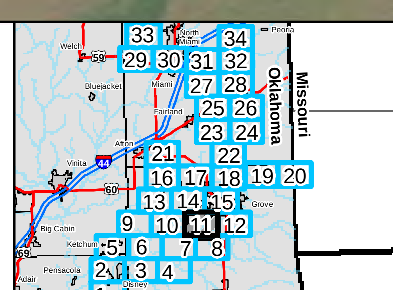
PROJECT LOCATION

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA




REFERENCE:
Transporation, OkDOT, 2012, 2017; Hydrology, Oklahoma Conservation Commission, 2020; Municipal Boundaries, Oklahoma Tax Commission, 2/2021.
ESRI World Imagery, 2021, Accessed 1/2022.
Vegetation and Landcover, MoRAP, 3/2015

**Legend**

Major Roadway
Waterbody
Waterway
200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 11 OF 34

PENSACOLA HYDROELECTRIC PROJECT
FERC No. P-1494

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Mead&Hunt

DRAWN BY: EMW
DATE: 3/9/2022
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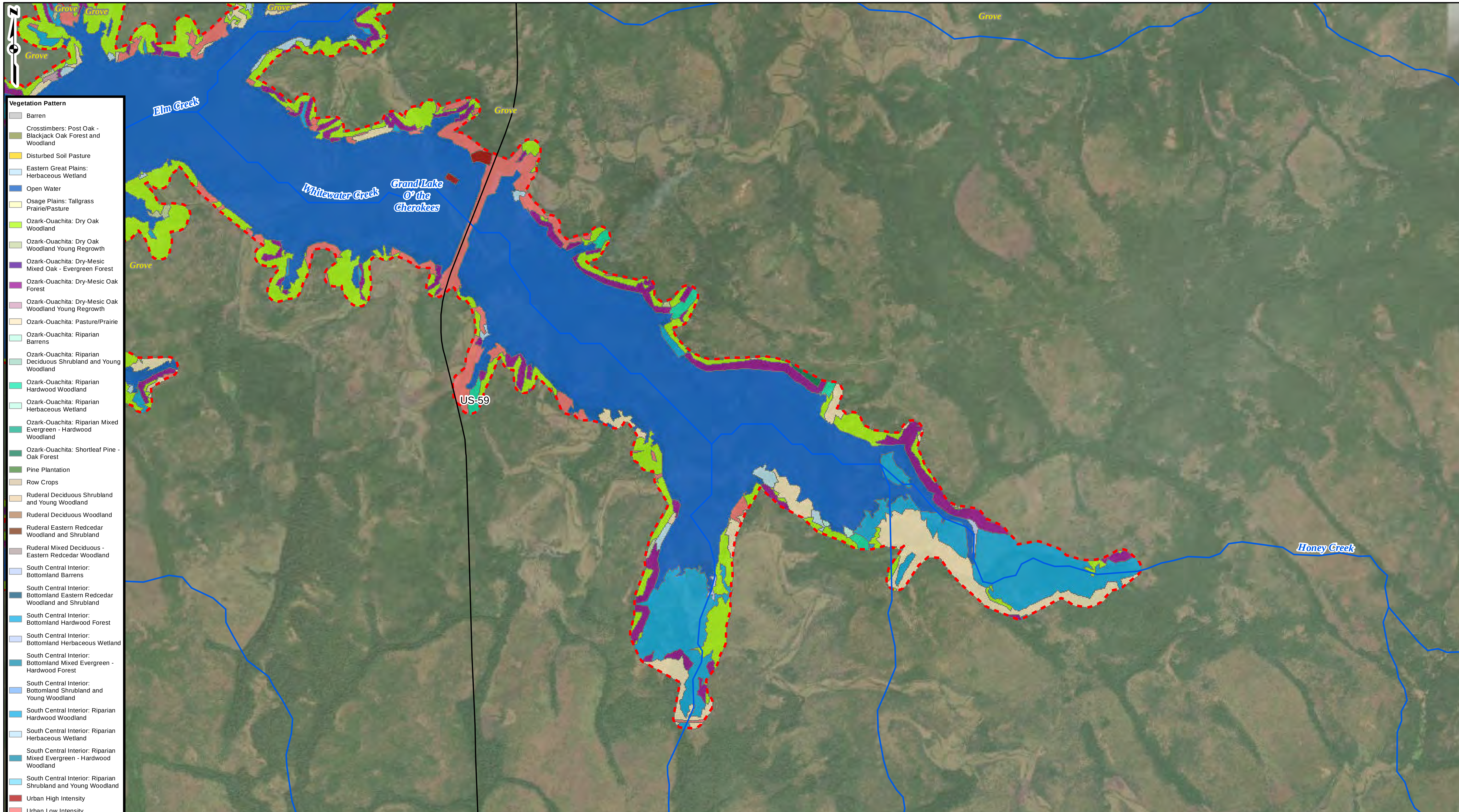
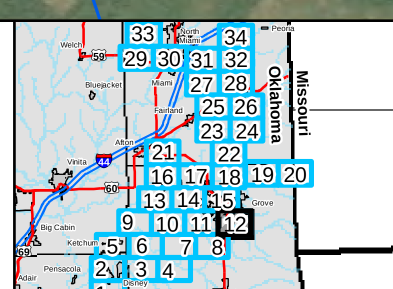



PROJECT LOCATION

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

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Transporation, OkDOT, 2012, 2017; Hydrology, Oklahoma Conservation Commission, 2020; Municipal Boundaries, Oklahoma Tax Commission, 2/2021.
ESRI World Imagery, 2021, Accessed 1/2022.
Vegetation and Landcover, MoRAP, 3/2015

**Legend**

| | |
|---|---|
| Major Roadway | Waterbody |
| Waterway | 200 ft Buffer Project Boundary (1/27/2014) |

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 12 OF 34

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PENSACOLA HYDROELECTRIC PROJECT
FERC No. P-1494

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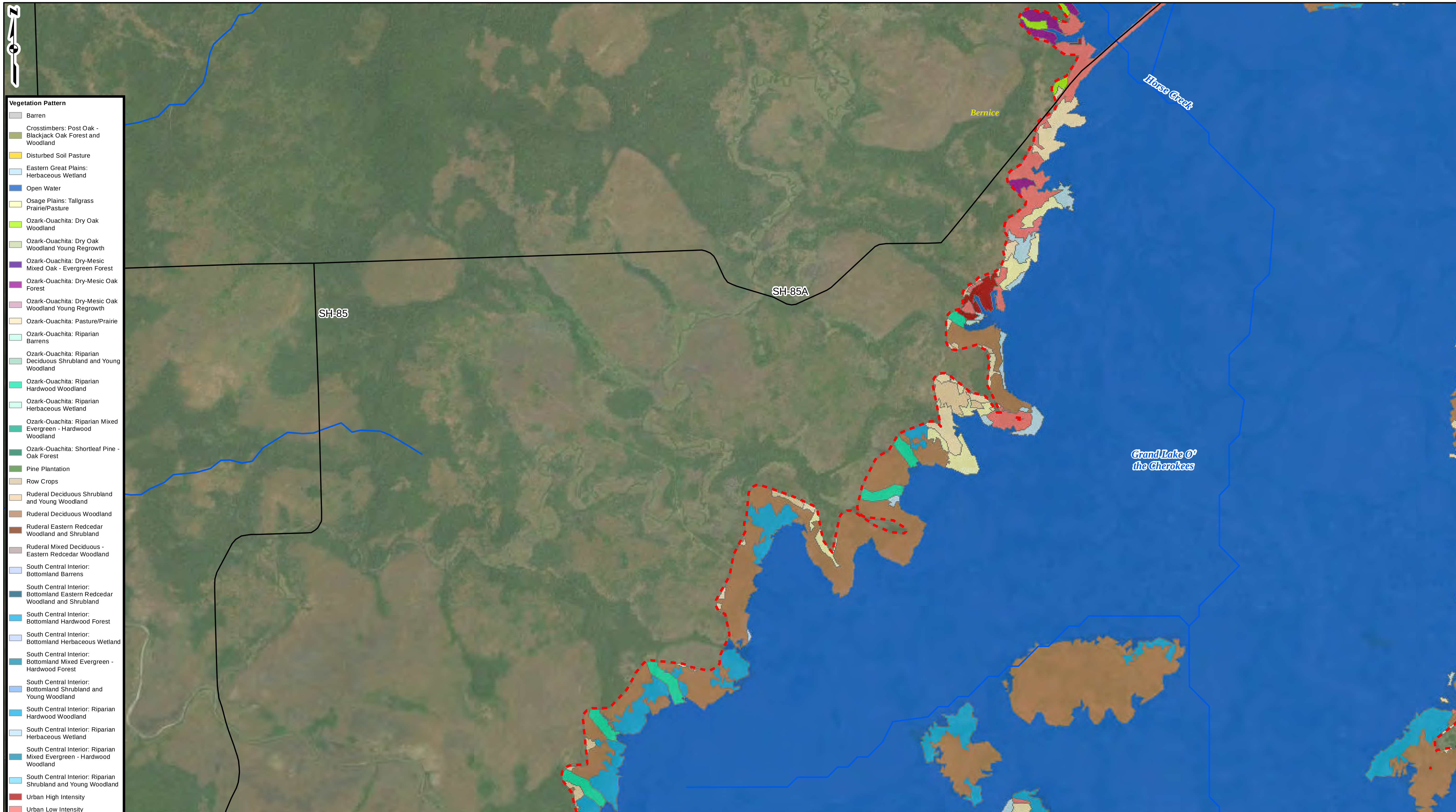
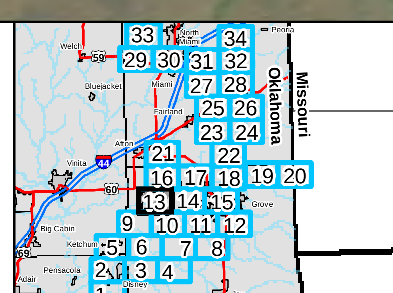



PROJECT LOCATION

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA




REFERENCE:
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ESRI World Imagery, 2021, Accessed 1/2022.
Vegetation and Landcover, MoRAP, 3/2015

## Legend

Major Roadway — Waterbody
Waterway — 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

# VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 13 OF 34

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PENSACOLA HYDROELECTRIC PROJECT
FERC No. P-1494

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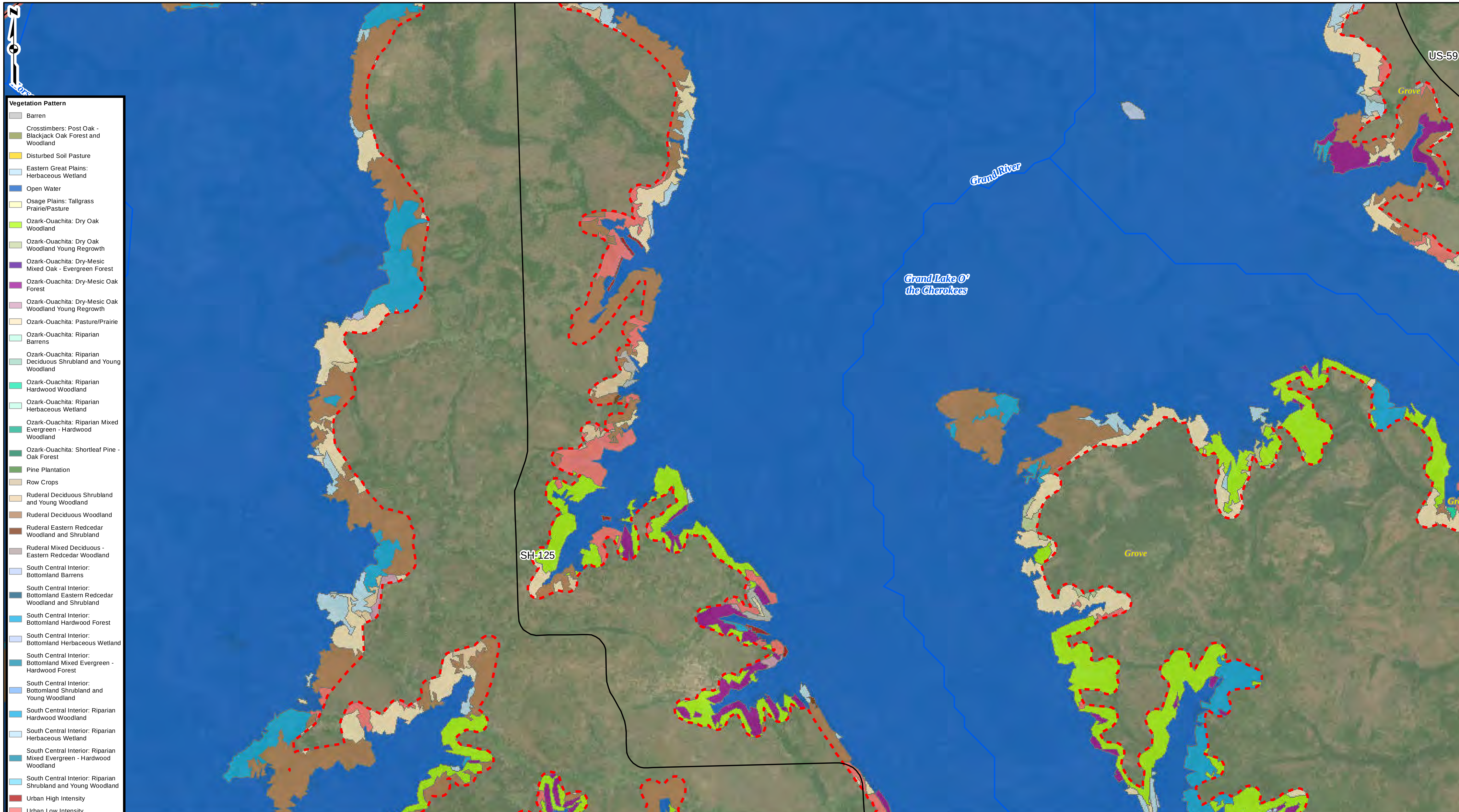
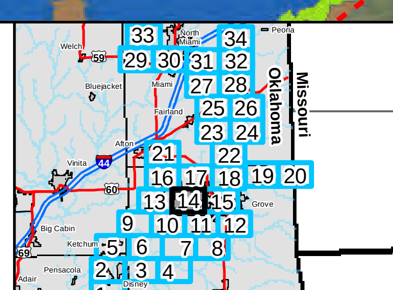



PROJECT LOCATION

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

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Transporation, OkDOT, 2012, 2017; Hydrology, Oklahoma Conservation Commission, 2020; Municipal Boundaries, Oklahoma Tax Commission, 2/2021.
ESRI World Imagery, 2021, Accessed 1/2022.
Vegetation and Landcover, MoRAP, 3/2015

**Legend**

Major Roadway | Waterbody
Waterway | 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 14 OF 34

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PENSACOLA HYDROELECTRIC PROJECT
FERC No. P-1494

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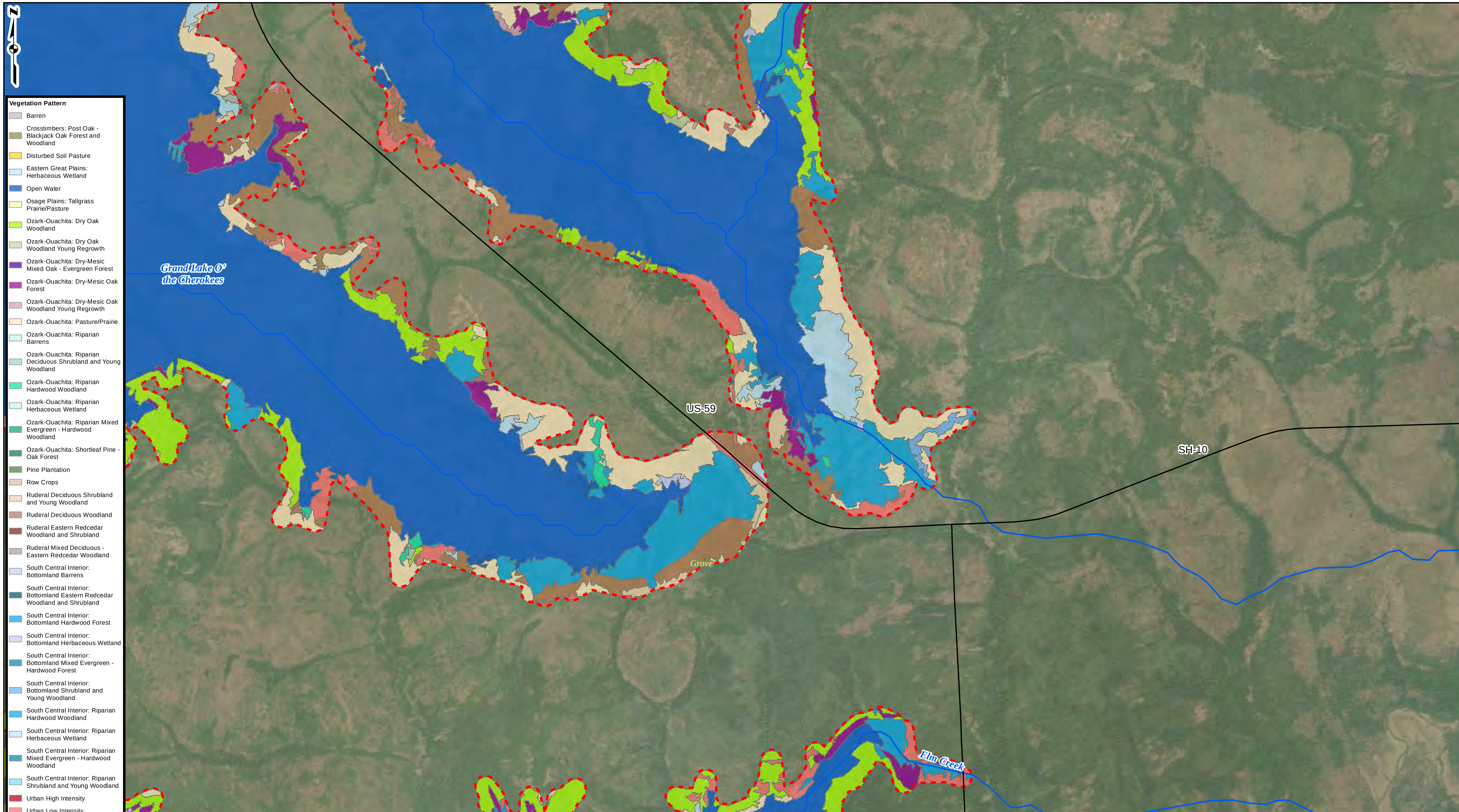
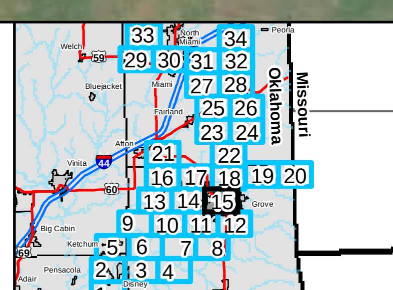



PROJECT LOCATION

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

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ESRI World Imagery, 2021, Accessed 1/2022.
Vegetation and Landcover, MoRAP, 3/2015

**Legend**

- Major Roadway
- Waterway
- Waterbody
- 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 15 OF 34

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PENSACOLA HYDROELECTRIC PROJECT
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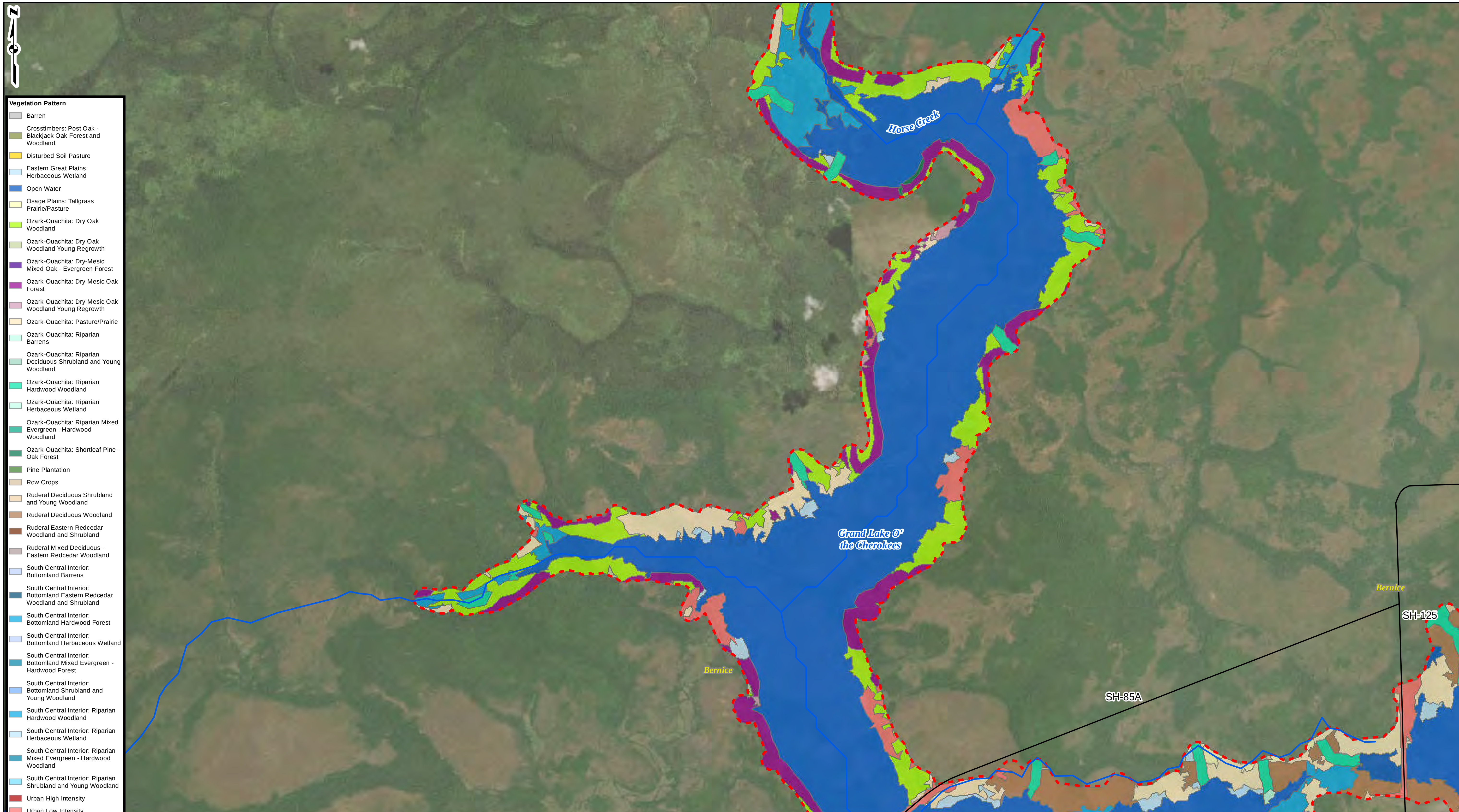


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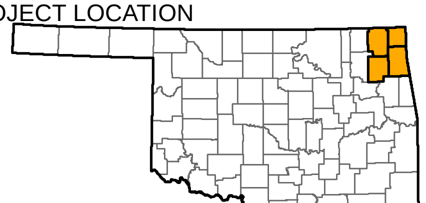
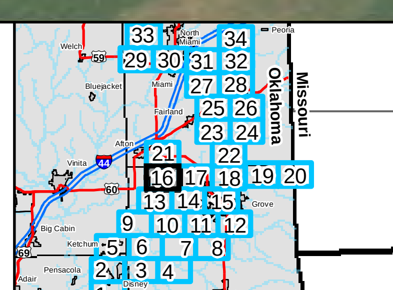


CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

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Vegetation and Landcover, MoRAP, 3/2015

## Legend

- Major Roadway
- Waterway
- Waterbody
- 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 16 OF 34

PENSACOLA HYDROELECTRIC PROJECT
FERC No. P-1494

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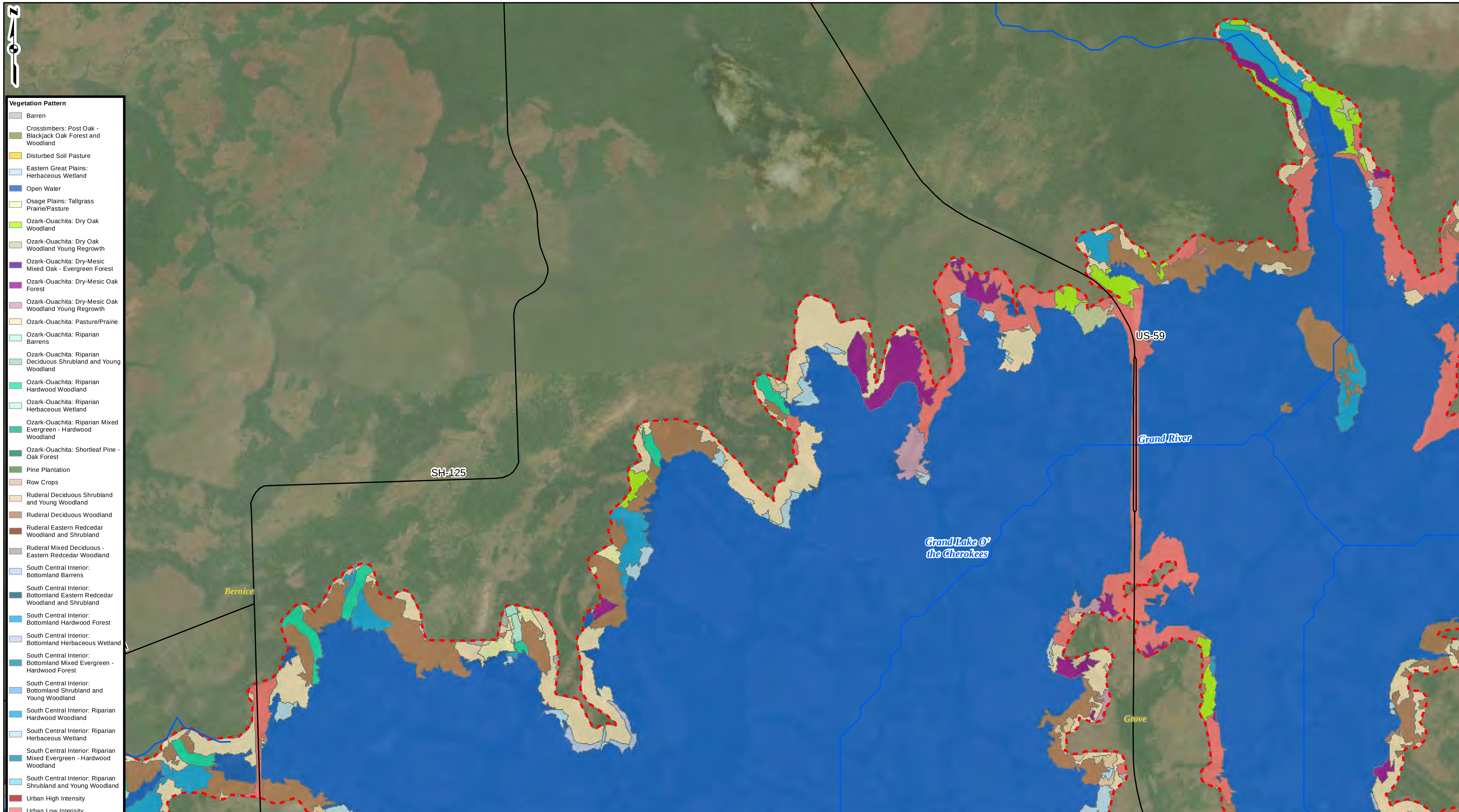
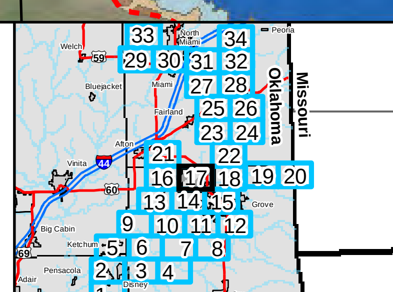



PROJECT LOCATION

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

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ESRI World Imagery, 2021, Accessed 1/2022.
Vegetation and Landcover, MoRAP, 3/2015

**Legend**

- Major Roadway
- Waterway
- Waterbody
- 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

# VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT SHEET 17 OF 34

PENSACOLA HYDROELECTRIC PROJECT
FERC No. P-1494

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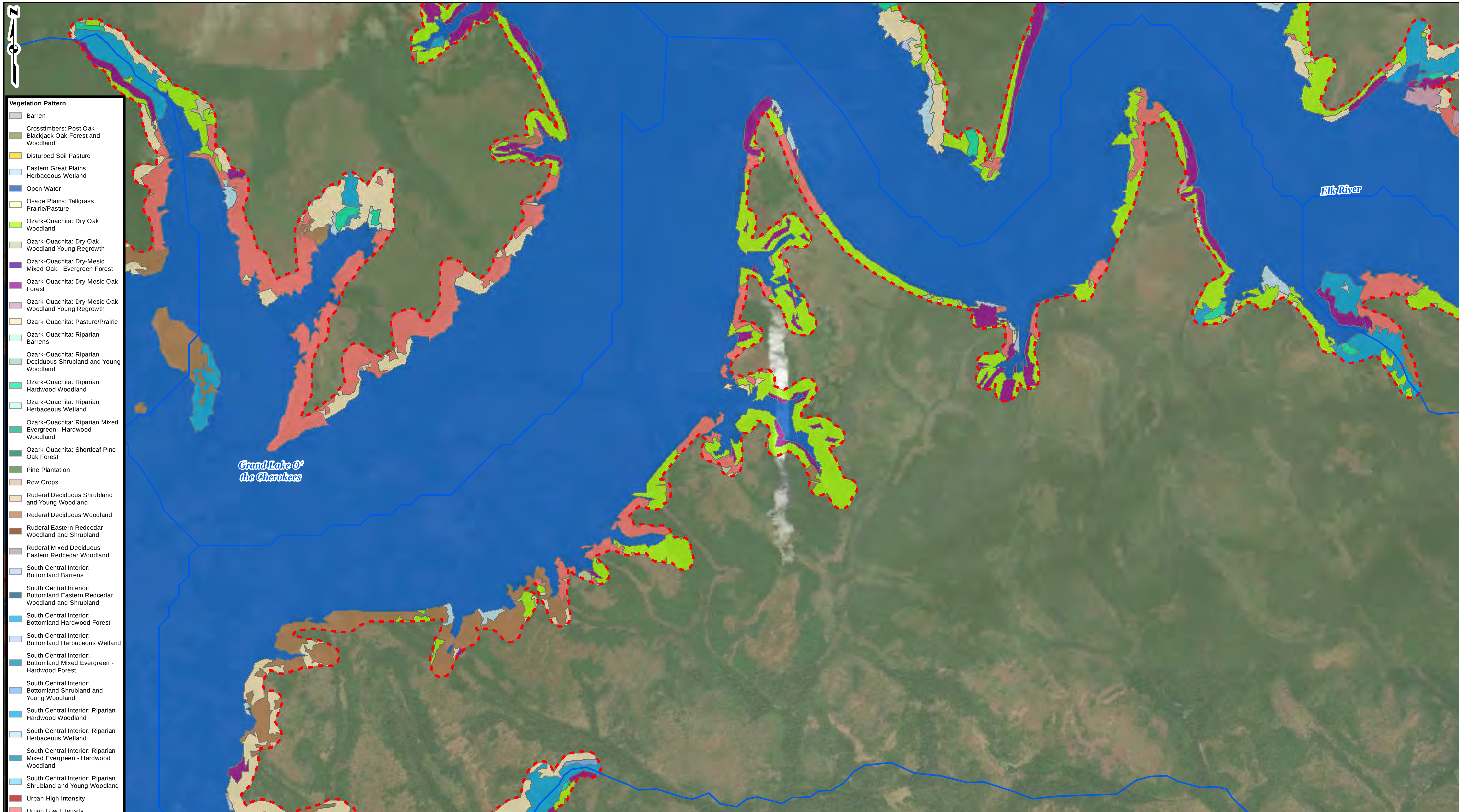
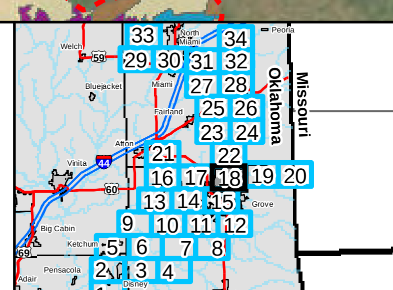



PROJECT LOCATION

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

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ESRI World Imagery, 2021, Accessed 1/2022.
Vegetation and Landcover, MoRAP, 3/2015

**Legend**

- Major Roadway
- Waterway
- Waterbody
- 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 18 OF 34

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PENSACOLA HYDROELECTRIC PROJECT
FERC No. P-1494

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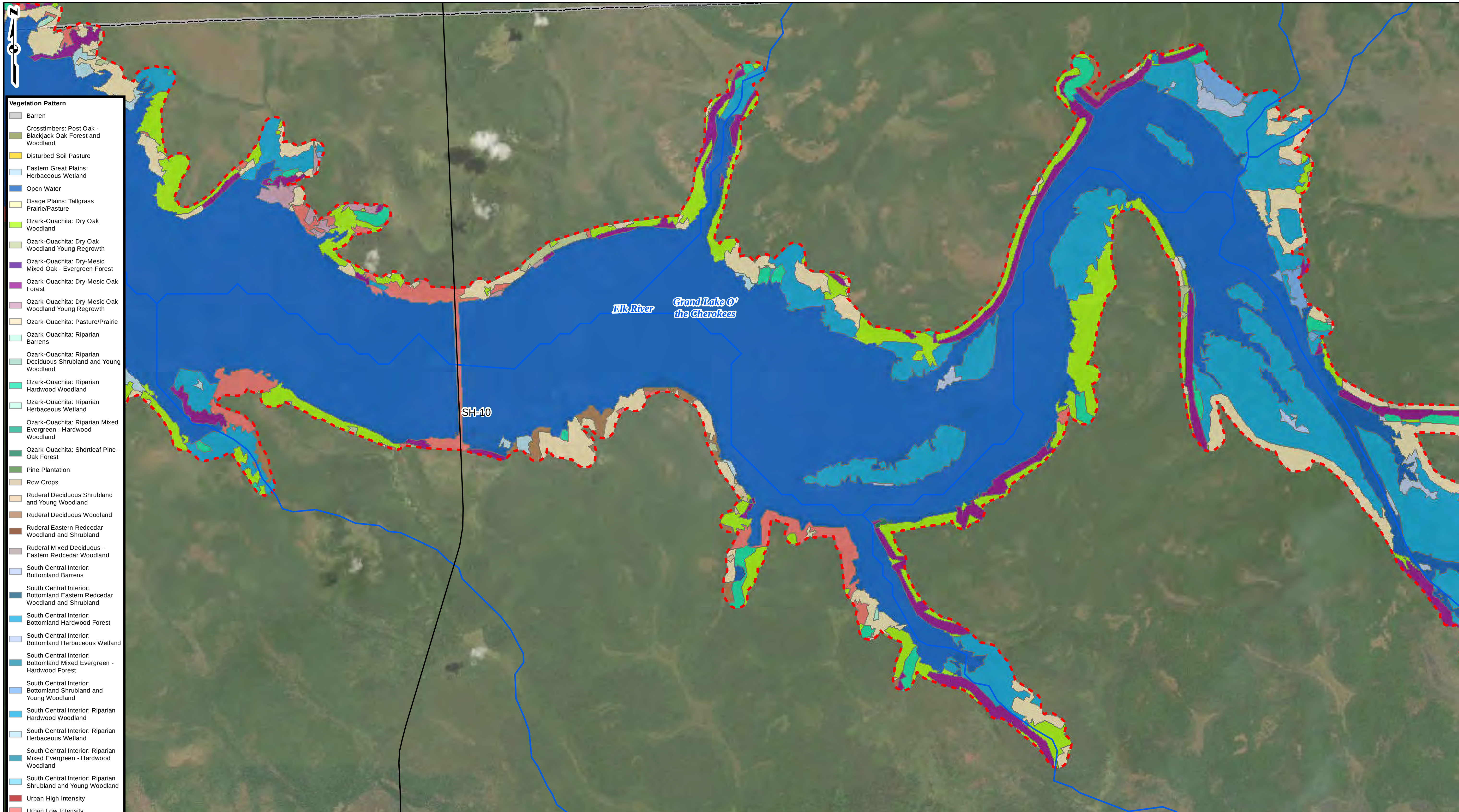
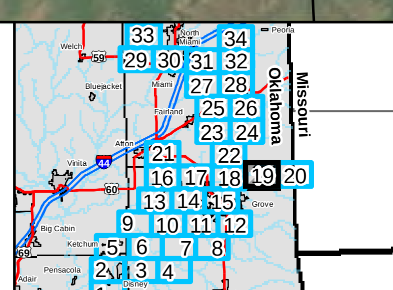



PROJECT LOCATION

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

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Transporation, OkDOT, 2012, 2017; Hydrology, Oklahoma Conservation Commission, 2020; Municipal Boundaries, Oklahoma Tax Commission, 2/2021.
ESRI World Imagery, 2021, Accessed 1/2022.
Vegetation and Landcover, MoRAP, 3/2015

**Legend**

Major Roadway
Waterbody
Waterway
200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 19 OF 34

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PENSACOLA HYDROELECTRIC PROJECT
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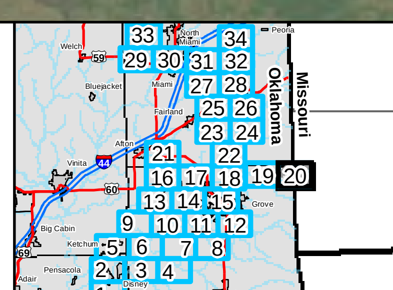
PROJECT LOCATION

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

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Transporation, OkDOT, 2012, 2017; Hydrology, Oklahoma Conservation Commission, 2020; Municipal Boundaries, Oklahoma Tax Commission, 2/2021.
ESRI World Imagery, 2021, Accessed 1/2022.
Vegetation and Landcover, MoRAP, 3/2015

**Legend**

- Major Roadway
- Waterway
- Waterbody
- 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 20 OF 34

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PENSACOLA HYDROELECTRIC PROJECT
FERC No. P-1494

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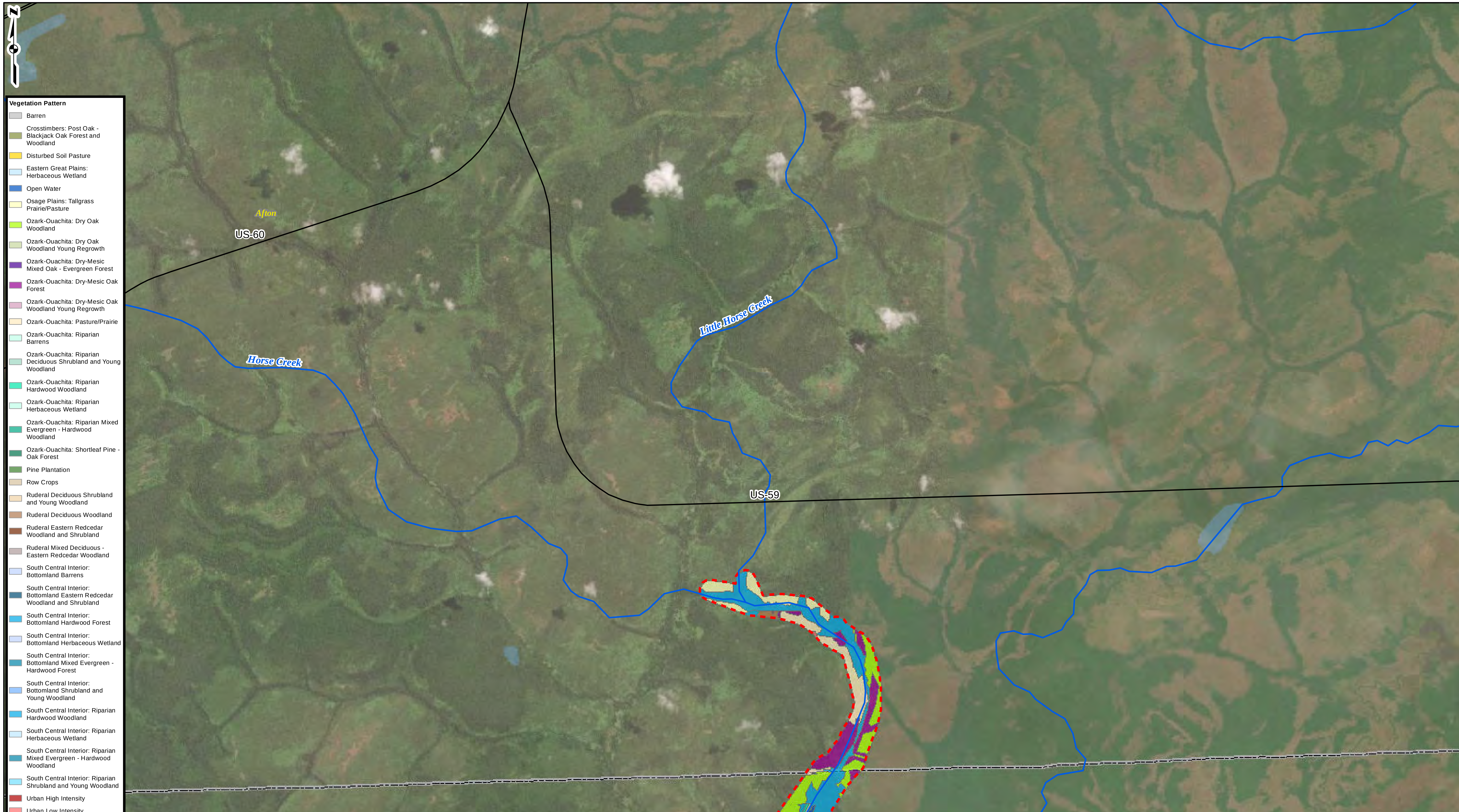
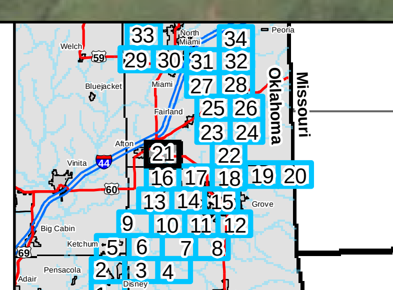



PROJECT LOCATION

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

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ESRI World Imagery, 2021, Accessed 1/2022.
Vegetation and Landcover, MoRAP, 3/2015

**Legend**

- Major Roadway
- Waterway
- Waterbody
- 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 21 OF 34

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PENSACOLA HYDROELECTRIC PROJECT
FERC No. P-1494

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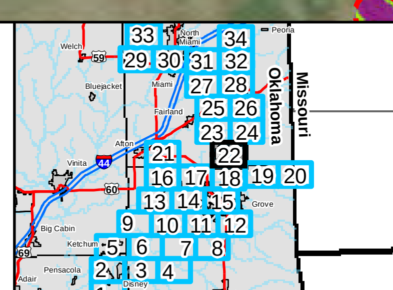
PROJECT LOCATION




CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

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ESRI World Imagery, 2021, Accessed 1/2022.
Vegetation and Landcover, MoRAP, 3/2015

**Legend**

- Major Roadway
- Waterway
- Waterbody
- 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 22 OF 34

PENSACOLA HYDROELECTRIC PROJECT
FERC No. P-1494

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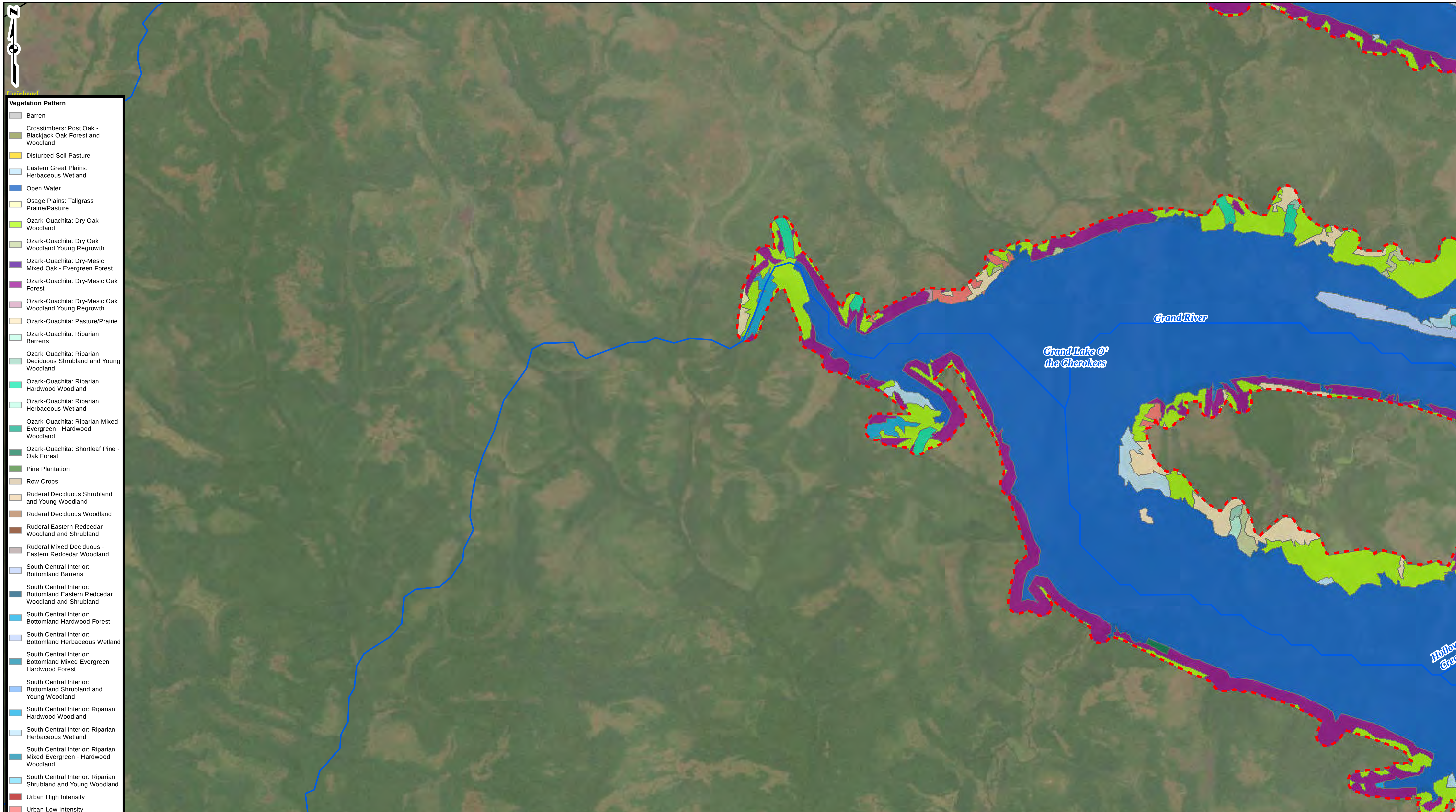
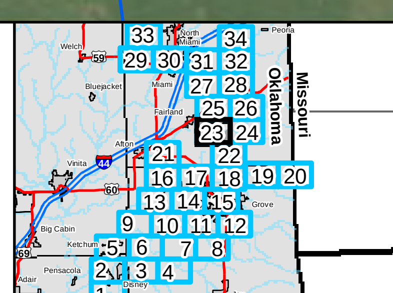



PROJECT LOCATION

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

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ESRI World Imagery, 2021, Accessed 1/2022.
Vegetation and Landcover, MoRAP, 3/2015

**Legend**

Major Roadway
Waterbody
Waterway
200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 23 OF 34

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PENSACOLA HYDROELECTRIC PROJECT
FERC No. P-1494

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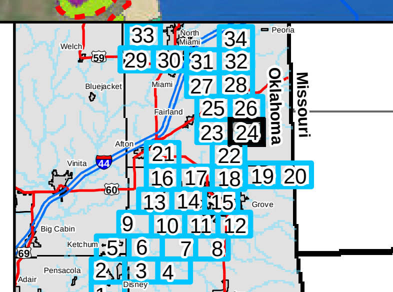
PROJECT LOCATION

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

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Vegetation and Landcover, MoRAP, 3/2015

**Legend**

- Major Roadway
- Waterway
- Waterbody
- 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 24 OF 34

PENSACOLA HYDROELECTRIC PROJECT
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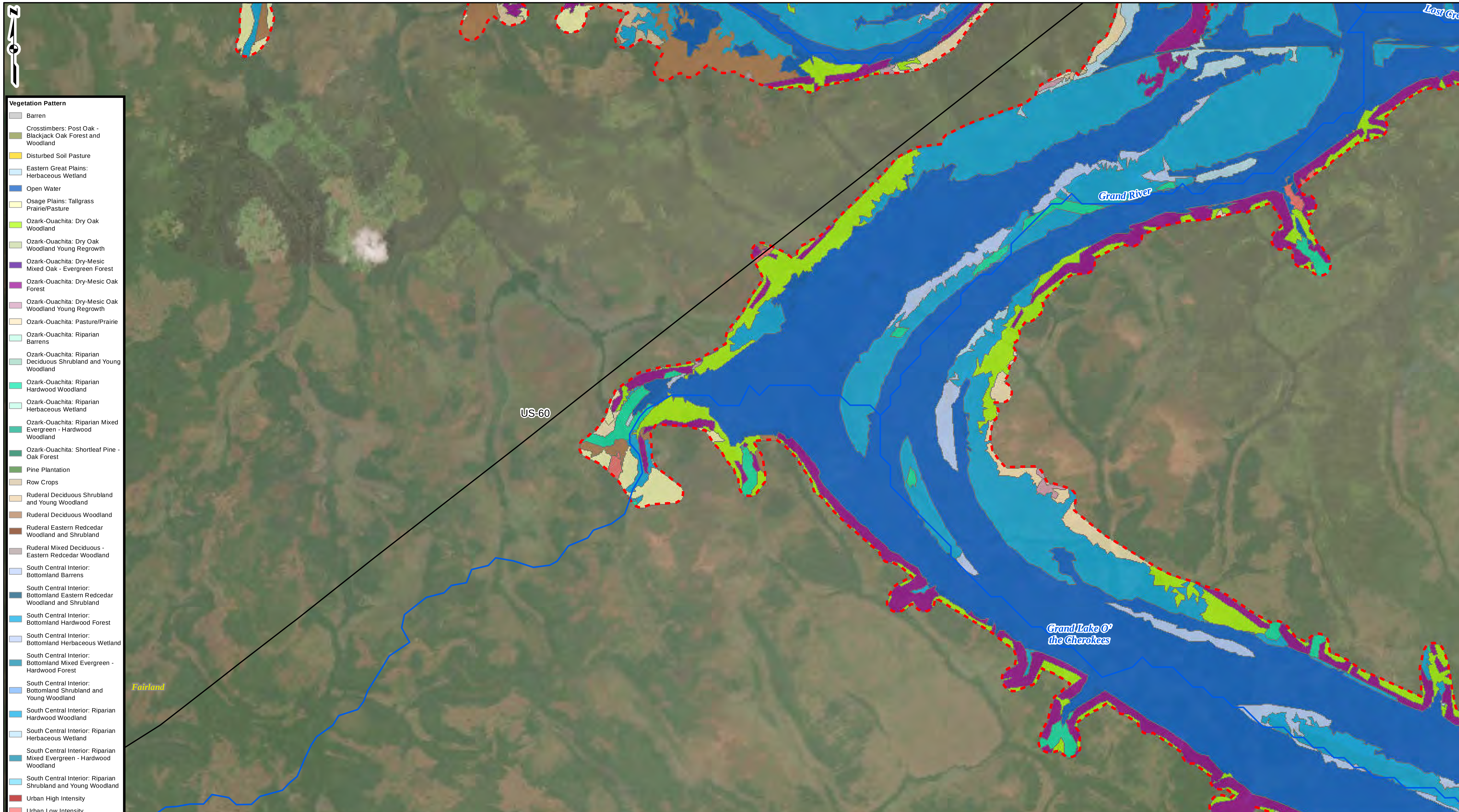
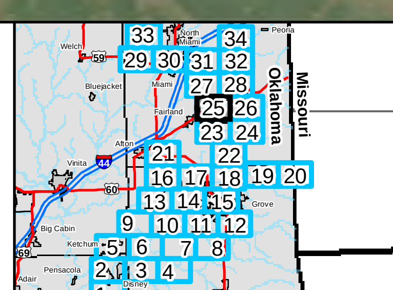



PROJECT LOCATION

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

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Vegetation and Landcover, MoRAP, 3/2015

**Legend**

Major Roadway
Waterbody
Waterway
200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 25 OF 34

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PENSACOLA HYDROELECTRIC PROJECT
FERC No. P-1494

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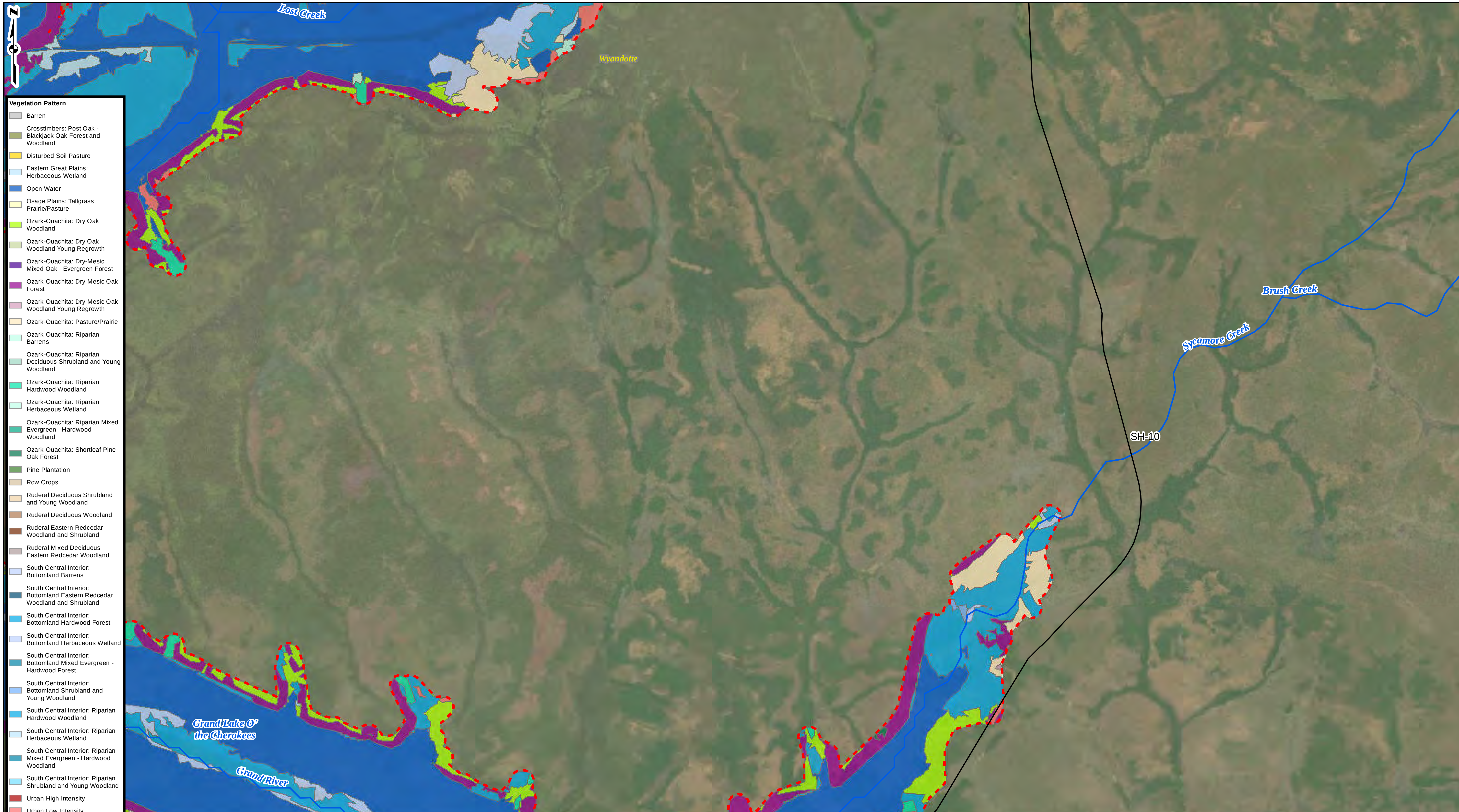


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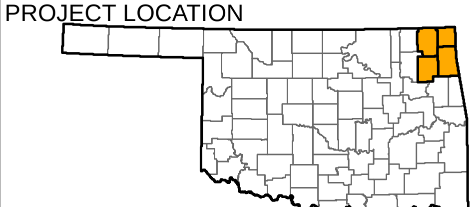
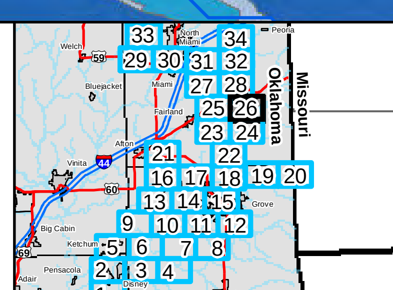


CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

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Vegetation and Landcover, MoRAP, 3/2015

**Legend**

Major Roadway | Waterbody
Waterway | 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 26 OF 34

PENSACOLA HYDROELECTRIC PROJECT
FERC No. P-1494

gai consultants | Mead&Hunt

DRAWN BY: EMW | DATE: 3/9/2022
CHECKED: TDB | APPROVED: DMJ

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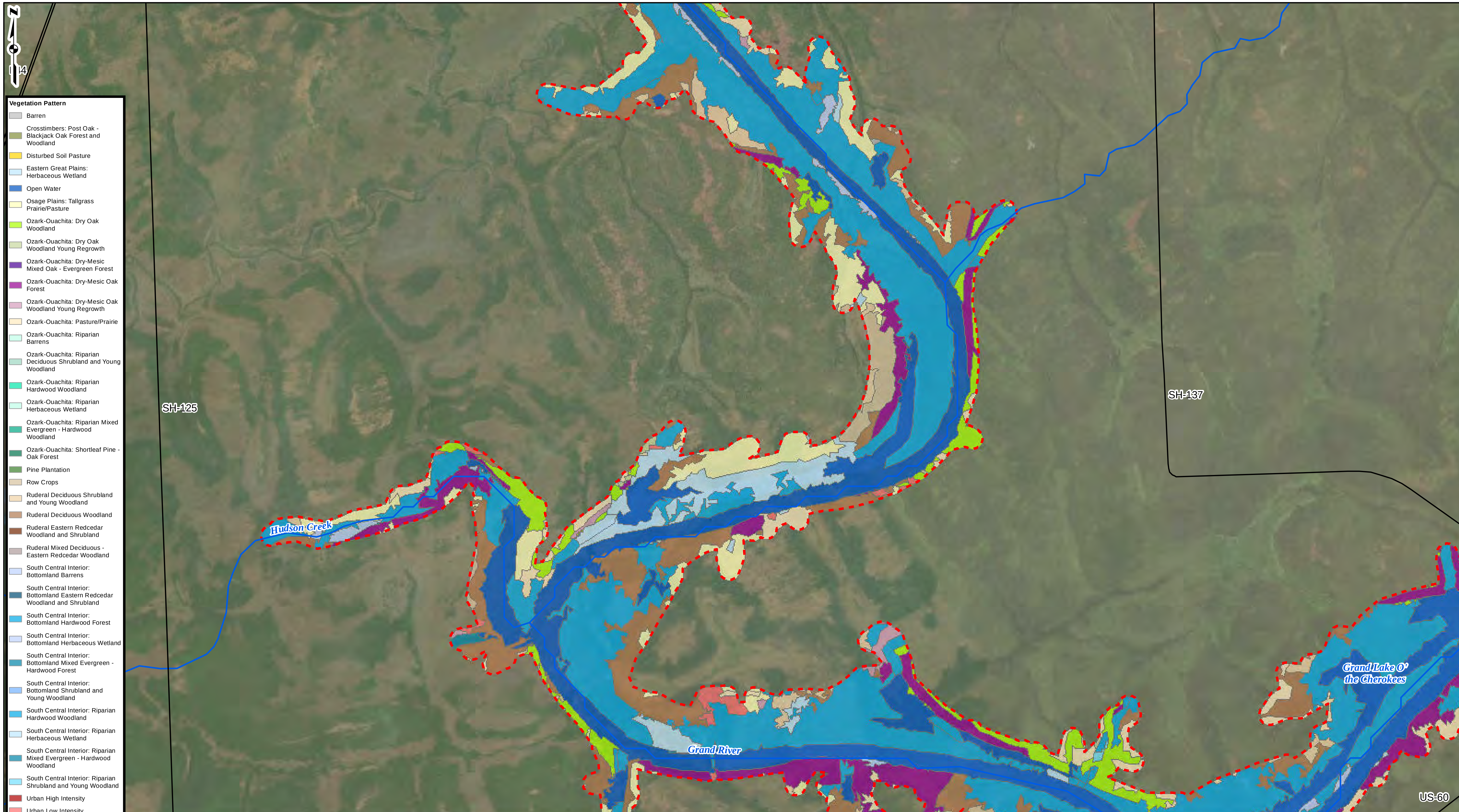
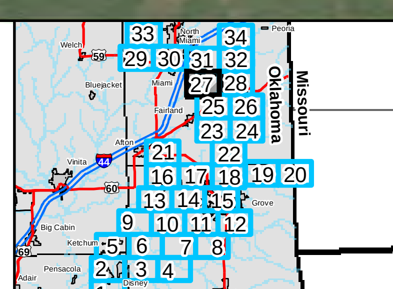



PROJECT LOCATION

CRAIG, DELAWARE, MAYES, AND OTTAWA COUNTIES, OKLAHOMA

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ESRI World Imagery, 2021, Accessed 1/2022.
Vegetation and Landcover, MoRAP, 3/2015

**Legend**

- Major Roadway
- Waterway
- Waterbody
- 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 27 OF 34

gai consultants

PENSACOLA HYDROELECTRIC PROJECT
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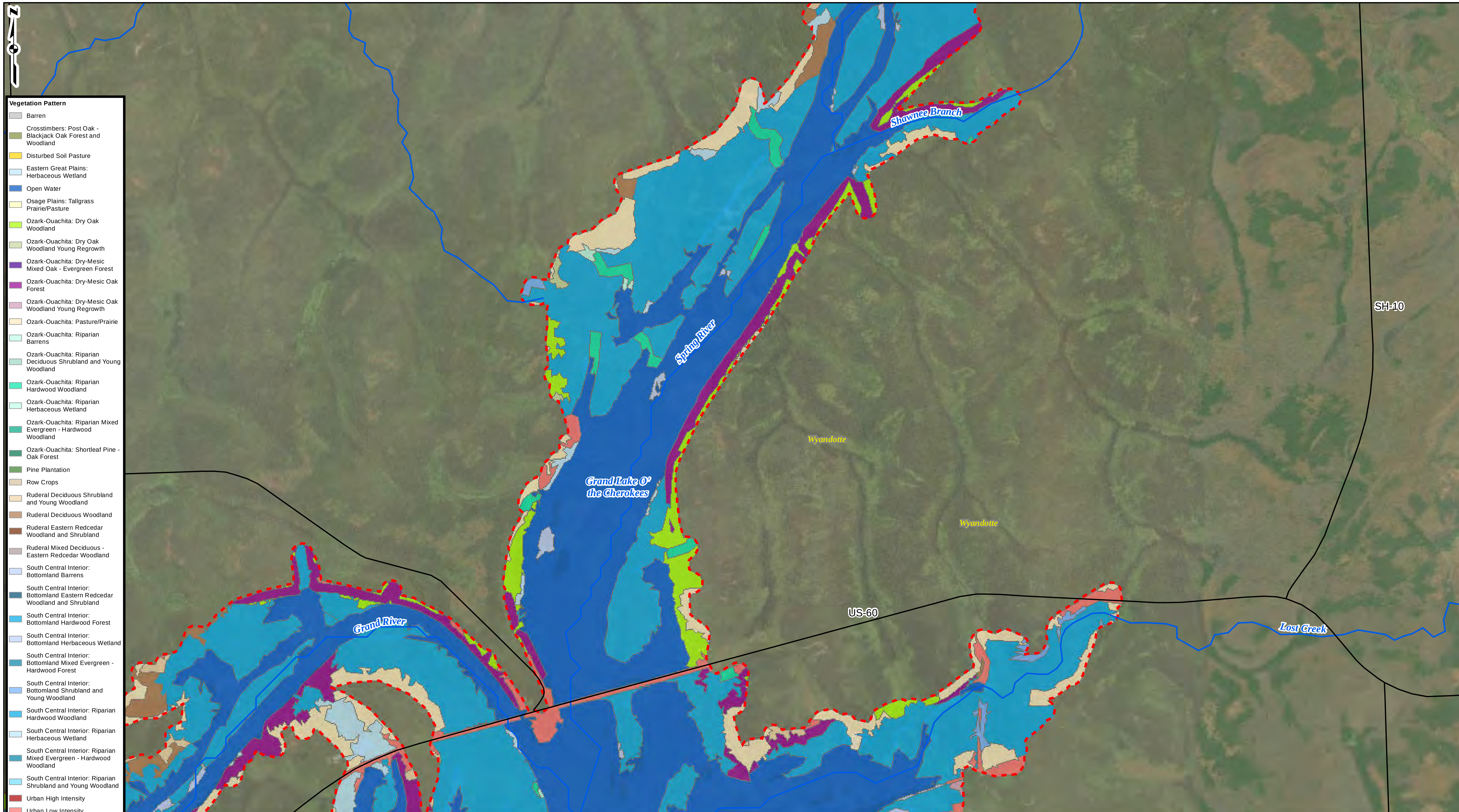


PROJECT LOCATION

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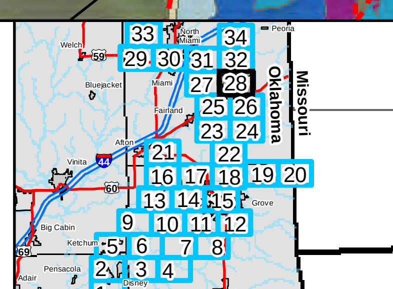


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**Legend**

Major Roadway | Waterbody
Waterway | 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 28 OF 34

PENSACOLA HYDROELECTRIC PROJECT
FERC No. P-1494

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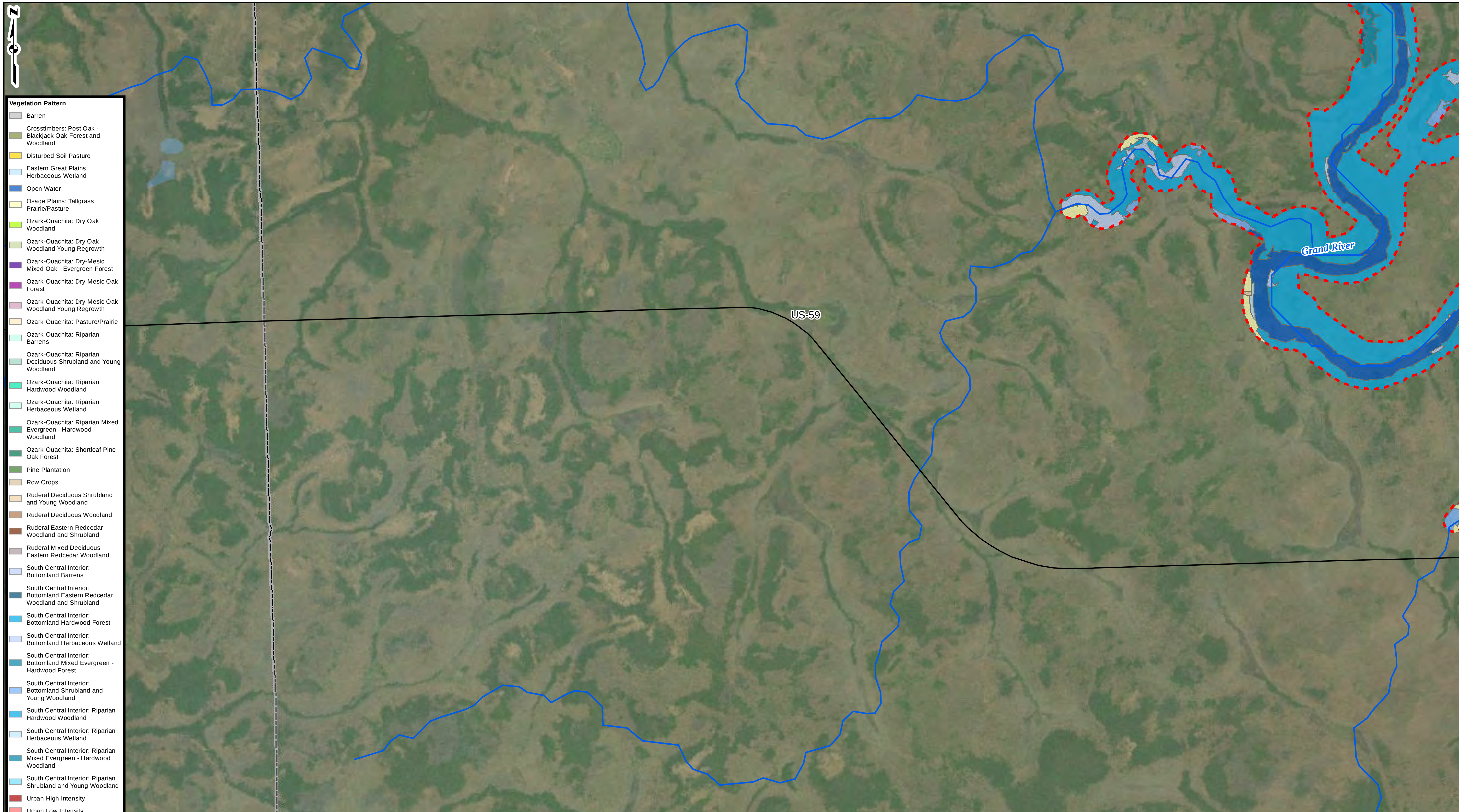


PROJECT LOCATION

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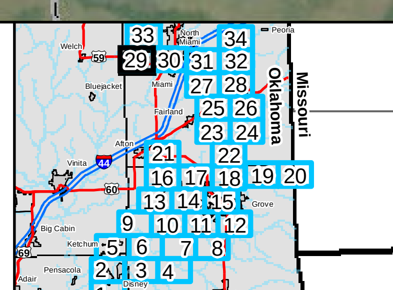


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- Waterway
- Waterbody
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VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 29 OF 34

PENSACOLA HYDROELECTRIC PROJECT
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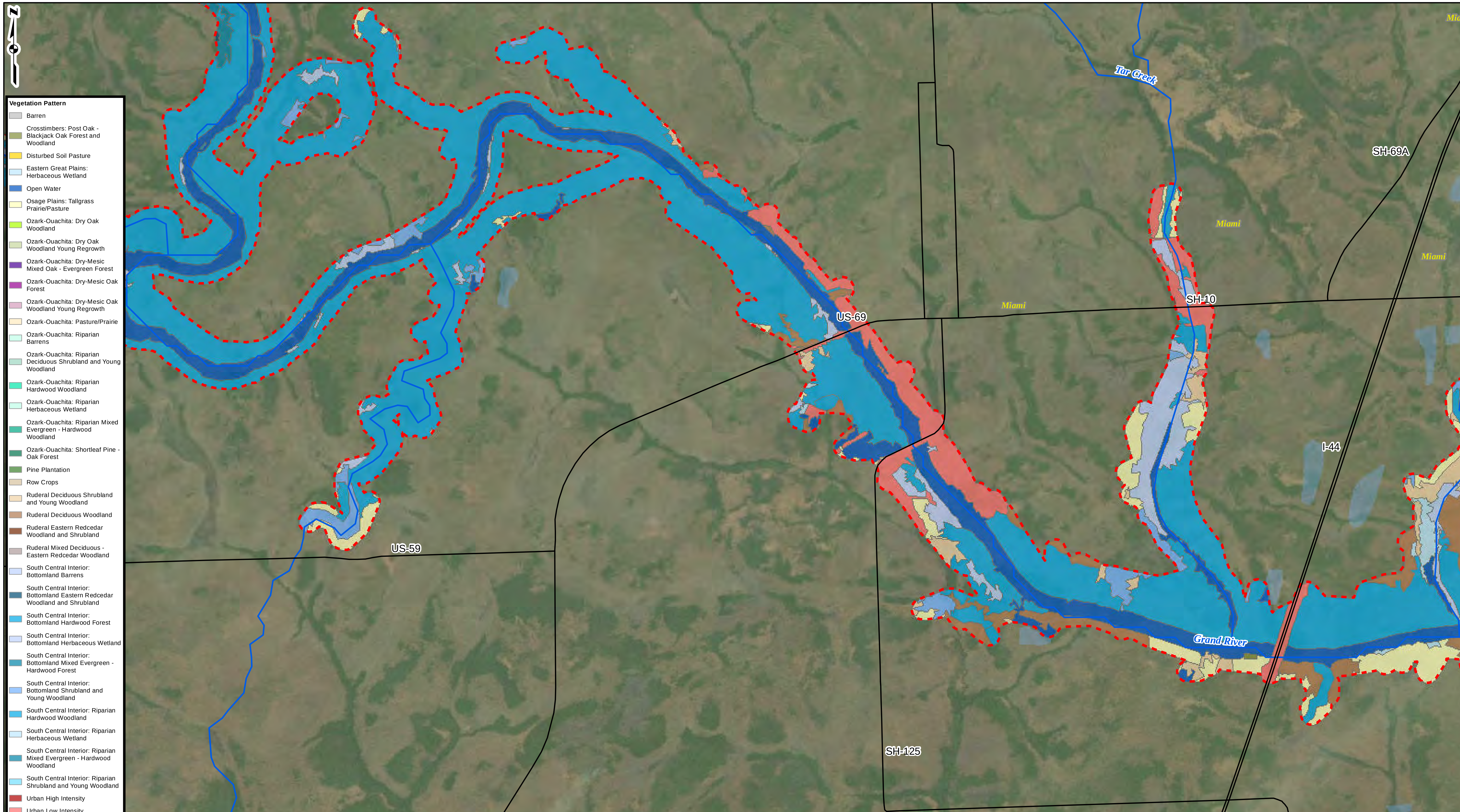


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## Legend

- Major Roadway
- Waterway
- Waterbody
- 200 ft Buffer Project Boundary (1/27/2014)

0 900 1,800 3,600 Feet

# VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT SHEET 30 OF 34

PENSACOLA HYDROELECTRIC PROJECT
FERC No. P-1494

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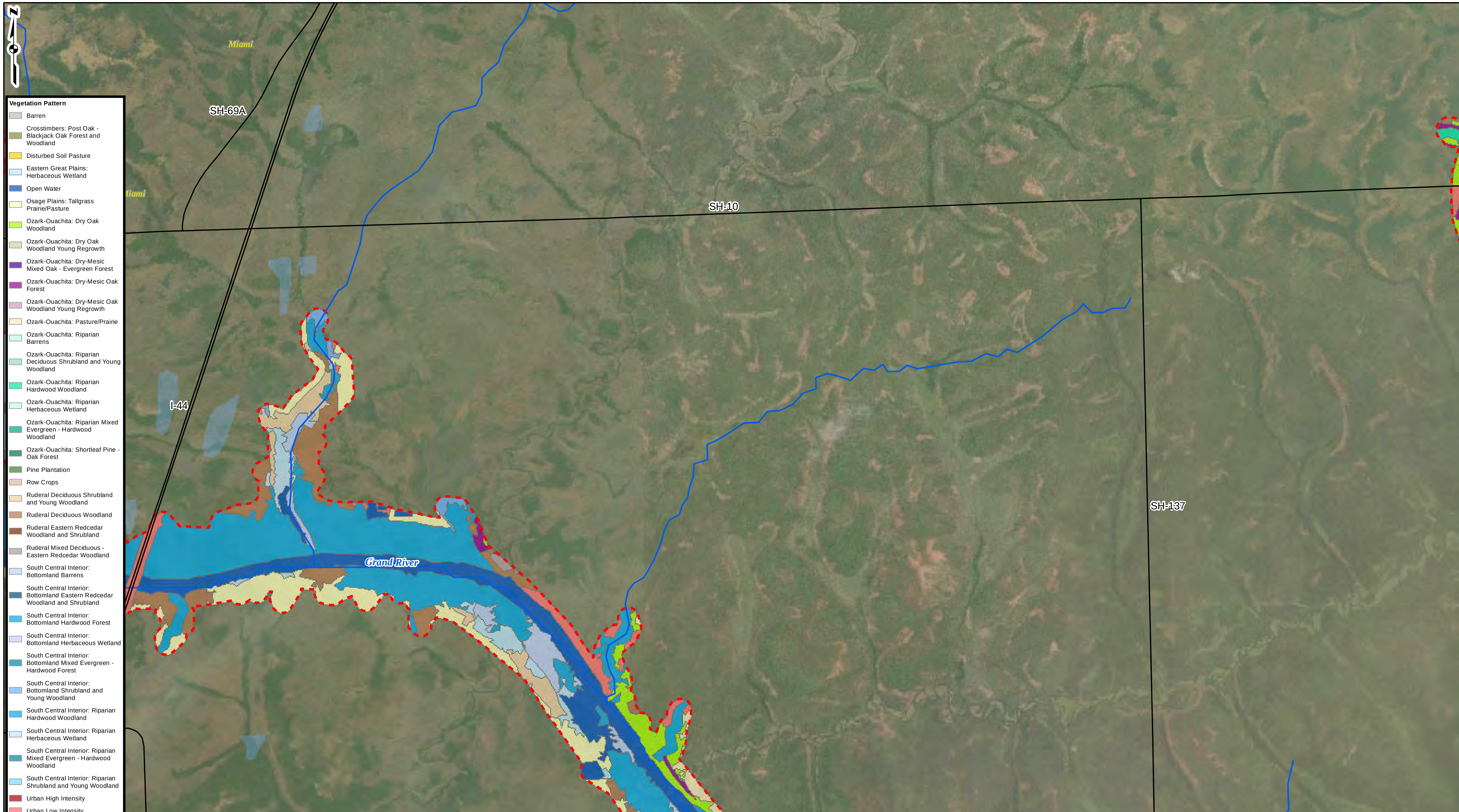


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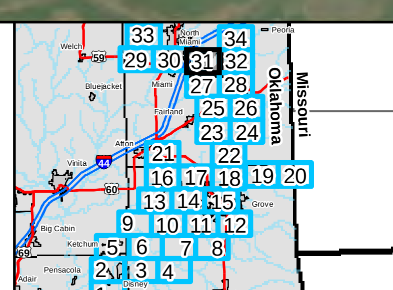


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- Waterway
- Waterbody
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VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 31 OF 34

PENSACOLA HYDROELECTRIC PROJECT
FERC No. P-1494

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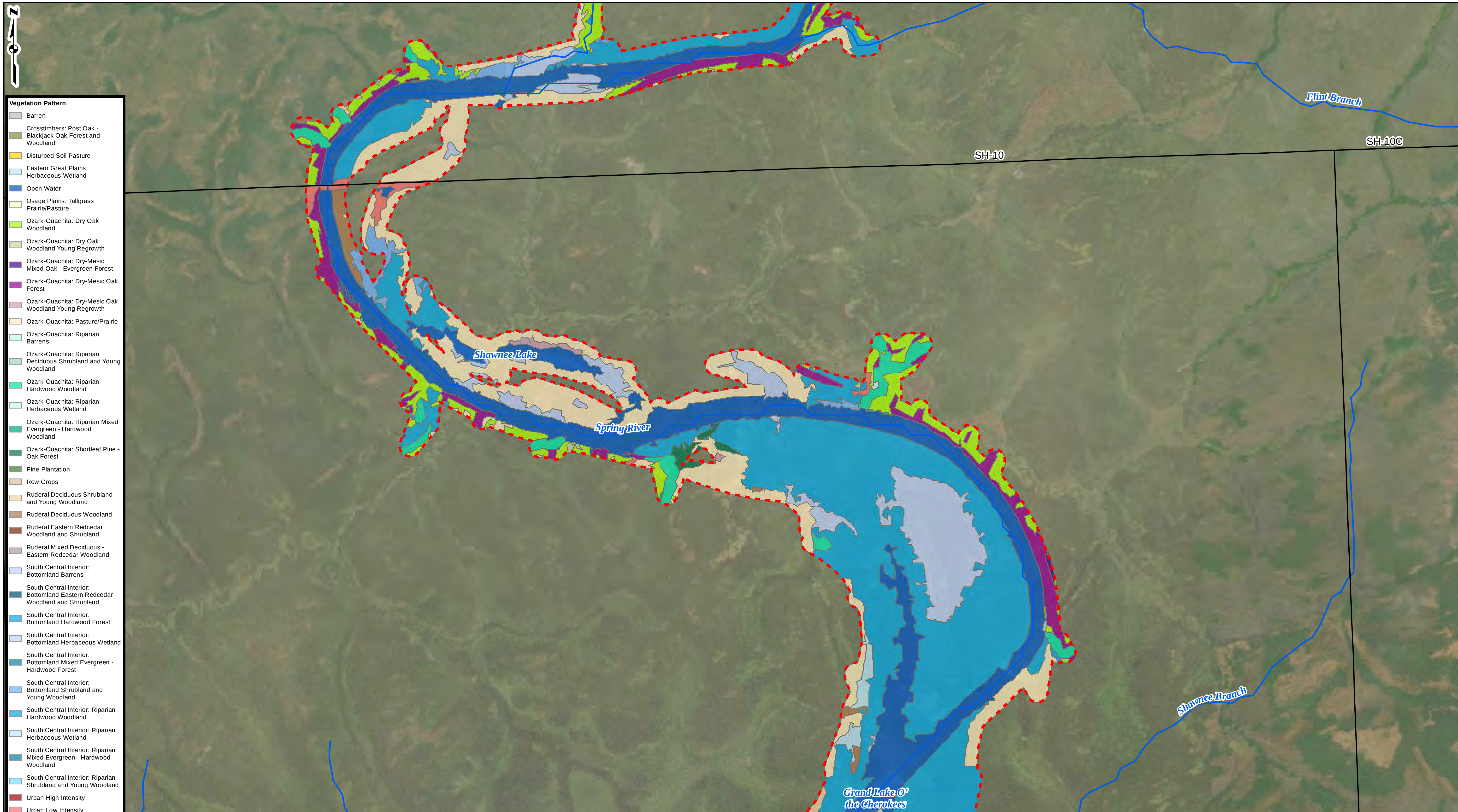


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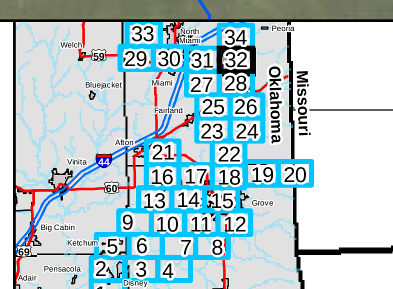


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- Waterbody
- Waterway
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0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 32 OF 34

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PENSACOLA HYDROELECTRIC PROJECT
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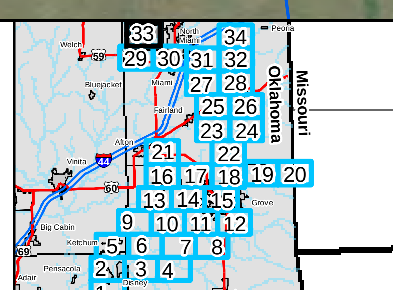


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VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 33 OF 34

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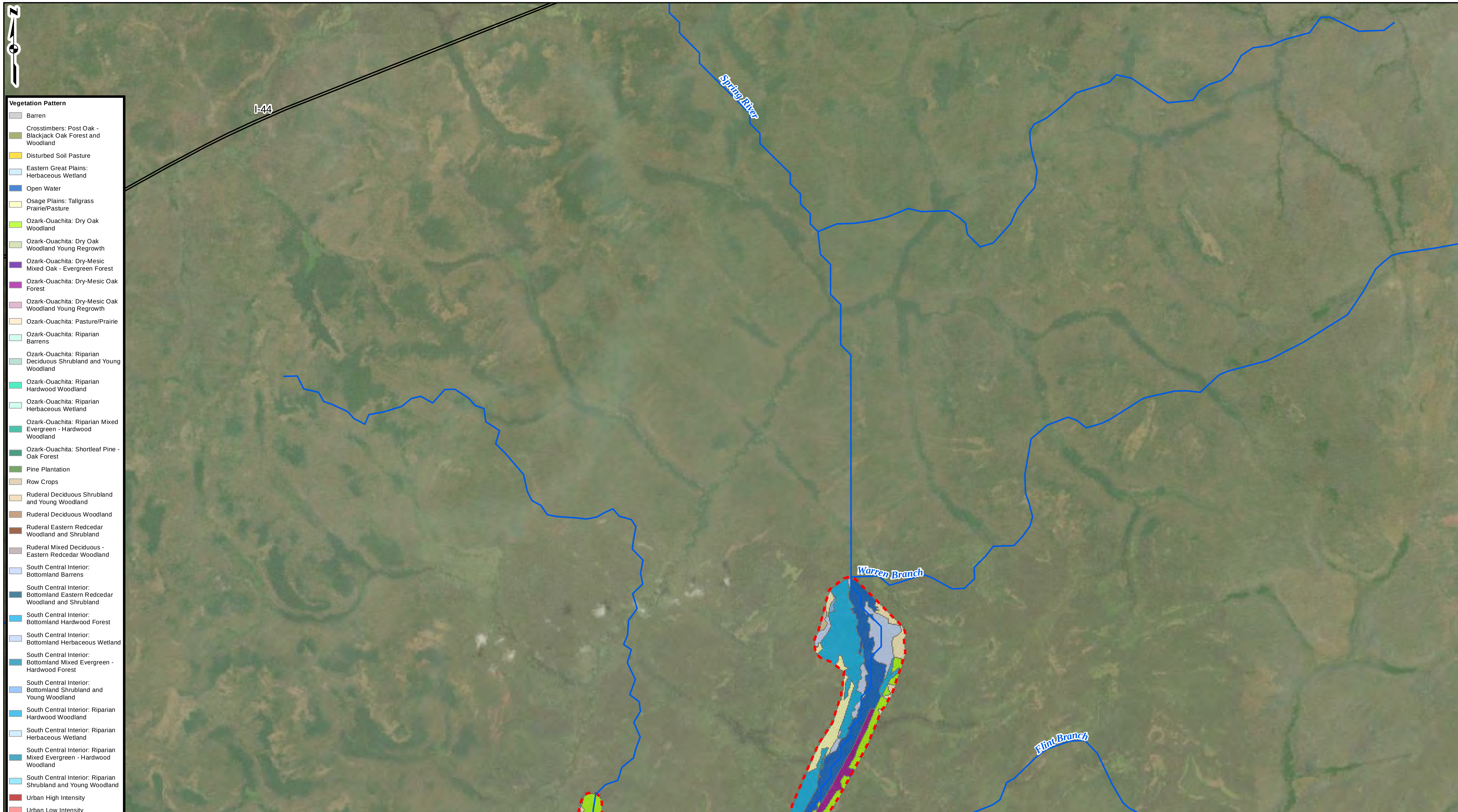


PROJECT LOCATION

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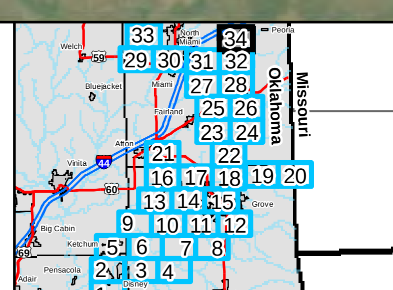


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## Legend

| | |
|---|---|
| Major Roadway | Waterbody |
| Waterway | 200 ft Buffer Project Boundary (1/27/2014) |

0 900 1,800 3,600 Feet

VEGETATION PATTERNS IN THE VICINITY OF THE PENSACOLA HYDROELECTRIC PROJECT
SHEET 34 OF 34

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PENSACOLA HYDROELECTRIC PROJECT
FERC No. P-1494

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**APPENDIX E-17 Grand Lake O' the Cherokees E-Bird Checklist (Cherokee State Park)**

# eBird Field Checklist

## Grand Lake O' the Cherokees--Recreation Area Number 1

Mayes, Oklahoma, US

ebird.org/hotspot/L2170720

128 species (+5 other taxa) - Year-round, All years

**Date:**______
**Start time:**______
**Duration:**______
**Distance:**______
**Party size:**______
**Notes:**

This checklist is generated with data from eBird (ebird.org), a global database of bird sightings from birders like you. If you enjoy this checklist, please consider contributing your sightings to eBird. It is 100% free to take part, and your observations will help support birders, researchers, and conservationists worldwide.

Go to ebird.org to learn more!

**Waterfowl**

___Canada Goose
___Muscovy Duck (Domestic type)
___Wood Duck
___Blue-winged Teal
___Northern Shoveler
___Gadwall
___Mallard
___Green-winged Teal

**Grouse, Quail, and Allies**

___Northern Bobwhite

**Grebes**

___Pied-billed Grebe
___Horned Grebe
___Eared Grebe

**Pigeons and Doves**

___Rock Pigeon
___Eurasian Collared-Dove
___Mourning Dove

**Cuckoos**

___Yellow-billed Cuckoo

**Hummingbirds**

___Ruby-throated Hummingbird

**Rails, Gallinules, and Allies**

___American Coot

**Shorebirds**

___Killdeer
___Spotted Sandpiper
___Willet

**Gulls, Terns, and Skimmers**

___Bonaparte's Gull
___Franklin's Gull
___Ring-billed Gull
___Herring Gull
___gull sp.
___Caspian Tern
___Forster's Tern

**Loons**

___Common Loon

**Cormorants and Anhingas**

___Double-crested Cormorant

**Pelicans**

___American White Pelican

**Herons, Ibis, and Allies**

___Great Blue Heron
___Great Egret
___Snowy Egret
___Cattle Egret
___Green Heron
___Black-crowned Night-Heron

**Vultures, Hawks, and Allies**

___Black Vulture
___Turkey Vulture
___Osprey
___Mississippi Kite
___Cooper's Hawk
___Bald Eagle
___Red-shouldered Hawk
___Red-tailed Hawk

**Owls**

___Barred Owl

**Kingfishers**

___Belted Kingfisher

**Woodpeckers**

___Yellow-bellied Sapsucker
___Red-headed Woodpecker
___Red-bellied Woodpecker
___Downy Woodpecker
___Hairy Woodpecker
___Downy/Hairy Woodpecker
___Pileated Woodpecker
___Northern Flicker

**Falcons and Caracaras**

___American Kestrel

**Tyrant Flycatchers: Pewees, Kingbirds, and Allies**

___Eastern Wood-Pewee
___Acadian Flycatcher
___Eastern Phoebe
___Great Crested Flycatcher
___Eastern Kingbird
___Scissor-tailed Flycatcher

**Vireos**

___White-eyed Vireo
___Bell's Vireo
___Yellow-throated Vireo
___Warbling Vireo
___Red-eyed Vireo

**Shrikes**

___Loggerhead Shrike

**Jays, Magpies, Crows, and Ravens**

___Blue Jay
___American Crow
___Fish Crow
___crow sp.

**Tits, Chickadees, and Titmice**

___Carolina Chickadee
___Tufted Titmouse

**Martins and Swallows**

___Northern Rough-winged Swallow
___Purple Martin
___Tree Swallow
___Barn Swallow
___Cliff Swallow
___swallow sp.

**Kinglets**

___Ruby-crowned Kinglet
___Golden-crowned Kinglet

**Nuthatches**

___Red-breasted Nuthatch
___White-breasted Nuthatch

**Gnatcatchers**

___Blue-gray Gnatcatcher

**Wrens**

___House Wren
___Carolina Wren
___Bewick's Wren

**Starlings and Mynas**

___European Starling

**Catbirds, Mockingbirds, and Thrashers**

___Gray Catbird
___Brown Thrasher
___Northern Mockingbird

**Thrushes**

___Eastern Bluebird
___Swainson's Thrush
___Wood Thrush
___American Robin

**Waxwings**

___Cedar Waxwing

**Old World Sparrows**

___House Sparrow

**Finches, Euphonias, and Allies**

___House Finch
___American Goldfinch

**New World Sparrows**

___Chipping Sparrow
___Lark Sparrow
___Dark-eyed Junco
___White-throated Sparrow
___Savannah Sparrow

**Blackbirds**

___Eastern Meadowlark
___Orchard Oriole
___Baltimore Oriole
___Red-winged Blackbird
___Brown-headed Cowbird
___Common Grackle
___Great-tailed Grackle

This field checklist was generated using eBird (ebird.org)

**Wood-Warblers**

___Louisiana Waterthrush
___Black-and-white Warbler
___Prothonotary Warbler
___Tennessee Warbler
___Orange-crowned Warbler
___Nashville Warbler
___Kentucky Warbler
___Common Yellowthroat
___American Redstart
___Northern Parula
___Yellow Warbler
___Yellow-rumped Warbler
___Yellow-throated Warbler
___Black-throated Green Warbler
___Wilson's Warbler

**Cardinals, Grosbeaks, and Allies**

___Summer Tanager
___Northern Cardinal
___Blue Grosbeak
___Indigo Bunting
___Painted Bunting
___Dickcissel

This field checklist was generated using eBird (ebird.org)

**APPENDIX E-18 2018 IPaC Official Species List**

FEDERAL ENERGY REGULATORY COMMISSION
MEMORANDUM

DATE: January 11, 2018

FROM: Rachel McNamara, Pensacola Project Relicensing Coordinator
South Branch, Division of Hydropower Licensing
Office of Energy Projects

TO: Public Files for the Pensacola Hydroelectric Project
(FERC Project No. 1494-438)

SUBJECT: List of Threatened, Endangered, Candidate, and Proposed Species
Generated by ECOS-IPaC Website on January 10, 2018.

On January 10, 2018, Commission staff accessed the U.S. Fish and Wildlife Service's ECOS-IPaC website (https://ecos.fws.gov/ipac/).

The endangered gray bat, Indiana bat, Ozark big-eared bat, Neosho mucket, winged mapleleaf, and American burying beetle may occur within the Pensacola Hydroelectric Project boundary or be affected by the project.

The threatened northern long-eared bat, piping plover, Neosho madtom, Ozark cavefish, and rabbitsfoot mussel may occur within the Pensacola Hydroelectric Project boundary or be affected by the project.

The endangered least tern may also occur within the project boundary; however, the IPaC report states that the species needs to be considered only for projects involving towers (i.e., radio, television, cellular, microwave, meteorological), wind turbines, and wind farms. The Pensacola Hydroelectric Project does not include such features.

No proposed or candidate species may occur within the project boundary or be affected by the project. No designated critical habitat is located within the project boundary.

A copy of the list is attached.

# United States Department of the Interior

FISH AND WILDLIFE SERVICE
Oklahoma Ecological Services Field Office
9014 East 21st Street
Tulsa, OK 74129-1428
Phone: (918) 581-7458 Fax: (918) 581-7467
http://www.fws.gov/southwest/es/Oklahoma/

In Reply Refer To: January 10, 2018
Consultation Code: 02EKOK00-2018-SLI-0635
Event Code: 02EKOK00-2018-E-01483
Project Name: Pennsicola

Subject: List of threatened and endangered species that may occur in your proposed project location, and/or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF

Non-federal entities conducting activities that may result in take of listed species should consider seeking coverage under section 10 of the ESA, either through development of a Habitat Conservation Plan (HCP) or, by becoming a signatory to the General Conservation Plan (GCP) currently under development for the American burying beetle. Each of these mechanisms provides the means for obtaining a permit and coverage for incidental take of listed species during otherwise lawful activities.

Please be aware that bald and golden eagles are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668 *et seq.*), and projects affecting these species may require development of an eagle conservation plan (http://www.fws.gov/windenergy/eagle_guidance.html). Additionally, wind energy projects should follow the wind energy guidelines (http://www.fws.gov/windenergy/) for minimizing impacts to migratory birds and bats.

Guidance for minimizing impacts to migratory birds for projects including communications towers (e.g., cellular, digital television, radio, and emergency broadcast) can be found at: http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/towers.htm; http://www.towerkill.com; and http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/comtow.html.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Tracking Number in the header of this letter with any request for consultation or correspondence about your project that you submit through our Project Review step-wise process http://www.fws.gov/southwest/es/oklahoma/OKESFO%20Permit%20Home.htm.

Attachment(s):

- Official Species List
- USFWS National Wildlife Refuges and Fish Hatcheries
- Migratory Birds
- Wetlands

# Official Species List

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

**Oklahoma Ecological Services Field Office**
9014 East 21st Street
Tulsa, OK 74129-1428
(918) 581-7458

# Project Summary

Consultation Code: 02EKOK00-2018-SLI-0635

Event Code: 02EKOK00-2018-E-01483

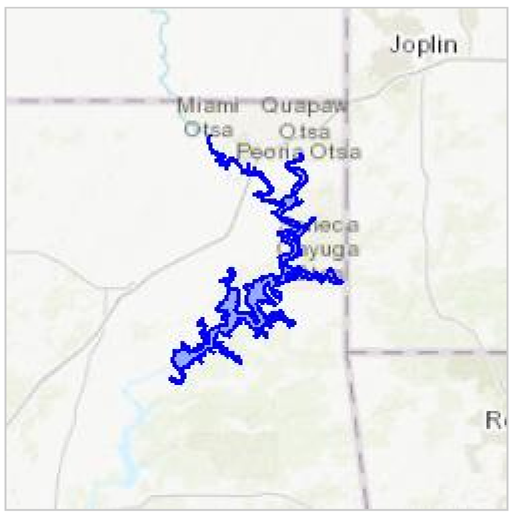
Project Name: Pennsicola

Project Type: POWER GENERATION

Project Description: Hydro relicense

Project Location:

Approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/place/36.67849039200004N94.77664843515234W




Counties: Craig, OK | Delaware, OK | Mayes, OK | Ottawa, OK

# Endangered Species Act Species

There is a total of 13 threatened, endangered, or candidate species on this species list. Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species. Note that 1 of these species should be considered only under certain conditions. See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

## Mammals

| NAME | STATUS |
|---|---|
| Gray Bat *Myotis grisescens*<br>No critical habitat has been designated for this species.<br>Species profile: https://ecos.fws.gov/ecp/species/6329 | Endangered |
| Indiana Bat *Myotis sodalis*<br>There is **final** critical habitat for this species. Your location is outside the critical habitat.<br>Species profile: https://ecos.fws.gov/ecp/species/5949 | Endangered |
| Northern Long-eared Bat *Myotis septentrionalis*<br>No critical habitat has been designated for this species.<br>Species profile: https://ecos.fws.gov/ecp/species/9045 | Threatened |
| Ozark Big-eared Bat *Corynorhinus (=Plecotus) townsendii ingens*<br>There is **proposed** critical habitat for this species. The location of the critical habitat is not available.<br>Species profile: https://ecos.fws.gov/ecp/species/7245 | Endangered |

## Birds

| NAME | STATUS |
| --- | --- |
| Least Tern *Sterna antillarum*<br>Population: interior pop.<br>No critical habitat has been designated for this species.<br>This species only needs to be considered under the following conditions:<br>▪ Towers (i.e. radio, television, cellular, microwave, meterological)<br>▪ Wind Turbines and Wind Farms<br>Species profile: https://ecos.fws.gov/ecp/species/8505 | Endangered |
| Piping Plover *Charadrius melodus*<br>Population: [Atlantic Coast and Northern Great Plains populations] - Wherever found, except those areas where listed as endangered.<br>There is **final** critical habitat for this species. Your location is outside the critical habitat.<br>Species profile: https://ecos.fws.gov/ecp/species/6039 | Threatened |
| Red Knot *Calidris canutus rufa*<br>No critical habitat has been designated for this species.<br>Species profile: https://ecos.fws.gov/ecp/species/1864 | Threatened |

## Fishes

| NAME | STATUS |
| --- | --- |
| Neosho Madtom *Noturus placidus*<br>No critical habitat has been designated for this species.<br>Species profile: https://ecos.fws.gov/ecp/species/2577 | Threatened |
| Ozark Cavefish *Amblyopsis rosae*<br>No critical habitat has been designated for this species.<br>Species profile: https://ecos.fws.gov/ecp/species/6490 | Threatened |

## Clams

| NAME | STATUS |
| --- | --- |
| Neosho Mucket *Lampsilis rafinesqueana*<br>There is **final** critical habitat for this species. Your location is outside the critical habitat.<br>Species profile: https://ecos.fws.gov/ecp/species/3788 | Endangered |
| Rabbitsfoot *Quadrula cylindrica cylindrica*<br>There is **final** critical habitat for this species. Your location is outside the critical habitat.<br>Species profile: https://ecos.fws.gov/ecp/species/5165 | Threatened |
| Winged Mapleleaf *Quadrula fragosa*<br>Population: Wherever found, except where listed as an experimental population<br>No critical habitat has been designated for this species.<br>Species profile: https://ecos.fws.gov/ecp/species/4127 | Endangered |

## Insects

| NAME | STATUS |
| --- | --- |
| American Burying Beetle *Nicrophorus americanus*<br>Population: Wherever found, except where listed as an experimental population<br>No critical habitat has been designated for this species.<br>Species profile: https://ecos.fws.gov/ecp/species/66 | Endangered |

## Critical habitats

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

# USFWS National Wildlife Refuge Lands And Fish Hatcheries

Any activity proposed on lands managed by the National Wildlife Refuge system must undergo a 'Compatibility Determination' conducted by the Refuge. Please contact the individual Refuges to discuss any questions or concerns.

REFUGE INFORMATION WAS NOT AVAILABLE WHEN THIS SPECIES LIST WAS GENERATED. PLEASE CONTACT THE FIELD OFFICE FOR FURTHER INFORMATION.

# Migratory Birds

Certain birds are protected under the Migratory Bird Treaty Act[1] and the Bald and Golden Eagle Protection Act[2].

Any person or organization who plans or conducts activities that may result in impacts to migratory birds, eagles, and their habitats should follow appropriate regulations and consider implementing appropriate conservation measures, as described below.

---

1. The Migratory Birds Treaty Act of 1918.
2. The Bald and Golden Eagle Protection Act of 1940.
3. 50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)

The birds listed below are birds of particular concern either because they occur on the USFWS Birds of Conservation Concern (BCC) list or warrant special attention in your project location. To learn more about the levels of concern for birds on your list and how this list is generated, see the FAQ below. This is not a list of every bird you may find in this location, nor a guarantee that every bird on this list will be found in your project area. To see maps of where birders and the general public have sighted birds in and around your project area, visit E-bird tools such as the E-bird data mapping tool (search for the name of a bird on your list to see specific locations where that bird has been reported to occur within your project area over a certain timeframe) and the E-bird Explore Data Tool (perform a query to see a list of all birds sighted in your county or region and within a certain timeframe). For projects that occur off the Atlantic Coast, additional maps and models detailing the relative occurrence and abundance of bird species on your list are available. Links to additional information about Atlantic Coast birds, and other important information about your migratory bird list can be found below.

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, click on the PROBABILITY OF PRESENCE SUMMARY at the top of your list to see when these birds are most likely to be present and breeding in your project area.

| NAME | BREEDING SEASON |
| --- | --- |
| Bald Eagle *Haliaeetus leucocephalus*<br>This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.<br>https://ecos.fws.gov/ecp/species/1626 | Breeds Sep 1 to Aug 31 |

| NAME | BREEDING SEASON |
| --- | --- |
| Black-billed Cuckoo *Coccyzus erythropthalmus*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.<br>https://ecos.fws.gov/ecp/species/9399 | Breeds May 15 to Oct 10 |
| Bobolink *Dolichonyx oryzivorus*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. | Breeds May 20 to Jul 31 |
| Cerulean Warbler *Dendroica cerulea*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.<br>https://ecos.fws.gov/ecp/species/2974 | Breeds Apr 21 to Jul 20 |
| Eastern Whip-poor-will *Antrostomus vociferus*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. | Breeds May 1 to Aug 20 |
| Henslow's Sparrow *Ammodramus henslowii*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.<br>https://ecos.fws.gov/ecp/species/3941 | Breeds May 1 to Aug 31 |
| Kentucky Warbler *Oporornis formosus*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. | Breeds Apr 20 to Aug 20 |
| Lesser Yellowlegs *Tringa flavipes*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.<br>https://ecos.fws.gov/ecp/species/9679 | Breeds elsewhere |
| Prairie Warbler *Dendroica discolor*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. | Breeds May 1 to Jul 31 |
| Prothonotary Warbler *Protonotaria citrea*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. | Breeds Apr 1 to Jul 31 |
| Red-headed Woodpecker *Melanerpes erythrocephalus*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. | Breeds May 10 to Sep 10 |
| Rusty Blackbird *Euphagus carolinus*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. | Breeds elsewhere |

| NAME | BREEDING SEASON |
|---|---|
| Semipalmated Sandpiper *Calidris pusilla*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. | Breeds elsewhere |
| Wood Thrush *Hylocichla mustelina*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. | Breeds May 10 to Aug 31 |

## Probability Of Presence Summary

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds.

**Probability of Presence** (■)

Each green bar represents the bird's relative probability of presence in your project's counties during a particular week of the year. (A year is represented as 12 4-week months.) A taller bar indicates a higher probability of species presence. The survey effort (see below) can be used to establish a level of confidence in the presence score. One can have higher confidence in the presence score if the corresponding survey effort is also high.

How is the probability of presence score calculated? The calculation is done in three steps:

1. The probability of presence for each week is calculated as the number of survey events in the week where the species was detected divided by the total number of survey events for that week. For example, if in week 12 there were 20 survey events and the Spotted Towhee was found in 5 of them, the probability of presence of the Spotted Towhee in week 12 is 0.25.
2. To properly present the pattern of presence across the year, the relative probability of presence is calculated. This is the probability of presence divided by the maximum probability of presence across all weeks. For example, imagine the probability of presence in week 20 for the Spotted Towhee is 0.05, and that the probability of presence at week 12 (0.25) is the maximum of any week of the year. The relative probability of presence on week 12 is 0.25/0.25 = 1; at week 20 it is 0.05/0.25 = 0.2.
3. The relative probability of presence calculated in the previous step undergoes a statistical conversion so that all possible values fall between 0 and 10, inclusive. This is the probability of presence score.

**Breeding Season** (■)
Yellow bars denote a very liberal estimate of the time-frame inside which the bird breeds across its entire range. If there are no yellow bars shown for a bird, it does not breed in your project area.

**Survey Effort** (|)

Vertical black lines superimposed on probability of presence bars indicate the number of surveys performed for that species in the counties of your project area. The number of surveys is expressed as a range, for example, 33 to 64 surveys.

**No Data (–)**
A week is marked as having no data if there were no survey events for that week.

**Survey Timeframe**
Surveys from only the last 10 years are used in order to ensure delivery of currently relevant information.

Additional information can be found using the following links:

- Birds of Conservation Concern http://www.fws.gov/birds/management/managed-species/birds-of-conservation-concern.php
- Measures for avoiding and minimizing impacts to birds http://www.fws.gov/birds/management/project-assessment-tools-and-guidance/conservation-measures.php
- Nationwide conservation measures for birds http://www.fws.gov/migratorybirds/pdf/management/nationwidestandardconservationmeasures.pdf

## Migratory Birds FAQ

**Tell me more about conservation measures I can implement to avoid or minimize impacts to migratory birds.**

Nationwide Conservation Measures describes measures that can help avoid and minimize impacts to all birds at any location year round. Implementation of these measures is particularly important when birds are most likely to occur in the project area. When birds may be breeding in the area, identifying the locations of any active nests and avoiding their destruction is a very helpful impact minimization measure. To see when birds are most likely to occur and be breeding in your project area, view the Probability of Presence Summary. Additional measures and/or permits may be advisable depending on the type of activity you are conducting and the type of infrastructure or bird species present on your project site.

**What does IPaC use to generate the migratory birds potentially occurring in my specified location?**

The Migratory Bird Resource List is comprised of USFWS Birds of Conservation Concern (BCC) and other species that may warrant special attention in your project location.

The migratory bird list generated for your project is derived from data provided by the Avian Knowledge Network (AKN). The AKN data is based on a growing collection of survey, banding, and citizen science datasets and is queried and filtered to return a list of those birds reported as occurring in the counties which your project intersects, and that have been identified as warranting special attention because they are a BCC species in that area, an eagle (Eagle Act requirements may apply), or a species that has a particular vulnerability to offshore activities or development.

Again, the Migratory Bird Resource list includes only a subset of birds that may occur in your project area. It is not representative of all birds that may occur in your project area. To get a list of all birds potentially present in your project area, please visit the E-bird Explore Data Tool.

**What does IPaC use to generate the probability of presence graphs for the migratory birds potentially occurring in my specified location?**

The probability of presence graphs associated with your migratory bird list are based on data provided by the Avian Knowledge Network (AKN). This data is derived from a growing collection of survey, banding, and citizen science datasets .

Probability of presence data is continuously being updated as new and better information becomes available. To learn more about how the probability of presence graphs are produced and how to interpret them, go the Probability of Presence Summary and then click on the "Tell me about these graphs" link.

**How do I know if a bird is breeding, wintering, migrating or present year-round in my project area?**

To see what part of a particular bird's range your project area falls within (i.e. breeding, wintering, migrating or year-round), you may refer to the following resources: The The Cornell Lab of Ornithology All About Birds Bird Guide, or (if you are unsuccessful in locating the bird of interest there), the Cornell Lab of Ornithology Neotropical Birds guide. If a bird entry on your migratory bird species list indicates a breeding season, it is probable that the bird breeds in your project's counties at some point within the timeframe specified. If "Breeds elsewhere" is indicated, then the bird likely does not breed in your project area.

**What are the levels of concern for migratory birds?**

Migratory birds delivered through IPaC fall into the following distinct categories of concern:

1. "BCC Rangewide" birds are Birds of Conservation Concern (BCC) that are of concern throughout their range anywhere within the USA (including Hawaii, the Pacific Islands, Puerto Rico, and the Virgin Islands);
2. "BCC - BCR" birds are BCCs that are of concern only in particular Bird Conservation Regions (BCRs) in the continental USA; and
3. "Non-BCC - Vulnerable" birds are not BCC species in your project area, but appear on your list either because of the Eagle Act requirements (for eagles) or (for non-eagles) potential susceptibilities in offshore areas from certain types of development or activities (e.g. offshore energy development or longline fishing).

Although it is important to try to avoid and minimize impacts to all birds, efforts should be made, in particular, to avoid and minimize impacts to the birds on this list, especially eagles and BCC species of rangewide concern. For more information on conservation measures you can implement to help avoid and minimize migratory bird impacts and requirements for eagles, please see the FAQs for these topics.

**Details about birds that are potentially affected by offshore projects**

For additional details about the relative occurrence and abundance of both individual bird species and groups of bird species within your project area off the Atlantic Coast, please visit the Northeast Ocean Data Portal. The Portal also offers data and information about other taxa besides birds that may be helpful to you in your project review. Alternately, you may download the bird model results files underlying the portal maps through the NOAA NCCOS Integrative Statistical

Modeling and Predictive Mapping of Marine Bird Distributions and Abundance on the Atlantic Outer Continental Shelf project webpage.

Bird tracking data can also provide additional details about occurrence and habitat use throughout the year, including migration. Models relying on survey data may not include this information. For additional information on marine bird tracking data, see the Diving Bird Study and the nanotag studies or contact Caleb Spiegel or Pam Loring.

**What if I have eagles on my list?**

If your project has the potential to disturb or kill eagles, you may need to obtain a permit to avoid violating the BGEPA should such impacts occur.

# Wetlands

Impacts to NWI wetlands and other aquatic habitats may be subject to regulation under Section 404 of the Clean Water Act, or other State/Federal statutes.

For more information please contact the Regulatory Program of the local U.S. Army Corps of Engineers District.

FRESHWATER EMERGENT WETLAND

- PEM1Ah
- PEM1Ch
- PEM1C
- PEM1A
- PEM1/SS1Ch
- PEM1Fh

FRESHWATER FORESTED/SHRUB WETLAND

- PFO1A
- PFO6F
- PFO1Ah
- PFO1/SS1Ah
- PFO1Ch
- PFO1C
- PFO1Fh
- PSS1Ch
- PSS1Fh
- PFO1/SS1Ch
- PSS1C
- PFO1/UBFh
- PSS1Ah
- PSS1A
- PFO5/UBHh
- PSS1/EM1Ad
- PSS1/EM1Ch
- PSS1F
- PSS1Cx
- PFO1/USCh
- PFO1F

FRESHWATER POND

- PUBHh
- PUBH
- PUBHx
- PUBFx
- PUBFh
- PUSC

LAKE

- L2USCh
- L1UBHh
- L2UBFh
- L1UBH

RIVERINE

- R2UBH
- R2USC

## APPENDIX E-19 2022 Updated IPaC Species List

# United States Department of the Interior

FISH AND WILDLIFE SERVICE
Oklahoma Ecological Services Field Office
9014 East 21st Street
Tulsa, OK 74129-1428
Phone: (918) 581-7458 Fax: (918) 581-7467

In Reply Refer To: October 14, 2022
Project Code: 2023-0004702
Project Name: Pensacola Hydroelectric Project Relicensing

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF

**Migratory Birds**: In addition to responsibilities to protect threatened and endangered species under the Endangered Species Act (ESA), there are additional responsibilities under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA) to protect native birds from project-related impacts. Any activity, intentional or unintentional, resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the U.S. Fish and Wildlife Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). For more information regarding these Acts see https://www.fws.gov/birds/policies-and-regulations.php.

The MBTA has no provision for allowing take of migratory birds that may be unintentionally killed or injured by otherwise lawful activities. It is the responsibility of the project proponent to comply with these Acts by identifying potential impacts to migratory birds and eagles within applicable NEPA documents (when there is a federal nexus) or a Bird/Eagle Conservation Plan (when there is no federal nexus). Proponents should implement conservation measures to avoid or minimize the production of project-related stressors or minimize the exposure of birds and their resources to the project-related stressors. For more information on avian stressors and recommended conservation measures see https://www.fws.gov/birds/bird-enthusiasts/threats-to-birds.php.

In addition to MBTA and BGEPA, Executive Order 13186: *Responsibilities of Federal Agencies to Protect Migratory Birds*, obligates all Federal agencies that engage in or authorize activities that might affect migratory birds, to minimize those effects and encourage conservation measures that will improve bird populations. Executive Order 13186 provides for the protection of both migratory birds and migratory bird habitat. For information regarding the implementation of Executive Order 13186, please visit https://www.fws.gov/birds/policies-and-regulations/executive-orders/e0-13186.php.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Code in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List
- USFWS National Wildlife Refuges and Fish Hatcheries
- Migratory Birds
- Wetlands

# Official Species List

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

**Oklahoma Ecological Services Field Office**
9014 East 21st Street
Tulsa, OK 74129-1428
(918) 581-7458

# Project Summary

Project Code: 2023-0004702
Project Name: Pensacola Hydroelectric Project Relicensing
Project Type: Dam - Operations
Project Description: Hydro relicensing. Draft License Application will be filed by January 1, 2023.
Project Location:

Approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@36.69235865,-94.76001548651183,14z

Counties: Oklahoma

# Endangered Species Act Species

There is a total of 13 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

## Mammals

| NAME | STATUS |
|---|---|
| Gray Bat *Myotis grisescens*<br>No critical habitat has been designated for this species.<br>Species profile: https://ecos.fws.gov/ecp/species/6329 | Endangered |
| Indiana Bat *Myotis sodalis*<br>There is **final** critical habitat for this species. Your location does not overlap the critical habitat.<br>Species profile: https://ecos.fws.gov/ecp/species/5949 | Endangered |
| Northern Long-eared Bat *Myotis septentrionalis*<br>No critical habitat has been designated for this species.<br>Species profile: https://ecos.fws.gov/ecp/species/9045 | Threatened |
| Ozark Big-eared Bat *Corynorhinus (=Plecotus) townsendii ingens*<br>No critical habitat has been designated for this species.<br>Species profile: https://ecos.fws.gov/ecp/species/7245 | Endangered |
| Tricolored Bat *Perimyotis subflavus*<br>No critical habitat has been designated for this species.<br>Species profile: https://ecos.fws.gov/ecp/species/10515 | Proposed Endangered |

## Birds

| NAME | STATUS |
|---|---|
| Piping Plover *Charadrius melodus*<br>Population: [Atlantic Coast and Northern Great Plains populations] - Wherever found, except those areas where listed as endangered.<br>There is **final** critical habitat for this species. Your location does not overlap the critical habitat.<br>Species profile: https://ecos.fws.gov/ecp/species/6039 | Threatened |
| Red Knot *Calidris canutus rufa*<br>There is **proposed** critical habitat for this species.<br>Species profile: https://ecos.fws.gov/ecp/species/1864 | Threatened |

## Reptiles

| NAME | STATUS |
|---|---|
| Alligator Snapping Turtle *Macrochelys temminckii*<br>No critical habitat has been designated for this species.<br>Species profile: https://ecos.fws.gov/ecp/species/4658 | Proposed Threatened |

## Fishes

| NAME | STATUS |
|---|---|
| Neosho Madtom *Noturus placidus*<br>No critical habitat has been designated for this species.<br>Species profile: https://ecos.fws.gov/ecp/species/2577 | Threatened |
| Ozark Cavefish *Amblyopsis rosae*<br>No critical habitat has been designated for this species.<br>Species profile: https://ecos.fws.gov/ecp/species/6490 | Threatened |

## Clams

| NAME | STATUS |
|---|---|
| Neosho Mucket *Lampsilis rafinesqueana*<br>There is **final** critical habitat for this species. Your location overlaps the critical habitat.<br>Species profile: https://ecos.fws.gov/ecp/species/3788 | Endangered |

## Insects

| NAME | STATUS |
|---|---|
| American Burying Beetle *Nicrophorus americanus*<br>Population: Wherever found, except where listed as an experimental population<br>No critical habitat has been designated for this species.<br>Species profile: https://ecos.fws.gov/ecp/species/66 | Threatened |
| Monarch Butterfly *Danaus plexippus*<br>No critical habitat has been designated for this species.<br>Species profile: https://ecos.fws.gov/ecp/species/9743 | Candidate |

## Critical habitats

There is 1 critical habitat wholly or partially within your project area under this office's jurisdiction.

| NAME | STATUS |
| --- | --- |
| Neosho Mucket *Lampsilis rafinesqueana*<br>https://ecos.fws.gov/ecp/species/3788#crithab | Final |

# USFWS National Wildlife Refuge Lands And Fish Hatcheries

Any activity proposed on lands managed by the National Wildlife Refuge system must undergo a 'Compatibility Determination' conducted by the Refuge. Please contact the individual Refuges to discuss any questions or concerns.

The following FWS National Wildlife Refuge Lands and Fish Hatcheries lie fully or partially within your project area:

| FACILITY NAME | ACRES |
|---|---|
| OZARK PLATEAU NATIONAL WILDLIFE REFUGE<br>https://www.fws.gov/refuges/profiles/index.cfm?id=21645 | 81.098 |

# Migratory Birds

Certain birds are protected under the Migratory Bird Treaty Act[1] and the Bald and Golden Eagle Protection Act[2].

Any person or organization who plans or conducts activities that may result in impacts to migratory birds, eagles, and their habitats should follow appropriate regulations and consider implementing appropriate conservation measures, as described below.

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1. The Migratory Birds Treaty Act of 1918.
2. The Bald and Golden Eagle Protection Act of 1940.
3. 50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)

**The birds listed below are birds of particular concern either because they occur on the USFWS Birds of Conservation Concern (BCC) list or warrant special attention in your project location.** To learn more about the levels of concern for birds on your list and how this list is generated, see the FAQ below. This is not a list of every bird you may find in this location, nor a guarantee that every bird on this list will be found in your project area. To see exact locations of where birders and the general public have sighted birds in and around your project area, visit the E-bird data mapping tool (Tip: enter your location, desired date range and a species on your list). For projects that occur off the Atlantic Coast, additional maps and models detailing the relative occurrence and abundance of bird species on your list are available. Links to additional information about Atlantic Coast birds, and other important information about your migratory bird list, including how to properly interpret and use your migratory bird report, can be found below.

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, click on the PROBABILITY OF PRESENCE SUMMARY at the top of your list to see when these birds are most likely to be present and breeding in your project area.

| NAME | BREEDING SEASON |
|---|---|
| Bald Eagle *Haliaeetus leucocephalus*<br>This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities. | Breeds Sep 1 to Aug 31 |
| Chimney Swift *Chaetura pelagica*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. | Breeds Mar 15 to Aug 25 |
| Eastern Whip-poor-will *Antrostomus vociferus*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. | Breeds May 1 to Aug 20 |

| NAME | BREEDING SEASON |
| --- | --- |
| Field Sparrow *Spizella pusilla*<br>This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA | Breeds Mar 1 to Aug 15 |
| Kentucky Warbler *Oporornis formosus*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. | Breeds Apr 20 to Aug 20 |
| Lesser Yellowlegs *Tringa flavipes*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.<br>https://ecos.fws.gov/ecp/species/9679 | Breeds elsewhere |
| Prothonotary Warbler *Protonotaria citrea*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. | Breeds Apr 1 to Jul 31 |
| Red-headed Woodpecker *Melanerpes erythrocephalus*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. | Breeds May 10 to Sep 10 |
| Rusty Blackbird *Euphagus carolinus*<br>This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA | Breeds elsewhere |
| Wood Thrush *Hylocichla mustelina*<br>This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. | Breeds May 10 to Aug 31 |

## Probability Of Presence Summary

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read and understand the FAQ "Proper Interpretation and Use of Your Migratory Bird Report" before using or attempting to interpret this report.

**Probability of Presence** (■)

Each green bar represents the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during a particular week of the year. (A year is represented as 12 4-week months.) A taller bar indicates a higher probability of species presence. The survey effort (see below) can be used to establish a level of confidence in the presence score. One can have higher confidence in the presence score if the corresponding survey effort is also high.

How is the probability of presence score calculated? The calculation is done in three steps:

1. The probability of presence for each week is calculated as the number of survey events in the week where the species was detected divided by the total number of survey events for that week. For example, if in week 12 there were 20 survey events and the Spotted Towhee

was found in 5 of them, the probability of presence of the Spotted Towhee in week 12 is 0.25.

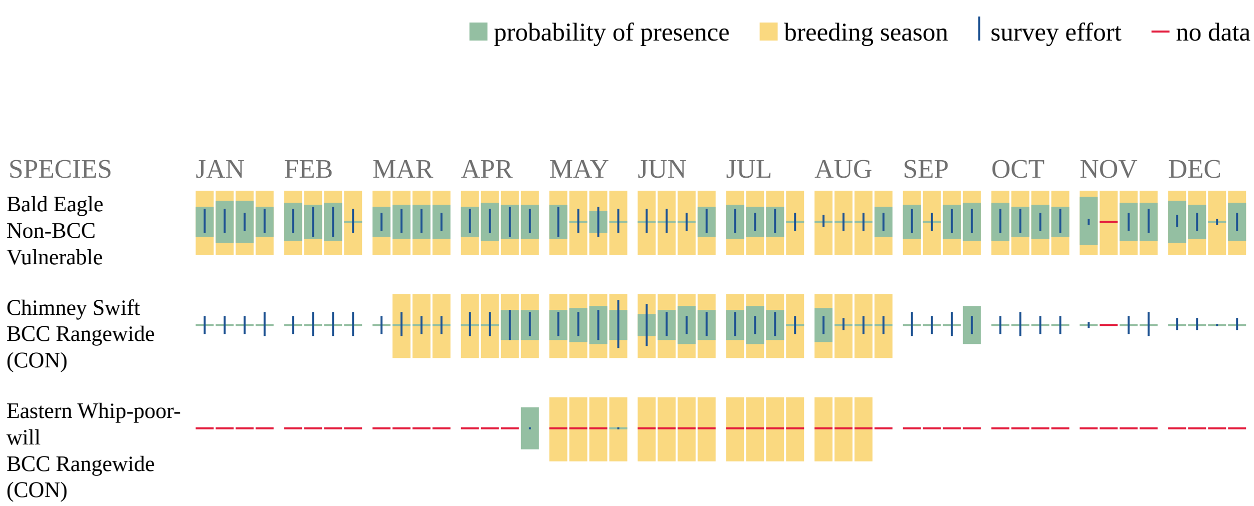
2. To properly present the pattern of presence across the year, the relative probability of presence is calculated. This is the probability of presence divided by the maximum probability of presence across all weeks. For example, imagine the probability of presence in week 20 for the Spotted Towhee is 0.05, and that the probability of presence at week 12 (0.25) is the maximum of any week of the year. The relative probability of presence on week 12 is 0.25/0.25 = 1; at week 20 it is 0.05/0.25 = 0.2.
3. The relative probability of presence calculated in the previous step undergoes a statistical conversion so that all possible values fall between 0 and 10, inclusive. This is the probability of presence score.

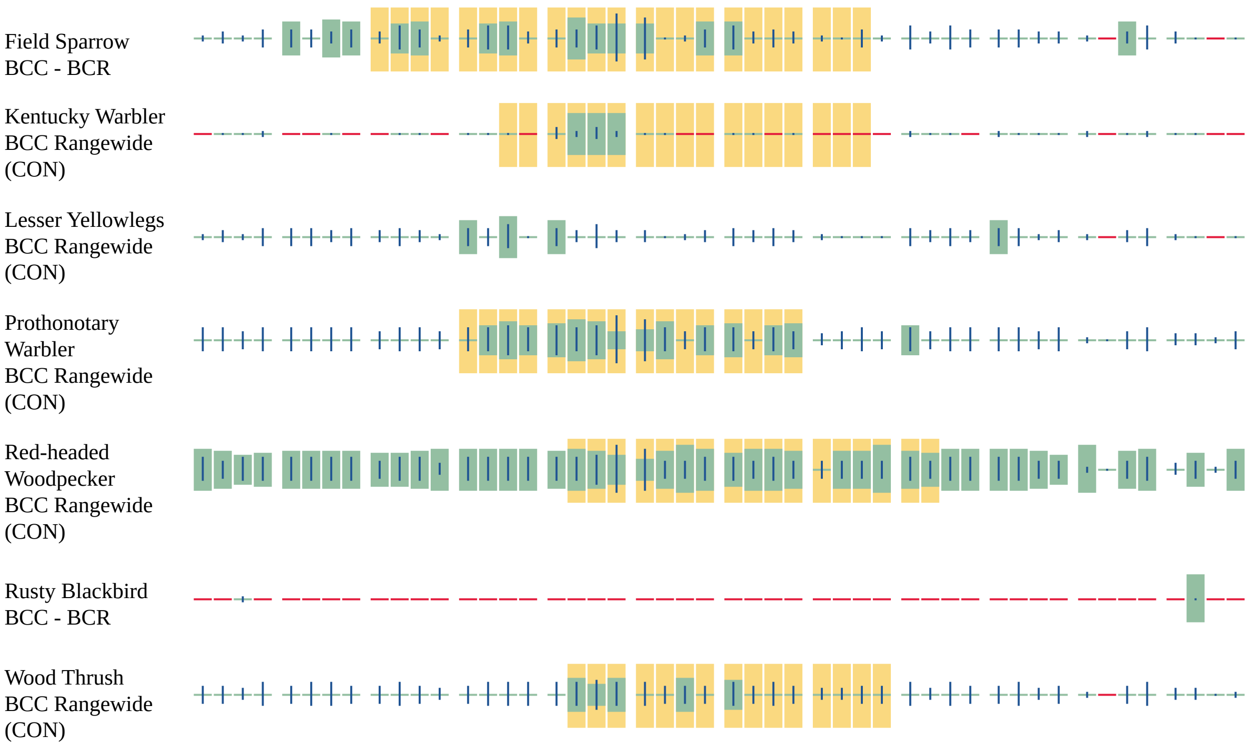
**Breeding Season** (■)
Yellow bars denote a very liberal estimate of the time-frame inside which the bird breeds across its entire range. If there are no yellow bars shown for a bird, it does not breed in your project area.

**Survey Effort** (|)
Vertical black lines superimposed on probability of presence bars indicate the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps. The number of surveys is expressed as a range, for example, 33 to 64 surveys.

**No Data** (–)
A week is marked as having no data if there were no survey events for that week.

**Survey Timeframe**
Surveys from only the last 10 years are used in order to ensure delivery of currently relevant information. The exception to this is areas off the Atlantic coast, where bird returns are based on all years of available data, since data in these areas is currently much more sparse.






Additional information can be found using the following links:

- Birds of Conservation Concern https://www.fws.gov/program/migratory-birds/species
- Measures for avoiding and minimizing impacts to birds https://www.fws.gov/library/collections/avoiding-and-minimizing-incidental-take-migratory-birds
- Nationwide conservation measures for birds https://www.fws.gov/sites/default/files/documents/nationwide-standard-conservation-measures.pdf

## Migratory Birds FAQ

**Tell me more about conservation measures I can implement to avoid or minimize impacts to migratory birds.**

Nationwide Conservation Measures describes measures that can help avoid and minimize impacts to all birds at any location year round. Implementation of these measures is particularly important when birds are most likely to occur in the project area. When birds may be breeding in the area, identifying the locations of any active nests and avoiding their destruction is a very helpful impact minimization measure. To see when birds are most likely to occur and be breeding in your project area, view the Probability of Presence Summary. Additional measures or permits may be advisable depending on the type of activity you are conducting and the type of infrastructure or bird species present on your project site.

**What does IPaC use to generate the list of migratory birds that potentially occur in my specified location?**

The Migratory Bird Resource List is comprised of USFWS Birds of Conservation Concern (BCC) and other species that may warrant special attention in your project location.

The migratory bird list generated for your project is derived from data provided by the Avian Knowledge Network (AKN). The AKN data is based on a growing collection of survey, banding, and citizen science datasets and is queried and filtered to return a list of those birds reported as occurring in the 10km grid cell(s) which your project intersects, and that have been identified as warranting special attention because they are a BCC species in that area, an eagle (Eagle Act requirements may apply), or a species that has a particular vulnerability to offshore activities or development.

Again, the Migratory Bird Resource list includes only a subset of birds that may occur in your project area. It is not representative of all birds that may occur in your project area. To get a list of all birds potentially present in your project area, please visit the Rapid Avian Information Locator (RAIL) Tool.

**What does IPaC use to generate the probability of presence graphs for the migratory birds potentially occurring in my specified location?**
The probability of presence graphs associated with your migratory bird list are based on data provided by the Avian Knowledge Network (AKN). This data is derived from a growing collection of survey, banding, and citizen science datasets.

Probability of presence data is continuously being updated as new and better information becomes available. To learn more about how the probability of presence graphs are produced and how to interpret them, go the Probability of Presence Summary and then click on the "Tell me about these graphs" link.

**How do I know if a bird is breeding, wintering or migrating in my area?**
To see what part of a particular bird's range your project area falls within (i.e. breeding, wintering, migrating or year-round), you may query your location using the RAIL Tool and look at the range maps provided for birds in your area at the bottom of the profiles provided for each bird in your results. If a bird on your migratory bird species list has a breeding season associated with it, if that bird does occur in your project area, there may be nests present at some point within the timeframe specified. If "Breeds elsewhere" is indicated, then the bird likely does not breed in your project area.

**What are the levels of concern for migratory birds?**
Migratory birds delivered through IPaC fall into the following distinct categories of concern:

1. "BCC Rangewide" birds are Birds of Conservation Concern (BCC) that are of concern throughout their range anywhere within the USA (including Hawaii, the Pacific Islands, Puerto Rico, and the Virgin Islands);
2. "BCC - BCR" birds are BCCs that are of concern only in particular Bird Conservation Regions (BCRs) in the continental USA; and
3. "Non-BCC - Vulnerable" birds are not BCC species in your project area, but appear on your list either because of the Eagle Act requirements (for eagles) or (for non-eagles) potential susceptibilities in offshore areas from certain types of development or activities (e.g. offshore energy development or longline fishing).

Although it is important to try to avoid and minimize impacts to all birds, efforts should be made, in particular, to avoid and minimize impacts to the birds on this list, especially eagles and BCC species of rangewide concern. For more information on conservation measures you can implement to help avoid and minimize migratory bird impacts and requirements for eagles, please see the FAQs for these topics.

**Details about birds that are potentially affected by offshore projects**
For additional details about the relative occurrence and abundance of both individual bird species and groups of bird species within your project area off the Atlantic Coast, please visit the Northeast Ocean Data Portal. The Portal also offers data and information about other taxa besides birds that may be helpful to you in your project review. Alternately, you may download the bird model results files underlying the portal maps through the NOAA NCCOS Integrative Statistical Modeling and Predictive Mapping of Marine Bird Distributions and Abundance on the Atlantic Outer Continental Shelf project webpage.

Bird tracking data can also provide additional details about occurrence and habitat use throughout the year, including migration. Models relying on survey data may not include this information. For additional information on marine bird tracking data, see the Diving Bird Study and the nanotag studies or contact Caleb Spiegel or Pam Loring.

**What if I have eagles on my list?**
If your project has the potential to disturb or kill eagles, you may need to obtain a permit to avoid violating the Eagle Act should such impacts occur.

**Proper Interpretation and Use of Your Migratory Bird Report**
The migratory bird list generated is not a list of all birds in your project area, only a subset of birds of priority concern. To learn more about how your list is generated, and see options for identifying what other birds may be in your project area, please see the FAQ "What does IPaC use to generate the migratory birds potentially occurring in my specified location". Please be aware this report provides the "probability of presence" of birds within the 10 km grid cell(s) that overlap your project; not your exact project footprint. On the graphs provided, please also look carefully at the survey effort (indicated by the black vertical bar) and for the existence of the "no data" indicator (a red horizontal bar). A high survey effort is the key component. If the survey effort is high, then the probability of presence score can be viewed as more dependable. In contrast, a low survey effort bar or no data bar means a lack of data and, therefore, a lack of certainty about presence of the species. This list is not perfect; it is simply a starting point for identifying what birds of concern have the potential to be in your project area, when they might be there, and if they might be breeding (which means nests might be present). The list helps you know what to look for to confirm presence, and helps guide you in knowing when to implement conservation measures to avoid or minimize potential impacts from your project activities, should presence be confirmed. To learn more about conservation measures, visit the FAQ "Tell me about conservation measures I can implement to avoid or minimize impacts to migratory birds" at the bottom of your migratory bird trust resources page.

# Wetlands

Impacts to NWI wetlands and other aquatic habitats may be subject to regulation under Section 404 of the Clean Water Act, or other State/Federal statutes.

For more information please contact the Regulatory Program of the local U.S. Army Corps of Engineers District.

Please note that the NWI data being shown may be out of date. We are currently working to update our NWI data set. We recommend you verify these results with a site visit to determine the actual extent of wetlands on site.

WETLAND INFORMATION WAS NOT AVAILABLE WHEN THIS SPECIES LIST WAS GENERATED. PLEASE VISIT HTTPS://WWW.FWS.GOV/WETLANDS/DATA/MAPPER.HTML OR CONTACT THE FIELD OFFICE FOR FURTHER INFORMATION.

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**APPENDIX E-20 Terrestrial Species of Concern Study Report**

# Terrestrial Species of Concern Study for the Pensacola Hydroelectric Project (FERC Project No. 1494) Craig, Delaware, Mayes, and Ottawa Counties, Oklahoma Updated Study Report

Job# HJN-21021

PREPARED FOR

GRDA
Grand River Dam Authority

GRAND RIVER DAM AUTHORITY

PREPARED BY

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SEPTEMBER 2022

# Contents



## Tables

# SECTION 1 BACKGROUND

This report serves as an update to the 2021 Initial Study Report (ISR) re: beetles and bats.

The purpose of the American Burying Beetle (*Nicrophorus americanus*; ABB) portion of this report is to provide a comparison of distributions of beetles to inundation maps generated by the Comprehensive Hydraulic Model (CHM) to characterize the effects of anticipated operations of the Pensacola Hydroelectric Project (Project) operations.

The purpose of the bat portion of this report is to assess the degree to which anticipated Project operations under the new license would inundate the main entrance to Beaver Dam Cave and compare the frequency of inundation with that associated with baseline operations. Grand River Dam Authority (GRDA) has determined whether the secondary exit suffices to provide an alternative access by gray bats (*Myotis grisescens*) to the cave (during times of inundation under anticipated Project operations).

Access to cave DL-2 (Beaver Dam Cave) and cave DL-91 (Twin Cave) has the potential to be affected by anticipated Project operations. Data generated by the CHM as part of the H&H Study were used and analyzed with respect to the gray bat to determine potential effects of anticipated Project operations to the species.

# SECTION 2 AMERICAN BURYING BEETLE

Horizon conducted a 2021 and 2022 American burying beetle (*Nicrophorus americanus*; ABB) presence/absence survey in accordance with the USFWS American Burying Beetle Range-Wide Presence/Absence Survey Guidance, dated May 2018 (Guidance). Communication with Kevin Stubbs (USFWS) (Appendix C) ensured Horizon that our Project Area sufficiently covered beetle habitat types including those located in GRDA's Wildlife Management Areas (WMA). The Project Area is located within the range of the federally threatened ABB, but outside of any conservation priority area (CPA) (Appendix A).

ABBs are habitat generalists and may use a variety of habitats that provide friable, moist soils and contain leaf litter and a variety of native vegetation above 8 inches in height to both retain soil moisture and support prey species. The USFWS provides guidance for what is considered unsuitable ABB habitat in their American Burying Beetle Conservation Strategy for the Establishment, Management, and Operation of Mitigation Lands for Impacts that Occur in Oklahoma guidance document, dated 1 September 2019.

**<u>ABB Habitat Exclusions</u>**

While the ABB uses a wide variety of habitats, the USFWS currently believes that areas exhibiting the following characteristics will not be of conservation value to ABBs and will not be credited as mitigation, except as possible buffer credits described below under the Crediting Method section. Areas exhibiting these characteristics should be excluded from mitigation lands because they are considered unfavorable for use by ABBs based on disturbance regime, vegetation structure, unsuitable soil conditions, and carrion availability:

1. Land that is tilled on a regular basis, planted in monoculture, and does not contain native vegetation.
2. Pasture or grassland that has been maintained through frequent mowing, grazing, or herbicide application at a height of 20 cm (8 inches) or less.
3. Land that has already been developed and no longer exhibits topsoil, leaf litter, or vegetation.
4. Urban areas with maintained lawns, paved surfaces, or roadways.
5. Stockpiled soil without vegetation.
6. Wetlands or permanent waterbodies with standing water or saturated soils. Areas adjacent to wetlands and/or riparian areas are not considered unfavorable for the ABB, as they may be important for ABBs seeking moist soils during dry conditions.

## 2.1 ABB Study Year One

As reported in the ISR, six traps were deployed within suitable, representative terrain within the Project Area. Trap sites were selected based on suitable habitat and capture of the most significant in size terrestrial areas within the study area boundary in Delaware and Ottawa counties. Surveys were conducted between 18 July and 23 July 2021 with valid weather conditions through the duration of the survey effort. No ABBs were found during the 2021 presence/absence survey (**Figure 1**).

### 2.2 ABB Study Year Two

Six baited pitfall bucket traps were deployed within suitable, representative terrain on 9 June 2022 in Delaware and Ottawa counties. This presence/absence survey was conducted as an early season survey in accordance with the approved study plan. Trap placement was also selected based on discussion and advisement of USFWS staff, in email communication dated 25 March 2022. Mr. Stubbs requested that the traps be placed within the best suitable habitat including designated WMAs and the Coal Creek wetland mitigation site (**Figure 2**).

The survey continued with five nights of valid weather parameters. Guidance defines valid weather parameters as:

1. Nighttime temperature during the survey period above 60º F (15.5 C)
2. Wind speed no greater than 10 mph in excess of 20% of the time (1 hour 24 minutes) between 9:00 p.m. and 4:00 a.m.,
3. Precipitation less than 0.5 inches between 9:00 p.m. and 4:00 a.m.

Weather conditions were valid throughout the course of the survey effort. No ABBs were captured or observed during this survey. These negative survey findings indicate that the ABB is not active within the Project Area; thus, take (defined by the Endangered Species Act [ESA] as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect any threatened or endangered species”) is not expected as a result of this project.

# SECTION 3 BATS

Based on the respective roosting habitats of the two bat species and known patterns of cave use adjacent to Grand Lake, the federally threatened northern long-eared bat (*Myotis septentrionalis*) is unlikely to be affected by alterations in cave access associated with Project operations. As a result, for this objective, GRDA will focus its efforts on federally endangered gray bats (*Myotis grisescens*) in the caves which they are known to use.

Cave DL-2 (Beaver Dam Cave) in Delaware County is adjacent to Drowning Creek, a tributary of Grand Lake, and is within the maximum inundation area on the lentic conversion maps (**Figures 3 and 4**). The cave passage is <65 meters (m) long with a single historical roost site for gray bats located 4 m above a persistent stream and about 5 m from the entrance to the cave. Complete inundation of the cave passage occurs at 752 feet in elevation. The roost was first documented as housing a colony of gray bats in 1981 when the colony was estimated to be 13,700 bats. Except during major flood events, based on recent exit and capture surveys at the entrance, the size and status (lactating females) of the colony remains relatively constant for the past 25 years.

Cave DL-91 (Twin Cave) is also located in Delaware County about 1 kilometer (km) from Grand Lake with an elevation (840 feet) precluding any threat of inundation. It is also outside of the maximum inundation area on the lentic conversion maps (**Figures 3 and 5**). The cave has a mapped passage of 803 m and has historical records of nine roost sites for gray bats. Prior to 1973, DL-91 historically housed the largest colony of gray bats in Oklahoma, estimated to be as many as 113,000 bats (Martin et al. 2000). Recent population estimates of the summer colony have been as high as 31,962 bats.

## 3.1 Procedures in 2021 Maternity Season

Infrared (IR)-illuminated entrance and night vision optics were used to conduct non-intrusive exit surveys and population estimates of gray bat colonies exiting caves DL-2 and DL-91 in the 2021 summer maternity and post-maternity season. Such surveys are used to document habitation, assist in estimating colony size at the respective caves, and monitor movements of the colony during potential high water and flood events on Grand Lake.

Exit surveys were conducted at cave DL-2 on 22 June and at cave DL-91 on 24 June and again on 16 July 2021 (Table 1). The post-maternity colony population estimate at cave DL-91 during late summer 2021 (Table 1) was within the range of 10,000 to 29,905 bats (average =18,245) over the past decade (Table 3).

**Table 1: Population estimates of gray bat colonies at caves DL-2 and DL-91 in Delaware County, OK in the 2021 maternity season**

| Date | Survey Method | Population at Cave DL-2 | Population at Cave DL-91 |
|---|---|---|---|
| 6/22/2021 | Exit Survey | 11,800 | |
| 6/24/2021 | Exit Survey | | 510 |

| Date | Survey Method | Population at Cave DL-2 | Population at Cave DL-91 |
|---|---|---|---|
| 7/16/2021 | Exit Survey | | 20,440 |

[1] Gray bat colony size estimates are based on exit surveys using infrared-illuminated entrances and night vision optics during summer 2021.

### 3.2 Procedures in 2022 Maternity Season

An IR-illuminated entrance and night vision optics were used to conduct non-intrusive exit surveys and population estimates of gray bat colonies exiting caves DL-2 and DL-91 in the 2022 summer maternity and post-maternity season. Such surveys are used to document habitation, assist in estimating colony size at the respective caves, and monitor movements of the colony during potential high water and flood events on Grand Lake.

Exit surveys were conducted at cave DL-2 on 27 June and at cave DL-91 on 10 May during a high-water event, and 22 June and 4 August (Table 1). The post-maternity colony population estimate at cave DL-91 during late summer 2022 (Table 2) was within the range of 10,000 to 29,905 bats (average =19,877) over the past decade (Table 3).

**Table 2: Population estimates of gray bat colonies[1] at caves DL-2 and DL-91 in Delaware County, OK in the 2022 maternity season**

| Date | Survey Method | Population at Cave DL-2 | Population at Cave DL-91 |
|---|---|---|---|
| 5/10/2022 | Exit Survey | | 20,620 |
| 6/22/2022 | Exit Survey | | 6,600 |
| 6/27/2022 | Exit Survey | 13,300 | |
| 8/4/2022 | Exit Survey | | 23,877 |

[1] Gray bat colony size estimates are based on exit surveys using infrared-illuminated entrances and night vision optics during summer 2022.

**Table 3: Ten-year post-maternity population[2] estimates of the colony of gray bats using caves DL-2 and DI-91 in Delaware County, Oklahoma**

| Date | Population at Cave DL-91 |
|---|---|
| 8/22/2013 | 29,905 |
| 9/11/2014 | 18,015 |
| 8/5/2015 | 20,585 |
| 7/21/2016 | 16,520 |
| 9/12/2017 | 19,340 |

| Date | Population at Cave DL-91 |
|---|---|
| 8/30/2018 | 18,000 |
| 5/21/2019 | 15,200 |
| 8/25/2020 | 16,883 |
| 7/16/2021 | 20,440 |
| 8/4/2022 | 23,877 |

[2] The post-maternity colony is historically found at cave DL-91.

Cave abandonment may result from high water events, or late-season migration after young become volant as often occurs in other areas of the species' range. Under favorable conditions, the colony ultimately vacates the maternity cave at DL-2 entirely in mid-summer and migrates to cave DL-91 located <5 km away (Grigsby et al. 1993; Martin et al. 2000) where the colony tends to remain until migration to hibernacula in November. Although cave DL-91 has intermittently served as a favorable maternity location, it is possible that it provides suboptimal climate conditions for a maternity colony compared to cave DL-2 with respect to microclimate and proximity to an abundant food source for developing young. Annual mid-summer migration phenomena are intriguing because migration of any type elicits its own inherent effects on animal populations that are exacerbated in young and reproductive adults.

During a high-water event in early May 2022 the exit survey at DL-91 was greater than 20,000 bats indicating the colony successfully vacated DL-2 prior to passage inundation by the rising Grand Lake levels. In review of surveys since 2007 there have now been 10 such high-water events resulting in the colony's successful relocation to cave DL-91. This leads to a trend of the colony using each cave on average about the same number of years as the maternity colony roost, and the ecological importance of management and monitoring of both sites. Historically when flooding events have occurred early in the spring followed by receding lake levels (April and early May), it is not unusual for the colony to return to cave DL-2 for the maternity period. This phenomenon was verified again on 27 June 2022 when the population was observed in cave DL-2 for the maternity period (Table 2). Observations from the 2022 season once again supports historical evidence that during high water or flood events during the maternity season, the maternity colony of the endangered gray bat can successfully vacate cave DL-2 and migrate to cave DL-91.

Complete inundation of the cave passage of DL-2 occurs at about elevation 752 feet Pensacola Datum (PD). When Grand Lake is at about elevation 751 feet PD, only about one foot of flyway exists between the top of the water in the cave and the rock ceiling of the flyway, likely resulting in a significant to normal behavior including feeding, rearing of young, and sheltering, and possibly forcing evacuation of the colony to the alternative cave (Table 4). Forcing the colony to vacate during critical maternity periods (March through July) likely adversely affects pregnant or lactating females, and non-volant or newly volant young. If bats become trapped in cave DL-2, they could survive only a limited amount of time due to the high energy demands of raising young. Other potential adverse effects include the stress of being trapped, drowning, and, if adults are trapped outside the cave, stress and mortality of non-volant young.

In October 2008 a small, high passage within cave DL-2 was identified and minimally excavated and enlarged. Enlarging this passage was suspected to provide an alternative escape route for exiting bats, particularly during high water. Additional excavation and enlargement of this second-high passage was completed in October 2013. The length of the high passage was about 5m and was widened to about 0.40 meters wide by 0.50 meters tall. An inspection of the passage following a flood event in summer 2015, and again during this project period in 2022, revealed scattered guano in the enlarged passage indicating use by bats. The post-inundation monitoring visit to the cave on 27 June 2022 failed to give any indication that take had occurred as a result of inundation in early May 2022.

**Table 4: Records of highwater events[3] where the elevation of Grand Lake exceeded elevation 750.00 feet PD from 2005-2022**

| Year | Date Beginning | Date Ending | Maximum Elevation (ft) | Total Duration | Impact on Colony |
|---|---|---|---|---|---|
| 2007 | 3 July | 16 July | 754.54 | 14 days | Successfully Vacated |
| 2008 | 11 April | 20 April | 753.04 | 10 days | Successfully Vacated |
| 2008 | 13 June | 26 June | 752.48 | 14 days | Successfully Vacated |
| 2011 | 27 April | 28 April | 750.80 | 2 days | Successfully Vacated |
| 2011 | 25 May | 26 May | 751.71 | 2 days | Successfully Vacated |
| 2015 | 27 May | 22 June | 754.89 | 27 days | Successfully Vacated |
| 2017 | 30 April | 25 May | 754.77 | 26 days | Successfully Vacated |
| 2019 | 14 May | 15 July | 755.02 | 63 days | Successfully Vacated |
| 2022 | 7 May | 10 May | 753.30 | 3 days | Successfully Vacated |

[3] At elevation 752 feet PD, the existing flyway inside cave DL-2 is inundated preventing colony exit and re-entry.

# SECTION 4 ANALYSIS

In support of the Terrestrial Species Study, GRDA performed additional simulations that were used to assess operational impact to specific terrestrial species. One product of the simulations specific to the ABB analysis was the development of maps showing areas of potential lentic or lotic conversion which could impact the habits of specific terrestrial species.

The seasonal period identified by the Terrestrial Species Study team was the entire calendar year, January 1 to December 31 because ABBs could be impacted during both their active and inactive or hibernation periods each year.

For both anticipated operations and baseline operations, the seasonal median operational level and inflows were simulated in the CHM. Results and maps were provided to the Terrestrial Species Study team.

In accordance with Section 2.6 of the Terrestrial Species Revised Study Plan, maximum inundation was also identified on all terrestrial maps created. The maximum inundation was virtually identical for anticipated and baseline operations because the maximum inundation boundary occurs when the USACE is in flood control operations, and it is not an effect of GRDA baseline or anticipated operations. Therefore, to analyze the impacts of the baseline versus the anticipated Project operations, the normal (median) inundations are used because they occur on such a regular basis that a habitat conversion can occur versus just a regular inundation.

See Appendix A, **Figures 6.1 – 6.23** for the Terrestrial Species Lentic Conversion Maps.

The second product of the CHM for the Terrestrial Species Study was specific to the gray bat analysis and provided the percentage of time the reservoir would be above the key reservoir elevations of 746 feet PD, 751 feet PD, and 752 feet PD for both the baseline and anticipated Project operations during the key season for gray bats of April 1 to July 31 each year.

The results are presented in Table 5.

**Table 5: Percentage of time Grand Lake Reservoir is above key elevations**

| Percentage of Time Above Reservoir Elevation | Baseline Operations | Anticipated Operations | Percentage Increase |
|---|---|---|---|
| 746 feet PD | 16.5% | 16.9% | 0.4% |
| 751 feet PD | 2.9% | 2.7% | (0.2%) |
| 752 feet PD | 1.9% | 1.9% | 0% |

## 4.1 ABB

The comparison of the baseline and anticipated Project operations yielded 2.79% terrestrial habitat may become aquatic habitat as a result of the anticipated operations (**Figures 6.1 – 6.23)**.

Much of this area is comprised of unsuitable ABB habitat such as rocky and/or sandy shoreline devoid of vegetation. Further, no ABBs have been located within the two years of project-specific study efforts nor have any ABBs been found within Delaware or Ottawa Counties in historical records provided by the USFWS spanning 1979 – 2018 (**Figure 7**). As a result, despite the expectation that some suitable ABB habitat may be converted to aquatic habitat, there is no reasonable expectation that ABBs are or have been using the habitat and thus, the impact, if any, is negligible.

### 4.2 Bats

The CHM analysis shows under the anticipated operations of the Project, the Grand Lake Reservoir will exceed 746 feet PD, the reservoir elevation at which water flows into the entrance of cave DL-2 (Beaver Dam) 16.5% under baseline operations and 16.9% under anticipated operations. The anticipated operations will cause this situation to occur 0.4% more frequently.

Evacuation of DL-2 generally does not begin to occur until Grand Lake reaches an elevation of approximately 751 feet PD. According to the CHM analysis, under the anticipated operations of the Project, the Grand Lake Reservoir will exceed 751 feet PD, 2.9% under baseline operations and 2.7% under anticipated operations. The anticipated operations will cause this situation to occur 0.2% less frequently.

A Grand Lake Reservoir elevation of 752 feet PD results in a complete inundation of the cave passage in DL-2 forcing evacuation. According to the CHM analysis, under the anticipated operations of the Project, the Grand Lake Reservoir will exceed 752 feet PD, 1.9% under baseline operations and 1.9% under anticipated operations. The anticipated operations will cause this situation to occur the same percentage of time as the baseline operations.

The average post-maternity colony size illustrates relative consistency, ranging from 15,200 to 29,905 bats with an average colony size of 19,877 gray bats for the past 10 years. (Table 2). Efforts should be concentrated on maintaining strong ties with the landowner of the access to cave DL-2, so that similar security efforts can continue there for the long-term.

In sum, the gray bat colony sharing caves DL-2 and DL-91 each summer appears to maintain a stable population size.

The CHM analysis shows very little increase (0.4%) in the potential for water to enter the cave opening of DL-2 at an elevation of 746 feet PD and very little decrease in the potential for water to enter the cave to an elevation of 751 feet PD that possibly forces and evacuation of the colony to the alternative cave. Lastly, the CHM results indicate there is no change in the percentage of time the passage in cave DL-2 becomes entirely submerged at an elevation of 752 feet PD under the anticipated operations.

# SECTION 5 CONCLUSIONS

## 5.1 ABB

Much of the habitat within the Project area is shoreline, and as such, is largely unsuitable for the ABB (rocky and/or sandy shoreline devoid of vegetation). Further, no ABBs have been located within the two years of project-specific study efforts nor have any ABBs been found within Delaware or Ottawa Counties, nor within the vicinity of the project area within Craig and Mayes Counties in historical records provided by the USFWS spanning 1979 – 2018. As a result, despite the expectation that some suitable ABB habitat could be converted to aquatic habitat, there is no reasonable expectation that ABBs are or have been using the habitat and thus, the impact, if any, is negligible and no further coordination with the USFWS is recommended.

## 5.2 Bats

The findings of the gray bat study indicate the secondary exit suffices to provide an alternative access by gray bats in cave DL-2. Regardless of the efficacy of the alternative access, the entrance to cave DL-2 does not become completely inundated to elevations 751 feet PD and greater (complete inundation is 752 feet PD) any more frequently under the anticipated Project operations than it becomes inundated under the baseline Project operations. Therefore, the impact to gray bats is negligible.

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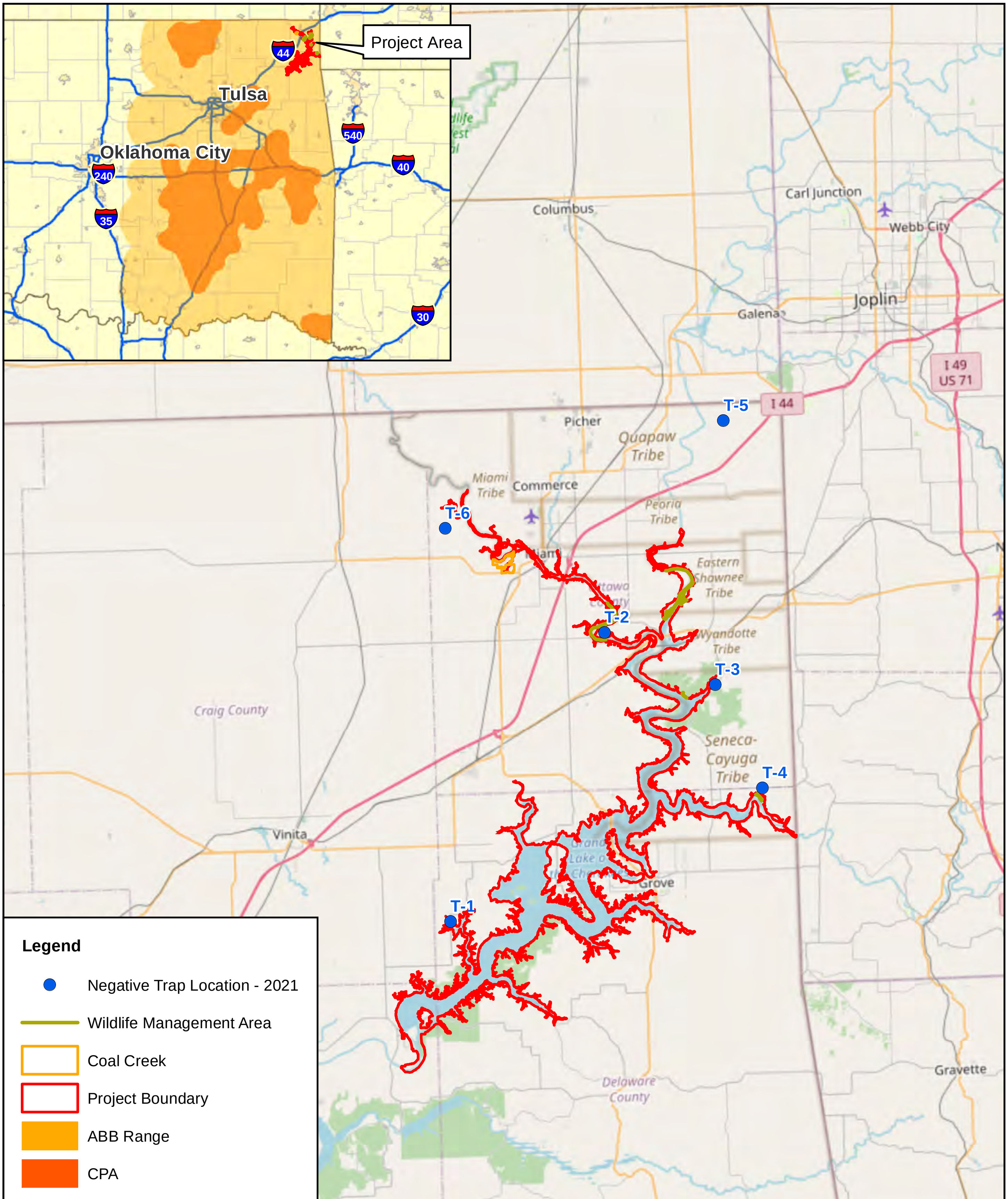
# APPENDIX A
Figures

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| Source: | OSM, 2021 |

**Figure 1**

2021 ABB Survey Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

0 4.5 9
Miles

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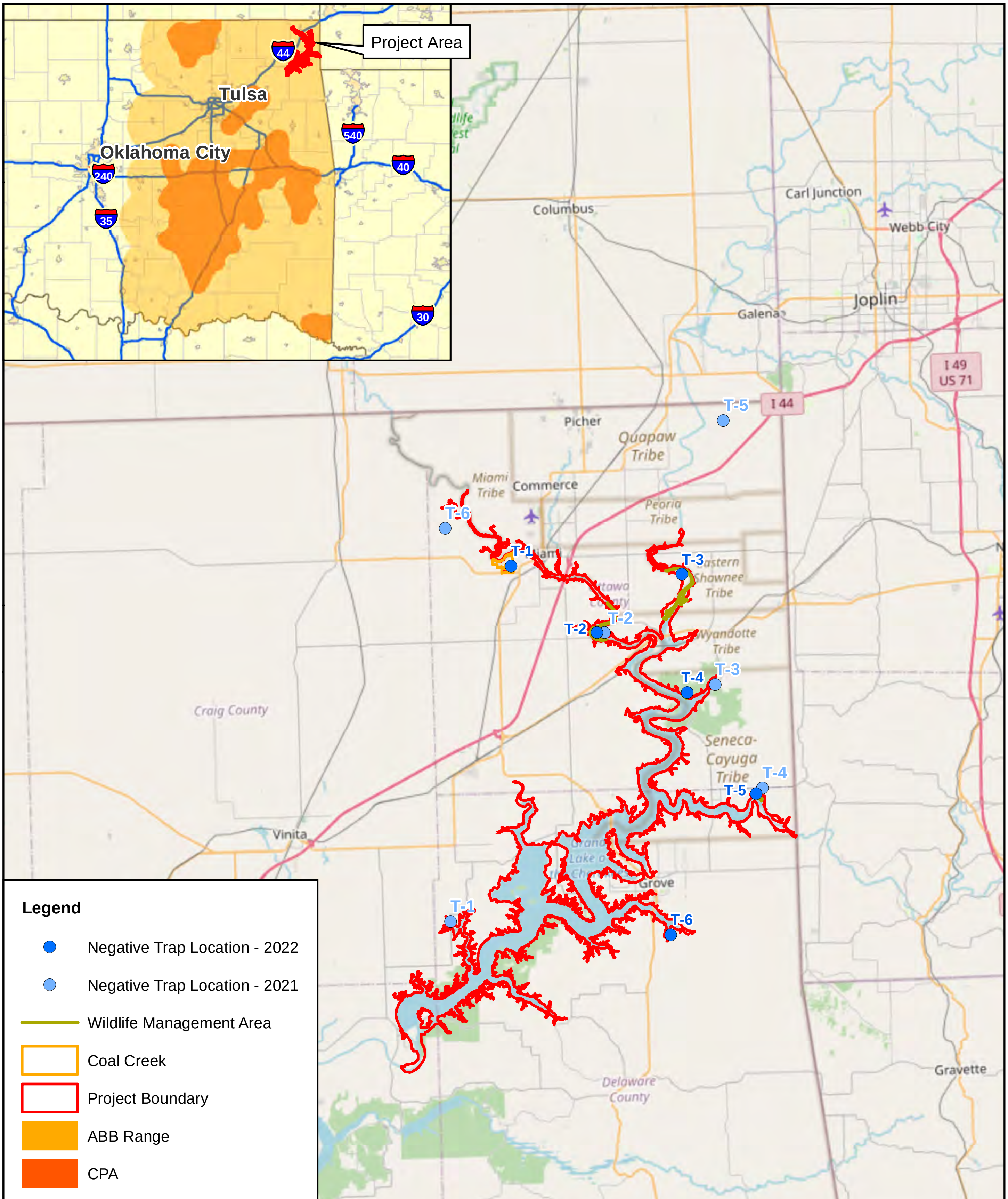


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| Source: | OSM, 2022 |

**Figure 2**

2022 ABB Survey Map
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

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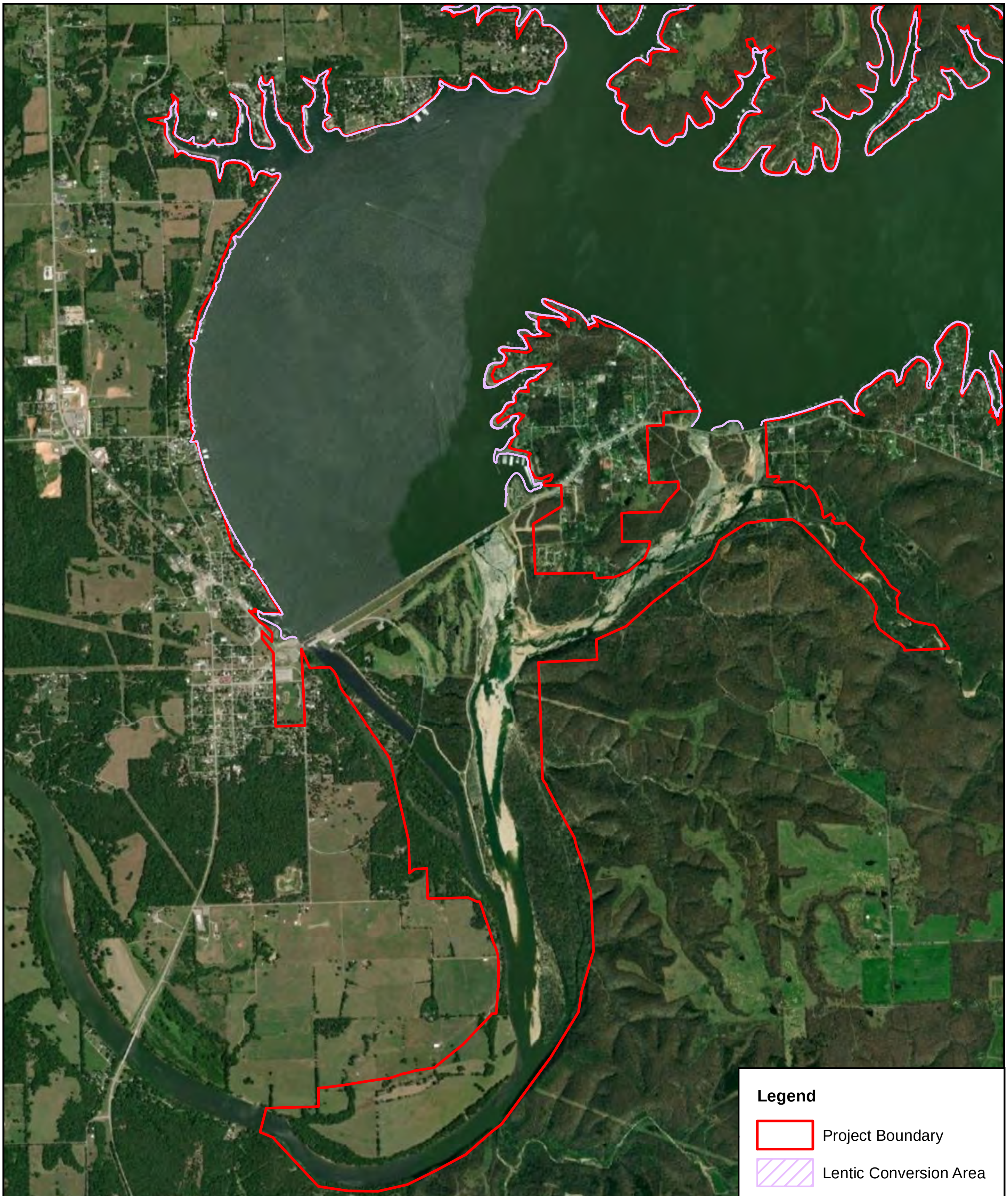
**Figures 3 - 5 are filed as privileged due to sensitive location information.**

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| Source: | Esri, 2020 |

Horizon Environmental Services, Inc.

**Figure 6.1**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

0 1,500 3,000
Feet

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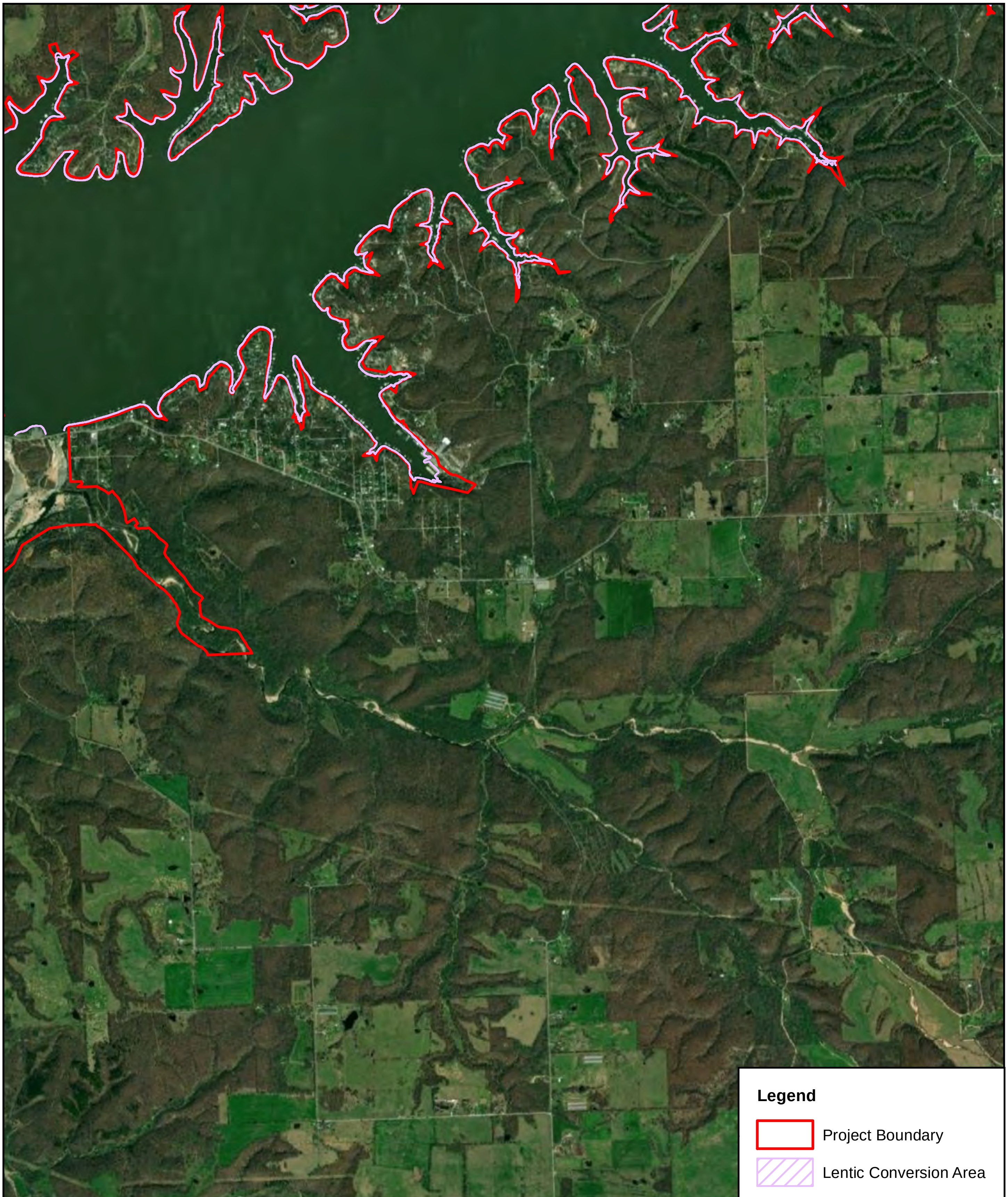

**Legend**

Project Boundary

Lentic Conversion Area

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Horizon™ Environmental Services, Inc.

**Figure 6.2**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

0 1,500 3,000
Feet

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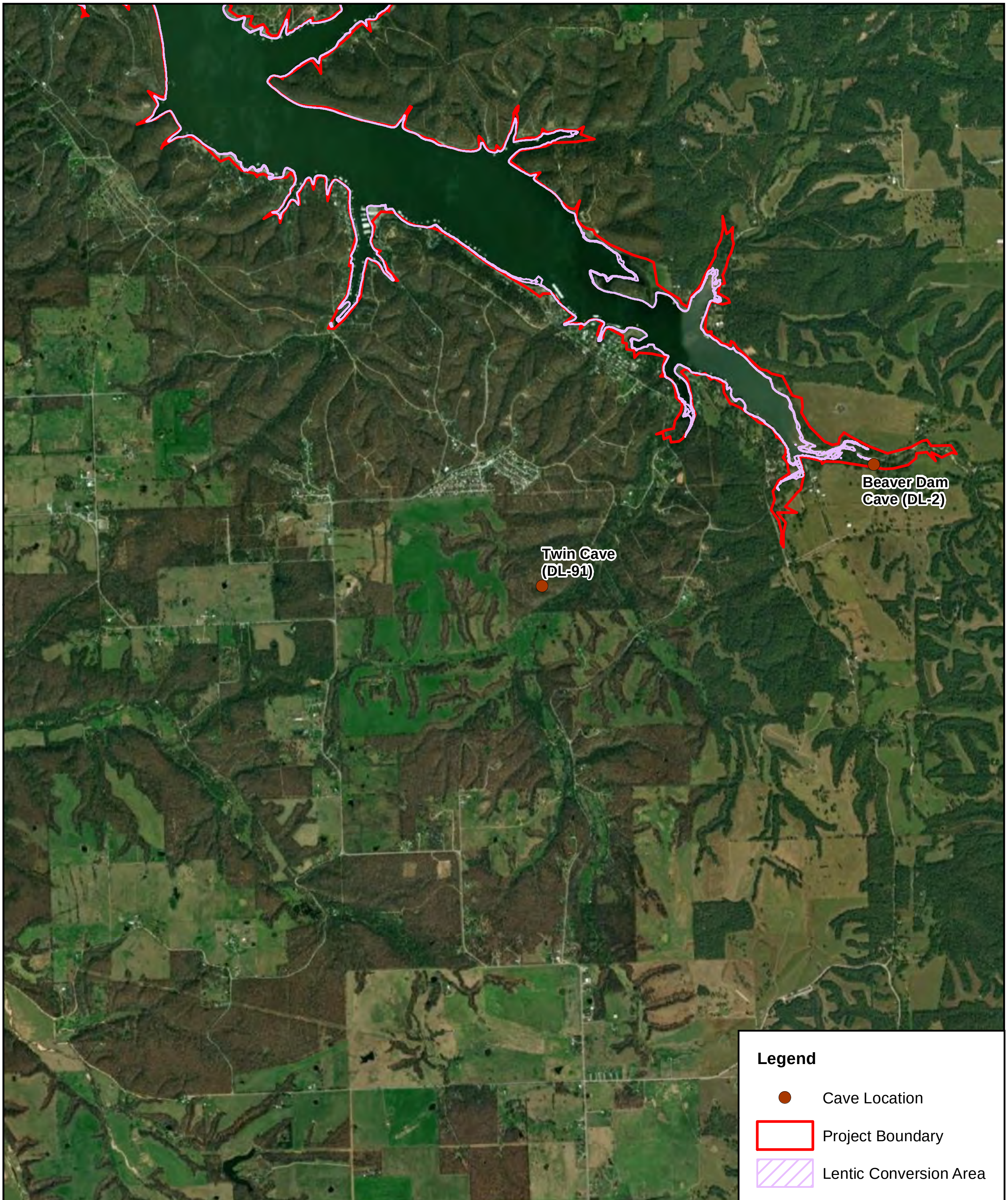


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Horizon Environmental Services, Inc.

**Figure 6.3**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

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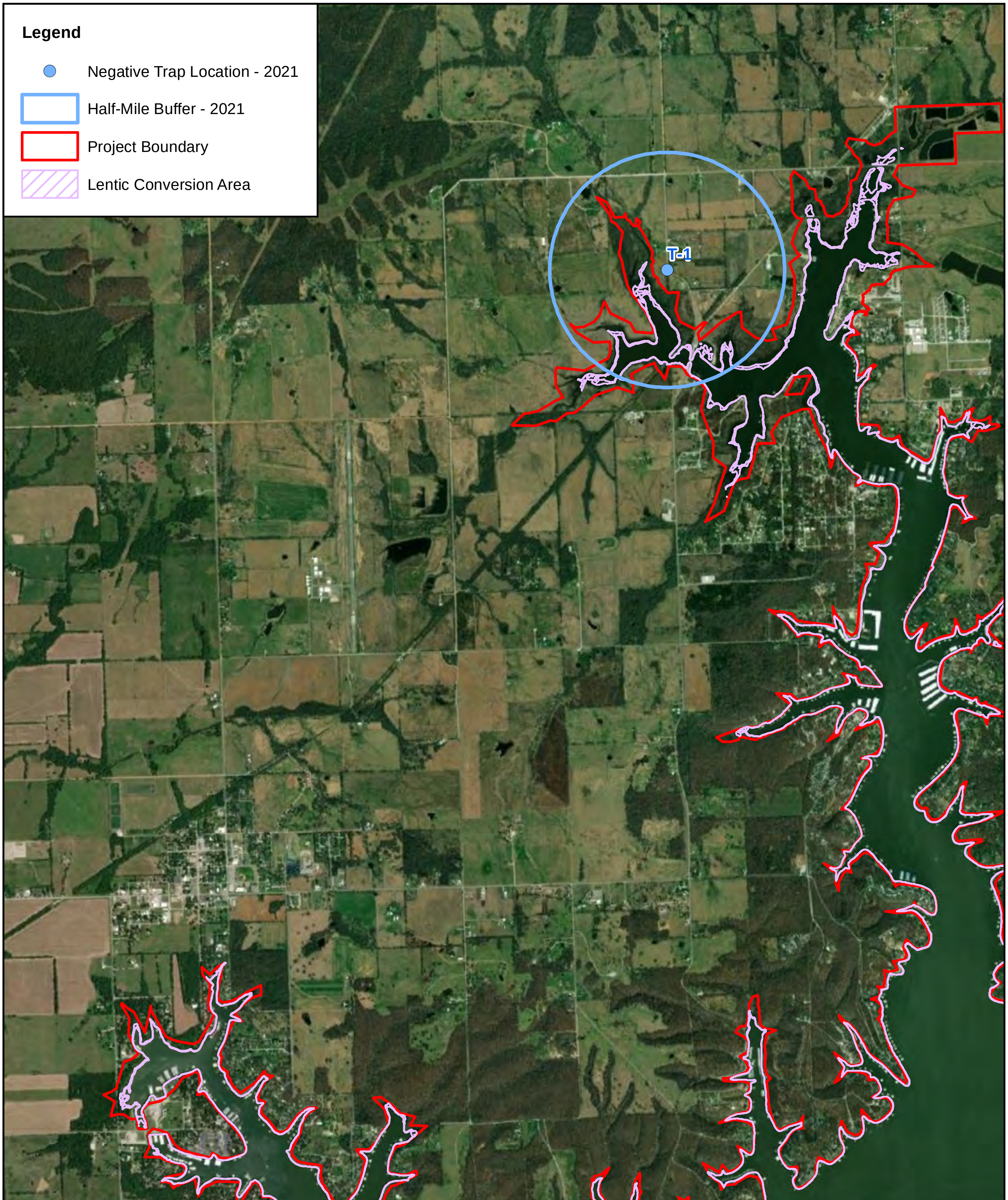


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**Figure 6.4**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

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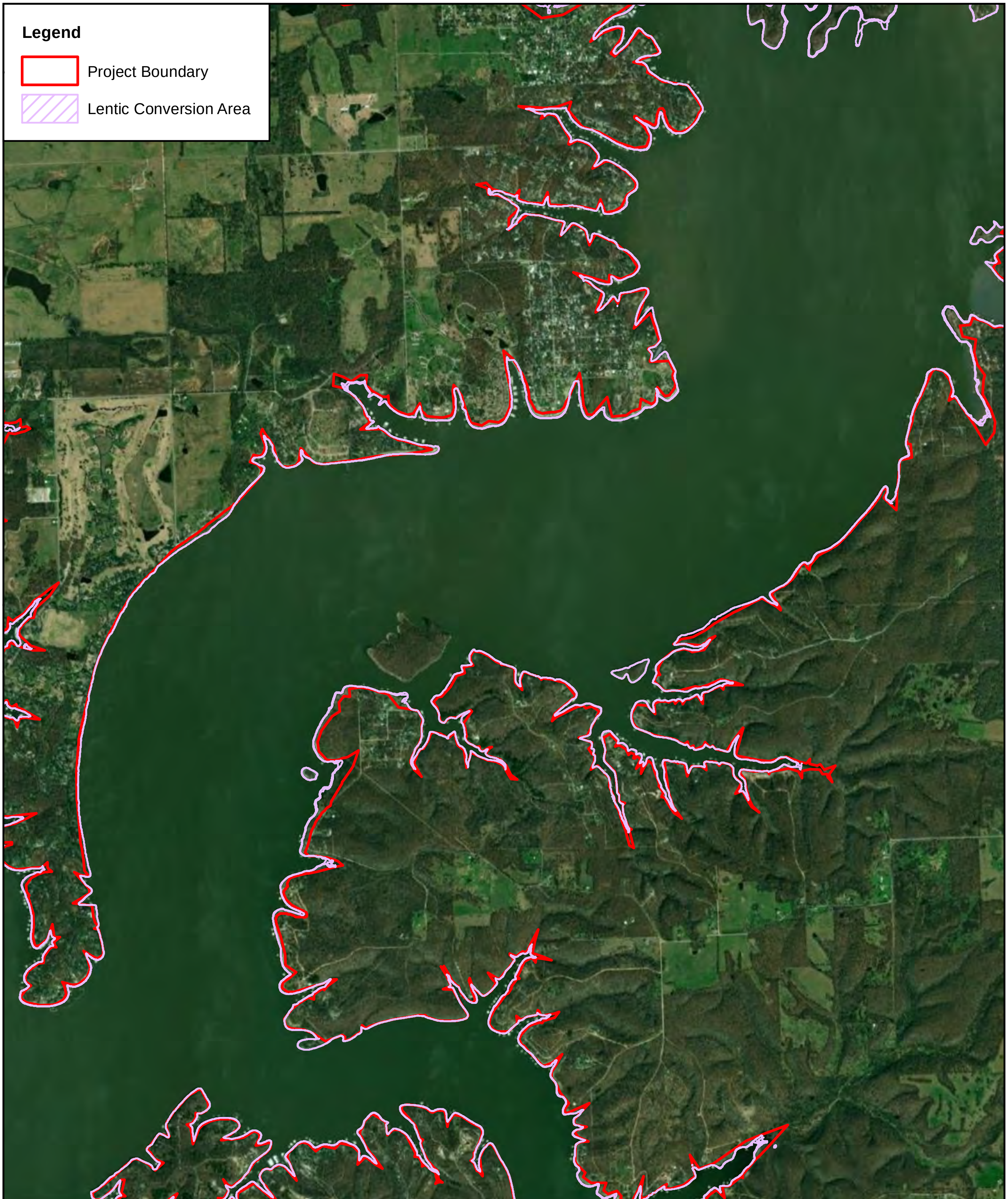


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**Figure 6.5**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

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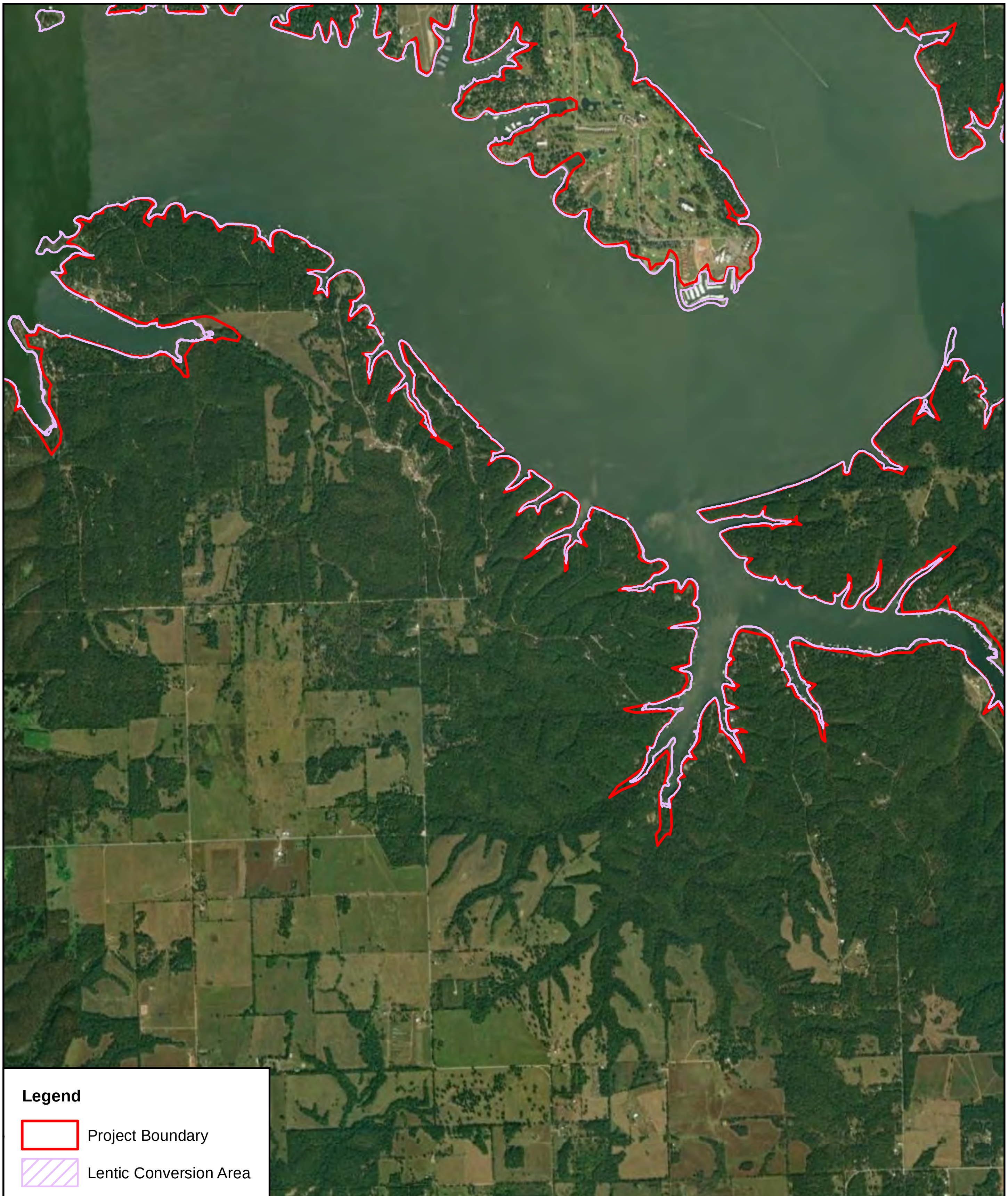


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**Figure 6.6**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

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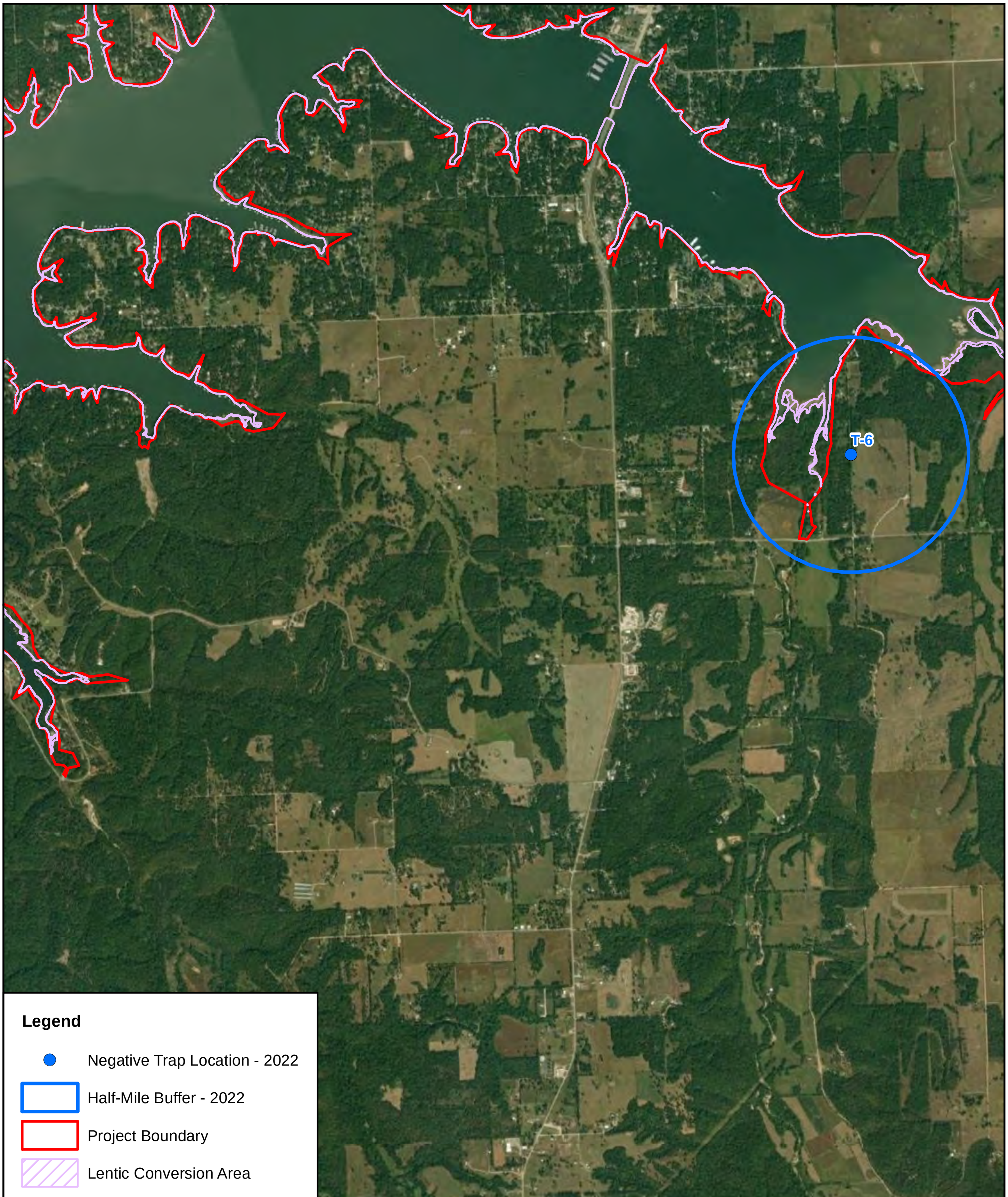


**Legend**

- Negative Trap Location - 2022
- Half-Mile Buffer - 2022
- Project Boundary
- Lentic Conversion Area

Horizon Environmental Services, Inc.

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**Figure 6.7**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

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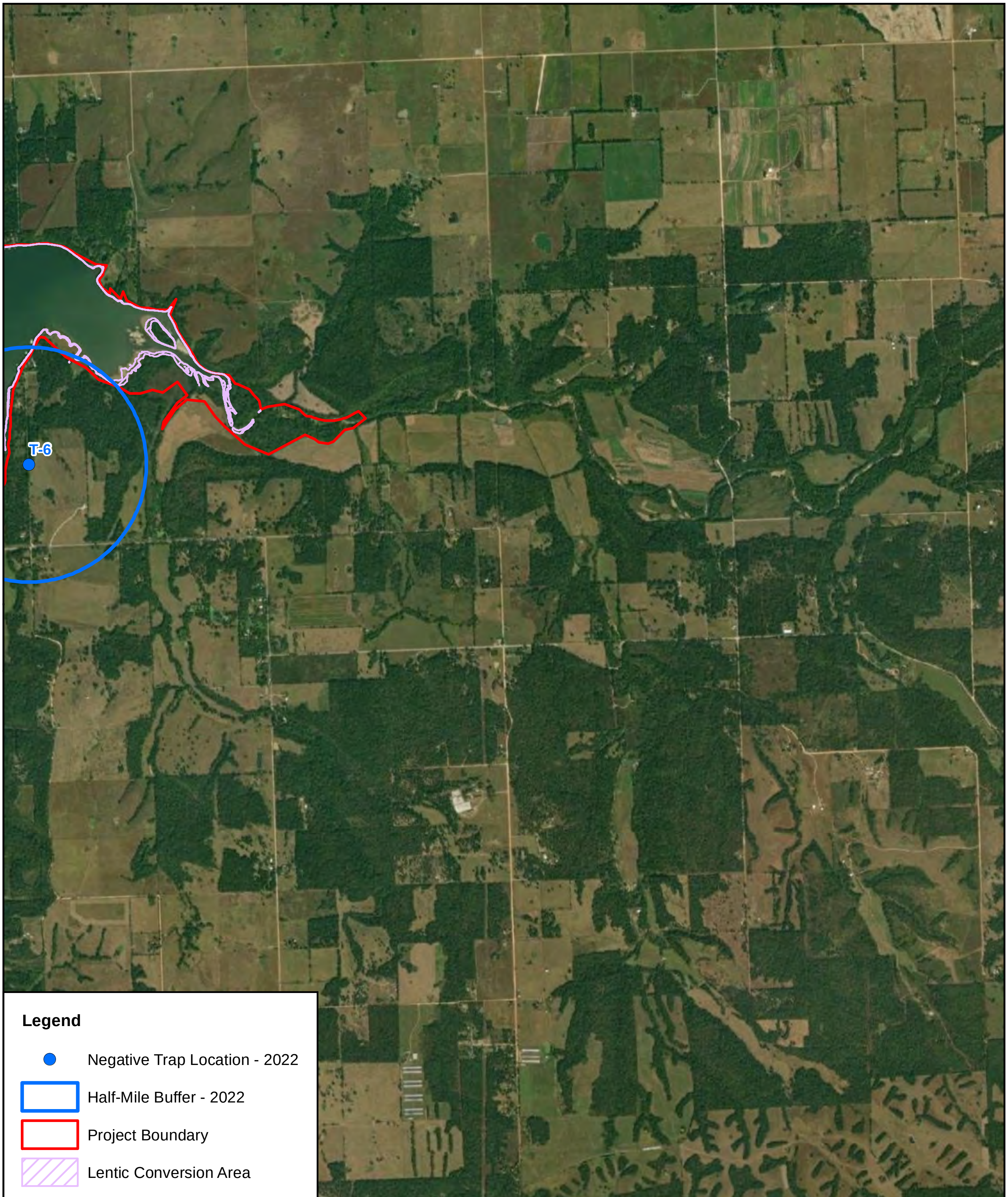


**Legend**

- Negative Trap Location - 2022
- Half-Mile Buffer - 2022
- Project Boundary
- Lentic Conversion Area

Horizon™ Environmental Services, Inc.

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**Figure 6.8**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

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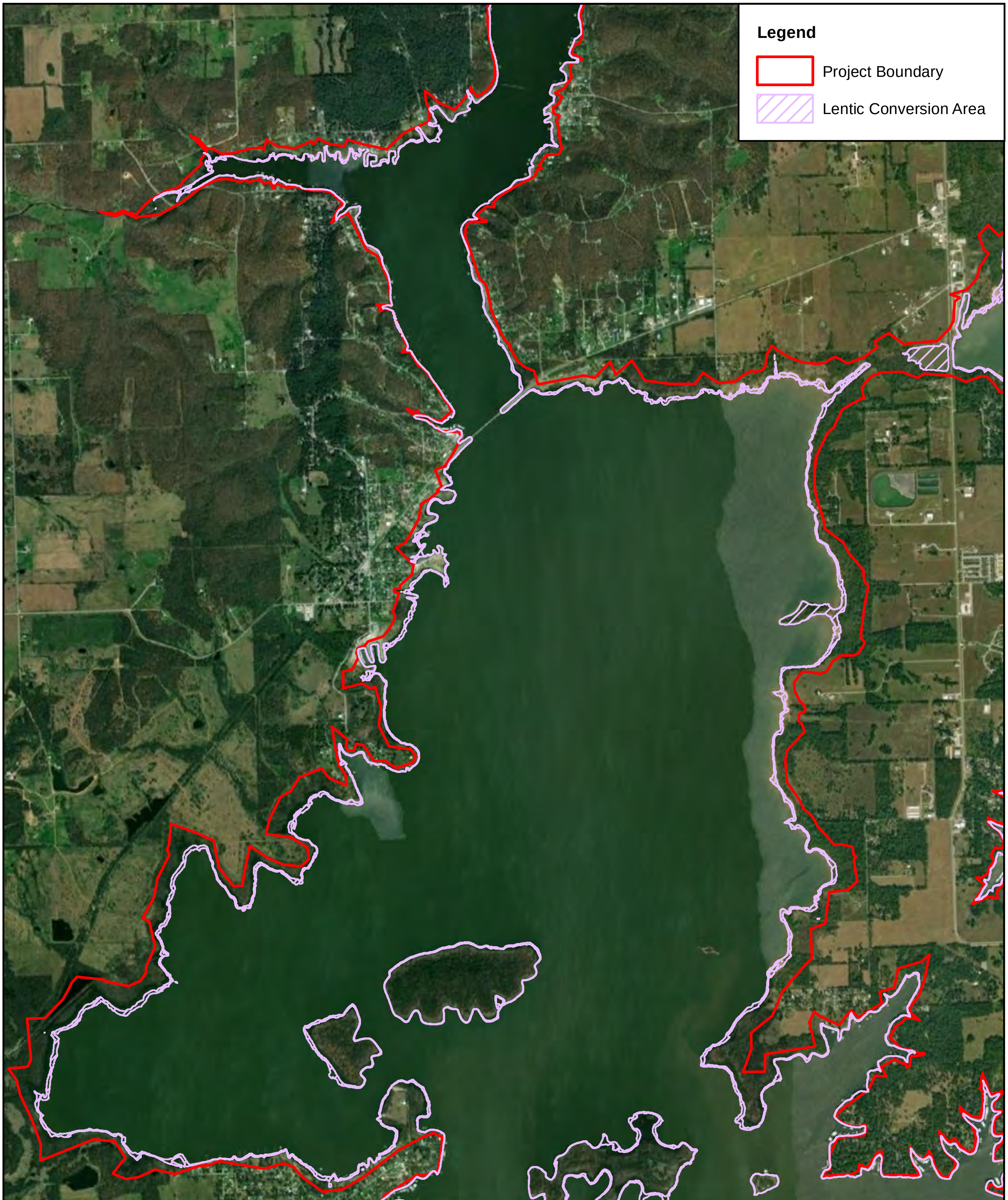


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**Figure 6.9**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

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**Figure 6.10**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

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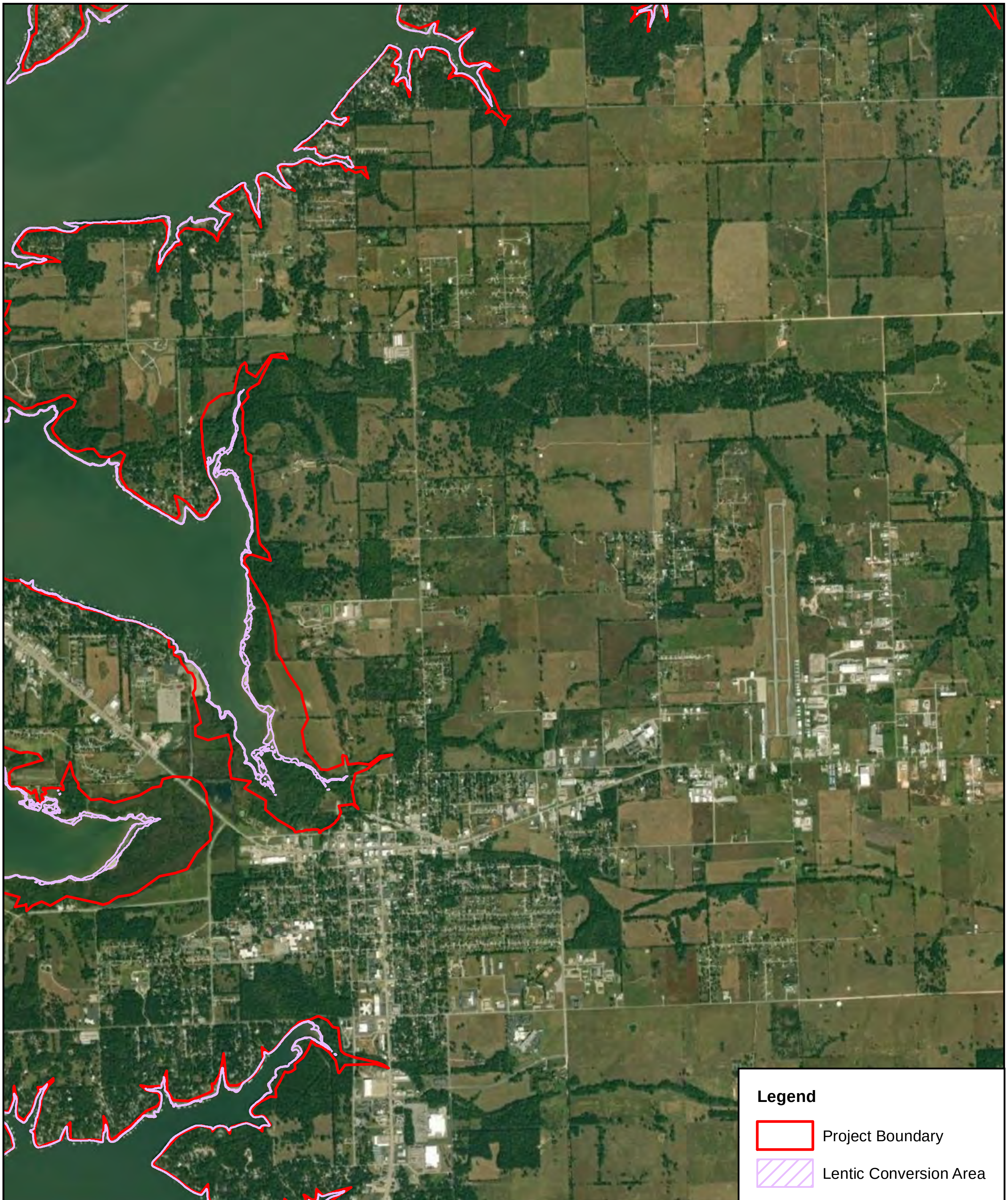


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**Figure 6.11**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

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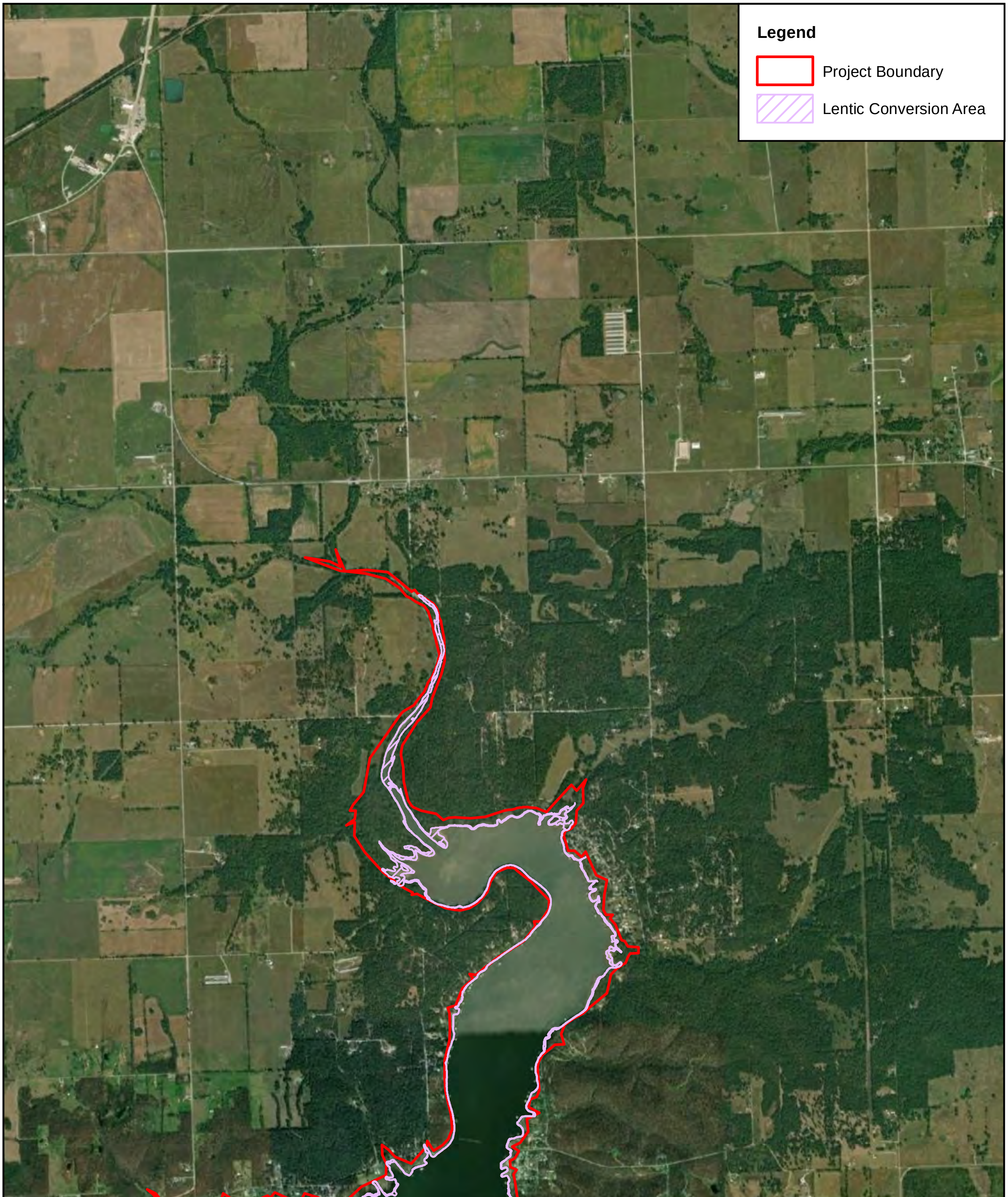


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**Figure 6.12**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

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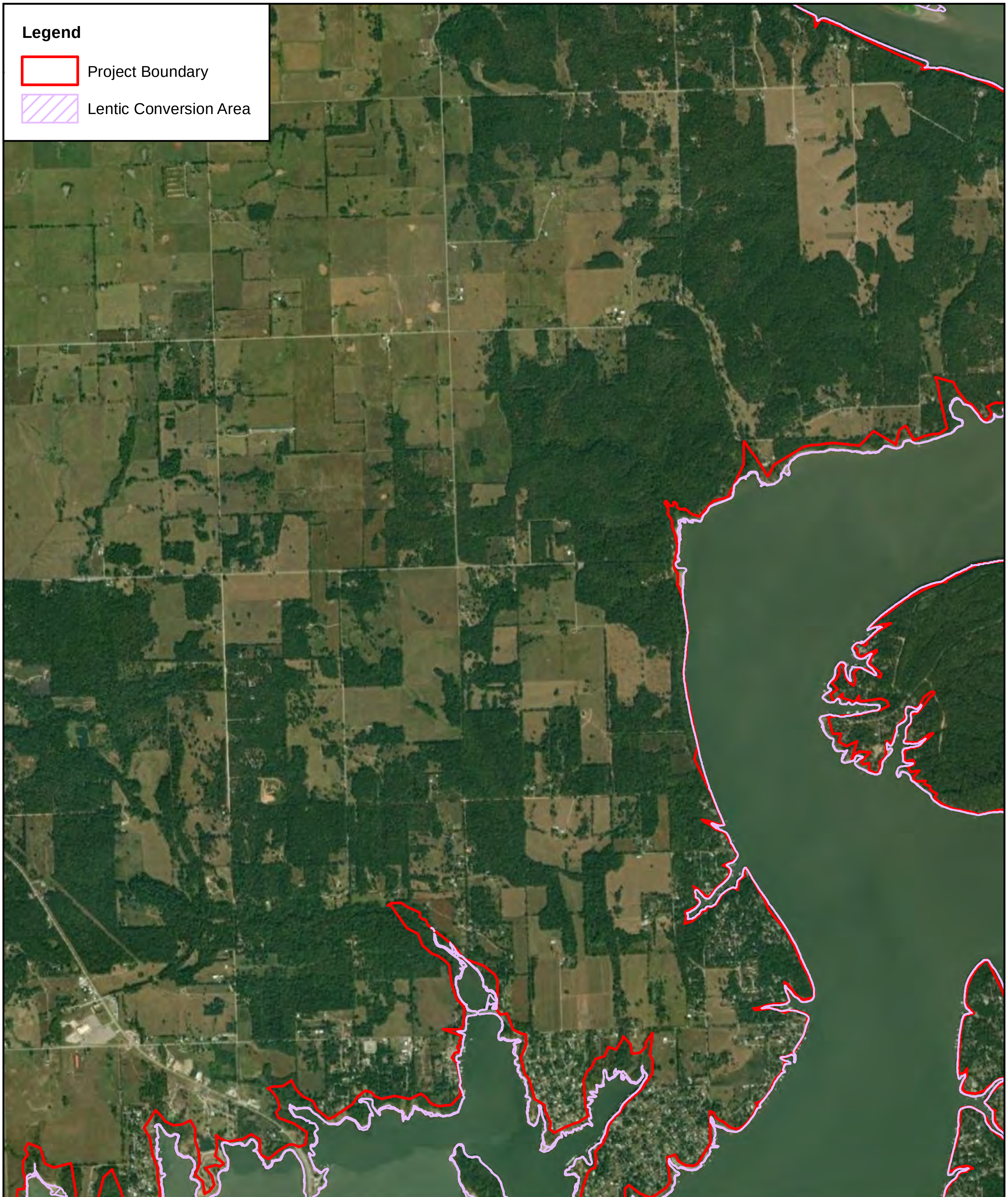


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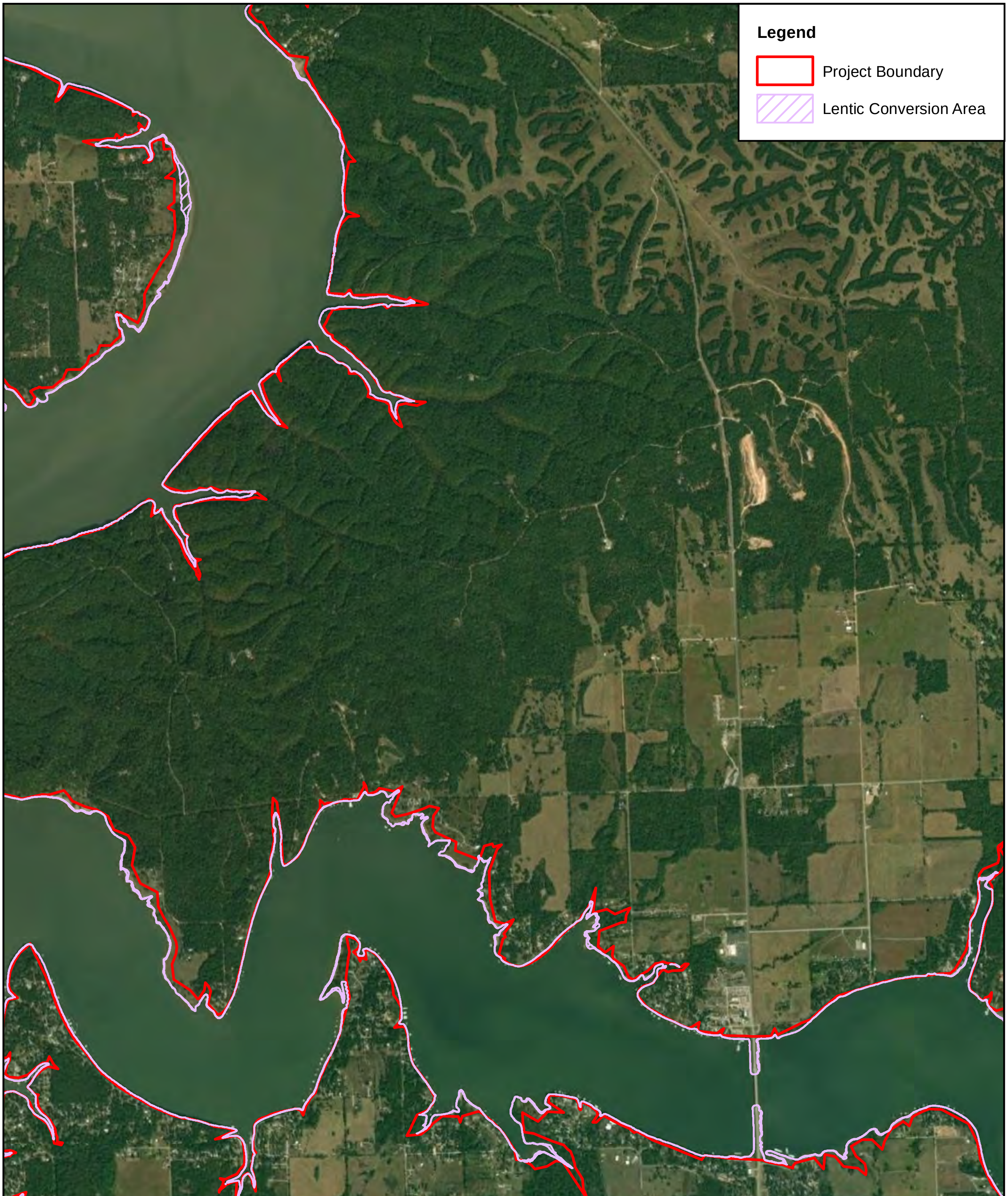


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**Figure 6.14**

Terrestrial Species Lentic Conversion Map
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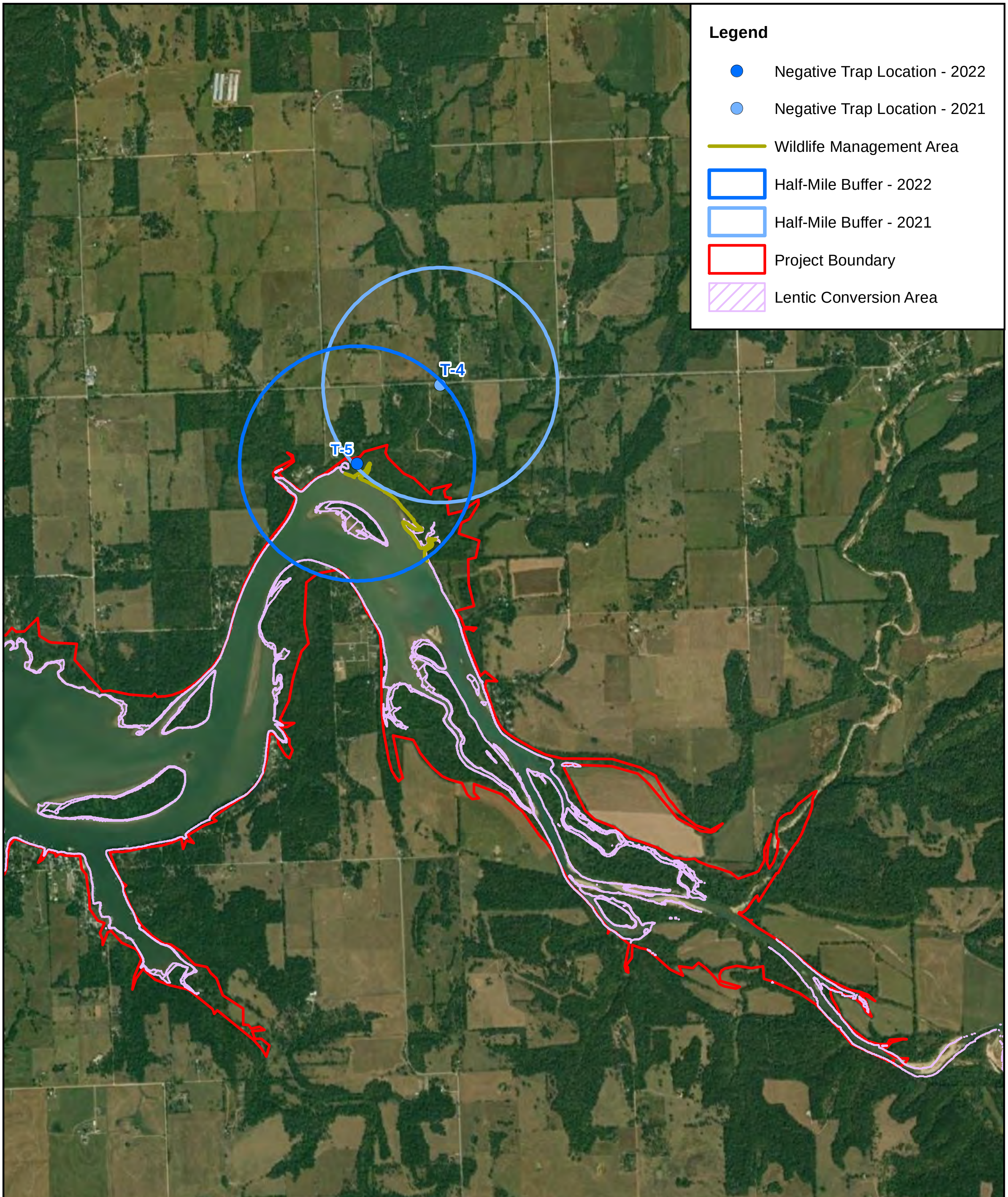


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**Figure 6.15**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
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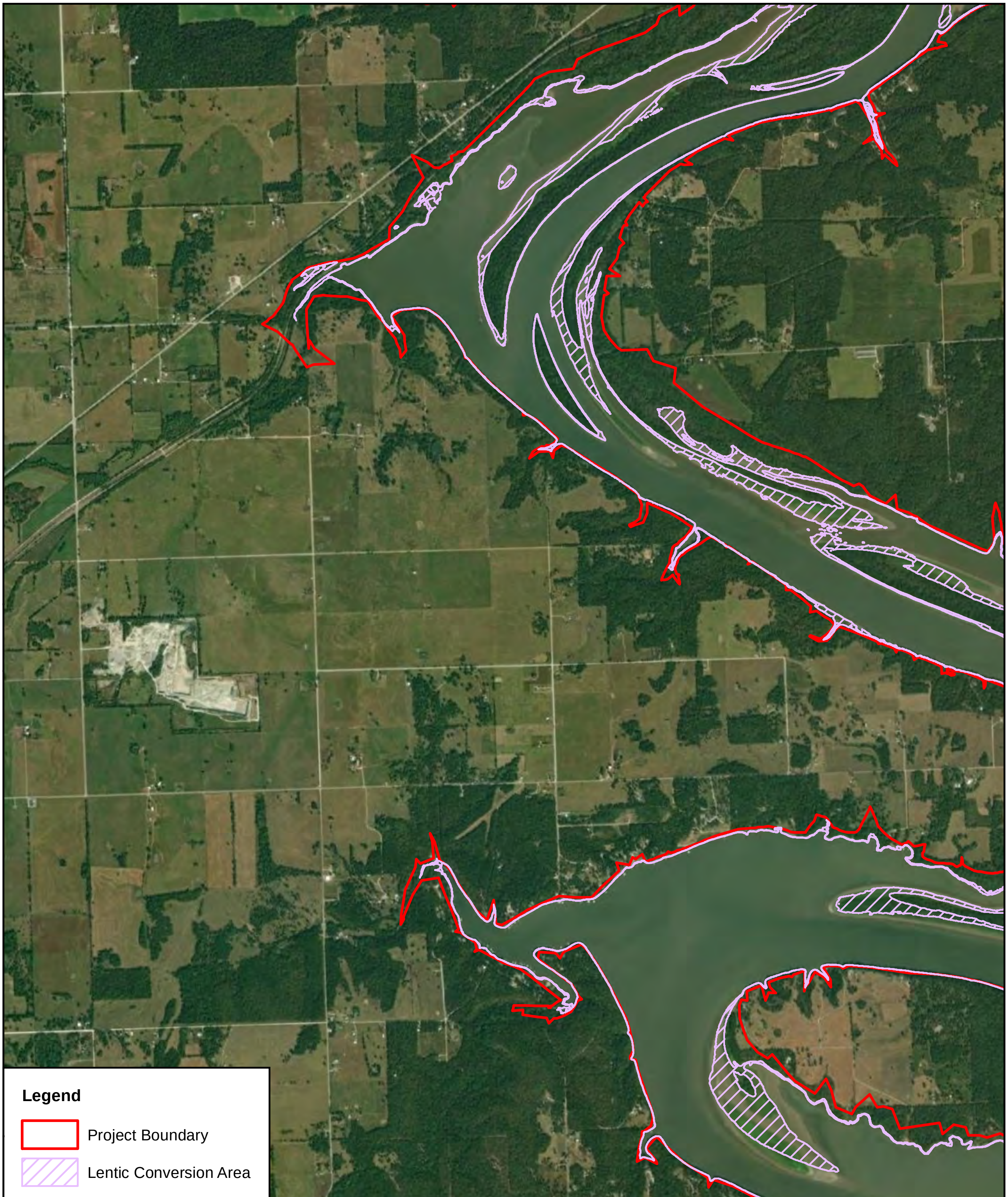


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**Figure 6.16**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

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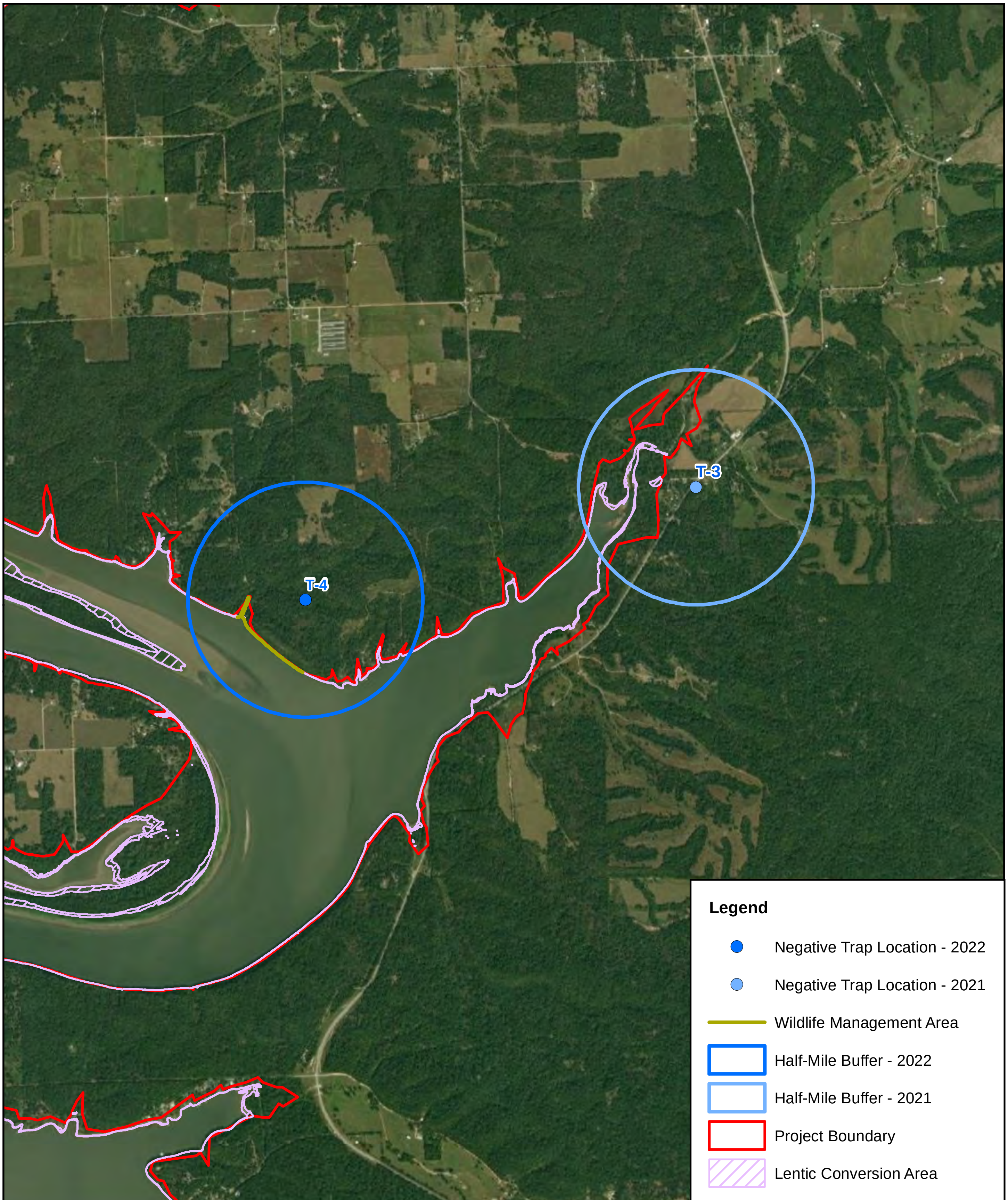


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**Figure 6.17**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

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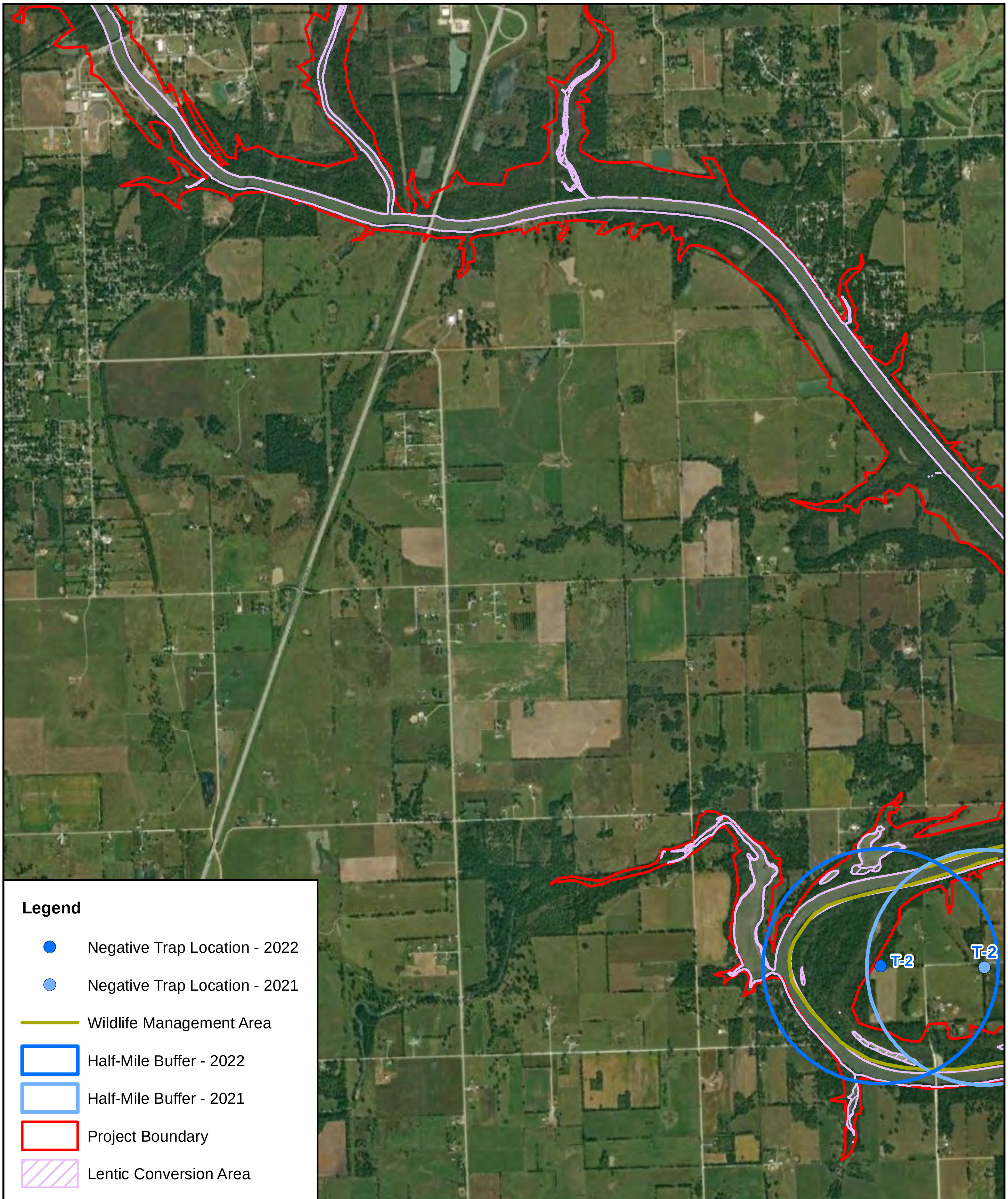


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**Figure 6.18**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

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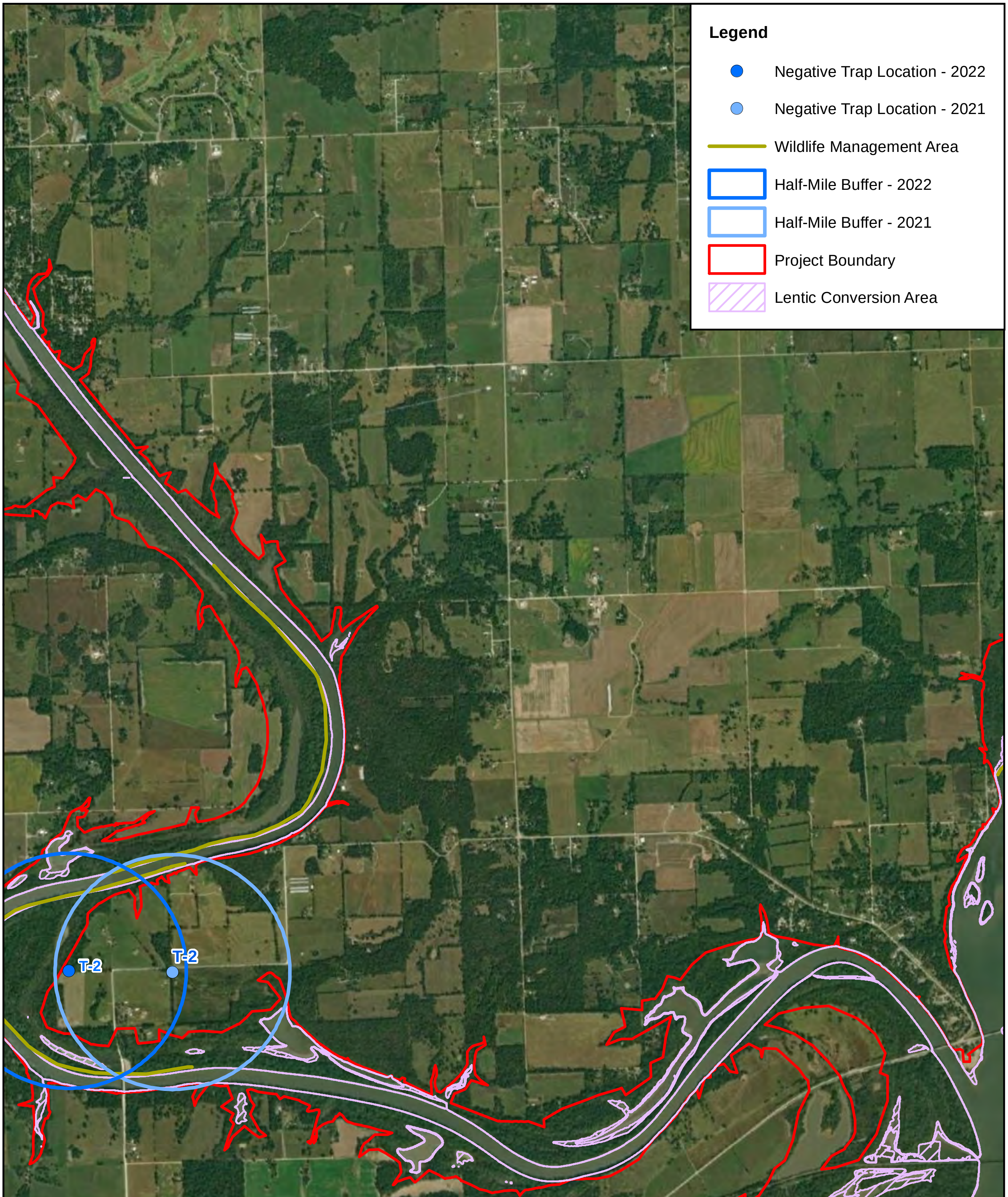


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**Figure 6.19**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

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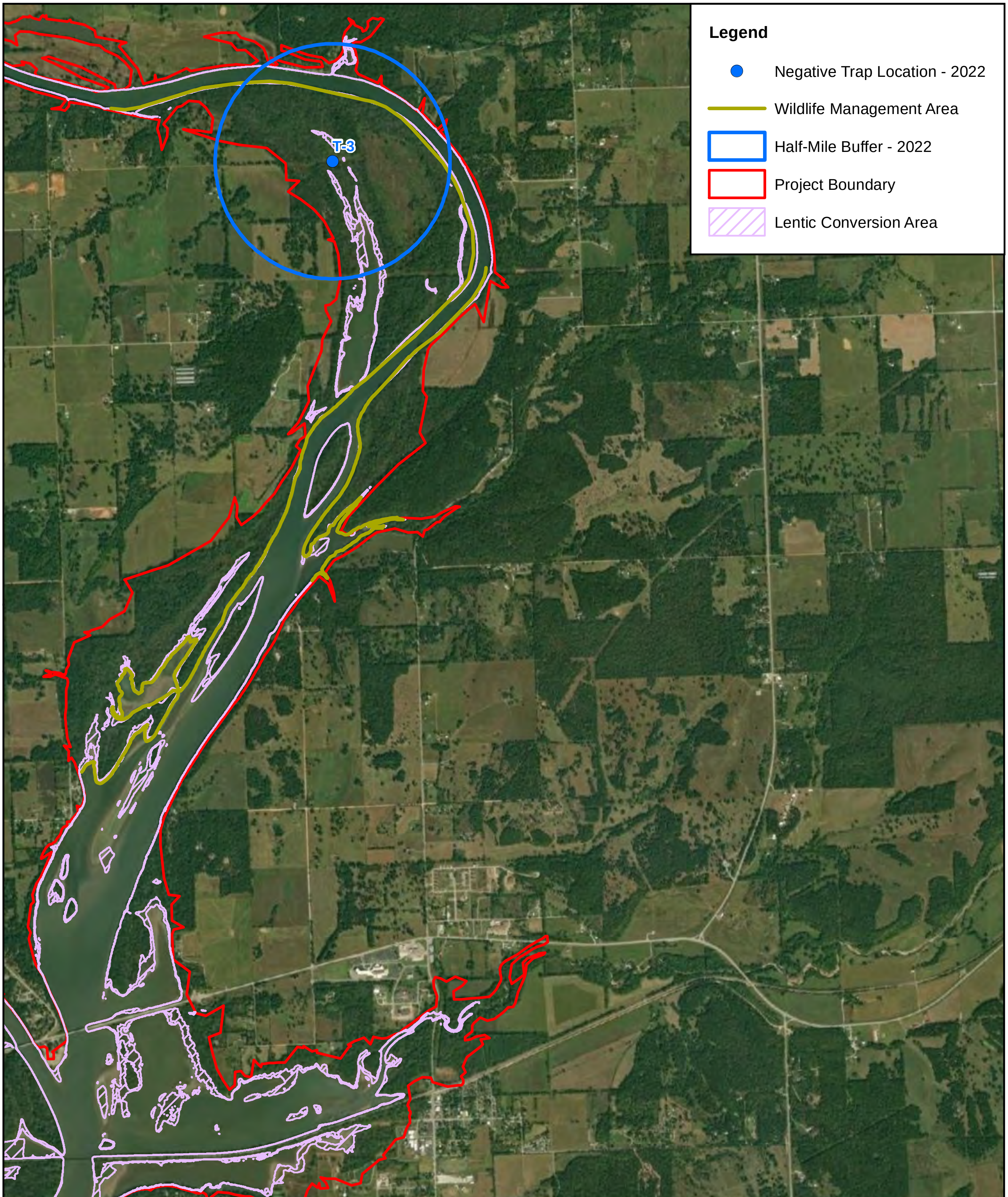


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Horizon Environmental Services, Inc.

**Figure 6.20**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

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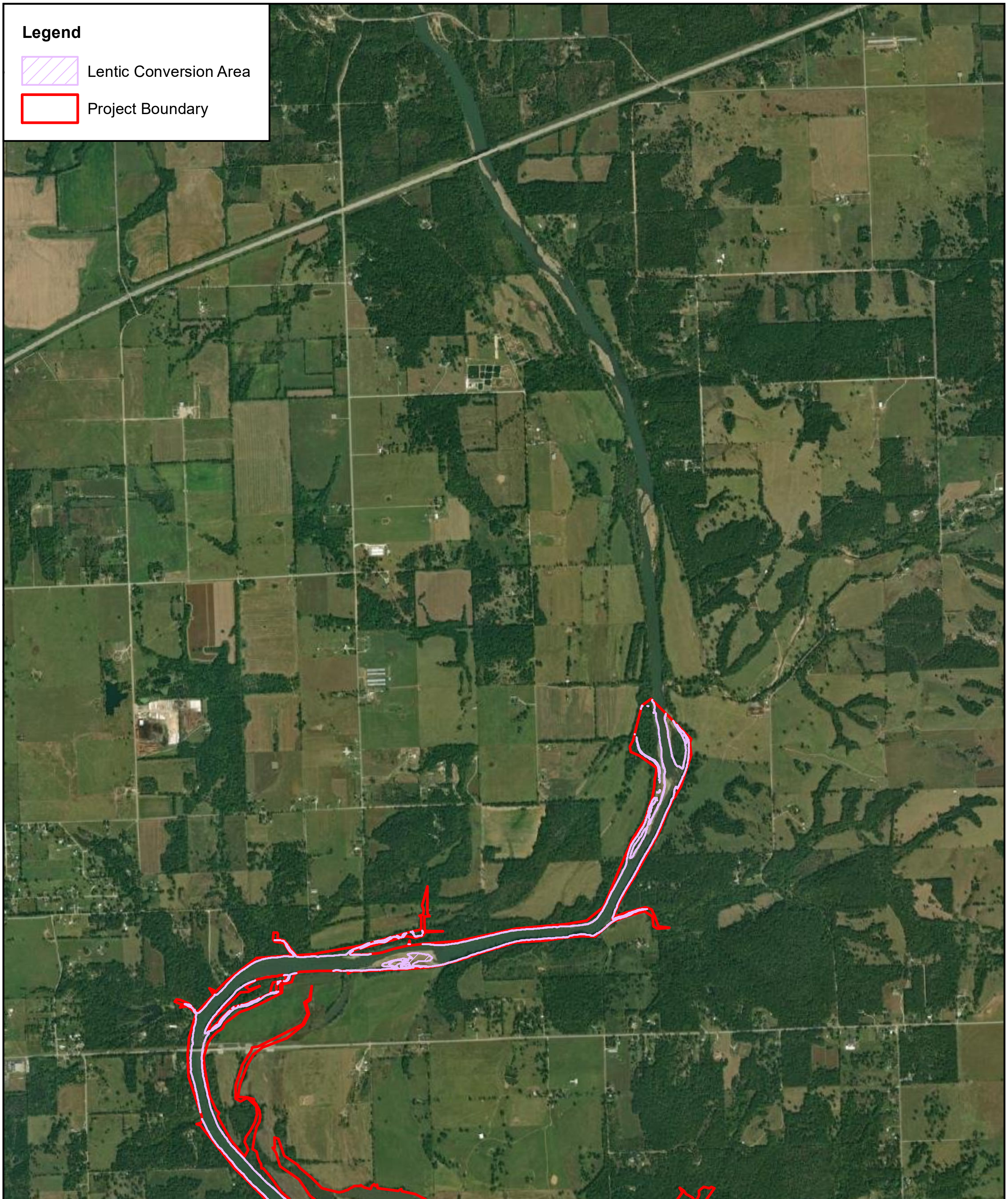


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**Figure 6.21**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

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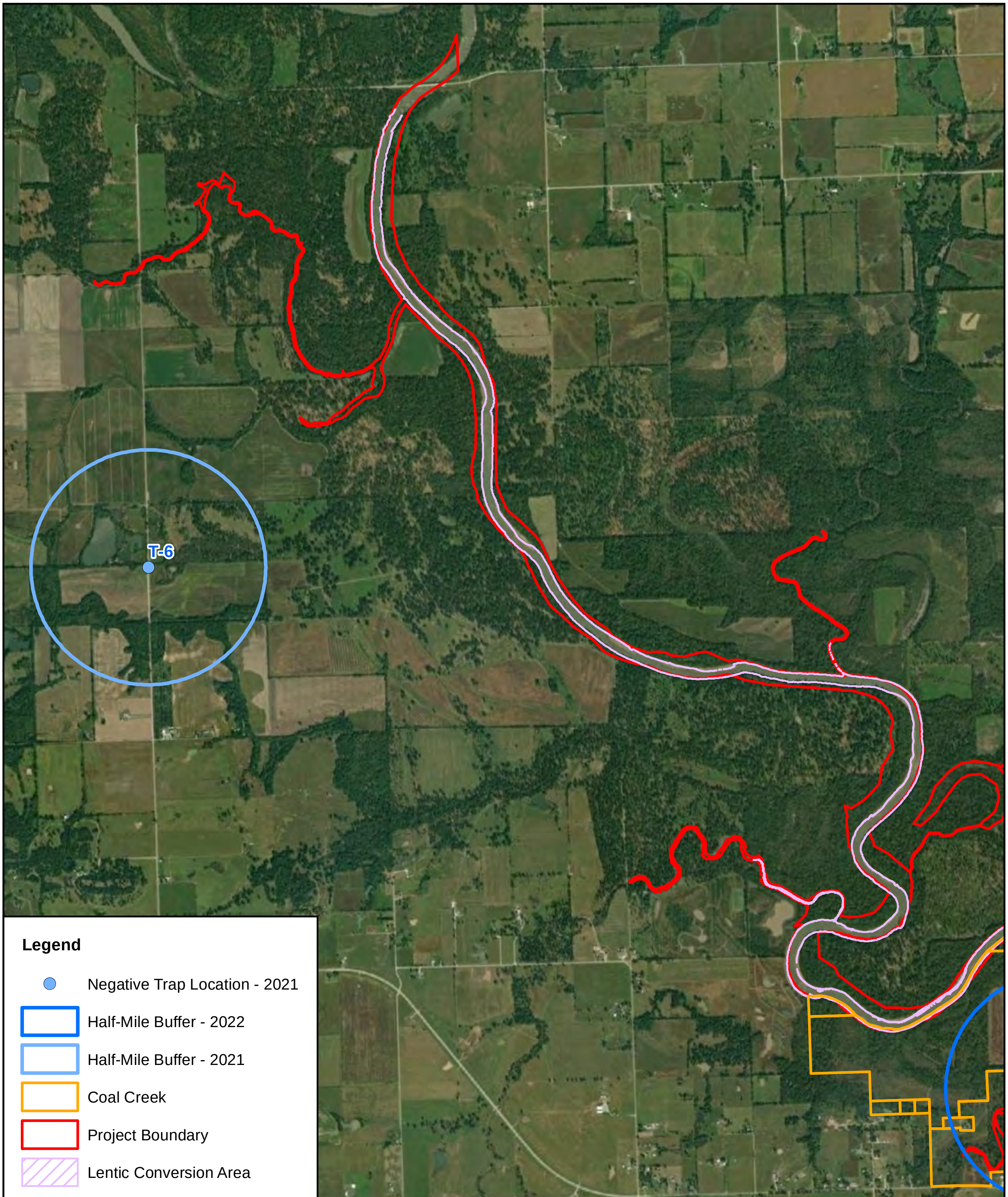


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**Figure 6.22**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

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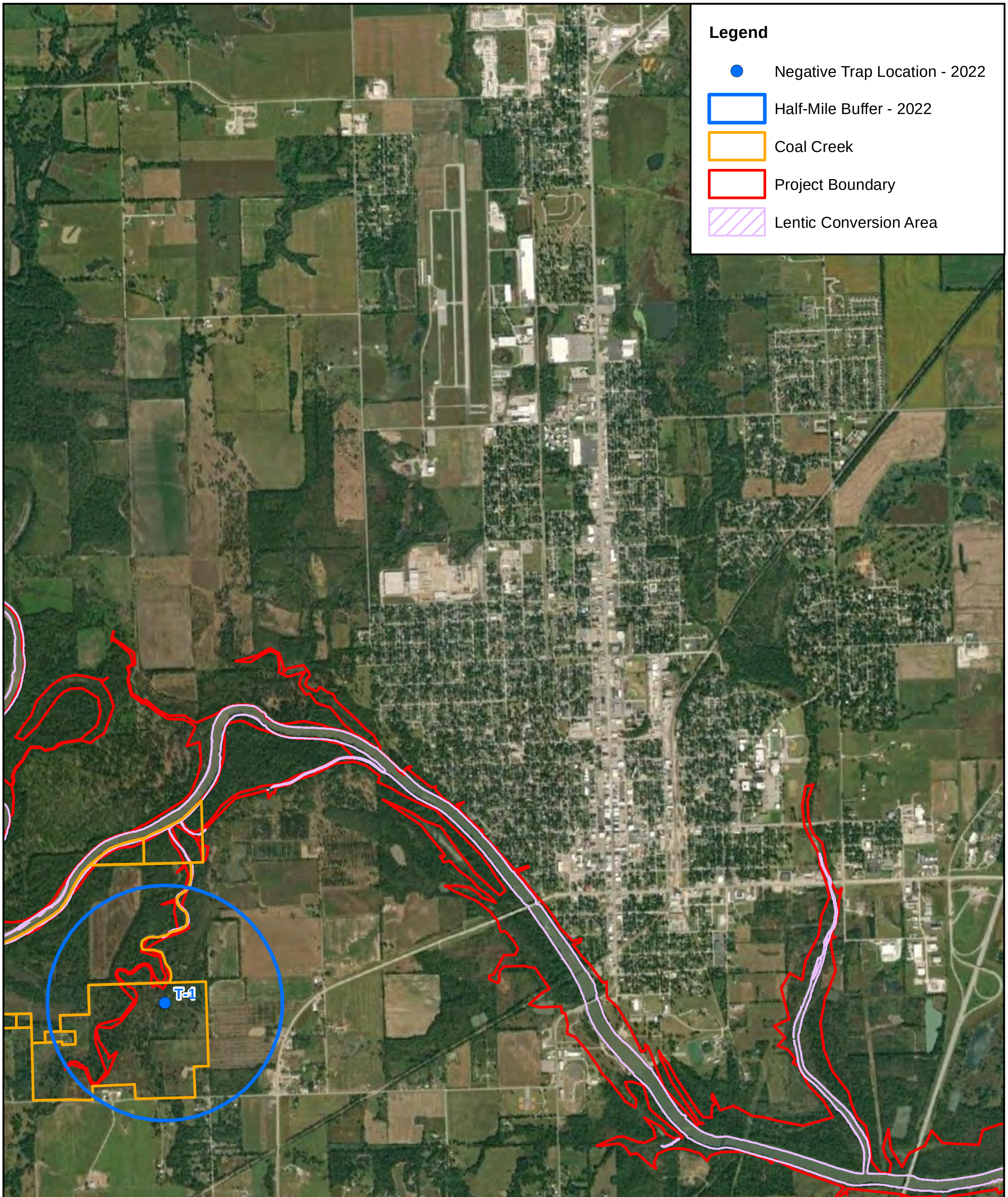
21021--GRDA_Pensacola_Project_Relicensing\Graphics\21021-002TE_06A_LenticMap_22




Horizon™ Environmental Services, Inc.

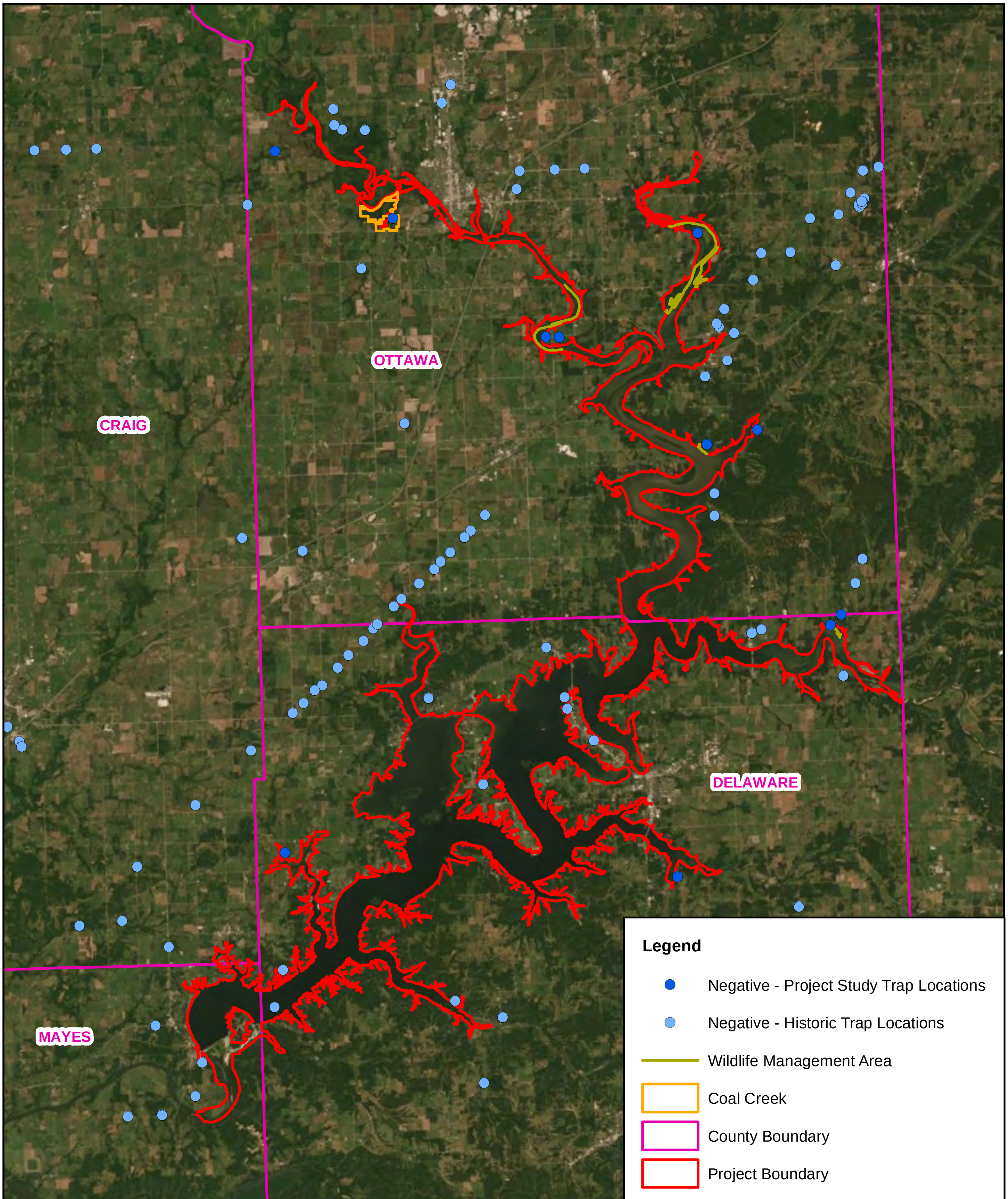
| | |
|---|---|
| Date: | 09/14/2022 |
| Drawn: | KRW |
| HJN NO: | 21021 |
| Source: | Esri, 2020 |

**Figure 6.23**

Terrestrial Species Lentic Conversion Map
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

0 1,500 3,000
Feet

21021--GRDA_Pensacola_Project_Relicensing\Graphics\21021-002TE_06A_LenticMap_23




| | |
|---|---|
| Date: | 08/30/2022 |
| Drawn: | KRW |
| HJN NO: | 21021 |
| Source: | Esri, 2020; USFWS, 2018 |

Horizon™ Environmental Services, Inc.

**Figure 7**

1979 - 2018 Historical ABB Data Map
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

0 2.5 5
Miles

21021--GRDA_Pensacola_Project_Relicensing\Graphics\21021-001ABB_03A_Historical_Traps

**APPENDIX B**

American Burying Beetle Pensacola Hydroelectric Project Survey Report 2022

30 August 2022

Jacklyn Jaggars
Director of Hydropower Projects
Grand River Dam Authority
420 OK-28
Langley, OK 74350
918-981-8473 Office
Jacklyn.Jaggars@grda.com

**RE: American Burying Beetle Presence/Absence Survey for the Pensacola Hydroelectric Project (Project; FERC [Federal Energy Regulatory Commission] No. 1494); Craig, Delaware, Mayes and Ottawa Counties, Oklahoma**

Dear Ms. Jaggers:

Horizon Environmental Services, Inc. (Horizon) appreciates the opportunity to provide environmental support services to the Grand River Dam Authority (GRDA) for the Pensacola Hydroelectric Project (Project; FERC [Federal Energy Regulatory Commission] No. 1494), spanning Craig, Delaware, Mayes & Ottawa Counties, Oklahoma (Project Area).

As part of the relicensing of the Pensacola Hydroelectric Project the GRDA filed a preapplication document with FERC on February 1, 2017 (GRDA 2017). The GRDA filed its Proposed Study Plan (PSP) for the relicensing on April 27, 2018 (GRDA 2018a). Also, on April 27, 2018, FERC released its Scoping Document 2 for the relicensing of the Project (FERC 2018).

In support of the relicensing effort, Horizon was contracted to conduct two years of presence/absence surveys for the American burying beetle (*Nicrophorus americanus*; ABB) to determine whether the ABB, a federally threatened species, may be present within the proposed Project Area. The Project Area is located within the ABB's current range, but outside of any conservation priority area (CPA) as defined by the US Fish and Wildlife Service (USFWS) (see attached Vicinity Map). The 2021 ABB survey was concluded in July 2021 with negative findings for all six survey locations. The 2022 ABB survey was completed in June 2022 with negative findings for all six survey locations.

On 9 June 2022, Horizon ABB Specialist Stephanie Rainwater (permit number TE-00284A) placed six (6) traps to cover a representative sample of all suitable habitat types within the Project Area (see attached Trap Maps), as well as covering the largest surface areas of potential terrestrial impact from potential water level fluctuations determined by the output from the Comprehensive Hydraulic Model (CHM) developed from as part of the Hydrologic and Hydraulic Modeling Study (H&H Study) associated with this project. The traps were designed, baited and checked following the guidelines of the *American Burying Beetle Range-wide Presence/Absence Survey Guidance* (USFWS, 2018). Trap locations were oriented in Delaware and Ottawa Counties only, but confirmed with Kevin Stubbs, USFWS National Species Lead via email as sufficiently representative of the overall four county Project Area.

The six traps were checked daily for a total of five nights with valid weather parameters and yielded no positive ABB findings. The survey effort concluded on 14 June 2022 (see attached Data Collection Forms). The results of this survey will remain valid until the conclusion of the 2022 ABB active season. These negative survey findings indicate that the ABB is not active within the Project Area; thus, take (defined by the Endangered Species Act [ESA] as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect any threatened or endangered species”) is not expected as a result of this project.

If you have any questions or concerns, please do not hesitate to contact me.

Sincerely,

Stephanie Rainwater
Project Manager/Biologist (USFWS Permit Number TE-00284A)
Horizon Environmental Services, Inc.
321 S. Boston Ave., Suite 300
Tulsa, OK 74103
918-219-9951
srainwater@horizon-esi.com

**Attachments:**

1. Maps
2. Data Collection Forms

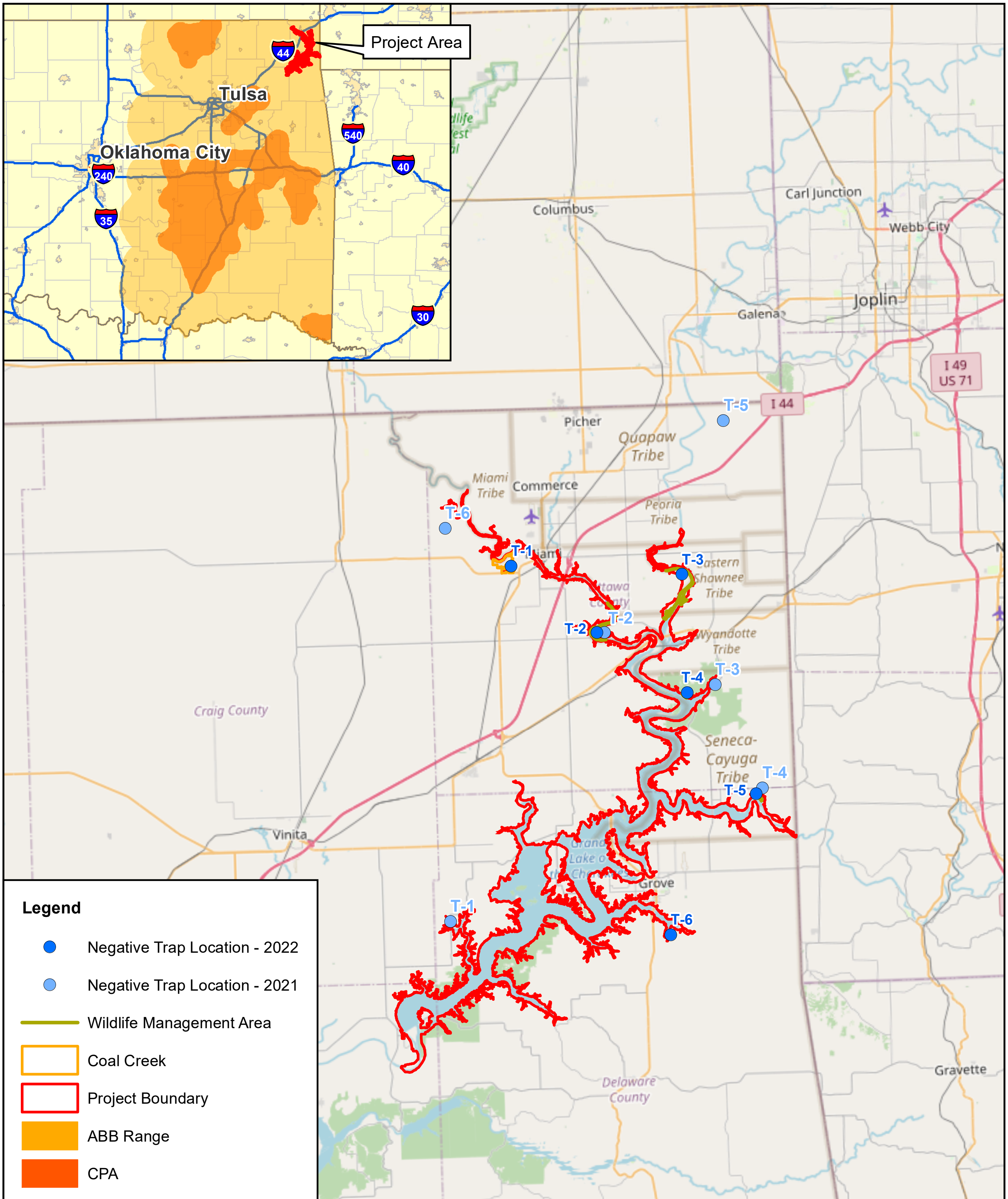
**References:**

(Esri) Environmental Systems Research Institute. World Imagery, <https://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9>. Imagery date 5 August 2020. Accessed 29 August 2022.

(OSM) OpenStreetMap contributors. OpenStreetMap, <http://www.openstreetmap.org>. Available under the Open Database License (www.opendatacommons.org/licenses/odbl). Accessed 10 August 2022.

(USFWS) US Fish and Wildlife Service. *American Burying Beetle (Nicrophorus americanus) Range-wide Presence/Absence Survey Guidance*, <https://www.fws.gov/southwest/es/oklahoma/Documents/ABB/Surveying%20final/ABB%20Rangewide%20Survey%20Guidance_Final8May2018.pdf>. Published May 2018.

(USFWS) US Fish and Wildlife Service, Oklahoma Ecological Services Field Office. *American Burying Beetle: Additional Information*. ABB Range Map and Conservation Priority Area GIS Shapefiles, available at <https://www.fws.gov/southwest/es/oklahoma/ABB_Add_Info.htm>. Range Map updated 2022; CPA Map updated 2022.




Horizon Environmental Services, Inc.

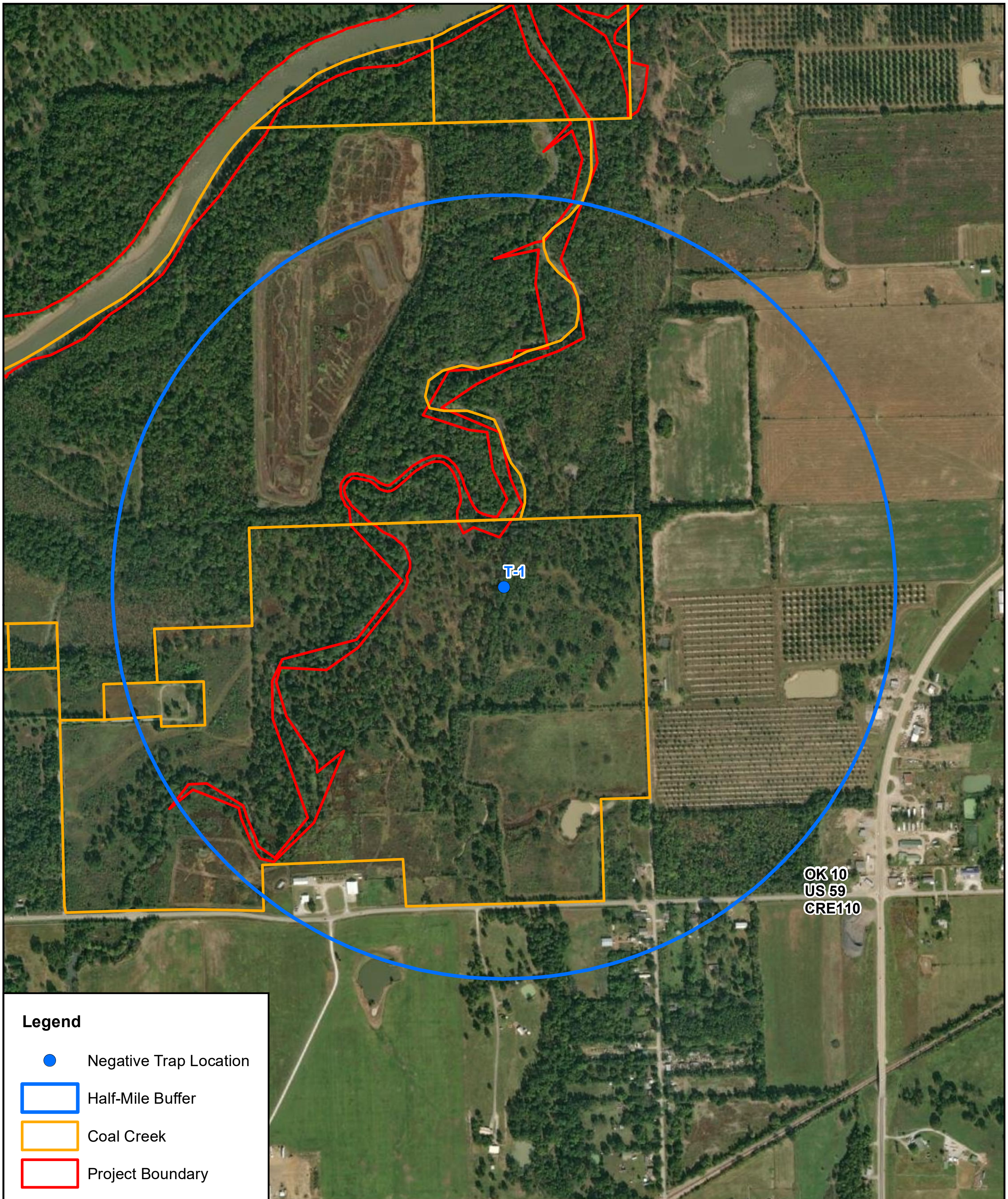
| | |
|---|---|
| Date: | 08/29/2022 |
| Drawn: | KRW |
| HJN NO: | 21021 |
| Source: | OSM, 2022 |

**Figure 2**

Vicinity Map
GRDA Pensacola Project
Craig, Delaware, Mayes & Ottawa Counties, Oklahoma

0 4.5 9
Miles

21021--GRDA_Pensacola_Project_Relicensing\Graphics\21021-002ABB_01A_Vicinity

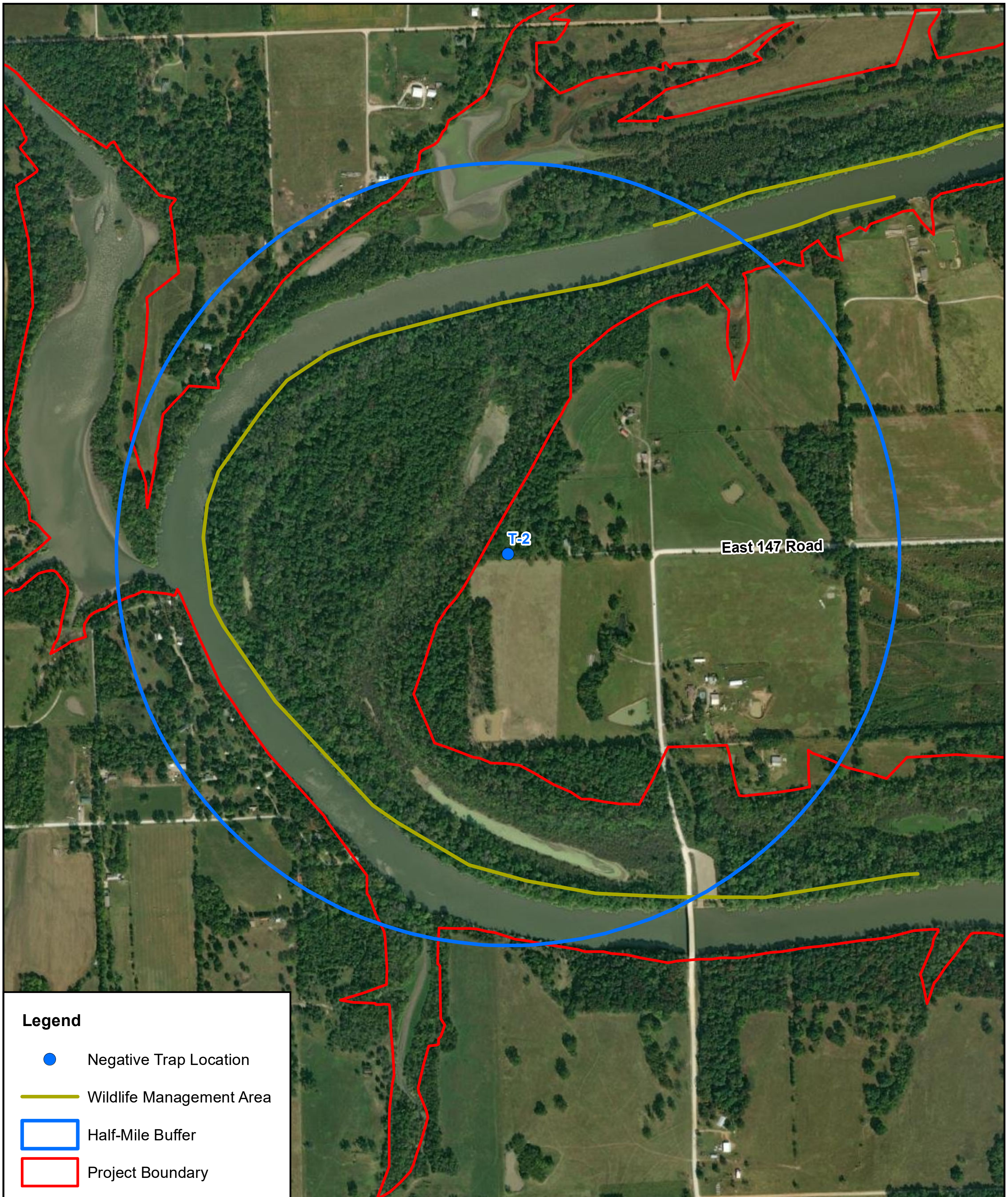



Horizon Environmental Services, Inc.

| | |
|---|---|
| Date: | 08/29/2022 |
| Drawn: | KRW |
| HJN NO: | 21021 |
| Source: | Esri, 2020 |

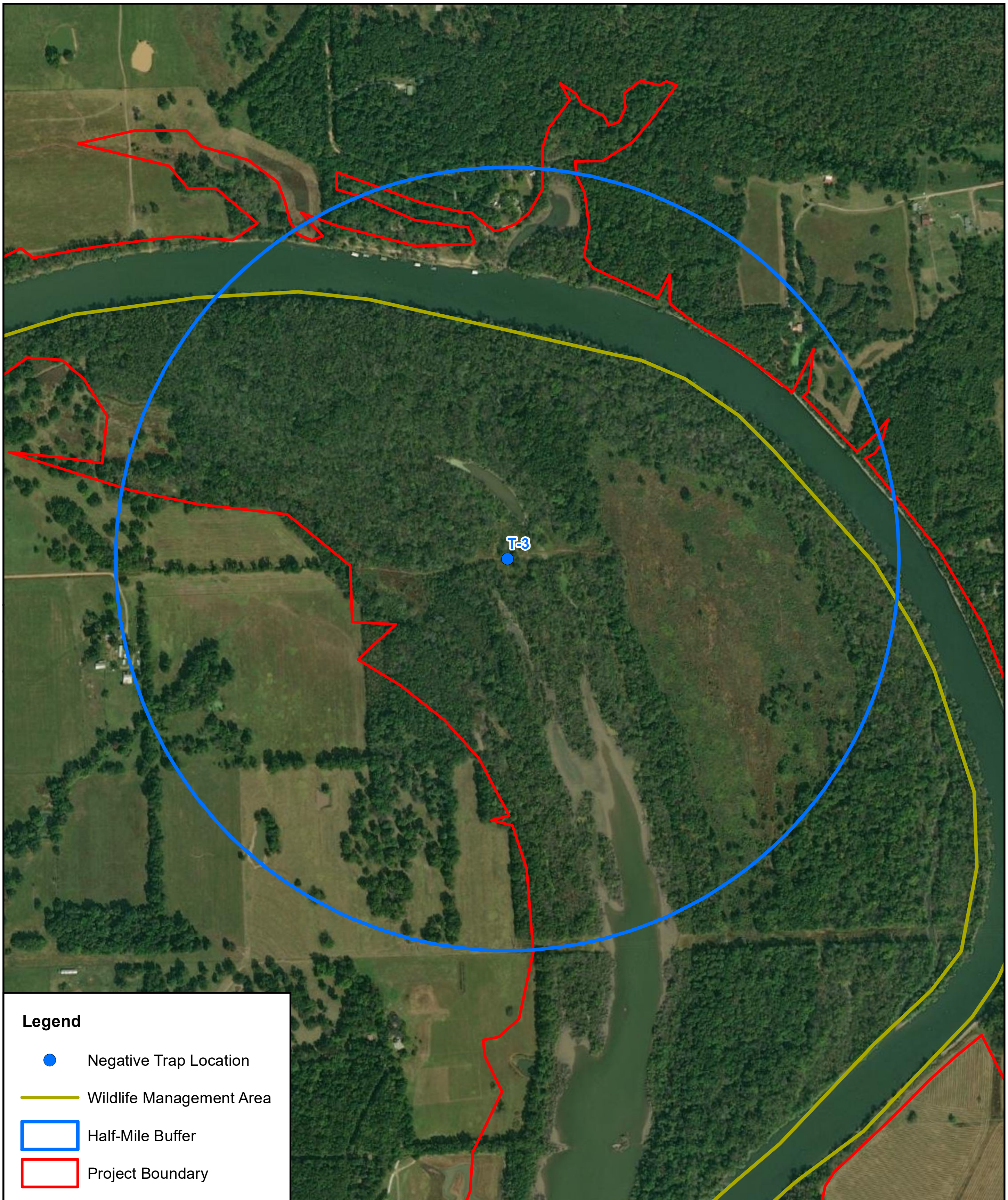
**Figure 2**

Trap Location Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma




| | | | | |
|---|---|---|---|---|
| Horizon Environmental Services, Inc. | Date: 08/29/2022 | Figure 3 | | |
| | Drawn: KRW | Trap Location Map | | |
| | HJN NO: 21021 | GRDA Pensacola Project | | |
| | Source: Esri, 2020 | Craig, Delaware, Mayes & Ottawa Counties, Oklahoma | 0 450 900 Feet | |

21021--GRDA_Pensacola_Project_Relicensing\Graphics\21021-002ABB_02A_Trap_T2



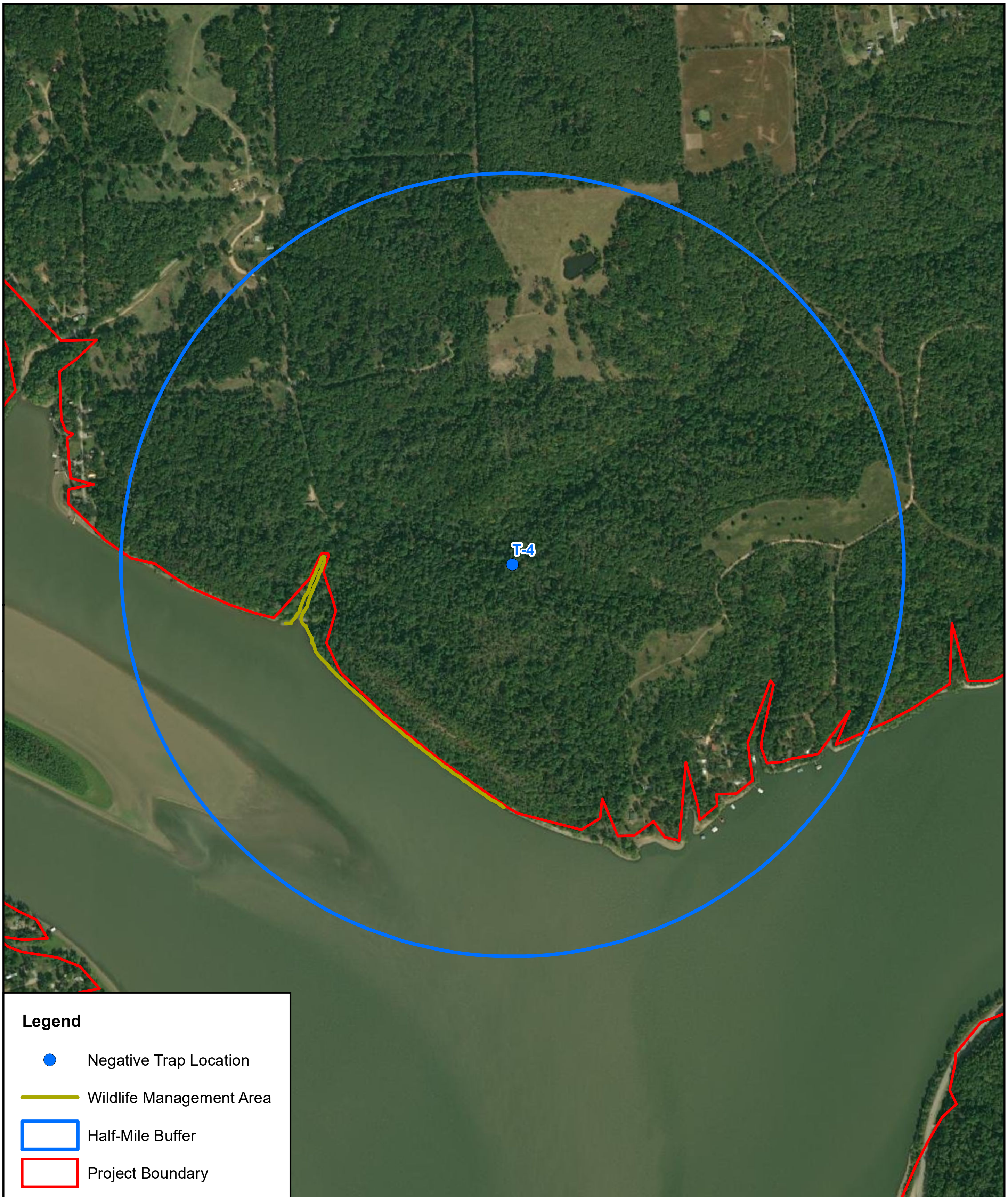

Horizon Environmental Services, Inc.

| | |
|---|---|
| Date: | 08/29/2022 |
| Drawn: | KRW |
| HJN NO: | 21021 |
| Source: | Esri, 2020 |

**Figure 4**

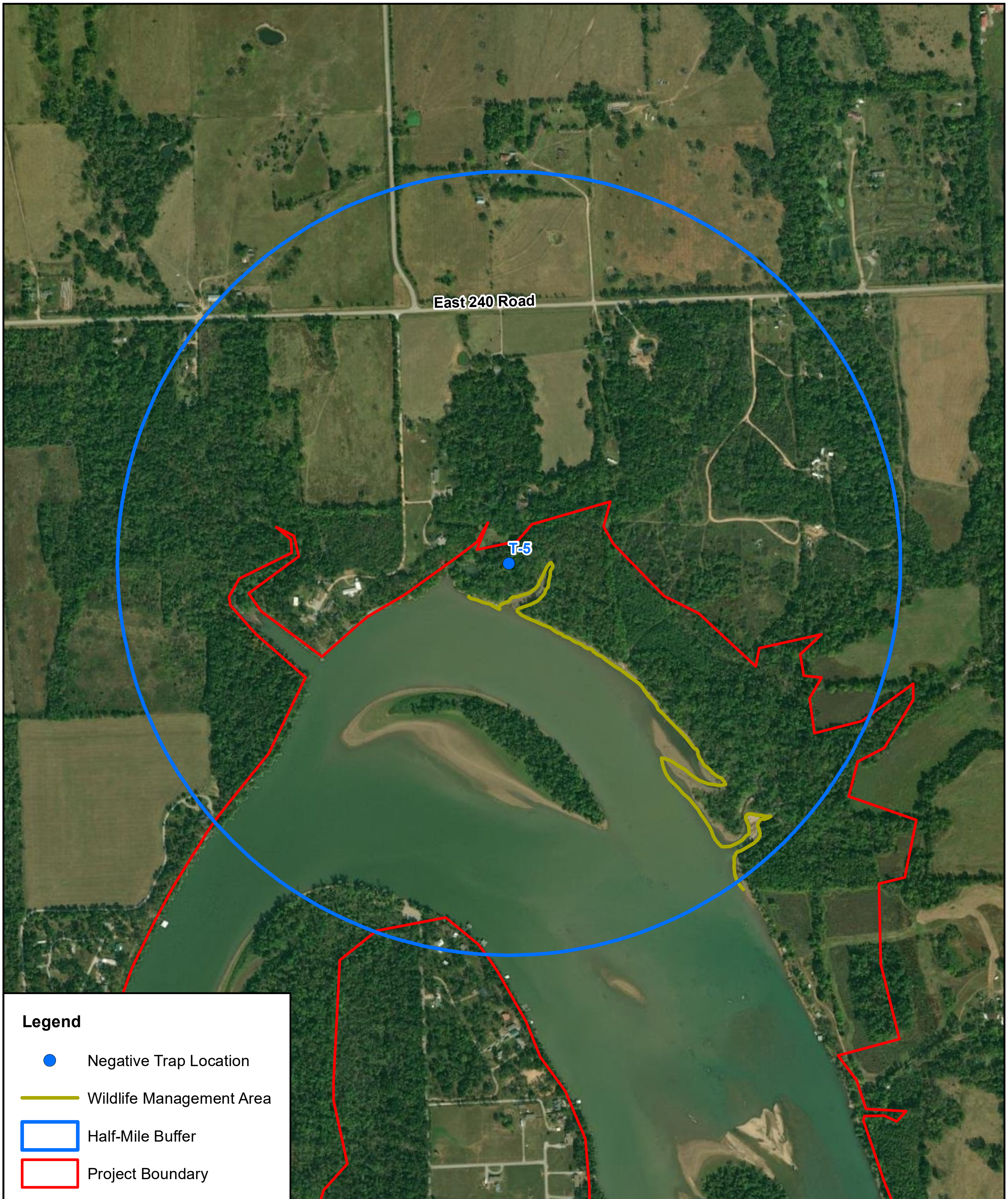
Trap Location Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

21021--GRDA_Pensacola_Project_Relicensing\Graphics\21021-002ABB_02A_Trap_T3




| | | | |
|---|---|---|---|
| Horizon Environmental Services, Inc. | Date: 08/29/2022 | **Figure 5** | 0 450 900 Feet |
| | Drawn: KRW | Trap Location Map | |
| | HJN NO: 21021 | GRDA Pensacola Project | |
| | Source: Esri, 2020 | Craig, Delaware, Mayes & Ottawa Counties, Oklahoma | |

21021--GRDA_Pensacola_Project_Relicensing\Graphics\21021-002ABB_02A_Trap_T4




Horizon Environmental Services, Inc.

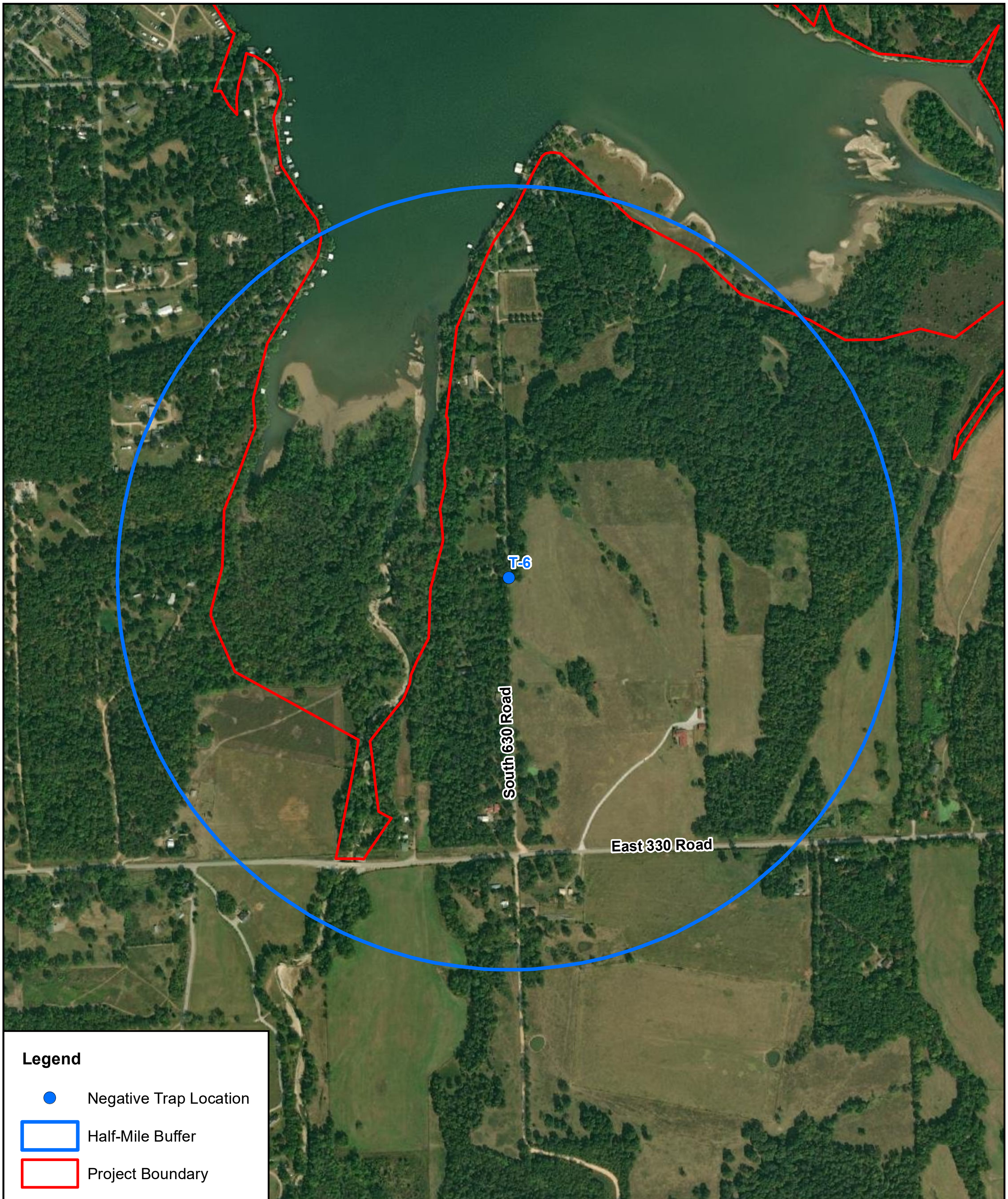
| | |
|---|---|
| Date: | 08/29/2022 |
| Drawn: | KRW |
| HJN NO: | 21021 |
| Source: | Esri, 2020 |

**Figure 6**

Trap Location Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

0 450 900
Feet

21021--GRDA_Pensacola_Project_Relicensing\Graphics\21021-002ABB_02A_Trap_T5




Horizon™ Environmental Services, Inc.

| | |
|---|---|
| Date: | 08/29/2022 |
| Drawn: | KRW |
| HJN NO: | 21021 |
| Source: | Esri, 2020 |

**Figure 7**

Trap Location Map
GRDA Pensacola Project
Craig, Delaware, Mayes &
Ottawa Counties, Oklahoma

N

0 450 900
Feet

21021--GRDA_Pensacola_Project_Relicensing\Graphics\21021-002ABB_02A_Trap_T6

Appendix A: Data Collection Forms*** American Burying Beetle Nicrophorus americanus Presence/Absence Live-trapping Survey Guidance

ENTER DATA IN COLOR-SHADED CELLS ONLY IN CELLS THAT REQUIRE DATA ENTRY - DO NOT ENTER DATA IN WHITE CELLS OR HEADER ROWS

# AMERICAN BURYING BEETLE SURVEY DATA COLLECTION FORM (April 2017)

Project Name: **Pensacola Relicensing**
Project Description: **Hydroelectric Relicensing**
Action Agency/Proponent: **Grand River Dam Authority**
Permittee: **Stephanie Rainwater**
TE Permit #: **TE-00284A**
Survey Company: **Horizon Environmental Services, Inc.**

No. of Transects Deployed: **6**
Trap Type: **Above Ground**
Bait Type: **Aged Chicken**
Trap Cover Size **24"**

Survey Night: **1**
Date Checked[1]: **June 10, 2022**

| | Month | Date | Year |
|---|---|---|---|
| Survey End Date: | June | 14 | 2022 |

## Trap Location Data

| | Trap Coordinates | | Legal Description | | | | | | Vegetation | | | | Weather |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trap No. | Latitude | Longitude | Township | Range | Section | Gen Location | County | State | Type | Primary Soil Name | Soil Description | Area | Station |
| 1 | 36.86497 | -94.912339 | 28N | 22E | 35 | Miami | Ottawa | OK | Forest | Osage silty clay | silt clay | 521 | MIAM |
| 2 | 36.805691 | -94.823145 | 27N | 23E | 21 | Wyandotte | Ottawa | OK | Forest | Dennis silt loam | silt loam | 521 | MIAM |
| 3 | 36.853037 | -94.730515 | 27N | 24E | 4 | Wyandotte | Ottawa | OK | Forest | Osage-Verdigris complex | silt loam | 521 | MIAM |
| 4 | 36.751592 | -94.729234 | 26N | 24E | 9 | Wyandotte | Ottawa | OK | Forest | Clarksville stony silt loam | silt loam | 521 | MIAM |

## Weather Data

| | (min.) | (max.) |
|---|---|---|
| Daytime Temps | 65.59 | 84.04 |
| Survey Period Temps | 65.84 | 71.42 |
| Humidity | 63.92 | 94.13 |

Wind>10mph?[6] **No** (Yes/No)
Heavy Rain?[5] **No**
Soil Moisture[4] **1.5556**

## Capture Data

| Trap No. | Disturbed (Y=1/N=0) | *Nicrophorus* species: *americanus* | *orbicollis* | *tomentosus* | *pustulatus* | *marginatus* | *carolinus* | *sayi* | *Necrophilia americana* | *Necrodes surinamensis* | *Other* | Trap Night Valid (No=0/Yes=1) | Time Checked[1]: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 7:00 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 0 | 1 | 7:49 |
| 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 3 | 1 | 7:26 |
| 4 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 5 | 1 | 8:20 |
| Totals | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 4 | 7 | 10 | 4 | |

No. of disturbed traps and/or bait (D): **0**
Additional survey night required because of weather?[8] **0** (No=0/Yes=1)
# Valid Trap Nights: **4**

List the individual ABB METRICS below and complete the appropriate columns. You will then COPY each row and PASTE into Individual ABB Capture Form BEGINNING at Cell A442 on Pg 6.

| ABB Number | Caught in Trap No. | Male | Female | Unknown Sex | Male New[9] | Male Old[9] | Female New[9] | Female Old[9] | Male Unknown Age[9] | Female Unknown Age[9] | Dead | Pronotum Width (mm) | Picture (Yes=1/No=0) | Recapture[10] | Newly Marked[11] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Automated Total | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | NA | 0 | | |

Comments: ________________________________________

# AMERICAN BURYING BEETLE SURVEY DATA COLLECTION FORM

| | | | | | |
|---|---|---|---|---|---|
| Project Name: | Pensacola Relicensing | Trap Type: | Above Ground | Survey Night: | *2* |
| Project Description: | Hydroelectric Relicensing | Bait Type: | Aged Chicken | Date Checked[1]: | June 11, 2022 |
| Action Agency/Proponent: | Grand River Dam Authority | Trap Cover Size | 24" | Permittee: | Stephanie Rainwater |
| | | | | TE Permit #: | TE-00284A |
| | | | | Survey Company: | Horizon Environmental Services, Inc. |

## Weather Data

| | (min.) | (max.) | | (min.) | (max.) | | (min.) | (max.) |
|---|---|---|---|---|---|---|---|---|
| Daytime Temps | 66.79 | 90.27 | Survey Period Temps | 68.36 | 78.26 | | 62.29 | 97.88 |

| | | | | | |
|---|---|---|---|---|---|
| Wind>10mph?6 | No (Yes/No) | Heavy Rain?[5] | No | Soil Moisture[4] | 1.5619 |

## Capture Data

| Trap No. | Disturbed (Y=1/N=0) | *Nicrophorus* species: *americanus* | *orbicollis* | *tomentosus* | *pustulatus* | *marginatus* | *carolinus* | *sayi* | *Necrophilia americana* | *Necrodes surinamensis* | *Other* | Trap Night Valid (No=0/Yes=1) | Time Checked[1]: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 7 | 1 | 6:55 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 2 | 6 | 1 | 7:45 |
| 3 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 2 | 8 | 1 | 7:22 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 5 | 1 | 8:15 |
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| **Totals** | **0** | **0** | **0** | **1** | **0** | **1** | **0** | **0** | **4** | **10** | **26** | **4** | |

| | | | | | |
|---|---|---|---|---|---|
| No. of disturbed traps and/or bait (D): | 0 | Additional survey night required because of weather?[8] | 0 (No=0/Yes=1) | # Valid Trap Nights: | 4 |

**List the individual ABB METRICS below and complete the appropriate columns. You will then COPY each row and PASTE into Individual ABB Capture Form on Pg 6.**

| ABB Number | Caught in Trap No. | Male | Female | Unknown Sex | Male New[9] | Male Old[9] | Female New[9] | Female Old[9] | Male Unknown Age[9] | Female Unknown Age[9] | Dead | Pronotum Width (mm) | Picture (Yes=1/No=0) | Recapture[10] | Newly Marked[11] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| Automated Tot. | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **NA** | **0** | | |

Comments:

# AMERICAN BURYING BEETLE SURVEY DATA COLLECTION FORM

| | | | | | |
|---|---|---|---|---|---|
| Project Name: | Pensacola Relicensing | Trap Type: | Above Ground | Survey Night: | *3* |
| Project Description: | Hydroelectric Relicensing | Bait Type: | Aged Chicken | Date Checked[1]: | June 12, 2022 |
| Action Agency/Proponent: | Grand River Dam Authority | Trap Cover Size | 24" | Permittee: | Stephanie Rainwater |
| | | | | TE Permit #: | TE-00284A |
| | | | | Survey Company: | Horizon Environmental Services, Inc. |

## Weather Data

| | (min.) | (max.) | | (min.) | (max.) | | (min.) | (max.) |
|---|---|---|---|---|---|---|---|---|
| Daytime Temps | 77.56 | 93.67 | Survey Period Temps | 78.26 | 81.5 | Humidity | 57.59 | 89.56 |

| | | | | | |
|---|---|---|---|---|---|
| Wind>10mph?6 | No (Yes/No) | Heavy Rain?[5] | No | Soil Moisture[4] | 1.5681 |

## Capture Data

| Trap No. | Disturbed (Y=1/N=0) | *Nicrophorus* species: *americanus* | *orbicollis* | *tomentosus* | *pustulatus* | *marginatus* | *carolinus* | *sayi* | *Necrophilia americana* | *Necrodes surinamensis* | *Other* | Trap Night Valid (No=0/Yes=1) | Time Checked[1]: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 6 | 1 | 7:02 |
| 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 8 | 7 | 1 | 7:50 |
| 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 7 | 1 | 7:25 |
| 4 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 2 | 1 | 4 | 1 | 8:25 |
| | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | |
| **Totals** | **0** | **0** | **0** | **1** | **2** | **1** | **0** | **0** | **5** | **15** | **24** | **4** | |

| | | | | | |
|---|---|---|---|---|---|
| No. of disturbed traps and/or bait (D): | 0 | Additional survey night required because of weather?[8] | 0 (No=0/Yes=1) | # Valid Trap Nights: | 4 |

**List the individual ABB METRICS below and complete the appropriate columns. You will then COPY each row and PASTE into Individual ABB Capture Form on Pg 6.**

| ABB Number | Caught in Trap No. | Male | Female | Unknown Sex | Male New[9] | Male Old[9] | Female New[9] | Female Old[9] | Male Unknown Age[9] | Female Unknown Age[9] | Dead | Pronotum Width (mm) | Picture (Yes=1/No=0) | Recapture[10] | Newly Marked[11] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| | | | | | | | | | | | | | | | |
| Automated Total | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **NA** | **0** | | |

Comments: Bait refreshed

# AMERICAN BURYING BEETLE SURVEY DATA COLLECTION FORM

| | | | | | |
|---|---|---|---|---|---|
| Project Name: | Pensacola Relicensing | Trap Type: | Above Ground | Survey Night: | 4 |
| Project Description: | Hydroelectric Relicensing | Bait Type: | Aged Chicken | Date Checked[1]: | June 13, 2022 |
| Action Agency/Proponent: | Grand River Dam Authority | Trap Cover Size | 24" | Permittee: | Stephanie Rainwater |
| | | | | TE Permit #: | TE-00284A |
| | | | | Survey Company: | Horizon Environmental Services, Inc. |

## Weather Data

| | (min.) | (max.) | | (min.) | (max.) | | (min.) | (max.) |
|---|---|---|---|---|---|---|---|---|
| Daytime Temps | 78.75 | 93.22 | | 80.6 | 85.64 | Humidity | 55.13 | 77.42 |

Wind>10mph?6: **No** (Yes/No) Heavy Rain?[5]: **No** Soil Moisture[4]: **1.6401**

| Capture Data | | *Nicrophorus* species | | | | | | | *Necrophilia* | *Necrodes* | *Other* | Trap Night Valid | Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trap No. | Disturbed (Y=1/N=0) | *americanus* | *orbicollis* | *tomentosus* | *pustulatus* | *marginatus* | *carolinus* | *sayi* | *americana* | *surinamensis* | | (No=0/Yes=1) | Checked[1]: |
| 1 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 4 | 3 | 1 | 7:10 |
| 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 5 | 6 | 1 | 8:00 |
| 3 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 5 | 6 | 5 | 1 | 7:35 |
| 4 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 1 | 3 | 4 | 1 | 8:29 |
| | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | |
| Totals | 0 | 0 | 3 | 1 | 2 | 3 | 0 | 0 | 6 | 18 | 18 | 4 | |

No. of disturbed traps and/or bait (D): **0** Additional survey night required because of weather?[8] **0** (No=0/Yes=1) # Valid Trap Nights: **4**

**List the individual ABB METRICS below and complete the appropriate columns. You will then COPY each row and PASTE into Individual ABB Capture Form on Pg 6.**

| ABB Number | Caught in Trap No. | Male | Female | Unknown Sex | Male New[9] | Male Old[9] | Female New[9] | Female Old[9] | Male Unknown Age[9] | Female Unknown Age[9] | Dead | Pronotum Width (mm) | Picture (Yes=1/No=0) | Recapture[10] | Newly Marked[11] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| | | | | | | | | | | | | | | | |
| Automated Tot. | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | NA | 0 | | |

Comments:

# AMERICAN BURYING BEETLE SURVEY DATA COLLECTION FORM

| | | | | | |
|---|---|---|---|---|---|
| Project Name: | Pensacola Relicensing | Trap Type: | Above Ground | Survey Night: | 5 |
| Project Description: | Hydroelectric Relicensing | Bait Type: | Aged Chicken | Date Checked[1]: | June 14, 2022 |
| Action Agency/Proponent: | Grand River Dam Authority | Trap Cover Size | 24" | Permittee: | Stephanie Rainwater |
| | | | | TE Permit #: | TE-00284A |
| | | | | Survey Company: | Horizon Environmental Services, Inc. |

## Weather Data

| | (min.) | (max.) | | (min.) | (max.) | | (min.) | (max.) |
|---|---|---|---|---|---|---|---|---|
| Daytime Temps | 78.08 | 89.56 | Survey Period Temps | 78.98 | 82.04 | Humidity | 52.05 | 77.04 |

Wind>10mph?6: **No** (Yes/No) Heavy Rain?[5]: **No** Soil Moisture[4]: **1.8303**

| Capture Data | | *Nicrophorus* species | | | | | | | *Necrophilia* | *Necrodes* | *Other* | Trap Night Valid | Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trap No. | Disturbed (Y=1/N=0) | *americanus* | *orbicollis* | *tomentosus* | *pustulatus* | *marginatus* | *carolinus* | *sayi* | *americana* | *surinamensis* | | (No=0/Yes=1) | Checked[1]: |
| 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 4 | 4 | 1 | 6:45 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 | 6 | 1 | 7:40 |
| 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 8 | 1 | 7:13 |
| 4 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 2 | 4 | 4 | 1 | 8:35 |
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| | | | | | | | | | | | | | |
| Totals | 0 | 0 | 0 | 3 | 2 | 1 | 0 | 0 | 7 | 16 | 22 | 4 | |

No. of disturbed traps and/or bait (D): **0** Additional survey night required because of weather?[8] **0** (No=0/Yes=1) # Valid Trap Nights: **4**

**List the individual ABB METRICS below and complete the appropriate columns. You will then COPY each row and PASTE into Individual ABB Capture Form on Pg 6.**

| ABB Number | Caught in Trap No. | Male | Female | Unknown Sex | Male New[9] | Male Old[9] | Female New[9] | Female Old[9] | Male Unknown Age[9] | Female Unknown Age[9] | Dead | Pronotum Width (mm) | Picture (Yes=1/No=0) | Recapture[10] | Newly Marked[11] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |
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| Automated Tot. | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | NA | 0 | | |

Comments: Survey concluded, trap pulled.

**DATA AUTOMATICALLY CALCUATED - DO NOT ENTER DATA IN BLOCKS 1, 3, OR 4**

Total Number of Traps: 6

**DATA ENTRY IS ONLY REQUIRED IN DATA BLOCK 2**

## BLOCK 1 - INDIVIDUAL TRAP CAPTURE DATA TOTALS BY SPECIES

**!!!!!DATA ENTRY IN THIS BLOCK NOT REQUIRED!!!!!!**

| Trap No. | Disturbed (0/1) | *americanus* | *orbicollis* | *tomentosus* | *pustulatus* | *marginatus* | *carolinus* | *sayi* | *Necrophilia* | *Necrodes* | *Other* | Total Trap Nights |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 14 | 22 | 5 |
| 2 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 14 | 25 | 25 | 5 |
| 3 | 0 | 0 | 2 | 2 | 0 | 3 | 0 | 0 | 5 | 15 | 31 | 5 |
| 4 | 0 | 0 | 0 | 5 | 2 | 3 | 0 | 0 | 7 | 12 | 22 | 5 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Totals | 0 | 0 | 3 | 7 | 7 | 7 | 0 | 0 | 26 | 66 | 100 | 20 |

No. of disturbed traps and/or bait (D): 0

Additional survey night required because of weather?[8] 0

## BLOCK 2 - Individual ABB Capture Data - DATA ENTRY *IS* REQUIRED IN THIS BLOCK

**COPY the INDIVIDUAL ABB Capture Data from Nightly Survey Forms and PASTE into the appropriate ROW *BY* ABB Number.**

| ABB Number | Caught in Trap No. | Male | Female | Unknown Sex | Male New[9] | Male Old[9] | Female New[9] | Female Old[9] | Male Unknown Age[9] | Female Unknown Age[9] | Dead | Pronotum Width (mm) | Picture (Yes=1/No=0) | Recapture[10] | Newly Marked[11] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| Total ABB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | NA | 0 | 0 | 0 |

Comments:

Total Number of Traps: 1

**!!!!!DO NOT ENTER ANY DATA IN THIS DATA BLOCK!!!!!**

## BLOCK 3 - Total ABB Capture Data by Trap / Transect - Data from THIS BLOCK autopopulates into the Survey Summary Form

| Trap No. | Total ABB | Male | Female | Unknown Sex | Male New[9] | Male Old[9] | Female New[9] | Female Old[9] | Male Unknown Age[9] | Female Unknown Age[9] | Dead | Total Trap/Bait Disturbed | Recapture[10] | Newly Marked[11] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Totals | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## BLOCK 4 - Cumulative Survey Period Weather Data Summary - NO DATA ENTRY REQUIRED IN THIS BLOCK

| Trap Night | Daytime Temp Range | | Survey Period Temp Range | | Daily Humidity Range | |
|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max |
| 1 | 65.59 | 84.04 | 65.84 | 71.42 | 63.92 | 94.13 |
| 2 | 66.79 | 90.27 | 68.36 | 78.26 | 62.29 | 97.88 |
| 3 | 77.56 | 93.67 | 78.26 | 81.5 | 57.59 | 89.56 |
| 4 | 78.75 | 93.22 | 80.6 | 85.64 | 55.13 | 77.42 |
| 5 | 78.08 | 89.56 | 78.98 | 82.04 | 52.05 | 77.04 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 |

***** - For surveys involving more than 10 transects, the surveyor should complete additional data forms. Project title information should remain the same, however the transect number(s) should continue in sequential order, i.e. Trap 11, 12…20.**

1. Date and time refer to when trap is checked;
2. Check that legal description fits decimal degrees location. Lat/long MUST be in decimal degrees, NAD 83
3. Max/Min temp from 9 pm to 4 am prior to checking traps, must use data from www.wunderground.com
4. Soil moisture must be obtained by obtaining the TR-05 report from http://www.mesonet.org/index.php/weather/daily_data_retrieval.
5. Rain from 9 pm to 4 am, must use data from www.wunderground.com
6. Wind exceeds 10 mph > than 20% of time between 9 pm to 4 am
7. Additional trapping required if any metrics exceed the allowable thresholds.
8. Determine total number of disturbed traps over all 5 survey nights. Any disturbance to 5-gallon traps requires an additional night of survey effort.
9. OLD=breeding adult; NEW=newly enclosed adult; UNK=age cannot be determined.
10. Recaptures refer to color and number of bee tag on beetles that have been previously marked.
11. Newly marked males and females refers to color, number of bee tag, and age of beetle (e.g. R54[old]).

Heavy Rain is defined by the World Meteorological Organization (http://severe.worldweather.org/raindoc.html) as "Rainfall greater than or equal to 50 mm [1.9685 inches] in the past 24 hours."

Last updated April 2017

Appendix A: Data Collection Forms*** American Burying Beetle Nicrophorus americanus Presence/Absence Live-trapping Survey Guidance

ENTER DATA IN COLOR-SHADED CELLS ONLY IN CELLS THAT REQUIRE DATA ENTRY - DO NOT ENTER DATA IN WHITE CELLS OR HEADER ROWS

# AMERICAN BURYING BEETLE SURVEY DATA COLLECTION FORM (April 2017)

| | | | | | |
|---|---|---|---|---|---|
| Project Name: | Pensacola Relicensing | No. of Transects Deployed: | 6 | Survey Night: | 1 |
| Project Description: | Hydroelectric Relicensing | Trap Type: | Above Ground | Date Checked[1]: | June 10, 2022 |
| Action Agency/Proponent: | Grand River Dam Authority | Bait Type: | Aged Chicken | | |
| Permittee: | Stephanie Rainwater | Trap Cover Size | 24" | | Month / Date / Year |
| TE Permit #: | TE-00284A | | | Survey End Date: | June / 14 / 2022 |
| Survey Company: | Horizon Environmental Services, Inc. | | | | |

## Trap Location Data

| | Trap Coordinates | | Legal Description | | | | | | Vegetation | | | | Weather |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trap No. | Latitude | Longitude | Township | Range | Section | Gen Location | County | State | Type | Primary Soil Name | Soil Description | Area | Station |
| 5 | 36.663097 | -94.659122 | 25N | 25E | 7 | Turkey Ford | Delaware | OK | Forest | Healing silt loam | silt loam | 521 | JAYX |
| 6 | 36.5446 | -94.75535 | 24N | 24E | 20 | Jay | Delaware | OK | Mixed | Britwater silt loam | silt loam | 521 | JAYX |
| | | | | | | | | | | | | | |
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## Weather Data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Daytime Temps | 65.05 (min.) | 82.4 (max.) | Survey Period Temps | 65.3 (min.) | 68.36 (max.) | -996 (min.) | -996 (max.) |
| Wind>10mph?[6] | No (Yes/No) | | Heavy Rain?[5] | No | Soil Moisture[4] | 1.4622 | |

## Capture Data

| | | *Nicrophorus* species | | | | | | | *Necrophilia* | *Necrodes* | *Other* | Trap Night Valid | Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trap No. | Disturbed (Y=1/N=0) | *americanus* | *orbicollis* | *tomentosus* | *pustulatus* | *marginatus* | *carolinus* | *sayi* | *americana* | *surinamensis* | | (No=0/Yes=1) | Checked[1]: |
| 5 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 5 | 18 | 3 | 1 | 9:00 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 5 | 1 | 9:30 |
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| Totals | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 7 | 23 | 8 | 2 | |

No. of disturbed traps and/or bait (D): 0

Additional survey night required because of weather?[8] 0 (No=0/Yes=1)

# Valid Trap Nights: 2

List the individual ABB METRICS below and complete the appropriate columns. You will then COPY each row and PASTE into Individual ABB Capture Form BEGINNING at Cell A442 on Pg 6.

| ABB Number | Caught in Trap No. | Male | Female | Unknown Sex | Male New[9] | Male Old[9] | Female New[9] | Female Old[9] | Male Unknown Age[9] | Female Unknown Age[9] | Dead | Pronotum Width (mm) | Picture (Yes=1/No=0) | Recapture[10] | Newly Marked[11] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| Automated Total | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | NA | 0 | | |

Comments: ____________________

# AMERICAN BURYING BEETLE SURVEY DATA COLLECTION FORM

| | | | | | |
|---|---|---|---|---|---|
| Project Name: | Pensacola Relicensing | Trap Type: | Above Ground | Survey Night: | 2 |
| Project Description: | Hydroelectric Relicensing | Bait Type: | Aged Chicken | Date Checked[1]: | June 11, 2022 |
| Action Agency/Proponent: | Grand River Dam Authority | Trap Cover Size | 24" | Permittee: | Stephanie Rainwater |
| | | | | TE Permit #: | TE-00284A |
| | | | | Survey Company: | Horizon Environmental Services, Inc. |

## Weather Data

| | (min.) | (max.) | | (min.) | (max.) | | (min.) | (max.) |
|---|---|---|---|---|---|---|---|---|
| Daytime Temps | 67.08 | 89.19 | Survey Period Temps | 68.36 | 73.04 | Humidity | -996 | -996 |

Wind>10mph?6: No (Yes/No) | Heavy Rain?[5]: No | Soil Moisture[4]: 1.4573

## Capture Data

| Trap No. | Disturbed (Y=1/N=0) | *Nicrophorus* species *americanus* | *orbicollis* | *tomentosus* | *pustulatus* | *marginatus* | *carolinus* | *sayi* | *Necrophilia americana* | *Necrodes surinamensis* | *Other* | Trap Night Valid (No=0/Yes=1) | Time Checked[1]: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 0 | 0 | 4 | 0 | 4 | 0 | 0 | 0 | 6 | 25 | 5 | 1 | 9:05 |
| 6 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 4 | 3 | 1 | 9:37 |
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| | | | | | | | | | | | | | |
| Totals | 0 | 0 | 4 | 1 | 4 | 0 | 0 | 0 | 9 | 29 | 8 | 2 | |

No. of disturbed traps and/or bait (D): 0 | Additional survey night required because of weather?[8] 0 (No=0/Yes=1) | # Valid Trap Nights: 2

**List the individual ABB METRICS below and complete the appropriate columns. You will then COPY each row and PASTE into Individual ABB Capture Form on Pg 6.**

| ABB Number | Caught in Trap No. | Male | Female | Unknown Sex | Male New[9] | Male Old[9] | Female New[9] | Female Old[9] | Male Unknown Age[9] | Female Unknown Age[9] | Dead | Pronotum Width (mm) | Picture (Yes=1/No=0) | Recapture[10] | Newly Marked[11] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| Automated Tot. | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | NA | 0 | | |

Comments:

# AMERICAN BURYING BEETLE SURVEY DATA COLLECTION FORM

| | | | | | |
|---|---|---|---|---|---|
| Project Name: | Pensacola Relicensing | Trap Type: | Above Ground | Survey Night: | 3 |
| Project Description: | Hydroelectric Relicensing | Bait Type: | Aged Chicken | Date Checked[1]: | June 12, 2022 |
| Action Agency/Proponent: | Grand River Dam Authority | Trap Cover Size | 24" | Permittee: | Stephanie Rainwater |
| | | | | TE Permit #: | TE-00284A |
| | | | | Survey Company: | Horizon Environmental Services, Inc. |

## Weather Data

| | (min.) | (max.) | | (min.) | (max.) | | (min.) | (max.) |
|---|---|---|---|---|---|---|---|---|
| Daytime Temps | 77.29 | 93.27 | | 77.9 | 80.6 | Humidity | -996 | -996 |

Wind>10mph?6: No (Yes/No) | Heavy Rain?[5]: No | Soil Moisture[4]: 1.5315

## Capture Data

| Trap No. | Disturbed (Y=1/N=0) | *Nicrophorus* species *americanus* | *orbicollis* | *tomentosus* | *pustulatus* | *marginatus* | *carolinus* | *sayi* | *Necrophilia americana* | *Necrodes surinamensis* | *Other* | Trap Night Valid (No=0/Yes=1) | Time Checked[1]: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 0 | 0 | 3 | 0 | 2 | 0 | 0 | 0 | 3 | 15 | 6 | 1 | 8:59 |
| 6 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 4 | 6 | 4 | 1 | 9:31 |
| | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | |
| Totals | 0 | 0 | 3 | 2 | 4 | 0 | 0 | 0 | 7 | 21 | 10 | 2 | |

No. of disturbed traps and/or bait (D): 0 | Additional survey night required because of weather?[8] 0 (No=0/Yes=1) | # Valid Trap Nights: 2

**List the individual ABB METRICS below and complete the appropriate columns. You will then COPY each row and PASTE into Individual ABB Capture Form on Pg 6.**

| ABB Number | Caught in Trap No. | Male | Female | Unknown Sex | Male New[9] | Male Old[9] | Female New[9] | Female Old[9] | Male Unknown Age[9] | Female Unknown Age[9] | Dead | Pronotum Width (mm) | Picture (Yes=1/No=0) | Recapture[10] | Newly Marked[11] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| Automated Total | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | NA | 0 | | |

Comments: Bait refreshed

## AMERICAN BURYING BEETLE SURVEY DATA COLLECTION FORM

| | | | | | |
|---|---|---|---|---|---|
| Project Name: | Pensacola Relicensing | Trap Type: | Above Ground | Survey Night: | 4 |
| Project Description: | Hydroelectric Relicensing | Bait Type: | Aged Chicken | Date Checked[1]: | June 13, 2022 |
| Action Agency/Proponent: | Grand River Dam Authority | Trap Cover Size | 24" | Permittee: | Stephanie Rainwater |
| | | | | TE Permit #: | TE-00284A |
| | | | | Survey Company: | Horizon Environmental Services, Inc. |

### Weather Data

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Daytime Temps | 78.48 | 91.49 (max.) | Survey Period Temps | 80.42 (min.) | 85.46 (max.) | Humidity | -996 (min.) | -996 (max.) |
| Wind>10mph?6 | No (Yes/No) | | Heavy Rain?[5] | No | | Soil Moisture[4] | 1.8307 | |

### Capture Data

| Trap No. | Disturbed (Y=1/N=0) | *Nicrophorus* species: *americanus* | *orbicollis* | *tomentosus* | *pustulatus* | *marginatus* | *carolinus* | *sayi* | *Necrophilia americana* | *Necrodes surinamensis* | *Other* | Trap Night Valid (No=0/Yes=1) | Time Checked[1]: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 5 | 22 | 7 | 1 | 9:07 |
| 6 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 2 | 5 | 6 | 1 | 9:40 |
| Totals | 0 | 0 | 3 | 2 | 0 | 0 | 0 | 0 | 7 | 27 | 13 | 2 | |

No. of disturbed traps and/or bait (D): 0

Additional survey night required because of weather?[8] 0 (No=0/Yes=1)

# Valid Trap Nights: 2

**List the individual ABB METRICS below and complete the appropriate columns. You will then COPY each row and PASTE into Individual ABB Capture Form on Pg 6.**

| ABB Number | Caught in Trap No. | Male | Female | Unknown Sex | Male New[9] | Male Old[9] | Female New[9] | Female Old[9] | Male Unknown Age[9] | Female Unknown Age[9] | Dead | Pronotum Width (mm) | Picture (Yes=1/No=0) | Recapture[10] | Newly Marked[11] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Automated Tot. | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | NA | 0 | | |

Comments:

## AMERICAN BURYING BEETLE SURVEY DATA COLLECTION FORM

| | | | | | |
|---|---|---|---|---|---|
| Project Name: | Pensacola Relicensing | Trap Type: | Above Ground | Survey Night: | 5 |
| Project Description: | Hydroelectric Relicensing | Bait Type: | Aged Chicken | Date Checked[1]: | June 14, 2022 |
| Action Agency/Proponent: | Grand River Dam Authority | Trap Cover Size | 24" | Permittee: | Stephanie Rainwater |
| | | | | TE Permit #: | TE-00284A |
| | | | | Survey Company: | Horizon Environmental Services, Inc. |

### Weather Data

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Daytime Temps | 76.6 (min.) | 88.11 (max.) | Survey Period Temps | 78.44 (min.) | 82.04 (max.) | Humidity | -996 (min.) | -996 (max.) |
| Wind>10mph?6 | No (Yes/No) | | Heavy Rain?[5] | No | | Soil Moisture[4] | 2.0404 | |

### Capture Data

| Trap No. | Disturbed (Y=1/N=0) | *Nicrophorus* species: *americanus* | *orbicollis* | *tomentosus* | *pustulatus* | *marginatus* | *carolinus* | *sayi* | *Necrophilia americana* | *Necrodes surinamensis* | *Other* | Trap Night Valid (No=0/Yes=1) | Time Checked[1]: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 6 | 17 | 6 | 1 | 9:20 |
| 6 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 2 | 4 | 8 | 1 | 9:55 |
| Totals | 0 | 0 | 1 | 1 | 4 | 0 | 0 | 0 | 8 | 21 | 14 | 2 | |

No. of disturbed traps and/or bait (D): 0

Additional survey night required because of weather?[8] 0 (No=0/Yes=1)

# Valid Trap Nights: 2

**List the individual ABB METRICS below and complete the appropriate columns. You will then COPY each row and PASTE into Individual ABB Capture Form on Pg 6.**

| ABB Number | Caught in Trap No. | Male | Female | Unknown Sex | Male New[9] | Male Old[9] | Female New[9] | Female Old[9] | Male Unknown Age[9] | Female Unknown Age[9] | Dead | Pronotum Width (mm) | Picture (Yes=1/No=0) | Recapture[10] | Newly Marked[11] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Automated Tot. | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | NA | 0 | | |

Comments: Survey concluded, trap pulled.

## DATA AUTOMATICALLY CALCUATED - DO NOT ENTER DATA IN BLOCKS 1, 3, OR 4

Total Number of Traps: 1

**DATA ENTRY IS ONLY REQUIRED IN DATA BLOCK 2**

## BLOCK 1 - INDIVIDUAL TRAP CAPTURE DATA TOTALS BY SPECIES

**!!!!!DATA ENTRY IN THIS BLOCK NOT REQUIRED!!!!!!**

| Trap No. | Disturbed (0/1) | *americanus* | *orbicollis* | *tomentosus* | *pustulatus* | *marginatus* | *carolinus* | *sayi* | *Necrophilia* | *Necrodes* | *Other* | Total Trap Nights |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 0 | 0 | 12 | 0 | 9 | 0 | 0 | 0 | 25 | 97 | 27 | 5 |
| 6 | 0 | 0 | 1 | 6 | 4 | 0 | 0 | 0 | 13 | 24 | 26 | 5 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Totals | 0 | 0 | 13 | 6 | 13 | 0 | 0 | 0 | 38 | 121 | 53 | 10 |

No. of disturbed traps and/or bait (D): 0

Additional survey night required because of weather?[8] 0

## BLOCK 2 - Individual ABB Capture Data - DATA ENTRY *IS* REQUIRED IN THIS BLOCK

**COPY the INDIVIDUAL ABB Capture Data from Nightly Survey Forms and PASTE into the appropriate ROW *BY* ABB Number.**

| ABB Number | Caught in Trap No. | Male | Female | Unknown Sex | Male New[9] | Male Old[9] | Female New[9] | Female Old[9] | Male Unknown Age[9] | Female Unknown Age[9] | Dead | Pronotum Width (mm) | Picture (Yes=1/No=0) | Recapture[10] | Newly Marked[11] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| Total ABB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | NA | 0 | 0 | 0 |

Comments:

Total Number of Traps: 6

**!!!!!DO NOT ENTER ANY DATA IN THIS DATA BLOCK!!!!!**

## BLOCK 3 - Total ABB Capture Data by Trap / Transect - Data from THIS BLOCK autopopulates into the Survey Summary Form

| Trap No. | Total ABB | Male | Female | Unknown Sex | Male New[9] | Male Old[9] | Female New[9] | Female Old[9] | Male Unknown Age[9] | Female Unknown Age[9] | Dead | Total Trap/Bait Disturbed | Recapture[10] | Newly Marked[11] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Totals | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## BLOCK 4 - Cumulative Survey Period Weather Data Summary - NO DATA ENTRY REQUIRED IN THIS BLOCK

| | Daytime Temp Range | | Survey Period Temp Range | | Daily Humidity Range | |
|---|---|---|---|---|---|---|
| Trap Night | Min | Max | Min | Max | Min | Max |
| 1 | 65.05 | 82.4 | 65.3 | 68.36 | -996 | -996 |
| 2 | 67.08 | 89.19 | 68.36 | 73.04 | -996 | -996 |
| 3 | 77.29 | 93.27 | 77.9 | 80.6 | -996 | -996 |
| 4 | 78.48 | 91.49 | 80.42 | 85.46 | -996 | -996 |
| 5 | 76.6 | 88.11 | 78.44 | 82.04 | -996 | -996 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 |

***** - For surveys involving more than 10 transects, the surveyor should complete additional data forms. Project title information should remain the same, however the transect number(s) should continue in sequential order, i.e. Trap 11, 12…20.**

1. Date and time refer to when trap is checked;
2. Check that legal description fits decimal degrees location. Lat/long MUST be in decimal degrees, NAD 83
3. Max/Min temp from 9 pm to 4 am prior to checking traps, must use data from www.wunderground.com
4. Soil moisture must be obtained by obtaining the TR-05 report from http://www.mesonet.org/index.php/weather/daily_data_retrieval.
5. Rain from 9 pm to 4 am, must use data from www.wunderground.com
6. Wind exceeds 10 mph > than 20% of time between 9 pm to 4 am
7. Additional trapping required if any metrics exceed the allowable thresholds.
8. Determine total number of disturbed traps over all 5 survey nights. Any disturbance to 5-gallon traps requires an additional night of survey effort.
9. OLD=breeding adult; NEW=newly enclosed adult; UNK=age cannot be determined.
10. Recaptures refer to color and number of bee tag on beetles that have been previously marked.
11. Newly marked males and females refers to color, number of bee tag, and age of beetle (e.g. R54[old]).

Heavy Rain is defined by the World Meteorological Organization (http://severe.worldweather.org/raindoc.html) as "Rainfall greater than or equal to 50 mm [1.9685 inches] in the past 24 hours."

Last updated April 2017

# APPENDIX C

USFWS Correspondence Re: Trap Placement

## Stephanie Rainwater

**From:** Stubbs, Kevin <kevin_stubbs@fws.gov>
**Sent:** Wednesday, March 23, 2022 1:55 PM
**To:** Stephanie Rainwater
**Subject:** Re: [EXTERNAL] GRDA Pensacola Relicensing Project - ABB Trap Placement

**[EXTERNAL EMAIL]**

That will work. Just put the traps in the best habitat that is available (more open grassland or mix with timber).

Kevin
918-695-6769

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**From:** Stephanie Rainwater <srainwater@horizon-esi.com>
**Sent:** Monday, March 21, 2022 5:39 PM
**To:** Stubbs, Kevin <kevin_stubbs@fws.gov>
**Subject:** RE: [EXTERNAL] GRDA Pensacola Relicensing Project - ABB Trap Placement

Kevin,

Good evening! I have attached a pdf map as well as a kmz showing the Coal Creek mitigation area and the wildlife management areas. I have overlaid five proposed trap sites which cover the four wildlife management areas and the mitigation site. We placed the 6th trap in a far southeastern area that has a somewhat significant terrestrial area between the project boundary and the shoreline. Please let me know if you concur these traps sites provide sufficient coverage in the proper areas for this project.

Thanks!

**Stephanie Rainwater**
Project Manager

**Horizon Environmental Services, Inc.**
www.horizon-esi.com | An LJA Company

**LJA Environmental Services, LLC**
www.ljaenv.com

321 S. Boston, Suite 300, Tulsa, OK 74103
O: 918.553.3232 | C: 918.219.9951

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**From:** Stubbs, Kevin <kevin_stubbs@fws.gov>
**Sent:** Monday, March 14, 2022 3:07 PM
**To:** Stephanie Rainwater <srainwater@horizon-esi.com>
**Subject:** Re: [EXTERNAL] GRDA Pensacola Relicensing Project - ABB Trap Placement

**[EXTERNAL EMAIL]**

The new project boundary will include all wildlife management and wetland mitigation areas Like the Coal Creek site. So I would put traps at those sites and any other sites with the best available habitat.

Kevin

918-695-6769

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**From:** Stephanie Rainwater <srainwater@horizon-esi.com>
**Sent:** Monday, March 14, 2022 1:25 PM
**To:** Stubbs, Kevin <kevin_stubbs@fws.gov>
**Subject:** [EXTERNAL] GRDA Pensacola Relicensing Project - ABB Trap Placement



Kevin,

Good afternoon! I'm currently trying to plan the 2022 ABB survey effort for the GRDA Pensacola Relicensing Project and would like to get your input. As a refresher, when I placed the six 2021 survey traps, I positioned them in areas that provided the most terrestrial coverage within the presumed project area which was defined at that time by the upstream extents model (see attached kmz titled "ABB_Trap_Project.kmz"). The boundary has since been reduced based on the results of the H&H study (see attached kmz titled "Project_Boundary_NEW_10012021.kmz"). As there a very few areas of significant terrestrial acreage between the shoreline and the project boundary for me to use the same site selection methodology, I was wondering if you would recommend the six locations that you would consider provide sufficient representation with respect to the project. You can just send me the lat/longs or drop pins in a kmz, whichever works best for you.

Thanks so much!

**Stephanie Rainwater**
Project Manager

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**LJA Environmental Services, LLC**
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**[EXTERNAL EMAIL]** Exercise caution. Do not open attachments or click links from unknown senders or unexpected email